UNIVERSITY OF DELHI

CNC-II/093/1/EC-1276/25/5
Dated: 31.07.2025

NOTIFICATION

Sub: Amendment to Ordinance V

(ECR 24-17/ dated 12.07.2025)

Following addition be made to Annexure-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

The syllabi of following Departments under Faculty of Science based on Postgraduate Curriculum Framework 2024 are notified herewith for the information of all concerned :

Department	Syllabi
Anthropology	M.Sc. Anthropology - Annexure-1 M.Sc. Forensic Science - Annexure-2
Botany	M.Sc. Botany - Annexure-3
Zoology	M.Sc. Zoology - Annexure-4
Physics & Astrophysics	M.Sc. Physics - Annexure-5
Chemistry	M.Sc. Chemistry - Annexure-6
Environmental Studies	1. M.Sc. /M.A. Environmental Studies (DSC/ SBC) - Annexure-7 2. M.Sc. /M.A. Environmental Studies (DSE Pool) - Annexure-8

REGISTRAR

First Year PG Curricular Structure for Two years PG Programme (3+2)							
Year-1				Year-1			
		Paper	Credits			Paper	Credits
Semester-1	DSC-1	Perspectives on Society and Culture	3+1	Semester-2	DSC-4	Fundamentals of Human Genetics	3+1
	DSC-2	Biological Anthropology	3+1		DSC-5	Kinship, Marriage and Family	3+1
	DSC-3	Archaeological Anthropology	3+1		DSC-6	Anthropological Theories	3+1
			12 credits				12 credits
	OPT for either 2 DSEs OR 1 DSE & 1 GE				OPT for either 2 DSEs OR 1 DSE & 1 GE		
	DSE	Social Institutions	3+1		DSE	Human Ecology and Adaptation	3+1
		Demographic Anthropology				Human Population Genetics	
		Human Growth and Development	3+1			Visual Anthropology	3+1
		Ethnic and Cultural Diversity of India				Museum Anthropology	
	GE	Forensic Anthropology	3+1		GE	Research Methods in Anthropology	3+1
		Environment and Sustainable Development				Anthropology of Development	
			8 credits				8 credits
	Skill Based/Workshop/Specialized Laboratory/Hands on Learning				Skill-Based/Workshop/Specialized Laboratory/Hands on Learning		
	Paper-1	Ethnographic Film Making			Paper-1	Corporate Anthropology	
	Paper-2	Anthropometry and Somatoscopy	2		Paper-2	Techniques in Human Genomics	2
		Total	22 credits			Total	22 credits

First Year PG Curricular Structure for Two years PG Programme (3+2)
Year-1

Semester-1

	Paper	**Credits**
DSC-1	Perspectives on Society and Culture	3+1
DSC-2	Biological Anthropology	3+1
DSC-3	Archaeological Anthropology	3+1
		12
OPT for ethier 2 DSEs OR 1 DSE & 1 GE		
DSE	Social Institutions	3+1
	Demographic Anthropology	
	Human Growth and Development	3+1
	Ethnic and Cultural Diversity of India	
GE-1	Forensic Anthropology	3+1
	Environment and Sustainable Development	
		8
Skill Based/Workshop/Specialized Laboratory/Hands on Learning		
Paper-1	Ethnographic Film Making	**2**
Paper-2	Anthropometry and Somatoscopy	
	Total	**22**

Discipline Specific Core-1

Perspectives on Society and Culture

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Perspectives on Society and Culture	**04**	**03**	**0**	**01**	**UG**

This course will introduce the basic concepts of social anthropology. Humans are bio-cultural beings and society and culture are universal human phenomena. There are myriad ways through which human beings organizes itself to come to terms with its surroundings and this course looks at this phenomena, the universality and the distinctions of myriad human social organizations .

Course Objectives:

1. The objective of this course is to introduce the students with the Anthropology and its main branches including social anthropology, their historical roots, the subject matter of social anthropology and its scope.
2. The paper looks at different traditions in social anthropology and the debates relating to the nature of society and culture.
3. It also familiarize the students with the fundamental concepts of structure, pattern organization, system, institutionalization and others.

Learning Outcomes:

1. The students will be able to understand and apply the basic concepts like groups, institutions, organization and community in understanding of society and culture.
2. They should be able to appreciate the significance of social anthropology and its contemporary role in the society.
3. They will also critically understand the various approaches to understand society and culture be able to understand how the knowledge of anthropology is important for health, business, ecology, psychology, media and public policy.

Contents:

Unit I **12 hours**

Introduction to Anthropology and its main branches. Subject matter, scope and its relations with other subjects, such as sociology, linguistics, psychology, history and economics Historical roots of anthropological tradition: Classical anthropology. Emergence of Fieldwork in anthropology

Unit II **10 hours**

Concept of society and culture and its characteristics, biology-culture-society debates, status and role; groups, association, institution, community, and organization. Ranking, Hierarchy, and stratification.

Unit III **13 hours**

Approaches to the study of society and culture; perspectives: Social fact and solidarity and social consciousness; social action, structure, function; social system, pattern variables, social organisation and structure, function, Indological perspectives

Unit IV **10 hours**

Anthropology as an applied and an engaged discipline: role of anthropology in public policy, tribal welfare and development, nation building. Contemporary social issues.

TUTORIAL: READINGS OF ETHNOGRAPHY **30 hours**

The theory will be supported with readings of ethnographies, that anthropologist produces at the end of their research work. The data in these work are gathered through an immersive and empathetic understanding and interpreted theoretically to arrive at inductive understanding of human behavior. The class room will provide the platform to debate and discuss three ethnographies to outline critically. The student will be required to critically comment on the methodology and findings of an ethnographic account as directed by the teacher concerned.

1. The student should be able to critically examine the theoretical approach followed.

2. Make a critical evaluation of data used.

3. Suggest alternative analytical tools.

4. Evaluate the impact made by this ethnography an anthropological theory.

Core Readings

- Barnard, Alan. 2000. *History and Theory in Anthropology*. Cambridge, U.K.: Cambridge University Press.
- Beattie, John. 1968. *Other cultures: Aims, Methods and Achievements in Social Anthropology*. Free Press.
- Nadel, S. F. 1951. *The Foundations of Social Anthropology*. Glencoe, Ill: Free Press. 7. Ingold, Tim. 1994. Companion Encyclopedia of Anthropology. Routledge reference. London: Routledge.
- Eriksen, Thomas Hylland. 2001. *Small Places, Large Issues: An Introduction to Social and Cultural Anthropology*. London: Pluto Press.
- Epstein, W. 1976. *The Craft of Anthropology*. Manchester: University of Manchester Press.

Suggested Reading

- Gay y Blasco, Paloma and Huon Wardle. 2017. *How to Read Ethnography*. Routledge. (NB Available as e-Book through the library)

- Geertz, C. 1973. Thick Description in *The Interpretation of Cultures*. New York: Basic Books. Geertz, C. 2004. After the Fact Chicago: University of Chicago Press.

- Gupta, A. and J. Ferguson. 1997. *Anthropological Locations: Boundaries and Grounds of a Field Science*. Berkeley: University of California Press Holly, V. 2000. The Comparative Method in Anthropology.

- Kuper, Adam. 1996 [1973]. *Anthropology and Anthropologists: the modern British School. London*: Routledge.

- Ingold, Tim. 1994. *Companion Encyclopedia of Anthropology*. London: Routledge
- Pandharinath H. Prabhu .2016. Hindu Social organization: Socio-Psychological and Idelogcal Foundation. Delhi: Sage
- Mandelbaum, D.G., 1970. *Society in India: Changes and Continuities*. Bombay : Popular Prakashan.

Teaching Learning Process

1. Classroom teachings

2. Seminars and Interactive sessions

3. Tutorial Sessions

Assessment Methods: Theory Examination and Continuous Assessment through tutorials

Keywords: Humanity, Society, Culture, Culture Change, Ethnography, Public and Engaged anthropology

Discipline Specific Core-2

Biological Anthropology

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Biological Anthropology	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. To learn the scope of the field and the relationship of its sub-fields with other disciplines.
2. To build a foundational understanding of Biological Anthropology through basic human biology, evolution, adaptation and diversity.
3. To provide insights into primate behavior and ecology for understanding the evolutionary origins of human behavior and cognition.

Learning Outcomes

Students will learn:

1. The scope of biological anthropology along with the key adaptive mechanisms of emergence of mankind in the context of human evolution.
2. The role of evolutionary forces in varying ecologies differentially shapes bio-cultural human adaptations.
3. To interpret primate biology and behavior in understanding human evolutionary development.

Course Content

Unit-I: 10 hours

Human biological classification, history of anthropology, and its sub-fields and relationship with other disciplines; Human cell structure, function and replication; Evolutionary Relationships-Convergence, Parallelism and Cladistics; Perspectives of Biological Anthropology and Indian Knowledge Systems

Unit-II: 10 hours

Early evolutionary theories; Fundamental theory of evolution: Lamarckism; Darwinism; Synthetic theory; Working of evolution (gradualism; punctuated equilibrium; macroevolution and adaptation); concept and formation of species; Evolution of Brain and language; Evolution of human behavior and sexual selection. Theories of evolution in the light of Indian knowledge system

Unit-III: 12 hours

Applied Biological anthropology, Concept of homeostasis and adaptation, Physical Human Growth: Stages of Growth, Nutrition and Development, Factors affecting growth, Methodologies for growth studies, Gerontology; Theories of ageing. Traditional Rearing Practices

Unit-IV: **13 hours**

Introduction to primate biology of living human primates; phylogenic and taxonomic distribution of living non-human primates and their arboreal & dietary adaptive strategies and behavioral plasticity. Classification and Characteristic features of Primates. Evolution of Erect posture and bipedalism. Indian Knowledge system in understanding of non-human primates and their conservation. Ethnic elements of India; Genetic, Climatic, Physiological and Nutritional adaptations; Critical assessment of Race, UNESCO statement on Race; Global and Indian Classifications of Mankind.

Practical **30 hours**

1. Human Osteology: Cranium, Mandible, Clavicle, Scapula, Long bones, Vertebrae and Pelvis
2. Somatometric and Somatoscopic Observation on living persons: Standing and Sitting height; Body weight; Head Circumference; Head Length, Breadth; Bizygomatic Breadth; Bigonial Breadth; Physiognomic Facial Height; Morphological Facial Height; Physiognomic Upper Facial Height; Morphological Upper Facial Height, Nasal Height; Nasal Length; Nasal Breadth; Cephalic Index; Nasal Index

References

Core Readings

1. Stanford, C., Allen, J. S., & Antón, S. C. (2018). *Biological anthropology: The natural history of humankind* (8th ed.). Pearson.
2. Frayer, D. W., & Ciochon, R. C. (2017). *The human evolutionary transition*. Pearson.
3. Strier, K. B. (2016). *Primate behavior and ecology* (4th ed.). Pearson.
4. Campbell, G. (2016). The Ethnology of India. Wentworth Press.

Suggested Readings

1. Eugenia Shanklin (1993). Anthropology and Race: The Explanation of Differences. Cengage Learning: 1 edition
2. Jurmain R., Kilogre L., Trevathan W., Ciochon R.L. (2012). Introduction to Physical Anthropology. Wadsworth Publications, USA.
3. Statement of Race: Annotated Elaboration and Exposition of the Four Statements on Race (1972). Issued by UNESCO. Oxford University Press. 14.

Keywords

Biological anthropology, Evolution, Primate Behavior, Human Variation, Race, Comparative anatomy.

Discipline Specific Core-3

Archaeological Anthropology

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Archaeological Anthropology	**04**	**03**	**01**	**0**	**UG**

Course Objectives:

1. To provide students with a foundational understanding of archaeological anthropology, focusing on tool typology, identification, and cultural interpretations.
2. To critically engage with the latest developments in archaeological theories and methodologies developments.

Learning Outcomes:

By the end of this course, students will:

1. Understand prehistoric archaeology's key concepts, terminologies, and methodologies comprehensively.
2. Analyse the chronological and cultural developments of Indian and European prehistory.
3. Critically assess the role of archaeological anthropology in interpreting prehistoric cultures.
4. Develop an understanding of new and emerging trends in archaeological anthropology: environmental, cognitive, and social archaeology.

Course Contents

Unit I: 11 hours

History and Development of Archaeology. Definitions and scope of archaeological anthropology. Overview of archaeological sites and materials. Dating Methods: Relative and absolute dating methods Theoretical Approaches: Cognitive Archaeology, Ethnoarchaeology, and others

Unit II: 11 hours

Paleolithic Culture: Lower Palaeolithic Culture:Atapuerca- Boxgrove. Middle Palaeolithic Culture-Neanderthals, Mousterian tools, and their cognitive implications. Upper Palaeolithic Culture-Emergence of Homo sapiens, cultural shifts, and symbolic behaviour. Cave art.

Mesolithic Culture. Transition from hunting-gathering to early farming societies.

Neolithic Revolution. Spread of farming, permanent settlements, and early agriculture.

Unit III: 12 hours

Palaeolithic Cultures. Lower, Middle, and Upper Palaeolithic culture and key sites (e.g., Bhimbetka, Narmada Valley). Mesolithic Culture. Key sites in India and their regional comparisons. Neolithic Culture: Early farming and domestication practices. Key sites in India and their regional comparisons. Prehistoric Art in India. Indus Valley Civilization.

Unit IV: **11 hours**

Trends and Recent Advances: Theories of human migration (Out of Africa, Multiregional, Partial Replacement). Evidence from genetic, linguistic, and archaeological data. Current Research in Archaeological Anthropology. Technology, gender, and Artificial Intelligence. Sites like Dmanisi (Georgia), Atapuerca (Spain), and recent interdisciplinary approaches

Practical **30 Hours**

1. Quaternary geological formations.
2. Detailed Study and Understanding of Tool Types and associated tool technology and its chronological evolution- Lower Palaeolithic Culture; Middle Palaeolithic Culture; Upper Palaeolithic Culture; Mesolithic Culture; Neolithic Culture; Art objects; Bone Tools and artefacts

Students can refer to the following resources for practical (Bhattacharya, D. K. (1979). *Old Stone Age tools: A manual of laboratory techniques of analysis*. Calcutta: K. P. Bagchi and Company; Inizan, M. L., Ballinger, M. R., Roche, H., and Tixier, J. (1999). *Technology and terminology of knapped stone*. Nanterre: CREP; Oakley, K. P. (1972). *Man the tool maker* (6th ed.). London: Trustees of the British Museum (Natural History); Sankalia, H. D. (1982). *Stone age tools: Their techniques, names and probable functions*. Poona: Deccan College).

Core Readings

1. Allchin, F. R. (1995). *The archaeology of early historic South Asia: The emergence of cities and states*. Cambridge University Press.
2. Bhattacharya, D. K. (1977). *Palaeolithic Europe*. Humanities Press.
3. Bhattacharya, D.K. (2006). An outline of Indian Prehistory. Delhi: Palaka Prakashan.
4. Bhattacharya, D. K. (2014). *Old Stone Age tools and techniques*. K.P. Bagchi Company.
5. Champion, T., Gamble, C., Shennan, S., and Whittle, A. (2016). *Prehistoric Europe*. Routledge.
6. Hodder, I. (1995). *Interpreting archaeology: Finding meaning in the past*. Routledge.
7. Milisauskas, S. (Ed.). (2011). *European prehistory: A survey*. Springer Science & Business Media.

Suggested Readings

1. Coles, J. M., & Higgs, E. S. (1969). *The archaeology of early man*. Faber and Faber.
2. Fagan, B. M., and Durrani, N. (2018). *People of earth: An introduction to world prehistory*. Routledge.
3. Paddayya, K. (1990). *New archaeology and aftermath: View from outside the Anglo-American world*. Ravish Publishers.
4. Renfrew, C., and Bahn, P. G. (1994). *Archaeology: Theories, methods and practice*. Thames and Hudson.
5. Sankalia, H. D. (1974). *Prehistory and protohistory of India and Pakistan*. Deccan College.

Keywords: Archaeological Anthropology. Prehistory. India. Europe. Art.

Discipline Specific Elective

Social Institutions

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Social Institutions	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. This course focuses on how human behavior is shaped by social practices across key areas like Kinship, Family, Economy and Marriage among others.
2. Students with be introduced to the standardized concepts like descent, alliance, kin which have been important areas of Anthropological discourse.

Learning Outcomes

1. The students will learn the analytical terms to understand diverse human societies and cultures.
2. They should be able to understand and describe the many different ways cultures change and grow in response to human aspirations and pursuit for a better life.

Course Content

Unit-I: **10 hours**

Concept of Social Institutions: Definition, types, and Approaches in Anthropology. Primary institutions including Kinship, Family and Marriage

Unit-II: **12 hours**

Economy: Formalist and Substantivist approaches. Reciprocity, redistribution and market. systems of production, consumption and distribution, Barter and ceremonial exchange, long distance trade in simple societies

Unit-III: **12 hours**

Religion: Concept of Supernatural and approaches to the study of religion; Religious Specialists; Witchcraft and Sorcery, Religion and its relationship to power in India

Unit-IV: **11 hours**

Political Institution: Concept of power and authority, political structure and process, state and stateless political systems, customary law. Leadership, nation state and citizenship

Tutorial **30 hours**

1. The student is required to familiarize the functionaries of the social institutions as instructed by the course teacher. They are to write down the functioning of these institutions: - Family, Kinship, Economic, Religious and Political.

2. Case study of any of the social institution (religion, economic, political) or inter-relationship between the institutions with respect to cultural perspective. The project may be presented as text or visual.

References

Core Readings

1. Asad, T. (1992). Religion and politics: An introduction. *Social Research*, 3-16.
2. Douglas, Mary. 2012. How institutions think? Syracuse University Press.
3. Elardo, J. A., & Campbell, 2006. A. Revisiting the Substantivist/Formalist Debate: A Formal Presentation of Three Substantivist Criticisms.
4. Ember, C.R., Melvis Ember, Peter N. Peregrine 2007 Anthropology. Pearson Education
5. Karve, Irawati. 1968. Kinship organization in India. London: Asia Publ. House.

Suggested Readings

1. Malinowski, B.1967 Argonauts of the Western Pacific. London: Routledge and Kegan Pau
2. Michael Lambeck (ed), 2002. A Reader in the Anthropology of Religion. Malden, Blackwell.
3. Radcliffe-Brown, A. R., and Cyril Daryll Forde. 1950. African systems of kinship and marriage. London: Published for the International African Institute by the Oxford University Press.
4. Vincent, Joan (ed.). 2002. The anthropology of Politics: A reader in ethnography, theory and critique. Blackwell publisher

Keywords: Institutions, Family, Religion, Kinship, Economy and Politics.

Discipline Specific Elective
Demographic Anthropology

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Demographic Anthropology	**04**	**03**	**01**	**0**	**UG**

Nature of the Course
Course Objective

1. To give the students a foundational understanding of population structure and its implications and to apprise them the essential concepts of demographic anthropology.
2. To disseminate knowledge on the different sources of demographic data and population policies in the country.

Course Learning Outcomes

1. Students will learn the basic concepts and approaches of the bio-social determinants of demographic processes in human populations.
2. They will know how human population growth is affected by human behaviour and the genetic and non-genetic factors.
3. The students will understand and make use of the governmental and non-governmental demographic sources in research and they will be capacitated to engage in the formulation of several national policies.

Unit 1 **10 hours**
Basic concepts in demographic anthropology: Scope, Relationships, Importance and Relevance of demography in anthropology. Population thought on growth and decline and its dilemma.

Unit 2 **10 hours**
Biological and socio-economic population theories: Malthusian, John Graunt and T. R. Malthus and Theory of Demographic Transition.

Unit 3 **13 hours**
Population structure: Age and sex composition, components of population change. Estimation of demographic rates and ratios; general and specific estimates of fertility and mortality. Sources of demographic data- Census, SRS, NSSO, NFHS-IIPS

Unit 4 **12 hours**
Determinants of Fertility, Mortality, Morbidity and Migration. Marriage and the effects of Inbreeding. National Population Policy, National Health Policy, Population ethics.

Practical **30 hours**

1. Estimation of Rates and Ratios
2. Population pyramid and its significance
3. Formulation of household and maternal & child health schedules and interview of respondents

4. Analysis of governmental demographic data and submission of project report for evaluation.

Core Readings

1. Bhende, A. and Kanitkar, T. (19th Ed), 2019. *Principles of Population Studies*. Himalaya Publishing House, Mumbai.
2. Bogue, DJ, 1969. *Principles of Demography*. Cambridge, UK
3. Caldwell, JC, 2006. *Demographic Transition Theory*. Springer
4. *Graunt's Bills of Mortality* (Digital Library quod.lib.umich.edu)
5. Patel, T. 1994.Fertility Behaviour: Population and Society in a Rajasthan Village. Chapter No. 3. Social and Cultural Context of Fertility. Oxford University Press, Delhi. P. 74-105.
6. Howell, N, 1986. Demographic Anthropology. *Ann. Rev. Anthropol*. 15: 219-246

Supplementary Readings

1. Jasper, R & Tronbjorn, T (eds.) 2004. *The Repugnant Conclusion: Essays on Population Ethics.* Kluwer Academic Publishers
2. National Family Health Survey, India (nfhsiips.in)
3. Shryock, HS & Siegel, JS, 1971.*The Methods & Materials in Demography*. Elsevier Academic Press
4. Sources of demographic data (censusofindia.gov.in; nfhsiips.in)
5. Weeks, JR (13th Ed), 2021. *Population: An Introduction to Concepts and Issues.* Cengage Learning, Inc. USA
6. Zubrow, EBW, 1976. *Demographic anthropology. Quantitative approaches*. University of New Mexico Press, Albuquerque

Teaching Learning Process

Lecture
Interactive group discussion
Black board and PPT
Class room presentation

Assessment Methods

Written Assignment
Presentation by students
Practical
Interview
Project Report

Keywords

Demographic anthropology, population theories, population structure, demographic sources, National policies

Discipline Specific Elective

Human Growth and Development

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Human Growth and Development	**04**	**03**	**01**	**0**	**UG**

Course Objectives:

- This course provides an interdisciplinary understanding of human growth and development across the lifespan, integrating biological, psychological, social, and cultural perspectives.
- It critically examines classical and modern theories, while incorporating advances in neuroscience, epigenetics, and cross-cultural research.
- Students gain practical insights into research methods and their applications in education, health, and social policy.

Learning Outcomes:

Upon successful completion of the course, students will be able to:

- Understand and critically analyse foundational and contemporary theories of human development.
- Demonstrate knowledge of developmental stages with an interdisciplinary lens including biological, cognitive, emotional, and sociocultural aspects.
- Evaluate the role of contextual, environmental, and technological factors in shaping developmental trajectories.

Unit I: 11 hours

Theoretical and Conceptual Foundations of Development

Concept and Scope of Human growth and development: Historical evolution, interdisciplinary nature; Classical Theories and applications of human growth; Emerging Perspectives: Dynamic systems theory, ecological systems theory (Bronfenbrenner), lifespan development approach; Role of Genetics, Epigenetics & Evolution in Human Development; Neurobiological bases of behaviour and cognition

Unit II: 11 hours

Lifespan Developmental Stages and Transitions

Prenatal Development: Genetic and environmental interplay, foetal programming; Infancy and Early Childhood: Brain development, attachment, early learning; Middle Childhood & Adolescence: Puberty, identity formation, academic and social challenges; Adulthood to Late Adulthood: Emerging adulthood, career and relationship development, cognitive aging, death and bereavement

Unit III: **11 hours**

Influences on Development

Biological and Health-related Influences: Hormonal changes, nutrition, and physical health; Environmental and Social Determinants: Parenting, schooling, peer influence, and digital media; Cultural Contexts and Global Perspectives: Cross-cultural comparisons and indigenous understandings of development; Technology and Development: Impact of digital environments on cognition, socialization, and identity

Unit IV: **12 hours**

Research and Applications in Human growth and Development

Introduction to Developmental Psychology and Interdisciplinary Research; Research Methodologies: Longitudinal vs cross-sectional, experimental, observational, mixed-methods approaches; Ethics in Developmental Research, Future Trends: AI and human behaviour studies, psychogenomics, and inclusive development frameworks

Practical **30 hours**

I Size and Shape measurements

1.Standing Height Vertex 2. Sitting Height Vertex 3. Body weight 4. Upper and lower Extremity Lengths (Direct & Indirect) 5. Biacromial Breadth 6. Bicristal Breadth 7. Chest Breadth (Transverse) 8. Chest Depth (Sagittal) 9. Chest Girth (Inspiration, Expiration, Normal) 10.Circumferences 11. Skinfolds at various sites

II Shape Growth Ratios

1. Relative Sitting Height vertex 2. Relative Right Total Upper Extremity Length 3. Relative Right Total Lower Extremity Length 4. Relative Right Fore Arm Length 5. Relative Right Hand Length 6. Relative Biacromial Breadth 7. Relative Bicristal Breadth 8. Relative Head and Face Segment 9. Relative Head and Neck Segment 10. Relative Height Gnathion 11. Relative Height Cervicale 12. Relative Right Upper arm length 13. Cephalic Index 14. Nasal Index

Core Readings:

1. Human Growth and Development: Issues and Applications – R.N. Vashisht (2002)
2. The Physiology of Human Growth – J.M. Tanner (1989)
3. Human Growth Assessment and Interpretation- A. Roche (2003)
4. Human Growth and Development – Noel Cameron (2002)
5. Bogin, B. (2020). *Patterns of human growth* (Vol. 88). Cambridge University Press.

Suggested Readings:

1. Ulijaszek, S. J., Johnston, F. E., & Preece, M. A. (Eds.). (1998). *The Cambridge encyclopedia of human growth and development*. Cambridge University Press.
2. Tanner, J. M. (1963). The regulation of human growth. *Child development*, 817-847.
3. Norris, S. A., Frongillo, E. A., Black, M. M., Dong, Y., Fall, C., Lampl, M., ... & Patton, G. C. (2022). Nutrition in adolescent growth and development. *The lancet*, *399*(10320), 172-184.

4. Wells, J. C., & Stock, J. T. (2020). Life history transitions at the origins of agriculture: a model for understanding how niche construction impacts human growth, demography and health. *Frontiers in Endocrinology, 11*, 325.

Keywords:

Lifespan Development, Developmental Neuroscience, Cross-cultural Psychology, Epigenetics, Applied Developmental Science

Discipline Specific Elective

Ethnic and Cultural Diversity of India

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Ethnic and Cultural Diversity of India	**04**	**03**	**0**	**01**	**UG**

Course Objectives:

- The objective of the course is to familiarise students with the underlying unity of Indian Civilisation in the context of cultural and ethnic diversity of India.
- To familiarise ethnic and biological composition of Indian Population and bio-cultural diversity
- To understand the factors, which contribute to the unity of the Indian Civilization despite its variations and diversity.

Learning Outcomes:

- In terms of biological variations students will be able to critically analyse the contributions of Risley, Guha, Rickstett and Sarkar towards understanding of ethnic elements in Indian population.
- They would be able to understand the composition, origin and evolution of civilization and the shortcomings and limitations of the universal approaches in Indian and western theories.
- They will be able to explain the critical concepts of tribe caste, class, gender in understanding of the Indian social reality with its varied hues and dynamics.

Contents

Unit I **12 hours**

Diversity of ethnic elements in India: Critical appraisal on the contributions of 20th Century. Anthropologists towards understanding ethnic distinctness in the Indian populations. Linguistic classification of Indian populations.

Unit II **10 hours**

Pre-historic and Proto-historic racial elements in India. Recent studies on Indian genetic diversity.

Unit III **12 hours**

Peopling of India and the emergence of Civilisation in India; Approaches to the study of Indian Civilization: The origin and evolution of social structures and their underlying philosophies. Unity and consciousness of Indian civilization.

Unit IV **11 hours**

Understanding the diversity in Indian social structure, Religion, Kinship Family and Marriage in India, Social realities – Dynamics of caste, class, tribe, communal and gender hierarchies and their transformation; Urbanization and urban social structure and changes in urban India.

Tutorial: **30 hours**

Mapping of communities based on language, religion, customs, cultural resources, modes of adaptation; Cultural zones of India.

Mapping and identification of all Eco-cultural zones with their characteristic features

Students will also work on two projects which would examine any of the facets of cultural and biological diversity of India. The project will be based on empirical data. They will submit project reports based on the analysis and conclusions drawn from the data.

Teaching Learning Process

1. Classroom teachings
2. Seminars and Interactive sessions
3. Hands on training and fieldwork
4. Practical classes

Assessment Methods: Theory and practical examinations (including practical records)

Core Readings

1. Bose, N.K. 1961. The Structure of Hindu Society. Delhi Orient Longman.
2. Basu, A., Sarkar, RN & Majumdar, PP, 2015. Genomic reconstruction of the history of extant populations of India reveals five distinct ancestral components and a complex structure. Proceedings of the National Academy of Sciences, USA.
3. Cohn S. Bernard: 2000. India: The Social Anthropology of Civilization. Delhi: Oxford University Press.
4. Dirks Nicholas. 2001. Castes of Mind: Colonialism and the Making of Modern India. Princeton University Press.
5. Gupta, Dipankar (ed). Social Stratification. Delhi: Oxford University Press.

Suggested Readings

1. Karve, Irawati 1961. Hindu Society: An Interpretation. Poona: Deccan College.
2. Majumdar, PP & Basu, A, 2021. A Genomic View of the Peopling and Population Structure of India. Cold Spring Harbor Laboratory Press.
3. Mandelbaum, D.G., 1970. Society in India: Changes and Continuities. Bombay: Popular Prakashan.
4. Reich et al., 2009. Reconstructing Indian population history. Nature, 461:08365.
5. Srivastava V. K. 1997, Religious Renunciation of a Pastoral people. Delhi: Oxford University Press.

Generic Elective

Forensic Anthropology

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Forensic Anthropology	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. To introduce students to the principles and methodologies of Forensic Anthropology, including its relevance in medico-legal investigations.
2. To develop practical skills in the analysis of skeletal remains, forensic odontology, personal identification, and the use of advanced forensic techniques.
3. To understand the medico-legal implications of various forensic anthropological practices, including forensic haematogenetics, fingerprint analysis, and DNA profiling.

Learning Outcomes: By the end of this course, students will be able to:

1. Apply the core principles of Forensic Anthropology to the identification of human remains and the determination of personal characteristics such as age, sex, ancestry, and stature.
2. Critically analyze skeletal trauma and pathology in relation to the forensic context, providing insights into cause and manner of death.
3. Students will develop expertise in forensic odontology, personal identification, and advanced forensic methods such as fingerprinting and DNA profiling, while also acquiring knowledge of the use of anthropological traits in disputed parentage cases and their role as expert witnesses in legal proceedings.

Course Content

Unit I: Foundations of Forensic Anthropology **12 hours**

Definition and Scope**.** Introduction to Forensic Anthropology as a sub-discipline of biological anthropology. Role of Forensic Anthropologists in medico-legal investigations. Ethical considerations in handling human remains.

Historical Development. Evolution of Forensic Anthropology and landmark contributions. Case studies illustrating the application of Forensic Anthropology.

Legal Relevance. Responsibilities of Forensic Anthropologists as expert witnesses. Overview of Section 45 of the Indian Evidence Act. Principles of forensic reporting and legal documentation.

Unit II: Human Remains and Biological Profiling **11 hours**

Skeletal Analysis: Identification of human skeletal elements. Estimation of biological sex, age, ancestry, and stature from long bones. Osteometric and Morphological Methods: Measurement techniques using osteometric tools and software. Morphometric and visual approaches for profiling. Forensic Odontology: Tooth anatomy and development. Dental methods for age estimation in children and adults. Bite mark analysis and individualisation using tooth pulp. Population-based variation in dental morphology.

Unit III: Identification Techniques in the Living and the Deceased 11 hours

Personal Identification Methods: Somatometric and somatoscopic analysis: body measurements, scars, tattoos, and physical deformities. Identification from skeletal remains through morphometric traits. Fingerprint Analysis: Classification and comparison of fingerprints. Recovery of partial, complete, and latent prints for identification.
Forensic Serology: Detection and analysis of bloodstains and body fluids (semen, saliva, urine). Species determination and blood grouping. Polymorphic enzyme and HLA typing for individualisation.

Unit IV: Advanced Forensic Applications 11 hours

DNA Profiling: Molecular basis: STRs, VNTRs, and sequence variation. DNA fingerprinting in personal identification and criminal investigation. Disputed Parentage Analysis: Use of anthropological and genetic traits in resolving paternity disputes. Field Recovery and Reporting: Protocols for the recovery of human remains. Maintaining chain of custody. Writing Forensic Anthropology reports and presenting expert testimony in legal proceedings.

Practical

Human Skeletal Identification and Profiling:
- o Estimation of sex (skull and pelvis), age (skull), and stature (long bones).

A. Odontological Profiling
   - o Tooth identification and analysis for age estimation.
   - o Bite mark comparison exercises using dental casts.
   - o Study of dental variations across populations using sample data.

B. Living and Deceased Identification
   - Somatometric and somatoscopic analysis (scars, tattoos, deformities, occupational marks, others).
   - Fingerprint classification and latent print development using powder and chemical methods.
   - Analysis of skeletal traits for individualisation in the deceased.

Forensic Serology and Molecular Identification
   - Preliminary tests for blood, saliva, semen, and urine detection.
   - ABO and Rh blood grouping techniques.
   - Demonstration: DNA profiling basics and polymorphic markers (STR, VNTR).
   - Simulation of parentage analysis using genetic trait charts.

Field Methods and Forensic Reporting
   - Simulated recovery of skeletal remains: excavation, documentation, and labelling.
   - Chain of custody protocol demonstration.
   - Preparation of forensic anthropology reports with mock legal documentation.
   - Roleplay: Presentation of expert witness testimony in a simulated courtroom.

Core Readings

1. Byers, Steven N. (2023). *Introduction to Forensic Anthropology* (6th ed.). Routledge.

2. Krogman, W. M. & Iscan, M. Y. (2013). *The Human Skeleton in Forensic Medicine*. (3rd ed.)
3. Steward, T. D. (1979). *Essentials of forensic anthropology*. Charles C. Thomas.
4. Steadman, D. W. (2009). *Hard Evidence: Case Studies in Forensic Anthropology* (2nd ed.). Prentice Hall.
5. Klepinger, L. L. (2006). Fundamentals of forensic anthropology. John Wiley & Sons.

Supplementary Readings

1. Koff, Clea (2005). *The Bone Woman: A Forensic Anthropologist's Search for Truth*. Random House.
2. Ubelaker, Douglas H. (2017). "A History of Forensic Anthropology." *American Journal of Physical Anthropology*, 165: 915–923.
3. Blau, Soren (2016). "How Traumatic: A Review of the Role of the Forensic Anthropologist." *Australian Journal of Forensic Sciences*, 49(3): 261–280.
4. Kirby, L. T. (1990). *DNA fingerprinting: An introduction.* Stockton Press.
5. Bhasin, M. K., & Nath, S. (2002). *Role of forensic science in the new millennium*. Kamla-Raj Enterprises.
6. Cattaneo, C. (2007). Forensic anthropology: Developments of a classical discipline in the new millennium. *Forensic Science International*, *165*(2–3), 185–193. https://doi.org/10.1016/j.forsciint.2006.05.018

For practicals students can refer to resources (Boorman, K. E., Dodd, B. E., & Lincoln, P. J. (1981). *Blood group serology: Theory, techniques, practical applications* (5th ed.). Churchill Livingstone; Burns, K. R. (2013). *Forensic Anthropology Training Manual* (3rd ed.). Pearson; White, Tim D., & Folkens, P.A. (2005). *The Human Bone Manual*. Elsevier Academic Press)

Keywords
Forensic Anthropology, Human Skeletal Analysis, Osteology, Trauma Analysis, Forensic Pathology, Legal Investigations, Age Estimation, Sex Determination

Generic Elective

Environment and Sustainable Development

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Environment and Sustainable Development	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. To understand the natural resources, their distribution, inter-relationships, uses, and the institutional arrangements governing their utilization
2. To investigate environmental challenges and risk of food security; and global climate change agreements
3. To develop strategies for environmental conservation, green growth, and sustainable development

Learning Outcomes

1. To acquire skills to identify traditional ecological knowledge for sustainability in various environments and correlate natural resources with sustainable livelihoods
2. To appreciate the use of Anthropological approach to find solutions to environmental problems
3. To gain insights into environment and sustainable development including case studies from different regions; and sustainable development goals

Course Content

Unit-I: **12 hours**

Environment: Basic concepts i.e., ecology, eco-system, natural resources; carrying capacity, socio-cultural environment; Population and environment; theoretical perspective of the environment and its sustainability

Unit-II: **11 hours**

Biodiversity: Definitions and values; Threats to biodiversity; Agriculture and food security; Integrated water resource management

Unit-III: **11 hours**

Sustainable Development: Definition, evolution and concepts; Green growth; Current issues on sustainable development; Millennium Development Goals, Sustainable Development Goals

Unit-IV: **11 hours**

Global environmental issues and policies: Climate change and its impact on food security, energy and water; coping mechanism, Environmental policies; Conventions and treaties on environment and climate change

Practical **30 hours**

Preparation of project reports related to traditional ecological knowledge, environment, livelihoods, sustainable development, and treaties on climate change.

References

Core Readings

1. Appadurai, A. (1996). Modernity at Large. Minnesota: University of Minnesota Press.
2. Evans-Pritchard E.E. (1940). The Nuer: A Description of the Modes of Livelihood and Political Institutions of a Nilotic People. Oxford: Clarendon Press.
3. Richard T. Wright, Dorothy F. Boorse (2017) Environmental Science: Toward A Sustainable Future, Pearson, 13th Edition
4. Schnaiberg, A. and K. Gould. (1994). Environment and Society: The Enduring Conflict. New York: St. Martin's Press.
5. Sharma, P.D. (2010.) Ecology and Environment. Meerut, UP. Rastogi Publications.
6. Warburton, D. (Ed.). (1998). Community & Sustainable Development: Participation in the Future. London: Earthscan Publications Limited.
7. Wilk. Richard and Haenn Nora (2006). The environment in Anthropology. New York University Press. New York.

Suggested Readings

1. Brand, U. and C. Gorg. (2008). "Sustainability and Globalization: A Theoretical Perspective". In J. Park, K. Conca and M. Finger (Eds). The Crisis of Global Environmental Governance. London: Routledge.
2. G. Tyler Miller and Scott Spoolman (2018) "Living in the Environment", International Edition.
3. Hempel, L. (1996). Environmental Governance: the global challenge. Washington: Island Press.
4. Kahn, M. (1995) Concepts, definitions, and key issues in sustainable development: the outlook for the future. Proceedings of the 1995 International Sustainable Development Research Conference, Manchester, England, Mar. 27]28, 1995, Keynote Paper, 2-13.
5. Ostrom, E. (1990). Governing the commons: the evolution of institutions for collective action. Cambridge: Cambridge University Press.
6. WCED (1987). Our Common Future. World Commission on Environment and Development. Oxford

Keywords:

Biodiversity, Climate change, Carrying capacity, Environment, Food security, Green growth, Sustainable development

Skill Enhancement Course (SEC)

Ethnographic Film Making

Course Title and Code	Total Credits	Credit distribution of the course	
		Lecture	Practical
Ethnographic Film Making	**2**	**1**	**1**

Course Objectives

1. Build confidence with equipment by training students to get comfortable using cameras and editing tools through hands-on practice with relevant tasks and projects.

2. Develop filmmaking skills in students by teaching them the basics of filming, sound recording, and editing so that they can create meaningful visual stories for research.

3. Encourage creative ethnographic research by using filmmaking to explore and represent human experiences, emotions, and social issues while working in teams and receiving expert guidance.

Learning Outcomes

1. Gain hands-on experience with cameras, sound recording tools, and editing software to create ethnographic films.
2. Learn the step-by-step workflow, from research and shooting to editing and presenting a final film.
3. Understand how ethnographic filmmaking can be used in research, including ethical considerations and its role in studying human experiences.

Course Content

Unit-I **(11 hours)**

Ethnographic filmmaking and anthropology: questions of representation, veracity, realism and reality, images of the Other and reflexivity, colonial relations of power; Images, Text, and Fieldwork: Exploring participant observation, literary, visual, and sensory approaches; Multimodal Ethnography

Unit-II **(11 hours)**

Anthropology and Observational Cinema: Exploring filmmaking styles beyond traditional ethnographic observation, diverse documentary approaches; writing film proposals, research and preparation, audio-visual production, post-production, exporting and presentation; ethical issues.

Practical **(15 hours)**

Students will produce a short documentary film (maximum 20 minutes) that explores themes discussed in the course. The films should be developed from the Visual Anthropology Lab at the department of Anthropology. The department retains the right to dissemination of films developed in the Visual Anthropology laboratory for research and teaching and public engagement.

Instructions:

1. Formation of a team: students are encouraged to work in pairs, sharing all production roles (research, filming, sound recording, and editing).
2. Preliminary research needs to be conducted to develop a concept before filming.
3. Film documentary within a one-week period over a mid-semester break. Limit footage to 5 hours.
4. Create a detailed log of rushes before editing.
5. Edit the film and submit it for assessment.
6. Films will be evaluated on technical quality, storytelling, and relevance to course themes.

This exercise will help students apply their knowledge in a structured and practical way, enhancing technical and creative documentary skills.

Core Readings

1. Crawford, Peter and David Turton, eds. 1992. *Film as Ethnography*. Manchester University Press.
2. Hockings, Paul ed. 2003. *Principles of Visual Anthropology*. Mouton de Gruyter.
3. Lawrence, Andy. 2020. *Filmmaking for Fieldwork: A practical handbook*. Manchester Univ Press
4. MacDougall. 2022. *The Art of the Observer: A Personal View of Documentary*. Manchester University Press.
5. Rose, G. 2000. *Visual Methodologies. An Introduction to Interpreting Visual Objects*. Sage Press

Suggested Readings

1. Collier, J. 1967. *Visual Anthropology: Photography as a Research Method*. Holt, Rinehart and Winston.
2. MacDougall, David, 2019. *The looking machine: Essays on cinema, anthropology and documentary filmmaking*. Manchester University Press.

Skill Enhanced Course (SEC)

Anthropometry and Somatoscopy

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Anthropometry and Somatoscopy	**02**	**01**	**01**	**0**	**UG**

Course Objectives:

- To provide an in-depth understanding of human body measurement techniques and their biological, functional, and health implications.
- It integrates advanced anthropometric technologies like 3D scanning, AI-based analysis, and digital health tracking.
- Applications in ergonomics, sports science, public health, and forensics are explored, alongside critical discussions on standardization, ethics, inclusivity, and data privacy in anthropometric research.

Learning Outcomes:

By the end of the course, students will be able to:

- Demonstrate proficiency in classical and advanced anthropometric methods and tools.
- Analyse anthropometric data for functional, health, ergonomic, and forensic purposes.
- Apply anthropometric knowledge to real-world problems in clinical assessment, product design, and sports performance.
- Evaluate emerging technologies and ethical issues in anthropometric research.
- Design and conduct anthropometric surveys, integrating interdisciplinary tools and techniques.

Unit I: Foundations and Advances of Anthropometry 19 hours

Historical evolution and scope of anthropometry; Anthropometric landmarks and anatomical reference points; Somatotyping and body proportion indices; Growth, development, and secular trends; Ethical considerations in human measurement and data collection; Traditional techniques and contemporary methods of anthropometry; Introduction to AI, machine learning, and digital imaging in body composition analysis; Standardization protocols (ISAK, WHO, CDC); Software and databases: Anthropometric data management and visualization tools

Unit II: Applications in applied research 19 hours

Anthropometry in clinical diagnostics, obesity assessment, and malnutrition; Sports anthropometry: Body composition and performance optimization; Ergonomics and human-centred product design; Forensic anthropometry and personal identification; Inclusive design: Addressing gender, disability, and age diversity in anthropometry; Designing anthropometric surveys and population-based studies; Multivariate statistical techniques in anthropometric research; Case studies: Anthropometry in refugee health, child growth monitoring, and wearable tech development; Anthropometry in policymaking: National Family Health Survey (NFHS), Poshan Tracker; Project work: Analysis of real or simulated datasets using open-access tools

- Purpose of measurements: Anthropometry and somatoscopy measurements serve to assess and document the physical characteristics of the human body for understanding variation, forensic, ergonomic, and research purposes. Anthropometry involves precise quantitative measurements such as height, weight, limb length, and body circumferences, which help evaluate growth patterns, nutritional status, and health risks. Somatoscopy, on the other hand, is a qualitative assessment of body which help to differentiate different ethnic groups. Together, these methods provide a comprehensive understanding of human body composition and structure, and population health studies.

Core Readings:

- Anthropometry - Indera P. Singh, M. K. Bhasin (1918 reprint). Kamla-Raj Enterprises
- A Manual of Biological Anthropology- Indera P. Singh (2004). Kamla-Raj Enterprises
- A Laboratory Manual of Anthropometry- Wilder, H. H. (1920). Philadelphia, P. Blakiston's Son & Co
- Montagu, M. F., & Brožek, J. C. (1960). A handbook of anthropometry. American Psychological AssociationAnthropometry - Indera P. Singh, M. K. Bhasin (1965)

Suggested Readings:

- AICH, D. S. (2023) Metric Quantifications in Anthropometry or Biometric Study of Anthropology in Human Population.
- Norton, K. I. (2018). Standards for anthropometry assessment. In *Kinanthropometry and exercise physiology* (pp. 68-137). Routledge.
- Parnell, R. W. (1954). Somatotyping by physical anthropometry. *American Journal of Physical Anthropology*, *12*(2), 209-240.

Keywords:

3D Body Scanning, Ergonomics, Sports Anthropometry, Digital Health, Inclusive Measurement

Year 1
Semester 2

	Paper	**Credits**
DSC-4	Fundamentals of Human Genetics	4
DSC-5	Kinship, Marriage and Family	4
DSC-6	Anthropological Theories	4
		12
OPT for either 2 DSEs OR 1 DSE & 1 GE		
DSE-3	Human Ecology and Adaptation	4
	Human Population Genetics	
DSE-4	Visual Anthropology	4
	Museum Anthropology	
GE-2	Research Methods in Anthropology	4
	Anthropology of Development	
		8
Skill Based/Workshop/Specialized Laboratory/Hands on Learning		
Paper-1	Corporate Anthropology	**2**
Paper-2	Techniques in Human Genomics	
	Total	**22**

Discipline Specific Core

Fundamentals of Human Genetics

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Fundamental of Human Genetics	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. To learn basic tenets of human genetics, its scope and applications
2. To understand the patterns of genetic disorders and mechanisms of genetic abnormalities
3. To learn methods of genetic data generations and its utility in genetic counselling and screening programs.

Learning Outcomes

Students will be able to explain

1. Structure and function of DNA, inheritance patterns of human traits and diseases.
2. Demonstrate proficiency in handling methods and techniques used in human genetics research.
3. Comprehend the importance of genetic counselling, including its role in the diagnosis, prevention, and management of genetic disorders.

UNIT-I: **11 hours**

History of Human genetics; Concept of Linkage; Concept of gene; Human Genome Project; Pharmacogenomics; Concepts of heterogeneity and pleiotropy. GaRBH Sanskar and rearing practice, Epigenetics, Role of genetics in indigenous treatments like Ayurveda and Homeopathy.

UNIT-II: **12 hours**

DNA to Chromosomal Structure and Function; Heterochromatin and Euchromatin DNA Replication, repair and recombination; Gene expression, coding and non-coding regions; Expression of genetic information: from Transcription to Translation. Genetic and Epigenetic regulation; Gene regulation: enhancers, promoters, transcription factors, silencers and the role of epigenetics. Genetic imprinting. Germ line, somatic mutations.

UNIT-III: **12 hours**

Mendelian inheritance (Autosomal and X linked); Co-dominance; Sex-linked and Sex influenced inheritance, Multiple allelism. Numerical and Structural chromosomal abnormalities; Uniparental Disomy; Dosage compensation. Single factor and multifactorial inheritance: Cancer genetics. Burden of mendelian genetic disorders in India.

UNIT-IV: **10 hours**

Pedigree analysis, methods of assessing chromosomal abnormalities (Banding techniques; Karyotyping; FISH); Genotyping methods and Sanger Sequencing method**;** New-born screening; Genetic counselling, Ensembl genome browser; OMIM database

Practical **30 hours**

Prepare brief reports on any two types Mendelian disorders either from hospital or population-based fieldwork. Visit to nearby Modern Private/Public Genetic Lab with state-of-art facility in genomics.

Core Readings

1. Klug WS (2012). Concepts of Genetics. Pearson.
2. Lewis R. (2009). Human Genetics: Concepts and Application. The McGraw–Hill Companies, Inc.
3. Vogel F. and Motulsky A.G. (2010). Human Genetics: Problems and Approaches. Springer, 3rd revised edition
4. Kresina, TF (2001). An Introduction to Molecular Medicine and Gene Therapy. Wiley-Riss, New York.
5. Ricki Lewis. Human Genetics: Concepts and Applications. McGraw-Hill, 2020

Suggested Readings

1. Loh, P. R., et al. (2016). *Local ancestry in admixed populations*. *Genetics, 192*(4), 1515-1530.
2. Korf, B. R., & Rehm, H. L. (2013). *The human genome and medical genetics*. *Nature Reviews Genetics, 14*(4), 242-254.
3. Brown TA. (2007). Genomes. Garland Science.
4. Cummings MR (2011). Human Heredity: Principles and Issues. Brooks/Cole, Cengage Learning

Keywords

Human Genetics, DNA, chromosomal abnormalities, anthropology, sequencing

Discipline Specific Core

Kinship, Marriage and Family

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Kinship, Marriage and Family	**04**	**03**	**01**	**0**	**UG**

Course Objectives:

1. To introduce foundational and contemporary approaches to kinship studies with special emphasis on Indian contexts.
2. To examine the dynamics of marriage, family, and domestic groups in traditional and transnational frameworks.
3. To explore how kinship intersects with contemporary social issues, such as alternative sexualities, and new reproductive technologies.

Learning Outcomes

1. Students can critically analyse kinship structures and descent systems across cultures, especially in Indian social settings.
2. Demonstrate understanding of marriage rules, family forms, and transnational kinship, and assess their transformation in a globalised world.
3. Engage with current debates on gender, sexuality, and technological influence in shaping alternative family forms and kinship identities.

Course Content

Unit I **11 hours**

History of Kinship studies. Approaches to the study of Kinship, Descent and Descent Groups, Descent and Alliance, Patrilineal and matrilineal puzzle. Kin Behaviour and Kinship Usgaes, Kinship Terminology: classificatory & Descriptive and other systems.

Unit II **11 hours**

Marriage and Alliance: Forms and Rules of marriage; Patterns of Marriage in India; Marital exchanges; Bride wealth and gift giving

Unit III **12 hours**

Family, Domestic Group and Transnational Family: Approaches to the study of family, the Hindu Joint Family, Family dynamics within the context of globalisation and migration.

Unit IV **11 hours**

Kinship and Contemporary Social Issues. Kinship in India Transnational kinship & global racialisation,

Practical **30 hours**

1. Genealogy – to discuss the age at marriage, type of marriage, marriage distance, context, marriage rule, success of marriage, divorce and intergenerational changes

2. Genealogy: to find out maintenance of patrilineal ties in terms of sharing the resources, gift exchange, Authority, inheritance, type of property, constrictions or expansion of resource base

3. Genealogy to find out migration, education, mobility, occupation.

4. Genealogy to trace the existence and function of Domestic group.

    a. Comment on intergenerational trend: statistics and trends
    b. Problem of memory and issue of mixing up
    c. Principles of Cognition and classification used by respondent
    d. Issue of privacy and emotional involvement in sharing the data
    e. Unfolding of social process

5. Family types and composition of household through genealogy

6. Types of Authority based on interview method

7. Life History of religious specialist

8. Cases to study witchcraft, sorcery, religion and power.

9. Interview technique to study concept of power and qualities of leadership

10. Interview schedule to study customary law and ideas of citizenship

11. Questionnaire on Belief in supernatural and its denial among the youth

12. Interview Schedule on Economy of gift exchange

13. Questionnaire on Perception of wealth and capital

14. Kinship terminology (terms of address and terms of reference) generation, gender and context.

Core Readings

1. Fox, Robin. 1967. *Kinship and Marriage: An Anthropological Perspective*. Baltimore: Penguin.
2. Karve, Irawati. 1965. *Kinship Organization In India* (revised edition). Asia Publishing House
3. Sahlins, Marshall. 2013. "What Kinship Is (Part One)." Journal of the Royal Anthropological Institute, 17:2-19.
4. Stone, Linda and Diane E. King. 2019. *Kinship and Gender: An Introduction* (Sixth Edition). Routledge
5. Uberoi, Patricia. 1997. *Family, Kinship, and Marriage in India*. Oxford University Press

Suggested Readings

1. Fortes, Meyer. 1949. *The web of kinship among the Tallensi: the second part of an analysis of the social structure of a Trans-Volta tribe*. London: Oxford University Press
2. Needham, Rodney. 1971. *Rethinking Kinship and Marriage.* Edinburgh: T &A Constable Ltd.
3. Schneider, David. 1984. *A Critique of the Study of Kinship*. Ann Arbor: University of Michigan Press.

Keywords:
Kinship, family, marriage, descent, domestic group, household

Discipline Specific Core

Anthropological Theories

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Anthropological Theories	**04**	**03**	**0**	**01**	**UG**

Course Objectives:

- This course will introduce students to some of the major social theories and debates that shaped anthropological thinking, imagination and practice.
- Familiarize the understanding of contemporary social issues or problems from the lenses of anthropological theories

Learning Outcomes:

- The student will be able to examine contemporary theoretical debates about and within anthropology
- Critically analyze the process of globalization and its effects upon cultures around the world.
- Articulate an anthropological perspective on current issues and concerns

Contents:

Unit I **12 hours**

Emergence of anthropological theory- The philosophical foundations and epistemological issues, Colonialism and its impact on anthropological theories. Empiricism, Comparision, and Generalization

Unit II **11 hours**

Structuralism: Structural analysis of symbols, myth and totemism**;** emergence of New Ethnography and Semantic analysis; Interpretive and Hermeneutical approach

Unit III **11 hours**

Post-structuralism and Postmodernism: Theories and trends; Feminism and Anthropology

Unit IV **11 hours**

Anthropological theories of Globalization. Networked Anthropology; Contemporary social anthropology: its foci and concerns

Tutorial **30 hours**

Students are required to make project reports on the application of anthropological theories and submit for evaluation on any of the following.

- Formulation of research topics using theories
- Structural studies such as of myths and rituals
- Studying complex and multicultural situations

Students also prepare an annotated bibliography and list of references for the same project.

Core Readings:

Appadurai, Arjun. *Modernity At Large: Cultural Dimensions of Globalization*. (Selected Chapters)

Collins, Samuel Gerald, and Matthew Slover Durington. 2015. *Networked Anthropology: A primer for ethnographers.* Oxon: Routledge

Foucault, Michel. 1992. *The order of things: an archeology of the human sciences*. London: Routledge

Geertz, Clifford. 1973. The interpretation of cultures: selected essays. New York, N.Y.: BasicBooks

McGee, R. Jon, and Richard L. Warms. *Anthropological Theory: An Introductory History*. (Relevant Chapters for review/context)

Suggest Readings

Moore, Henrietta L., and Todd Sanders (Eds.). *Anthropology in Theory: Issues in Epistemology*.

Ortner, Sherry B. (Ed.). *The Fate of "Culture": Geertz and Beyond*. OR *Anthropology and Social Theory: Culture, Power, and the Acting Subject*.

Lévi-Strauss, Claude. 1963. *Structural anthropology*. New York: Basic Books.

Leach, Edmund. 1985. *Culture & [and] Communication:*. Cambridge: Cambridge Univ. Press. Lewin, Ellen (ed) 2009. *Feminist Anthropology: A Reader.* John Wiley and Sons.

Inda, Jonathan Xavier, and Renato Rosaldo. 2002. *The anthropology of globalization: A Reader. Blackwell readers in anthropology*. Blackwell Publishers.

Keywords: Anthropological theories: Philosophical foundations, Structuralism, Post-structuraism, Post-modenism, Globalisation, Feminism

Discipline Specific Elective

Human Ecology and Adaptation

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Human Ecology and Adaptation	**04**	**03**	**01**	**0**	**UG**

Course Objectives:

- This course examines the reciprocal relationship between humans and their environments through ecological and evolutionary perspectives.
- It analyzes human adaptation to environmental changes, past and present, including the Anthropocene.
- Students explore contemporary issues like climate justice, planetary health, urban adaptation, and environmental data ethnography, while developing critical thinking and research skills to address sustainability, disaster resilience, and adaptive strategies across ecosystems.

Learning Outcomes:

By the end of the course, students will be able to:

- Understand and critique major theories in human ecology, adaptation, and resilience.
- Analyze the impact of environmental and climatic stressors on human societies using evolutionary and cultural frameworks.
- Apply anthropological tools to study local and global environmental issues, sustainability practices, and ecological risks.
- Engage with interdisciplinary approaches and technologies used in climate adaptation research and environmental monitoring.
- Develop case-based insights into indigenous knowledge systems, urban ecosystems, and disaster response.

Unit I: **12 hours**

Human Ecology: Definition, scope, and principles of human ecology from a bio-cultural perspective; Theoretical models of adaptation: Genetic, developmental, physiological, and cultural buffering (biological emphasis); Cultural mode of adaptation: hunting gathering, pastoralism, shifting cultivation, Hydraulic civilization, and ecological themes of state formation.

Unit II: Environmental Stressors and Physiological Adaptations **11 hours**

Thermal environments: Adaptation to heat and cold; High-altitude hypoxia: Andean, Tibetan, and Ethiopian adaptations; UV radiation, pigmentation, and vitamin D synthesis; Hydration and water-scarcity adaptations; Sleep, circadian rhythms, and light environment adaptations

Unit III: **11 hours**

Culture as a tool of adaptation: Nature culture debate. Concept of sustainability, common property resources and traditional ecological knowledge in management of natural resources

Unit IV: **11 hours**

Emerging Issues: Urbanization and biological stress: Noise, pollution, crowding; Climate change and emerging ecological issues; Anthropocene and Adaptation in displaced and refugee populations;

Practical **30 hours**

***A. Size and Shape Measurements*:**

1. Stature
2. Sitting Height
3. Body Weight
4. Total Upper Extremity Length Size
5. Total Lower Extremity Length
6. Nasal Breadth
7. Nasal Height

B. Size and Shape Indices:

1. Body Mass Index
2. Relative Sitting Height
3. Relative Upper Extremity Length
4. Relative Total Lower Extremity Length
5. Nasal Index

C. Somatoscopy

D. 1-2 public talks/workshops/project over the academic semester on research topics on human ecology and biological adaptation. These talks would bring students with brainstorming discussion on current issues.

Make a project report pertaining to any contemporary environmental problem from the secondary data

Core Readings:

1. Ehrlich, Paul R., Anne H. Ehrlich and John P. Holdress. 1973. Human ecology: Problems and Solutions. W.H. Freeman & Company, San Francisco.
2. Contemporary Studies in Human Ecology- M.K.Bhasin (1998)
3. Studies in Human Ecology- N. Wolanski (1973)
4. Cohen, Y.A. 1968. Man in Adaptation, The Cultural Present. Chicago, Aldine Pub. co.
5. Lee, R. B. & Irven Devore 1968 Man the Hunter. Chicago, Aldine Pub. co.
6. Wittifogal, K A 1957. Oriental Despotism: A Comparative Study of Total Power. New Haven: Yale University Press.

Suggested Readings:

1. Schutkowski, H. 2006. Human ecology: biocultural adaptation in human communities. Berlin: Springer Verlag
2. Stapledon. 1964. Human ecology. Faber & Faber.
3. Theodorson, G.A. 1961. Studies in Human Ecology. New York: Row, Peterson & Company Elmsford.
4. Berry, J.B. 1976. Human ecology and cognitive style: comparative studies in cultural and physical adaptation. New York: John Wiley.

Keywords:

Ecological resilience, Ecological stressors, Ethnobiology, Ecological modelling

Discipline Specific Elective

Human Population Genetics

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Human Population Genetics	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. To learn the major concepts of human population genetics and their inferences in understanding human evolution
2. To use the measures of human genetic diversity and their use in understanding population structure
3. To understand phylogenetic tree reconstruction and their interpretation
4. To learn major evolutionary forces and their dynamic relationship to each other

Learning Outcomes

Students will be able to explain

1. Explain the basic terms/concepts of human population genetics
2. Appreciate the mechanisms of evolutionary forces in shaping biological diversity
3. Be familiar with the terminology and tools used in phylogenetic tree reconstruction
4. Be able to link different evolutionary forces and dynamic interaction between in human evolution

UNIT-I: 12 hours

History of Human Population Genetics, Definition and scope of population genetics, its relevance in anthropology; its relationship and differences with other branches of anthropology. Mating system: Random mating/panmixia; selective mating/ preferential mating; mate choice/sex selection; Assortative mating. Mendelian populations, Genotypic and Allelic frequencies; Hardy-Weinberg Equilibrium (HWE), Measuring of departure from HWE. Application of HWE in human population genetics

UNIT-II: 11 hours

Genetic Drift, Effective Population Size, Models of Selection, Dynamics of genetic drift, mutation and selection. Reproductive and Geographic genetic isolates. Transient and balanced polymorphism. Haemoglobin polymorphisms and their distribution, Thalassaemia, G6PD Deficiency and its distribution. Neutral theory of human evolution.

UNIT-III: 11 hours

Mutation; Migration, Admixture and Gene flow models: 'island' model, 'diffusion' model; 'isolation by distance model', role of social divisions and hierarchy in genetic isolation Coalescence Theory; Population Sub-division; Wahlund Effect, Divergence Models; Inferring Population History and Demography. Approaches to study structure of human populations: geographic, demographic and genetic.

UNIT-IV: 11 hours

Measures of Genetic Distance; Ethnicity/Endogamous groups; Biological consequences of mating systems: consanguinity; inbreeding and outbreeding. Inbreeding coefficient (F ratios) inbreeding depression: heterozygosis; homozygosis; genetic load. Epigenetics in human evolution. DNA Biobanks in India and world.

Practical 30 hours

1. ABO (Subgroups), MN and Rh Blood Group Systems
2. PTC and Colour Blindness
4. G6PD Deficiency
5. Genotyping, DNA sequencing

Keywords: Genetic distance, natural selection, polymorphisms, genetic drift, Inbreeding

References

Core Readings

1. Cavalli - S. Ferza & Bodmer (1976). The genetics of Human Population. Freeman, San Francisco.
2. Vogel F. and Motulsky A.G. (2010). Human Genetics: Problems and Approaches. Springer, 3rd revised edition
3. Cummings MR (2011). Human Heredity: Principles and Issues. Brooks/Cole, Cengage Learning
4. Jobling, MA Hurles, M and Tyler-Smitth, C (2004). Human Evolutionary Genetics, Origins, Peoples and Disease. Garland Science, New York.
5. Malhotra, K. C. Statistical methods in human population genetics. Calcutta: Indian Institute of Bio-Social Research and Development; 1988

Suggested Readings

1. Reece, RJ (2004). Analysis of Genes and Genomes. John Wiley and Sons Ltd, England.
2. Daniel Hartl & Clark, A. G. (1997). Principles of Population Genetics. Sinaver, Associates, Inc.
3. Peter Snustad & Simmons, M. J. (2006). Principles of Genetics.John Wiley and Sons
4. Benjamien Pierce (2003). Genetics: A Conceptual Approach. W. H. Freeman & Company.

Discipline Specific Elective

Visual Anthropology

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Visual Anthropology	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. To explore the foundational theories and ethical debates in visual anthropology, including semiotics, cultural studies, and postcolonial perspectives.
2. To critically analyse the role of images, and ethnographic filmmaking in representing cultures, with an emphasis on colonial and post-colonial visual production.
3. To engage students in practical applications of visual research methods, including documentary filmmaking, photographic essays, and the analysis of ethnographic films.

Learning Outcomes

1. Students can critically examine and deconstruct visual representations of cultures, identifying power dynamics, authenticity, and subjectivity.
2. Develop skills in using visual methods for ethnographic research with ethical considerations in mind.
3. Demonstrate an understanding of intercultural aesthetics and methodologies by analysing and comparing the works of key visual anthropologists.

Course Content

Unit-I: **10 hours**

Foundations of Visual Anthropology: Origins of visual anthropology; Exhibiting others, colonial gaze; philosophical and ethical debates in Visual Anthropology- semiotics, cultural studies, and visual communication.

Unit II: **12 hours**

Images, Films and Post-Colonial Visual Production: Ethnographic filmmaking as a method of representation; Visual anthropology in post-colonial contexts; Examining subjectivity, reflexivity, and ethical considerations in image-making; Studying image-making during colonial and post-colonial periods; Power dynamics, representation, and authenticity in visual media.

Unit-III: **11 hours**

Politics and Poetics of Visual Representation: Identity formation through visual culture; Anthropology and politics of representation; Examining the role of images in shaping social and cultural narratives; Indigenous media

Unit-IV: **11 hours**

Visual Methods and Approaches to Ethnographic Film: Multimodal anthropology; Sensory ethnography; Visual research methods and ethics; Form and content of documentary film and media; Intercultural aesthetics - works of Margaret Mead, Robert Gardner, John Marshall, Jean Rouch, David MacDougall.

Practical **30 hours**

1. Produce a short documentary film capturing a cultural or social practice, incorporating reflexivity and ethical awareness.
2. Analyse historical ethnographic films and photographs to identify elements of the colonial gaze and discuss ethical considerations in representation.
3. Curate a photographic essay (using original photographs) on relevant themes as discussed in the course, followed by a class discussion on representation and authenticity.
4. Analyse and compare scenes from films by Margaret Mead, Jean Rouch, and David MacDougall, focusing on intercultural aesthetics, methodology, and content.
5. Use the photo-elicitation method to elicit research participants' comments on a topic the course teacher suggested.

Core Readings

1. Hockings, Paul ed. 2003. *Principles of Visual Anthropology*. Mouton de Gruyter.
2. Lawrence, Andy. 2020. *Filmmaking for Fieldwork: A practical handbook*. Manchester University Press
3. Pink, Sarah. 2010. *Doing Sensory Ethnogra*phy. Sage Publications
4. Ruby, Jay and M. Banks. 2011. *Made to be Seen: A History of Visual Anthropology*. University of Chicago Press.
5. Worth, Sol. 1981. *Studying Visual Communication*. University of Pennsylvania Press.

Suggested Readings

1. Asch, Tim. 1992. The Ethics of Ethnographic Film-making. In *Film as Ethnography*, eds. Peter Ian Crawford and David Turton. Manchester: Manchester University Press. Pp. 196-204.
2. Ginsburg, Faye. 2003 "'Now Watch this Very Carefully'" The Ironies and Afterlife of Margaret Mead's Visual Anthropology. *The Scholar and Feminist*. 1:2
3. Turner, Terence. 1992. Defiant Images: Kayapo Appropriation of Video. *Anthropology Today*. 8:6.(Dec). 5-16.
4. Zhimo, A.G. 2021. ‘We were the Others: Visuality in Colonial Writings’. In *Materiality and Visuality in North East India: An Interdisciplinary Perspective*, edited by Tiplut Nongbri and Rashi Bhargava. Singapore: Springer.

Keywords:
Visual anthropology, images, film, Identity, ethnography

Discipline Specific Elective

Museum Anthropology

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Museum Anthropology	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. To provide students with an in-depth understanding of the historical and theoretical foundations of Museum Anthropology, with a focus on the role of museums in the representation and interpretation of cultural materials.
2. To critically engage with the processes of curation, representation, and interpretation of ethnographic collections, examining both historical legacies and contemporary practices.
3. To offer practical experience in the documentation, conservation, and exhibition planning processes, through hands-on training and experiential learning opportunities.

Learning Outcomes: By the end of this course, students will be able to

1. Critically analyse the historical and contemporary intersections between anthropology and museums, with an emphasis on the evolving roles of museums in research, education, and public engagement.
2. Demonstrate the ability to conceptualise, critique, and design anthropologically informed exhibitions by integrating theoretical frameworks with practical, ethical, and curatorial considerations.
3. Apply interdisciplinary and inclusive approaches to curating, conserving, and interpreting cultural materials, with competence in both traditional and digital exhibition practices.

Course Content

Unit I: **11 hours**

Anthropology, Museums, and Material Culture: Definitional probelms, Historical Trajectories: Evolution of anthropological museums and their role in research and education. Colonial origins of ethnographic museums and enduring legacies of colonialism in museum practices. Cultural objects and their anthropological significance.

Unit II: **12 hours**

Museums and the Politics of Display: Theoretical debates on objectification, identity, and the representation of the 'Other' in museum exhibitions. Authority, narrative framing, and cultural hierarchies. Decolonisation and Indigenous Agency Repatriation, restitution, and the inclusion of Indigenous perspectives in curatorial practice. Ethical dilemmas in curation.

Unit III: **11 hours**

Curation, Conservation, and Interpretation Collection and Documentation: Methods of collecting, cataloguing, and documentation. Community participation, oral histories, and ethical acquisition practices. Methods of exhibition, and conservation of objects: traditional and modern methods.

Unit IV: **11 hours**

Contemporary Concerns: Visitor studies and participatory museum models. Designing for diverse publics: Museums in tourism, outdoor exhibits, and living museums. Virtual museums and reimagine museum space and temporality. Case studies: National Musuem, IGRMS, IGNCA, etc. Anthropology departments involved in curatorial work. Tribal and community-driven museums as models of collaborative heritage curation.

Practical Component **10 hours**

Study tour: Organised visits to key museums (e.g., National Museum, Crafts Museum, IGRMS, IGNCA) to observe and critically evaluate exhibit design, visitor engagement, and curatorial practices.

Hands-on Workshops: Practical experience in object cataloguing, registration, and basic conservation techniques. Development of a thematic mini-exhibition proposal, either physical or virtual, applying anthropological theories and methodologies.

Interactive Sessions: Guest lectures by museum professionals and curators to provide insights into contemporary museum practices. Written critiques and reflective assignments aimed at fostering analytical skills and deepening understanding of museum anthropology.

Core Readings

1. Ames, M. M. (1992). *Cannibal tours and glass boxes: The anthropology of museums*. UBC Press.
2. Bennett, T. (1995). *The birth of the museum: History, theory, politics*. Routledge.
3. Burcaw, G. E. (1997). *Introduction to museum work* (3rd ed.). AltaMira Press.
4. Hooper-Greenhill, E. (2000). *Museums and the interpretation of visual culture*. Routledge.
5. Lavine, S. D. (1991). *Exhibiting cultures: The poetics and politics of museum display*. Smithsonian Institution Press.
6. Karp, I., & Kratz, C. A. (Eds.). (2006). *Museum frictions: Public cultures/global transformations*. Duke University Press.

Suggested Readings

1. Alexander, E. P., & Alexander, M. (2008). Natural history and anthropology museums. In *Museums in motion: An introduction to the history and functions of museums* (2nd ed., pp. 53–84). AltaMira Press.
2. Clifford, J. (1997). Museums as contact zones. In *Routes: Travel and translation in the late twentieth century* (pp. 188–219). Harvard University Press.
3. Jacknis, I. (2000). A New Thing? The National Museum of the American Indian in Historical and Institutional Perspective. In D. A. Mihesuah (Ed.), *Repatriation reader: Who owns American Indian remains?* (pp. 115–129). University of Nebraska Press.
4. Mihesuah, D. A. (2000). *Repatriation reader: Who owns American Indian remains?* University of Nebraska Press.
5. Macdonald, S. (2006). A people's history of the museum. In S. Macdonald (Ed.), *A companion to museum studies* (pp. 1–35). Blackwell Publishing.
6. Bedekar, V. H. (1995). *New museology for India*. National Museum Institute of History of Art, Conservation, and Museology.
7. Guha-Thakurta, T. (2004). *Monuments, objects, histories: Institutions of art in colonial and postcolonial India*. Columbia University Press.
8. Willmott, C. (2008). Visitors' voices: Lessons from conversations in the Royal Ontario Museum's Gallery of Canada: First Peoples. *Material Culture Review*, 67, 45–55.

Keywords: Anthropological Museums, Material Culture, Colonial Legacies, Cultural Representation, Ethical Curation, Decolonisation, Community Engagement, Digital Transformation, Indigenous Perspectives, Museum Practices in India

Generic Elective

Research Methods in Anthropology

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Research Methods in Anthropology	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. This course will introduce the diverse set of methods and techniques used in anthropological analysis.
2. To understand the process of designing an effective research study in Anthropology
3. To learn the appropriate research skills of scientific writing.

Learning Outcomes

1. Students will be able to understand how to formulate a scientific research problem and frame a research for addressing it.
2. Students will be able to choose the appropriate methods and techniques according to the type of research they want to conduct.
3. Students will be able to understand the importance of ethics in the field of research.

Course Content

Unit-I: 10 hours

Research Methods: Concepts and Definitions; Epistemology; Qualitative vs. Quantitative; Research Design: Types: Explanatory, Descriptive, Exploratory and Experimental, Literature Review, Formulating a Research Problem, Identifying Research Objectives, Hypothesis

UNIT-II: 12 Hours

Fieldwork and Tools for Data collection: Questionnaire and Schedule, Interview- Unstructured, Structured, Key informant interview, Focused, Group Discussion, Genealogy and life history, Case study. Observation: Direct, Indirect, Participant, Non-participant, Controlled; Population and Samples; types of sampling.

UNIT-III: 12 Hours

Descriptive statistics; Measurers of Central Tendency; Measure of Variation: Range, Variance and Standard deviation, Normal Distribution, Skewness and Kurtosis; Test of Significance Student t Test; Chi-square Test; Pedigree Analysis; Correlation and regression; Statistical softwares: SPSS, R and STATA

UNIT-IV: 11 Hours

Research Ethics: History, Informed Consent, Confidentiality, ethical guidelines at international and national level, Fraud and Plagiarism, Authorship and Publication guidelines, Conflicts of Interest. Scientific misconduct, Data cleaning, management and sharing

Practical **30 hours**

A detailed research proposal (approx. 3000-4000 words) for a potential PG-level anthropological study. Must include: Introduction/Problem Statement, Literature Review, Research Questions, Detailed Methodology, Ethical Considerations, Timeline, and Justification. This is the capstone

Construction and use of Genealogy; Undertaking Observation: Direct, Indirect, Participant, Non-participant, controlled. Designing Questionnaire and Ethnographic Interview-Unstructured, Semi-structured, Focused Group Discussion, and Free listing, pile sorting.

Collection of Case studies and life histories.

Core Readings

1. Madrigal L. Statistics for Anthropology. Cambridge: Cambridge University Press. 2012. Zar JH. Biostatistical Analysis. Prentice Hall. 2010.
2. Bernard H.R. Research Methods in Anthropology, Qualitative and Quantitative Approaches. Jaipur: Rawat Publications. 2006.
3. Srivastava, V. K. (1994). *Methodology and Fieldwork*. Oxford University Press
4. Pelto, P. J., & Pelto, G. H. (1978). *Anthropological research: The structure of inquiry*. Cambridge University Press

Suggested Readings

1. Emerson RM, Fretz RI and Shaw L. Writing Ethnographic Fieldnotes. Chicago, University of Chicago Press. 1995
2. Hammersly, M., Atkinson, P. (2019). Ethnography: Principles in Practice (4th edition). Routledge.
3. Goode, W. J., & Hatt, P. K. (1952). Methods in social research.

Keywords: Research, Methodology, Fieldwork, Tools and Techniques.

Generic Elective

Anthropology of Development

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Anthropology of Development	**04**	**03**	**01**	**0**	**UG**

Course Objectives

1. To understand the term Development, evolution of the concept and its theoretical paradigms.

2. To study the engagement by different stakeholders at various development activities

3. To understand ethical issues and evaluation of development project, community participation, livelihood and empowerment

Learning Outcomes

- By studying, the students will be able to understand the concept and approaches in anthropology of development
- The students will be able to know the ground realities of developmental issues at grassroots level
- Examine the role of anthropologist and other agencies in development process, etc

Course Content

Unit I: **11 hours**
Development: Definition and meaning and Scope, Evolution of concept. Sustainable development: United National Sustainable Development Goals

Unit II: **11 hours**
Perspectives and Approaches of Development in Anthropology,

Unit III: **12 hours**
Anthropology and Development Interfaces, Globalization, Constitutional Provision, Gender and Development, Indigenous Knowledge and Development, Issues of Displacement, Development and conservation debate

Unit IV: **11 hours**
Role of Anthropology in Development, Community Development, Agencies for Development Issues and challenges for Development, Social Impact Assessment, RRA/PRA

Practical **30 Hours**

1. Prepare a project based on any contemporary issues relating to development project in India by employing various sources viz. books, journals, magazines, government reports newspaper articles, etc.

2. Provide a comprehensive bibliography.

3. Presentation of the project and group discussion

Core Readings

Cochrane, Glynn. 1971. Development Anthropology. OUP

Edelman, Marc & Angelique Haugerud (eds) 2005. *The anthropology of development and globalisation: From classical political economy to contemporary neoliberalism*. Oxford: Blackwell.

Gardener, K. & D. Lewis 2015. *Anthropology and Development: Challenges for the twenty-first century*. London: Pluto

Escobar, Arturo. 1995. *Encountering Development: The Making and Unmaking of the Third World*, Princeton, N. J. Princeton University Press.

Harrison, E. & Crewe, E. 1999. *Whose development? An ethnography of aid*. London: Zed Books

Mathur, Hari Mohan (ed). 1977. Anthropology in Development Process. New Delhi. Vikas Publishing House

Suggested Readings

Berreman, Gerald D. 1994. Anthropology, Development and Public Policy. *Occasional Papers in Sociology and Anthropology* Vol.4, pp.3-32.
https://www.nepjol.info/index.php/OPSA/article/view/1083

Chambers, Robert, 2013.*Rural Development: Putting the Last First*, London: Longman (1983).

Mosse, David, and David Lewis. 2005. *The Aid Effect: Giving and Governing in International Development.* Pluto Press

Olivier de Sardan, Jean-Pierre. 2005. *Anthropology and Development: understanding social change*. London: Zed Press.

Mair, Lucy.1984. Anthropology and Development. London: Macmillan

Keywords: Policy, Development, Community, Evaluation, Agencies, PRA

Skill Enhancement Course (SEC)

Corporate Anthropology

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Corporate Anthropology	**02**	**01**	**01**	**0**	**UG**

Course Objective

- The objective of the course is to provide students with an anthropological knowledge of Corporate Industry, wherein students get to reflect upon the needs of Corporate Industry with respect to local cultures, community development goals, government programmes & policies,
- The course aims to critically reflect on the role and relevance of NGOs at grassroots levels, imparting them anthropological skills to engage with rural and urban communities in Indian ethnographic contexts.

Course Learning Outcomes

- The students will be trained to attempt ethnographic exercises in Corporate Industry.
- They will be equipped with research methodologies to experience Corporates as an ethnographic universe in itself, thereby seeking hands on knowledge
- They can engage with Corporate Industry in serving as anthropological consultants in National and International organisations.

Unit 1 **12 hours**

Doing Anthropology in Organisational contexts: Undertaking ethnography in corporate environments: Health care organisations, media organisations, industrial organisations. Challenges and opportunities. Relevant case studies. Business entrepreneurship-basic skills, Business and Corporate organisations & corporate social responsibility (CSR)

Unit 2 **11 hours**

Techniques of Conducting Fieldwork in Corporate Organizations: conventional ethnographic methods, Rapid ethnography, Doing corporate ethnography as an insider and outsider (ethical dimensions), Network analysis, Virtual ethnography. Digital ethnography

Practical. **15 hours**

1. Students are required to prepare a research design to in order to conduct an ethnographic study of an Corporate office of their choice. Visit a corporate organisation and make a brief project report on any one significant dimension of the corporate sector.

2. Review a corporate ethnography.

Core Readings

Jordan, Ann T. 2003. Business Anthropology. Waveland Press, Long Grove, Illinois.

Walnut Creek, CA.2013. Advancing ethnography in Corporate Environments: Challenges and emerging opportunities by Brigitte Jordan (eds), left coast press Inc.,

Melissa Cefkin, 2010. Ethnography and the corporate encounter: Reflections on Research and of Corporations.

Christina Garsten, Anette Nyqvist Pluto press, 2013. Organisational Anthropology: Doing Ethnography in and among complex organisation

Suggested Readings

Timothy de Waal Malefyt, Robert Morais, Routledge, 2017. Ethics in the anthropology of Business: Explorations in Theory, practice and pedagogy

Catherine Dolan and Dinah Rajak, New York, Berghahn 2016. The anthropology of corporate social responsibility

Danielle Braub, Jitse Kramer, Routledge, 2018. The corporate tribe; organisational lessons from Anthropology

Melissa, Cefkin 2009. Corporate Anthropology Ethnography and the corporate encounter Berghahn Books

Keywords

Corporate, ethnography, network, organisational culture, human resource, entrepreneurship, information technology, corporate social responsibility.

Skill Enhancement Course (SEC)

Techniques in Human Genomics

Course Title and Code	Total Credits	Credit distribution of the course			Eligibility
		Lecture	Practical	Tutorial	
Techniques in Human Genomics	02	0	02	0	UG

Course Objectives
1. To learn the various technologies used for genetic data generation
2. To learn the various aspects of next generation sequencing technology

Course Learning Outcomes
1. Student will learn various technologies used in genetic data generation
2. Student will learn aspects of next generation sequencing technology

Practical

UNIT-I: **11 hours**
DNA Extraction Methods and Quantification technique, Polymerase Chain Reaction; Single SNP genotyping; Multiple SNP genotyping (MassARRAY), High throughput genotyping-GWAS

UNIT-II: **12 hours**
Classic Sanger sequencing; Design and Analysis of Epigenotyping, ChIP Sequencing, Next Generation Sequencing Methods: NGS technologies, library preparation, computer set-up, Reference genome

Core Readings

1. Kathleen E. Steinmann et al. High-Throughput Next Generation Sequencing: Methods and Applications *[1 ed.]*. Humana Press, 2011
2. C. Alexander Valencia et al. Next Generation Sequencing Technologies in Medical Genetics *[1 ed.]*. Springer-Verlag New York, 2013.
3. Vogel F. and Motulsky A.G. (2010). Human Genetics: Problems and Approaches. Springer, 3rd revised edition

Keywords
DNA extraction, Sequencing, Genotyping, and Next generation sequencing

Revised

Annexure_2

First Year PG Curricular Structure for Two years PG Programme Forensic Science (3+2)							
Year-1				**Year-1**			
		Paper	**Credits**			**Paper**	**Credits**
Semester-1	**DSC-1**	Criminology and Crime Ethnographies in India	3+1	**Semester-2**	**DSC-4**	Forensic Physics	3+1
	DSC-2	Forensic Serology and DNA Profiling	3+1		**DSC-5**	Forensic Anthropology	3+1
	DSC-3	Forensic Dermatoglyphics and other Impressions	3+1		**DSC-6**	Forensic Chemistry and Toxicology	3+1
			12				**12**
	OPT for either 2 DSEs OR 1 DSE & 1 GE				**OPT for either 2 DSEs OR 1 DSE & 1 GE**		
	DSE	Fundamentals of Cyber Security and Penetration Testing	3+1		**DSE**	Women, violence and Crimes in India	3+1
		Information Security Audit and Compliance				Forensic Photography and Visuals	
		Criminal Law and Forensic Implications	3+1			Forensic Entomology and Wildlife Forensics	3+1
		Police Administration and Law Enforcement Agencies				CBRNE Forensics	
						Forensic Ballistics	
	GE	Quality Management and Laboratory Management systems	3+1		**GE**	Criminology and Forensic Psychology	3+1
		Techniques of Research in Forensic Science				Statistics and Ethics in Forensic Research	
			8				**8**
	Skill Based/Workshop/Specialized Laboratory/Hands on Learning				**Skill Based/Workshop/Specialized Laboratory/Hands on Learning**		
	Paper-1	Crime Scene Documentation with Laboratory training	**2**		**Paper-1**	Chemical Evidence Analysis with Laboratory training	**2**
	Paper-2	Biological Evidence Analysis with Laboratory training			**Paper-2**	Pattern Evidence Analysis with Laboratory training	
		Total	**22**			**Total**	**22**

DSC-1: CRIMINOLOGY AND ETHNOGRAPHIES OF CRIME IN INDIA

Credit distribution, eligibility and pre-requisites of the course

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
Criminology and Ethnographies of Crime in India	04	03	01	0	Bachelors in Forensic science, Anthropology and allied sciences

(Teaching hours required - Theory: 45 hours; Practical: 30 hours)

Course objectives:

- Provide forensic science students with a culturally nuanced and context-specific understanding of crime in India.
- Integrate forensic science with criminology and ethnographic methodology to understand crime and criminal behavior in India.
- Understand the theoretical perspectives in criminology and their application in understanding of crimes in India.
- Critically understand the nature, form and typologies of crimeand their prevalence in India, including traditional and emerging forms.

Learning outcomes:

By the end of this course, students will be able to:

- Describe the evolution of criminological thought, including ancient texts and recent legislative changes.
- Analyse crime as a socio-cultural construct influenced by law, economy, psychology, and anthropology.
- Identify and compare various crime typologies and apply relevant criminological theories to real-world contexts.
- Apply ethnographic methods to understand criminal behaviour, justice systems, and forensic processes, particularly in rural, tribal, and marginalized communities.
- Evaluate organized, socio-economic, gender-based, and transnational crimes using interdisciplinary and ethnographic perspectives in forensic investigations.

Unit 1: Foundations of Criminology and Crime in the Indian context (12 Hrs)

Foundation of criminology and crimes in Indian context, Ancient Indian perspectives on Crime and Justice (*Dharmashastra, Arthashastra*), Colonial Impact: *Bhartiya Nyaya Sanhita (2023), Bhartiya Nagrik SurakshaSanhita (2023),* and *Bhartiya Sakshya Adhiniyam (2023).*

Unit 2: Perspectives on Crime (12 Hrs)

Anthropological perspective on crime and its relationship to law, sociology, economics and psychology, Key Concepts of evidence, justice, crime, deviance, delinquency in the Indian context, Traditional crimes, Socio-economic offenses, Cybercrime, Left-wing extremism, Insurgency, Cross-border terrorism, and Forensic investigation.

Unit 3: Crime typologies and Criminological theories (9 Hrs)

Crime typology: Class, rural, urban and tribal communities, Crime scenario: Catalysts of criminal behavior: traditional and emerging factors, Theories of crime causation: Pre-classical and Neo- classical, constitutional, geographical, economic, psychological, sociological, multiple-causation, and biological approach, Subculture theory of crime, Feminist, rural, and environmental criminology, Forensic Science and community.

Unit 4: Ethnographic approaches to Crime and their Forensic applications (12 Hrs)

Ethnographic method and its application in criminal investigation, Ethnography in criminal profiling: Socio-cultural factors influencing criminal behavior,Cross-cultural ethnographies of crime including the study of customary law, dispute resolution, and restorative justice in tribal and rural societies, Ethnographic case studies of ex criminals and denotified tribes and their applications in Indian forensic science, focusing on organized, socio-economic, gender-based, and transnational crimes. Classical ethnographies in crime and custom in indigenous societies

Practical (30 Hrs)

1. Designing and implementing ethnographic research proposals relevant to Indian crime phenomena
2. Writing ethnographic reports based on empirical observations and data collection

Keywords: Ethnographic methods, Criminal profiling, Customary law, Restorative justice, Tribal justice systems, Organized crime, Transnational crime, Gender-based violence

Essential readings

- Kapoor AK, Dhall M, Mayank Singh, Kaur J. 2024.Handbook of Forensic Criminology and Criminal Anthropology. SSB Publications
- Adler PA, Adler P (1998) Foreword: Moving backward. In: Ferrell J, Hamm MS (eds) *Ethnography at the Edge: Crime, Deviance, and Field Research*. London: Northeastern University Press, pp. xii–xvi.
- Bare Act of *BharatiyaNyayaSanhita* (2023)
- Bare Act of *BhartiyaNagrikSurakshaSanhita*(2023)
- Bare Act of *BhartiyaSakshyaAdhiniyam*(2023)
- Crime in India Reports (Annual) by the National Crime Records Bureau (NCRB)
- Ferrell J, Hayward K, Young J (2015) *Cultural Criminology: An Invitation*. London: SAGE.
- Haggerty KD (2004) Ethics creep: Governing social science research in the name of ethics. *Qualitative Sociology* 27(4): 391–414.
- Malinowski B.(1989) Crime and custom in savage society. Elix Books
- Meena radha Krishnan (2008). Dishonoured by History: 'Criminal Tribes' and British Colonial Policy. Orient BlackSwan

Suggested readings

- Karandikar, Sharvari, et al. 2013. A qualitative examination of women involved in prostitution in Mumbai, India: The role of family and acquaintances. *Int Soc Work* 56: 496–515.
- Hall S, Winlow S (2012) The need for 'new directions' in criminological theory. In: Hall S, Winlow S (eds) *New Directions in Criminological Theory*. London: Routledge, pp. 1–15.
- Hall S, Winlow S (2015) *Revitalizing Criminological Theory: Towards a New Ultra-Realism*. London: Routledge.
- The Oxford Handbook of Ethnographies of Crime and Criminal Justice
- Hillyard P, Tombs S (2004) Beyond criminology? In: Hillyard P, Pantazis C, Tombs S, et al. (eds) *Beyond Criminology: Taking Harm Seriously*. London: Pluto Press, pp. 10–29
- Malinowski. B. 1928. *Crime and customs in Savage society.* London, K. Paul, Trench, Trubner& co., ltd.
- Treadwell, James. "Criminological ethnography: An introduction." (2019): 1-240.
- Vashishtha Sanjay. 2024 (8th Edition). *Ahmad Siddique's Criminology, Penology and Victimology*. Eastern Book Company

DSC-2: FORENSIC SEROLOGY AND DNA PROFILING

Credit distribution, eligibility and pre-requisites of the course

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
Forensic Serology and DNA profiling	04	03	01	0	Bachelors in Forensic science, Anthropology and allied sciences

(Teaching hours required - Theory: 45 hours; Practical: 30 hours)

Course objectives:

- Student will be introduce the principles and forensic relevance of serology, including blood composition, blood group systems, and biological fluid identification.
- Explain the basics of immunology, species determination, and blood pattern analysis.
- Provide foundational knowledge of the biochemical composition of biomolecules and cellular structures.
- Develop understanding of DNA structure, genome organization, and its role in forensic investigations.
- Familiarize students with various DNA polymorphisms, molecular techniques, and the legal aspects of DNA profiling.

Course outcomes:

By the end of the course, students will be able to:

- Identify and analyze blood and biological fluids using serological, immunological, and spectroscopic methods.
- Differentiate between human and animal blood and determine secretor status.
- Apply knowledge of biomolecules and cell organelles in forensic sample analysis.
- Explain the structural and functional aspects of DNA, RNA, and the human genome.
- Perform and interpret DNA profiling techniques such as PCR, STR, RFLP, and assess their forensic and legal significance.

Unit 1: Basic Serology and Immunology (12 Hrs)

Blood and its composition, Blood Typing/Grouping – 'ABO' system and its significance in forensic investigation, Various blood group antigens, Lutheran and Bombay blood group, Methods of ABO blood grouping from fresh blood and biological stains, Determination of origin of species, Determination of secretor status, Blood pattern analysis, Ageing of bloodstains, Difference between human and animal bloodstains, Spectroscopic analysis, Identification of other biological fluids and their forensic significance, Basics of immunology, immune response, antigens, haptens and antibodies, Function of antisera, Lectins.

Unit 2: Biochemistry and Cell Biology (12 Hrs)

Chemistry of Carbohydrates - Definition, classification and their importance in forensic investigation. Chemistry of Lipids - Definition, classification and their importance in forensic investigation. Types and properties of amino acids, structure of proteins and their importance in forensic investigation. Introduction of plant and animal cells. Different eukaryotic cellular organelles, Plasma membrane, Transport across membrane, Endoplasmic Reticulum, Golgi complex, Mitochondria, Chloroplast and Lysosomes. Organization of Nucleus and nuclear transport, Cell division - Mitosis and Meiosis; Barr bodies and their importance in forensic investigation.

Unit 3: DNA Profiling (10 Hrs)

History of DNA fingerprinting, Double helical structure of DNA, Alternate forms of DNA double helix, Denaturation and renaturation of DNA, DNA binding proteins, Factors affecting DNA stability, Types and structure of RNA. Chemical nature of DNA and RNA. Nature and structure of human genome and its diversity, Mitochondrial DNA, Y-Chromosome, Forensic DNA profiling and its application in criminal and civil investigations, Important case studies of DNA fingerprinting.

Unit 4: DNA Polymorphism (11 Hrs)

Concept of gene – Conventional and modern views, Concept of sequence variation - VNTRs, STRs, Mini STRs, SNPs, Detection techniques - RFLP, PCR, Amp-FLP, sequence polymorphism, Y-STR, Mitochondrial DNA, Disputed paternity cases, Legal admissibility of DNA evidence,Techniques and equipment for DNA extraction and purification, Different methods of DNA quantitation, DNA separation and detection techniques, Polymerase Chain Reaction (PCR).

Practical (30 Hrs)

- Physical, biochemical and spectrophotometric examination of blood stains.
- Blood group typing of biological fluid stains by mixed agglutination techniques.
- Biochemical and microscopic examination of Saliva, Semen stain and Urine
- Microscopic examination of mitotic and meiotic cell division
- Staining and visualization of Barr Bodies.
- Extraction and quantification of DNA from blood sample.
- Extraction of DNA using FTA card.

Keywords: Biological fluids, Secretor status, Blood pattern analysis, Immunology, Carbohydrates, Lipids, Proteins, Cell organelles, Polymorphism, DNA quantification, Legal admissibility

Essential Readings

- The examination and Typing of Blood Stains in the crime laboratory-BJ Culliford, U.S.Dept.of Justice, Washington D. C. (1971)
- Blood Group Serology - Boorman KE, Dodd BE and LOncoln PJ, ChuchillLivingstoneInc. New York (2018).
- Laboratory Procedure Manual - Forensic Serology (2005), Directorate of Forensic Science, MHA, New Delhi
- Lehninger Principles of Biochemistry 6th Edition (2012) – Nelson and Cox, W.H. Freeman, ISBN: 978-142923414
- Laboratory Procedure Manual - DNA Profiling (2005), Directorate of Forensic Science,MHA, New Delhi.
- Molecular Biology of the Cell, 6th Edition (2014) - Bruce Alberts, et al., Garland Science, ISBN: 978-0815341055

Suggested readings

Genes XI (2012) - Benjamin Lewin, Jones & Bartlett Learning, ISBN: 978-1449659851

Kuby Immunology6th Edition-Kindt, Goldsby and Osborne, W.H. Freeman and Co. ISBN: 978-0716767640

Lehninger Principles of Biochemistry 6th Edition (2012) - Nelson and Cox, W.H. Freeman, ISBN: 978-1429234146

Microbiology 5th Edition - Pelczaret. al., McGraw-Hill Inc., ISBN: 978-0074623206

Prescott's Microbiology 9th Edition (2013) - Joanne Willey, Linda Sherwood, Christopher J. Woolverton, McGraw-Hill Education, ISBN: 978-0073402406

An Introduction to Forensic Genetics 2nd Edition (2010) - William Goodwin, Adrian Linacre and SibteHadi, Wiley-Blackwell, ISBN: 978-0470710197

DSC-3:FORENSIC DERMATOGLYPHICS AND OTHER IMPRESSIONS

Credit distribution, eligibility and pre-requisites of the course

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
Forensic Dermatoglyphics and Other impressions	04	03	01	0	Bachelors in Forensic science, Anthropology and allied sciences

(Teaching hours required - Theory: 45 hours; Practical: 30 hours)

Course objectives:

- Introduce the principles, history, and scope of fingerprint science.
- Explain fingerprint types, development, classification, and comparison techniques.
- Provide knowledge on the forensic significance, collection, and analysis of lip prints, bite marks, and ear prints.
- Develop skills in recording, developing, and comparing palm prints and foot/footwear impressions.
- Highlight the application of pattern evidence in criminal investigations through case studies.

Course outcomes:

By the end of the course, students will be able to:

- Demonstrate understanding of fingerprint science and its forensic applications.
- Classify and compare fingerprints using manual and automated systems.
- Analyze lip prints, bite marks, and ear prints for forensic identification.
- Record, develop, and compare palm prints and foot/footwear impressions.
- Apply pattern evidence analysis in crime scene reconstruction and case evaluation.

Unit 1: Introduction to Fingerprint science (10 Hrs)

Definition, History, Development, Scope of Fingerprint science, Composition of sweat, Skin structure: Friction ridges and volar pads, Types of crime scene prints, Introduction to chance prints: search, development (physical, chemical, fuming methods etc.) and collection procedure, Maintaining the fingerprint slips: rolled and plain prints, Identification of fingerprints: poroscopy, pattern analysis, ridge characteristics, comparison of fingerprints, Ridge tracing, Ridge counting, Photography of fingerprint exhibits.

Unit 2: Fingerprint classification techniques (9 Hrs)

Single digit, 10-digit Henry classification, Numerical value, Symbol, Primary classification, Secondary classification, Sub-secondary classification, Final classification, Key classification and Major classification, NCIC classification, Introduction to FACTS and AFIS, Comparison and individualization of fingerprints.

Unit 3: Forensic analysis of Lip prints, Bite marks, and Ear prints (14 Hrs)

Introduction to Cheiloscopy and history of lip prints, Classification of lip prints, Collection, Development, Identification and Comparison of lip prints. Objectives and forensic importance of bite mark examination, the typical bite marks morphology, types of bite marks, Evidence collection from victims and suspects, Photography, Lifting, Preservation and casting of bite marks, Identification and comparison of bite marks, Case studies. Ear prints: Introduction to the history of ear prints, Morphology of the ear, Procedure of taking standards from the suspects, Identification and comparison of ear prints.

Unit 4: Forensic analysis of Palm prints and Foot prints/Footwear impressions (12 Hrs)

Forensic importance of palm prints, Anatomy of the palm, Classification of palm prints, Class and Individual characters, Development of latent palm prints, Powder and chemical development techniques, Identification of palm prints, Comparison of ridge characteristics and crease patterns, Digital and 3D methods of palm print recording, Case studies.

Introduction to footprints & footwear impressions, Anatomy of the foot and sole ridge patterns, Locating impressions at the scene of crime, Evidence collection: Collection, Lifting/Casting and Preservation of foot/footwear impressions, Gait pattern analysis, Case studies.

Keywords: Fingerprint, Friction ridges, Ridge characteristics, Fingerprint classification, Gait analysis, Pattern comparison

Practical (30 Hrs)

- Take plain and rolled fingerprints and to identify the patterns
- Perform ridge tracing and ridge counting.
- Identify ridge characteristics
- Classify and compare the fingerprints
- Develop latent fingerprints with powders, fuming and chemical methods
- Analysis of fingerprints with microscopic techniques for the ridge and pore dimensions with the complete identification profiling
- Comparison of males and female's fingerprints with the specific reference to the ridge dimensions.

Essential readings

- C.E. O ‘Hara al d .J.W. Osterburg; An Introduction to Criminalistics: Indiana University Press, Blomington.
- R. Saferstein; Forensic Science Handbook, Vols. I, II; (Ed); Prentice Hall, Eaglewood Cliffs,NJ;
- David R. Ashbaugh; Quantitative and Qualitative Friction Ridge Analysis, CRCPress
- E. Roland Menzel; Fingerprint Detection, with Lasers, Second edition; Marcel, Dekker,Inc. USA.
- James F. Cowger; Friction Ridge skin CRC PressLondon.
- Mehta, M.K: Identification of Thumb Impression & Cross Examination of Finger Prints, N.M. Tripathi (P) Ltd,Bombay
- Kaur, J., &Dhall, M. (2023).Useless or used less?Poroscopy: The evidence of sweat pores. Heliyon, 9(7).
- Moenssens: Finger Prints Techniques, Chitton Book Co. Philadelphia, NewYork.

Suggested readings

- Kaur, J., &Dhall, M. (2022). Reproducibility and reliability of fingerprint microfeatures: effect of immersing hand in water at different temperatures. Journal of Forensic and Legal Medicine, 91, 102424.
- Kaur, J., &Dhall, M. (2022).Reproducibility of fingerprint microfeatures. Egyptian Journal of Forensic Sciences, 12(1), 7.
- Kaur, J., &Dhall, M. (2024). Epidermal ridge sweat pore density: A forensic approach to sex determination. Forensic Science International: Reports, 10, 100378.
- Chatterjee S.K., Speculation in Finger print identification, Jantralekha, Printing Works,Kolkata.
- Cowger, James F: Friction ridge skin: Comparison and Identification of Fingerprints; CRCPress, Boca Raton, NewYork.
- Cook Nancy: Classifying fingerprints -Innovative learning publication MentoPark
- Cossidy, M. J. Footwear Identification, Royal Canadian Mounted Police, Ontario,Canada.
- J A Seigel, P.J Saukoo and G C Knupfer; Encyclopedia of Forensic Sciences Vol. I, II andIII, Acad.Press

DSE FUNDAMENTALS OF CYBER SECURITY AND PENETRATION TESTING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
FUNDAMENTALS OF CYBER SECURITY AND PENETRATION TESTING	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Introduce the fundamental concepts of cyber security and its relevance in digital forensic investigations.
- Familiarize students with the types of cyber threats, vulnerabilities, and attack vectors.
- Impart knowledge of basic tools and techniques used in penetration testing.
- Develop practical understanding of cyber laws and ethical responsibilities in forensic contexts.

Learning Outcomes:

- Understand core concepts of cyber security, network vulnerabilities, and threat mitigation.
- They will acquire foundational skills in ethical hacking, penetration testing, and digital defense mechanisms, preparing them to identify, assess, and prevent cyberattacks in forensic and investigative contexts.

Unit I: Introduction to Cyber Security and Digital Threat Landscape (10 Hrs)

Definitions and scope of cyber security; Relevance of cyber security in forensic science and anthropology; Types of cyber threats: malware, phishing, social engineering, insider threats; Network and information system vulnerabilities; Introduction to risk management and cyber hygiene; Case studies of cybercrimes in forensic investigations

Unit II: Cyber Security Mechanisms and Defense Strategies (11 Hrs)

Principles of secure system design; Authentication, authorization, and access control mechanisms; Cryptography: basic concepts, symmetric and asymmetric encryption, hashing; Firewalls, intrusion detection and prevention systems (IDS/IPS); Endpoint security and antivirus technologies; Basics of secure browsing, email security, and data backup protocols

Unit III: Fundamentals of Penetration Testing (12 Hrs)

Introduction to ethical hacking and penetration testing; Methodologies: reconnaissance, scanning, gaining access, maintaining access, covering tracks; Common penetration testing tools (e.g., Nmap, Metasploit, Wireshark, Burp Suite); Web application testing and vulnerability scanning; Reporting and documentation of penetration testing findings; Legal and ethical considerations in penetration testing

Unit IV: Cyber Forensics and Legal Framework (12 Hrs)

Role of cyber forensics in criminal investigations; Forensic acquisition and preservation of digital evidence; Chain of custody and admissibility in court; Overview of Indian cyber laws: IT Act, 2000 and its amendments; International conventions on cybercrime; Responsibilities of forensic experts in digital investigations

Keywords: cyber security, pen testing, chain of custody, Indian cyber laws, defense strategies

Practical/ Tutorials (30 Hrs)

- Explore and list the steps required to type in an Indian language using UNICODE.
- Encode the word 'COMPUTER' using ASCII and convert the encode value into binary values.
- To study about ports and protocols of networks and the DNS information.
- Recording, editing, processing, and conversion of audio files
- Speech acquisition and Spectrographic analysis of Voice
- Detection of tampering in audio & video files
- Audio restoration and speech enhancement
- Analysis and enhancement of video/image/CTV Footages

Essential Readings

1. Wilhelm, T. (2025). *Professional penetration testing: Creating and learning in a hacking lab*. Elsevier.
2. Dhall M, Dimpal, Kaur J, Kapoor AK, 2024. Handbook of Digital Forensics and Cyber Crime. SSB Publications
3. Formosa, P., Wilson, M., & Richards, D. (2021). A principlist framework for cybersecurity ethics. *Computers & Security*, *109*, 102382.
4. Crumpler, W., & Lewis, J. A. (2022). *Cybersecurity workforce gap* (p. 10). Center for Strategic and International Studies (CSIS).
5. Javaid, M., Haleem, A., Singh, R. P., &Suman, R. (2023). Towards insightingcybersecurity for healthcare domains: A comprehensive review of recent practices and trends. *Cyber Security and Applications*, *1*, 100016.

Suggested Readings

1. Easttom II, W. (2018). *Penetration testing fundamentals: A hands-on guide to reliable security audits*. Pearson IT Certification.
2. Oriyano, S. P. (2016). *Penetration testing essentials*. John Wiley & Sons.

3. Paráda, I. (2018). BASIC OF CYBERSECURITY PENETRATION TEST. *Military Engineer/Hadmérnök*, *13*(3).
4. Firmansyah, B. (2024). Cybersecurity Fundamentals. In *Challenges in Large Language Model Development and AI Ethics* (pp. 280-320). IGI Global.
5. Kaur, G., Bharathiraja, N., Singh, K. D., Veeramanickam, M. R. M., Rodriguez, C. R., &Pradeepa, K. (2024). Emerging Trends in Cybersecurity Challenges with Reference to Pen Testing Tools in Society 5.0. *Artificial Intelligence and Society 5.0*, 196-212.

DSE INFORMATION SECURITY AUDIT AND COMPLIANCE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
INFORMATION SECURITY AUDIT AND COMPLIANCE	**4**	**3**	**0**	**1**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- To provide a foundational understanding of information security policies, procedures, and audit processes.
- To enable students to evaluate the effectiveness of security controls through structured audits.
- To introduce national and international standards related to information security compliance.
- To explore the role of audits in forensic investigations and digital risk management.

Learning Outcomes:

- Recognize principles of information security frameworks,auditing processes, and legal compliance standards
- Apply frameworks to assess security risks and controls.
- Evaluate compliance with national and international standards.

Unit I: Introduction to Information Security and Governance (10 Hrs)

Principles of information security: confidentiality, integrity, availability (CIA triad); Organizational roles and responsibilities in security governance; Introduction to Information

Security Management Systems (ISMS); Security policies, standards, guidelines, and procedures; Risk assessment and risk treatment plans; Overview of security controls and control objectives

Unit II: Security Auditing Fundamentals (12 Hrs)

Purpose and types of security audits: internal, external, compliance, and risk-based audits; Audit planning: scope, objectives, and resources; Audit process: preparation, fieldwork, evidence collection, reporting; Techniques and tools for security auditing; Common findings and audit responses; Role of audits in forensic documentation and digital evidence handling

Unit III: Compliance Standards and Regulatory Frameworks (12 Hrs)

Overview of major security and privacy standards:ISO/IEC 27001 and 27002, NIST Cybersecurity Framework, GDPR (General Data Protection Regulation), HIPAA (Health Insurance Portability and Accountability Act), PCI-DSS (Payment Card Industry – Data Security Standard); Indian regulatory environment:IT Act, 2000 (and amendments), Data Protection Bill (as applicable), Sector-specific compliance (e.g., healthcare, banking)

Unit IV: Audit Reporting and Incident Management (11 Hrs.)

Structuring an audit report: findings, recommendations, and risk ratings; Communicating results to stakeholders; Security incident reporting and management procedures; Role of audits in incident response and business continuity; Follow-up audits and remediation tracking; Ethics, accountability, and professional conduct in audit practice

Keywords: audit reporting, security auditing, compliance standards

Tutorial (30 Hrs)

Prepare a project on Information security audit and compliance

Essential Readings

1. Ilori, O., Lawal, C. I., Friday, S. C., Isibor, N. J., &Chukwuma-Eke, E. C. (2022). Cybersecurity auditing in the digital age: A review of methodologies and regulatory implications. *Journal of Frontiers in Multidisciplinary Research*, *3*(1), 174-187.
2. Folorunso, A., Wada, I., Samuel, B., & Mohammed, V. (2024). Security compliance and its implication for cybersecurity. *World Journal of Advanced Research and Reviews*, *24*(01), 2105-2121.
3. Alassaf, M., &Alkhalifah, A. (2021). Exploring the influence of direct and indirect factors on information security policy compliance: a systematic literature review. *IEEE Access*, *9*, 162687-162705.
4. Deshmukh, K. (2022). Indian Cyber Law Regime and Significance of IT Audit. *Issue 1 Indian JL & Legal Rsch.*, *4*, 1.
5. Singh, R., Pandiya, B., Upadhyay, C. K., & Singh, M. K. (2020). IT-governance framework considering service quality and information security in banks in

India. *International Journal of Human Capital and Information Technology Professionals (IJHCITP)*, *11*(1), 64-91.

6. Grima, S., Thalassinos, E., Cristea, M., Kadłubek, M., Maditinos, D., &Peiseniece, L. (Eds.). (2023). *Digital transformation, strategic resilience, cyber security and risk management*. Emerald Publishing Limited.

Suggested Readings

1. Henriques, J., Caldeira, F., Cruz, T., &Simões, P. (2024). A survey on forensics and compliance auditing for critical infrastructure protection. *IEEE Access*, *12*, 2409-2444.
2. Iipumbu, E., Nhamu, I., &Chitauro, M. (2023). A Comparative Analysis of Information Systems Audit and Digital Forensics Processes. *Available at SSRN 4648699*.
3. Stafford, T., Deitz, G., & Li, Y. (2018). The role of internal audit and user training in information security policy compliance. *Managerial Auditing Journal*, *33*(4), 410-424.
4. Vroom, C., & Von Solms, R. (2004). Towards information security behavioural compliance. *Computers & security*, *23*(3), 191-198.
5. Longley, D., Branagan, M., Caelli, W. J., & Kwok, L. F. (2008, September). Feasibility of automated information security compliance auditing. In *IFIP International Information Security Conference* (pp. 493-508). Boston, MA: Springer US.

DSE CRIMINAL LAW AND FORENSIC IMPLICATIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
CRIMINAL LAW AND FORENSIC IMPLICATIONS	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Understand the BNS, BNSS, and BSA in everday life
- Explore legal admissibility and expert testimony.
- Apply legal reasoning in evidence handling and reporting.
- Discuss case laws and landmark judgments in forensic science.

Learning Outcomes:

- Describe the structure of the Indian legal system relevant to forensics.
- Interpret forensic evidence within the framework of law.
- Analyze the legal responsibilities of forensic experts.

Unit I: Introduction to Indian Criminal Law (10 Hrs)

Overview of the Indian legal system and its components; Nature and scope of criminal law; Classification of offences: cognizable and non-cognizable, bailable and non-bailable; Definitions and general exceptions under the Bharatiya Nyaya Sanhita (BNS); Elements of crime: actusreus and mensrea; Relevance of criminal law to forensic investigations

Unit II: Bharatiya Nyaya Sanhita (BNS) and Forensic Relevance (12 Hrs)

Key sections of BNS relevant to forensic experts, including: Homicide (Section 299–304) Hurt and grievous hurt (Section 319–326) Sexual offences (Section 375–376D) Dowry deaths and cruelty (Section 304B, 498A) Forgery and counterfeiting (Section 463–477A) Criminal negligence and medical malpractice; Case studies involving forensic applications in BNS offences

Unit III: Bharatiya Nagarik Suraksha Sanhita (BNSS) and Law of Evidence (14 Hrs)

Stages of a criminal case: FIR, arrest, investigation, charge-sheet, trial; Role of police, magistrate, and court during criminal proceedings; Powers and duties of investigating officers; Relevant sections of BNSS for forensic scientists: Search and seizure (Section 100, 165) Medical examination and post-mortem (Section 53, 174); Bharatiya Sakshya Adhiniyam: Definitions: evidence, fact, expert opinion Relevance and admissibility of forensic evidence (Section 45, 46) Examination and cross-examination of expert witnesses Documentary and electronic evidence

Unit IV: Responsibilities, Ethics, and Legal Challenges for Forensic Experts (9 Hrs)

Legal and ethical duties of forensic professionals; Courtroom demeanor and preparation of expert reports; Perjury, professional misconduct, and liability; Protection of human rights in forensic practice; Emerging legal issues: data privacy, cyber laws, and digital evidence; National and international guidelines on forensic ethics (e.g., NHRC, UN guidelines)

Keywords: Indian Penal Code, professional misconduct, stages of cases

Practical (30 Hrs)

- To study about Sys-Internals, windows Logs and filter logs based on scenarios.
- To study and implement any SIEM (Security Information & Event Management) tool.
- To study real-time visibility across an organization's information security systems using any SIEM tool.
- To perform acquisition of any drive (HDD, SSD, USB) using FTK Imager.
- To perform primary level analysis using HxDEditor and manipulating Data by Using HxD.
- To perform detailed analysis of Forensic Image using Forensic Toolkit.

Essential Readings

1. Kothari, P. (2023). Exploring the Role of Forensic Science in Indian Criminal Justice System. *Available at SSRN 4565177*.
2. Banerjee, S. (2023). Forensic Science and Its Applicability in the Indian Criminal Justice System. *Issue 1 Indian JL & Legal Rsch.*, *5*, 1.
3. Srivastava, A., Harshey, A., Das, T., Kumar, A., Yadav, M. M., &Shrivastava, P. (2022). Impact of DNA evidence in criminal justice system: Indian legislative perspectives. *Egyptian Journal of Forensic Sciences*, *12*(1), 51.
4. Chapman, B., Keatley, D., Oatley, G., Coumbaros, J., & Maker, G. (2020). A review and recommendations for the integration of forensic expertise within police cold case reviews. *Journal of Criminal Psychology*, *10*(2), 79-91.

Suggested Readings

1. Shali, S. K. (2018). Applicability of Forensic Science in Criminal Justice System in India With Special Emphasis on Crime Scene Investigation. *Medico-Legal Desire Media and Publications, Medico-Legal Reporter, Inaugural Issue*.

2. Grover, N., &Tyagi, I. (1910). Development of Forensic Science and Criminal Prosecution-India. *Nature*, *23*(578), 76.
3. Mack, S., &Chatterjee, I. (2021). Role of forensic evidence in criminal justice delivery system in India.
4. Khrystov, O., &Lipynskyi, V. (2019). Comparative analysis of forensic expert activity: an administrative, criminal, criminalistic, economic approach. *Baltic journal of economic studies*, *5*(2), 242-248.

DSE POLICE ADMINISTRATION AND LAW ENFORCEMENT AGENCIES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
POLICE ADMINISTRATION AND LAW ENFORCEMENT AGENCIES	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Describe the evolution and role of police in India.
- Classify various law enforcement agencies and their mandates.
- Analyze inter-agency coordination in criminal justice.
- Summarize administrative and operational challenges.

Learning Outcomes:

- Identify the organizational structure of Indian police and law enforcement agencies.
- Compare the functions of central and state law enforcement bodies.
- Evaluate challenges in modern policing and law enforcement.

Unit I: Introduction to Police Administration (9 Hrs)

History and evolution of policing in India; Organization and structure of police at state and central levels; Police hierarchy, recruitment, training, and responsibilities; Role of police in crime prevention, investigation, and public order; Police reforms and recommendations of major commissions (e.g., NPC, Malimath Committee)

Unit II: Investigation and Policing Practices (12 Hrs)

Registration of FIR and preliminary inquiry; Arrest, interrogation, and search/seizure procedures; Crime mapping, patrolling, and beat systems; Role of forensic science in police investigations; Use of technology in policing: CCTNS, facial recognition, e-FIR systems; Community policing and citizen participation

Unit III: Central and Specialized Law Enforcement Agencies (12 Hrs)

Overview of central agencies and their mandates:CBI (Central Bureau of Investigation), NIA (National Investigation Agency), NCRB (National Crime Records Bureau), IB (Intelligence Bureau), RAW (Research & Analysis Wing), FBI, SSB, BSF, CRPF, ITBP, and others; Coordination among central and state police forces; Challenges in multi-agency investigations

Unit IV: International Law Enforcement and Modern Challenges (12 Hrs)

Role of INTERPOL and its functions; Cross-border crime control and extradition procedures; Cooperation under treaties and mutual legal assistance treaties (MLATs); Law enforcement and terrorism, cybercrime, drug trafficking; Human rights and accountability in policing; Ethical policing, custodial violence, and public trust

Practical (30 Hrs)

Visit to NCRB and other Police stations, CBI office and other concerned agencies and prepare a report.

To examine the strategies and methods adapted by police and other agencies in crime detection analysis and legal follow up.

Essential Readings

1. Cordner, G. W. (2023). *Police administration*. Routledge.
2. Schnurr, E. (2022). Local law enforcement and public administration. In *Global Encyclopedia of Public Administration, Public Policy, and Governance* (pp. 7856-7860). Springer, Cham.
3. Dempsey, J. S., Forst, L. S., & Carter, S. B. (2022). *An Introduction to Policing (2019)*. Cengage SUPPLEMENTARY MATERIALS.

Suggested Readings

1. Sood, A., &Kashyap, S. (2018). Administration Of Criminal Justice And Role Of Forensics In India: A Study. *International Journal of Innovative Research and Advanced Studies*, *5*(4), 69-73.
2. Kathane, P., Singh, A., Gaur, J. R., &Krishan, K. (2021). The development, status and future of forensics in India. *Forensic Science International: Reports*, *3*, 100215.
3. Tripathi, U. M. The Role of Forensic Science in Strengthening Criminal Investigations: Challenges and Future Prospects in India.

4. Khan, G. F., &Ahad, S. (2018). Role of Forensic Science in Criminal Investigation: Admissibility in Indian Legal System and Future Perspective. *International Journal of Advance Research in Science and Engineering*, *7*(4), 220-234.
5. Strom, K. J., & Hickman, M. J. (2010). Unanalyzed evidence in law-enforcement agencies: A national examination of forensic processing in police departments. *Criminology & Public Policy*, *9*(2), 381-404.
6. Naumenko, S. M. (2020). The system of law enforcement agencies interacting with forensic science institutes. *Theory and practice of forensic science and criminalistics*, (22), 211-225.
7. Williams, R. (2012). Policing and forensic science. In *Handbook of policing* (pp. 788-821). Willan.

GE QUALITY MANAGEMENT AND LABORATORY MANAGEMENT SYSTEMS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
QUALITY MANAGEMENT AND LABORATORY MANAGEMENT SYSTEMS	**4**	**3**	**0**	**1**	Bachelors in Forensic science, Anthropology and allied sciences.

Course Objectives:

- Define ISO/IEC standards relevant to forensic science labs.
- Demonstrate planning and auditing of laboratory processes.
- Apply principles of quality management in case analysis.
- Compare national and international quality benchmarks.

Learning Outcomes:

- Recognize principles of quality assurance and control in forensic labs.
- Analyze laboratory accreditation and documentation systems.
- Evaluate implementation of management systems in forensic settings.

Unit I: Fundamentals of Quality Management (10 Hrs)

Concepts and importance of quality in forensic science' Definitions: Quality Assurance (QA), Quality Control (QC), and Total Quality Management (TQM); Quality indicators and performance metrics; Role of quality management in evidence handling and analysis; Elements of a quality manual and quality policy; Overview of Six Sigma and Lean principles in lab settings

Unit II: Laboratory Management Systems and Standards (11 Hrs.)

Introduction to laboratory management systems**;** Structure and elements of ISO/IEC 17025:2017 (General requirements for the competence of testing and calibration laboratories)**;** ISO 15189 and ISO 17020: relevance to forensic and medical labs**;** NABL (National Accreditation Board for Testing and Calibration Laboratories) guidelines and procedures**;** Proficiency testing, inter-laboratory comparisons, and traceability of measurements**;** Documentation: SOPs, technical records, validation, and verification

Unit III: Internal Audits, Accreditation and Compliance (12 Hrs)

Internal audits: planning, conducting, reporting, and follow-up; Management review and continual improvement process; Corrective and preventive actions (CAPA); Non-conformance identification and resolution; Accreditation process and audit checklists; Case studies on accreditation of forensic laboratories in India and abroad

Unit IV: Laboratory Operations, Safety, and Ethics (12 Hrs)

Laboratory organization and personnel management; Resource allocation, infrastructure, and equipment maintenance; Waste management and biohazard control; Occupational health and safety (OHS) in forensic labs; Ethical responsibilities and legal implications in laboratory practices; Confidentiality, integrity, and impartiality in reporting

Tutorials (30 Hrs)

Visit Forensic science laboratory and understand the management system. Prepare a project on the visit.

Essential Readings

1. Ross, A., &Neuteboom, W. (2021). Implementation of quality management from a historical perspective: the forensic science odyssey. *Australian Journal of Forensic Sciences*, *53*(3), 359-371.
2. Kumar, S., Chhabra, G., Sehrawat, K. S., & Singh, M. (2024). Developing a competency assessment framework for medical laboratory technologists in primary healthcare settings in India. *Plos one*, *19*(4), e0294939.
3. Aswal, D. K. (2020). Quality infrastructure of India and its importance for inclusive national growth. *Mapan*, *35*(2), 139-150.

4. Weyermann, C., Willis, S., Margot, P., & Roux, C. (2023). Towards more relevance in forensic science research and development. *Forensic Science International*, *348*, 111592.

Suggested Readings

1. Doyle, S. (2018). *Quality management in forensic science*. Academic Press.
2. Milosevic, M., Bjelovuk, I., &Kesic, T. (2009). Quality management system in forensic laboratories. *NBP. Nauka, bezbednost, policija*, *14*, 1.
3. Venter, C. H. (2010). *International benchmarking of quality management in forensic science drug laboratories* (Doctoral dissertation, North-West University).
4. Tilstone, W. J. (2010). Quality in the Forensic Science Laboratory. In *The Forensic Laboratory Handbook Procedures and Practice* (pp. 335-367). Totowa, NJ: Humana Press.
5. Arican, H. İ., &Yalçın, N. (2025). ISO 17025 and ISO 9001: A Review on Quality Management in Digital Forensics Laboratories. *The Journal of International Scientific Researches*, *10*(1), 18-28.

GE TECHNIQUES OF RESEARCH IN FORENSIC SCIENCE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
TECHNIQUES OF RESEARCH IN FORENSIC SCIENCE	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Define the steps of research design and hypothesis formulation.
- Apply data collection and interpretation techniques.
- Evaluate sources of error and bias in research.
- Illustrate the structure and writing of scientific reports.

Learning Outcomes:

- Describe types of research and sampling techniques and understand the principles of scientific research design.
- Formulate research question, Interpret research data using appropriate tools.
- Analyze the components of a scientific research processand conduct ethical and systematic research relevant to forensic science and interdisciplinary investigations.

Unit I: Foundations of Research **(12 Hrs)**

Meaning, objectives, and importance of research in forensic science; Types of research: basic, applied, qualitative, quantitative, and mixed methods; Research problem identification and formulation; Hypothesis: types, formulation, and testing; Review of literature: sources, referencing styles, use of online databases and indexing; Research questions and objectives

Unit II: Research Design and Sampling **(11 Hrs)**

Research design: exploratory, descriptive, experimental, cross-sectional, longitudinal; Variables: independent, dependent, confounding, control; Sampling techniques: probability and non-probability sampling; Sample size determination and power analysis; Tools of data collection: questionnaires, interviews, observations, case studies; Designing and pretesting research instruments

Unit III: Data Analysis and Interpretation **(12 Hrs)**

Types of data: nominal, ordinal, interval, ratio; Descriptive statistics: measures of central tendency and dispersion; Inferential statistics: t-tests, chi-square, ANOVA, correlation, regression (basic concepts); Introduction to statistical software (e.g., SPSS, R); Data interpretation, tabulation, and graphical presentation; Common errors in data analysis and reporting

Unit IV: Ethics, Reporting, and Scientific Writing **(10 Hrs)**

Research ethics: informed consent, confidentiality, plagiarism, fabrication/falsification; Institutional Ethics Committees and approval process; Structure of a research report, dissertation, and thesis; Writing scientific papers: abstract, introduction, methodology, results, discussion, references; Referencing styles: APA, MLA, Vancouver, and referencing tools (Zotero, Mendeley); Publication process: peer-review, impact factor, predatory journals

Keywords:hypothesis, ethics, scientific writing, study design, data analysis

Practical **(30 Hrs)**

Prepare a research proposal related to topic of Forensic science

Essential Readings

1. Bell, S. (2019). *Forensic science: an introduction to scientific and investigative techniques*. CRC press.
2. Houck, M. M., & Siegel, J. A. (2009). *Fundamentals of forensic science*. Academic Press.
3. Tilstone, W. J. (2006). *Forensic science: An encyclopedia of history, methods, and techniques*. Bloomsbury Publishing USA.
4. Bhattacharyya, D. K. (2006). *Research methodology*. Excel Books India.

Suggested Readings

1. Rajasekar, D., &Verma, R. (2013). *Research methodology*. Archers & Elevators Publishing House.
2. Kumar, A., &Praveenakumar, S. G. (2025). *Research methodology*. Authors Click Publishing.
3. Gupta, A., & Gupta, N. (2022). *Research methodology*. SBPD publications.
4. Nickell, J., & Fischer, J. F. (2014). *Crime science: methods of forensic detection*. University Press of Kentucky.
5. Cooper, G. S., &Meterko, V. (2019). Cognitive bias research in forensic science: A systematic review. *Forensic science international*, *297*, 35-46.
6. Illes, M., & Wilson, P. (2020). Forensic epistemology: exploring case-specific research in forensic science. *Canadian Society of Forensic Science Journal*, *53*(1), 26-40.
7. Noon, R. K. (2009). *Scientific method: applications in failure investigation and forensic science*. CRC Press.

SKILL BASED PAPER - CRIME SCENE DOCUMENTATION WITH LABORATORY TRAINING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
CRIME SCENE DOCUMENTATION WITH LABORATORY TRAINING	**2**	**1**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Explain principles of systematic crime scene recording.
- Apply appropriate documentation tools in case scenarios.
- Analyze reconstruction methods from documented evidence.
- Discuss the legal value of scene documentation.

Learning Outcomes:

- Identify types of documentation at crime scenes.
- Demonstrate techniques of sketching, note-making, and photography.
- Evaluate crime scene documentation in forensic analysis.

Unit I: Fundamentals and methods of Crime Scene Analysis and documentation (10 Hrs)

The idea of ‘evidence’ in Forensic Science and their legal admissibility, Introduction to crime scene investigation; Types of crime scenes; Securing and protecting the scene; Chain of custody and evidence integrity; Role and responsibilities of forensic experts and crime scene investigators; Legal and ethical considerations in crime scene handling; Principles and objectives of documentation; Note-taking: essentials, format, and terminology; Photography, Sketching, measurement methods; Video recording and its forensic value; Use of evidence markers and log sheets

Unit II: Advanced Documentation of specific crimes using various Techniques (13 Hrs)

3D crime scene reconstruction; Computer-aided drawing (CAD) in forensic sketching; Geographic Information Systems (GIS) in crime mapping; Drones and aerial imaging for scene documentation; Laser scanning and virtual walkthroughs; Digital data storage, preservation, and security. Homicide and violent crime scenes; Sexual assault and domestic violence scenes; Arson and fire scenes; Vehicular accidents and hit-and-run cases; Mass disaster scenes and identification challenges; Case study discussions: crime scene documentation errors and lessons learned

Practical

- To carry out photography of indoor and outdoor crime scenes
- Crime scene photographic processing and development in different light sources and using different filters.
- To carry out digital photography of various forensic evidences
- Mock crime scene investigation and writing a report on evaluation of crime scene.
- Interpretation of crime scene notes, photos, sketches and reconstruction of crime scene
- Microscopy of various physical evidences
- Portrait parley

Keywords:crime scene, GIS, sketching, aerial imaging, chain of custody

Essential Readings

1. Kothari, P. (2023). Exploring the Role of Forensic Science in Indian Criminal Justice System. *Available at SSRN 4565177*.
2. Kumari, A. (2023). Admissibility and Evidentiary Value of Forensic Evidence in India. *Issue 2 Indian JL & Legal Rsch.*, *5*, 1.
3. Ranga, P. D., & Singh, Y. (2021). Expert Opinion at Crime Scene: An Overview. *Indian Journal of Forensic Medicine & Toxicology*, *15*(3).
4. Singh, H. N. (2021). Crime scene investigation. *International Journal of Science and Research (IJSR)*, *10*(11), 642-648.
5. Jayaprakash, P. T. (2022). *Crime Scene Investigation and Reconstruction: An Illustrated Manual and Field Guide*. CRC Press.

6. Galvin, R. (2020). *Crime Scene Documentation: Preserving the Evidence and the Growing Role of 3D Laser Scanning*. CRC Press.
7. James et al (2015). Forensic Science: An Introduction to Scientific and Investigative Techniques

Suggested Readings

1. deLeeuwe, R. (2017). The hiatus in crime scene documentation: Visualisation of the location of evidence. *Journal of Forensic Radiology and Imaging*, *8*, 13-16.
2. Meghwal, T. (2025). CRIME SCENE INVESTIGATION IN INDIA: LEGAL FRAMEWORK, PROCEDURES & CHALLENGES. *PROCEDURES & CHALLENGES (April 17, 2025)*.
3. Gupta, S., & Jain, I. B. (2023). Crime Scene Investigation And Forensic Evidence: Forensic Analysis And Tools. *Journal of Pharmaceutical Negative Results*, *14*(2).
4. Barbaro, A., & Mishra, A. (Eds.). (2022). *Manual of Crime Scene Investigation*. CRC Press.
5. Borah, U. (2021). Role of Law Enforcement Agencies and Police in Crime Scene Investigation. *Indian JL & Legal Rsch.*, *3*, 1.

SKILL BASED PAPER - BIOLOGICAL EVIDENCE ANALYSIS WITH LABORATORY TRAINING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
BIOLOGICAL EVIDENCE ANALYSIS WITH LABORATORY TRAINING	**2**	**1**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Explain biochemical and microscopic analysis techniques.
- Apply serological and presumptive tests.
- Interpret patterns and conditions affecting biological samples.
- Discuss contamination control and preservation of evidence

Learning Outcomes:

- Recognize types of biological evidence and their forensic value.
- Demonstrate testing methods for blood, semen, saliva, and tissues.
- Analyze the results of biological evidence examination.

Unit I: Introduction to Biological Evidence and its analysis (13Hrs.)

Definition, classification, and significance of biological evidence; Types of biological materials: blood, semen, saliva, urine, sweat, hair, bones, tissues; Crime scene protocols: identification, collection, packaging, labeling, and preservation; Contamination prevention and chain of custody maintenance; Legal and ethical considerations in handling biological evidence. Presumptive and confirmatory tests for: Blood, Semen, Saliva and urine; Species determination and ABO blood group typing; Enzyme markers and protein polymorphisms; Degradation and stability of biological materials

Unit IV: Specialized Biological Evidence technologies and Interpretation (10 Hrs)

Introduction to forensic DNA analysis: nuclear and mitochondrial DNA; DNA extraction, quantification, amplification (PCR); STR (Short Tandem Repeat) analysis, Y-STR, mtDNA typing; DNA fingerprinting, electrophoresis, and capillary electrophoresis; Interpretation of DNA profiles and statistical evaluation; DNA databases and privacy concerns. Analysis of bones, age, sex, stature, ancestry; Forensic odontology; Hair and fiber examination, Wildlife forensics and plant material identification; Challenges in mixed samples, degraded evidence, and trace quantities; Report writing, court presentation, and expert testimony

Keywords:biological fluids, serological analysis, DNA, STR, court presentation, expert testimony

Practical **(15 Hrs)**

- Protocol of handling different biological sample and maintaining their chain of custody
- Karyotyping, different banding patterns of chromosome
- Examination of Diatoms and Pollen grains
- Examination of hair characteristics for identification of species
- Anthropometry - Identification of individuals (in living)

Essential Readings

1. Pal, S. K., Kumari, V., & Devi, N. (2023). Impact of biological evidences on DNA profiling of sexual assault cases. *Indian journal of forensic and community medicine*, *10*(1), 11-21.
2. Kumar, N., Gautam, A. K., Prajapati, P. K., Paul, S., Gupta, S. K., Sharma, A., &Verma, D. (2023). Biological Evidence Management at the Crime Scene: An Overview. *Indian Journal of Forensic Medicine & Toxicology*, *17*(3).
3. Rao, P. K., Pandey, G., &Tharmavaram, M. (2020). Biological evidence and their handling. *Technology in Forensic Science: Sampling, Analysis, Data and Regulations*, 35-53.
4. De Silva, K. B. N., Dharmasiri, K. S., Buddhadasa, M. P. A. A., &Ranaweera, K. G. N. U. (2021). Criminal Investigation: A Brief Review of Importance of Biological Evidence. *European Scholar Journal*, *2*(8), 8-12.

Suggested Readings

1. Magalhães, T., Dinis-Oliveira, R. J., Silva, B., Corte-Real, F., &Nuno Vieira, D. (2015). Biological evidence management for DNA analysis in cases of sexual assault. *The Scientific World Journal*, *2015*(1), 365674.
2. McClintock, J. T. (2017). *Forensic analysis of biological evidence: a laboratory guide for serological and DNA typing*. CRC Press.
3. Byne, W. (1994). The biological evidence challenged. *Scientific American*, *270*(5), 50-55.
4. Li, R. (2008). *Forensic biology: identification and DNA analysis of biological evidence*. CRC press.
5. Schaapveld, T. E., Opperman, S. L., &Harbison, S. (2019). Bayesian networks for the interpretation of biological evidence. *Wiley Interdisciplinary Reviews: Forensic Science*, *1*(3), e1325.

SEMESTER II

DSC-4 FORENSIC PHYSICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
FORENSIC PHYSICS	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences.

Course Objectives:

- Describe the concept of forensic examination of various evidences like soil, cement, fiber, glass etc. at crime scene.
- Evaluate specific techniques to be used for the examination of forensic evidences especially paint, fibre, soil, glasses and tool marks involved with the crime.

Learning Outcome

- Identify types and composition of soil, microscopic examination, Mortar and concrete analysis.
- Analyse types of paint and fibres, their composition, their macroscopic and microscopic analysis.
- Demonstrate about the different types of glass and their composition.
- Identify the use of tool marks their restoration and method of recording those restored marks.

Unit 1 Soil, Cement and Concrete (12 Hrs.)

Types and composition of soil, sample preparation, removal of contaminants, colour, molecular particle size distribution, turbidity test, pH measurements, microscopic examination, density gradient analysis, ignition-loss test, elemental analysis, interpretation of soil evidence. Spectroscopic methods for organic materials of soil, XRD analysis. Cement bromoform test, fineness test, ignition-loss test. Identification of adulterated cement. Mortar and concrete analysis.

Unit 2 Paint and Fibre (10 Hrs)

Types of paint and their composition, macroscopic and microscopic analysis, pigment distribution, micro-chemical analysis using various techniques, interpretation of paint evidence. Types of fibres, forensic aspects of fibre examination- fluorescence, optical properties, refractive index, birefringence, dye analysis. TLC, IR-micro spectroscopy, Py-GCMS. Difference between natural and man-made fibres. Chemical compositions of papers, examination of wood and paper fibers, elemental analysis.

Unit 3 Glass **(9 Hrs)**

Types of glass and their composition-soda. Matching and comparison. Forensic examinations of glass fractures- rib marks, hackle marks, cone fracture, wavy, backward fragmentation, concentric and radial fractures. Colour, fluorescence, physical measurements, refractive index, density gradient, becke-line, specific gravity examination and elemental analysis of glass evidence.

Unit 4 Tool marks **(14 Hrs)**

Tool marks and compression marks, striated marks, combination of compression and striated marks, repeated marks, class and individual characteristics, tracing and lifting of marks, skid marks and their analysis, Photographic examination of tool marks and cut marks on clothes and wall etc. Restoration of erased / obliterated marks- Method of making-cast, punch, engrave; methods of obliteration, restoration, recording of restored marks – restoration of marks on wood, leather, polymer etc.

Practical **(30 Hrs)**

- Preliminary examination of glass, soil, fibre, paint and cloth evidences.
- Examination of physical properties of glass, soil, fibre and paint evidences.
- Restoration techniques of tool mark impressions and casting footprints.

Keywords:terminal ballistics, projectile velocity, toolmarks, soil, paint, glass, spectrscopy

Essential Readings

- Mathews, J.H; Firearms Identification, Vol I, II and III, Charles C. Thomas, USA, 1977.
- Kaur J, Dhall M, Tyagi R, Kapoor AK, 2024 Handbook of Forensic Physics. SSB Publications
- Warlow, T.A.; Firearms, The Law and Forensic Ballistics, Taylor and Francis, London,1996.
- Schooeble, A.J. and Exline, L.D; Current methods in Forensic Gunshot Residue Analysis, CRC Press, New York, 2000.
- Wilber; Ballistic Science for the Law Enforcement Officer, Charles C. Thomas, USA, 1977

Suggested Readings

- Caddy, B; Forensic Examination of Glass and Paint Analysis and Interpretation, CRC Press, New York, 2001.
- Shaw, D; Physics in the Prevention and Detection of Crime, Contem Phys. Vol.17, 1976.
- Saferstein, R; Forensic Science Handbook. Vol. I,II, (Ed.), Prentice Hall, New Jersey, 1988.

- Working Procedure Manual; Physics BPR&D Publication, 2000.
- Sharma, B.R; Forensic Science in Criminal Investigation and Trials (3rd Ed.), Universal Law Publishing Co., New Delhi, 2001.
- Working Procedure Manual- Physics, BPR&D Publication. 2000
- Hess, K.P; Textile Fibers and their Use, 6th Edn, Oxford and IBH Publishing Co., 1974.
- Sharma, B.R.; Firearms in Criminal Investigation & Trials, 4th Ed, Universal LawPublishing Co Pvt Ltd, New Delhi, 2011.

DSC FORENSIC ANTHROPOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
FORENSIC ANTHROPOLOGY	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Define osteological and anthropometric techniques.
- Apply methods of forensic facial reconstruction.
- Evaluate skeletal evidence in medicolegal investigations.
- Compare human and non-human remains.

Learning Outcomes:

- Recognize human skeletal remains and biological characteristics.
- Classify bones based on age, sex, and ancestry.
- Analyze skeletal trauma and pathology.

Unit 1 Personal Identification (14 Hrs)

Genesis and development of forensic anthropology. Personal identification of living persons Identification through somatometric and somatoscopic observation, nails, occupation marks, scars, tattoo marks and deformities; handwriting and mannerisms. Genetic traits of forensic significance: Colour blindness, ear lobe, brachydactyly, polydachtyly, widow's peak, eye colour, hair colour, face form, frontal eminences, nasal profile, nasal tip, lips, chin form. Identification of the recently dead and decomposed bodies.

Unit 2 Human Growth and Development (8 hrs)

Major stages of human growth and development- Prenatal growth, Postnatal growth and their characteristics, Factor affecting growth- Genetic and Environmental. Methods of studying Human Growth, Significance of age in growth studies Methods of assessing age-chronological age, dental age, skeletal age, secondary sex character age and morphological age.

Unit 3 Forensic Morphometry of Skeletal Remains (13 Hrs)

Techniques for recovering skeletonised human remains. Laboratory analysis of skeletal and decomposing remains; maceration, skeletal analysis. Human and Animal remains. Bone fragments, Attribution of sex, estimation of age and reconstruction of stature from skeletal remains. Trauma analysis and identifying skeletal pathology. Antimortem, perimortem, post-mortem and pseudo mortem trauma. Pathological changes in bone. Establishment of partial and complete identity of skeletal material and dead bodies-morphometric techniques.

Unit 4 Forensic Odontology (10 Hrs)

Tooth structure and growth. Estimation of age from odontological evidences. Population differences in size and morphology. Individualisation of tooth pulp. Bite marks and its forensic significance. Photography, lifting and preservation of bite marks. Comparison and evaluation of bite mark evidences.

Practical (30 Hrs)

- Examination of original skeletal remains- Long bones and skull
- Identification by original long bones
- Stature estimation of individuals by long bones
- Determination of sex from Skull with mandible
- Determination of age from Skull with mandible
- Determination of sex from pelvis and sacrum.
- Identification of individuals by dental examination
- Anthropometry - Identification of individuals (in living)

Keywords: Forensic Morphometry, odontology, significance of age, personal identification

Essential Readings

1. James, R; Forensic examination of hair, Taylor & Francis, 2ND Ed. London, 1999.
2. Kaur J, Dhall M, Tyagi R, Kapoor AK, 2024 Handbook of Forensic Anthropology. SSB Publications
3. Byers, S. N., & Juarez, C. A. (2023). *Introduction to forensic anthropology*. Routledge.
4. Passalacqua, N. V., &Pilloud, M. A. (2021). The need to professionalize forensic anthropology. *European Journal of Anatomy*, *25*(S2), 35-47.
5. Jayaprakash, P. T., Alarmelmangai, S., &Pushparani, C. (2021). Past progress and future needs of forensic anthropology in India. *Med. Sci. & L.*, *61*, 163.
6. Shrivastava, P., Lorente, J. A., Srivastava, A., Badiye, A., &Kapoor, N. (Eds.). (2023). *Textbook of forensic science*. Springer.
7. Shubhra, G; Introduction to forensic examination, Selective Scientific Books, New Delhi, 2008
8. Michael, W. Haney, H.A. &Freas, L.E; The Forensic Anthropology Laboratory, CRC Press, 2008.

Suggested Readings

1. Obertová, Z., Stewart, A., &Cattaneo, C. (Eds.). (2020). *Statistics and probability in forensic anthropology*. Academic Press.
2. Reddy,V.R; Dental Anthropology, Inter-India Publication, New Delhi, 1985.
3. Singh, I.P. &Bhasin M.K; A manual of biological Anthropology, Kamla Raj Enterprises, New Delhi, 2004.
4. Kroeber; Anthropology, Oxford & IBH Publishing Company, New Delhi, 1972.
5. Pickering, R. & Bachman D; The use of Forensic Anthropology, CRC Press, Costa Rica, 2009.
6. Bose, N K; Anthropology, Narayana Press, Denmark, 1972.
7. Eveleth, P.B. & Tanner, J.M; Worldwide Variation in Human Growth, Cambridge University Press, London, 1976.

DSC- FORENSIC CHEMISTRY AND TOXICOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
FORENSIC CHEMISTRY AND TOXICOLOGY	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Understand the effect of toxic substance on body physiology
- Identify routes of exposure and effects of toxins.
- Understand the dynamics of chromatography, spectrometry, and wet tests.
- Interpret toxicological data in forensic reports.
- Classify poisons, drugs and other chemical substances having implication on crime.

Learning Outcomes:

- Demonstrate analytical techniques for toxicological samples.
- Describe common poisons and chemical evidences in crimes.

- Analyze toxic substances in biological and environmental samples.

Unit 1 Forensic Chemistry **(13 Hrs)**

Introduction to Forensic chemistry, understand the effect of toxic substance on body physiology sampling of chemical evidences, presumptive, screening (colour/ spot test), inorganic analysis. Detective dyes- cases and importance in trap cases. Arson Chemistry of fire, searching of fire scene, collection, preservation and examination of arson evidences. Adulteration in Petroleum products. Analysis of beverages. Significance of alcohol in breath and breath screening devices. Forensic analysis of Fertilizers/ insecticides/ pesticides/ biocides.

Unit 2 Explosives **(11 Hrs)**

Classification of explosives, synthesis and characteristics of Tri-nitro toluene (TNT), Pentaerythritoltetranitrate (PETN) and Research and Development Explosives (RDX). Explosion process, blast waves, searching of scene of explosion. Post blast residue collection and analysis, blast injuries and detection of hidden explosives. Improvised explosive devices.

Unit 3 Forensic Toxicology and Pharmacology **(10 Hrs)**

Definition, classification of poisons- organic, inorganic, metallic, non-metallic etc. Acute and chronic poisoning, Accidental, homicidal and suicidal poisoning, Extraction and identification of commonly used poisons. Dosage, Frequency, Route of administration, Absorption, distribution and metabolism and factors affecting metabolism and excretion. Toxicological techniques.

Unit 4 Drugs of Abuse **(11 Hrs)**

Natural and synthetic drugs of abuse. Drug dependence, classification of drugs- Narcotics, Hallucinogens, Depressants, Stimulants, Anabolic steroids. Psychotropic and Psychedelic drugs of abuse. Field and laboratory tests of drugs of abuse. Instrumental methods of analysis, collection, preservation and transportation of drug evidences. Comparative understanding of youth behavior and substance abuse

Keywords:drugs, poisoning, explosives, chemical evidences, chromatography, toxic substances, spectrometry

Practical **(30 Hrs)**

- TLC and spot test of alkaloids of drugs of abuse and toxic substances.
- Isolation and instrumental analysis of different toxic substances and drugs.
- Thin layer chromatography of explosive substances
- Examination of petroleum products as per BIS standards.
- Examination procedures involving standard methods and instrumental techniques

- Detection and identification of doping drugs from- hair, blood, saliva, urine and other body fluid and estimation of alcohol from breath, urine and blood.
- UV-Visible Spectroscopic analysis of Drugs

Essential Readings

1. Bell, S. (2022). *Forensic chemistry*. CRC Press.
2. Flanagan, R. J., Cuypers, E., Maurer, H. H., &Whelpton, R. (2020). *Fundamentals of analytical toxicology: Clinical and forensic*. John Wiley & Sons.
3. Lappas, N. T., &Lappas, C. M. (2021). Forensic toxicology: Principles and concepts.
4. Malaca, S., Carlier, J., &Busardò, F. P. (2020). Advances in forensic toxicology. *Curr Pharm Des*, *26*(31), 3779-80.
5. Dawidowska, J., Krzyżanowska, M., Markuszewski, M. J., &Kaliszan, M. (2021). The application of metabolomics in forensic science with focus on forensic toxicology and time-of-death estimation. *Metabolites*, *11*(12), 801.
6. Nisbet, L. A., DiEmma, G. E., & Scott, K. S. (2023). Drug stability in forensic toxicology. *Wiley Interdisciplinary Reviews: Forensic Science*, *5*(4), e1481.

Suggested Readings

1. Niesink, RJM; Toxicology- Principles and Applications, CRC Press,1996
2. Modi, JP, Textbook of Medical Jurisprudence & Toxicology, N.M. Tripathi Pub,2001
3. Chadha, PV; Handbook of Forensic Medicine & Toxicology, Jaypee Brothers, New Delhi,2004
4. Parikh, C.K; Text Book of Medical Jurisprudence, Forensic Medicine & Toxicology, CBS Pub. New Delhi,1999
5. Morrison R.T and Boyd R. N;Organic Chemistry 6th Ed Prentice Hall, 2003
6. Laboratory Procedure Manual : Petroleum Products ,Directorate of Forensic Science, MHA, Govt. of India, 2005
7. Working Procedure Manual on Chemistry ; Directorate of Forensic Science MHA Govt. of India
8. Bureau of Indian Standard Specifications related to Alcohols and Petroleum Products.
9. Welcher F; Standard Methods of Chemical Analysis, 6th Ed.VanNostrand Reinhold, New York, 1969
10. Watson C. A; Official and Standardised Methods of Analysis, Royal Society of Chemistry, UK,1994.
11. Central Excise Act ; Universal Law Publication.
12. Essential Commodity Act, 1955
13. Feigl, F; Spot Test in Inorganic Analysis , Elsevier Publ. New Delhi, 2005.
14. Curry A.S ; Analytical Methods in Human Toxicology : Part II ,CRC Press Ohio, 1986.
15. Curry, A.S : Poison Detection in Human Organs, C Thomas Spring field, CRC Press, Costa Rica, 1976

DSE- WOMEN, VIOLENCE AND CRIMES IN INDIA

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
Women, Violence and Crimesin India	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives:

- Define crimes such as domestic violence, trafficking, and dowry death.
- Analyze case studies and legal interventions.
- Explore psychological and forensic profiling of perpetrators.
- Discuss the role of NGOs and policy reforms.

Learning Outcomes:

- Describe gender-based violence and legal provisions in India.
- Interpret the sociological implications of violence against women.
- Evaluate preventive measures and support systems.

Unit 1 **(10 Hrs)**

Basic concepts of gender, sex, violence against women and intersectionality; historical and contemporary perspective on the status of women in India; socio-cultural context of violence against women in India patriarchy, power imbalances, and gender inequality; Feminist criminology and their relevance to India; Critique of mainstream criminology for its male-centric bias.

Unit 2 **(12Hrs)**

Forms, typology and pattern of Crimes directed against women in India: Institutional and Legal framework for protection and safety of India and their shortcoming: Bhartiya Nyaya Sanhita and Bhartiya Nagarik Suraksha Sanhita, 2023, Chapter 5 Sec 63-92. Special Laws and Acts protection of Women in India; Policing and women, Women in court: Women as offenders in correctional homes: Gender sensitization in criminal Justice system.

Unit 3 **(14 Hrs)**

Forensic Science and Gender; Forensic science in investigation of crime against women: Gender sensitive approach to crime scene management and collection of evidence; different types of evidence including biological, chemical, physical (fingerprint, hair, fiber, footwear impression): digital forensic and investigation of crimes against women Ethnographies of Social and Gender-Based Crimes in India including**,** sexual violence, honour killings and domestic violence, dowry deaths and forensic investigations

Unit 4 (9Hrs)

Forensic Psychology: Role in victim profiling, offender profiling (where relevant and ethically sound), Psychological trauma of victims and victimology in India; Secondary victimization. Professional responsibility and gender sensitization of forensic professionals; Contemporary research in forensic science and crimes against women in India

Practical (30 Hrs)

Forensic case Studies: Students will collect and analyze cases from India involving women as victims or perpetrators, with a strong emphasis on the role of forensic science. This involves reviewing case files (if accessible and anonymized), court judgments, news reports, and forensic expert opinions.

Hands on experience and Module development for interacting with female victims especially related to sexual assault, Role playing and Mock interviews with victims. Demonstrating of Forensic kits.

Keywords: Crime against Women, determinant factors, Women, crime and Society, Forensic Investigation in crimes against women

Essential Readings

Belknap, J. (2020). *The invisible woman: Gender, crime, and justice*. Sage Publications.

DeKeseredy, W. S. (2020). *Woman abuse in rural places*.Routledge.

Edwards, S. S. (2025). *Policing'domestic'violence: Women, the law and the state*. Taylor & Francis.

Amaral, S., Bhalotra, S. R., &Prakash, N. (2021). *Gender, crime and punishment: Evidence from women police stations in India* (No. 14250). IZA Discussion Papers.

Jassal, N. (2020). Gender, law enforcement, and access to justice: Evidence from all-women police stations in India. *American Political Science Review*, *114*(4), 1035-1054.

Suggested Readings

Adler, Freda. (1975). *Sisters in Crime: The Rise of the New Female Criminal*. McGraw-Hill

Ahmad, J., Khan, N., &Mozumdar, A. (2021). Spousal violence against women in India: A social–ecological analysis using data from the National Family Health Survey 2015 to 2016. *Journal of interpersonal violence*, *36*(21-22), 10147-10181.

Daly, Kathleen. (1994). *Gender, Crime, and Punishment*.Yale University Press.

Government of India, Ministry of Law and Justice. *The Protection of Women from Domestic*

Heidensohn, Frances. (1996). *Women and Crime* (2nd ed.). Macmillan *Violence Act, 2005*

Justice Verma Committee Report. 2012-13

The Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013.

The Immoral Traffic (Prevention) Act, 1956.

DSE- FORENSIC PHOTOGRAPHY AND VISUALS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
Forensic Photography and Visuals	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

(Teaching hours required: Theory, 45 hours; Practical, 30 hours)

Course Objectives:

- Explain principles of photography and lighting.
- Apply image processing and enhancement methods.
- Illustrate digital imaging workflows in forensic labs.
- Discuss ethical handling and archiving of visual evidence.

Learning Outcomes

- Describe key principles of forensic photography and its role in crime scene investigation.
- Demonstrate the ability to capture, process, and present photographic evidence.
- Evaluate the admissibility and accuracy of photographic documentation in legal settings.
- Recognize photographic techniques used in forensic documentation.

Unit I: Fundamentals of Forensic Photography (10 Hrs)

History and evolution of forensic photography; Basics of camera operations: ISO, aperture, shutter speed; Types of Camera and lenses, photographic instruments: light sources, optical filters, fundamentals of light and vision, Spectral sensitivity of photographic materials, Camera exposure determination. Basic principles and techniques of Black & White and colour photography, Concepts of coloured photography, Linkage of cameras and film negatives

Unit II: Techniques in Crime Scene Photography (5 Hrs)

Photography of indoor and outdoor crime scenes; Photographing physical evidence: bloodstains, footprints, weapons; Use of scale and reference markers

Unit III: Forensic video examination (14 hrs)

Definition, scope and significance in crime investigation, technical aspects of the video, collection, handling and preservation of video files, video analysis: frame extraction, frame by frame analysis, shot by shot analysis. Video processing and enhancement, Video authentication, Metadata analysis, hash value generation. Biometric Analysis for personal identification, facial biometrics, related case studies

Unit IV: Legal and Ethical Aspects (6 Hrs)

Chain of custody and image authentication; Courtroom presentation and admissibility of photographic evidence; Ethical handling and storage of forensic images; Explain principles of photography and lighting; Apply image processing and enhancement methods; Illustrate digital imaging workflows in forensic labs; Discuss ethical handling and archiving of visual evidence.

Practical (30 Hrs)

- Identification of parts of Camera
- Study the Depth of Field using photography
- Evidences photography
- Crime scene photography-long shot, medium and close ups
- Photomicrography & Macro-photography
- Analysis and enhancement of video/image/CTV Footages
- Detection of tampering in video files.

Essential Readings

1. Hill, T. (2020). CCTV Handbook: Buying, Installing, Configuring, & Troubleshooting: A User’s Guide to CCTV Security. Independently published.
2. Weiss, S. (2021). *Handbook of forensic photography*. CRC Press.
3. Damjanovski, V. (2005). CCTV: Networking and Digital Technology (2nd ed.). ButterworthHeinemann.
4. Kroener, I. (2014). CCTV: A Technology under the Radar? (1st ed.). Routledge.

5. G. (2020, March 18). Types of CCTV Cameras – The Complete Guide. Business Watch. https://www.businesswatchgroup.co.uk/types-of-cctv-cameras-the-complete-guide

Suggested Readings

1. Telyatitskaya, T. (2021). Digital photography of crime scenes in the production in forensic examinations. *Forensic Examinations–Terms and Techniques*.
2. Fatima, F. (2019). Forensic photography: a visual and legal record of crime scene. *International Journal for Electronic Crime Investigation*, *3*(2), 10-10.
3. Dey, A., Rao, P. K., &Rawtani, D. (2023). Forensic Photography. *Modern Forensic Tools and Devices: Trends in Criminal Investigation*, 315-334.
4. Gouse, S., Karnam, S., Girish, H. C., &Murgod, S. (2018). Forensic photography: Prospect through the lens. *Journal of forensic dental sciences*, *10*(1), 2-4.
5. Leone, M. (2021). From fingers to faces: Visual semiotics and digital forensics. *International Journal for the Semiotics of Law-Revue internationale de Sémiotiquejuridique*, *34*(2), 579-599.

DSE- FORENSIC ENTOMOLOGY AND WILDLIFE FORENSICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
FORENSIC ENTOMOLOGY AND WILDLIFE FORENSICS	**4**	**3**	**0**	**1**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Classify entomological stages of decomposition.
- Apply techniques for species identification and age estimation.
- Evaluate evidence from poaching and illegal trade.
- Discuss laws and protocols in wildlife forensics.

Learning Outcomes:

- Identify insect species relevant to death investigations.
- Interpret entomological evidence in postmortem interval estimation.

- Analyze wildlife crime evidence.

Unit I: Introduction to Forensic Entomology (10 Hrs)

Definition, scope, and historical development of forensic entomology; Types of forensic entomology: urban, stored-product, and medico-legal; Role of insects in estimating post-mortem interval (PMI); Insect succession on decomposing remains; Factors affecting insect colonization: temperature, environment, body concealment; Collection, preservation, and documentation of entomological evidence

Unit II: Insect Taxonomy and Analysis Techniques (12 Hrs)

Identification of major insect orders of forensic importance: Diptera, Coleoptera, Hymenoptera; Morphological characteristics of larvae, pupae, and adults; Developmental stages and growth rate calculations; Rearing techniques for laboratory analysis; Molecular methods for species identification (DNA barcoding); Case studies involving forensic entomology in crime scene investigation

Unit III: Introduction to Wildlife Forensics (13 Hrs)

Definition, scope, and significance in biodiversity and conservation; Common wildlife crimes: poaching, illegal trade, trafficking, habitat destruction; Key wildlife species and body parts commonly trafficked in India; Overview of national and international wildlife protection laws: Wildlife (Protection) Act, 1972 (India) CITES (Convention on International Trade in Endangered Species) Role of forensic science in wildlife law enforcement

Unit IV: Techniques and Applications in Wildlife Forensics (10 Hrs)

Identification of species from biological samples: hair, feathers, bones, teeth, skin Morphological and anatomical markers for species determination Genetic analysis: mitochondrial DNA analysis, STR profiling, DNA barcoding Analysis of wildlife products: ivory, bile, meat, leather, traditional medicine Chain of custody and evidence handling in wildlife crimes National and international case studies in wildlife forensics

Keywords: wildlife trafficking, habitat deconstruction, wildlife crime and wildlife protection act, CITES, insect colonization

Tutorials (30 Hrs)

Visit to laboratory, Bio Diversity Park and forests and make a report on the data collected.

Essential Readings

1. Singh, R., Kumawat, R. K., Singh, G., Jangir, S. S., Kushwaha, P., &Rana, M. (2022). Forensic entomology: A novel approach in crime investigation. *GSC Biol Pharm Sci*, *19*(2), 165-174.
2. Gouda, S., Kerry, R. G., Das, A., &Chauhan, N. S. (2020). Wildlife forensics: a boon for species identification and conservation implications. *Forensic Science International*, *317*, 110530.
3. Singh, K., Rajput, N., Singh, K. P., Jadav, K. K., Bhandari, R., & Sharma, J. (2020). Application of forensic entomology in carcass examination of royal Bengal tigers (Pantheratigristigris) in Madhya Pradesh.
4. Bhuyan, P. R., Borah, B. K., Rajkumari, P., Borah, N., Bora, B., &Chaya, S. Forensic entomology: Unraveling the secrets of insect evidence.
5. Puri, A., Mahalakshmi, N., Chauhan, T., Mishra, A., &Bhatnagar, P. (Eds.). (2024). *Fundamentals of Forensic Biology*. Springer Nature Singapore.

Suggested Readings

1. Tomberlin, J. K., & Sanford, M. R. (2011). Forensic entomology and wildlife. *Wildlife forensics: methods and applications*, 81-107.
2. Rolo, E. A., Oliveira, A. R., Dourado, C. G., Farinha, A., Rebelo, M. T., & Dias, D. (2013). Identification of sarcosaprophagousDiptera species through DNA barcoding in wildlife forensics. *Forensic Science International*, *228*(1-3), 160-164.
3. Anderson, G. S. (1999). Wildlife forensic entomology: determining time of death in two illegally killed black bear cubs. *Journal of Forensic Sciences*, *44*(4), 856-859.
4. Anderson, G. S., & Byrd, J. H. (2019). Wildlife forensic entomology. In *Forensic Entomology* (pp. 475-483). CRC Press.
5. Rivers, D. B., &Dahlem, G. A. (2022). *The science of forensic entomology*. John Wiley & Sons.

DSE CBRNE FORENSICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
CBRNE FORENSICS	4	3	1	0	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Describe types and impacts of CBRNE materials.
- Apply decontamination and detection techniques.
- Evaluate forensic protocols in mass disaster scenes.
- Summarize safety and legal issues in CBRNE investigations.

Learning Outcomes:

- Recognize threats from chemical, biological, radiological, nuclear, and explosive agents.
- Demonstrate response and sampling procedures in CBRNE scenarios.
- Analyze evidence from hazardous incidents.

Unit I: Introduction to CBRNE Threats and Forensic Relevance (10 Hrs)

Definitions and classification of CBRNE agents Historical overview and case studies of CBRNE incidents National and international frameworks for CBRNE response Role of forensic science in CBRNE investigationsLegal and ethical considerations in hazardous material forensics First responder protocols and decontamination procedures

Unit II: Chemical and Biological Forensics (13 Hrs)

Types of chemical warfare agents (CWAs) and toxic industrial chemicals (TICs) Detection and analysis techniques for chemical agents (GC-MS, FTIR, Raman) Forensic microbiology: collection and identification of biological agents Biosafety levels and laboratory protocols Toxins and bioterrorism: ricin, anthrax, botulinum Sample preservation and contamination prevention

Unit III: Radiological and Nuclear Forensics (14 Hrs)

Radiological and nuclear materials: types, sources, threats; Detection and measurement of radiation (Geiger-Müller counter, scintillation detectors); Radiological dispersal devices (RDDs) and "dirty bombs"; Radioisotope identification and source attribution; Health risks and protective measures; Chain of custody and evidentiary challenges in radiological incidents

Unit IV: Explosive Forensics and Scene Management (8 Hrs)

Classification of explosives: low vs. high, military, improvised explosive devices (IEDs); Collection and analysis of explosive residues (TLC, HPLC, XRD); Post-blast investigation and crater analysis; Bomb scene management, safety, and evidence recovery; Trace analysis of detonators, wiring, and packaging materials; Role of forensic laboratories in counter-terrorism

Keywords:frameworks for CBRNE, chemical warfare agents, biosafety, bioterrorism, RDDs

Practical (30 Hrs)

Learn various techniques included in CBRNE inForensic laboratory

Essential Readings

1. Suryawanshi, D. M., Surekha, A., Divya, R., Gunasekaran, K., &Malini, I. (2022). Awareness and preparedness of first responders regarding chemical, biological, radiological, nuclear and explosive (CBRNE) disaster management of a tertiary medical institute in South India: A mixed methods study. *Journal of Family Medicine and Primary Care*, *11*(10), 6115-6120.
2. Barry, A., Thomson, S., Dimayuga, I., Chaudhuri, A., & Do, T. (2022). Isotope ratio method: state-of-the-art of forensic applications to CBRNE materials. *Canadian Society of Forensic Science Journal*, *55*(3), 115-141.
3. Guicheteau, J. A., Howle, C. R., & Myers, T. L. (2025). Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XXVI. In *Proc. of SPIE Vol* (Vol. 13478, pp. 1347801-1).
4. Lessig, R., &Prinz, M. (2022). Mass Disaster Victim Identification. *Handbook of Forensic Medicine*, *1*, 291-309.
5. Mishra, S., & Jacob, H. (2020). *Nuclear security Governance in India: institutions, instruments, and culture (2019)* (No. SAND-2020-10916). Sandia National Lab.(SNL-NM), Albuquerque, NM (United States); PanditDeendayal Petroleum Univ., Gujarat (India); Jawaharlal Nehru Univ., New Delhi (India).

Suggested Readings

1. Barry, A., Thomson, S., Dimayuga, I., Chaudhuri, A., & Do, T. (2022). Isotope ratio method: state-of-the-art of forensic applications to CBRNE materials. *Canadian Society of Forensic Science Journal*, *55*(3), 115-141.
2. Ludovici, G. M., Cenciarelli, O., Carestia, M., Malizia, A., Tamburrini, A., Gabbarini, V., ...&Rinaldi, T. (2015). The importance of forensic microbiology in CBRNe investigations. *Technol. Res. Inst. Def*, *8*, 153-161.

3. Regal, G., Murtinger, M., &Schrom-Feiertag, H. (2022, May). Augmented CBRNE responder-directions for future research. In *13th Augmented Human International Conference* (pp. 1-4).
4. Barchett, P. (2023). A Manual for the Recovery of CBRNE (Chemical, Biological, Radiological, Nuclear, and Explosive) Contaminated Human Remains.

DSE FORENSIC BALLISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
FORENSIC PHYSICS AND BALLISTICS	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Describe internal, external, and terminal ballistics.
- Apply methods to examine firearms, bullets, and cartridge cases.
- Analyze shooting reconstruction scenarios.
- Evaluate firearm identification systems.

Learning Outcomes:

- Identify physical principles behind forensic tools and techniques.
- Demonstrate ballistic examination procedures.
- Analyze firearm evidence in forensic casework.

Unit 1 Forensic ballistics (12 Hrs)

History and background of Firearms, their classification and characteristics, rifling – various class characteristics, types and methods to produce rifling. Mechanism of rifling. Projectile velocity determination.Techniques of dismantling/assembling of firearm. Types of ammunitions, classification and constructional features of different types of cartridges, types of primers and priming composition, propellants and their compositions, velocity and pressure characteristics under different conditions, various types of bullets and compositional aspects, latest trends in their manufacturing and design, smooth bore firearm projectile, identification of origin, improvised ammunition and safety. Identification of origin, improvised/ country made/ imitative firearms and their constructional features.

Unit 2 Internal and External Ballistics (10 Hrs)

Definition, ignition of propellants, shape and size of propellants, manner of burning, various factors affecting the internal ballistics, equation of motion of projectile, principal problems of exterior ballistics, vacuum trajectory, effect of air resistance on trajectory, base drag, yaw, shape of projectile and stability, trajectory computation, ballistics coefficient and limiting velocity, Ballistics tables, measurements of trajectory parameters, introduction to automated system of trajectory computation and automated management of ballistics data.

Unit 3Terminal Ballistics (8 Hrs)

Effect of projectile on hitting the target, Tumbling of bullets, effect of instability of bullet, effect of intermediate targets, influence of range, Cavitation, Ricochet and its effects, stopping power, Wound Ballistics; Threshold velocity for penetration of skin/flesh/bones, preparation of gel block, penetration of projectiles in gel block and other targets, nature of wounds and velocities with various types of projectiles, explosive wounds, evaluation of injuries caused due to shot-gun, rifle, handguns and country made firearms, methods of measurements of wound ballistics parameters, post-mortem and anti-mortem firearm injuries.

Unit 4 Examination and identification (15 Hrs)

Firearms, ammunition and their components identification and examination, different types of marks produced during firing process on cartridge, identification of various parts of firearms, techniques for obtaining test material from various types of weapons and their linkage with fired ammunition, class and individual characteristics, GSR analysis: Mechanism of formation of GSR, source and collection, spot test, chemical test, identification of shooter and instrumental methods of GSR Analysis, Management and reconstruction of crime scene; suicide, murder and accidental and self-defence cases.

Practical

- Linkage of suspected bullet and cartridge case with the firearm on the basis of class and individual characteristics.
- Classification and designation of ammunition using physical measurements
- GSR collection and analysis of various components of GSR.
- Estimation of Range.
- Determination of velocity and energy of projectiles.

Keywords:terminal ballistics, GSR, projectile velocity

Essential Readings

1. Mathews, J.H; Firearms Identification, Vol I, II and III, Charles C. Thomas, USA, 1977.
2. Kaur J, Dhall M, Tyagi R, Puri, Kapoor AK, 2024 Handbook of Forensic Ballistics. SSB Publications

3. Hatcher, Jury and Weller; Firearms Investigation, Identification and Evidence, StackpoleBooks, Harrisburg, Pennsylvania,1997.
4. Heard, B.J; Handbook of Firearms and Ballistics, John Wiley, England, 1997.
5. Warlow, T.A.; Firearms, The Law and Forensic Ballistics, Taylor and Francis, London,1996.
6. Schooeble, A.J. and Exline, L.D; Current methods in Forensic Gunshot Residue Analysis, CRC Press, New York, 2000.
7. Wilber; Ballistic Science for the Law Enforcement Officer, Charles C. Thomas, USA, 1977

Suggested Readings

1. Saferstein, R; Forensic Science Handbook. Vol. I,II, (Ed.), Prentice Hall, New Jersey, 1988.
2. Sharma, B.R; Forensic Science in Criminal Investigation and Trials (3rd Ed.), Universal Law Publishing Co., New Delhi, 2001.
3. Sharma, B.R.; Firearms in Criminal Investigation & Trials, 4th Ed, Universal LawPublishing Co Pvt Ltd, New Delhi, 2011.

GE CRIMINOLOGY AND FORENSIC PSYCHOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
CRIMINOLOGY AND FORENSIC PSYCHOLOGY	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Define forensic psychology and its applications.
- Apply psychometric tools and interviews.
- Evaluate case studies using psychological theories.
- Explore rehabilitation and risk assessment models.

Learning Outcomes:

- Describe psychological theories of criminal behavior.
- Interpret offender profiling techniques.
- Analyze criminal motives and behavioral patterns.

Unit I: Foundations of Criminology (12 Hrs)

Definition, scope, and objectives of criminology; Historical development and schools of criminological thought; Classical and positivist theories of crime; Sociological theories: strain theory, differential association, labelling theory; Types of crime: violent, property, white-collar, organized, and cybercrime; Crime statistics and patterns in India

Unit II: Biological and Psychological Theories of Crime (12 Hrs)

Biological predispositions to criminal behavior: genetics, neuroanatomy, hormones; Psychological perspectives: Freud's psychoanalysis, behaviorism, cognitive theories; Mental disorders and their relationship with criminality; Psychopathy and antisocial personality disorder; Developmental and family influences on offending behavior; Case studies and forensic implications

Unit III: Forensic Psychology and Criminal Profiling (12 hrs)

Definition and scope of forensic psychology; Role of forensic psychologists in criminal investigations and courtrooms; Criminal profiling: techniques, typologies, and limitations; Behavioral analysis and modus operandi; Psychological autopsy; Interviewing and interrogation techniques: cognitive interview, Reid technique

Unit IV: Applications and Legal Interface (9 Hrs)

Psychological assessment and testing in forensic settings; Assessment of competency, insanity, and risk of reoffending; Juvenile delinquency: causes, assessment, and interventions; Victimology: psychological impact on victims, victim profiling; Ethical and legal considerations in forensic psychology practice; Role of forensic psychologists in correctional and rehabilitative settings

Practical (30 Hrs)

- To prepare a case study on the case specific to Forensic psychology
- Introduction to different kits used for crime scene investigation.
- Polygraph (Lie-detection), Narco analysis, Brain mapping

Essential Readings

1. Sahni, S. P., &Bhadra, P. (Eds.). (2021). *Criminal psychology and the criminal justice system in India and beyond* (Vol. 328). Springer.
2. Kacker, P., &Pandya, A. (2020). Forensic psychology for prevention of crime and rehabilitation of offenders: public health perspectives. *GAP Indian Journal Of Forensics And Behavioural Sciences*, *1*, 5-7.
3. Tiwari, A., &Kusum, S. (2024). Role of Forensic Criminology in Access to Justice—A Critical Analysis. In *Forensic Justice* (pp. 42-67). Routledge.
4. Tanuj. (2024). The Psychology of Criminal Behavior in India-Sociological and Psychological Perspectives. *Legal Lock J.*, *4*, 226.
5. Sahni, S. P., &Phakey, N. (2021). Criminal psychology: Understanding criminal behaviour. *Criminal Psychology and the Criminal Justice System in India and Beyond*, 21-30.
6. Jamal, F., Walia, M., Sharma, B. K., & Sharma, S. C. (2022). Forensic Psychology: In Pursuit for Better Justice System. *Bulletin of Environment, Pharmacology and Life Sciences*, *5*, 39-42.
7. Sarraf, S. (2021). The Holistic Approach Of Criminology.

Suggested Readings

1. Hollin, C. R. (2019). Forensic (criminological) psychology. In *Companion encyclopedia of psychology* (pp. 1231-1253). Routledge.
2. Gavin, H. (2024). Criminological and forensic psychology.

3. Bartol, C. R., &Bartol, A. M. (Eds.). (2011). Current perspectives in forensic psychology and criminal behavior.
4. Petherick, W., Turvey, B. E., & Ferguson, C. E. (Eds.). (2009). *Forensic criminology*. Academic Press.
5. Gudjonsson, G. H. (2003). Psychology brings justice: The science of forensic psychology. *Criminal Behaviour and Mental Health*, *13*(3), 159-167.

GE- STATISTICS AND ETHICS IN FORENSIC RESEARCH

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
STATISTICS AND ETHICS IN RESEARCH	**4**	**3**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Apply hypothesis testing and regression analysis.
- Classify types of data and variables.
- Discuss research misconduct and ethical frameworks.
- Analyze case examples of ethical dilemmas.

Learning Outcomes:

- Recognize statistical methods in forensic research.
- Interpret data using descriptive and inferential tools.
- Evaluate ethical considerations in scientific investigations.

Unit I: Basics of Statistics and Data Types (7Hrs)

Introduction to statistics: importance in forensic science research; Types of data: qualitative vs. quantitative; discrete vs. continuous; Scales of measurement: nominal, ordinal, interval, ratio; Frequency distribution, tabulation, and graphical representation (bar charts, histograms, pie charts); Measures of central tendency: mean, median, mode; Measures of dispersion: range, variance, standard deviation

Unit II: Inferential Statistics and Hypothesis Testing (12 Hrs)

Sampling techniques and sampling distributions; Normal distribution and standard scores; Formulation of hypotheses (null and alternative); Parametric and non-parametric tests:t-test, chi-square test, ANOVA, Mann–Whitney U test; Correlation and regression: concepts and applications; Introduction to statistical software (e.g., SPSS, R)

Unit III: Scientific Integrity and Research Ethics (14 Hrs)

Principles of research ethics: honesty, objectivity, confidentiality, and accountability; Ethical issues in human and animal research; Informed consent and voluntary participation; Plagiarism, fabrication, falsification, and authorship misconduct; Role of Institutional Ethics Committees and Institutional Review Boards; Publication ethics and guidelines (COPE, ICMJE, UGC regulations)

Unit IV: Ethical Practices in Forensic and Applied Research (12 Hrs)

Ethics in forensic casework and expert testimony; Handling sensitive and personal data; Legal frameworks for research with vulnerable populations; Data sharing, transparency, and reproducibility; Ethical challenges in collaborative, interdisciplinary, or field-based research; Case studies in ethical lapses and lessons learned

Practical (30 Hrs)

Learning of various software for quantitative and qualitative data

Analysis and interpretation of primary data

Essential Readings

1. Balakumar, P., Sellappans, R., Nagarkar, S., Hazra, A., &Jagadeesh, G. (2024). Research Planning, Statistical Analysis, Ethics, and Successful Publishing. *Indian Journal of Pharmaceutical Education and Research*, *58*(4s), s1102-s1107.
2. Kambhampati, S. B., Menon, J., &Maini, L. (2023). Ethics in research and publications. *Indian Journal of Orthopaedics*, *57*(11), 1722-1734.
3. Khan, F., &Mer, A. (2024). The Ethical Considerations of DNA Profiling for Resilience in a Forensic Setting in India: A Comparative Study with International Guidelines. In *The Framework for Resilient Industry: A Holistic Approach for Developing Economies* (pp. 121-134). Emerald Publishing Limited.
4. Bhalshankar, A. D. S. The Ethics of forensic Science in Criminal Trials: Balancing Justice and Privacy. *Worldwide International Inter Disciplinary Research*, 15.

Suggested Readings

1. Wassertheil-Smoller, S., Smoller, J., Wassertheil-Smoller, S., &Smoller, J. (2015). Research Ethics and Statistics. *Biostatistics and Epidemiology: A Primer for Health and Biomedical Professionals*, 217-224.

2. Gelman, A. (2011). Ethics and statistics: Open data and open methods. *Chance*, *24*(4), 51-53.
3. DeMets, D. L. (1999). Statistics and ethics in medical research. *Science and Engineering Ethics*, *5*, 97-117.
4. Bonsu, D. O., Afoakwah, C. B., Abedi, M., Higgins, D., & Austin, J. J. (2022). Ethics reporting in forensic science research publications–A review. *Forensic science international*, *335*, 111290.
5. Bowen, R. T. (2017). *Ethics and the practice of forensic science*. CRC Press.

SKILL BASED PAPER - CHEMICAL EVIDENCE ANALYSIS WITH LABORATORY TRAINING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
CHEMICAL EVIDENCE ANALYSIS	**2**	**1**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Describe sample collection and preparation procedures.
- Apply spectroscopy, chromatography, and microscopy.
- Interpret analytical results and report findings.
- Evaluate limitations of chemical analysis in forensics.

Learning Outcomes:

- Identify chemical residues and trace materials in forensic cases.
- Demonstrate analytical techniques for chemical analysis.
- Analyze chemical evidence to reconstruct crime scenes.

Unit I: Fundamentals of Chemical Evidence and Analysis of Drugs and Toxic Substances

(11 Hrs)

Definition, classification, and forensic significance of chemical evidence, types of chemical evidence, Collection, labeling, preservation, and transportation protocols, Safety measures and handling of hazardous materials, Chain of custody and admissibility in court. Classification of drugs, hallucinogens, Analysis of controlled substances using various techniques, Forensic toxicology: classification of poisons, routes of administration, Extraction techniques: liquid-liquid and solid-phase extraction, Detection of common poisons in biological and non-biological matrices

Unit II: Explosives and Fire Debris Analysis & Trace and Environmental Chemical Evidence (12 Hrs)

Types of explosives, Sampling and preservation of explosive residues, Screening and confirmatory tests, Chemical tests for nitrate, nitrite, chlorate, and perchlorate, Analysis of fire debris: accelerants and their identification, Interpretation and reporting in explosive and arson cases. analysis of paint, glass, soil, and metals, Layer comparison, refractive index, elemental analysis, Forensic analysis of inks, dyes, and pigments, Chemical profiling in environmental forensics, Use of spectroscopy and microscopy in trace evidence analysis, Case studies and challenges in chemical evidence interpretation

Practical (15 Hrs)

- Multicomponent Quantitative estimation of drug by UV-VIS
- Detection of anabolic agents in supplements by GCMS
- Concept & Parts identification of GC, GCMS, HPLC
- Extraction and identification of organochlorine pesticides from biological matrices by TLC and GC-MS
- Extraction of heavy metals by conventional methods and analysis by color tests.

Essential Readings

1. Kumari, A. (2023). Admissibility and Evidentiary Value of Forensic Evidence in India. *Issue 2 Indian JL & Legal Rsch.*, *5*, 1.
2. Gupta, S., & Jain, I. B. (2023). Crime Scene Investigation And Forensic Evidence: Forensic Analysis And Tools. *Journal of Pharmaceutical Negative Results*, *14*(2).
3. AchathuparambilGopalakrishnan, B., & Varghese, G. K. (2025). Chemical Speciation of Particulate Matter as a Tool in Air Pollution Forensics: A Case Study. *Environmental Forensics*, *26*(2), 261-275.
4. Sood, A., &Kashyap, S. (2018). Administration Of Criminal Justice And Role Of Forensics In India: A Study. *International Journal of Innovative Research and Advanced Studies*, *5*(4), 69-73.

Suggested Readings

1. Van Asten, A. (2022). *Chemical analysis for forensic evidence*. Elsevier.
2. Woodman, P. A., Spiranovic, C., Julian, R., Ballantyne, K. N., &Kelty, S. F. (2020). The impact of chemical trace evidence on justice outcomes: Exploring the additive value of forensic science disciplines. *Forensic science international*, *307*, 110121.
3. Rendle, D. F. (2005). Advances in chemistry applied to forensic science. *Chemical Society Reviews*, *34*(12), 1021-1030.
4. Kumar, R., & Sharma, V. (2018). Chemometrics in forensic science. *TrAC Trends in Analytical Chemistry*, *105*, 191-201.
5. Mistek, E., Fikiet, M. A., Khandasammy, S. R., &Lednev, I. K. (2018). Toward Locard's exchange principle: Recent developments in forensic trace evidence analysis. *Analytical chemistry*, *91*(1), 637-654.

SKILL BASED PAPER - PATTERN EVIDENCE ANALYSIS WITH LABORATORY TRAINING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Paper	Total Credit	Lecture	Practical/ Practice	Tutorials	Pre-requisite of the course
PATTERN EVIDENCE ANALYSIS	**2**	**1**	**1**	**0**	Bachelors in Forensic science, Anthropology and allied sciences

Course Objectives:

- Define classification systems for pattern evidence.
- Apply documentation and lifting techniques.
- Analyze patterns for identification and reconstruction.
- Discuss the admissibility of pattern evidence in courts.

Learning Outcomes:

- Recognize types of pattern evidence such as tool marks, shoe prints, and tire impressions.
- Demonstrate comparative analysis methods.
- Evaluate the reliability and significance of pattern evidence.

Unit I: Fundamentals of Pattern Evidence **(5 Hrs)**

Definition, scope, and types of pattern evidence, Class and individual characteristics in pattern comparison, Scientific basis of pattern recognition and its forensic value, Methods of documentation and preservation of pattern evidence, Legal standards for admissibility of pattern evidence in court

Unit II: Fingerprint and Impression Evidence **(7 Hrs)**

Fingerprint types: latent, patent, and plastic, Classification: loops, whorls, arches; ridge characteristics, Techniques for development and lifting of latent fingerprints,Comparison and identification using AFIS (Automated Fingerprint Identification System), Footwear and tire impressions: recovery, casting, and comparison, Examination of tool marks and striation analysis

Unit III: Bloodstain Pattern Analysis (BPA) **(6 Hrs)**

Nature and types of bloodstain patterns: passive, transfer, and projected, Impact angle, directionality, and point of origin determination, Pattern reconstruction techniques in violent crimes, Differentiation between high, medium, and low-velocity impact stains, Documentation of bloodstain patterns: photography, sketches, and mapping, Limitations and interpretation challenges in BPA

Unit IV: Advanced Methods and Case Applications **(5 Hrs)**

Use of digital tools in pattern evidence comparison (e.g., image enhancement software),3D scanning and virtual reconstruction in impression analysis, Pattern evidence in wildlife forensics and environmental crimes, Case studies involving fingerprint, footwear, and bloodstain evidence, Expert testimony and cross-examination of pattern evidence in court, Emerging technologies and research trends in pattern forensics

Keywords: AFIS, BPA, digital tools, bloodstain patterns, impression evidence

Practical **(15 Hrs)**

- Physical, biochemical and spectrophotometric examination of blood stains.
- Gait Pattern Analysis
- Facial Recognition System
- Facial Geometry
- Reconstruction and evaluation of scene of crime
- To develop latent fingerprints with powders, fuming and chemical methods.

Essential Readings

1. Kumari, A. (2023). Admissibility and Evidentiary Value of Forensic Evidence in India. *Issue 2 Indian JL & Legal Rsch.*, *5*, 1.
2. Gupta, S., & Jain, I. B. (2023). Crime Scene Investigation And Forensic Evidence: Forensic Analysis and Tools. *Journal of Pharmaceutical Negative Results*, *14*(2).
3. Banerjee, S. (2023). Forensic Science and Its Applicability in the Indian Criminal Justice System. *Issue 1 Indian JL & Legal Rsch.*, *5*, 1.
4. Mack, S., &Chatterjee, I. (2021). Forensic Evidence Relevance in Police Procedure And Criminal Justice Procedure. *Turkish Online Journal of Qualitative Inquiry*, *12*(10).
5. Teotia, D., &Pokhriyal, S. (2024). Using Forensic Science in the Analysis of Homicidal Crimes. *Issue 3 Int'l JL Mgmt. & Human.*, *7*, 919.

Suggested readings

1. Jayaprakash, P. T. (2013). Practical relevance of pattern uniqueness in forensic science. *Forensic science international*, *231*(1-3), 403-e1.
2. Redmayne, M., Roberts, P., Aitken, C., & Jackson, G. (2011). Forensic science evidence in question. *Criminal Law Review*, *5*, 347-356.
3. Heizmann, M., & Leon, F. P. (2001, February). Model-based analysis of striation patterns in forensic science. In *Enabling Technologies for Law Enforcement and Security* (Vol. 4232, pp. 533-544). SPIE.
4. Findley, K. A. (2020). The absence or misuse of statistics in forensic science as a contributor to wrongful convictions: From pattern matching to medical opinions about child abuse. *Dickinson L. Rev.*, *125*, 615.

Annexure-3

Department of Botany

University of Delhi

POST-GRADUATE CURRICULAR FRAMEWORK IN BOTANY - 2025

(BASED ON NEP 2020)

(Students opting for two-year M.Sc. Botany program will study courses listed in Semesters I & II)

M.Sc. Ist year syllabus (w.e.f. July 2025)

POST-GRADUATE CURRICULAR FRAMEWORK IN BOTANY - 2025

(BASED ON NEP 2020) - COURSEWORK + RESEARCH

M.Sc. Botany Ist Year Syllabus w.e.f. 2025

SEMESTER	DSC (4x3=12 credits) (2 Credits Theory + 2 Credits Practical)	DSE & GE (4x2=8 Credits)* (2 Credits Theory + 2 Credits Practical)	SKILL BASED COURSE/SPECIALISED LABORATORY (2 Credits)	DISSERTATION	TOTAL CREDITS
I	**DSC-1** Biology of Algae and Microbes	**DSE-1** Traditional Knowledge Systems	**SBC-1** Laboratory and Field Experiments in Plant Biology	NIL	22
	DSC-2 Biology of Bryophytes, Pteridophytes and Gymnosperms	**DSE-2** Recombinant DNA Technology			
		DSE-3 Molecular Biology			
	DSC-3 Plant Taxonomy and Evolution	Choose any two **DSE** Or one **DSE** and any one **GE** offered by other Departments			
II	**DSC-4** Developmental Biology of Plants	**DSE-3** Industrial Microbiology	**SBC-2** Analytical Techniques in Plant Biology	NIL	22
	DSC-5 Pathogens and Pests of Crop Plants	**DSE-4** Evolutionary Biology			
	DSC-6 Physiology and Biochemistry	**DSE-5** Basics of Proteomics			
		Choose any two **DSE** Or one **DSE** and any one **GE** offered by other Departments			

* Students can opt for two DSE papers OR one DSE and one GE paper offered by other Departments.

The following GEs will be offered by the Department for students other than M.Sc. Botany:
GE-1 Plants, People and The Planet (To be offered in Semester I)
GE-2 Climate Change and Ecosystem Function (To be offered in Semester II)

Index and syllabus of courses being offered in M.Sc. Botany Semester I & II

Semester I

DISCIPLINE SPECIFIC CORE COURSE-1

Biology of Algae and Microbes

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biology of Algae and Microbes DSC-1	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives:

This course aims to enhance students' understanding of the diversity, ecological significance, and economic importance of algae, bacteria, and viruses. It covers their classification, structural characteristics, life cycles, and growth patterns.

Course Learning Outcomes:

1. The course will increase the understanding of the students about the diversity, classification, structure, and growth of algae and microorganisms.
2. It will also develop theoretical knowledge and technical skills in fundamental of Phycology and microbiology.
3. Students will realize the heterogeneity and polyphyletic nature of the algae as a group. They will also be apprised of their diversity in form, structure and reproduction and the diverse habitats where algae abound.
4. Students will become aware of algae's evolving systematics and become familiar with the characteristics of presently accepted different groups and interrelationships among these groups.
5. Students will realize the vast economic, ecological and biotechnological project and realized potential of this group. They will learn basic knowledge of microbiology. Isolate and culture bacteria from nature, learn important microscopic characteristics, adaptation to hosts, modes of infections, intra-cellular and genetic/genomic features.

<u>Theory: 15 x 2 hrs.= 30 hours</u>

Contents:

Unit I: Algal diversity and Systematics: (10 hours)

Cell structure, thallus organization, reproductive strategies and types of life cycles (Haplontic, diplontic, and haplodiplontic cycles). Diversity of algal groups and their evolutionary relationships: Cyanophyta (Cyanobacteria), Glaucophyta, Rhodophyta (Red Algae), and Viridiplantae (Green Algae and related lineages). Heterokontophyta (Bacillariophyceae - Diatoms, Phaeophyceae - Brown Algae, and other classes). Dinophyta (Dinoflagellates), Cryptophyta, Euglenophyta, Haptophyta, and Chlorarachniophyta. Advances in molecular systematics and phylogenetics of algae.

Unit II: Ecological and economical importance of algae: (6 hours)

Ecological significance: algae as primary producers and CO_2 fixers in global carbon cycles; algal blooms, eutrophication, and their environmental impact. Biotechnological and industrial applications: algae as biofactories: production of bioactive compounds, biofuels, bioplastics, and sustainable resource utilization.

Unit III: Bacteria (10 hours)

Classification of bacteria according to Berger's Manual of Determinative Bacteriology. Ultra structure of bacteria and archaea (cell wall, flagella, fimbriae, pilli, slime layer, S-layers; cell membrane; mesosomes, ribosomes, cytoplasmic inclusion bodies and nucleoid). Bacterial nutrition and growth. Genetic recombination and transformation.

Unit IV: **Viruses (4 hours)**

General properties of viruses; Viral genomes; Plant viruses – replication, transmission and interaction with host plants, Phage biology: features and economic importance; natural mechanisms and transgenic strategies for virus resistance, relevance to Indian agriculture.

<u>Practicals: 15 x 4 hrs.= 60 hours.</u>

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below:

1. To study different types of algae by collecting water samples from different water bodies.
2. To study thallus, cryptostomata and reproductive structure of *Sargassum*.
3. To study thallus, and reproductive structure (carpogonium, conceptacles and cystocarp) of *Gracilaria*.
4. To study morphology of museum specimens.

5. To study the vegetative and reproductive structures using permanent slides: Chlorophycean, Cyanophycean, Xanthophycean, Rhodophycean and Phaeophycean members.
6. To study sterilization, isolation, culturing, and preservation of bacteria.
7. To measure dimension of microbial spores using stage and ocular micrometers.
8. To determine the density of given spore suspension using a haemocytometer.
9. Isolation of microbes producing enzymes of industrial importance.
10. Identification of disease symptoms caused by common plant viruses in field-collected samples.
11. Principles of serology and data analysis for ELISAs to identify plant viruses.

Suggested Readings:

1. Sahoo, D. (2000). *Farming the ocean: seaweeds cultivation and utilization.* 1st edition. Aravali International, New Delhi.
2. Sahoo, D. and Seckbech, J. (Eds) (2015). *The Algae World*, 1st edition. Springer, Dordrecht.
3. Willey, J M., Sandman, K. and Wood, D. (2022). *Prescott's Microbiology*, 12th Edition, McGraw-Hill Education, USA
4. Hull, R. (2013). *Plant Virology*, 5th edition. Academic Press, Elsevier, USA**.**
5. Lee, R.E. (2018). *Phycology*, Fifth Edition. Cambridge University Press, Cambridge.

Additional Readings:

6. Barsanti, L. and Gualtieri, P. (2021). *Algae: Anatomy, Biochemistry, and Biotechnology*, 3rd edition. CRC Press, New York.
7. Graham, L.E., Graham, J.M. and Wilcox, L.W. (2009) *Algae*, 2nd Edition. Benjamin Cummings, California.
8. Maloy, S.R., Cronan, J.E. and Freifelder, D. (1994). *Microbial Genetics*, 2nd edition. Jones & Bartlett Publishers, USA.
9. Pelczar M.J., Chan E.C.S and Krieg N.R. (1997). *Microbiology: An Application Based Approach*, 5th edition. Tata McGraw-Hill, India.
10. Van Den Hoek, C., Mann, D.G. and Jhans, H.M. (1995). *Algae: An Introduction to Phycology*, 1st edition. Cambridge University Press, Cambridge.
11. Whitman, W.B., Goodfellow, M., Kämpfer, P., Busse, H.-J., Trujillo, M.E., Ludwig, W. and Suzuki, K.-i. (eds., 2012). Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 5, parts A and B, Springer-Verlag, New York, NY.

DISCIPLINE SPECIFIC CORE COURSE - 2

Biology of Bryophytes, Pteridophytes and Gymnosperms

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biology of Bryophytes, Pteridophytes and Gymnosperms DSC-2	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives:

The course aims to have understanding of evolutionary diversification of early land plants and morphological and reproductive innovations in land plants, bryophytes, pteridophytes and gymnosperms and to have understanding the process of evolution in a broad sense. To have a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants through study of morphology, anatomy, reproduction and developmental changes in these plants.

Course Learning Outcomes:

The students will be learning about

1. The organ formation occurred in the early land plants that resulted in the diversity of species of “bryophytes”, “pteridophytes” and “gymnosperms”?
2. The strategies for conduction of water and photosynthates?
3. The reproductive strategies and breeding systems in bryophytes, pteridophytes and gymnosperms?
4. The ecological and economic importance of bryophytes, pteridophytes and gymnosperms that help to understand their role in ecosystem functioning.
5. The threats to biodiversity and sensitize towards the Biodiversity Conservation for sustainable development.

Theory: 15 x 2 hrs.= 30 hours

Contents:

Unit I: (8 hours)

Vegetative and Reproductive innovations in land plants; Comparative morphology and developmental anatomy of Anthocerophyta, Marchantiophyta and Bryophyta.; Vegetative and reproductive innovations, Breeding system in bryophytes;

Unit II (5 hours)

Plant substratum relationship, Growth Forms and life strategies, Bryophytes as site indicators; Role of Bryophytes in Ecosystem Dynamics and in global carbon budget, Bryogeography and conservation of bryophytes.

Unit III: (10 hours)

Meristem organization and organ diversity in Pteridophytes, Comparative anatomy of vegetative and reproductive organs of Pteridophytes, Fern Classification, Biogeography, Diversity of Ferns - an ecological perspective, biogeography, Gametophyte ecology, Nutrient ecology.

Unit IV: (7 hours)

Comparative morphology and developmental anatomy of Gymnosperms, Reproductive Biology of Gymnosperms, Evolution of Pollination mechanism in Gymnosperms; Impact of coniferous forest on human life;

Practicals: 15 x 4 hrs.= 60 hours

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below:

1. Comparison of thyroid liverworts simple and complex thalli *Dumortiera*, *Conocephalum, Plagiochasma* through anatomical sections.

2. Comparison of various leafy liverworts to compare the leaf modifications, trigones and oil bodies.

3. Morphology and anatomy of gametophyte of Polytrichaceae member (*Pogonatum* or *Atrichum*) to see the lamellae and special conducting cells and nematodontous peristome.

4. Study of members of pottiaceae (moss) to observe the adaptations, alar cells, papillae, and conducting cells.

5. Study of Pleurocarpous mosses to observe the leaf modification for water retention.

6. Section of rhizome and petiole of commonly available fern species.

7. Section through sorus to study the morphology of sporangia and spores.

8. Salvinia morphology and anatomy of leaf and rhizome.

9. Herbarium specimen of unique fern species to study the soral patterns.

10. Anatomy of stem and leaf of *Agathis robusta*.

11. Anatomy of stem and leaf of *Thuja*.

12. Permanent slides of *Ginkgo biloba*.

Suggested Readings:

1. Schofield, W.B. (1985). Introduction to Bryology. Macmillan. ISBN, 0029496608, 9780029496602.

2. Vanderpoorten, A. and Goffinet, B. (2009). Introduction to bryophytes. Cambridge University Press, Cambridge .. ISBN 978-0-521-70073-3.

3. Goffinet, B. and Shaw, A. J. (Edited) (2008). Bryophyte biology. 2nd ed. – XIV + 565 pp., Cambridge University Press, Cambridge. ISBN 978-0-521-69322-6.

4. Dyer, A.F. (1979). Experimental biology of ferns. Academic Press

5. Ranker, T.A. and Haufler, C.H. (2008). Biology and Evolution of Ferns and Lycophytes. Cambridge University Press, Cambridge

Additional Readings:

6. Mehlereter, K., Walker, L.A. and Sharpe, J.M. (2010). Fern Ecology. Cambridge University Press, Cambridge

7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International P Limited. Publishers, New Delhi.

DISCIPLINE SPECIFIC CORE COURSE-3

Plant Taxonomy and Evolution

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Taxonomy and Evolution DSC-3	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives:

This course aims to introduce the students regarding significance of plant taxonomy in biological sciences and interpret the evolutionary relationships among taxa.

Course Learning Outcomes:

The students will be learning about

1. The importance of plant systematics and how is it useful.
2. The different methods and data of naming plants and how ICN governs it.
3. The patterns of biological variation and what are the underlying processes responsible for these patterns.
4. The evolution and evolutionary history of plants and what are the methods of study.
5. The evidence used to understand evolutionary changes.
6. The inferring phylogenetic trees and process of speciation?

Theory: 15 x 2 hrs.= 30 hours

Contents:

Unit I **(8 hours)**

Plant Systematics: Concepts and components; Plant collection and documentation: Methods of collecting plants, Herbaria and Botanical gardens; Plant Identification: Taxonomic Keys; taxonomic literature; Taxonomic evidences: Structural to molecular; Classification of flowering plants: APG system of classification

Unit II **(4 hours)**

Botanical Nomenclature: Principles of nomenclature; Scientific names; synonyms; ranks; author citations; typification; valid publication; priority of publication; conservation of names; orthography; gender; name changes.

Unit III **(9 hours)**

Introduction to Evolution – Pattern and process component of scientific theories; biological variation and evolutionary changes (evidences for evolution); Darwin and Wallace; Natural Selection; Adaptation; Microevolution and Macroevolution; Evolutionary history.

Unit IV **(9 hours)**

Molecular divergence; Molecular models; Reading trees; Inferring phylogenies; Gene tree; Species tree. Speciation.

Practicals: 15 x 4 hrs.= 60 hours.

List of Practicals: Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below:

1. Study field collection techniques for different plant groups and the ethical considerations in plant collections.
2. Study methods of specimen preservation, mounting, and cataloguing (including a visit to Delhi University Herbarium (DUH)).
3. Learn methods of plant identification (including preparation of taxonomic keys).
4. Examine taxonomic literature to learn the rules of nomenclature as per ICNafp.
5. Morphological analysis of basal angiosperms (examples from ANA grade).
6. Comparison of traditional and current classification systems using Magnoliids as an example.
7. Study selected members of Monocots using morphological and anatomical data.
8. Comparative study of major Eudicot clades and understand their structural adaptations.
9. Understanding the role of integrative taxonomic approach in plant systematics and the significance of molecular phylogeny.
10. Analysis of taxonomic data using various Molecular Phylogenetic software.
11. Reading and interpretation of phylogenetic trees.

Suggested Readings:

1. Angiosperm Phylogeny Group (2016). An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.

2. Pandey, A.K., & Kasana, S. (2021). Plant Systematics (1st ed.). CRC Press.
3. Judd, W.S., Campbell, C.S, Kellogg, E.A., Stevens, P.A. and Donoghue, M.J. (2016). Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
4. Simpson, M.G. (2010). Plant Systematics. Elsevier, Amsterdam.
5. Stuessy, T.F. (2009). Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.

Additional Readings :

1. Futuyma, D. J. (1998). Evolutionary Biology (3rd Edition). Sinauer Associates.
2. Stuessy, T.F., Crawford, D.J., Soltis, D.E. and Soltis, P.S. (2014). Plant Systematics: The origin, interpretation, and ordering, of plant biodiversity. Koeltz Scientific Books, Konigstein, Germany.
3. Crawford, D.J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.

DISCIPLINE SPECIFIC ELECTIVE-1

Traditional knowledge systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Traditional Knowledge Systems DSE-1	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course objectives

This is one of the major courses that is directly linked with human health. Students will gain exposure to knowledge regarding the major medicinal products/formulations being obtained from algae to higher plants. Progress in understanding the synthesis of characteristic medicinal metabolites/molecules produced naturally in plants and their mode of action will open up avenues for better implementation of such compounds for curing diseases. Knowledge of technological advancements for detection of these metabolites will broaden the skill base of students in medicinal botany.

Course outcomes

The students will learn about

1. The relevance of traditional knowledge in the present context, the ethnic groups and tribes of India.
2. The plants used by the indigenous societies for food, medicines plants, intoxicants and beverages, resins and oils.
3. The major natural products of medicinal importance being obtained from different sources.
4. The Intellectual Property Rights and Traditional Knowledge; databases and knowledge resource (Traditional Knowledge Digital Library);
5. The pathways by which medicinal compounds are produced in plants and what is their mode of action to cure diseases.
6. Biochemical and molecular pathways of specific metabolite production in plants (*viz.* antibacterial, antivirals, antimalarial, anticancerous, antidiabetics etc.)
7. The technologies involved in isolation & characterization of plant-based bioactive compounds useful for pharma industries

8. Cultivation practices and product development *In vivo* and *In vitro* strategies. Brief account on elicitation of bioactive compounds, bioreactors.

<u>Theory: 15 x 2 hrs.= 30 hours</u>

Contents:

Unit I: (7 hours)

The relevance of Traditional knowledge and practices with suitable examples; ethnic groups and tribes of India, and their lifestyles; Plants used by the indigenous societies: a) Food plants, b) Medicinal plants, c) intoxicants and beverages, d) Resins and oils and miscellaneous uses. Diversity of natural products used as medicine: Brief account of major sources cum formulations of current medicines from Lichens, Fungi, Algae, Archegoniatae, Higher plants. Significance of the selected plants in ethnobotanical practices (along with their habitat and morphology)

Unit II: (7 hours)

Folk lore, Narcotics, Biostimulants; Nutritional, Medicinal traditional knowledge; Ethnoveterinary knowledge. Sharing of wealth concept with few examples from India, Biopiracy, Intellectual Property Rights and Traditional Knowledge; databases and knowledge resource (Traditional Knowledge Digital Library); Natural pathways of medicinal compounds/molecules synthesis: Biochemical and molecular pathways of specific metabolite production in plants (*viz.* antibacterial, antivirals, antimalarials, anticancerous, antidiabetics etc.)

Unit III: (9 hours)

Ancient Literature and oral traditions; Archaeological finding inferences; Religious and sacred places. Protecting Knowledge; Traditional Herbal Medicine: Indigenous systems of medicine; international plant drugs, their export and import; important controversial medicinal plants and their substitutes; endangered and rare plants of India; role of plant drugs in pharmaceutical industry. protect interests of ethnic groups and benefit sharing, Case studies of traditional medicines leading to development of modern pharmaceutical products (use of *Trichopus zeylanicus* by Kaani tribe and *Artemesia* sp. for malaria cure). Role of traditional healers.

Unit IV: (7 hours)

Cultivation practices and product development: *In vivo* and *In vitro* strategies. Brief account on elicitation of bioactive compounds, bioreactors, extraction methods for plants used as drugs in pharma industries such as antimalarials, antidiabetics; current techniques used for detection and purity of bioactive compounds. Case studies on factors that influence the amount and quality of bioactive compounds during the process of collection and processing of medicinal plants (including packaging, storage). Regulations and biosafety.

Practicals: 15 x 4 hrs.= 60 hours.

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below:

1. Ancient use of algae and thalassotherapy.
2. Traditional uses of mosses, ferns and gymnosperms.
3. Study of plant parts used in aromatherapy.
4. Infusion and decoction method of extraction
5. Maceration based extraction
6. Essential oil hydro distillation, degree of volatility
7. Antimicrobial activity assay
8. Antioxidant activity assay
9. Anti-inflammatory activity assay
10. Cultivation practices of medicinal plants
11. Herbal gardens, germplasm repositories & Medicinal and Aromatic Plant (MAP) institutes
12. Study of ethnobotanicals used in medicine
13. Study of endangered medicinal plants
14. Visit to Ayurvedic pharmacy or MAP processing unit.

Suggested readings

1. Nakar, R.N., Dhaduk, H.L. and Chovatia, V.P. (2016). Medicinal plants- Cultivation and Uses, Daya Publishing House, India

2. Kayser, O. and Quax, W.J. (2007). Medicinal Plant Biotechnology, From Basic Research to Industrial Applications, Vol. I &II. Wiley-VCH, Weinheim

3. Ashhara, A., Crozier, A. and Komamine, A. (2011). Plant Metabolism and Biotechnology. John Wiley and Sons, England (UK).

4. Buchanan, B.B., Gruissem, W. and Jones, R.L (2015). Biochemistry and molecular biology of plants. John Wiley and Sons Ltd., UK.

5. Surajit Pathak, Antara Banerjee (2024) Plant Derived Bioactive Compounds in Human Health and Disease, 1st Ed, CRC Press

DISCIPLINE SPECIFIC ELECTIVE-2

Recombinant DNA Technology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Recombinant DNA Technology DSE- 2	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives:

1) To understand the principles of genetic engineering, its applications. Gain knowledge of DNA modifying enzymes and basic cloning vectors.
2) To gain hands-on expertise in recombinant DNA techniques. Develop practical knowledge of cloning strategies and molecular cloning techniques. Understand methods for gene isolation and library construction.
3) To learn PCR and sequencing methods for molecular biology applications.
4) To evaluate ethical considerations and biosafety regulations in genetic engineering.

Course Learning Outcomes:

This course is designed to provide a comprehensive foundation in the principles and methodologies of recombinant DNA technology. It gives in-depth knowledge of the molecular tools and enzymatic techniques that underpin genetic engineering. Students will gain hands-on training in important procedures including gene isolation, vector design, cloning strategies, PCR and its applications, DNA sequencing methods and library construction techniques for genomic and cDNA libraries. The course encourages students to critically engage with the ethical, regulatory, and biosafety considerations associated with genetic manipulation. The students will understand how recombinant DNA technology is applied in fields such as medicine, agriculture, and biotechnology preparing them for advanced research or careers in the life sciences.

<u>Theory: 15 x 2 hrs.= 30 hours</u>

Contents:

Unit I: Fundamentals of Genetic Engineering and DNA Manipulation (7 hours)

a) Introduction to genetic engineering and its applications
b) DNA modifying enzymes: restriction enzymes, ligases, polymerases

c) Overview of cloning strategies
d) Plasmids, bacteriophages, cosmids, BACs, PACs, YACs

Unit II

Cloning Strategies and Molecular Tools **(8 hours)**

a) Viral vectors for gene expression (Plant viral vectors)
b) Cloning techniques: Restriction enzyme-based cloning, TA cloning, Gateway, Gibson, TEDA, Golden Gate, Topoisomerase-based cloning
c) Construction and screening of genomic and cDNA libraries.
d) Methods for gene isolation: hybridization-based techniques, subtractive cloning, differential screening and differential displays.

Unit III: Amplification and Sequencing Technologies **(7 hours)**

a) PCR: principles and applications
b) Nested PCR, QPCR, TAIL-PCR, Inverse PCR
c) Sanger sequencing and Maxam-Gilbert sequencing
d) Introduction to Next-Generation Sequencing (NGS)

Unit IV: Applications, Ethics, and Regulatory Framework **(8 hours)**

a) Applications of recombinant DNA in medicine, agriculture and industry
b) Gene therapy and transgenic plants
c) Ethical issues and biosafety
d) Regulatory guidelines and public concerns

Practicals: 15 x 4 hrs.= 60 hours.

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below:

Basic Molecular Biology Techniques

a) Isolation of plasmid DNA
b) Gel electrophoresis and DNA quantification.
c) Restriction digestion, elution and ligation of DNA.
d) PCR amplification of a gene, Primer design.

Cloning and Transformation

a) Preparation of competent cells.
b) Transformation and selection of recombinant clones.
c) Screening of transformed colonies (blue-white screening, colony PCR).

Gene SOE-ing (Splicing by Overlap Extension) by PCR

a) Principle and applications.
b) Designing primers for mutagenesis.
c) Performing SOEing-PCR and validation by gel electrophoresis.

RNA Isolation and Quantification

a) Extraction of total RNA from plant tissues.
b) RNA purity analysis using spectrophotometry.
c) Agarose gel electrophoresis for RNA integrity assessment.

Construction of Restriction Maps and Analysis of restriction sites on a given DNA sequence:

a) In silico restriction map construction using bioinformatics tools.
b) Validation of restriction patterns using restriction digestion and gel electrophoresis.

Fragment size prediction and mapping:

a) Digestion of plasmid DNA with single and double restriction enzymes.
b) Determination of fragment sizes by electrophoresis.

Suggested Readings:

1. Brown, T.A. (2016). Gene Cloning and Analysis: An Introduction. Seventh edition. Wiley-Blackwell Publishing, UK.
2. Dale J.W., Schantz M.V. and Plant N. (2011). From Genes to Genomes: Concepts and Applications of DNA Technology. Third edition. John Wiley & Sons, UK.
3. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Fourth edition. ASM Press, USA.
4. Primrose, S.B. and Twyman, R.M. (2006). Principles of Genetic Manipulation and Genomics. Seventh Edition. Blackwell Publishing, UK.
5. Voet, D., Voet, J.G. and Pratt, C.W. (2012). Principles of Biochemistry. Fourth edition. John Wiley & Sons, UK.

Additional Readings:

1. Wilson, K. and Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology, Seventh edition, Cambridge University Press, USA.

DISCIPLINE SPECIFIC ELECTIVE- 3

Molecular Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
MOLECULAR BIOLOGY DSE 3	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives:

The objective of the present course content is to provide foundation and background in concepts and principles of molecular biology, primarily focused on the eukaryotic system. The course content has been designed to emphasize the relationship between genome structure (including nuclear and organellar), and mechanisms of replication, transcription, translation and gene regulation.

Course Learning Outcomes:

The students will be learning:

1. The various components of the eukaryotic nuclear and organellar genome, with special reference to their regulatory role.
2. The commonly used bioinformatics tool and their principles for analysis of genes, genetic elements and genomes.
3. The principle mechanisms of genome replication, maintenance, function and regulation of expression.
4. The relationship between organization of the genome and regulation.
5. The epigenetic modifications can lead to regulation of gene expression.
6. The non-coding RNAs and what are their role/s in gene regulation.

Theory: 15 x 2 hrs.= 30 hours

Contents:

Unit I: Eukaryotic genome structure **(8 hours)**

Nuclear genome: Eukaryotic genome and gene structure: Genomic components: Coding (protein/RNA coding) and non-coding regions; 3-D architecture and chromosomal territories; Gene and promoter structure: Variation in size and distribution of introns and exons, and function; promoter diversity and function; Other Cis-regulatory elements (enhancers, insulators, silencers; UTRs);

Organellar genome: Structure, organization, diversity and evolution; Cross-talk between nuclear and organellar genetic machinery and its implications: Applications of organellar genomics

Computational tools to analyze gene and genome structure.

Unit II: Eukaryotic genome: replication and transcription (8 hours)

Replication initiation; Replicative machinery; DNA polymerases and other components; structural insights; structure-function relationship; fidelity; end-replication problem; organellar replication

Transcriptional processes in nuclear genome: Transcription initiation- role of promoters and enhancers; Transcription factors; mediator complexes; Transcriptional process and control including promoter proximal pause, pause release; Co-transcriptional and Post-transcriptional processes:- Initiation, elongation, termination, polyadenylation, splicing, alternative splicing; Organellar transcription, backsplicing; Transcription termination.

Unit III: Eukaryotic genome: translation (7 hours)

Translation and post-translational modifications in nuclear and organellar genome; RNA surveillance mechanism and pioneering round of translation; Models of translation initiation; Translation (initiation, elongation, termination); Structural insights into translational controls; Alternative reading frames and Peptide diversity; small ORFs (sORFs) and Micropeptides (miRPeps)

Unit IV: Principles of Eukaryotic gene regulation: TGS, PTGS, PTMs: (7 hours)

Basic principles of epigenetics and non-coding RNA; epigenetic modifications-types; Epigenetic control of gene regulation; types and classes on non-coding RNA; non-coding RNAs in gene regulation-types, classes and modes of action; post-translational modifications (PTMs)

Practicals: 15 x 4 hrs.= 60 hours.

Practicals are based on the theoretical content of the syllabus.

1. To study gene structure and detect presence of exons-introns
2. To study replication, transcription and translational control using inhibitors on growth of *Escherichia coli*
3. To study replication, transcription and translational control using inhibitors on growth of *Saccharomyces cerevisiae* (budding yeast)
4. To use computational tools for detection of Open Reading Frames

5. To use computational tools for gene prediction and annotation using BLASTN and BLASTP
6. To use computational tools for prediction of secondary structure of RNA
7. To use computational tools for prediction of secondary structure of Protein
8. To study the application of organellar genome as molecular marker through bar-coding.
9. To study the application of organellar genome as molecular marker through PCR-RFLP
10. To perform functional analysis of eukaryotic promoter using promoter-reporter transcriptional fusions

Suggested Readings:

1. Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff (2022) Molecular Biology of the Cell. WW Norton & Co Publishers.; 1404 pages
2. Gerald Karp, Janet Iwasa, Wallace Marshall (2020) Karp's Cell and Molecular Biology, 9th Edition. John Wiley & Sons, USA. 944 pages
3. Brown, T. A. (2023) Genomes 5; 5th edition. CRC Press, Taylor & Francis Group, USA. 560 pages
4. Buchanan, B.B., Gruissem, W. and Jones, R.L (2015) Biochemistry and molecular biology of plants. 2nd edition; Wiley Publisher; pages: 1280 pages
5. Jonathan Pevsner (2015) Bioinformatics and Functional Genomics, 3rd edition. Wiley-Blackwell Publisher; pages: 1160 pages

Additional Readings:

1. Berk, A., Kaiser, C.A., Lodish, H., Amon, A., Ploegh, H, Bretscher (Author), Monty Krieger, A., Martin, K.C. (Eds). (2016) Molecular Cell Biology. Freeman & Co., USA.

SKILL BASED COURSE / SPECIALISED LABORATORY

SBC-1 Laboratory and Field Experiments in Plant Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Laboratory and Field Experiments in Plant Biology SBC -1	2	0	0	2	Graduate with Botany as one of the subjects	Nil

Course objectives

This course will train the students in various techniques related to plant biology. These techniques will build the foundation of students both for plant-related research activities and applied work.

<u>Practicals 15 x 4hr. = 60 hours</u>

1. Good laboratory practices and research ethics
2. Methods of collecting plant materials and their long-term preservations.
3. Preparation of herbarium specimens.
4. Fixation of plant tissues for microtomy, types of fixatives, tissue embedding media, and sectioning.
5. Vegetation sampling techniques
6. Use of weighing balances, pH meter, media preparation and sterilization, autoclave, filter sterilization.
7. Bacterial culture methods: streaking, plating, replica plating, inoculation in liquid media.
8. Chromosome preparation: mitosis and meiosis.
9. Plant propagation methods nursery methods.
10. Hydroponics system
11. Good agricultural agroecosystem practices.
12. Practices for high value botanicals.
13. Bioentrepreneurship.
14. Cultivation of high value microgreens.

Suggested Readings:

1. Evert, R. F., Eichhorn, S. E., Perry, J.B. (2012). Laboratory Topics in Botany. W.H. Freeman and Company.
2. Mesh, M.S., Kebede-Westhead, E. (2012). Essential Laboratory Skills for Biosciences. John Wiley & Sons, Ltd.
3. Mu, P., Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw-Hill Education.
4. Mann, S. P. (2016). Introductory Statistics, 9th edition. Hoboken, NJ, John Wiley and Sons Inc.
5. Danniel, W.W. (1987). Biostatistics. New York, NY: John Wiley Sons.

Additional Readings:

1. Jones, A.M., Reed, R., Weyers, J. (2016). Practical Skills in Biology, 6th Edition, Pearson
2. Bisen, P.S. (2014). Laboratory Protocols in Applied Life Sciences, 1st edition. CRC Press.
3. Zar, Z. H. (2010). Biostatistical Analysis, 5th edition, Pearson Prentice Hall, New Jersey, USA.

Semester II

DISCIPLINE SPECIFIC CORE COURSE – 4

Developmental Biology of Plants

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
DEVELOPMENTAL BIOLOGY OF PLANTS DSC - 4	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives

Unlike animals, plants are modular and characterized by developmental reiteration of organs in their body plan. In order to understand this complexity, one has to look into the various aspects of growth, development and reproduction. This course aims at making the students acquainted with the fundamentals, and current understanding of the mechanisms associated with specification, development and differentiation of various plant organs.

Course Learning Outcomes

The students will be learning the following main aspects.

1. The aspects of growth in plants different types of networks that regulate growth and development.
2. The main growing regions of the plant and maintenance of their meristematic identity while forming cells that are determined and undergo differentiation.
3. Different organs or tissues with specific structures and functions are formed in the plant body and what are the key mechanisms that regulate their development.
4. Formation of three-dimensional structures in plants and the mechanisms that are responsible for the diversity observed in their architecture.
5. Transformation of shoot apical meristem into an inflorescence and floral meristem, and their development.
6. Establishment of male and female germ lines, and coordination of a variety of tissues coordinate to form gametes.
7. Accomplishment of seed development, and the mechanisms by which rejection reaction occurs during the progamic phase.
8. Necessity of fertilization for a seed to be formed. A cross-talk between fertilized egg and central cells lead to embryo and endosperm formation.

Theory 15 x 2 hrs.= 30 hours

Contents:

Section A

Unit I (7 hours)

Key concepts in growth and development, plant growth vs animal growth, positive and negative regulatory networks; coordination of growth, isotropic and anisotropic growth, polarity, proliferation and termination of growth, growth and development of three-dimensional structures, developmental plasticity; Meristems, different types, RAM, SAM, Cell fate determination, lineage decisions, developmental patterning.

Unit II (8 hours)

Differentiation of cells: stomata, trichomes, tracheary elements etc.; development of organs, key regulatory mechanisms for organ identity, shape and size of specific organs such as leaf, stem, root; plant architecture, growth of main stem and lateral organs, determinate and indeterminate growth, branching pattern and apical dominance, root and shoot architecture, phyllotaxy.

Section B

Unit III (8 hours)

Transition to flowering; Inflorescence and floral meristems; maintenance of inflorescence and floral domains; Floral homeotic mutations in *Arabidopsis*, *Antirrhinum* and *Petunia*; Regulation of anther and ovule development, Microsporogenesis and microgametogenesis, Megasporogenesis and megagametogenesis, Domains of pollen-wall; Pollen embryogenesis, Male sterility.

Unit IV (7 hours)

Pollination; Progamic phase; *In vitro* pollen germination; Pollen tube growth and guidance; Double-fertilization; Self-incompatibility; Polarity during embryogenesis; Maternal to zygotic transition; Embryo pattern mutants, *In vitro* fertilization, endosperm development, Apomixis, Polyembryony, Somatic embryogenesis.

Practicals: 15 x 4 hrs.= 60 hours

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below

Section A

1. Study of surface structures in plants-I Stomata
2. Study of surface structures in plants-II Trichomes
3. Study of planar structures in plants
4. Study of complex tissues xylem and phloem
5. Study of stem development in dicots and monocots
6. Study of root development in dicots and monocots

Section B

1. Assessment of pollen fertility and viability.
2. Comparative assessment of viability, germinability and vigour of pollen.
3. Role of transcriptional and translational inhibitors on pollen germinability and tube growth.
4. Assessment of stigma-receptivity by localising non-specific esterases, phosphatases and peroxidases.
5. Study of megasporogenesis, megagametogenesis and mature female gametophyte with the help of permanent slides and electron micrographs.
6. Study of the stages of pollen and ovule development in the wild and mutant plants using permanent slides, electron micrographs and available phenotypes.
7. Study of types and structures of stigma and style through sections in selected taxa.
8. Study of the embryo, endosperm and haustorium in selected taxa through dissections.

Suggested Readings

1. Beck, C.B. (2010). An Introduction to Plant Structure and Development, II edition
2. Howell, S.H. (1998). Molecular Genetics of Plant Development, Cambridge University Press.
3. Wolpert, L., Jessell, T., Meyerowitz, E., Robertson, E. and Smith, J. (2007). Principles of Development; Oxford, Oxford University Press.
4. Raghavan, V. (1997). Molecular Embryology of Flowering Plants. Cambridge. University Press.
5. Shivanna, K.R. (2003). Pollen Biology and Biotechnology, Science Publishers.
6. Shivanna, K.R. and Rangaswamy, N.S. (1992). Pollen Biology A Laboratory Manual, Springer.

Additional Reading

1. Pua, E-C. and Davey, M.R. (2010). Plant Developmental Biology-Biotechnological perspectives
2. Fosket, D.E. (1994). Plant, Growth and Development A Molecular Approach, Academic Press.
3. Hopkins, W.G. (2006). The Green World Plant Development, Chelsea House Publication
4. Leyser, O. and Day, S. (2003). Mechanism of Plant Development, Blackwell Press, 241p.
5. Raghavan, V. (2000). Developmental Biology of Flowering Plants, Springer, Netherlands
6. Bhojwani, S.S., and Razdan, M.K. (1996). Plant Tissue Culture Theory and Practice, Elsevier
7. Whitelam, G.C. and Halliday, K.J. (2007). Light and plant development; Blackwell Publishing.

DISCIPLINE SPECIFIC CORE COURSE-5

Pathogens and Pests of Crop Plants

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Pathogens and Pests of Crop Plants DSC-5	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives

This course aims to enhance understanding of students in basic concepts of mycology and importance of fungi, as well as develop skills for handling fungi. An introduction to the diversity of pests encountered by crop plants and agricultural produce will be provided. The course deals with basic concepts in plant pathology and interaction of plants with herbivores. Introduction to agricultural pathogens and pests of national importance will be accompanied by basic concepts in integrated disease/pest management, and breeding plants for durable resistance against insect pests and pathogens.

Course Learning Outcomes

The students will

1. Understand basic fungal biology, taxonomy of the fungi and major fungal lineages.
2. Gain skills necessary to isolate and handle fungi from nature, and to discern important microscopic characteristics of fungi.
3. Develop functional knowledge on differentiating disease caused by virus, fungi, and bacteria.
4. Learn about the biology of major, and emerging pathogens and pests of crop plants.
5. Examine advantages and disadvantages of current control practices based on chemical ecology, genetics of plant resistance and breeding including transgenic approaches.
6. Combine theoretical and practical knowledge of plant disease and pest management.

Theory 15 x 2 hrs.= 30 hours

Contents:

Unit I

Overview of Fungi (6 hours)

A higher-level phylogenetic classification of the Fungi.

True fungi: characteristics and important genera of Phyla – Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota, and Basidiomycota. Physiology of fungal growth, reproduction (asexual and sexual), and mating compatibility.

Unit II

Fungus-like organisms (4 hours)

Characteristics and important genera of Phyla - Myxomycota, Acrasiomycota, Plasmodiophoromycota, and Oomycota

Unit III

General concepts of plant pathology and agricultural pests (8 hours)

General characteristics of plant pathogenic organisms and phytophagous pests. Molecular approaches for the investigation of plant diseases and pest outbreaks. Control mechanisms based on chemical treatments, biological control and genetic engineering.

Unit IV

Plant interactions with pathogens and pests (12 hours)

Plant-virus interactions with emphasis on potyviruses and horticultural crops; Plant-bacterial interactions with emphasis on *Erwinia* sp. and potatoes; Plant-fungus interactions with emphasis on *Magnaporthe* sp. and rice; Plant-nematode interactions with emphasis on *Meloidogyne* sp. and tomato; Plant-insect interactions with emphasis on *Pieris* sp. and crucifers.

Practicals 15 x 4 hrs.= 60 hours

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below

1. Isolation and morphological identification of fungi from rotten food sample.
2. Antifungal screening using plant extract.
3. Demonstration of molecular identification of fungi.
4. Histochemical staining of intraradical colonization of arbuscular mycorrhizal fungi (AMF) in plant roots.
5. Estimation of cell wall degrading enzymes in pathogenic fungi.
6. To estimate and compare total phenol content in resistant and susceptible plants against fungal pathogens.

7. To estimate and compare the activity of polyphenol oxidase in resistant and susceptible plants against fungal pathogens.
8. To estimate and compare the activity of phenylalanine ammonia lyase in resistant and susceptible plants against fungal pathogens.
9. Identification of common insect pests and predators in agricultural fields.
10. Estimation of leaf damage caused by an economically important insect pest from crop fields sprayed with Bt biopesticide powder.
11. DAS-ELISA and data analysis for serological identification of economically important plant viruses in field-collected, symptomatic plant samples.

Suggested Readings

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (2007). Introductory Mycology. Fourth Edition Wiley India Pvt. Limited
2. Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge University Press. Cambridge and New York
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi & Their Allies, Second Edition. MacMillan Publishers Pvt. Ltd., Delhi, India
4. Burchett, S. and Burchett, S. (2018). Plant Pathology, Garland Science, US
5. Koul, O., Dhaliwal, G.S. and Cuperus, G.W. (2004). Integrated Pest Management Potential, constraints and challenges, CABI Press, UK.

Additional Readings

1. Dickinson, M. (2003). Molecular Plant Pathology, Bios Scientific Publishers, London.
2. Dhaliwal, G.S. and Arora, R. (1996). Principles of Insect Pest Management, National Agricultural Technological Information Center, Ludhiana, India.
3. Recent and seminal articles from scientific journals.

DISCIPLINE SPECIFIC CORE COURSE-6

Physiology and Biochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Physiology and Biochemistry DSC-6	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives

This course aims to educate student on concepts of proteins, enzymes, basic plant signaling mechanisms, sensory photobiology. The course further deals with physiology of nutrient uptake
mechanism, phytohormones signaling, and basics of flower evocation.

Course Learning Outcomes

1. Students will be learning about proteins, folding into specific structures, post translational modifications and degradation mechanisms. The course will also teach about catalytic mechanism of enzymes, its inhibitors and regulation.
2. The students will be learning about the various signal transduction mechanisms in plants. The concept of second messengers, calcium signaling, kinases/phosphatases in plant signaling would be delineated to enhance their grasping power for understanding of different signaling pathways operative in plants. Two component signaling concepts would be introduced and extended to plant hormone signaling. Quorum sensing and its potential biotechnological applications should be clear to students after these classes.
3. During the course students will gain knowledge about various mechanisms such as channel or transport proteins involved in nutrient uptake in plants. Further the course will deal with various phytohormones and their role in physiology of growth and development.
4. This course will introduce students to physiological advances in sensory photobiology. Students will gain the knowledge on physiology of flowering, molecular basis of light mediation of flowering mechanism.

<u>Theory 15 x 2 hrs.= 30 hours</u>

Contents:

Unit I

Protein structure, Enzymes and Signal Transduction (10 hours)

Hierarchical structure of proteins; folding; ticketing; degradation; molecular motors and pumps. Enzymes and regulation of enzymatic activity. Overview of signal transduction, second messengers, receptors, phospholipid signaling, calcium-calmodulin cascade, specific signaling mechanisms and their regulation, e.g. simple and hybrid type of two-component sensor-regulator system in bacteria and plants, quorum sensing.

Unit II

Nutrient Uptake (6 hours)

Apoplastic and symplastic transport mechanisms, role of aquaporins and transporter proteins, structure-function relationship of inward and outward ion channels, dual action of ATPases/pumps and modulation of their activity.

Unit III

Phytohormones Biosynthesis, Signaling and Stress Responses (6 hours)

Concept of phytohormones as chemical messengers, techniques for detection and quantification of phytohormones, classical approaches and use of mutants in understanding phytohormones actions, phytohormones under biotic and abiotic stresses, synthetic regulatory compounds and their diverse uses.

Unit IV

Physiology of photomorphogenesis and flowering (8 hours)

Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; scotomorphogenesis and photomorphogenesis. Flowering as a multi-organ function, floral induction, evocation and development. Regulation of flowering by light and temperature and role of circadian rhythm.

<u>Practicals 15 x 4 hrs.= 60 hours</u>

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below

1. Comparative assessment of methods for protein quantitation.
2. Study of enzyme kinetics for determination of Km value, nature of inhibition – competitive/non-competitive.
3. Study of enzyme kinetics for effect of time/ enzyme concentration/ pH.
4. Extraction of proteins from root and shoot of Brassica seedlings and comparative quantitative estimation of proteins by Bradford’s method.
5. Qualitative comparison of root and shoot protein profile on SDS PAGE
6. To determine molecular weight of polypeptides from root/ shoot samples from CBB stained SDS PAGE gel

7. To study the lipid peroxidation under salinity stress in Indian mustard leaf samples by estimating the malondialdehyde (MDA) content
8. To study the role of compatible osmolyte for salinity tolerance in Indian mustard by estimating the proline content in leaf samples
9. Analysis of total nitrogen and ammonium contents in leaves using Nessler's and other associated reagents to get an insight of N-metabolism in plants.
10. In vivo assay for nitrate reductase in leaf tissues.
11. Qualitative and quantitative analysis of photosynthetic pigments and anthocyanins by spectrophotometric and chromatographic techniques.

Suggested Readings:

1. Buchanan, B., Gruissem, G. and Jones, R. (2015). Biochemistry and Molecular Biology of Plants. 2nd Edition, American Society of Plant Physiologists, USA.
2. Davies P J. (2010). Plant Hormones Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.
3. Jordan, B.R. (2006). The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB International, U.K.
4. Nelson, D.L., and Cox, M.M. (2021). Lehninger Principles of Biochemistry (8th edition). W.H. Freeman & Co., New York.
5. Taiz, L. and Zeiger, E., Møller, I.M., Murphy, A. (2023) Plant Physiology and Development.. 7th Edition. Sinauer Associates, USA.

Additional Readings:

1. Heldt, H-W. and Piechulla, B. (2024). Plant Biochemistry, 6th Edition. Academic Press, NY.
2. Bhatla, S.C., Lal, M.A. (2024). Plant Physiology, Development and Metabolism. 2nd Edition. Springer Nature, Singapore.

DISCIPLINE SPECIFIC ELECTIVE-4

Industrial Microbiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Industrial Microbiology DSE-4	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives

The course is designed to introduce students to the diversity and industrial relevance of microorganisms, including bacteria, fungi, yeasts, actinomycetes, and microalgae. It aims to develop a comprehensive understanding of fermentation technologies, key process parameters, and downstream processing techniques. The course highlights the application of microorganisms in the production of food, beverages, biofuels, pharmaceuticals, and agriculturally important products. It also familiarizes students with the use of both conventional and genetically engineered microorganisms for the production of enzymes and metabolites. Emphasis is placed on the role of industrial microbiology in promoting sustainable development across the food, pharmaceutical, agricultural, and bioprocessing sectors.

Course Learning Outcomes

Students will be able learn identification and characterization of industrially important microorganisms and explain their maintenance and culture techniques. They will be able to differentiate between submerged and solid-state fermentation processes and evaluate the critical parameters that influence fermentation efficiency. Students will apply their knowledge of microbial processes in the production of fermented foods, dairy products, biofuels, organic acids, and amino acids. They will analyze the role of microorganisms in pharmaceutical manufacturing, including the production of antibiotics, vaccines, enzymes, and hormones. Additionally, students will evaluate the use of microorganisms in agriculture for biocontrol, plant growth promotion, and biofertilization.

Theory 15 x 2 hrs.= 30 hours

Contents:

Unit I

Introduction to industrial microbiology & microorganisms (6 hours)

Introduction to industrial microbiology and its significance. Industrially important microorganisms - Bacteria, filamentous fungi, yeasts, actinomycetes, microalgae. Culture techniques Isolation, identification, and maintenance of industrial microorganisms. Overview of microbial metabolic diversity relevant to industrial processes.

Unit 2

Fermentation technology (8 hours)

Types of fermentation Submerged fermentation, and solid-state fermentation. Key parameters and conditions for optimal fermentation pH, temperature, aeration, agitation, substrate concentration. Fermentation process optimization strategies. Downstream processing Isolation and purification of microbial products enzymes, antibiotics, and metabolites.

Unit 3

Microorganisms in biomanufacturing of foods and industrial products (8 hours)

Role of microorganisms in functional food production, Fermented foods, plant-based food additives, yeast-fermented products, mushroom, and microalgae-based products. Microbial contribution to dairy and dairy-based products. Microbial production of industrial chemicals Ethanol, amino acids, organic acids using conventional and recombinant organisms. Industrially important enzymes applications in food, leather, textile, paper, detergent, and pharmaceutical industries.

Unit 4

Microorganisms in pharmaceuticals and agriculture industries (8 hours)

Role of microbes in pharmaceutical biomanufacturing production of antibiotics, vaccines, hormones, diagnostic proteins, vitamins, steroids, enzymes, and amino acids. Microbial applications in agriculture biofertilizers, biopesticides, biocontrol of pathogens, plant growth promoters, secondary metabolites.

Practicals 15 x 4 hrs.= 60 hours

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below

1. Determination of colony forming units (CFUs) using haemocytometer, dimensions of microbes using ocular- and stage-micrometer.

2. Differential staining of bacteria using Gram-stain; Endospore staining using Malachite Green; Methods for measurement of bacterial growth.

3. Isolation and estimation of bacterial proteins; Study of amylase and protease activity in bacteria.

4. Estimation of phosphate solubilizing capacity of microorganisms; Characterization of Plant Growth Promoting Rhizobacteria – Production of ammonia, IAA, siderophores, HCN, antibiotics, antifungal metabolites.

5. Isolation of *Rhizobium* from root nodules.

6. Isolation, identification and enumeration of AM fungal spores from soil.

7. Isolation of bacterial nucleic acids from soil to study microbial diversity of unculturables.

8. A visit to any educational institute/industry to see different parts of an industrial fermenter and downstream processing techniques.

Suggested Readings

1. Crueger W, Crueger A, Aneja KR (2017). *Biotechnology A Textbook of Industrial Microbiology*, 3rd edition. Medtech Publishers, India.Glazer AN, Nikaido H (2007). *Microbial Biotechnology Fundamentals of Applied Microbiology*, 2nd edition. Cambridge University Press, UK.
2. Okafor N, Okeke BC (2017). *Modern Industrial Microbiology and Biotechnology*, 2nd edition. CRC Press, UK.
3. Willey JM, Sandman K, Wood D (2023). *Prescott's Microbiology*, 12th edition. McGraw-Hill Education.
4. Stanbury PF, Whitaker A, Hall SJ (2016). *Principles of Fermentation Technology*, 3rd edition. Elsevier Science, Netherlands.
5. Subba Rao NS, Dommergues YR (eds.) (2000). *Microbial Interactions in Agriculture and Forestry*, Vol. 2. Science Publishers, Enfield, NH, USA.
6. Waites MJ, Morgan NL, Rockey JS, Higton G (2001). *Industrial Microbiology An Introduction*, 1st edition. Wiley-Blackwell, USA.

DISCIPLINE SPECIFIC ELECTIVE-5

Evolutionary Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Evolutionary Biology DSE-5	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives

The objective of the course is to provide an understanding of the meaning of Dobzhansky's oft-quoted statement, "Nothing in biology makes sense except in the light of evolution".

Course Learning Outcomes

The students will be learning

1. Evolutionary history and methods of study
2. Processes of evolution and patterns of biological variation and underlying processes responsible for these patterns.
3. Population thinking, skills in application

<u>Theory 15 x 2 hrs.= 30 hours</u>

Contents

Unit I (4 hours)

Evolutionary trends, distance based methods, Maximum parsimony, maximum likelihood, Bayesian analysis; origin and evolution of traits across life and green plants; Tree of life.

Unit II (8 hours)

Fossil records; Phylogeny; geological fundamentals; Evolutionary trends; Rates of evolution; Geography of life; Major patterns of distribution. Historical biogeography; phylogeography.

Unit III (10 hours)

The Modern synthesis Population genetics; Forces of evolution Genetic Drift – sampling error; Mutation. Migration/Gene Flow. Adaptation-Fitness, coefficient of selection. One locus model, multi locus models, modes of selection. Non adaptive traits. Molecular evolution. Neutral theory. Molecular clock. Testing for selection. Modes of selection.

Unit IV **(8 hours)**

Species concepts and processes of speciation. Drivers of speciation. Geographic patterns. Reproductive isolation. Evolutionary mechanisms. Post-zygotic and pre zygotic isolation in allopatry and sympatry, reinforcement, character displacement. Hybrid speciation, hybrid zones. Adaptive radiation.

Practicals <u>15 x 4 hrs.= 60 hours</u>

1. Studying variation in plant samples.
2. Reading phylogenetic trees. Distance based methods, MP method to reconstruct trees.
3. Introducing plant projects for poster presentation.
4. Studying evolutionary trends using Mesquite
5. Studying Fossils
6. Studying Biogeography using Cucurbitaceae/other as an example
7. Flow of Alleles in populations (through fish simulation game)
8. Poster presentations
9. Measuring fitness using seed germination as a criteria
10. Simulation of various evolutionary forces using PopGen
11. Molecular evolution and phylogenetic inference (MEGA)

Suggested Readings

1. Futuyma, D. J. (1998). Evolutionary Biology (3rd Edition). Sinauer Associates. Ridley, M. (2003). Evolution (3rd edition), Blackwell.
2. Page, R. D. M. and Holmes E. C. (1998). Molecular Evolution A Phylogenetic Approach, Blackwell. Herron J. C. and Freeman, S. C. (2015). Evolutionary Analysis (5th Edition). Prentice Hall.
3. Hall, B. K. and HallgrÃ-msson, B. (2014). Strickberger’s Evolution (4th Edition). Jones & Bartlett.

DISCIPLINE SPECIFIC ELECTIVE-6

Basics of Proteomics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basics of Proteomics DSE-6	4	2	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives

This course is designed to provide a contextual and inquiry-based learning of modern-day advances in the field of basic proteomics.

Course Learning Outcomes

Students will acquire understanding of

1. Basic principles and modern age applications of proteomics. Understand primary to tertiary protein structure, peptide bonds, folding mechanisms, and the nature of non-covalent interactions.
2. Translational mechanisms in prokaryotes vs. eukaryotes and explain common post-translational modifications.
3. Understand expression systems and optimization strategies for recombinant protein production in different hosts.
4. Develop hands-on knowledge of electrophoresis and chromatographic separation based on protein properties.
5. Learning molecular and technical skills along with applications of the instrumentation.
6. Gain a comprehensive understanding of proteomics techniques, data interpretation, and functional application in biological systems. Application of proteomics knowledge in agriculture, medicine, and environmental biology.
7. Designing/conducting experiments and analyzing experimental data.

.**<u>Theory 15 x 2 hrs.= 30 hours</u>**

Contents:

Unit I

Basics of Proteins structure, synthesis and post-translational modifications (6 hours)

a) Introduction to protein structure, Peptide bonds, non-covalent forces in proteins.
b) Principles of folding; Hydrophilicity, hydrophobicity & amphipathicity in proteins.
c) Comparative account of translation in prokaryotes and eukaryotes.
d) Major Post translational modifications.

Unit II

Protein Expression and Engineering (6 hours)

a) Overview of over-expression of proteins in heterologous systems *E. coli*, yeast, baculovirus and mammals.
b) Over-expression and purification of proteins in *E. coli*-Use of vectors and hosts.

Unit III

Protein Extraction and purification techniques (5 hours)

a) History, principles of protein purification based on the properties of proteins using chromatographic techniques and electrophoresis.
b) Column chromatography, ion exchange and affinity chromatography.

Unit IV

Proteomics in post genomic era (13 hours)

a) Introduction to proteomics, comparative account with genomics and transcriptomics, overview of various techniques available in field and applications.
b) Proteome analysis-two dimensional - separation of total cellular proteins isolation and sequence analysis of individual protein spots by mass spectroscopy.
c) Applications of Proteomics as a tool for plant genetics, breeding and diversity studies.
d) Application of proteomics in drug development, agriculture for production of medically and agronomically useful proteins, application in fundamental biological research and environmental sciences and therapeutic applications.

<u>Practicals 15 x 4 hrs.= 60 hours</u>

Practicals will be based on the theoretical content of the syllabus. A representative list of practicals is provided below

1) Preparation of reagents and buffers for protein extraction, protein extraction from plant and bacterial cells followed by protein estimation using Bradford and UV spectroscopy.
2) Bacterial growth curve.

3) Transformation of pET vector based recombinant clones into *E. coli* overexpression host.
4) Recombinant protein induction using IPTG followed by sample preparation by sonication.
5) Preparation of different buffers and reagents for SDS PAGE. Gel preparation and running *E. coli* protein over- expression samples. Staining and destaining of gels followed by analysis.
6) Preparation of different buffers, reagents followed by Enzyme-Linked Immunosorbent Assay -Dot ELISA.
7) Western blotting.
8) Preparation of different buffers, reagents and nutritional selection media plates for yeast transformation.
9) Yeast competent cell preparation followed by transformation.
10) Yeast two hybrid analysis to identify protein-protein interaction.

Suggested Readings:

1. Voet, D., Voet, J.G. and Pratt, C.W. (2012). Principles of Biochemistry. Fourth edition. John Wiley & Sons, UK.
2. Wilson, K. and Walker, J. (2010). Principles and Techniques of Biochemistry and Molecular Biology, Seventh edition, Cambridge University Press, USA.
3. Daniel, C.L. (2002). Introduction to Proteomics-Tools for New Biology. Humana Press, Totowa, NJ.
4. Twyman, R. (2014). Principles of Proteomics. Second edition. Garland Science, Taylor and Francis group, UK Comai, L., Katz, J. and Mallick, P. (2017) Proteomics-Methods and Protocols, Springer Protocols, Springer New York.

SKILL BASED COURSE/SPECIALISED LABORATORY

SBC-2 Analytical Techniques in Plant Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Analytical Techniques in Plant Biology SBC-2	2	0	0	2	Graduate with Botany as one of the subjects	Nil

Course Objectives

This course will train the students in various techniques related to plant biology. Students will learn foundational experiments including microscopy, molecular biology, bioinformatics and biotechnology.

<u>Practicals 15 x 4 hrs.= 60 hours</u>

1. Databases and online tools
2. Nucleic acid isolation and electrophoresis (DNA and RNA)
3. Protein extraction and electrophoresis
4. Microscopy bright field, fluorescence, confocal, phase contrast, differential interference contrast, scanning and transmission electron microscopy
5. Spectrophotometry
6. Bacterial transformation using different methods
7. Handling model systems in biology
8. Polymerase Chain Reaction
9. Thin layer chromatography for the separation of various metabolites
10. Analysis of nitrogenous compounds from plants.

Suggested Readings:

1. Cooper, G.M., Hausman, R.E. (2009). The Cell: A Molecular Approach, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.
2. Iwasa, J., Marshall, W. (2016). Karps's Cell and Molecular Biology: Concepts and Experiments. New Jersey, U.S.A.: John Wiley & Sons.
3. Hofmann, A., & Clokie, S. (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (8th ed.). Cambridge University Press.
4. Karp, G., Iwasa, J., & Marshall, W. (2019). Karp's Cell and Molecular Biology, 9th Edition: Wiley.
5. O' Brien, T.P. and Cully, M.E. (1981). The Study of Plant Structure. Principles and selected Methods, Termarcarphi Pty. Ltd., Melbourne.

GENERIC ELECTIVE - 1

Plants, People and the Planet

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
PLANTS, PEOPLE AND THE PLANET GE-1	4	3	1	0	Graduate in any discipline	Nil

Course Objectives

To present a dynamic history of plant use by humans and show the impact of plant life on human development.

Course Learning Outcomes

Students will understand historical interactions between plants and humans. Influence of vegetation on the earth's landscape and beginning of agriculture and of human civilization. They wil get the insight on the Plant utilization, dispersal and genetics and influence of plant products on human migrations, colonization. They will learn about the science of crop domestication and improvement and genetically modified organisms and the contentious issues involved with their cultivation and utilization. Students will enhance their ability to deal with present planetary conditions and prepare for future challenges.

Theory 15 x 3 hrs. = 45 hours

Contents

Unit I **(10 hours)**

Plants and earth’s early landscape; origin of plants; plants as geo-engineers of early atmosphere, role of early plants in biogeochemical cycles; evolution of trees; first forests and their role in global climate change; formation of the first grasslands, plants and water bodies.

UNIT II **(15 hours)**

"Taming" of wild plants by man, Beginning of Agriculture- when, where and how; Story of transforming wild plants to modern day crops; Role of plants in human civilizations; Influence of plants on language, religious and cultural practices, folklore, fine arts and *vice-versa*; Plants in trade, and human migrations; plants/plant groups that affected human settlements such as wheat, rice, sugarcane, apple, spices, tea, cotton, potato, narcotic plants, etc.

UNIT III **(10 hours)**

Plants and Politics: specific plants/plant-related issues and politics; Ecological capitalism; Amaranth in indigenous civilizations of Mesoamerica and Spanish invasion- consequences; the 'Columbian exchange'; plant disease epidemics and famines; Indigo revolt and origin of India's non-violent struggle for independence; 'Chipko' movement; Reversing the Anthropocene.

UNIT IV **(10 hours)**

Genetically modified plants: contentious issues, apprehensions and fears - myths or reality, market forces versus scientific logic; 'Plants of the future and the future of plants'; Super-domestication; Novel uses of plants, new crop plants- permaculture, edible weeds; Vertical agriculture; Plants as candidates for colonization of other planets; plants in bioterrorism and biosecurity; Traditional knowledge benefit sharing; Intellectual property rights.

<u>Tutorials 15 x 1 hr. = 15 hours</u>

Group Discussions: Tutorials will provide an opportunity for students to discuss issues raised during the lectures.

Suggested readings

1. Laws, B. (2015). Fifty Plants that Changed the Course of History. Firefly Books Ltd. ISBN 978-1770855885.

2. Fowler, C. and Mooney, P. (1991). The Threatened Gene: Food, Politics, and the Loss of Genetic Diversity. Lutterworth press. ISBN 978-0-7188-2830-1.

3. Ladizinsky, G. (1998). Plant Evolution under Domestication. Kluwer. ISBN 978-0412822100.

4. Zohary, D., Hopf, M. and Weiss, E. (2012). Domestication of Plants in the Old World: The Origin and Spread of Domesticated Plants in Southwest Asia, Europe, and the Mediterranean Basin. Oxford University Press. ISBN 978-0-19-954906-1.

5. Anderson, D., Goudie, A.D. and Parker, A. (2013). Global Environments Through the Quaternary: Exploring Environmental Change. Oxford University Press. p. 283. ISBN 978-0-19-969726-7.

Additional readings

1. Sidney, M. (1986). Sweetness and Power: The place of sugar in modern history, Penguin. ISBN 978-0-14-009233-2.
2. Crosby, A.W. (1972) The Columbian Exchange: Biological and Cultural Consequences of 1492. Greenwood Publishing Co. ISBN 9780-837158211.
3. Pieroni, A. and Vandebroek, A.I. (2007). Traveling cultures and plants: The Ethnobiology and Ethnopharmacy of Human Migrations. Berghahn Books. ISBN 978-1-84545-373-2.
4. Office of International Affairs (1989). Lost Crops of the Incas: Little-Known Plants of the Andes with Promise for Worldwide Cultivation. National Academy Press.. p. 92. ISBN 030904264X.
5. Zabel, P., Bamsey, M., Schubert, D. and Tajmar, M. (2016). Review and analysis of over 40 years of space plant growth systems. Life Sciences in Space Research 10: 1-16.
6. Gaudet, J. (2015). Papyrus: The plant that changed the World from Ancient Egypt to Today's Water Wars. Pegasus. ISBN-13: 978-1605985664.

GENERAL ELECTIVE 2

CLIMATE CHANGE AND ECOSYSTEM FUNCTION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Climate change and ecosystem function GE 2	4	3	1	0	Graduate in any discipline	Nil

Course Objectives

This course aims to introduce the students with the issues related to climate change and how it is affecting the functioning of various ecosystems on which human livelihood is dependent.

Course Learning Outcomes

The students will be learning

1. The meaning of terms weather, climate and how variability in weather is distinctly different from climate change.
2. The role of greenhouse gases in supporting life on earth and how anthropogenic activities changed the balance of these gases over time.
3. The past and present climate scenarios and how this information was derived?
4. What are ecosystem functions and how climate change affects them?
5. Climate change and species migration ecological, reproductive and genetic evidences
6. What are IPCC climate models? How modeling species in the light of climate change and socioeconomic relevance would help species conservation and ecosystem functioning?
7. Climate conventions and India's commitment to fight climate change.
8. Understanding climate change and the clean development mechanism.
9. Climate change mitigation, adaptational mechanisms and climate resilient technologies.
10. What is the role of International policy on climate mitigation?

Theory <u>15 x 3 hrs.= 45 hours</u>

Unit I **(4 hours)**

Definitions of terms – weather, climate and ecosystem functions. Climate change over different time scales (evolutionary and current).

Unit II **(4 hours)**

Drivers of ecosystem function change over temporal scale, abiotic factors and their impact on ecosystem function, anthropogenic disturbances in ecosystem function.

Unit III **(10 hours)**

Climate change and its consequences for – sea level, rainfall pattern, hydrological systems, extreme events, greenhouse gas emissions past, current and future trends, IPCC climate models and future scenarios, Modeling species and ecosystem response, estimating extinction risk from climate change, the Warsaw framework on REDD+, Impact of REDD+ projects on climate mitigation and people's livelihood, Clean development mechanism biological to industrial, International policy and action.

Unit IV **(12 hours)**

Expected impacts of climate change on major ecosystems and their consequences for human livelihood, Climate change and species range shift ecological and genetic evidences, climate change effects on plant reproductive traits, effect of climate change on plant-pathogen interaction, technologies for climate resilient agriculture, impact of climate change on cell signalling pathways, effect of heavy metal pollution on the environment and climate.

Tutorials 15 x 1 hrs.= 15 hours

Group Discussions: Tutorials will provide an opportunity for students to discuss and clear doubts arising during the lectures.

Suggested Readings:

1. Bonan, G. 2015. Ecological Climatology Concepts and Applications. Cambridge University Press. ISBN 9781107339200. 692 pages.
2. Best, R.J., Stone, M.N. & Stachowicz, J.J. 2015. Predicting Consequences of Climate Change for Ecosystem Functioning Variation Across Trophic Levels, Species and Individuals. John Wiley & Sons Limited.
3. Hannah, L. 2022. Climate Change Biology. 3rd Edition, Academic Press, ISBN 9780081029756, https//doi.org/10.1016/B978-0-08-102975-6.18001-X. 508 pages.
4. Post, E. 2013. Ecology of Climate Change The Importance of Biotic Interactions. Princeton University Press. ISBN 978-0-691-14847-2. 376 pages.
5. Smith, T.M., Shugart, H.H. & Woodward, F.I. (Eds.) 1997. Plant Functional Types Their Relevance to Ecosystem Properties and Global Change. Cambridge University Press. ISBN 0 521 56643 6. 371 pages.

Additional Readings:

1. Romm, J. 2018. Climate Change. What Everyone Needs to Know. Second Edition. Oxford University Press. ISBN 978 0190866105. 300 pages.
2. UNFCC United Nations Framework Convention on Climate Change. https//unfccc.int/
3. IPCC Intergovernmental Panel on Climate Change. https//www.ipcc.ch/

Annexure-6

दिल्ली विश्वविद्यालय

UNIVERSITY OF DELHI

Master of Science (M. Sc.) in Chemistry

(Effective from Academic Year 2025-26)

ABOUT THE DEPARTMENT

The Chemistry teaching started in 1922 with three constituent colleges St. Stephens, Hindu and Ramjas. The chemistry teaching was confined to a two year course for B. Sc. Degree department and the teaching up to I.Sc. Level was conducted in the constituent colleges of the University. In October 1933, the University offices and Library shifted to the Viceregal Lodge Estate and the chemistry department made an inconspicuous beginning in the Viceregal kitchen which was used for conducting the lectures and practical classes. In 1942, new Laboratories and lecture rooms were constructed and visionary faculty members were invited by special efforts of illustrious Vice Chancellor, Sir Maurice Gwyer. In June 1949, Professor TR Seshadri took over as head of the department and owing to his untiring effort, the research activities gradually increased, and the department attained formidable reputation in the international scene as one of the finest schools of chemistry. In 1963, the University Grants Commission recognized the department of chemistry as a Centre of Advanced Study for the Chemistry of Natural Products. In 1965, the department of chemistry was recognized as a Centre of Advanced Study in Chemistry. In eighties several faculty members joined the department and the department expanded rapidly in terms of both research and teaching and a large number of small independent groups started flourishing. Various faculty members made significant contributions in computational chemistry, biopolymers, physical chemistry of polymers, organic synthesis, medicinal chemistry, apart from the structure elucidation of natural products, biotransformations, chemical communications, structure investigation of metal complexes, organometallic chemistry and analytical chemistry. After the year 2000 new group of faculty members joined the department with specialization in newer areas that included biomolecular structures, synthesis of nucleosides, medicinal chemistry, electrochemistry and material chemistry. With advent of the new era of materials and nanomaterials other young and energetic faculty members have also joined the department. With this input the department is marching forward in newer areas of research and teaching. The Department of Chemistry is well known for its excellence in teaching and research. The faculty members of the department are engaged in state of the art research as well as guiding the Ph.D., M. Tech. M. Sc. and Post Doctoral Students. The Department has made great strides by revising and updating the M. Sc. syllabus time and again. A thoroughly updated and revised M. Sc. syllabus has been implemented in the year 2009. In the international year of chemistry, the Department started new project work in M. Sc. syllabus where students have exposure of writing the project and also develop communication skills. Advanced level optional courses are also offered at the Ph.D. levels and these courses are taught semester wise. Collaborative research programmes with many research laboratories and research institutes in Delhi and outside India are also operating very successfully with mutual benefit. The Department has distinguished itself as a centre for innovative and pioneering research in a wide range of areas in chemistry and chemistry interfacing with physical and biological sciences. It has attained the status of a DST-FIST Sponsored department by DST in 1982. The department is recognized as one of the best performing chemistry department in the country by DST in the International Year of Chemistry (2011).

1st Year of PG Curricular Structure for 2 Year M. Sc. Under NEP-2020

Semester	**DSC** (2T + 2P)	**DSE** (3T + 1P)	**Skill-based course/workshop/specialised laboratory/hands-on learning** (2 Credits= 1T+1P)	Dissertation/ Academic Project/ Entrepreneurship	Total credits
I	DSC-1 **(CH-DSC-101)** DSC-2 **(CH-DSC-102)** DSC-3 **(CH-DSC-103)** **(3 x 4 credits = 12 credits)**	**DSE-1* and DSE-2*** **(2 x 4 credits = 8 credits)** ***Note:** 1. DSE Course Options for M.Sc. Chemistry Students: Students enrolled in the M.Sc. Chemistry program will have the option to choose two DSE (Discipline Specific Elective) courses from the following combinations: Set-1: CH-DSE-104 and CH-DSE-105 Set-2: CH-DSE-104 and CH-DSE-106 Set-3: CH-DSE-105 and CH-DSE-106 2. Allocation of Sets: Each of the above three sets will be allotted to one-third of the total admitted students in this combination on the basis of Academic merit and Preferences submitted by the students. **Or** **DSE-1*** and **GE-1** (choose only one GE course offered by other Departments) **(2 x 4 credits = 8 credits).** Provision for Opting DSE-1 and GE-1 Combination 1. Students enrolled in the M.Sc. Chemistry programs are required to choose one Discipline Specific Elective (DSE) course from the options CH-DSE-104, or CH-DSE-105, or CH-DSE-106 and each of the above three DSE papers will be allotted to one-third of the total admitted students in this combination based on Academic merit and Preferences submitted by the students. 2. A provision has been made to allow a maximum of 25% of the total allocated students to opt for a combination of: One DSE course (as listed above), and One Generic Elective (GE) course offered by other departments (subject to the terms and conditions of the respective departments). 3. The allotment of the DSE-GE combination will on the basis of Academic merit, and Preferences submitted by the students.	**SEC-1#** **2 Credits** **Note:** 1. SEC Course Options for M.Sc. Chemistry Students: Students pursuing the M.Sc. program in the Chemistry Department will be required to choose one Skill Enhancement Course (SEC) from the following options: CH-SEC-107, CH-SEC-108, CH-SEC-109* and CH-SEC-110* *Only one course will be offered from among CH-SEC-109 and CH-SEC-110, depending on availability and departmental decision. 2. Each SEC paper will be allotted to one-third of the total number of allocated seats to the department on the basis of Academic merit and Preferences submitted by the students.	Nil	22

II	DSC-4 **(CH-DSC-201)** DSC-5 **(CH-DSC-202)** DSC-6 **(CH-DSC-203)** (3 x 4 credits = 12 credits)	**DSE-3* and DSE-4* (2 x 4 credits = 8 credits)** **Note:** 1. DSE Course Options for M.Sc. Chemistry Students: Students enrolled in the M.Sc. Chemistry program will have the option to choose two DSE (Discipline Specific Elective) courses from the following combinations: Set-1: (CH-DSE-204 and CH-DSE-205) Set-2: (CH-DSE-204 and CH-DSE-206) Set-3: (CH-DSE-205 and CH-DSE-206) 2. Allocation of Sets: Each of the above three sets will be allotted to one-third of the total admitted students in this combination on the basis of Academic merit and Preferences submitted by the students **Or** **DSE-2*** and **GE-2** (choose only one GE course offered by other Departments) **(2 x 4 credits = 8 credits).** Provision for Opting DSE-2 and GE-2 Combination 1. Students enrolled in the M.Sc. Chemistry program are required to choose one Discipline Specific Elective (DSE) course from the options CH-DSE-204, or CH-DSE-205, or CH-DSE-206 each of the above three DSE papers will be allotted to one-third of the total admitted students in this combination based on Academic merit and Preferences submitted by the students. 2. A provision has been made to allow a maximum of 25% of the total allocated students to opt for a combination of: One DSE course (as listed above), and One Generic Elective (GE) course offered by other departments (subject to the terms and conditions of the respective departments). 3. The allotment of the DSE-GE combination will on the basis of Academic merit, and Preferences submitted by the students.	**SEC-2# 2 Credits** **Note**: SEC Course Options for M.Sc. Chemistry Students: 1. Students pursuing the M.Sc. program in the Chemistry Department will be required to choose one Skill Enhancement Course (SEC) from the following options: CH-SEC-207, CH-SEC-208, CH-SEC-209*, CH-SEC-210* *Only one course will be offered from among CH-SEC-209 and CH-SEC-210, depending on availability and departmental decision. 2. Each SEC paper will be allotted to one-third of the total number of allocated seats to the department on the basis of Academic merit and Preferences submitted by the students.	Nil	22

General Elective Table*

	Pool of GE offered (3T + 1P)*		
Ist Semester (GE-I)	**CH-GE-111**	**CH-GE-112**	**CH-GE-113**
IInd Semester (GE-II)	**CH-GE-211**	**CH-GE-212**	**CH-GE-213**

*Provision for Admitting Students from Other Departments to GE Courses Offered by the Department of Chemistry

1. Admission Provision: A provision has been made to admit up to 25% of the total seats allocated to the Department of Chemistry for Generic Elective (GE) courses to students from other departments of the university. Admission will be on the basis of Academic merit, and Preferences submitted by the students.

2. Allocation of Seats to GE Courses: The three GE courses offered by the Department of Chemistry in each semester will be allotted to one-third of the total admitted students.

Distribution of Courses and credits for M. Sc. Chemistry Semester I & II under NEP-2020

DISCIPLINE SPECIFIC CORE COURSES (DSC) FOR SEMESTERS- I & II			
Semester	**Name of the Course**	**Course Code**	**Credits**
I	Stability constants of metal complexes and their applications	**CH-DSC-101**	**T=2** **P=2**
	Reactive Intermediates in Organic Chemistry	**CH-DSC-102**	**T=2** **P=2**
	Principles of quantum chemistry and approximate methods.	**CH-DSC-103**	**T=2** **P=2**
II	Chemistry of *d*- and *f*- block elements	**CH-DSC-201**	**T=2** **P=2**
	Advanced Organic Spectroscopy	**CH-DSC-202**	**T=2** **P=2**
	Statistical Mechanics and Thermodynamics	**CH-DSC-203**	**T=2** **P=2**

POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSE) FOR SEMESTERS- I & II			
Semester	**Name of the Course**	**Type of Courses**	**Credits**
I	Supramolecular chemistry and Photoinorganic Chemistry	**CH-DSE-104**	**T=3** **P=1**
	Advanced Stereochemistry of Organic Compounds	**CH-DSE-105**	**T=3** **P=1**
	Mathematical methods in Chemistry	**CH-DSE-106**	**T=3** **P=1**
II	Group Theory and its Applications in Chemistry	**CH-DSE-204**	**T=3** **P=1**

	Methods in Organic Synthesis	**CH-DSE-205**	**T=3** **P=1**
	Electrochemistry, Macromolecules and Chemical Kinetics by Statistical Thermodynamics	**CH-DSE-206**	**T=3** **P=1**
POOL OF SKILL ENHANCEMENT COURSES (SEC) **FOR SEMESTERS- I & II**			
Semester	**Name of the Course**	**Type of Courses**	**Credits**
I	Introduction to Basic Lab Safety and Softwares for Research work	**CH-SEC-107**	**T=1** **P=1**
	Best Practices in Chemical Laboratory Safety	**CH-SEC-108**	**T=1** **P=1**
	Introduction to Computer Programming and Numerical Methods	**CH-SEC-109**	**T=1** **P=1**
	Electrochemical Energy Devices and Technologies	**CH-SEC-110**	**T=0** **P=2**
II	Hands-on Training of Analytical Instruments	**CH-SEC-207**	**T=1** **P=1**
	Hands-on Training of Separation Techniques	**CH-SEC-208**	**T=1** **P=1**
	Recent Trends in Advanced Molecules and Materials	**CH-SEC-209**	**T=1** **P=1**
	Concepts and Applications of Artificial Intelligence and Machine Learning in Chemistry	**CH-SEC-210**	**T=1** **P=1**
POOL OF GENERIC ELECTIVE COURSES (GE) **FOR SEMESTERS- I & II**			
Semester	**Name of the Course**	**Type of Courses**	**Credits**
I	Basics of Mineral Chemistry	**CH-GE-111**	**T=3** **P=1**

	Introduction to Drug Discovery and Development	**CH-GE-112**	**T=3** **P=1**
	Biophysical and Nanomedicinal Chemistry	**CH-GE-113**	**T=3** **P=1**
II	Introductory Chemistry of The Earth's Atmosphere	**CH-GE-211**	**T=3** **P=1**
	Medicines and Therapeutics in Daily Life	**CH-GE-212**	**T=3** **P=1**
	Modern Materials of Chemistry and Physics	**CH-GE-213**	**T=3** **P=1**

NOTE: GE courses will be offered to students of other Departments only up to 25 % of the total allocated seats of the Chemistry Department based on the merit and preferences given by the students.

Assessment Method:

The assessment of all courses will follow the guidelines prescribed by the University.

For Practical Chemistry papers, the assessment will be carried out as follows:

50% of the total marks will be based on Continuous Evaluation (including regular performance, records, viva, etc.).

50% of the total marks will be based on the End Semester Examination.

SEMESTER-I

DISCIPLINE SPECIFIC CORE COURSE (DSC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical		
Stability constants of metal complexes and their applications **CH-DSC-101**	**04**	**02**	—	**02**	U.G. Chemistry	--

Course objectives

The objectives of this course are as follows:

- To impart advanced knowledge on the analytical chemistry aspects of complexometric titrations.
- To comprehend the stability, reactions of supra molecular complexes of alkali metal and other univalent ions.

Learning outcomes

After completing the course, the students will be able to:

- Define stability constant, differentiate between overall and stepwise stability constants and identify factors influencing the stability of metal complexes.
- Students will learn how the nature of the metal ion, the ligand, and the chelate effect impact stability.
- Students will understand various techniques used to measure stability constants, including potentiometry (pH measurement), spectrophotometry, and other analytical methods and hence, will be able to calculate the concentrations of metal ions, ligands, and complexes, using the stability constants.

- Students will learn how knowing the stability constants of metal complexes can be useful for applications, in the fields of Analytical Chemistry, Biochemistry, Environmental Science, Medicinal Chemistry, and so on.

THEORY COMPONENT (2 Credit: 30 Hours)

UNIT 1: (15 Hours)

INTRODUCTION TO METAL COMPLEX FORMATION, COMPLEX FORMATION FUNCTIONS AND THEIR DETERMINATION BY VARIOUS METHODS

Stoichiometric and thermodynamic equilibrium constants, Stepwise and overall formation constants, trends in stepwise formation constants, conditional equilibrium constants; factors affecting stability of metal complexes with reference to nature of metal ion, ligand, chelate effect and thermodynamic origin (statistical and non-statistical factors influencing stability of complexes in solution); role of the hydrogen ion concentration in complex formation.

Formation functions, φ, n and αC and relationship between different functions. Calculation of protonation and stability constants. Determination of formation constant by: Graphical Methods: using sets of data {φ, [A]}; {αC, [A]} and {n, [A]}. Curve fitting method, Elimination method, Numerical method.

UNIT 2: (15 Hours)

DETERMINATION OF STABILITY CONSTANTS AND APPLICATIONS OF COMPLEX FORMATION WITH EXAMPLES

Potentiometric method, Method of corresponding solutions, Ion exchange method-cation and anion exchange, Solvent extraction, Polarographic method and Spectrophotometric methods, which include Job's method of continuous variation, Logarithmic method, Bent and French mole ratio method. Turner and Anderson methods and Yatsimirskii's method.

Analytical applications of complex formation; gravimetric analysis, complexometric titrations (Conditional constants, titration curves, titration error, detection of end point using metal indicators and instrumental methods. Indicator errors, Indicator correction, etc. Simultaneous titrations, stepwise titrations, replacement titrations, back titrations); analysis of mixtures of metals. Use of masking and demasking agents in complexometric titrations.

PRACTICAL COMPONENT (2 Credits: 60 Hours)

EXPERIMENTS:

1. Quantitative analysis of mixtures of metal ions by complexometric titrations (mixture of two metals) with the use of masking and de-masking agents.

2. Any other relevant experiment from time to time during the semester.

ESSENTIAL/RECOMMENDED READINGS (Theory)

1. Christian, G. D., Analytical Chemistry, 6th Ed., John Wiley & Sons, Inc. (2004).

2. Khopkar, S.M., Basic Concepts of Analytical Chemistry 3rd Edition, Publisher: New Age International Publishers (2008), ISBN: 9788122420920, 8122420923.

3. Hartley, F. R., Burgess, C. & Alcock, R. M. Solution Equilibria. Prentice-Hall: Europe (1980).

4. Srivastava and Mishra, Fundamental of Analytical Chemistry (First Edition, 2016)

5. Robinson, J.W, Undergraduate Instrumental Analysis, CRC Press (2014).

6. Inczedy, J. Analytical applications of complex equilibria Halsted Press: New York, NY (1976).

7. Vogel, A. I. Vogel's Qualitative Inorganic Analysis - 7th ed. (revised by G. Svehla) Longmans (1996) ISBN 058-221866-7.

SUGGESTED READINGS (Practical)

1. Vogel, A. I. Vogel's Qualitative Inorganic Analysis - 7th ed. (revised by G. Svehla) Longmans (1996) ISBN 058-221866-7.

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC CORE COURSE (CH-DSC-102)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reactive Intermediates in Organic Chemistry **CH-DSC-102**	**4**	**2**	**0**	**2**	U.G. Chemistry	NIL

Course Objectives:
1) To learn and understand the involvement of intermediates, their role in reaction mechanisms, predict their behaviour, and apply this knowledge to organic synthesis.
2) To develop experimental skills of various separation and purification techniques and preparative TLCs and study of reactions involving different reactive intermediates.

Learning Outcomes: At the completion of this course, the students should be able to:
1) Understand the structure-reactivity pattern of reactive intermediates involved in organic reactions.

2) Write the mechanism of organic reactions involving reactive intermediates and apply these reactions in organic synthesis.
3) The students will acquire knowledge of:
i) Chromatographic separation and identification of organic compounds.
ii) Purification, Crystallization, and different Distillation processes.
iii) Synthesis using substitution and condensation reactions

SYLLABUS OF CH-DSC-102
THEORY COMPONENT **(2 Credit: 30 Hours)**

UNIT 1: **(15 Hours)**
INTRODUCTION
A review of reaction mechanisms, including methods of determination.
Linear free energy relationships and their applications (Hammett equation and modifications).

CARBOCATIONS
Non-classical carbocations, stability and reactivity of bridgehead carbocations, neighbouring group participation, ion-pairs, molecular rearrangements in acyclic, monocyclic and bicyclic systems, C-C bond formation involving carbocations. Generation and application of Contemporary Carbocations: (i) Electrochemically generated carbocations (ii) Allenyl and propargylic Cations (iii) Superelectrophilic Carbocations: Charge Migration and Remote Functionalization (iv) Boronic Acids (a Lewis Acid) generated carbocations.

CARBANIONS
Generation, structure, stability, and reactivity including molecular rearrangements. Ambident ions, and their general reactions; HSAB principle and its applications.

UNIT 2: **(15 Hours)**
FREE RADICALS
Generation, structure, stability and reactions, cage effects; radical-cations including Hofmann–Löffler–Freytag & radical anions, Bergmann cyclization, allenyl radicals and their application in organic synthesis, other radical cyclization reactions.

CARBENES
Formation and structure, reactions involving carbenes, N-heterocyclic carbenes (NHC), and carbenoids.

NITRENES
Generation, structure, and reactions of nitrenes and nitrenoids.

ARYNES
Generation and reactivity of arynes and nucleophilic aromatic substitution reactions.

PRACTICAL COMPONENT **(2 Credits: 60 Hours)**

EXPERIMENTS

i) Analytical and preparative TLCs (mixtures containing three or more compounds, natural extracts and use of different developing agents)

ii) Preparations involving stereochemical aspects (geometrical isomers and stereoisomers) and different reactive intermediates:

(a) Condensation reaction,
(b) Bromine addition,
(c) Carbene addition,
(d) Nucleophilic and Electrophilic substitution reaction,
(e) Rearrangement reactions involving carbocations and carbanions

iii) Identification of organic compounds using UV and IR

ESSENTIAL/RECOMMENDED READINGS

Theory

1. A. Carey and R. A. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th edition, Springer, New York, 2007.
2. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, First South Asian Edition 2005, Cambridge University Press.
3. J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edition, Wiley, 2007.
4. Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd edition
5. Peter Sykes, A guidebook to mechanisms in organic chemistry

Practical

1. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
3. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5. Pasricha, S., Chaudhary, A. (2021), Practical Organic Chemistry: Volume–I, I K International Publishing House Pvt. Ltd, New Delhi

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC CORE COURSE (DSC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Principles of Quantum Chemistry and Approximate Methods **CH-DSC-103**	**04**	**02**	**-**	**02**	U.G. Chemistry	10+2 in Science with Mathematics

Course Objectives:

- To provide a foundation in the fundamental quantum mechanical principles and associated mathematical framework.
- To explore and solve exactly solvable quantum systems, including particle models, harmonic oscillators, etc.
- To understand angular momentum and its applications to atomic and molecular systems.
- To learn and apply approximate methods such as variational techniques and perturbation theory to complex quantum problems.
- To study quantum mechanical approaches to chemical bonding and molecular orbital theory, including applications to conjugated and polyatomic systems.

Learning Outcomes: By the end of the course, students will be able to:

- Acquire a foundational understanding of key quantum chemistry concepts and the mathematical tools necessary to describe chemical phenomena.
- Apply mathematical techniques to solve problems in quantum chemistry.
- Understand and utilize quantum mechanical principles to evaluate the properties of atomic and molecular systems.
- Interpret and predict the chemical properties and behavior of atomic and molecular systems based on quantum theory.
- Connect theoretical quantum concepts with real-world chemical applications.

Theory Course Contents: **Credit 2 (30 hours)**

Unit I: **15 hours**

A. Postulates of Quantum mechanics, Linear and Hermitian operators, Turn-over rule, Commutation of operators and Heisenberg's Uncertainty principle (qualitative discussion). *Some exactly soluble problems*: Particle in a Ring, 2D and 3D box. Degeneracy, Jahn-Teller distortion, and accidental degeneracy. Simple harmonic oscillator problem by factorization method (step-up, step-down Ladder operators), Calculation of various average values utilizing step-up and step-down operators or recursion relations.

B. Angular momentum operators and their commutation relations, utilization of raising and lowering operators for eigenvalues and eigen-functions of rigid rotator; H-atom (qualitative discussion), Radial distributions, Radial density, and nodes.

Unit II: **15 hours**

A. *Approximate methods:* First order time-independent perturbation theory for non-degenerate states. Variation theorem and variational methods. Use of these methods illustrated with some examples (particle in a box with a finite barrier, anharmonic oscillator, approximate functions for particle in a box and hydrogen atom), Ground and excited state of helium atom. Pauli's Exclusion principle.

B. *Chemical bonding:* Born-Oppenheimer approximation. Variational treatment of hydrogen molecule ion. Valence bond and MO (LCAO) treatment of hydrogen molecule. Comparison of the MO and VB treatments and their equivalence limit. Configuration Interaction. Extension of MO theory to other systems- Homonuclear and heteronuclear diatomic, polyatomic.

C. *HMO method and its applications:* π-Electron approximation, Huckel Molecular Orbital Theory of conjugated systems, Calculation of properties- Delocalization energy, electron density, bond order, non-alternant hydrocarbons, cyclic molecules.

Recommended Texts:

1. Lowe, J. P. & Peterson, K. Quantum Chemistry Academic Press (2005).
2. McQuarrie, D. A. Quantum Chemistry Viva Books Pvt Ltd.: New Delhi (2003).
3. Pilar F. L. Elementary Quantum Chemistry 2nd Ed., Dover Publication Inc.: N.Y. (2001).
4. Cohen-Tannoudji, Claude, Bernard Diu, and Franck Laloë F., Quantum Mechanics (Translated by G. G. Levine and D. S. Constable), vols-I&II, Wiley-Interscience, New York (1977).
5. Levine, I. L. Quantum Chemistry 5th Ed., Prentice-Hall Inc.: New Jersey (2000).
6. Atkins, Peter, and Ronald Friedman. Molecular Quantum Mechanics, Oxford University Press, 5th ed. (2011).
7. Sakurai, J. J. and Napolitano, J. Modern Quantum Mechanics, 2nd Ed., Addison-Wesley, (2011).
8. Merzbacher, E. Quantum Mechanics, John Wiley & Sons, 3rd Edition, (1998).
9. Landau, L. D. and Lifshitz, E. M. Quantum Mechanics: Non-Relativistic Theory, Vol. 3, Pergamon Press, 3rd Edition (English), (1977).
10. Messiah, A. Quantum Mechanics, North-Holland Publishing Company, 1961, Reprinted by Dover Publications (2014).

<u>Practical Components</u>: **Credit 2**

Chemical Kinetics

1. Determine the specific rate constant for the acid catalysed hydrolysis of methyl acetate by the *Initial Rate Method*. Study the reaction at two different temperatures and calculate the thermodynamic parameters.
2. Compare the strengths of hydrochloric acid and sulphuric acid by studying the rate of hydrolysis of methyl acetate.
3. Study the saponification of ethyl acetate with sodium hydroxide volumetrically.

Conductometry

1. Determine the Cell Constant of the given conductivity cell at room temperature and study the equivalent conductance versus square root of concentration relationship of a strong electrolyte (KCl or NaCl) and weak electrolyte (acetic acid).
2. Determine the equivalent conductance at infinite dilution for acetic acid by applying Kohlrausch's law of independent migration of ions.
3. Determine the equivalent conductance, degree of dissociation and dissociation constant (K_a) of acetic acid.
4. Study the conductometric titration of hydrochloric acid with sodium carbonate and determine the concentration of sodium carbonate in a commercial sample of soda ash.
5. Study the conductometric titration of potassium sulphate solution vs. barium chloride solution
6. Study the conductometric titration of (a) Acetic acid vs. sodium hydroxide, (b) Acetic acid vs. ammonium hydroxide, (c) HCl vs. NaOH. Comment on the nature of the graphs.
7. Study the stepwise neutralization of a polybasic acid e.g. oxalic acid, citric acid, succinic acid by conductometric titration and explain the variation in the plots.

Potentiometry

1. Titrate hydrochloric acid and sodium hydroxide potentiometrically.
2. Determine the dissociation constant of acetic acid potentiometrically.
3. Titrate oxalic acid and sodium hydroxide potentiometrically.
4. Titrate a mixture of (a) Strong and weak acids (Hydrochloric and acetic acids); (b) Weak acid (acetic acid) and dibasic acid (oxalic acid) (c) Strong acid (hydrochloric acid) and dibasic acid (oxalic acid) versus sodium hydroxide.
5. Titrate a solution of Mohr's salt against potassium permanganate potentiometrically. (ii). Titrate a solution of Mohr's Salt and potassium dichromate potentiometrically.

<u>Recommended Texts/References:</u>

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis, Brooks/Cole Pub Co; 7th edition (1 January 2017).
3. Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. Fundamentals of Analytical Chemistry, Publisher: Holt, Rinehart & Winston of Canada Ltd; International 2 Revised ed edition (1 February 1988).

DISCIPLINE SPECIFIC ELECTIVE COURSES

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DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical		
Supramolecular & Photoinorganic Chemistry **CH-DSE-104**	**04**	**03**	—	**01**	U.G. Chemistry	--

Course objectives

The Objectives of this course are as follows:

- To comprehend the fundamental knowledge of supramolecular chemistry and its importance.
- To impart advanced knowledge the crystal engineering and catalysis of supramolecular complexes and their applications.
- Knowledge of various Photochemical electron transfer in metal complexes and their applications.

Learning outcomes

After completing the course, the students will be able to:

- Demonstrate the role of supramolecular chemistry in understanding of molecular bonding and structure.
- Interpret the supramolecular interactions in proteins and enzymes.
- Elucidate the understanding of self-assembly of biological molecules.
- Understand various types of photochemical reactions of coordination compounds and solar energy conversion in semiconductor systems.

THEORY COMPONENT **(3 Credit. 45 Hours)**

UNIT 1: **(8 Hours)**

FUNDAMENTALS OF SUPRAMOLECULAR CHEMISTRY

Classification of Molecules, Large Molecules, Supermolecules, and Supramolecules, Nomenclature, Thermodynamic and Kinetic selectivity, Supramolecular interactions, Chelate, macrocyclic, and macro-bicyclic effects, High dilution synthesis, Template synthesis.

UNIT 2: **(15 Hours)**

CRYSTAL ENGINEERING

Introduction to Tectons and Synthons and their classification; Hydrogen bonds, strong, moderate, weak H-bonds; acidity and basicity of hydrogen bonds and hydrogen bonding Synthons; Use of H-bonds in crystal engineering and molecular recognition.

SELF-ASSEMBLY & MOLECULAR RECOGNITION

Introduction to self-assembly; biological examples of self-assembly; self-assembly in synthetic systems; self-assembly in coordination complexes; Supramolecular host design, Macrocyclic versus acyclic hosts, Catenanes; Rotaxanes.

SUPRAMOLECULAR CATALYSIS

Introduction; supramolecular interactions in proteins and enzymes for the control of their function; enzyme mimics; artificial enzymes; supramolecular catalysis in synthetic systems.

UNIT 3: **(22 Hours)**

PHOTOINORGANIC CHEMISTRY

Introduction to inorganic photochemistry, Redox reactions of transition metal complexes in excited states, excited-state electron transfer, Marcus-Hush model, Photochemical electron transfer in $[Ru(bipy)_3]^{2+}$, $[Os(bpy)_3]^{2+}$ and $[Fe(bpy)_3]^{3+}$ complexes, Role of spin-orbit coupling, life-times of excited states in these complexes, Photochemical supramolecular devices, devices for photo-induced energy or electron transfer, photo-chemically driven molecular machines.

ENERGY CONVERSION

Solar energy storage, solar energy conversion, Metal complex sensitizers and electron relays in semiconductor supported metal oxide systems, water-photolysis, Nitrogen fixation and CO_2

reduction. Supramolecular photochemistry in natural and artificial systems: photosynthesis, bacterial photosynthesis and artificial photosynthesis.

PRACTICAL COMPONENT **(1 Credit: 30 Hours)**

EXPERIMENTS:

1. Synthesis, characterization (XRD, IR, UV, TGA, etc.) of semiconductors metal oxides and their photocatalytic applications.
2. Synthesis of a series of Cr(III) complexes (with ligands of varying ligand field strength), electronic spectral interpretation.
3. Synthesis, spectral studies and crystal structure of Ru(II) and Os(II) complexes.
4. Any other relevant experiment from time to time during the semester.

ESSENTIAL/RECOMMENDED READINGS (Theory)

1. Christian, G. D., Analytical Chemistry, 6th Ed., John Wiley & Sons, Inc. (2004).
2. Khopkar, S.M., Basic Concepts of Analytical Chemistry 3rd Edition, Publisher: New Age International Publishers (2008), ISBN: 9788122420920, 8122420923.
3. Eldik, R. V.; Stochel G. Advances in Inorganic Chemistry: Inorganic Photochemistry, Volume 63, 1st Edition, Academic Press (2011)
4. Hartley, F. R., Burgess, C. & Alcock, R. M. Solution Equilibria. Prentice-Hall: Europe (1980).
5. Atwood, J. L. & Steed, J. W. Supramolecular Chemistry: A Concise Introduction John Wiley & Sons (2000).
6. Lehn, J. M. Supramolecular Chemistry: Concepts & Perspectives, Print ISBN:9783527293124 Wiley-VCH (2006).
7. Principles and Applications of Photochemistry, B. Wardle, John Wiley, 2009
8. Ligand Field Theory and Its Applications; B. A. Figgis and M. A. Hitchman; Wiley India, 2000
9. Mechanism of Inorganic Reactions; Katakis, Gordon; Wiley; 1987.
10. Inorganic Chemistry, Principles of structure and reactivity; 4th edn; J. E. Huheey, E. A. Keiter and R. L. Keiter. Pearson Education Inc.2003
11. Mechanism of Inorganic Reactions, 2nd edn, Basalo, Pearson; Wiley Eastern, 1997.
12. Photochemistry, C. J. Wayne and R. P. Wayne; Oxford University Press; 1996.

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (CH-DSE-105)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Stereochemistry of Organic Compounds **CH-DSE-105**	**4**	**3**	**0**	**1**	U.G. Chemistry	NIL

Course Objectives: To impart knowledge of advanced concepts of stereochemical principles and asymmetric synthesis of organic compounds, and provide hands-on training in the synthesis and resolution of chiral compounds through laboratory experiments.

Learning Outcomes: Students will develop the ability to analyse the spatial arrangements, and study the properties and reactivity of stereoisomers through the knowledge of symmetry and chirality in organic molecules, gained through this course. The students will be able to predict and design different methods to attain enantioselectivity and diastereoselectivity in a reaction and examine the factors guiding the observed stereoselectivities. Students will attain hands-on training in synthesis, resolution, and optical purity determination of chiral compounds through laboratory experiments that would enhance employability in the chemical, especially pharmaceutical, industry where synthetic organic chemists work on stereo-selective synthesis of industrially relevant compounds.

SYLLABUS OF CH-DSE-105

THEORY COMPONENT **(3 Credits. 45 Hours)**

UNIT 1: **(15 Hours)**

MOLECULAR SYMMETRY AND CHIRALITY

Symmetry operations and symmetry elements, point group classification, and symmetry number.

STEREOISOMERISM

Classification, racemic modification, molecules with one, two or more chiral centres; Assigning configuration (D/L, R/S, E/Z and P/M). Axial, planar, and helical chirality;

stereochemistry of allenes, spiranes, alkylidine cycloalkanes, adamantanes, catenanes, biphenyls (atropisomerism), bridged biphenyls, ansa compounds, and cyclophanes.

TOPICITY AND PROSTEREOISOMERISM

Topicity of ligands and faces and their nomenclature; Stereogenicity, chirogenicity, and pseudoasymmetry, stereogenic and prochiral centres. Simple chemical correlation of configurations with examples, quasiracemates.

UNIT 2: (15 Hours)

CYCLOSTEREOISOMERISM

Configurations, conformations and stability of cyclohexanes (di-, and trisubstituted), cyclohexenes, cyclohexanones, halocyclohexanones, decalins, decalols and decalones.

MOLECULAR DISSYMMETRY AND CHIROPTICAL PROPERTIES

Linear and circularly polarised lights, circular birefringence and circular dichroism, ORD and CD curves, Cotton effect. The axial haloketone rule, octant diagrams, helicity, and Lowe's rule. Application of ORD and CD to structural and stereochemical problems.

UNIT 3: (15 Hours)

ASYMMETRIC INDUCTION

Cram's, Prelog's, and Felkin-Ahn models; Dynamic stereochemistry (acyclic and cyclic), Qualitative correlation between conformation and reactivity, Curtin-Hammett Principle.

ASYMMETRIC SYNTHESIS

Significance and basic principles, stereoselective and stereospecific synthesis: Enantioselective and diastereoselective reactions. Methods of asymmetric synthesis: Resolution – Classical resolution, kinetic resolution, and dynamic kinetic resolution of racemic compounds/*meso*-compounds by resolving agents. Development in asymmetric synthesis from prochiral substrates using chiral auxiliaries, chiral reagents, and chiral catalysts.

PRACTICAL COMPONENT (1 Credit: 30 Hours)

EXPERIMENTS

(i) Determination of optical purity of organic compounds such as tartaric acid, glucose, phenylalanine, proline, and limonene etc. by polarimeter.
(ii) Classical resolution of racemic compounds such as cis-/trans-1,2-diaominocyclohexane or 1-phenyl ethylamine by using a resolving agent.
(iii) Synthesis of racemic BINOL.
(iv) Resolution of racemic BINOL using (1*R*,2*R*)-diaminocyclohexane and determination of optical purity by polarimeter.
(v) *cis*-/*trans*- Isomerisation of alkenes.

(vi) Asymmetric aldol reaction catalysed by (L)-proline/(L)-prolinamide.

(vii) Oxidative kinetic resolution of secondary alcohols by using (1*R*,2*R*)-Jacobsen Mn(III) salen complex using an oxidant

(viii) Determine the Cotton effect of chiral compounds by CD.

ESSENTIAL/RECOMMENDED READINGS

1. Eliel, E. L. Stereochemistry of Carbon Compounds, Textbook Publishers (2003).
2. Nasipuri, D. N. Stereochemistry of Organic Compounds: Principles & Applications, South Asia Books (1994).
3. Kalsi, P. S. Stereochemistry: Conformation and Mechanism, New Age International Pvt. Ltd. (2022)
4. Finar, I. L. Organic Chemistry Vol. 1, Longman (1998).
5. Bruice, P. Y. Organic Chemistry, Pearson Education, (2020)
6. Sengupta, S. Basic Stereochemistry of Organic Molecules, Oxford University Press (2018)
7. Clayden, J; Greeves, N.; Warren, S. Organic Chemistry, Oxford University Press, (2014)
8. Gawley, R. E.; Aube, J. Principles of Asymmetric Synthesis (Tetrahedron series in Organic Chemistry), Pergman, (1996).
9. Catalytic Asymmetric Synthesis I. Ojima, Ed.; VCH: New York, (1993).
10. Schanz, H.; Linseis, M. A.; Gilheany, D. G. Improved resolution methods for (R,R)- and (S,S)-cyclohexane-1,2-diamine and (R)- and (S)-Binol. Tetrahedron: Asymmetry, 2003, 14, 2763.
11. Walsh, P. J., Smith, D.K.; Castello, C. Resolution of Trans-Cyclohexane-1,2-diamine and Determination of the Enantiopurity Using Chiral Solid Phase HPLC Techniques and Polarimetry. J. Chem. Educ. 1998; 75, 11, 1459.

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Fundamentals of Mathematics for Chemistry **CH-DSE-106**	**04**	**03**	**-**	**01**	U.G. Chemistry	10+2 in Science with Mathematics

Course Objective:

- To develop a sound foundation in mathematical methods essential for basics in study and research of Chemistry.
- To understand the application of linear algebra, multivariable calculus, differential equations, Fourier and other integral transforms, and statistical methods.
- To focus on mathematical approaches relevant to quantum chemistry, thermodynamics, kinetics, spectroscopy, and data analysis.
- To advance analytical skills to formulate and solve mathematical models of complex chemical systems.
- To prepare students to interpret experimental data quantitatively and engage in computational and theoretical chemical research.

Learning Outcomes: By the end of this course, students will be able to:

- Recognize and apply basic calculus concepts, including differentiation and integration in quantum chemistry, thermodynamics, electrochemistry, and kinetics.
- Solve differential equations relevant to physical chemistry problems.
- Understand basic linear algebra, including vectors and matrices, to describe molecular structures and quantum systems.
- Apply elementary statistics for analyzing chemical data and phenomena.
- Interpret functions of several variables and use partial derivatives in thermodynamics and physical chemistry contexts.

Theory Course Contents: **Credit 3 (45 hours)**

Unit I: **15 hours**

A. Operators and Eigen-vectors: Linear operator and geometrical interpretation, Linear vector spaces; linear independence (qualitative discussion on Wronskian), basis vectors, inner product, Dirac bra-ket notation, hermitian conjugates (differential operators). Orthonormal sets. Completeness.

B. Vectors: Differentiation and integration of vectors, scalar and vector fields, divergence &

curl, theorems on line, surface, and volume integrals. Transformation of rectilinear cartesian to curvilinear spherical polar coordinates.

Unit II: 15 hours

A. Differential calculus: Ordinary differential equations (ODE), ordinary and singular points of an ODE, and Partial differential equations (PDE), general solution of homogeneous equations. Power series solutions- particle in a box model, solutions of Associated Legendre polynomials- for integer *l* and second solution, harmonic oscillator, Laguerre, and associated Laguerre polynomials. Linear ODE of hypergeometric functions (qualitative discussion); Generating functions-recursion formulae and orthonormality: Hermite, Legendre, and Laguerre Polynomials.

B. Determinant and matrices: Properties of determinants and Laplace expansion (qualitative discussion). Matrices- diagonal, symmetric and anti-symmetric, hermitian and anti-hermitian, orthogonal, and unitary matrices, normal matrices, Eigenvectors and eigenvalues of Hermitian and unitary matrices, Cayley-Hamilton theorem, degenerate eigenvalues, Diagonalization of matrices (change of basis and similarity transformation).

Unit III: 15 hours

A. Fourier sine-, cosine-, and exponential series. Fourier transform, Dirac delta function, Fourier sine and cosine transforms, applications of Fourier transforms. Laplace transform, theorems and Inverse Laplace transform, Solution of initial value problems using Laplace transform.

H-atom (quantitative discussion), Virial theorem, Hyper-virial theorem, and its applications to harmonic oscillator and H-like atoms.

B. Algebra of spin: Stern-Gerlach experiment, concept of spin operators and spin-eigenfunctions, two-electron spin systems; Pauli Exclusion Principle, Hartree product, antisymmetrization operator and Slater determinantal wavefunctions (qualitative discussion). Multiconfiguration calculations and Hartree-Fock theory (qualitative discussion).

Recommended Texts/References:

1. Pilar F. L. Elementary Quantum Chemistry 2nd Ed., Dover Publication Inc.: N.Y. (2001).
2. Cohen-Tannoudji, Claude, Bernard Diu, and Franck Laloë F., Quantum Mechanics (Translated by G. G. Levine and D. S. Constable), vols-I&II, Wiley-Interscience, New York (1977).
3. Levine, I. L. Quantum Chemistry 5th Ed., Prentice-Hall Inc.: New Jersey (2000).
4. Atkins, Peter, and Ronald Friedman. Molecular Quantum Mechanics, Oxford University Press, 5th ed. (2011).
5. Howard Anton, Elementary Linear Algebra, John Wiley & Sons (2010).
6. Mortimer, Robert G., Mathematics for Physical Chemistry, 3rd ed., Academic Press (2010).
7. Arfken, George B., Hans J. Weber, and Frank E. Harris. Mathematical Methods for Physicists, 7th ed., Academic Press (2012).
8. Kreyszig, E., Advanced Engineering Mathematics, John Wiley & Sons, Inc. (2006).
9. Boas, Mary L., Mathematical Methods in the Physical Sciences, 3rd ed., Wiley (2005).

Practical Components **Credit 1**

1. Plot atomic orbitals (Spherical Harmonics $S(\theta)$ *versus* θ using polar graph paper. Students will be provided with the p-, d-, and f- functions.
2. Plot wavefunctions $\psi_n(x)$, and probability densities $|\psi_n(x)|^2$ for the 1D harmonic oscillator at different energy levels over the domain $-\infty < x < +\infty$.
3. Calculate the bond length of conjugated dye molecules (e.g., cyanine, β-carotene, etc.) using the particle-in-a-1D-box model.
4. Assign IR bands using symmetry considerations and selection rules for various molecules.
5. Develop familiarity with computational tools for analysis of experimental data:
   (a) Word processing, electronic spreadsheets etc.
   (b) Data processing software, mathematical packages, etc.
   (c) Chemical structure drawing, and molecular modelling, etc.
6. Perform statistical treatment of error analysis, including:
   (a) Null hypothesis testing,
   (b) T-test, F-test, Q-test (criteria for rejection of hypothesis),
   (c) Statistical analysis of laboratory data.
7. Determine standard deviation, mean and maximum absolute errors, root-mean-square deviation (error), and correlation coefficient of linear straight-line plots.

Recommended Texts/References:

1. McQuarrie, D. A. & Simon, J. D. *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books (2001).
2. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis, Brooks/Cole Pub Co; 7th edition (1 January 2017).
3. Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. Fundamentals of Analytical Chemistry, Publisher: Holt, Rinehart & Winston of Canada Ltd; International 2 Revised ed edition (1 February 1988).

SKILL ENHANCEMENT COURSES

SKILL ENHANCEMENT COURSE (SEC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Introduction to Basic Lab Safety and Softwares for Research work **CH-SEC-107**	**02**	**01**	—	**01**	U.G. Chemistry	--

Course Objectives:

The course is designed to provide the fundamental understanding of the principle of operation, interpretation and learning of chemistry related softwares and Spectral Analysis, which will be highly helpful especially for their higher studies.

Learning Outcomes:

The students will be to:

1. Be aware of their and lab safety.
2. Analyze, interpret and index experimental data/theoretical data collected after various characterizations of their inorganic materials. It will enhance understanding of chemical concepts, improve problem-solving skills and the ability to utilize various tools in research and analysis.
3. Understand reaction mechanisms, visualizing molecular interactions, quantitative analysis, data interpretation, report writing and presentation, access to scientific literatures, software proficiency etc.

THEORY COMPONENT (1 Credit: 15 Hours)

Unit-I (15 Hours)

Types of personal protections (such as eye protection, gloves, lab coats, fire extinguishers etc.) their use, and limitations. Physical hazards like fire safety, electrical safety, glassware safety, radiation safety etc. Materials Safety Data Sheet (MSDS) file of all the available chemicals. Disposal of chemical waste, handling of hazardous chemicals, Identification of corrosives, flammables, and toxic substances etc. Handling and storing chemicals, including segregation and labelling.

ChemDraw: Widely used for creating 2D and 3D chemical structures, reactions, and pathways.

Origin: A data analysis and graphing software used for visualizing and analyzing data from experiments.

Chemsketch: To draw chemical structures, such as inorganic, organic, organometallic, polymers etc.

Vesta: A 3D visualization tool for structural data files, including those from crystallography. Chemical Databases and their utility.

X-pert High-score: Widely used to analyze X-ray diffraction (XRD) data with various applications such as phase identification, crystallographic analysis, cluster analysis, and Rietveld calculations.

International Centre for Diffraction Data (ICDD): Used to identify crystalline phases in materials using X-ray diffraction (XRD) data. It allows researchers to compare experimental XRD patterns against a vast database of reference patterns to determine the composition and structure of unknown materials.

Inorganic Crystal Structure Database (ICSD): To search, visualize, and analyze crystal structures. Valuable software for materials scientists, crystallographers, and other researchers who need precise information about the arrangement of atoms in solids. **Scifinder and Web of Science:** Databases and search engines for Chemical Literature.

Mendeley: To organize, manage, and cite research papers, articles, and other sources.

PRACTICAL COMPONENT (1 Credit: 30 Hours)

EXPERIMENTS:

1. Use of ChemDraw to create 2D and 3D chemical structures.
2. Data analysis and interpretation using Origin for 2D and 3D graphs, performing statistical analysis, signal processing, curve fitting and peak analysis.
3. Drawing, editing, and visualizing chemical structures, reaction drawing, molecular property calculations using Chemsketch software
4. Modeling and visualizing crystal structures, including unit cells, atomic positions, and bonds, handling of multiple structural models using Vesta software.
5. Hands on training on X-pert High-score software for XRD analysis.

6. To search, analyze and curating chemical information, as well as for accessing spectral data, synthetic methods, and safety information using ChemSpider, and Mendeley.

Reference (Theory):

1. Handbook for Laboratory Safety, Benjamin R. Sveinbjornsson and Sveinbjorn Gizurarson, Copyright © 2022 Elsevier Inc. ISBN 978-0-323-99320-3

2. Laboratory Safety for Chemistry Students, Robert H. Hill and David Finster, Wiley–Blackwell (20 August 2010). ISBN-13 : 978-0470344286.
3. https://csl.du.ac.in/
4. https://www.youtube.com/watch?v=hhfckQtdfKw

References (Practical):

1. https://www.youtube.com/watch?v=fHEe7AZ7sS0
2. https://www.youtube.com/watch?v=8tCUg2B523o
3. https://share.google/NiP4QGBFQFT8wZnZm
4. https://www.youtube.com/watch?v=TwVyvh628wE
5. https://www.acdlabs.com/resources/free-chemistry-software-apps/chemsketch-freeware/ (Freeware software)
6. https://www.youtube.com/watch?v=l06ljePcg8U
7. https://www.youtube.com/watch?v=CpW7khVmSAE
8. https://www.youtube.com/watch?v=dASaENblC_4
9. https://www.youtube.com/watch?app=desktop&v=TpuL4NgCMYc&t=0s
10. https://www.youtube.com/watch?v=lST-yMe322Y
11. https://www.youtube.com/watch?v=Go-BdmnYusU
12. https://www.youtube.com/c/mendeley/videos
13. https://www.youtube.com/watch?v=PJXnfBSq4Lg

*Students are encouraged to participate in various chemistry related workshops/conferences and submit their certificates and learning outcomes (1 page).

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SKILL ENHANCEMENT COURSE (CH-SEC-108)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Best Practices in Chemical Laboratory Safety **CH-SEC-108**	**2**	**1**	**0**	**1**	U.G. Chemistry	NIL

Course Objectives: For a majority of students, chemistry laboratory safety is limited to a set of safety precautions explained by the instructors during a chemistry practical class. These safety precautions, though important are not sufficient to prepare a student for a research laboratory or an industrial job in the field of chemistry. This course aims to provide an in-depth knowledge on the best practices in chemistry laboratory safety. The students will be made aware of the need for safety culture through various documented laboratory accidents and near misses. This course will delve into recognition of hazards, risk assessment and its minimization in a chemistry laboratory through lectures, hands on learning/ demonstration and activities. This course will also prepare the students for responding to a chemical emergency.

Learning Outcomes:

After the completion of this course the students will develop a positive attitude towards safe laboratory practices. They will be able to recognise the potential hazards in a chemistry laboratory, assess these hazards by GHS, SDSs and other resources and will be able to minimise the risks. This course will also prepare them to respond to any emergencies in a chemistry laboratory. The students will also learn about chemical laboratory safety through hands on training, demonstration and activities. This advance course on best practices in chemistry laboratory safety will make students more employable in the field of chemistry in both academia and industry.

SYLLABUS OF CH-SEC-108

THEORY COMPONENT **(1 Credit: 15 Hours)**

UNIT 1: **(15 Hours)**

LABORATORY SAFETY CULTURE

Understanding RAMP strategy, ethics and safety, learning from lab incidents.

RECOGNIZING HAZARDS

Globally Harmonized System of Classification and Labelling of Chemicals (GHS) and Safety Data Sheets (SDSs); toxicity, corrosives, carcinogens, biological hazards, hazards of nanomaterials, flammable chemicals, incompatible chemicals, explosion hazards, reactive and unstable chemicals, gas cylinders, cryogenic liquid tanks, cryogenic hazards, low- or high-pressure systems.

ASSESSING RISK

Understanding Occupational Exposure Limits (OEL), assessing chemical exposure, risk assessment for new experiments.

MINIMIZING RISK

Strategies to minimise risk, Personal Protective Equipment (PPE), fume hood, common laboratory safety measures in a chemistry laboratory, handling chemical wastes, management of chemicals in a laboratory- chemical inventory, storage and chemical security.

PREPARE FOR EMERGENCIES

Responding to emergencies in a chemistry laboratory, chemical spills, fire emergencies, first-aid.

PRACTICAL COMPONENT (1 Credit: 30 Hours)

1. Demonstration/ hands on learning of the:
    a. Appropriate use of common laboratory devices and equipment (e.g., Bunsen burners, laboratory ovens, magnetic stirrers, U.V. chambers, centrifuges, vacuum pumps, rotary evaporators, refrigerators, freezers etc.).
    b. Proper use of a safety shower and an eyewash.
    c. Basic first aid procedures for common minor laboratory accidents
    d. Proper disposal of "sharps" and prevention of lacerations while handling glassware.
    e. Proper techniques for cleaning up minor spills (acid, base, or organic spill) in the laboratory.
    f. Appropriate use of PPE in response to a minor chemical spill.
    g. Proper use of the fire extinguisher.
    h. Storage protocols for laboratory chemicals (incompatible chemicals, flammables and corrosives)

2. Understanding Risk Assessment in a laboratory through activities.

3. Safety Data Sheet practice for a few commonly used laboratory chemicals.

ESSENTIAL/RECOMMENDED READINGS

1. Laboratory Safety for Chemistry Students by David Finster and Robert Hill. https://institute.acs.org/acs-center/lab-safety/education-training/college-univ-guidelines/laboratory-safety-for-chemistry-students-etextbook.html
2. Hill, R.H.; Finster, D.C. Laboratory Safety for Chemistry Students, 2nd Ed; Wiley: Hoboken, NJ, 2016.
3. Guidelines for Chemical Laboratory Safety in Academic Institutions, ACS Committee on Chemical Safety, Washington, DC., 2016. www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/acs-safety-guidelines-academic.pdf?logActivity=true
4. Safety in academic chemistry laboratories 8th edition best practices for first- and second-year university student. https://www.acs.org/content/dam/acsorg/about/governance/committees/chemicalsafety/publications/safety-in-academic-chemistry-laboratories-students.pdf
5. Prudent practices in the laboratory: Handling and management of chemical hazards, Updated version. Washington, DC: The National Academies Press. https://doi.org/10.17226/12654.
6. United Nations. Globally Harmonized System of Classification and Labelling of Chemicals (GHS), Fifth revised edition, ST/SG/AC.10/30/Rev.5; New York and Geneva, 2013.
7. Bretherick's Handbook of Reactive Chemical Hazards, 8th Edition; Urben, P., Ed.; Elsevier, 2017.

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SKILL ENHANCEMENT COURSE (SEC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	**Credits**	**Credit distribution of the course**			**Eligibility criteria**	**Pre-requisite of the course (if any)**
		Lecture	**Tutorial**	**Practical /Practice**		
Introduction to Computer Programming and Numerical Methods CH-SEC-109	**02**	**01**	**-**	**01**	U.G. Chemistry	10+2 in Science with Mathematics

Course Objectives

- To introduce the evolution of programming languages and the rationale behind structured programming.
- To familiarize students with the syntax, compilation/execution process, and development environments for programming, variables, data types, operators, expressions, and program structure
- Understand the fundamental principles and need for numerical methods in solving mathematical problems.
- Develop the ability to implement numerical methods using programming tools.

Learning Outcome

1) Write, compile, and execute basic programs using appropriate IDEs and compilers across different platforms.
2) Design modular code using user-defined functions, input/output operations, control statements and formatted data handling
3) Explain the concepts and importance of numerical methods in computational problem-solving.
4) Apply numerical techniques for solving equations
5) Implement numerical methods using suitable programming languages or tools.

Theory Component **Credit: 1 (15 hours)**

Unit I:

A. Computer Programming: Evolution of programming languages; Importance of structured programming; Syntax overview and compilation/execution flow; IDEs and compilers.
Variables and Data Types (constants; variables, and declarations); Integer, real, double, character, logical, Mix-mode arithmetic and type conversion; Comments and program structure; Operators and Expressions, Logical and arithmetic expressions, Built-in (library) functions; Control Structures (Conditional branching, Loops), Input/Output Operations, Concepts of Functions, Procedures, and Modular Programming; Arrays and Strings
B. Finding roots of an equation, Iterative method, Successive bisection method, Method of false position and Newton-Raphson method.

Recommended Texts/References:

1) Rajaraman, V., *Computer Programming in C*. PHI Learning; 2nd edition (2019)
2) Kanetkar, Y. P. *Let us C*, BPB Publications; 15th edition (2024)
3) Rajaraman, V., *Computer Programming in Fortran 90 and 95*. 2nd Edition, PHI Learning (1997)
4) Chapman, S. J., *Fortran 90/95 for Scientists and Engineers*, McGraw-Hill Higher Education; 2nd edition (2003)
5) Zelle, J. M. *Python Programming: An Introduction to Computer Science*, 4th Edition, Shroff Publishers & Distributors Pvt. Ltd. (2024)
6) Schatzman, M., *Numerical Analysis: A Mathematical Introduction*, 1st edition, Oxford University Press. (2002).
7) Press, W. H., Teukolsky, S. A., Vetterling, W. T. and Flannery, B. P., *Numerical Recipes: The Art of Scientific Computing*, Vol 1, 3rd Edition, Cambridge University Press (2007).

Lab Components **Credit: 1**

1) Write a program to compute (i) the area and circumference of a circle, given the radius, (ii) to check whether a number is positive, negative, or zero, (iii) *H* and *S* from *Cp* from given data, (iv) *p*H of a weak and strong acid, (v) convert Celsius to Fahrenheit or vice versa, (vi) leap year checker, (vii) palindrome checker, (viii) Fibonacci series
2) Write a function to compute the factorial of a number.
3) Write a program to reverse a given string.
4) Calculate the sum of the first 10 natural and prime numbers using a loop.
5) Write a program to check whether a given number is even or odd.
6) Write a program to find the maximum and minima for a set of numbers.
7) Write a program to find a root using the bisection method.
8) Write a program for false position method for root-finding.
9) Write a program to solve a nonlinear equation using the fixed-point iteration (simple iteration) method
10) Use the Newton-Raphson method to solve systems of simultaneous nonlinear equations.
11) Implement and compare the Bisection and Newton-Raphson methods for solving nonlinear equations.
12) Write a program to compare Bisection, Regula Falsi, and Newton-Raphson methods on the same function.

Recommended Texts/References:

1) Rajaraman, V., *Computer Programming in C*. PHI Learning; 2nd edition (2019)
2) Kanetkar, Y. P. *Let us C*, BPB Publications; 15th edition (2024)
3) Rajaraman, V., *Computer Programming in Fortran 90 and 95*. 2nd Edition, PHI Learning (1997)
4) Chapman, S. J., *Fortran 90/95 for Scientists and Engineers*, McGraw-Hill Higher Education; 2nd edition (2003)
5) Zelle, J. M. *Python Programming: An Introduction to Computer Science*, 4th Edition, Shroff Publishers & Distributors Pvt. Ltd. (2024)
6) Schatzman, M., *Numerical Analysis: A Mathematical Introduction*, 1st edition, Oxford University Press. (2002).
7) Press, W. H., Teukolsky, S. A., Vetterling, W. T. and Flannery, B. P., *Numerical Recipes: The Art of Scientific Computing*, Vol 1, 3rd Edition, Cambridge University Press (2007).

SKILL ENHANCEMENT COURSE (SEC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre- requisite of the course (if any)
		Lecture	Tutorial	Practical/Practice		
Electrochemical Energy Devices and Technologies **CH-SEC-110**	02	0	-	02	U.G. Chemistry	10+2 in Science with Mathematics

Course Objectives:

- To learn process of making contemporary electrochemical energy devices and their testing methodology. Course is developed through videos of process of making and assembling Li ion batteries, Dye-sensitized Solar Cell, and associated devices.

Learning outcomes: On successful completion of the course, students will be able to

- Know how to assemble and test an electrochemical energy device of various kinds.

Lecture Demonstration Course Contents: **(Credit 2; 60 Hours)**

1. Assembling and testing of liquid-electrolyte based Li-ion Rechargeable Battery and its working mechanism.
2. Assembling and testing of All solid-electrolyte based Li-ion Rechargeable Battery and its working mechanism.
3. Demonstration of Dye-sensitized Solar cell and its working mechanism.
4. Principle of electrolysis and demonstration of Hydrogen Production.
5. Demonstration of Supercapacitor and its working mechanism.

Recommended Texts/References:

1. Electrochemical Energy: Advance Materials and Technologies, Edt P.K. Shen, C-Y Jiang, X. Sun, J. Zhang, CRC Press, 2016
2. Bockris, John O'M. and Reddy, A.K. N. Vol 1: Modern Electrochemistry , Ionics, 2nd Edition Springer (1998)
3. Bockris, John O'M., Reddy, A.K. N. and Gamboa-Aldeco, M. Modern Electrochemistry, Vol 2A, Fundamental of Electrodes, 2nd Edition Springer (2000)

GENERIC ELECTIVE COURSES

Generic Elective (GE)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Basics of Mineral Chemistry **CH-GE-111**	**04**	**03**	—	**01**	B.Sc. (any stream)	NIL

Course objectives:

Introducing students to the naturally occurring inorganic solids called as the minerals that are formed by complex processes over wide-ranging temperatures and pressures.

That the study of the minerals is essentially learning about their chemistry, physical and chemical properties.

Learning outcome:

Upon successful completion of this course, the students will be able to:

- Recognize the relevance of inorganic chemistry concepts to understand the minerals.
- The development of the structural chemistry of a vast majority of the inorganic solids is related to the various mineral structural families.

THEORY COMPONENT **(3 Credit: 45 Hours)**

Unit-1: INTRODUCTION, PHYSICAL PROPERTIES OF MINERALS AND ELEMENTS OF CRYSTAL CHEMISTRY **(15 Hours)**

Definition of Mineral, Economic importance of minerals, Naming of minerals

Crystal form and Crystal Habit, Intergrowths, Twins and striations, State of aggregation, Properties depending on light, Luster, Color and streak, Play of colors, Luminescence, Fluorescence and Phosphorescence, Cleavage, Parting and Fracture, Hardness, Tenacity, Specific Gravity and its determination, Magnetism, Radioactivity, Piezoelectricity.

Chemical Composition of earth's crust, Bonding forces in crystals, Atomic and Ionic radii, Examples of common structure types, NaCl structure, CsCl structure, Sphalerite (ZnS) structure, CaF_2 structure, Rutile (TiO_2) structure, Perovskites (ABO_3) structure, spinel (AB_2O_4) structure, Silicate structures, Substitutional solid solution, Interstitial solid solution, Omission solid solution.

Unit-2: MINERAL REACTIONS, STABILITY AND BEHAVIOR (15 Hours)

Reaction in an Igneous regime, reaction under metamorphic conditions, Reaction in a weathering environment, Ultra-high-pressure reactions, Mineral stability, one -, two-, three- or more component diagrams, mineral reactions involving H_2O or CO_2, Eh-pH diagrams, Polymorphic reactions, Origin of color, Magnetic properties and Radioactivity.

Unit-3: CRYSTAL STRUCTURE OF ROCK-FORMING SILICATES (15 Hours)

Classifications, structures and properties. Nesosilicates, Sorosilicate, Cyclosilicates, Inosilicates, Phyllosilicates, Tectosilicates including aluminosilicates and Zeolite group.

PRACTICAL COMPONENT (1 Credit: 30 Hours)

EXPERIMENTS:

1. Analysis: Few qualitative analysis experiments to confirm the presence of frequently occurring (e.g. Na, K, Mg, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Al, Si, Pb, F, Cl, Br, I, S) cations and anions in minerals along with few quantitative estimation experiments.
2. Physical characterization methods, IR, UV-Visible experiments, and PL (Photo Luminescence) Emission. Simple inorganic compounds may be used to draw the analogy with the minerals.
3. Powder X-Ray diffraction. Experiments to demonstrate the identification using the literature available as data base; XRF analysis. Demonstration experiments if possible to detect the using simple minerals or analogs ($CaCO_3$ mixed with $MgCO_3$)

4. Magnetic property measurements at RT.
5. Any other relevant experiment from time to time during the semester.

References (Theory):

1. The 22nd Edition of the Manual of Mineral Science, Cornelis Klein, John Wiley & Sons, Inc. New York, 2002.
2. Inorganic Chemistry (Fifth Edition), Shriver & Atkins, 2010, Oxford University Press
3. Vogel's Qualitative Inorganic Analysis – Arthur. I. Vogel, Imperial College, Longmans, Green and Co, London, New York, Toronto, 1937 or 7th Edition – G. Svehla and B. Ravisankar, Pearson Education 2008.
4. Textbook of quantitative chemical analysis – Arthur. I. Vogel, Longman Publisher, 5th edition 1989.
5. Quantitative Chemical Analysis 7th Edition Daniell C. Harris, Freeman & Company, New York 2007.

References (Practical)

1.Textbook of quantitative chemical analysis – Arthur. I. Vogel, Longman Publisher, Latest edition.

2.Quantitative Chemical Analysis 7th Edition Daniell C. Harris, Freeman & Company, New York 2007.

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

GENERIC ELECTIVE COURSE (CH-GE-112)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Drug Discovery and Development **CH-GE-112**	**4**	**3**	**0**	**1**	B.Sc. (any stream)	NIL

Course Objectives:

Understand what drugs are and how they are processed in the body, and how molecular characteristics impact the success of pharmaceutical drugs. Gaining knowledge about the molecular interactions that form the basis of drug-target interactions. Understanding the factors that enhance such interactions to make more effective therapeutics. Understand and predict how drugs are metabolized at the molecular level, including functional groups that are metabolic liabilities and those that are toxic. Discuss and describe modern strategies to identify chemical compounds from large chemical libraries that may serve as a source for new drugs.

Learning Outcomes:

1. Develop knowledge of the process through which potential new therapeutics are identified.
2: Develop an understanding of important drug discoveries.
3: Develop knowledge of modern drug discovery techniques and methodologies.
4: Understanding the various approaches to screen and design.
5: Present advanced knowledge to demonstrate understanding of drug discovery and development.
6. The students will acquire the following skills through experiments:
 i) Synthesis of the common APIs, involving functional group manipulations.
 ii) Use purification techniques to purify common APIs.

SYLLABUS OF CH-GE-112

THEORY COMPONENT **(3 Credit: 45 Hours)**

UNIT 1: **(15 Hours)**

KEY CONCEPTS FOR DRUG DEVELOPMENT

Introduction and role of medicinal chemistry, difference between a drug and medicine, history and development, drug discovery approaches, drug targets (lipids, proteins including enzymes and receptors, nucleic acids and carbohydrates), drug-receptor interaction, mode of actions, agonist, antagonist, reverse agonist, therapeutic index, random/non-random screening, pharmacophore, Lipinski rule (rule of five), role of chirality in drug discovery (thalidomide history).

UNIT 2: **(15 Hours)**

PROCESS OF DRUG DEVELOPMENT

Lead discovery, lead modification, bioisosterism, optimizing drug-target interactions, structure-activity relationship, concept of prodrug, pharmacokinetics, pharmacodynamics, drug metabolism (ADME), drug administration routes, toxicity, clinical trials, repurposing of drugs, me-too drugs, aspirin, paracetamol, remdesivir.

UNIT 3: **(15 Hours)**

THERAPEUTICS IN ACTION

General introduction to antibiotics, mechanism of action of β-lactam antibiotics, non-β-lactam antibiotics, quinolones, antiviral drugs, gene therapy, anti-sense therapy, and drug resistance.

PRACTICAL COMPONENT **(1 Credit: 30 Hours)**

EXPERIMENTS

1. Separation and Purification techniques: Distillation, Recrystallization, Chromatography
2. Synthesis of APIs
    - 2.1 Synthesis of aspirin
    - 2.2 Synthesis of sulphanilamide
    - 2.3 Synthesis of paracetamol
3. Isolation of APIs from tablets
    - 3.1 Isolation of paracetamol
    - 3.2 Isolation of naproxen
4. Isolation of biologically active natural products from plant materials
    - 4.1 Isolation of caffeine from tea leaves
    - 4.2 Isolation of curcumin from turmeric
    - 4.3 Isolation of eugenol from clove oil
    - 4.4 Isolation of lycopene from tomato

ESSENTIAL/RECOMMENDED READINGS

Theory

1. V. K. Ahluwalia and Madhu Chopra, Medicinal Chemistry, Anes Student Edition, 2008.
2. S. K. Gupta, Drug screening methods, New Delhi: Jaypee Brothers Medical Publishers (P) Ltd; 2004.

3. N. K. Dunlap, & D. M. Huryn, Medicinal Chemistry, Garland Science, New York, 2018.
4. Graham L. Patrick, An Introduction to Medicinal Chemistry, Oxford University Press, 1995.
5. T. L. Lemke & D. A. William, Foye's Principles of Medicinal Chemistry, 5th Ed., USA, 2002.
6. A. Gringuage, Introduction to Medicinal Chemistry, Wiley-VCH, 1997.
7. E. Stevens, Medicinal Chemistry-The Modern Drug Discovery Process, Pearson, 2014.
8. Richard Silverman, The Organic Chemistry of Drug Design and Drug Action, 3rd Ed, Academic Press.

Practical

1.Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
3. Reddy, Y. K., Jayaveera, K. N., Subramanyam, S. (2013), Practical Medicinal Chemistry, S. Chand Publication.
4. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press.

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

Generic Elective (GE)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Interface Chemistry: Bridging Biophysics, and Nanomedicine **CH-GE-113**	**04**	**03**	**-**	**01**	B. Sc in Science	--

Course Objectives:

- To introduce the fundamental principles of colloidal and surface chemistry, including micellization, adsorption phenomena, and the thermodynamics of self-assembly.
- To develop an understanding of macromolecules and polymers, their synthesis, characterization, and physicochemical properties.

- To explain the structural and thermodynamic properties of biological macromolecules, such as proteins and enzymes, and to apply quantitative models to ligand binding and enzymatic reactions.
- To explore the design, function, and biological interactions of nanomaterials used in diagnostics and drug delivery, including targeting strategies and pharmacokinetics.
- To familiarize learners with modern analytical and optical techniques used in studying biological systems, such as spectroscopy, calorimetry, and microscopy.

<u>Learning outcomes</u>: By the end of the course, students will be able to:

- Understand of surface chemistry principles, including micellization, adsorption isotherms, and thermodynamics of surfactant systems.
- Analyze the properties, synthesis, and characterization techniques of macromolecules and polymers, including molecular weight determination and polymerization types.
- Interpret the structural and thermodynamic behavior of biological macromolecules, and apply enzyme kinetics models such as the Michaelis-Menten equation and inhibition mechanisms.
- Evaluate the biomedical applications of lipid-, polymer-, and inorganic-based nanomaterials, focusing on drug delivery, diagnostics, cellular uptake, and biological barrier transport.
- Apply modern analytical and optical techniques-including spectroscopy, calorimetry, and microscopy-for studying biomolecular interactions and structures.

<u>Course Contents (Theory)</u>: **Credit: 3 (45 hours)**

Unit-I: **15 hours**

A. Surface-active agents, micellization, hydrophobic interaction, critical micelle concentration (CMC), Krafft temperature. Packing parameters, thermodynamics of micellization.

Adsorption: Gibbs adsorption isotherm, Langmuir and BET isotherms, surface area measurements.

Macromolecules and types of polymerizations, Degree of polymerization, number and mass average molecular masses, Polymer characterization: osmometry, viscometry, light scattering, diffusion.

B. Isoelectric point of amino acids, Configuration, and conformation of biological macromolecules, Thermodynamics of protein folding/stability, Thermodynamics and kinetics of ligand interactions, Macromolecule-ligand binding and cooperativity (including Hill equation).

Unit II: **15 hours**

Lipid-, polymer-, inorganic-based and hybrid nanomaterials for biomedical applications. Nanomaterials in optical, magnetic-resonance, radio and other diagnostics. Encapsulation and release of drugs, DNA, and other active agents. Interaction of nanomaterials with mammalian and pathogenic cells. Endocytosis, phagocytosis and other cell-entry mechanisms. In vitro assays: cell viability, ROS determination, etc. Routes of administration of nanoparticles in the body. Delivery of nanoparticles across biological barriers: RES barrier, blood-brain barrier, skin barrier, mucosal barrier, etc. Bioavailabilty, PK/PD of nanomaterials in the body. Passive and active targeting. Long-term fate and toxicological aspects of nanomaterials in the body.

Unit III: **15 hours**

A. Enzyme catalysis: Michaelis-Menten equation (with derivation), Lineweaver-Burk plot, define the turnover number and Michaelis constant, Enzyme inhibition-reversibility and products inhibition.

B. Basic principles and applications of analytical and optical techniques in biological systems: Absorption and fluorescence spectroscopy, Isothermal Titration Calorimetry (ITC), Linear and Circular Dichroism (CD), Optical Microscopy (Basic principles and Instrumentations).

Recommended Texts/References:

1. Wilson, K. & Walker, J., Principles and Techniques of Biochemistry and Molecular Biology, Eight Editions, 2018.
2. Lehninger, Principles of Biochemistry Seventh Edition, 2017.
3. Voet, D.; Voet, J. G.; Pratt, C. W. Voet's Principles of Biochemistry Fifth Edition, 2018.
4. Lakowicz, J. R. Principles of Fluorescence Spectroscopy, Third Edition, 2006.
5. Carraher, C. E., Introduction to Polymer Chemistry, Fourth Edition, 2017.
6. Prasad, P. N. Introduction to Nanomedicine and Nanobioengineering. Wiley, 2012.
7. Webster, T. J. Nanomedicine Technologies and Application (2nd Edition), ScienceDirect, 2023.
8. Jain. K. K. The Handbook of Nanomedicine. Springer, 2017

Practical Components: **Credit 1**

1. (a) Determination of critical micellar concentration (cmc) of surfactant solutions and (b) calculation of thermodynamic parameters of micellizations.
2. Study the kinetics of the reaction of crystal violet with sodium hydroxide.
3. Determination of molecular weight of polymers
4. Determination of isoelectric points of amino acids.
   a) Neutral, b) Basic and c) acidic amino acids
5. Study of the oscillating reaction using a redox system.
6. Develop familiarity with computational tools for analysis of experimental data:
   (a) Word processing, electronic spreadsheets etc.
   (b) Data processing software, mathematical packages, etc.
   (c) Chemical structure drawing, and molecular modelling, etc.
7. Determine standard deviation, mean and maximum absolute errors, root-mean-square deviation (error), and correlation coefficient of linear straight-line plots using experimental data.

Recommended Texts/References:

1. McQuarrie, D. A. & Simon, J. D. *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books (2001).
2. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis, Brooks/Cole Pub Co; 7th edition (1 January 2017).

3. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
4. Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. Fundamentals of Analytical Chemistry, Publisher: Holt, Rinehart & Winston of Canada Ltd; International 2 Revised ed edition (1 February 1988).

SEMESTER- II

DISCIPLINE SPECIFIC CORE COURSES

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DISCIPLINE SPECIFIC CORE COURSE (DSC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical		
Chemistry of *d*- and *f*- block elements **CH-DSC-201**	**04**	**02**	—	**02**	U.G. Chemistry	--

Course objectives

The Objectives of this course are as follows:

- To learn about the fundamental structural and bonding aspects of d- and f-block metal chemistry.
- Imparting knowledge of the physical properties of these metal complexes.

Learning outcomes

After completing the course, the students will be able to:

- Interpret the experimental electronic absorption spectra
- Establish the structure property correlation for magnetic metal complexes
- Elucidate stability of various metal complexes based on the bonding aspects

THEORY COMPONENT **(2 Credit: 30 Hours)**

UNIT 1: **(15 Hours)**

BONDING AND STRUCTURAL ASPECTS IN *d* AND *f*-BLOCK METAL COMPLEXES

Brief discussion on Crystal Field Theory (CFT), splitting in octahedral, tetrahedral, square planar and trigonal bipyramidal and square pyramidal crystal field; application of crystal field stabilisation energy (CFSE) in different thermodynamic aspects, the Irving–Williams series; static and dynamic Jahn-Teller distortion**;** Molecular orbital theory (MOT) for octahedral, tetrahedral and square planar complexes; Ligand Field Theory (LFT) for complexes with σ-donor, π- donor and π- acceptor ligands**;** Angular Overlap Model (AOM) for quantitative assessment of bonding in the metal complexes. Structural diversity in transition and lanthanoid based complexes, structural isomerism and stereoisomerism inmetal complexes;Dewar-Chatt-Duncanson model for structure and bonding in complexes containing π-acceptor ligands; metal-metal bonds, cluster compounds of *d*-block elements, poly-oxometallates of Ruthenium, Osmium and Molybdenum.

UNIT 2: (15 Hours)

PHYSICAL PROPERTIES OF *d*- AND *f*-BLOCK COMPLEXES

d- and *f*-Orbitals and oxidation states, electronic configuration, microstates, Term symbol, Russel-Saunders scheme, spin-orbit coupling, Hund's rule for ground state term symbol. Electronic absorption spectra of octahedral and tetrahedral complexes, Interpretation of electronic absorption spectra: Orgel diagram, Tanabe-Sugano diagram; determination of Dq, Racah parameters, Nephelauxetic parameter; Quantum non-crossing rule, Selection rules, charge transfer absorption, fluorescence and phosphorescence spectra of *d*- and *f*- block metal complexes; Magnetic properties of transition metal and lanthanide complexes; Introduction to transition and lanthanide metal based single molecular magnets (SMMs), Relativistic effects affecting the properties of heavier transition elements; application of lanthanoid shift reagents in NMR spectroscopy.

PRACTICAL COMPONENT (2 Credit: 60 Hours)

EXPERIMENTS:

1. Qualitative analysis of mixtures of salts including rare element salts (soluble and insoluble) containing eight radicals including interfering ions.
2. Synthesis of lanthanide and cerium complexes and their analysis: Magnetic moments, IR, NMR
3. Synthesis and characterization of iron/chromium complexes: IR, electronic spectra and magnetic susceptibility
4. Utilization of coordination chemistry to demonstrate invisible ink in laboratory.

5. Colour effects due to ligand-exchange in nickel complexes: Demonstration of ligand-field strength in the spectrochemical series.

6. Any other relevant experiment from time to time during the semester.

ESSENTIAL/RECOMMENDED READINGS (Theory)

1. Shriver, D. F., Atkins, P. W. & Langford, C. H. Inorganic Chemistry, 2nd Ed., Oxford Univ. Press (1998).
2. Purcell, K. F. & Kotz, J. C. Inorganic Chemistry, W. B. Saunders and Co.: N. Y. (1985).
3. Wulfsberg, G. Inorganic Chemistry Univ. Science books: Viva Books: New Delhi (2000)
4. Mabbs, F. E. & Machin, D. J. Magnetism and Transition Metal Complexes Chapman and Hall: U.K. (1973).
5. Drago, R. S. Physical Methods in Chemistry W. B. Saunders Co.: U.K. (1982).

SUGGESTED READINGS (Theory)

1. Housecroft, C. E. and Sharpe, A. G. Inorganic Chemistry, Pearson (2018).
2. Miessler, G. L.; Fischer P. J. and Tarr D. A. Inorganic Chemistry, Pearson (2018).
3. Dutta, R. L. and Syamal, A. Elements of Magnetochemistry, Affiliated East-West Publishers (1993).

ESSENTIAL/RECOMMENDED READINGS (Practical)

- Svehla, G. Vogel's Textbook of Macro and Semi-micro Qualitative Inorganic Analysis, 5^{th} Edition (1979)

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC CORE COURSE (CH-DSC-202)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Organic Spectroscopy **CH-DSC-202**	**4**	**2**	**0**	**2**	U.G. Chemistry	NIL

Course Objectives: Understanding of spectroscopic principles and advanced techniques of NMR and Mass, and their application in the structural elucidation of organic compounds.

Learning Outcomes*:* Students will gain an understanding of the basic principles of NMR spectroscopy, such as chemical shift, coupling constant, and anisotropy, and describe how they are affected by molecular structure, and identify organic compounds by analysis and interpretation of spectral data. At the end of this course the students will be able to analyse an unknown organic compound by interpreting its UV-Vis, IR, ^{1}H NMR, ^{13}C NMR, 2D-NMR, and mass spectral data. The students will synthesise organic compounds and will characterise these with the help of IR, NMR (^{1}H and ^{13}C NMR) and mass spectral data, D_2O exchange, DEPT and 2D-NMR techniques.

SYLLABUS OF CH-DSC-202

THEORY COMPONENT **(2 Credit: 30 Hours)**

UNIT 1: **(15 Hours)**

PROTON MAGNETIC RESONANCE SPECTROSCOPY

Basics of NMR with focus on ^{1}H, ^{13}C, ^{19}F, ^{31}P nuclei; chemical shift and spin-spin coupling; coupling patterns; chemical and magnetic equivalence; proton exchange; and factors affecting the coupling - First and non-first order spectra; simplification of complex spectra (solvent effect, field effect, double resonance and lanthanide shift reagents) and NOE experiment; study of dynamic processes by Variable temperature (VT) NMR; Applications of PMR in structural elucidation of simple and complex compounds.

UNIT 2: **(15 Hours)**

CARBON-13 NMR SPECTROSCOPY

Resolution and multiplicity of ^{13}C NMR, ^{1}H-decoupling, noise decoupling, broadband decoupling; deuterium, fluorine, and phosphorus coupling; NOE signal enhancement, offresonance, proton decoupling, structural applications of CMR; DEPT and INEPT experiments; introduction to 2D-NMR; COSY, HETCOR, HSQC, HMBC, NOESY, HOESY, ROESY spectra.

MASS SPECTROMETRY

Theory, instrumentation and modifications; Unit mass and molecular ions; Important terms: singly, doubly/multiple charged ions, metastable peak, base peak, isotopic mass peaks, relative intensity, FTMS, etc.; Recognition of M+ ion peak; Nitrogen rule; Ionization methods (EI, CI, FAB, ESI, APCI and MALDI), General fragmentation rules: Fragmentation of various classes of organic molecules, including compounds containing oxygen, sulphur, nitrogen and halogens; α-, β-, allylic and benzylic cleavage; McLafferty rearrangement, ortho effect etc.

STRUCTURE ELUCIDATION USING SPECTROSCOPIC DATA

Structure elucidation of organic compounds using IR, NMR, and Mass Spectral data.

PRACTICAL COMPONENT (2 Credits: 60 Hours)

EXPERIMENTS

Note: All the synthesized compounds will be characterized with the help of IR, NMR (^{1}H and ^{13}C NMR) and mass spectral data. D_2O exchange, DEPT and 2D-NMR will also be performed wherever necessary.

1. Acetylation/benzoylation reactions of arylamines, phenols, hydroquinone, salicylic acid, carbohydrates.
2. Synthesis of heterocyclic compounds.
3. Identification of exchangeable protons by D_2O exchange experiments.
4. Identification of $-CH_3$, $-CH_2$, CH and quaternary carbons by DEPT and APT experiment.
5. Identification of inter and intramolecular hydrogen bonding by IR and NMR.
6. Application of the coupling constant to identify cis- and trans-isomers, diastereotopic protons in organic compounds by NMR.

ESSENTIAL/RECOMMENDED READINGS

Theory

1. Kemp, W. Organic Spectroscopy 3rd Ed., W. H. Freeman & Co. (1991, reprinted 2002).
2. Silverstein, R. M., Bassler, G. C. & Morrill, T. C. Spectroscopic Identification of Organic Compounds John Wiley & Sons (2014).
3. Pavia, D. L.; Lampmann, G. M.; Kriz, G. S.; Vyvyan, J. R. Introduction to Spectroscopy Cengage Learning (2015).
4. Organic Structures from spectra; L. D. Field, S. Sternhell and J R Kalman, John Wiley & Sons Ltd., 2007.

Practical

1. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
2. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.

3. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
5. Ahluwalia, V. K., Aggarwal, R. (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC CORE COURSE (DSC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Fundamentals of Statistical Mechanics and Thermodynamics **CH-DSC-203**	**04**	**02**	**-**	**02**	U.G. Chemistry	10+2 in Science with Mathematics

<u>Course Objective:</u>

- To develop a foundation in the core principles of classical and quantum statistical mechanics.
- To understand the concept of ensembles and their role in statistical mechanics.
- To explain how statistical methods connect macroscopic thermodynamic behavior with microscopic quantum systems.
- To apply these principles to systems such as ideal gases and monoatomic crystals.
- To study the Third Law of Thermodynamics and its implications using statistical mechanics.

<u>Learning Outcomes:</u> By the end of this course, students will be able to:

- Learn the fundamental principles of statistical mechanics linking microscopic properties to macroscopic observables.
- Understand the concept of ensembles and their significance in statistical mechanics.
- Explore the applications of the Boltzmann distribution in various physical systems.
- Understand and apply Bose-Einstein and Fermi-Dirac statistics.

- Students will be able to gain knowledge about monoatomic crystals and chemical equilibrium through molecular partition functions.

<u>Theory Course Contents:</u> **Credit 2 (30 hours)**

Unit I **15 Hours**

A. Fundamentals: Idea of microstates and macrostates. Concept of distributions- Binomial & multinomial distributions for non-degenerate and degenerate systems, Thermodynamic probability and most probable distribution. Lagrange's undetermined multipliers. Stirling's approximation

B. Ensemble Concepts, Canonical and other ensembles. Statistical mechanics for systems of independent particles and its importance in chemistry. Types of statistics: Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Thermodynamic probability (W) for the three types of statistics. Derivation of distribution laws (most probable distribution) for the three types of statistics. Molecular partition function and its importance. Assembly partition function.

Unit II: **15 Hours**

A. Applications to ideal gases: The molecular partition function and its factorization. Evaluation of translational, rotational and vibrational partition functions for monatomic, diatomic and polyatomic gases. The electronic and nuclear partition functions. Calculation of thermodynamic properties of ideal gases in terms of partition function. Statistical definition of entropy.

B. Ortho- and para-hydrogen, statistical weights of ortho and para states, symmetry number. Calculation of equilibrium constants of gaseous solutions in terms of partition function, perfect gas mixtures. Strongly and weakly degenerate Fermi and Bose gases (Qualitative discussion)
Einstein theory and Debye theory of heat capacities of monatomic solids.
Third law of thermodynamics, Residual entropy.

<u>Recommended Texts/References:</u>

1. McQuarrie, D. A. *Statistical Mechanics*, Viva Books Pvt. Ltd.: New Delhi (2003).
2. Reif, Frederick., Fundamentals of Statistical and Thermal Physics, McGraw-Hill, (1965).
3. Huang, Kerson, Statistical Mechanics, 2nd ed., Wiley (1987).
4. Pathria, R. K., and Paul D. Beale, Statistical Mechanics, 3rd ed., Elsevier (2011).
5. Pal, Palash B., Statistical Mechanics: Principles and Applications, Narosa Publishing House, (2008).
6. Bagchi B., Statistical Mechanics for Chemistry and Material Science, CRC Press (2018).
7. Landau, L. D. and Lifshitz, E. M. Statistical Mechanics, Part I, Butterworth-Heinemann, 3rd ed. (2005).
8. Laidler, K. J. *Chemical Kinetics* 3rd Ed., Benjamin Cummings (1997).

Practical Components: **Credit 2**

<u>CHEMICAL KINETICS</u>

1. Determine the specific reaction rate of the potassium persulphate-iodide reaction by the

Initial Rate Method.

2. Study the kinetics of the iodination of acetone in the presence of acid by the *Initial Rate Method*.

CONDUCTOMETRY

1. Study the conductometric titration of a mixture of a strong and weak acid.
2. Titrate a moderately strong acid (salicylic/ mandelic acid) by the, (a) salt-line method and (b) double alkali method.
3. Titrate a mixture of copper sulphate, acetic acid and sulphuric acid with sodium hydroxide.
4. Titrate a tribasic acid (phosphoric acid) against NaOH and $Ba(OH)_2$ conductometrically.
5. Titrate magnesium sulphate against $BaCl_2$ and its reverse titration.
6. Estimate the concentration of each component of a mixture of $AgNO_3$ and HNO_3 by conductometric titration against NaOH.
7. Determine the degree of hydrolysis of aniline hydrochloride.

POTENTIOMETRY

1. Determine the solubility and solubility product of an insoluble salt, AgX (X=Cl, Br or I) potentiometrically.
2. Determine the mean activity coefficient ($\gamma_\pm$) of 0.01 M hydrochloric acid solution.
3. Titrate phosphoric acid potentiometrically against sodium hydroxide.
4. Find the composition of the zinc ferrocyanide complex by potentiometric titration.
5. Titrate potentiometrically solutions of (a) KCl/ KBr/ KI; (b) mixture of KCl + KBr + KI and determine the composition of each component in the mixture.
6. Titrate Fe^{2+} with Ce^{4+} potentiometrically.
7. Determine zinc in the presence of calcium by potentiometric titration.
8. Verify the Debye-Hückel theory through the solubility of ionic salts.

Recommended Texts/References:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. McQuarrie, D. A. & Simon, J. D. *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books (2001).
3. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis, Brooks/Cole Pub Co; 7th edition (1 January 2017).
4. Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. Fundamentals of Analytical Chemistry, Publisher: Holt, Rinehart & Winston of Canada Ltd; International, 10th Revised edition (4th August 2021).

DISCIPLINE SPECIFIC ELECTIVE COURSES

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Group Theory and its Applications in Chemistry **CH-DSE-204**	**04**	**03**	—	**01**	U.G. Chemistry	--

Course Objectives:

The objective of this course is to understand symmetry of molecules and implication of symmetry aspect on molecular properties.

Learning Outcomes:

Upon successful completion of this course, students will be able to:

- Understand the fundamental mathematical concepts of group theory.
- Identify and classify symmetry elements and operations in molecules.
- Assign point groups to molecules systematically.
- Construct and interpret character tables for various point groups.
- Apply group theory principles to predict molecular properties such as polarity and chirality.
- Utilize group theory to simplify and analyze molecular orbitals and chemical bonding.
- Determine selection rules for various spectroscopic techniques (IR, Raman, UV-Vis) based on molecular symmetry.
- Apply group theory to understand and predict vibrational modes of molecules.
- Gain an appreciation for the power of symmetry in various chemical phenomena.

THEORY COMPONENT **(3 Credit: 45 Hours)**

UNIT I: FUNDAMENTALS OF SYMMETRY AND GROUP THEORY (09 Hours)

Introduction to Symmetry, Symmetry in nature and chemistry, Importance of symmetry in chemical problems, Symmetry elements and symmetry operations, definition of group and its characteristics, subgroups, classes, similarity transformation. Products of symmetry operations, equivalent atoms and equivalent symmetry elements, relations between symmetry elements and operations, classes of symmetry operations, point groups, and classification.

Group multiplication tables, Systematic assignment of molecular point groups (Schoenflies notation): Low symmetry groups (C_1, C_s, C_i), High symmetry groups (T_d, O_h, I_h), Special symmetry groups (C_{nv}, C_{nh}, D_n, D_{nh}, D_{nd}). Group generators, symmetry of Platonic solids. Relationship between symmetry and physical properties (polarity, chirality, optical activity).

UNIT II: REPRESENTATION THEORY AND CHARACTER TABLES (15 Hours)

Matrix Representation of Symmetry Operations, Representing symmetry operations by matrices, Reducible and irreducible representations, Properties of matrix representations: similarity transformation

Character Tables: Definition and significance of characters, The Great Orthogonality Theorem (GOT) and its consequences, Construction of character tables for simple point groups (e.g., C_{2v}, C_{3v}, C_{2h}, D_{3h}, C_{4v}), Properties of irreducible representations (IRs), Direct product of irreducible representations, Standard reduction formula for reducing reducible representations, position vector and base vector as basis for representation, some properties of vectors

UNIT III: APPLICATIONS IN CHEMICAL BONDING AND MOLECULAR ORBITALS (21 Hours)

Symmetry Adapted Linear Combinations (SALCs): Concept of basis sets and projection operators, Generating SALCs for various ligand types (sigma, pi), Construction of molecular orbitals for polyatomic molecules using SALCs, Examples: water, ammonia, methane, planar MX_3 and octahedral MX_6 complexes.

Symmetry and Bonding in Transition Metal Complexes: Ligand field theory and d-orbital splitting in various geometries (octahedral, tetrahedral, square planar) using group theory, Jahn-Teller effect from a symmetry perspective, Symmetry and bonding in metal carbonyls.

Spectroscopic Applications of Group Theory

Vibrational Spectroscopy (IR and Raman): Normal modes of vibration and their symmetries (3N Cartesian coordinates, internal coordinates), Determination of symmetries of vibrational modes using reducible representations, Selection rules for IR and Raman spectroscopy based on symmetry (activity of vibrational modes), Overtones, Hot bands, Combination bands, Ascent-Descent in Symmetry Relationships, Mutual exclusion principle, Examples: H_2O, CO_2, BF_3, NH_3, SF_6.

Electronic Spectroscopy (UV-Visible spectroscopy):

(i) Symmetry of molecular electronic states, Selection rules for electronic transitions (Laporte selection rule, spin selection rule), Symmetry aspects of charge transfer spectra.

(ii) Symmetry rules for Inorganic reactions, and Construction of correlation diagrams.

PRACTICAL COMPONENT **(1 Credit: 30 Hours)**

EXPERIMENTS:

1. Apply group theory to predict the number, symmetry, and IR/Raman activity of vibrational modes in selected ligands andtheir transition metal complexes ($[Co(NH_3)_6]^{3+}$, $[PtCl_4]^{2-}$, etc.).
2. Investigate the change in molecular symmetry and its spectroscopic consequences during structural transformations of metal carbonyl complexes (Octahedral to Tetrahedral Transformation or vice-versa).
3. Synthesize metal oxides (NiO, CuO, etc.) and characterize their vibrational properties using group theory to interpret the obtained spectra.
4. Any other relevant experiment from time to time during the semester.

References:

1. **F.A. Cotton,***Chemical Applications of Group Theory*, John Wiley & Sons, 1991.
2. **A. Vincent,***Molecular Symmetry and Group Theory: A Programmed Introduction to Chemical Applications*, John Wiley & Sons, 2013.
3. **K.V. Reddy,***Symmetry and Spectroscopy of Molecules*, New Age International Ltd. 2020.
4. **D.C. Harris and M.D. Bertolucci,***Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy*, Dover Publications. 1989.
5. **Davidson, G.** Group theory for chemists. London: Macmillan.1991.
6. Jaffe, H. H. &Orchin, M. Symmetry in Chemistry, Dover Publications (2002).
7. Hatfield, W. E. & Parker, W. E. Symmetry in Chemical Bonding & Structure. C. E. Merrill Publishing Co. USA (1974).
8. Garg, B.S. Chemical Applications of Molecular Symmetry and Group Theory, Macmillan Publishers India Ltd (2012).

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (CH-DSE-205)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Methods in Organic Synthesis **CH-DSE-205**	**4**	**3**	**0**	**1**	U.G. Chemistry	NIL

Course Objectives: The students will acquire knowledge on various metal catalyzed coupling reactions, reducing agents, oxidizing agents, protecting and deprotecting reagents and their applications in organic synthesis. To equip students with the knowledge and skills to design a synthesis.

Learning Outcome: Students will gain an understanding of the basic principles of metal catalyzed coupling reactions, reducing agents, oxidizing agents, protecting and deprotecting reagents and their applications in organic synthesis. Students will learn various synthetic methodologies employed in organic synthesis. After completing this course, the students will be able to design synthetic routes and execute them.

SYLLABUS OF CH-DSE-205

THEORY COMPONENT (3 Credit: 45 Hours)

UNIT I (15 Hours)

C-C, C-N, C-S, AND C-O BOND FORMATION REACTION

Introduction of various bond formation reactions at sp, sp^2 and sp^3 carbons, challenges in Csp^2-C, N, S, O bond formation reaction, Catalytic cycles for aromatic C-C, C-N, C-S, and C-O bond formation, Ligands, mono-, bi- and multidentate phosphine ligands and their uses in various catalytic reaction, Role of Pd, Cu and Ni based catalysts in C-C, C-N, C-S, and C-O bond formation (Applications: Stille, Suzuki and Sonogashira coupling, Heck reaction and Negishi coupling, Buchwald-Hartwig amination reactions).

C-H BOND ACTIVATION REACTION

Metal-catalysed C-H bond activation reaction at sp^2 carbon, Catalytic cycle involved in N-directed C-H activation reaction, Pd and Ru mediated N-Directed C-H activation reaction for C-C bond formation reactions

UNIT 2 **(15 Hours)**

Synthesis and applications of BuLi, Grignard reagent, organoaluminium, and organozinc reagents, lithium organocuprates, lower and higher order cuprates, organosilicon compounds.

REDUCTIONS

Stereochemistry, stereo-selection, and mechanism of catalytic hydrogenation and metal-liquid ammonia reductions.

HYDRIDE TRANSFER REAGENTS

Sodium borohydride, sodium cyanoborohydride, Triacetoxyborohydride, lithium aluminium hydride (LAH), and alkoxy-substituted LAH reducing agents, DIBAL.

HOMOGENEOUS HYDROGENATIONS

Mechanisms and applications using Rh, Ru, and other metal complexes for homogeneous hydrogenation.

UNIT 3 **(15 Hours)**

OXIDATIONS

Scope of the oxidizing reagents with relevant applications and mechanisms: Ceric Ammonium Nitrate, Sodium perborate, Tetramethyl piperidin-1-oxyl (TEMPO), Thallium nitrate, Selenium dioxide, Phase-transfer-catalyst (PTC), Crown ethers, Oxone, and sulphur. Tamao-Fleming Oxidation; Dimethyldioxirane (DMDO) Oxidation; DMSO (Barton modification & Swern Oxidation); Lead Acetate, Phenyliodine (III) diacetate (PIDA), Dess Martin periodinane, Tetrapropylammonium perruthenate, Ruthenium tetroxide. Sharpless Asymmetric epoxidation, Asymmetric hydroxylation, and aminohydroxylation.

Applications of hydroboration (reductions, oxidations, and carbonylation): Diborane, 9-BBN.

PRACTICAL COMPONENT **(1 Credit: 30 Hours)**

EXPERIMENTS

(i) TLCs (mixtures containing three or more compounds, and use of different visualizing/developing reagents).
(ii) Protection and deprotection reactions of carboxylic acids, amines, alcohols, 1,2-diols, aldehydes/ketones, etc.
(ii) Oxidation reactions of alcohols, aldehydes, etc.
(iii) Reduction reactions of aldehydes/ ketones, carboxylic acids, carbon-carbon multiple bonds, nitro compounds
(iv) Metals/ metal salts catalysed coupling reactions
(v) Bromination reactions involving allylic/ benzylic bromination and aromatic substitution reactions
(vi) Diazotisation reactions for substitutions and couplings

(vii) Condensation reactions
(viii) Esterification, transesterification and hydrolysis reactions
(ix) Preparation of phenoxyacetic acids and 2,4-D (2, 4-dichlorophenoxyacetic acid)

ESSENTIAL/RECOMMENDED READINGS

Theory

1. Carruthers, W. *Modern Methods of Organic Synthesis* Cambridge University Press (1996).
2. Carey, F.A. & Sundberg, R. J. *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
3. March, J. *Advanced Organic Chemistry* John Wiley & Sons (1992).

Practical

1. Pasricha, S., Chaudhary, A. (**2021**), Practical Organic Chemistry: Volume–I, I K International Publishing house Pvt. Ltd, New Delhi
2. Pasricha, S., Chaudhary, A. (**2021**), Practical Organic Chemistry: Volume–II, I K International Publishing house Pvt. Ltd, New Delhi
3. Vogel, A. I. (**2012**). Quantitative Organic Analysis, Part 3, Pearson Education
4. Furniss, B. S., Hannaford, A. J., Smith, P.W.G., Tatchell, A. R. (**2012**), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson
5. Ahluwalia, V.K., Dhingra, S. (**2004**), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Electrochemistry, Macromolecules and Chemical Kinetics: Statistical Approach **CH-DSE-206**	**04**	**03**	**-**	**01**	U.G. Chemistry	10+2 in Science with Mathematics

Course Objective:

- To provide a comprehensive understanding of electrolytes and electrochemical interfaces through the principles of Statistical Mechanics and Thermodynamics.
- To introduce foundational concepts in macromolecular science and chemical kinetics.
- To explore the structure, synthesis, and properties of macromolecules such as polymers and biopolymers.
- To examine chemical reaction mechanisms, rate laws, and kinetic modeling of chemical systems.
- To develop the ability to analyze and design macromolecular and reactive systems in industrial and biological contexts.

Learning Outcomes: By the end of this course, students will be able to:

- Apply the Boltzmann distribution and statistical thermodynamics to analyze ionic systems and interpret activity coefficients in electrolyte solutions.
- Describe the structural features, classifications, and physical properties of macromolecules.
- Model chemical reaction rates, mechanisms, and rate laws in both homogeneous and heterogeneous systems using principles of chemical kinetics.
- Explain the role of catalysis-including enzyme and heterogeneous catalysis—and solve problems involving chain reactions, photochemical kinetics, and complex mechanisms.
- Relate the kinetic behavior of macromolecular systems to their functional performance in both industrial and biological applications.

Theory Course Contents: **Credit 3 (45 hours)**

Unit I: **15 hours**

A. Poisson-Boltzmann equation, Derivation of Debye-Hückel model of dilute electrolytic solution, Ionic atmosphere and Debye screening length, Contribution of the Ionic Cloud to the electrostatic potential at central ion and chemical potential change, Activity coefficients and ion-ion interactions. Physical significance of activity coefficients, mean activity coefficient of an electrolyte and its determination. Finite ion size correction to model.

B. Derivation of Gouy-Chapman diffuse charge model of the double layer and capacitance. Qualitative discussion of electric double layer.

Unit II: **15 hours**

Macromolecules: Concepts of number average and mass average molecular weights. Methods of determining molecular weights (osmometry, viscometry, sedimentation equilibrium methods). Theta state of polymers. Distribution of chain lengths. 1-D random walk model in detail, Average end-to-end distance. Brownian Dynamics (Qualitative discussion).

Unit III: **15 hours**

A. Theories of reaction rates: Collision theory. Potential energy surfaces (basic idea). Transition state theory (both thermodynamic and statistical mechanics formulations). Theory of unimolecular reactions, Lindemann mechanism, Hinshelwood treatment, RRKM model (qualitative treatment).

B. Solution kinetics: Factors affecting reaction rates in solution. Effect of solvent and ionic strength (primary salt effect) on the rate constant. Secondary salt effects.

Recommended Texts/References:

1. Bockris, John O'M. and Reddy, A.K. N. Vol 1: Modern Electrochemistry, Ionics, 2nd Edition Springer (1998)
2. Bockris, John O'M., Reddy, A.K. N. and Gamboa-Aldeco, M. Modern Electrochemistry, Vol 2A, Fundamental of Electrodes, 2nd Edition Springer (2000)
3. Atkins, P and Paula, Julio de. Atkin's Physical Chemistry, Oxford University Press, (2002).
4. Laidler, K. J., Chemical Kinetics 3rd Ed., Benjamin Cummings (1997).
5. Billmeyer, F. W., Textbook of Polymer Science, 3rd Ed., Wiley-Interscience: New York (1984).
6. Teraoka, I., Polymer Solutions: An Introduction to Physical Properties, John Wiley & Sons, (2002).

Practical Components: **Credit 1**

1. Conductometric Study of critical micellar concentration (cmc).
2. Calculation of the thermodynamic parameters of micellization of surfactants from (a) conductivity and (b) spectroscopic measurements.
3. Study of the oscillating reaction in redox systems.
4. Determine the dissociation constant of an indicator (phenolphthalein) using calorimetry/spectroscopy.
5. Study the kinetics of the reaction of phenolphthalein with sodium hydroxide.
6. Study the kinetics of the reaction of crystal violet with sodium hydroxide.
7. Determine the molecular weight of macromolecules by the viscosity method.
8. Determine the viscosity-average molecular weight of poly (vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.

Recommended Texts/References:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), Senior Practical Physical Chemistry, R. Chand & Co, New Delhi.
2. McQuarrie, D. A. & Simon, J. D. *Physical Chemistry: A Molecular Approach* 3rd Ed., Univ. Science Books (2001).
3. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis, Brooks/Cole Pub Co; 7th edition (1 January 2017).
4. Skoog, D. A.; West, D. M.; Holler, F. J.; Crouch, S. R. Fundamentals of Analytical Chemistry, Publisher: Holt, Rinehart & Winston of Canada Ltd; International, 10th Revised edition (4th August 2021).

SKILL ENHANCEMENT COURSES

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SKILL ENHANCEMENT COURSE (SEC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title &Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Hands-on Training of Analytical Instrumentation **CH-SEC-207**	**02**	**01**	—	**01**	U.G. Chemistry	--

Course Objectives:

The course is designed to provide the learning of development of chemistry related models/hands-on training such as sampling for various analytical instruments, which is crucial for higher studies students in materials science, chemistry, and related fields.

Learning Outcomes:

The students will understand the principals of numerous characterization related to their work. Seriousness of safety protocols with various instruments and materials. Components of sample preparation for mentioned techniques: sample quantity, sample form, sample conductivity, sample thinning, sample holder, sample mounting, selection of suitable solvent, crucible selection, reference materials, purge gas selection, interpretation of resulting data etc.

THEORY COMPONENT **(1 Credit: 15 Hours)**

Unit-I : **(15 Hours)**

X-ray diffraction: Brief discussion of principles of X-ray generation, diffraction phenomena and the components of a diffractometer. Sample handling, data analysis techniques like peak indexing, phase identification, and quantitative analysis, including the effects of crystallite size and strain. Applications in materials science, medical, forensic science, mining and mineralogy etc.

Thermogravimetric Analysis and Differential Thermal Analysis: Principles, instrumentation, data interpretation, and applications of both techniques. Theoretical concepts, practical exercises and case studies to provide a thorough understanding of thermal analysis methods.

X-Ray Photoelectron Spectroscopy: Operational fundamentals, components, sample preparation, data acquisition and spectral interpretation.

Auger Electron Spectroscopy: Brief outline of principles, components of an AES system (i.e vacuum system, electron gun, electron energy analyzer etc.), sample handling. Applications in elemental surface analysis, imaging, chemical state analysis etc.

Scanning and Transmission Electron Microscopy: Principles and fundamentals of electron microscopy, its components, and practical applications including sample preparation and image interpretation. Applications in materials science, nanotechnology, biology etc.

PRACTICAL COMPONENT **(1Credit: 30 Hours)**

EXPERIMENTS:

1. Rietveld refinement for crystal structure determination, refinement of crystal structure, stress-strain analysis, use of Bragg's law and all related assignments.

2. Hands on training on Thermogravimetric Analysis and Differential Thermal Analysis.

3. Introduction, experimental setup, instrumentation (electrodes, potentiostat, data acquisition system etc), data analysis and interpretation using Cyclic Voltammetry.

4. Surface area analysis and the procedures for sample preparation, measurement and data analysis using Brunauer-Emmett-Teller (BET) instrument.

5. Electromagnetic spectrum, electronic transitions, function of various components like light sources, monochromators, sample holders, detectors, and recording of spectra using UV-Vis spectrophotometry.

6. Fundamental of instrumentation (light sources, wavelength selection, atomization, beam, signal processing etc.) and interferences, applications in environmental analysis, clinical chemistry, food science, pharmaceutical analysis, quality control etc. using atomic absorption spectrophotometer.

References (Theory):

1. Elements of X-Ray Diffraction, B.D. Cullity, Pearson; 3rd edition (2001), ISBN-13 : 978-0201610918.

2. Thermal Analysis: From Introductory Fundamentals to Advanced Applications, El-Zeiny Ebeid, Mohamed Barakat Zakaria, Elsevier - Health Sciences Division (2021), ISBN-13 : 978-0323901918

3. X-ray Photoelectron Spectroscopy - An Introduction to Principles and Practices, P van der Heide, John Wiley & Sons Inc; 1st edition (2012), ISBN-13 : 978-1118062531.

4. Auger- and X-Ray Photoelectron Spectroscopy in Materials Science: A User-Oriented Guide, Siegfried Hofmann, Springer; 2013th edition (2012), ISBN-13 : 978-3642273803.

5. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM, R.F. Egerton, Springer Cham (2016), ISBN978-3-319-39876-1.

References (Practical):

1. Powder Diffraction: The Rietveld Method and the Two Stage Method to Determine and Refine Crystal Structures from Powder Diffraction Data, Georg Will, Springer Science & Business Media (2006), ISBN: 9783540279860.

2. Electroanalytical Methods, Guide to Experiments and Applications, Fritz Scholz, Springer Berlin, Heidelberg (2002), ISBN: 978-3-662-04757-6.

3. Characterization of Porous Solids and Powders: Surface Area, Pore Size and Density, S. Lowell , Joan E. Shields , Martin A. Thomas , Matthias Thommes, Springer Dordrecht (2004), ISBN: 978-1-4020-2302-6.

4. UV-VIS Spectroscopy and Its Applications, Perkampus Heinz-Helmut, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG, ISBN: 9783540554219.

5. Atomic Absorption Spectrometry: Theory, Design and Applications, S.J. Haswell, Edition: 1, Volume: 5, Elsevier Science (1991), ISBN: 9780444882172

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SKILL ENHANCEMENT COURSE (CH-SEC-208)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Hands-on Training of Separation Techniques **CH-SEC-208**	**2**	**1**	**0**	**1**	U.G. Chemistry	NIL

Course Objectives

The objectives of this course are as follows:

- To learn about the fundamentals of separation techniques employed in organic synthesis and purification of organic compounds.
- To understand instrumentation (hardware/software) understanding of equipment usually employed in analysis and identification of organic compounds.
- Hands-on training on several sophisticated spectroscopic instruments and separation techniques employed in organic synthesis.

Learning outcomes

After completing the course, the students will:

- Gain experience in various separation techniques typically employed for monitoring reaction progress and purification of pure compounds from mixture.
- Be able to work independently on sophisticated equipment used in organic synthesis, correlating with the principle and the instrumentation part.

SYLLABUS OF CH-SEC-208

THEORY COMPONENT **(1 Credit: 15 Hours)**

UNIT 1: **(15 Hours)**

THIN LAYER CHROMATOGRAPHY

Principle of using TLC in monitoring organic reactions, Polarity of Solvents, Retention factor, Principle and application of HP TLC.

COLUMN CHROMATOGRAPHY

Theory of Column Chromatography, Gradient Solvent Systems, Application of Column Chromatography in purification of mixtures.

GAS CHROMATOGRAPHY

Basics and applications of GC, Instrumentation of GC, Applications of GC.

HIGH-PERFORMANCE LIQUID CHROMATOGRAPHY

Basics and Instrumentation of HPLC, Normal & Reverse Phase HPLC, Preparative HPLC, Applications of HPLC.

OPTICAL ROTATION

Importance of optical activity, Instrumentation of Polarimeter, Sample preparation, Recording Optical rotation of organic compounds.

PRACTICAL COMPONENT (1 Credit: 30 Hours)

1. (a) To determine the number of organic compounds, present in the given mixture by TLC, and calculate their respective R_f values.

(b) To determine the relative polarities of a set of given organic compounds by comparing their R_f on TLC.

2. (a) To separate a mixture of two or more non-polar organic compounds by column chromatography using gradient solvent system (Hexanes/EtOAc).

(b) To separate a mixture of two or more medium/high polarity organic compounds by column chromatography using gradient solvent system.

3. (a) Hand-on training on running a Gas Chromatography instrument.

(b) To optimize the base peak while running Gas Chromatography.

(c) To separate a mixture of essential oils using Gas Chromatography.

4. (a) Hand-on training on running a HPLC instrument.

(b) To optimize the base peak while running HPLC machine.

(c) To separate a mixture of medium polarity diastereomers with C-18 column using a reverse phase HPLC.

(d) To separate a mixture of enantiomers (e.g. diastereomers) with a chiral column using a reverse phase HPLC.

5. (a) Hand-on training on running a polarimeter and sample preparation.

(b) To measure the optical rotation of a pair of enantiomers.

ESSENTIAL/RECOMMENDED READINGS

- Furniss B. S., Hannford A. J., Smith, P. W. G., Tatcheli, A. R., “Vogel's Textbook of Practical Organic Chemistry” 5th ed., Longman Scientific &Technical.
- Kemp W., 'Organic Spectroscopy', 3rd ed., Palgrave, New York (1991).
- Willard H. H., Merritt Jr. L. L., Dean J. A., Settle F. A. S., “Instrumental Methods of Analysis”, 7th Ed., Wadsworth, 2009, Cengage Learning India Pvt. Ltd. Fifth Indian reprint by CBS Publishers & Distributors Pvt. Ltd.
- Silverstein R. M., and Webster F. X., “Spectrometric Identification of Organic Compounds”, 6th ed., John Wiley & Sons, New York (1998).
- Skoog D. A., Holler F. J., and Crouch S. R., “Principles of Instrumental Analysis”, 6th ed., Thomson Brooks/Cole, Cengage Learning, New Delhi (2007).

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

SKILL ENHANCEMENT COURSE (SEC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Recent Trends in Advanced Molecules and Materials **CH-SEC-209**	**02**	**01**	-	**01**	U.G. Chemistry	10+2 in Science with Mathematics

Course Objectives:

- To provide a comprehensive understanding of the synthesis, properties, and applications of advanced nanomaterials and nanoparticles.
- To develop knowledge of polymeric materials, liquid crystals, and their technological applications in modern materials science.
- To equip students with the skills to understand and apply various thin film deposition techniques and Langmuir-Blodgett film fabrication.
- To introduce the fundamentals and applications of optoelectronic materials and luminescent molecules in sensors and lighting technologies.
- To foster the ability to critically analyze material characteristics in relation to synthesis methods and their impact on functional applications in nanotechnology and materials science.

Learning outcomes: On successful completion of the course, students will be able to:

- To explain the fundamental concepts of advanced nanomaterials, including quantum dots, quantum confinement, and their applications, along with methods for nanoparticle synthesis and stabilization.
- To describe the properties, types, and applications of polymeric materials, including conducting and ferroelectric polymers, and to understand the mesomorphic behavior and phase transitions in liquid crystals.
- To demonstrate knowledge of various thin film preparation techniques and Langmuir-Blodgett film growth methods and their significance in material science.

- To identify and explain the characteristics and applications of optoelectronic materials, including luminescent phosphors, rare-earth based, semiconducting, and organic molecules used in lighting and sensing.
- To analyze the relationship between material synthesis methods, structure, and functional properties for applications across nanotechnology, polymer science, thin films, and optoelectronics.

Theory Course Contents: **Credit 1 (15 hours)**

Unit I:

A. Advanced Nanomaterials: Quantum dots, band gap, excitons, quantum confinement effect, Bhor's radius. Applications of Quantum dots, Methods of preparation nano particles, Chemical synthesis, Self-assembly processes, stabilization, different reducing agents, stability of nano particles, reactivities and catalytic activities of nanoparticles, different applications. Top down and bottom up approach in nano technology, Green synthesis: clean routes, super critical solvents, ionic liquids, green catalyst, auto exhaust catalyst and clean technology.
B. Polymeric Materials, polymer types and their applications, conducting and ferro-electric polymers; Liquid Crystals, Mesmorphic behavior, thermotrophic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases; smectic–nematic transition.
C. Thin film and Langmuir-Blodgett Films: Preparation techniques; evaporation/sputtering, chemical processes, MOCVD, sol-gel etc. Langmuir-Blodgett (LB) Film, growth techniques.
D. Optoelectronic Materials and molecules: Luminescent phosphor materials including rare-earth based, semiconducting and organic based molecules and materials for lighting/sensor and other applications.

Recommended Texts/References:

1. West, A.R. Solid State Chemistry and its Applications, John Wiley & Sons, 2nd Edition, (2014)
2. Nanomaterials Chemistry: Recent Developments and New Directions by C. N. R. Rao, A. Muller and A. K. Cheetam, Willey- VCH Gmbh & Co (2007).
3. Cao, G. Nanostructures and Nanomaterials: Synthesis, Properties and applications, Imperial College Press, London (2011).
4. Sylvia, L. Nanomaterials (Architecture & Design), Springer Verlag (2008)
5. Brechignac,C. Houdy, P. and Lathmani, M. Nanomaterials and Nanochemistry by, Springer Verlag, Berlin, 1st Edition, 2007.
6. Callister, W. D. Materials Science and Engineering, an Introduction, Willey, 10th Edition, 2018.
7. Thermotropic Liquid Crystals, Ed., G. W. Gray, John Willey (1987).

Practical Contents: **Credit 1**

1. (a) Synthesis of any semiconducting nanomaterials (CdSe, ZnSe, In_2S_3 etc.) and (b) understanding their structural and optical properties like band gap, luminescence, recombination etc. using available laboratory equipments.
2. (a) Preparation of a polymer from their monomer counterpart and (b) their characterization using available equipment and chemicals.

3. (a) Preparation of a liquid crystal using simple soft chemical route in laboratory and (b) their characterization using available equipment and facility.
4. (a) Synthesis of Lanthanide doped nanophosphors using any soft chemical approach and (b) understanding their phosphorescence and other properties.
5. (a) Synthesis of any ionic liquid (for example any imidazolium based ionic liquid) and (b) then confirming its structure by FTIR, ^1H NMR studies and other techniques.

Recommended Texts/References:

1. Nanomaterials Chemistry: Recent Developments and New Directions by C. N. R. Rao, A. Muller and A. K. Cheetam, Willey- VCH Gmbh & Co (2007).
2. Gurtu, J.N. Advanced Physical Chemistry Experiments, Pragati Publications, (2008)
3. Khosla, B.D. , Garg, V.C. and Gulati, A. Senior Practical Physical Chemistry by (R. Chand & Co, New Delhi), 18th Edition, 2018
4. Lakowicz, J. R Principles of Fluorescence Spectroscopy, 2nd edition, 1999
5. Banwell, C. N. Fundamentals of Molecular Spectroscopy, 4th Edition, 2017
6. Kemp. W. Organic Spectroscopy, Third Edition, 2002

SKILL ENHANCEMENT COURSE (SEC)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURS

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Concepts and Applications of Artificial Intelligence and Machine Learning in Chemistry **CH-SEC-210**	**02**	**01**	**-**	**01**	U.G. Chemistry	10+2 in Science with Mathematics

Course Objectives:

- To understand core concepts and types of AI/ML
- To learn the mathematical foundations of ML
- To explore AI/ML applications in chemistry (e.g., drug discovery, materials design)
- To apply AI/ML to molecular modelling, quantum chemistry, and catalysis
- To gain practical experience with AI/ML tools for chemical problem-solving

Learning Outcomes: On successful completion of the course, students will be able to:

- Grasp key AI/ML concepts, including data handling, training, and evaluation
- Build and evaluate models (e.g., regression, classification, neural networks) for chemical problems
- Apply AI/ML to property prediction, reaction pathways, and spectroscopy
- Enhance quantum chemistry workflows using AI/ML techniques

Theory Component **Credit: 1 (15 h)**

Unit I: **15 hours**

A. Introduction to AI/ML in Chemistry: Description and overview of Artificial Intelligence (AI) and Machine Learning (ML). Data pre-processing, model selection, training, and evaluation. Types of learning: Supervised and unsupervised learning, Chemistry-specific challenges in applying AI/ML.

Regression and classification models (Linear Regression, SVMs, Decision Trees), Kernel Ridge regression, Neural networks and deep learning. Importance of classical numerical methods in AI/ML Models

B. Qualitative/brief ideas on AI/ML applications across domains of

- Healthcare: AI-assisted diagnosis, treatment planning, and medical image analysis
- Finance: Detection of fraud, algorithmic trading, and risk evaluation
- Transportation: Self-driving vehicles and traffic flow optimization
- Education & Communication: AI-powered chatbots, adaptive learning
- Scientific and Industrial Research: Molecular & Pharmaceutical Chemistry: Drug discovery, reaction pathway modeling, molecular docking, and binding affinity prediction, Spectroscopy & Quantum Chemistry: AI-driven prediction of IR, NMR, Raman spectra; enhancing quantum chemical computations. Emerging trends and future directions in AI.

References:

1) Machine Learning in Chemistry: The Impact of Artificial Intelligence, Hugh M Cartwright (Ed), Royal Society of Chemistry; 1st edition (2020)
2) Machine Learning in Chemistry" by Jon Paul Janet, Heather J. Kulik, American Chemical Society (2020)
3) Applications of Artificial Intelligence in Chemistry, Hugh M. Cartwright, Oxford Chemistry Primers (1994)
4) Quantum Chemistry in the Age of Machine Learning, Pavlo O. Dral, Elsevier - Health Sciences Division (2022)
5) A Gentle Introduction to Machine Learning for Chemists: An Undergraduate Workshop Using Python Notebooks for Visualization, Data Processing, Analysis, and Modeling, *J. Chem. Educ.* 2021, 98, 9, 2892–2898
6) Combining Machine Learning and Computational Chemistry for Predictive Insights Into Chemical Systems, *Chem. Rev*. 2021, 121, 9816−9872
7) Current and Future Roles of Artificial Intelligence in Medicinal Chemistry Synthesis, *J. Med. Chem.* 2020, 63, 8667−8682

8) Artificial Chemical Intelligence: AI for Chemistry and Chemistry for AI by Prof. Pratyush Tiwary, Link: https://www.youtube.com/watch?v=B3wn3C2ANUw

Lab Components **Credit: 1**

1) Fit a polynomial curve using Excel or spreadsheets (linear, quadratic, cubic, quartic, etc) to find a trendline.
2) Examine interpolation to find the missing data.
3) Examine extrapolation to predict future values or trends.
4) Write a program for data interpolation: from classical methods to machine learning regression models.
5) Write a program for data extrapolation: from classical methods to machine learning regression models.
6) Write a program to implement gradient descent from scratch and apply it to linear regression, highlighting the role of numerical optimization in machine learning model training.
7) Write a program to solve systems of linear equations in ML models.
8) Write a program that demonstrates how numerical methods for solving differential equations can be integrated into ML models
9) Running a simple neural network model in machine learning.
10) Use neural networks for Potential Energy Surface (PES) fitting.
11) Train regression models to predict spectra from structural data.
12) Exploring tools like Jupyter notebooks/Google Colab and libraries like Numpy, scikit-learn, PyTorch etc. for chemistry research, education, and data analysis.

Recommended Texts/References:

1. A Gentle Introduction to Machine Learning for Chemists: An Undergraduate Workshop Using Python Notebooks for Visualization, Data Processing, Analysis, and Modeling, *J. Chem. Educ.* 2021, 98, 9, 2892–2898
2. The Dawn of Generative Artificial Intelligence in Chemistry Education, *J. Chem. Educ.* 2024, 101, 2957−2959
3. Combining Machine Learning and Computational Chemistry for Predictive Insights into Chemical Systems, *Chem. Rev*. 2021, 121, 9816−9872
4. a) https://jupyter.org/ b) https://www.python.org/ c) https://numpy.org/ d) https://scikit-learn.org/stable/ e) https://pytorch.org/

GENERIC ELECTIVE COURSES

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GENRIC ELECTIVE (GE)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Introductory Chemistry of The Earth's Atmosphere **CH-GE-211**	**04**	**03**	—	**01**	U.G. Chemistry	--

Course objectives

Atmospheric chemistry encompasses the branch of chemistry which deals with the chemical composition and the reactions happening within the earth's atmosphere. Owing to the current scenario where pollution outstands as a major threat to environment and mankind. For example, the depletion of ozone layer and extending insights into ozone recovery, visibility degradation, acid rain phenomena, smog events, and climate change issues, and other hazards of the chemical reactions taking place in the atmosphere all through advancing scientific knowledge of atmospheric reactivity. This paper will give students the understanding the basic chemistry happening within the earth's atmosphere.

Learning outcomes

On successful completion of the paper the student will have a firm understanding about the chemical composition and its reactivity within the earth's atmosphere. One will learn the impact of trace chemicals and its reactivity, how analytical instrumentation can be used to measure chemical composition of trace chemicals in the earth's atmosphere. Students will also learn the global crisis due to ozone depletion, acid rain, climate change.

THEORY COMPONENT **(3 Credit: 45 Hours)**

Unit-1: INTRODUCTION TO THE EARTH'S ATMOSPHERE **(15 Hours)**

(i) Composition & Evolution of the Earth's atmosphere – History of earth's atmosphere in early times - Layers of atmosphere – Proportion of gases in the atmosphere - Pressure and Temperature variations. Types of atmospheric reactions – Photolysis – Bimolecular

(ii) Atmospheric Photochemistry & BioGeoChemical Cycle of Mercury

Photochemistry – Absorption of radiation by atmospheric gases – Absorption by O_2 and O_3 – Photolysis rate as a function of altitude – Photodissociation of O_3, NO_2. GeoChemical cycle of mercury – Mercury oxidation by bromine – mercury deposition in the ocean

(iii) Aerosols and Other Physical Processes:

Aerosols – formation – Size distribution – Chemical composition – Oxidation of SO_2 to sulfate – Sea salt aerosal – aerosol nitrate - thermodynamics of aerosols; Nucleation – Classical theory of homogeneous nucleation – Experimental measurement of nucleation rates – heterogeneous nucleation - Wet and dry deposition. Glyoxal as a source of organic aerosol.

Unit-2: ROLE OF CHEMICAL COMPOUNDS ON OZONE BUDGET (15 Hours)

Chemical composition of the Earth's atmosphere – Compounds containing Sulfur, Nitrogen, Carbon, Halogens – Green House gases – Global climate change and carbon foot print – Major Atmospheric pollutants and its sources - Atmospheric Ozone – Ozone production effciency – Isoprene effect - Ozone loss – role of the chemical compounds – Atmospheric lifetimes – Theories – Determination of the lifetimes – Laser Induced Fluorescence Studies (LIF measurements) – Cavity Ring Down method; Radicals in the Earth's atmosphere – Ozone generation – Global warming – Global Warming Potential (GWP) – Ozone Depletion Potential (ODP)

Unit-3: CHEMISTRY OF TROPOSPHERE AND STRATOSPHERE (15 Hours)

(i) Troposphere – Chemistry of hydroxyl radicals – Photochemical cycles of NO_2, NO and O_3 – Chemistry of NO_x and Methane – Mapping and partitioning NO_x Tropospheric reservoir molecules – H_2O_2, CH_3OOH, HONO, PAN, Role of VOC and NO_x in the ozone formation – Chemistry of VOCs – sulfur compounds – nitrogen compounds;

(ii) Stratosphere – Chapman mechanism – HO_x cycle – HO_x catalysed ozone loss - NO_x catalysed ozone loss - Halogen cycles – Antarctic ozone hole – Polar stratospheric clouds – Heterogeneous stratospheric chemistry – Global sulfur and carbon cycles – Role of H_2O in both troposphere and the stratosphere – Biomass Burning - Acid rain.

PRACTICAL COMPONENT **(1Credit: 30 Hours)**

EXPERIMENTS:

1. Synthesis & Instrumentation: Synthesis of aerosol nanoparticles, AAS and AES Instrumental technique. Qualitative & Quantitative analysis experiments to confirm the presence of Mercury, Cadmium and other inorganic pollutants.
2. Physical characterization methods using FT-IR, UV-Visible experiments
3. Separation Techniques: Fundamentals of GC and hyphenated techniques GC-MS Ex. Identification of key oxidants and breakdown products of Volatile hydrocarbons.
4. Experiments related to DSC and Thermal analysis. Eg. Experiment related to emulsification of dicarboxylic acid.
5. Any other relevant experiment from time to time during the semester.

References (Theory):

2. Atmospheric chemistry and Physics by John H. Seinfeld, Spyros N. Pandis; Second edition, John Wiley, 1997.
3. Introduction to Atmospheric Chemistry by Daniel J. Jacob, Princeton University Press, 1999.
4. Introduction to Atmospheric Chemistry by Peter V. Hobbs, Cambridge University Press, 1st edition, 2000.
5. Chemistry of Atmospheres: An Introduction to the Chemistry of the Atmospheres of Earth, the Planets, and Their Satellites by Richard P. Wayne, Cambridge University Press, 3rd edition, 1991.
6. Atmospheric Chemistry by IstvánLagzi, RóbertMészáros, GyörgyiGelybó, and ÁdámLeelőssy Copyright © 2013 EötvösLoránd University.

References (Practical):

1. Vogel's Qualitative Inorganic Analysis – Arthur. I. Vogel , Imperial College, Longmans, Green And Co, London, New York, Toronto, 1937 or 7th Edition – G. Svehla and B. Ravisankar, Pearson Education 2008.
2. Textbook of quantitative chemical analysis – Arthur. I. Vogel, Longman Publisher, 5th edition 1989.
3. Quantitative Chemical Analysis 7th Edition Daniell C. Harris, Freeman & Company, New York 2007.

4. Principles of Instrumental Analysis – Douglas A. Skoog, F. James Holler & Stanley R. Crouch 7th Edition, Cengage Learning, Australia, 2018

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

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GENERIC ELECTIVE COURSE (CH-GE-212)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Medicines and Therapeutics in Daily Life **CH-GE-212**	**4**	**3**	**0**	**1**	B.Sc. (any stream)	NIL

Course Objectives: The course is designed to study the basic details about various therapeutics of general uses, which are crucial for various diseases. This course also gives the knowledge of active pharmaceutical ingredients in some medicines, their synthesis; therapeutic effects and side effects on human physiology. Therapeutics are essential for a healthy day-to-day life and therefore this course will aware the students about its positive and negative effects.

Learning Outcomes:
By the end of the course, the students will be able to:
- Understand the role of different therapeutics on human physiology.
- Gain the knowledge of active pharmaceutical ingredient and their roles in different diseases.
- Learn the proper use of different therapeutics and their effect and side effects.
- Learn the techniques of administering blood group, pulse rate, blood pressure and may other general diagnostic applications.

SYLLABUS OF CH-GE-212

THEORY COMPONENT **(3 Credit: 45 Hours)**

UNIT 1: **(15 Hours)**

DIFFERENT CLASSES OF MEDICINES

Introduction- Health, disease, drugs, chemotherapy, classification of drugs and their origin. Structure of active ingredients, uses, dosage, side effects and their natural remedies: *Analgesics and antipyretics*- Aspirin, paracetamol, ibuprofen, morphine, codeine *Antibiotics*- Amoxicillin, norfloxacin, ciprofloxacin; *Antihistamines* or *antiallergics*- Cetrizine and Levocetrizine (role of stereoisomers); *Antiparasitic*- Albendazole; Antidiabetics- Insulin, Glipizide and metformin; *Antihypertensive*–Amlodipine and its natural remedies- Rauwolfia; Diuretic- Lasix; *Antidepressant*- Zoloft and its natural treatment; *Antifungal* – fluconazole, Ketoconazole, Itraconazole; Antacids- Ideal properties of antacids, combinations of antacids, Sodium bicarbonate, ranitidine, milk of magnesia, aluminium hydroxide gel; *Anticoagulants/antiplatelet drugs*- Warfarin, heparin and Ecosprin; *Anaesthetics*- Atracurium, Desflurane. Synthesis of small-molecule drugs like aspirin and paracetamol.

UNIT 2: **(15 Hours)**

VACCINES AND SEDATIVE/ HYPNOTIC DRUGS

Introduction to Vaccines and Their Significance in Immunisation Against Life- threatening diseases. Classification of Vaccines with examples - live attenuated, inactivated, subunit, toxoid, mRNA, and viral vector vaccine.

Sedative and hypnotic drugs and their classification. Structure of active ingredients, uses, dosage, side effects and their natural remedies- Benzodiazepines (e.g. diazepam, alprazolam), Barbiturates (e.g. phenobarbital, secobarbital), Z-drugs (e.g. zolpidem, zaleplon), *Antidepressant*- Zoloft and its natural treatment.

UNIT 3: **(15 Hours)**

MEDICINAL PLANTS

Introduction to medicinal plants, Primary vs. secondary metabolites, Major classes of bioactive compounds: alkaloids, glycosides, flavonoids, terpenoids, tannins, saponins. Active principles, and therapeutic uses of important medicinal plants- *Azadirachta indica* (Neem), *Withania somnifera* (Ashwagandha), *Ocimum sanctum* (Tulsi), *Phyllanthus amarus, Aloe vera, Tinospora cordifolia* (Giloy), *Curcuma longa* (Turmeric), Ginkgo biloba, Tea tree oil. Role of medicinal plants in drug discovery, Examples of plant-derived modern drugs (e.g., morphine, quinine, artemisinin).

PRACTICAL COMPONENT **(1 Credit: 30 Hours)**

1. Determination of heart rate and pulse rate, blood pressure and discussion on medicines affecting them.

2. Synthesis of Benzimidazole, precursor for various pharmaceutical agents.
3. Synthesis of Benzocaine, a topical pain reliever.
4. Isolation of paracetamol (API) from a commercial tablet
5. Isolation of aspirin (API) from tablet and recording of melting point (synthesis needs discussion)
6. Estimation of Vitamin C.
7. To perform the ibuprofen/aspirin assay as per I.P. and determine its percentage purity.
8. Extraction of phytochemicals (demonstration of alkaloid or flavonoid extraction).
9. To isolate caffeine from tea leaves using solvent extraction techniques.
10. Visits to herbal gardens, research institutes, or pharmaceutical industries.

ESSENTIAL/RECOMMENDED READINGS

Theory:

1. Patrick, G. L. (2001). Introduction to Medicinal Chemistry, Oxford University Press.
2. Lemke, T. L. & William, D. A. (2002), Foye's Principles of Medicinal Chemistry, 5th Ed., USA.
3. Singh H.; Kapoor V.K. (1996), Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan.
4. Chatwal, G.R. (2010), Pharmaceutical chemistry, inorganic (vol. 1), Himalayan publishing house.
5. Prasad, A. K. (2022) Vaccine Development: From Concept to Clinic, RSC.
6. Beale, Jr., J. M.; Block, J. H. (2023) "Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry", Lippincott Williams & Wilkins.
7. Pengelly, A. (2021) "The Constituents of Medicinal Plants", CAB International.
8. Swamy, M. K.; Patra, J. K.; Rudramurthy, G. R. (2019), Medicinal Plants Chemistry, Pharmacology, and Therapeutic Applications, CRC Press.

Practical:

1. Jeffery, G.H., Bassett, J., Mendham, J., Denney, R.C. (1989), Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.
2. Ahluwalia, V.K., Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
3. Munwar, S., Ammaji, S. (2019), Comprehensive Practical Manual of Pharmaceutical Chemistry, Educreation Publishing.
4. Mondal, P., Mondal, S. (2019), Handbook of Practical Pharmaceutical Organic, Inorganic and Medicinal chemistry, Educreation Publishing.

Assessment methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.

GENRIC ELECTIVE (GE)

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical /Practice		
Modern Materials of Chemistry and Physics, **CH-GE-213**	**04**	**03**	**-**	**01**	U.G. Chemistry	10+2 in Science with Mathematics

Course Objectives

- To introduce basic concepts of nanoparticles including quantum confinement effect.
- To provide understanding different facets of liquid crystals.
- To introduce superconductivity and different types of superconductive materials.
- To explore different kinds of optical materials including nonlinearity.
- To explain multiphase materials specially ferrous and non-ferrous alloys

Learning Outcomes: By the end of the course, students will be able to:

- Understand the concept of nanoscience and technology including synthesis using top-down and bottom-up approaches, exciton Bohr radius, quantum confinement etc.
- Understand details and different types of liquid crystals and their transitions etc.
- Understand superconductivity, BCS theory and principles of High Tc superconductors
- Describe the basic principles of optical materials in all three categories i.e, semiconducting, lanthanide doped and organic emitting materials.
- Understand Fe-C phase transformations in ferrous alloys and some other aspect of non-ferrous alloys.

Course Contents (Theory) **Credit: 3 (45 hours)**

Unit I: Nanoparticles and its Chemistry **15 hours**

A. Nanoparticles: Top down and bottom-up approach to prepare different kinds of nanomaterials**,** Quantum dots, mechanism on the basis of band gap, excitons, quantum confinement effect, Bohr's radius in quantum dots, Different applications

B. Liquid Crystals: Mesomorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases; smectic–nematic transition and clearing temperature-homeotrophic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic A and smectic C phases

Unit II: Superconductivity and Multiphase Materials **15 hours**

A. Superconductivity**:** Conventional Superconductors; Types of Superconductive Materials, Magnetic Properties, BCS Theory; High temperature superconductors, Cuprates- & Iron superconductors; Theory of High Tc superconductors; Uses of high temperature Superconductors
B. Multiphase Materials: Ferrous alloys; Fe-C phase transformations in ferrous alloys; stainless steels, non-ferrous alloys, properties of ferrous and non-ferrous alloys and their applications

Unit III: Optical materials: **15 hours**
Types and mechanism of optical materials (semiconducting, lanthanide doped and organic emitting); Transition through various energy levels and understanding through Franck-Condon principle, Zablonsky diagram etc.; radiative and non-radiative emission and life time analysis; Basics of Nonlinear optical materials and nonlinear optical effects.

Recommended Texts:

1. Nanomaterials Chemistry: Recent Developments and New Directions by C. N. R. Rao, A. Muller and A. K. Cheetam, Willey- VCH Gmbh & Co (2007).
2. Cao, G. Nanostructures and Nanomaterials: Synthesis, Properties and applications, Imperial College Press, London (2011).
3. Callister, W. D. Materials Science and Engineering, an Introduction, Willey, 10th Edition, 2018.
4. Thermotropic Liquid Crystals, Ed., G. W. Gray, John Willey (1987).
5. Ashcroft, N. W. and. Mermin, N. D. Solid State Physics, Saunders College Publishing, (1976)
6. Keer, H. V. Principles of the Solid State, Willey Eastern (1993).
7. Billmeyer Jr, F. W. Textbook of Polymer Sciences, Wiley, 3rd Edition
8. Cowie, J. M. G. Physics and Chemistry of Polymers, Blackie Academic and Professional, 3rd Edition (2007).

Practical Components: **Credit 1**

1. Preparation of semiconducting CdSe, ZnSe, In_2S_3 (any of one) nanomaterials by any soft chemical approach (emulsion based, co-precipitation etc.).
2. Preparation of any metallic nanoparticle (for example Ag, Cu, Ni-any of one) using standard reducing and capping agent.
3. Preparation of a liquid crystals using soft chemical route.
4. Determination of band gap of a semiconducting nanoparticle (in solution) using UV-visible spectrophotometer.
5. Determination of band gap of a semiconducting nanoparticle (in solid) using UV-visible spectrophotometer (DRS mode).
6. Measurement of photoluminescence properties of semiconducting nanomaterials (at least one) using fluorescence spectroscopy.
7. Measurement of photoluminescence properties of lanthanide doped nanomaterials using fluorescence spectroscopy.

8. Studying photocatalytic degradation of environmentally pollutant dye (Crystal Violet, Rhodamine B, methyl orange etc.) by any semiconducting (In_2S_3, CdSe, ZnO- any of one) or metallic nanoparticles under visible light irradiation and using UV-Visible spectrophotometer.

Recommended Texts/References:

1. Nanomaterials Chemistry: Recent Developments and New Directions by C. N. R. Rao, A. Muller and A. K. Cheetam, Willey- VCH Gmbh & Co (2007).
2. Gurtu, J.N. Advanced Physical Chemistry Experiments, Pragati Publications, (2008)
3. Khosla, B.D. , Garg, V.C. and Gulati, A. Senior Practical Physical Chemistry by (R. Chand & Co, New Delhi), 18^{th} Edition, 2018
4. Lakowicz, J. R Principles of Fluorescence Spectroscopy, 2^{nd} edition, (1999)
5. Banwell, C. N. Fundamentals of Molecular Spectroscopy, 4^{th} Edition, (2017)
6. Kemp. W. Organic Spectroscopy, Third Edition, (2002)

UNIVERSITY OF DELHI

MASTER OF SCIENCE in PHYSICS

(Two Years Programme-NEP)

(Effective from Academic Year 2025-26)

Proposed Postgraduate Curricular Framework 2025
(based on NEP 2020)

LEVELS 6 AND 6.5

Programme Specific Outcomes (PSOs)

- ❖ Understanding the basic concepts of physics particularly concepts in classical mechanics, quantum mechanics, statistical mechanics and electricity and magnetism to appreciate how diverse phenomena observed in nature follow from a small set of fundamental laws through logical and mathematical reasoning.
- ❖ Learn to carry out experiments in basic as well as certain advanced areas of physics such as nuclear physics, condensed matter physics, nanoscience, lasers, and electronics.
- ❖ Understand the basic concepts of certain sub fields such as nuclear and high energy physics, atomic and molecular physics, solid state physics, and plasma physics, and astrophysics, general theory of relativity, nonlinear dynamics and complex systems.
- ❖ Gain hands-on experience to work in applied fields.
- ❖ Enhancing skills in experimental techniques and computation
- ❖ Gain a thorough grounding in the subject to be able to teach it at college and school levels.
- ❖ Viewing physics as a training ground for the mind to develop a critical attitude and a faculty of logical reasoning that can be applied to diverse fields.

Programme Structure

The M. Sc. programme is a two-year course divided into four semesters. A student is required to complete **88** credits (LEVEL 6 AND 6.5) for the completion of the course and the award of degree. The student who exits after one year at level 6 (44 credits) and acquires required credits shall be awarded with PG diploma. The M.Sc. Physics Programme would make the students competent in natural science, viz., Physics, and help them understand its role in modern day technology. Overall, the course would enable the students to understand the fundamental concepts and experimental methods of physics which would help them to innovate/apply/generate new devices/applications/insights/knowledge. Knowledge gained through the open electives would be an asset in branching out in fields other than physics.

		Semester	Semester
Part – I	First Year	Semester I	Semester II
Part – II	Second Year	Semester III	Semester IV

PG curricular structure for 2 year PG Programmes (3+2)

Course Credit Scheme for M.Sc. Physics

Semester	Core Courses			Elective Course			SEC			Total Credits
	No. of papers	Credits (L+T+P)	Total Credits	No. of papers	Credits (L+T+P)	Total Credits	No. of papers	Credits (L+T+P)	Total Credits	
I	03 (3DSC) DSC1 DSC2 DSC3	9+3+0	12	02 (DSE1)	4	8	1	2	2	**22**
				(DSE2/ GE1)	4					
II	03 (4DSC) DSC4 DSC5 DSC6	9+3+0	12	02 (DSE3)	4	8	1	2	2	22
				(DSE4/ GE2)	4					
III	02 DSC7 DSC8	8	8	DSE5 DSE6 DSE7 3DSEs or 2DSEs +1 GE3	4 4 4	12	1	2	2	22
IV	02 DSC9 DSC10	8	8	DSE8 DSE9 DSE10 3DSEs or 2DSEs and 01 GE4	4 4 4	12	1	2	2	22
Total Credits for the Course			40			40			8	88

The mode(s) of internal assessment will vary from course to course. The internal assessment marks will be based on performance in tests / quizzes / assignments / project work / presentations / attendance, etc. All laboratory courses will be evaluated based on continuous evaluation and end-of-semester examination as per the university's rules.

M. Sc. Programme (Semester-wise)

Semester I						
Number of Core courses: 4		Credits in each core course				
CORE COURSES:	Page	Lecture (L)	Practical (P)	Tutorial (T)	Credits
PH-DSC4101: Classical Mechanics *(Essential for Nuclear physics, GTR, Astrophysics, Solid State Physics, Plasma Physics, relativistic mechanics, EMT)*	7	3	0	1	4
PH-DSC4102: Quantum Mechanics I *(Essential for Advanced Solid State Physics, Cond. Matter Physics, Nuclear Physics, Particle Physics, QFT, Quantum information)*	9	3	0	1	4
PH-DSC4103: Electronics *(Essential for Nuclear Physics, Laser Spectroscopy Nano science/physics, Adv. Electronics theory , Adv. Solid state Physics All labs)*	11	3	0	1	4
Total credits in Core courses: 12					12
Number of Elective courses: 2 (DSE1, DSE2/GE1)					8
DSE – 1 (Pool A: Select one DSE Course)					
PH-DSE4111: Foundational Laboratory in Experimental Physics *(Essential for all adv. Labs and corresponding theory papers and several standalone theory courses.)*	13	0	4	0	4
PH-DSE4112: Experimental Laboratory in Materials and Optical Physics *(Essential for all adv. Labs and corresponding theory papers and several standalone theory courses)*	15	0	4	0	4
DSE -2 (Pool-B: Select one DSE Course or GE)					
PH-DSE4113 Mathematical Physics *(Recommended for QM2, QFT, Particle Physics, GTR, Fluid dynamics)*	18	3	0	1	4
PH-DSE4114 Relativistic Dynamics and Applications *(Recommended for QFT, Electrodynamics and EMT, GTR, Particle Physics)*	20	3	0	1	4
PH-DSE4115 Experimental Techniques in Nuclear Science	22	3	0	1	4
PH-DSE4116 Materials Characterization Techniques	24	3	0	1	4

PH-DSE4117 Techniques in Theoretical Physics *(Essential for QFT, Electrodynamics and EMT, GTR, Particle Physics)*	26	3	0	1	4
Total credits in Elective courses: 8					8
No. of Skill Enhancement courses: 1 (Total credits: 2) PH-SEC4171 Workshop skills PH-SEC4172 Python for physicists PH-SEC4173 Radiation Safety PH-SEC4174 Order of Magnitude Physics PH-SEC4175 Strategies for Scientific Dialogue in Research	 28 29 30 32 34	 0 0 1 2 1	 2 2 1 0 1	 0 0 0 0 0 -	2 2 2 2 2 2
Total credits in SEC courses: 2					2
Total number of credits in Semester I: 22					22

Semester II					
Number of Core courses: 4		Credits in each core course			
CORE COURSES:	Page	Lecture (L)	Practical (P)	Tutorial (T)	Credits
PH-DSC4201: Quantum Mechanics II *(Essential for Advanced Solid State Physics, Cond. Matter Physics, Nuclear Physics, Particle Physics, QFT, Quantum information)*	36	3	0	1	4
PH-DSC4202: Electromagnetic theory and Electrodynamics *(Essential for GTR and Cosmology, Plasma Physics, Particle Physics, QFT, Laser and spectroscopy)*	38	3	0	1	4
PH-DSC4203: Solid State Physics (*Essential* for *Laser Spectroscopy Physics at Nanoscale, Adv. Electronics theory, Adv. Solid State Physics, All labs, computational material science, condensed matter physics)*	40	3	0	1	4
Total credits in Core courses: 12					12
Number of Elective courses: 02 (DSE3, DSE4/GE2)					8
DSE – 3 (Pool A: Select one DSE Course) **PH-DSE4211: Foundational Laboratory in Experimental Physics** *(Essential for all adv. Labs and corresponding theory papers and several standalone theory courses.)*	42	0	4	0	4

PH-DSE4212: Experimental Laboratory in Materials and Optical Physics *(Essential for all adv. Labs and corresponding theory papers and several standalone theory courses)*	44	0	4	0	4
DSE – 4 (Pool-C: Select one DSE Course or GE)					
PH-DSE4213 Materials Characterization Techniques	37	3	0	1	4
PH-DSE4214 Experimental Techniques in Nuclear Science	49	3	0	1	4
PH-DSE4215 Techniques in Theoretical Physics *(Essential for QFT, Electrodynamics and EMT, GTR, Particle Physics*	51	3	0	1	4
PH-DSE4216:Theoretical Techniques in the Quantum World	53	3	0	1	4
Total credits in Elective courses: 8					8
Number of Skill Enhancement courses 1 (Total credits: 2)					2
PH-SEC4271: Workshop skills	54	0	2	0	2
PH-SEC4272: Computational Physics	55	0	2	0	2
PH-SEC4273: Amateur Astronomy	56	0	2	0	2
PH-SEC4274: Magnet Design and Simulation	57	1	1	0	2
PH-SEC4275: Data Simulation and Interpretation	60	1	1	0	2
PH-SEC4276: Electronic Circuit and Simulation	62	0	2	0	2
PH-SEC4277: Strategies for Scientific Dialogue in Research	63	1	1	0	2
Total credits in SEC courses: 2					2
Total number of credits in Semester II					22

Course Wise Content Details for M. Sc. Physics Programme

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSC4101

Course Name: Classical Mechanics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Classical Mechanics DSC	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

The primary objective is to teach the students Classical Mechanics at a level more advanced than what they have learnt in B.Sc. This is a course which forms the basis of Physics of many areas of Physics.

Contents:

Unit I (15 hours)

Newton's laws and symmetries. Generalized coordinates and constraints on dynamical systems. Variational calculus. Action and Euler-Lagrange equations. Cyclic coordinates and conserved quantities, Louville's theorem, Scaling laws, potential reconstruction. Examples. Hamiltonians and Hamiltonian equations. Phase space trajectories. Canonical variables and Poisson bracket. Examples.

Unit II (10 hours)

Kepler problem. Perturbation and precessing orbits. The classical scattering problem. Small oscillations (non-diagonal kinetic and potential terms).

Unit III (8 hours)

Canonical transformations, Generators of infinitesimal canonical transformations. Hamilton-Jacobi equation, Action and angle variables, Adiabatic invariants.

Unit IV (12 hours)

- Rigid Body, Euler angles, the symmetrical top.
- System with infinite degrees of freedom Classical fields : Lagrangian and Hamiltonian formulations Equations of motion. Symmetries and invariance principles, Noether's theorem.

Course Learning Outcomes

Students will be equipped for advanced and specialized courses. The student learns to deal with particle mechanics at an advanced level and to learn the foundations of the classical theory of fields.

Suggested Readings

1. Mechanics, L. D. Landau and E. M. Lifshitz (3rd Ed., Pergamon, 1976).
2. Classical Mechanics, H. Goldstein (Pearson Education, 2014).
3. Classical Mechanics, N. C. Rana and P. S. Jaog (McGraw-Hill, 1991).

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSC4102

Course Name: Quantum Mechanics - I

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Quantum Mechanics-I DSC	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

The primary objective is to teach the students the physical and mathematical basis of quantum mechanics for non-relativistic systems

Contents:

Unit I (15 hours)

Abstract formulation of Quantum Mechanics: Mathematical properties of linear vector spaces. Dirac's bra and ket notation. Hermitian operators, eigenvalues, and eigenvectors. Orthonormality, completeness, closure. Postulates of quantum mechanics. Matrix representation of operators. Position and momentum representations – connection with wave mechanics. Commuting operators. Generalised uncertainty principle. Change of basis and unitary transformation. Expectation values. Ehrenfest theorem.

Unit II (12 hours)

Quantum Dynamics: Schrodinger picture, Heisenberg picture, Heisenberg equation of motion, classical limit, solution of the simple harmonic oscillator problem by the operator method, general view of symmetries and conservation laws. Spatial translation – continuous and discrete, time translation. parity, time reversal, Density matrices - properties, pure and mixed density matrices, expectation value of an observable, time-evolution, reduced density Matrix, Bloch sphere.

Unit III (9 hours)

Angular Momentum as generator of rotation. Commutation relations of angular momentum operators, eigenvalues, eigenvectors, ladder operators and their matrix representations. Identical particles: Many-particle systems, exchange degeneracy, symmetric and anti-symmetric wavefunctions. Pauli exclusion principle

Unit IV (9 hours)

Approximate Methods: time-independent non-degenerate perturbation theory (Both Rayleigh-Schrodinger and Brillouin-Wigner), degenerate perturbation theory, variational methods.

Course Learning Outcomes

Students will learn the mathematical formalism of Hilbert space, Hermitian operators, eigenvalues, eigenstates, and unitary operators, which form the fundamental basis of quantum theory. Application to simple harmonic oscillators and hydrogen-like atoms will teach the students how to elegantly obtain eigenvalues and eigenstates for such systems. Students will learn to apply first- and second-order non-degenerate and degenerate perturbation theory. The topic of density matrices, which plays a significant role in quantum information theory and statistical mechanics, will also help the students considerably.

Suggested Readings:

1. Quantum Mechanics, B. H. Bransden & C. J. Joachain (Pearson Education, 2000)
2. Principles of Quantum Mechanics,R. Shankar (3rd Ed., Springer, 2008)
3. Quantum Mechanics (Vol. I),Claude Cohen-Tannoudji, Bernard and Frank Laloe16 (Wiley, 1977)
4. Modern Quantum Mechanics, J. J. Sakurai (Addison-Wesley, 1993)
5. Advanced Quantum Mechanics, F. Schwabl (Springer, 2000)
6. Quantum Mechanics, A. S. Davydov (2nd Ed., Pergamon, 1991)
7. Quantum Mechanics, Eugen Merzbacher (3rd Ed., Wiley, 1997)
8. Quantum Mechanics: Concepts and Applications, Nouredine Zettili (Wiley 2nd edition 2009)
9. The Principles of Quantum Mechanics, P. A. M. Dirac, (International Series of Monographs on Physics,1981).
10. Quantum Computation and Quantum Information, Michael A. Nielsen, Isaac L. Chuang, (Cambridge University Press,2010)

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSC4103

Course Name: Electronics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electronics DSC	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

To build up on the basic knowledge of electronics with the introduction of advanced topics like circuit analysis and applications of semiconductor devices in analog and digital circuits.

Contents:

Unit I (10 hours)

Circuit Analysis: Admittance, impedance, scattering and hybrid matrices for two and three port networks and their cascade and parallel combinations. Review of Laplace Transforms. Response functions, location of poles and zeros of response functions of active and passive systems (Nodal and Modified Nodal Analysis).

Unit II (13 hours)

Physics of Semiconductor Devices: p-n junction, Tunnel Diode, JFET, UJT, 4 layer pnpn device (SCR), Introduction of Power devices: DIAC, TRIAC, accumulation, depletion and inversion, MOSFET: I-V, C-V characteristics. Enhancement and depletion mode MOSFET. Ohmic and Rectifying contacts, Schottky diode, I-V, C-V relations.

Unit III (14 hours)

Analog circuits: Active filters and equalizers with feedback, Phase shift and delay.

Digital Circuits: Introduction to digital IC parameters (switching time, propagation delay, fan out, fan in etc.). TTL, MOS and CMOS gates, Emitter-coupled logic, MOSFET as transmission gate. A/D and D/A converters. Basics of micro-processor and micro-controller (8-bit AVR).

Unit IV (8 hours)

Communication Systems: Amplitude, Angle and Pulse-analog modulation: Generation and detection. Model of communication system, classification of signals, representation of signals.

Course Learning Outcomes

A student of this course is expected to be able to understand the design and functional performance of electronic circuits using various semiconductor devices. In addition, the student will understand the functional properties and characteristics of semiconductor devices in analog & digital circuits using analog and digital signals.

Suggested Readings

1. Network Analysis and Synthesis, F.F. Kuo (2nd Ed., Wiley, 2010)
2. Network Analysis with Applications, W.D. Stanley (4th Ed., Pearson, 2003)
3. Electronic Devices and Circuits, J. Millman and C. C. Halkias and S. Jit (4th Ed., McGraw-Hill, 2015)
4. Integrated Electronics, J. Millman, C. C. Halkias and C. D. Parikh (2nd Ed., McGraw-Hill, 2011)
5. Physics of Semiconductor Devices: J.P. Colinge and C. A. Colinge (KLUWER ACADEMIC PUBLISHERS, NEW YORK)
6. Physics of Semiconductor Devices: S.M. Sze (2nd Edition, Wiley Interscience Publications, John Wiley & Sons)
7. Communication Systems, Simon Haykins (5th Ed., Wiley, 2009)
8. Digital Signal Processing, J. G. Proakis and D. G. Manolakis (4th Ed., Pearson, 2007)
9. Solid State Electronic Devices, B.G. Streetman (7th Ed., Pearson, 2015)
10. Digital Design, M. Mano (5th Ed., Pearson, 2013)
11. Digital Principles and Applications, A.P. Malvino and D.P.Leach (8th Ed., McGrawHill, 2014)

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSE4111

Course Name: Foundational Laboratory in Experimental Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Foundational Laboratory in Experimental Physics DSE	4	0	0	4	

Duration: 120 Hours (8P/Week)

Course Objective

The major objective of this course is to revise the basic concepts of electronics/nuclear physics through standard set of experiments. In addition, the continuous evaluation process allows each and every student to not only understand and perform the experiment but also suitably correlate them with the corresponding theory.

Contents:

Electronics

Unit I-

Device Characteristics and Application

1. p-n junction diodes-clipping and clamping circuits.
2. FET – characteristics, biasing and its applications as an amplifier.
3. MOSFET – characteristics, biasing and its applications as an amplifier.
4. UJT – characteristics, and its application as a relaxation oscillator.
5. SCR – Characteristics and its application as a switching device.

Unit II-

- Linear Circuits

1. Resonant circuits.
2. Filters-passive and active, all pass (phase shifters).
3. Power supply-regulation and stabilization.
4. Oscillator design and study.
5. Multi-stage and tuned amplifiers.
6. Multivibrators-astable, monostable and bistable with applications.
7. Design and study of a triangular wave generator.
8. Design and study of sample and hold circuits.

- Digital Circuits and Microprocessors

1. Combinational.
2. Sequential.
3. A/D and D/A converters.
4. Digital Modulation.
5. Microprocessor application.

Nuclear Physics

Unit III- Detectors

1. G.M. Counters – characteristics, dead time and counting statistics
2. Spark counter-characteristics and range of x-particles in air
3. Scintillation detector-energy calibration, resolution and determination of gamma ray energy
4. Solid State detector – surface barrier detector, its characteristics and applications.

Unit IV-

- Applications

1. Gamma ray absorption-half thickness in lead for 60Co gamma-rays.
2. Beta ray absorption – end point energy of beta particles.
3. Lifetime of a short lived radioactive source..

- High Energy Physics

1. Study of pi-mu-e decay in nuclear emulsions.
2. Study of high energy interactions in nuclear emulsions.

Course Learning Outcomes

At the end of this laboratory course, each and every student is expected to understand the basic concepts of electronics/nuclear physics through experiments, which would immensely help them in acquiring knowledge to tackle various competitive exam questions.

Suggested Readings

Electronics:

1. Electronic Instrumentation and Measurement Techniques, W. D. Cooper and A. D. Helfrick (2nd Ed., Phi Learning, 2008)
2. Electronic Devices and Circuits, J. Millman and C. C. Halkias and S. Jit (4th Ed., McGraw-Hill, 2015)
3. Measurement, Instrumentation and Experimental Design in Physics and Engineering, M. Sayer and A. Mansingh (Prentice Hall India, 2010)

Nuclear Physics:

4. Radiation Detection and Measurement, G. F. Knoll (3rd Ed, John Wiley & Sons, Inc, 2000)
5. Physics & Engineering of Radiation Detection, S. N. Ahmed (Academic Press 2007)
6. Techniques for Nuclear and Particle Physics Experiments, W.R. Leo (Springer Verlag 1987)

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSE4112

Course Name: Experimental Laboratory in Materials and Optical Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Experimental Laboratory in Materials and Optical Physics DSE	4	0	0	4	

Duration: 120 hours (8P/Week)

Course Objective:

The major objective of this course is to revise the basic concepts of electronics/nuclear physics through standard set of experiments. In addition, the continuous evaluation process allows each and every student to not only understand and perform the experiment but also suitably correlate them with the corresponding theory.

Contents:

Solid State Physics

Unit I- Experimental Techniques

- Production and measurement of low pressures.
- Production and measurement of high pressures.
- Measurement and control of low temperatures.
- Production and characterization of plasma.
- Electron Spin Resonance.
- Nuclear Magnetic Resonance.

Unit II- Electrical Transport Properties

- Measurement of resistivity – Four probe and van der Paw techniques; determination of band gap.
- Measurement of Hall coefficient – determination of carrier concentration.
- Measurement of magneto resistance.
- Measurement of thermoelectric power.
- Measurement of minority carrier lifetime in semiconductors Hyne Shockley experiment.

Phase Transitions and Crystal Structure

- Phase Transitions and Crystal Structure: Determination of transition temperature in ferrites.
- Determination of transition temperature in ferroelectrics.
- Determination of transition temperature in high Tc superconductors.

- Determination of transition temperature in liquid crystalline materials.
- Crystal structure determination by x-ray diffraction powder photograph method.

Unit III - : Waves and Optics

- Velocity of sound in air by CRO method.
- Velocity of sound in liquids – Ultrasonic Interferometer method.
- Velocity of sound in solids – pulse echo method.
- Propagation of EM waves in a transmission line – Lecher wire.
- Determination of Planck's constant.
- Jamin's interferometer – refractive index of air.
- Study of elliptically polarized light.

Unit IV-:

Optical Spectroscopy

- Constant deviation spectrometer-fine structure of Hg spectral lines.
- e/m or hyperfine structure using Febry Perot's interferometer.
- Band spectrum in liquids.
- Raman scattering using a laser source.
- Luminescence.

Laser Based Experiments

- Optical interference and diffraction.
- Holography.
- Electro-optic modulation.
- Magneto-optic modulation.
- Acousto-optic modulation.
- Sound modulation of carrier waves.

NOTE:

The list of experiments given above should be considered as suggestive of the standard and available equipment. The teachers are authorized to add or delete from this list whenever considered necessary.

Course Learning Outcomes

At the end of this laboratory course, each and every student is expected to understand the basic concepts of electronics/nuclear physics through experiments, which would immensely help them in acquiring knowledge to tackle various competitive exam questions.

Suggested Readings

Solid State Physics

1. Introduction to Solid State Physics: Charles Kittel, 8^{th} edition (John Wiley and Sons, inc, 2005)
2. Physics of Semiconductor devices S.M. Sze (Wiley, 2006)

Waves and Optics:

1. Lasers: Fundamental and Applications, Graduate Text in Physics, 2nd edition, K. Thyagarajan, Ajoy Ghatak (Springer, 2002)
2. Polarization of light, by Ajoy Ghatak and Arun Kumar (Mc GrawHill Education, 2012)
3. Introduction to Fibre Optics, Ajoy Ghatak and K. Thyagarajan, (Cambridge University Press, 2000)
4. Teaching laser physics by experiments, Am. J. Phys., (2011), http://doi.org/1-3488984

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSE4113

Course Name: Mathematical Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Mathematical Physics DSE	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

The primary objective is to teach the students basic mathematical methods that will be used in many of the other courses in the M.Sc. Syllabus.

Contents:

Unit I (12 hours)

Linear Vector Space: A brief review of linear vector spaces, Inner product, norm, Schwarz inequality, Gram-Schmidt Orthogonalization, linear operators, eigenvalue and eigenvector, adjoint operator, Hermitian or self-adjoint operators and their properties, unitary operators, orthonormal basis–discrete and continuous.

Unit II (10 hours)

Theory of Probability and Statistics: Random Variables, Binomial, Poisson and Normal Distributions. Central Limit Theorem, Hypothesis Testing and Data Analysis in Statistics.

Unit III (8 hours)

Complex Analysis: Complex Analysis including use of residue theorem. Integral Transforms, Green's functions.

Unit IV (15 hours)

Discrete Group Theory: Abstract groups: subgroups, classes, cosets, factor groups, normal subgroups, cyclic, permutation, direct product of groups; Homomorphism & isomorphism. Representations: reducible and irreducible, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations.

Course Learning Outcomes

Students will learn the required Mathematics techniques that may have not been covered in the courses in B.Sc. CBCS program and which will be useful in many other courses in M. Sc.

Suggested Readings

1. Mathematical Physics, V. Balakrishnan (Ane Books, 2018)
2. Mathematical Methods for Physicists, G. Arfken (Elsevier, 2012)
3. Advanced Engineering Mathematics, E. Kreyzig (Pearson, 2002

4. Elements of Group Theory for Physicists, A.W. Joshi (John Wiley, 1997).
5. Groups and Symmetry, M. A. Armstrong(Springer, 1988).
6. Introductory Statistics, S. M. Ross (Academic Press Inc., 2005)
7. Elements Of Group Theory for Physicists, AW Joshi (New Age International Private Limited, 2018)

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSE4114

Course Name: Relativistic Dynamics and Applications

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Relativistic Dynamics and Applications DSE	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

To develop a conceptual and mathematical understanding of the Special theory of Relativity and relativistic particle dynamics, providing students substantial aptitude and familiarity with Lorentz transformations, the Lightcone structure of the Minkowski space-time, vectors and tensors in the Minkowski space-time, both from the theoretical perspective and in applied contexts, such as in the particle collision and decay problems.

Unit I:

Foundations of Special Relativity : (16 hours)

Fallout of Galilean Relativity: confrontation with Maxwell's electrodynamics, the postulates of Special Relativity, Lorentz and Poincaré transformations, rotations and boosts, the invariant line element, Lorentz transformations for single and multiple boost(s), Lorentz transformations as hyperbolic rotations: rapidity, successive Lorentz boosts and the relativistic velocity addition, Thomas precession .

Schematic Illustration of Relativistic Space-times :

Minkowski space-time diagrams, worldlines and coordinates of events, the simultaneity lines, the rapidity angle, the Lightcone, the temporal ordering of events, super-luminal signals and causality, space-time intervals – space-like, time-like and null, the proper time and time dilation, length contraction, relativistic Doppler effect, Illustrations of the twin paradox, train-rain paradox, etc using Minkowski diagrams.

Unit II: Vectors and Tensors in Special Relativity (9 hours)

Rules of transformation of coordinate differentials and derivatives, the Jacobian determinant and inverse transformations, internal transformations: polar and axial vectors, definition and categorization of tensors, contravariance and covariance, tensor operations, norm and trace, the metric tensor and its properties and application, the Minkowski metric, symmetric and antisymmetric tensors, symmetrization and antisymmetrization of tensors, the Levi-Civita tensor and the generalized Kronecker delta, tensor duality, tensor calculus: gradient; divergence; curl and the D'Alembertian; the invariant four volume and tensor integration; the integral theorems.

Unit III: Relativistic Particle Dynamics and Applications (12 hours)

Four-velocity and four-acceleration, four-momentum and energy, mass-energy equivalence, energy-momentum conservation, proper acceleration and four-force, the least action principle for relativistic particles, covariant Lagrangian and Hamiltonian, relativistic Hamilton-Jacobi equation, transformation of distribution functions for relativistic particle momenta, Illustrations: Compton effect; particle collision and decay; two-body interactions and scattering in laboratory and center-of-mass frames; the Lorentz invariant scattering cross section.

Unit IV: Relativistic Fields, Symmetries and Applicable Systems (8 hours)

Energy-momentum tensor, relativistic angular momentum and spin, Lorentz and Poincaré groups, proper and improper homogeneous Lorentz transformations, representations of the infinitesimal Lorentz group, Noether's theorem, Applicable systems: real and complex scalar fields; relativistic electromagnetic field and charge/current distributions; relativistic perfect fluids. . Course Outcomes By the end of this course, the students can understand and apply special relativity and Lorentz transformations to physical phenomena using Minkowski spacetime diagrams and relativistic kinematics, work with tensors, analyze the dynamics pertaining to relativistic interactions such as Compton scattering and particle decays, develop substantial skill in using relativistic approaches for specific systems of particles and fields.

Suggested Reading:

1. The Classical Theory of Fields (Course of Theoretical Physics Series), L.D. Landau, E.M. Lifshitz (4th Edition, Volume 2, Butterworth-Heinemann, Elsevier, 1975).
2. Classical Mechanics, Herbert Goldstein, Charles P. Poole, John L. Safko (3rd Edition, Addison-Wesley, 2002).
3. Introduction to Special Relativity, Robert Resnick (John Wiley & Sons, 1968).
4. Introduction to Special Relativity, Wolfgang Rindler (2nd Edition, Oxford, 1991).
5. Gravitation and Cosmology, Steven Weinberg (John Wiley & Sons, 1972).

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSE4115

Course Name: Experimental Technique in Nuclear Science

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Experimental Technique in Nuclear Science DSE	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objective

To provide a comprehensive understanding of the principles of radioactivity and nuclear decay processes required for experiments performed at the laboratory. To familiarize students with the interaction of nuclear radiation with matter and the mechanisms involved. To introduce various radiation detectors, counting techniques, and statistical methods used in nuclear experiments. To equip students with foundational knowledge of signal processing and applications of nuclear radiation in diverse fields.

Content

Unit I (Hours: 10)

Radioactivity: Introduction to Radioactivity, Decay Law, Units and Production of radioactivity, Radioactive sources, Growth of Daughter activities, , Branching Ratios, Half-life and mean life, Nuclear Decay processes, Decay Equation, Decay Schemes, Alpha Decay: alpha decay energies, qualitative theory of alpha decay and alpha-ray spectra, Beta Decay: Beta spectrum, Gamma Decay: Energetics and spectrum, Semiempirical Mass Formula, Q-value of Decay and reactions.

Unit II (Hours: 10)

Interaction of Radiation with Matter: Interaction of light charged particles with matter, Ionization, Bragg Curve and Bragg Peak, Range and Energy Relation, Radiation length and straggling, Interaction of Gamma Radiation with Matter: Attenuation of Gamma rays, Compton Effect, Photoelectric Effect and Pair Production, Attenuation and absorption Coefficients.

Unit III (Hours: 12)

Radiation Detectors and Counting Statistics: Classification, Gas-filled Detectors: Ionisation, Proportional and Geiger-Muller Counters; Concept of Multiplication, Quenching, and Dead Time. Brief introduction of scintillators and semiconductor detectors,

Types of uncertainties in a measurement, Probability and Cumulative distribution function, variance and standard deviation; Binomial, Poisson and Gaussian distribution, Error Propagation

Unit IV (Hours: 13)

Basics of Signal Processing: Basic electronic circuits for signal processing (GM and Scintillator detectors), Logic standard, Pulse shaping and digital signal processing for energy, time and position measurement, Digital Oscilloscope.

Application of Nuclear Radiation in Medicine, Industry, Research, Security, Agriculture and Space.

Learning outcome

After successful completion of the course, students will be able to: Understand and explain the physical principles governing radioactive decay and nuclear interactions. Analyze the behavior of nuclear radiation as it passes through matter and interpret relevant parameters such as range, attenuation, and energy loss. Select and apply appropriate radiation detection techniques and interpret experimental data using statistical analysis. Demonstrate an understanding of signal processing techniques and recognize real-world applications of nuclear science in medicine, industry, and other sectors.

Suggested Readings:

1. Radiation Detection and Measurement by G. F. Knoll (3rd Ed. John Wiley & Sons, Inc.,2000)
2. Physics & Engineering of Radiation Detection by S. N. Ahmed (Academic Press 2007)
3. Techniques for Nuclear and Particle Physics Experiments by W.R. Leo (Springer-Verlag 1987)
4. Nuclear Physics, Principles and Applications by J.S. Lilly (John Wiley & Sons, Inc., 2002).
5. Radiation Detection: Concept, Method and Devices by Douglas S. McGregor and J. Kenneth Shultis, (Taylor and Francis 2020)

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-ET4116

Course Name: Materials Characterization Techniques

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Materials Characterization Techniques DSE	4	3	1	0	

Duration: 60 Hours(45L+15T)

Course Objectives:

This course intends to provide knowledge on the advanced characterization techniques used to identify the physical and chemical properties of new materials prepared in laboratories. This includes, materials, electrical, optical, magnetic, and dielectric properties of materials and their specific applications. The students will have the experience of different characterization techniques used in experimental condensed matter physics with the available theories, operation, and instrumentation.

Unit I (8 hours)

Structure analysis: X-ray diffraction (XRD): Basic principle, Fourier analysis of the basis, structure factor and atomic form factor, indexing and lattice parameter determination, features of XRD experiment, film negative and Straumannis chamber, powder method, Laue method, information from peak position, intensity and width of XRD pattern. Crystal size and microstrain determination by Scherrer, modified Scherrer and Williamson-Hall methods.

Unit II (18 hours)

Imaging Techniques - Optical and electron microscopies, Electron Beam – Specimen Interaction, Secondary and Backscattered electrons, Interaction cross-section and volume, Scanning electron microscope (SEM), operational systems of SEM instrumentation and imaging modes, energy dispersive X-ray spectroscopy, transmission electron microscope, selected area electron diffraction, pattern writing using optical and electron beams

Spectroscopies: Characterization of fluorescence emission, Jablonski diagram, fluorescence quantum yield and life time, instrumentation for fluorescence spectroscopy, absorption and photoluminescence spectroscopy, Tauk plot, energy band gap determination, Raman spectroscopy, Fourier transform infrared spectroscopy, X-ray photoemission spectroscopy, X-ray absorption spectroscopy, Nuclear magnetic resonance (NMR) spectroscopy.

Unit III (14 hours)

Surface Morphology and Topography, scanning probe microscopy, scanning tunneling microscope (STM), atomic force microscope (AFM), concept and modes of operation of STM and AFM, conducting AFM.

Rutherford backscattering spectrometry, scattering geometry and kinematic factor, scattering cross-section, energy loss and stopping cross section, energy straggling, surface impurity on an elemental bulk target, Thermogravimetric analysis and differential thermal analysis: principle and instrumentation, differential scanning calorimetry.

Unit IV (5 hours)

Physical Properties: Electrical measurements: Resistivity, temperature dependence of resistivity in materials, resistance in bulk and low-dimensional systems, Current voltage characteristics, estimation of resistivity using four probe Van-der Pauw methods.

Dielectric and magnetic measurements: Frequency dependence on capacitance-voltage characteristics, estimation of dielectric constant. diamagnetics, paramagnetics, feromagnetics, B-H loop, operation and analysis of vibrating-sample magnetometry, ferroelectrics, polarization-electric field loop.

Course Learning Outcomes:

The students should able to experience the advanced characterization techniques pursued in the experimental condensed matter physics for studying the physical properties of the materials in the semiconductor technologies and nanotechnology.

Suggested readings:

1) X–Ray Crystallography by M. J. Buerger: Wiley–Blackwell; 99th ed. edition (1 January 1966)
2) Elements of X-ray Diffraction by B. D. Cullity: Addison-Wesley Publishing Company Inc. (1978)
3) Analytical Electron Microscopy for Materials Science by D. Shindo and T. Oikawa, Springer Verlag, Japan; 2002nd edition
4) Handbook of Spectroscopy edited by Günter Gauglitz, Tuan Vo-Dinh: WILEY-VCH Verla GmbH & Co, 2003
5) Scanning Probe Microscopy: Atomic Force Microscopy and Scanning Tunneling Microscopy by Bert Voigtländer, Springer-Verlag Berlin Heidelberg, 2015

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-DSE4117

Course Name: Technique in Theoretical Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Technique in Theoretical Physics DSE	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

The course will introduce to the students' basic concepts of finite and infinite groups. Examples from various fields will be considered. Techniques for solving integral equations will be learnt. Introduction to Green functions and its construction will be studied.

Contents:

Unit I (10 hours)

Introduction of finite discrete Group: subgroups, classes, cosets, factor groups, normal subgroups, direct product of groups; Examples: cyclic, symmetric, matrix groups, regular n-gon. Mappings: homomorphism, isomorphism, automorphism. Representations: reducible and irreducible representation, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations.

Unit II (15 hours)

Continuous Group: Review of the continuous groups: Lie groups, rotation and unitary groups. Representation of SO(2), SO(3), SU(2), SU(3), Tensors. Applications: point groups, translation and space groups, representation of point groups; introduction to symmetry group of the Hamiltonian.

Unit III (10 hours)

Integral Equations: Conversion of ordinary differential equations into integral equations, Fredholm and Volterra integral equations, separable kernels, Fredholm theory, eigen values and eigen functions.

Unit IV (10 hours)

Green function: Boundary Value Problems: boundary conditions: Dirichlet and Neumann; self-adjoint operators, Sturm-Liouville theory, Green's function, eigenfunction expansion.

Course Learning Outcomes

The understanding of the classification of finite groups will be achieved. Upon completion of this course, students should be able to use these concepts in various fields, particularity in crystallography. Students will be able to learn the different analytical techniques for solving integral equations and construct Green's functions for many important boundary value problems.

Suggested Readings:

1. Elements of Group Theory for Physicists, A.W. Joshi (John Wiley, 1997).
2. Groups and Symmetry,M. A. Armstrong(Springer, 1988).
3. Advanced Method of Mathematical Physics, R. S. Kaushal & D. Parashar (Narosa, 2008).
4. Group Theory and Its Applications to Physical Problems, M. Hamermesh (Dover, 1989).
5. Chemical Applications of Group Theory, F. Albert Cotton (John Wiley, 1988).
6. Mathematical Methods for Physicists,G. Arfken, H. Weber, & F. Harris (Elsevier, 2012).
7. Linear Integral Equations, W. V. Lovitt (Dover, 2005).
8. Introduction to Integral Equations with Applications, A. J. Jerri (Wiley-Interscience, 1999).

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-SEC4171

Course Name: Workshop skills

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Workshop skills SEC	2	0	0	2	

Duration: 60 Hours

Course objective:
The aim is to teach them how to handle machines which can be useful for precise cutting in lab accessories useful for experiments.

Content:
Hands-on experience:
Unit-I:
- Lathe machine (Plane turning, step turning, taper turning)
- Drill machine

Unit-II:
- Plate cutting
- Hand tools (hacksaw, drilling, tapping, filing)

Learning outcome:
The student will be confident and skilled for handling lab useables and small repairs.
(Not more than seven students at a time due to space constraints and safety.)

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Semester I
Course Code: PH-SEC4172

Course Name: Python for Physicists

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Python for Physicists SEC	2	0	0	2	

Duration: 60 hours

Course Objective:
This course is intended to be an Introduction to a programming Language (Python) for physics students. The course would impart training in the structure of Python and basic applications.

Content:
Unit-I:
- Basic Python (loops, mathematical and logical operations), Arrays, numpy, and reading and writing to files.
- Matrices, Matrix algebra, eigenvalue , eigenvector .

Unit-II:
- Basic plotting using Gnuplot and Python
- Simple applications: series, summation, root finding

Course Learning Outcomes
A student having taken the course would be expected to be proficient in programming in the language (Python). In addition, it is also expected that the student would be able to use Python to solve problems of summing up infinite series, root finding.

Suggested reading:
1. Lab manual for Python for Physicists, Department of Physics and Astrophysics, University of Delhi, 2025.
2. https://www.python.org/doc/
3. Numerical Recipes in C: The Art of Scientific Computing, William H. Press, Brian P. Flannery, Saul A. Teukolsky, William T. Vetterling (2nd Ed., Cambridge University Press, 2002)

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-SEC4173

Course Name: Radiation Safety

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Radiation Safety SEC	2	1	0	1	

Duration: 45 Hours (15T+30P)

Course Objectives

The primary objective of this course is to provide students with a comprehensive understanding of radiation fundamentals, interaction mechanisms, detection principles, dosimetric techniques, and regulatory frameworks associated with radiation safety and protection. Through theoretical instruction and practical demonstrations, students will gain both conceptual and operational knowledge required for safe handling, measurement, and monitoring of ionizing radiation, along with a sound understanding of national guidelines and protocols for radiation protection and waste management.

Contents:

Unit I (15 hours)

Basics of Radiation: Origin of radiation, binding energy and Q-value, stable and unstable isotopes, radioactive decay (alpha, beta, neutron, and electromagnetic transitions), mean life and half life, Basic idea of different units of activity, radiation quantities; exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, quality factor, radiation and tissue weighting factors, committed equivalent dose, committed effective, radiation dose to individuals from natural radioactivity in the environment and man-made sources

Devices for radiation measurement and survey: Radiation interaction with matter, kinematics of nuclear reactions, slowing down and moderation of neutrons, Interaction of ionizing and non-ionising radiation at the cellular level. introduction to types of radiation detectors; semiconductor, scintillator and gas detectors(Geiger-Muller counters, ionisation chamber and proportional counters). principles of radiation counting statistics, dead time, and calibration standards. types of Radiation Dosimeters: thermoluminescence, radiographic films, calorimetry, semiconductor diodes; Relation between detection and dosimetry.

Regulatory Framework: classification of radioactive sources (A/D classification), the system of radiological protection, justification of practice, optimization of protection, and individual limits, categories of exposures-occupational, public, and medical exposures, evaluation of external Radiation hazard-effect of distance, time, and shielding, shielding calculation; internal radiation hazards. Personnel and area monitoring, radiation accidents and disaster monitoring, Radioactive waste & classification of Radioactive waste, transport of radioactive sources/waste, responsibilities of licensee regulatory bodies AERB, and the government.

Unit II (30 hours)

Suggested Exercises / Practical Demonstrations

1) Demonstration handling of radiation monitor and survey instruments.
2) Demonstration of Distance, Time, and shielding concept of the ALARA principle.
3) Demonstration of the Search and Secure procedure for handling radioactive sources
4) Measurement of the activity of an unknown radioactive source.
5) Radiation Protection Survey of a Radioisotope Laboratory
6) Contamination Measurement and Decontamination Procedures
7) Calibrate radiation monitors using standard radioactive sources.
8) Classification of Radiation facility using AERB guidelines.
9) Packing classification and Transport Index (TI) for radioactive isotope/waste transport.

Course Learning Outcomes

A sound understanding of the principles underlying the operation of various radiation detectors, the calculation of radiation doses and permissible exposure levels for different categories of users, the effects of radiation, the use of instrumentation in practical scenarios, proper management of radioactive materials, and strict adherence to safety protocols.

Suggested Readings

1. Nuclear and Particle Physics, W. E. Burcham and M. Jobes (Pearson Education, 1995)
2. Radiation detection and measurement, G. F. Knoll (4^{th} Ed., Wiley, 2010)
3. Thermoluminescence Dosimetry, Mcknlay, A. F., Bristol, Adam Hilger (Medical Physics Hand book 5)
4. Fundamental Physics of Radiology, W. J. Meredith and J. B. Massey (John Wright and Sons, 1989)
5. An Introduction to Radiation Protection, A. Martin and S. A. Harbisor (John Willey & Sons, 1981)
6. Medical Radiation Physics, W. R. Hendee (Medical Publishers Inc., 1981)
7. Nuclear Physics : Principles and applications, John Lilley (Wiley, 2001)
8. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (2^{nd} Ed., Elsevier, 2014)
9. Techniques for Nuclear and Particle Physics Experiments, W.R. Leo (2^{nd} Ed., Springer, 2013)
10. AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities.
11. AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources.

MASTER of SCIENCE in PHYSICS

Semester I
Course Code: PH-SEC4174

Course Name: Order of Magnitude Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Order of Magnitude Physics SEC	2	2	0	0	

Duration:30hours

Course Objectives

Often before doing a detailed theoretical calculation or prior to setting up an experiment to measure an effect, One needs to have a rough idea as to weather or not our set up or the calculation is likely to give a meaning result and weather spending efforts time and funds are worth it. It is in this context that this course is significant. The objective of this course is to train students to make estimates without having to do a detailed calculation or experiment to get a rough idea of how the results could look.

Course Contents

Unit I :

- **Estimation of Physical quantities using Dimensional Analysis.** (12 hours)

Dimensional analysis in Mechanics: Damping in a pendulum, Free Gravitational collapse of a dust sphere, Oscillation time period of a star, Time taken for photon to diffuse out of sun, Dimensional analysis in Fluid Mechanics: Reynolds', Froude and Strouhaul numbers in Fluids, terminal velocity

- **Scaling analysis in Classical Physics** (6 hours)

Orbital time period vs Orbital size of planets, Dynamics in a power law potential, Estimating the acceleration due to gravity on the surface of the moon, How high can an animal jump? Orbital time of planets, Scale height of the Atmosphere

Unit II :

- **Application to different areas in Physics.** (18 hours)

Electrodynamics. Quantum Physics, Waves, Materials

- **Applications to Integrals and differential equations:**

Estimating integrals, steepest descent approximation. Approximate solutions to differential equations.

Course Learning Outcomes

Students will come away from the course with an appreciation of the characteristic scales associated to a physical system, and how to use simple approximate models to estimate a variety of quantities of physical interest. They will also learn approximation techniques for integrals and differential equations.

Suggested Reading

1. Peter Goldreich, Sanjoy Mahajan and Sterl Phinney - Order of Magnitude Physics.
2. Sanjoy Mahajan - Estimating gas mileage: An example of order-of-magnitude physics (arXiv:physics0512209)
3. Steven Doty and Sandra Doty, Dielectric breakdown of air as order of magnitude physics (Physics teacher Volume 36, Pages 6-9, 1998)

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-SEC4175

Course Name: Strategies for Scientific Dialogue in Research

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Strategies for Scientific Dialogue in Research SEC	2	1	0	1	

Duration: 45 hours

Course Objectives:

The course is designed to develop and strengthen students' ability to communicate scientific ideas clearly and effectively, both in written and oral formats. It aims to expose students to cutting-edge research through seminars delivered by faculty members and invited experts. Emphasis is placed on cultivating skills in scientific literature review, critical analysis, and academic discourse. The course also prepares students for academic presentations, thesis defenses, and professional scientific interactions. Recognizing that many students produce excellent research but struggle to present it effectively, this course seeks to bridge that crucial gap.

Course Learning Outcomes:

Upon successful completion of the course, students will be able to: Comprehend and effectively communicate recent research developments in physics and allied disciplines. Summarize and synthesize scientific literature with clarity, coherence, and critical insight. Prepare and deliver well-structured, confident, and audience-appropriate scientific presentations. Engage thoughtfully in scholarly discussions and respond competently to academic queries.
This course will be particularly beneficial for students planning to undertake project work or a dissertation in the third and fourth semesters.

Course Structure and Activities:

UNIT -I (15 Hours)

Lecture Attendance & Research Exposure:

➢ Students must attend a minimum of 10 research lectures organized by the department. These may include:
   1. Presentations by department faculty on their current research.
   2. Lectures by invited national or international experts.

➢ Students will submit comprehensive summaries (approx. 400–500 words) of at least five selected lectures, highlighting key concepts, methods, and findings.

UNIT -II (30 Hours)

Seminar Preparation and Delivery (20 Hours):

- ➢ Students will be assigned a research topic or paper, drawn from current research themes or courses offered in the M.Sc. syllabus.
- ➢ They will receive study materials, including relevant papers, reviews, or resources from the faculty.
- ➢ Each student must prepare a written synopsis (~800–1000 words) on the assigned topic.
- ➢ Students will then present a seminar (15–20 minutes) based on their understanding, followed by a Q&A session.

The course is structured in the spirit of a Dissertation under the DSE category, but with lower credit weightage and, accordingly, reduced academic rigor. As such, the number of hours assigned is indicative rather than prescriptive, intended to reflect the approximate level of effort expected.

Assessment and Evaluation:

Component

i) Participation in Departmental Lectures
ii) Written Summaries of Attended Lectures
iii) Written Review of Assigned Research Topic
iv) Seminar Presentation (Content, Clarity, Delivery)

The Evaluation will be conducted by:

i) A three-member departmental committee for the overall course.
ii) A two-member subcommittee for seminar presentation evaluation.

Notes for Implementation:

- ➢ Attendance at department seminars will be tracked.
- ➢ Students may optionally include key questions or insights from each attended lecture.
- ➢ Emphasis will be placed on communication skills, depth of understanding, organization of content, and response to questions.
- ➢ This course encourages peer learning and academic engagement beyond the classroom.

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-DSC4201

Course Name: Quantum Mechanics-II

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Quantum Mechanics-II DSC	4	3	1	0	

Duration: 60 Hours (45L+15T)

Course Objectives

The primary objective is to teach the students various approximation methods in quantum mechanics. The important topic of quantum scattering is also dealt with. Also some aspects of non-Hermitian systems and Relativistic quantum theory, such as the Dirac equations, are covered.

Contents:

Unit I (13 hours)

WKB method, hydrogen-like atoms, and spherical harmonics. Spin-half particle : nonrelativistic (Pauli theory) and relativistic (Dirac equation and plane wave solution), Addition of angular momenta. Clebsch-Gordan coefficients, Wigner-Eckart theorem, application of approximate methods.

Unit II (13 hours)

Approximation Methods for time-dependent perturbations: Interaction picture. Time-dependent perturbation theory. Transition to a continuum of final states – Fermi's Golden Rule. Application to constant and harmonic perturbations, sudden and adiabatic Approximations.

Unit III (12 hours)

Scattering: Wave packet description of scattering. Lippmann-Schwinger Equations, Formal treatment of scattering by Green's function method. Born approximation and applications. Definition and properties of S-Matrix Partial wave analysis. Optical theorem.

Unit IV (7 hours)

Introduction to non-Hermitian systems: energy eigenvalues, eigenvectors and their spectral properties, exceptional points, PT symmetric systems.

Course Learning Outcomes

Students will learn how to use perturbation theory to obtain corrections to energy eigenstates and eigenvalues when an external electric or magnetic field is applied to a system. Scattering theory will teach them how to use projectiles to infer details about the target quantum system. Exposer to Dirac's equation and non-hermitian systems.

Suggested Readings:

1. Quantum Mechanics, L.I. Schiff, McGraw-Hill,2017
2. Principles of Quantum Mechanics, R. Shankar, Springer,2011
3. Introduction to Quantum Mechanics, D.J. Griffiths, Cambridge University Press, 2018
4. A Modern Approach to Quantum Mechanics, J.S. Townsend, Viva Books
5. E. Merzbacher, Quantum Mechanics, John Wiley and Sons
6. F. Schwabl, Advanced Quantum Mechanics, Springer
7. A. Das, Hours on Quantum Mechanics, Hindustan Book Agency
8. M. Le Bellac, Quantum Physics, Cambridge University Press
9. J. J. Sakurai, Modern Quantum Mechanics, Pearson
10. S. Flügge, Practical Quantum Mechanics, Springer
11. K. Gottfried and T.-M. Yan, Quantum Mechanics: Fundamentals, Springer
12. R.P. Feynman, Feynman Hours on Physics (Vol. III), Addison-Wesley
13. C. Cohen-Tannoudji, B. Diu and F. Laloe, Quantum Mechanics (Vols. I and II),Wiley
14. A. Messiah, *Quantum Mechanics (Vols. I and II),* Dover
15. P. A. M. Dirac, The Principles of Quantum Mechanics (International Series of Monographs on Physics).

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-DSC4202

Course Name: Electromagnetic Theory & Electrodynamics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electromagnetic Theory & Electrodynamics DSC	4	3	1	0	

Duration:60hours (45L+15T)

Course Objectives

To develop a conceptual and mathematical basis for Classical Electromagnetism and its Relativistic formulation. The course reviews and builds on the students' knowledge of Special Relativity using Minkowski space-time diagrams and tensorial analysis. While building up the covariant formulation of electrodynamics, this course also provides a detailed account of obtaining the electromagnetic four-potential using Green's functions, the transformation of the electromagnetic field, the study of motion of relativistic charges in electric and magnetic fields, as well as radiation from moving point charges and localized time-harmonic distributions.

Unit I: Basic electromagnetism, relativistic concepts and covariant electrodynamics (20 hours)

A brief review of basic electromagnetic (EM) theory. Maxwell's equations and the motivation for introducing Special Relativity (SR). Conceptual basis of SR theory: the postulates, Lorentz and Poincaré transformations, the invariant line element, worldlines and coordinates of events, Minkowski space-time diagrams, simultaneity and rapidity, types of space-time intervals, the causal structure of spacetime and the Lightcone. Vectors and tensors in Minkowski space-time. Tensor algebra, symmetry and antisymmetry, duality, differentiation and differential operators. Mass-energy relation, four-momentum and its conservation. Covariant Lorentz force equation. EM field tensor and conserved four-current. Covariance of the Maxwell's equations. EM scalar invariants and the transformation laws. EM four-potential. Gauge invariance of the EM field. Gauge conditions: Coulomb and Lorentz gauges. EM wave equation. Retarded and advanced solutions for the EM four-potential using Green's functions.

Unit II: Relativistic charged particle dynamics (5 hours)

Electric and magnetic fields due to a uniformly moving charged particle. Motion of charged particles in a uniform static magnetic field, uniform static electric field and crossed electric and magnetic fields. Particle drifts (velocity and curvature) in non-uniform static magnetic fields.

Unit III: Electromagnetic Radiation (15 hours)

Radiation from a moving point charge: Lienard-Wiechert potentials and fields, Larmor power formula and its relativistic generalization – the Lienard result, charged particle accelerators, angular distribution of radiation from accelerated charged particles. Radiation from localized time-harmonic charges, currents and their distributions: specification of EM vector potential in the Lorentz gauge, near and far zone fields, multipole expansion, Poynting theorem for a time-harmonic source current. Electric dipole, magnetic dipole and electric quadrupole radiation. Centre-fed linear dipole antenna.

Unit IV: Lagrangian Formulation of Electrodynamics (5 hours)

Lagrangian for a relativistic charged particle in an EM field, for the free electromagnetic field and for interacting charged particles and fields. Energy-momentum tensor and related conservation laws.

Course Learning Outcomes

Students having taken this course are expected to have a fair degree of familiarity with tensors and the tensorial formulation of electrodynamics. In addition, they are expected to be able to solve problems on motion of charged particles in various field formations as well as find the radiation patterns from different time-varying charge and current densities.

Suggested Readings

1. Classical Electrodynamics, John David Jackson (3rd ed.,Wiley, 1998).
2. The Classical Theory of Fields (Course of Theoretical Physics Series, volume 2), L.D. Landau and E.M. Lifshitz (4th ed., Butterworth-Heinemann, Elsevier, 1975).
3. Introduction to Electrodynamics, David J. Griffiths (3rd ed., Benjamin Cummings, 1999).
4. Principles of Electrodynamics, Melvin Schwartz (Dover Publications, 1987).
5. Classical Electrodynamics, J. Schwinger, L.L. Deraad Jr., K.A. Milton, W-Y. Tsai and J. Norton (Westview Press, 1998).
6. Modern Problems in Classical Electrodynamics, Charles A. Brau (Oxford, 2003).
7. Electrodynamics of Continuous Media (Course of Theoretical Physics Series, volume 8), L.D. Landau, L.P. Pitaevskii and E.M. Lifshitz (2nd ed., Butterworth-Heinemann, Elsevier, 1984).

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-DSC4203

Course Name: Solid State Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Solid State Physics DSC	4	3	1	0	

Duration:60hours(45L+15T)

Course Objective

This course intends to provide knowledge of conceptual solid-state physics. In addition, this course aims to provide a general introduction to theoretical and experimental topics in solid state physics.

Contents:

Unit I (16 hours)

Metals: Drude theory, DC conductivity, magneto-resistance, thermal conductivity, thermoelectric effects, Fermi-Dirac distribution, thermal properties of an electron gas, WiedemannFranz law, critique of free-electron model.

Crystal Lattices: Diffraction of electromagnetic waves by crystals: X-rays, Electrons and Neutrons, Symmetry operations and classification of Bravais lattices, common crystal structures, reciprocal lattice, Brillouin zone, X-ray diffraction, Bragg's law, Von Laue's formulation, diffraction from non-crystalline systems. Geometrical factors of SC, FCC, BCC and diamond lattices; Basis of quasi crystals.

Unit II (8 hours)

Crystal Binding: Bond classifications – types of crystal binding, covalent, molecular and ionic crystals, London theory of van der Waals, hydrogen bonding, cohesive and Madelung energy.

Defects and Diffusion in Solids: Point defects: Frenkel defects, Schottky defects, examples of colour centres, line defects and dislocations.

Unit III (12 hours)

Lattice Dynamics: Failure of the static lattice model, adiabatic and harmonic approximation, vibrations of linear monoatomic lattice, one-dimensional lattice with basis, models of three-dimensional lattices, quantization of lattice vibrations, Einstein and Debye theories of specific heat, phonon density of states, neutron scattering.

Band theory of Solids: Periodic potential and Bloch's theorem, weak potential approximation, density of states in different dimensions, energy gaps, Fermi surface and Brillouin zones. Origin of energy bands and band gaps, effective mass, tight-binding approximation and calculation of simple band-structures. Motion of electrons in lattices, Wave packets of Bloch electrons, semi-classical equations of motion, motion in static electric and magnetic fields, theory of holes, cyclotron resonance.

Unit IV (9 hours)

Semiconductors: General properties and band structure, carrier statistics, impurities, intrinsic and extrinsic semiconductors, drift and diffusion currents, mobility, Hall effect.

Superconductors: Phenomenology, review of basic properties, thermodynamics of superconductors, London's equation and Meissner effect, Type-I and Type-II superconductors, BCS theory of superconductors.

Course Learning Outcomes

The students should be able to elucidate the important features of solid state physics by covering crystal lattices and binding, lattice dynamics, band theory of solids and semiconductors.

Suggested Readings

1. Introduction to Solid State Physics, C. Kittel (8th Ed., Wiley, 2012)
2. Solid State Physics, N. W. Ashcroft and N. D. Mermin (Ist Ed., Cengage Learning, 2003)
3. Principles of the Theory of Solids, J. M. Ziman (2nd Ed., Cambridge University Press, 1972)
4. Solid State Physics, A. J. Dekker (1st Ed., Macmillan India, 2000)
5. Solid State Physics, G. Burns (1st Ed., Academic Press, 1985)
6. Condensed Matter Physics, M. P. Marder (Wiley, 2010)

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-DSE4211

Course Name: Foundational Laboratory in Experimental Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Foundational Laboratory in Experimental Physics DSE	4	0	0	4	

Duration: 120 Hr
(8P/Week)

Course Objective

The major objective of this course is to revise the basic concepts of electronics/nuclear physics through standard set of experiments. In addition, the continuous evaluation process allows each and every student to not only understand and perform the experiment but also suitably correlate them with the corresponding theory.

Contents:

Electronics

Unit I-

Device Characteristics and Application

1. p-n junction diodes-clipping and clamping circuits.
2. FET – characteristics, biasing and its applications as an amplifier.
3. MOSFET – characteristics, biasing and its applications as an amplifier.
4. UJT – characteristics, and its application as a relaxation oscillator.
5. SCR – Characteristics and its application as a switching device.

Unit II-

- Linear Circuits

1. Resonant circuits.
2. Filters-passive and active, all pass (phase shifters).
3. Power supply-regulation and stabilization.
4. Oscillator design and study.
5. Multi-stage and tuned amplifiers.
6. Multivibrators-astable, monostable and bistable with applications.
7. Design and study of a triangular wave generator.
8. Design and study of sample and hold circuits.

- Digital Circuits and Microprocessors

1. Combinational.
2. Sequential.
3. A/D and D/A converters.

4. Digital Modulation.
5. Microprocessor application.

Nuclear Physics
Unit III- Detectors
1. G.M. Counters – characteristics, dead time and counting statistics
2. Spark counter-characteristics and range of x-particles in air
3. Scintillation detector-energy calibration, resolution and determination of gamma ray energy
4. Solid State detector – surface barrier detector, its characteristics and applications.

Unit IV-

- Applications

1. Gamma ray absorption-half thickness in lead for 60Co gamma-rays.
2. Beta ray absorption – end point energy of beta particles.
3. Lifetime of a short lived radioactive source..

- High Energy Physics

1. Study of pi-mu-e decay in nuclear emulsions.
2. Study of high energy interactions in nuclear emulsions.

Course Learning Outcomes

At the end of this laboratory course, each and every student is expected to understand the basic concepts of electronics/nuclear physics through experiments, which would immensely help them in acquiring knowledge to tackle various competitive exam questions.

Suggested Readings
Electronics:
1. Electronic Instrumentation and Measurement Techniques, W. D. Cooper and A. D. Helfrick (2nd Ed., Phi Learning, 2008)
2. Electronic Devices and Circuits, J. Millman and C. C. Halkias and S. Jit (4th Ed., McGraw-Hill, 2015)
3. Measurement, Instrumentation and Experimental Design in Physics and Engineering, M. Sayer and A. Mansingh (Prentice Hall India, 2010)

Nuclear Physics:
4. Radiation Detection and Measurement, G. F. Knoll (3rd Ed, John Wiley & Sons, Inc, 2000)
5. Physics & Engineering of Radiation Detection, S. N. Ahmed (Academic Press 2007)
6. Techniques for Nuclear and Particle Physics Experiments, W.R. Leo (Springer Verlag 1987)

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-DSE4212

Course Name: Experimental Laboratory in Materials and Optical Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Experimental Laboratory in Materials and Optical Physics DSE	4	0	0	4	

Duration: 120 hours (8P/Week)

Course Objective:

The major objective of this course is to revise the basic concepts of electronics/nuclear physics through standard set of experiments. In addition, the continuous evaluation process allows each and every student to not only understand and perform the experiment but also suitably correlate them with the corresponding theory.

Contents:

Solid State Physics

Unit I- Experimental Techniques

- Production and measurement of low pressures.
- Production and measurement of high pressures.
- Measurement and control of low temperatures.
- Production and characterization of plasma.
- Electron Spin Resonance.
- Nuclear Magnetic Resonance.

Unit II- Electrical Transport Properties

- Measurement of resistivity – Four probe and van der Paw techniques; determination of band gap.
- Measurement of Hall coefficient – determination of carrier concentration.
- Measurement of magneto resistance.
- Measurement of thermoelectric power.
- Measurement of minority carrier lifetime in semiconductors Hyne Shockley experiment.

Phase Transitions and Crystal Structure

- Phase Transitions and Crystal Structure: Determination of transition temperature in ferrites.
- Determination of transition temperature in ferroelectrics.

- Determination of transition temperature in high Tc superconductors.
- Determination of transition temperature in liquid crystalline materials.
- Crystal structure determination by x-ray diffraction powder photograph method.

Unit III - : Waves and Optics

- Velocity of sound in air by CRO method.
- Velocity of sound in liquids – Ultrasonic Interferometer method.
- Velocity of sound in solids – pulse echo method.
- Propagation of EM waves in a transmission line – Lecher wire.
- Determination of Planck's constant.
- Jamin's interferometer – refractive index of air.
- Study of elliptically polarized light.

Unit IV-:

Optical Spectroscopy

- Constant deviation spectrometer-fine structure of Hg spectral lines.
- e/m or hyperfine structure using Febry Perot's interferometer.
- Band spectrum in liquids.
- Raman scattering using a laser source.
- Luminescence.

Laser Based Experiments

- Optical interference and diffraction.
- Holography.
- Electro-optic modulation.
- Magneto-optic modulation.
- Acousto-optic modulation.
- Sound modulation of carrier waves.

NOTE:

The list of experiments given above should be considered as suggestive of the standard and available equipment. The teachers are authorized to add or delete from this list whenever considered necessary.

Course Learning Outcomes

At the end of this laboratory course, each and every student is expected to understand the basic concepts of electronics/nuclear physics through experiments, which would immensely help them in acquiring knowledge to tackle various competitive exam questions.

Suggested Readings

Solid State Physics

1. Introduction to Solid State Physics: Charles Kittel, 8th edition (John Wiley and Sons, inc, 2005)

2. Physics of Semiconductor devices S.M. Sze (Wiley, 2006)

Waves and Optics:

3. Lasers: Fundamental and Applications, Graduate Text in Physics, 2nd edition, K. Thyagarajan, Ajoy Ghatak (Springer, 2002)
4. Polarization of light, by Ajoy Ghatak and Arun Kumar (Mc GrawHill Education, 2012)
5. Introduction to Fibre Optics, Ajoy Ghatak and K. Thyagarajan, (Cambridge University Press, 2000)
6. Teaching laser physics by experiments, Am. J. Phys., (2011), http://doi.org/1- 3488984

MASTER of SCIENCE in PHYSICS

Semester II
Course Code: PH-DSE4213
Course Name: Materials Characterization Techniques

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Materials Characterization Techniques DSE	4	3	1	0	

Duration: 60 Hours(45L+15T)

Course Objectives:
This course intends to provide knowledge on the advanced characterization techniques used to identify the physical and chemical properties of new materials prepared in laboratories. This includes, materials, electrical, optical, magnetic, and dielectric properties of materials and their specific applications. The students will have the experience of different characterization techniques used in experimental condensed matter physics with the available theories, operation, and instrumentation.

Unit I (8 hours)

Structure analysis: X-ray diffraction (XRD): Basic principle, Fourier analysis of the basis, structure factor and atomic form factor, indexing and lattice parameter determination, features of XRD experiment, film negative and Straumannis chamber, powder method, Laue method, information from peak position, intensity and width of XRD pattern. Crystal size and microstrain determination by Scherrer, modified Scherrer and Williamson-Hall methods.

Unit II (18 hours)

Imaging Techniques - Optical and electron microscopies, Electron Beam – Specimen Interaction, Secondary and Backscattered electrons, Interaction cross-section and volume, Scanning electron microscope (SEM), operational systems of SEM instrumentation and imaging modes, energy dispersive X-ray spectroscopy, transmission electron microscope, selected area electron diffraction, pattern writing using optical and electron beams.

Spectroscopies: Characterization of fluorescence emission, Jablonski diagram, fluorescence quantum yield and life time, instrumentation for fluorescence spectroscopy, absorption and photoluminescence spectroscopy, Tauk plot, energy band gap determination, Raman spectroscopy, Fourier transform infrared spectroscopy, X-ray photoemission spectroscopy, X-ray absorption spectroscopy, Nuclear magnetic resonance (NMR) spectroscopy.

Unit III (14 hours)

Surface Morphology and Topography, scanning probe microscopy, scanning tunneling microscope (STM), atomic force microscope (AFM), concept and modes of operation of STM and AFM, conducting AFM.

Rutherford backscattering spectrometry, scattering geometry and kinematic factor, scattering cross-section, energy loss and stopping cross section, energy straggling, surface impurity on an elemental bulk target, Thermogravimetric analysis and differential thermal analysis: principle and instrumentation, differential scanning calorimetry.

Unit IV (5 hours)

Physical Properties: Electrical measurements: Resistivity, temperature dependence of resistivity in materials, resistance in bulk and low-dimensional systems, Current voltage characteristics, estimation of resistivity using four probe Van-der Pauw methods.

Dielectric and magnetic measurements: Frequency dependence on capacitance-voltage characteristics, estimation of dielectric constant. diamagnetics, paramagnetics, feromagnetics, B-H loop, operation and analysis of vibrating-sample magnetometry, ferroelectrics, polarization-electric field loop.

Course Learning Outcomes:

The students should able to experience the advanced characterization techniques pursued in the experimental condensed matter physics for studying the physical properties of the materials in the semiconductor technologies and nanotechnology.

Suggested readings:

1) X–Ray Crystallography by M. J. Buerger: Wiley–Blackwell; 99th ed. edition (1 January 1966)
2) Elements of X-ray Diffraction by B. D. Cullity: Addison-Wesley Publishing Company Inc. (1978)
3) Analytical Electron Microscopy for Materials Science by D. Shindo and T. Oikawa, Springer Verlag, Japan; 2002nd edition
4) Handbook of Spectroscopy edited by Günter Gauglitz, Tuan Vo-Dinh: WILEY-VCH Verla GmbH & Co, 2003
5) Scanning Probe Microscopy: Atomic Force Microscopy and Scanning Tunneling Microscopy by Bert Voigtländer, Springer-Verlag Berlin Heidelberg, 2015

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-DSE4214

Course Name: Experimental Technique in Nuclear Science

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Experimental Technique in Nuclear Science DSE	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objective

To provide a comprehensive understanding of the principles of radioactivity and nuclear decay processes required for experiments performed at the laboratory. To familiarize students with the interaction of nuclear radiation with matter and the mechanisms involved. To introduce various radiation detectors, counting techniques, and statistical methods used in nuclear experiments. To equip students with foundational knowledge of signal processing and applications of nuclear radiation in diverse fields.

Content

Unit I (Hours: 10)

Radioactivity: Introduction to Radioactivity, Decay Law, Units and Production of radioactivity, Radioactive sources, Growth of Daughter activities, , Branching Ratios, Half-life and mean life, Nuclear Decay processes, Decay Equation, Decay Schemes, Alpha Decay: alpha decay energies, qualitative theory of alpha decay and alpha-ray spectra, Beta Decay: Beta spectrum, Gamma Decay: Energetics and spectrum, Semiempirical Mass Formula, Q-value of Decay and reactions.

Unit II (Hours: 10)

Interaction of Radiation with Matter: Interaction of light charged particles with matter, Ionization, Bragg Curve and Bragg Peak, Range and Energy Relation, Radiation length and straggling, Interaction of Gamma Radiation with Matter: Attenuation of Gamma rays, Compton Effect, Photoelectric Effect and Pair Production, Attenuation and absorption Coefficients.

Unit III (Hours: 12)

Radiation Detectors and Counting Statistics: Classification, Gas-filled Detectors: Ionisation, Proportional and Geiger-Muller Counters; Concept of Multiplication, Quenching, and Dead Time. Brief introduction of scintillators and semiconductor detectors,

Types of uncertainties in a measurement, Probability and Cumulative distribution function, variance and standard deviation; Binomial, Poisson and Gaussian distribution, Error Propagation

Unit IV (Hours: 13)

Basics of Signal Processing: Basic electronic circuits for signal processing (GM and Scintillator detectors), Logic standard, Pulse shaping and digital signal processing for energy, time and position measurement, Digital Oscilloscope.

Application of Nuclear Radiation in Medicine, Industry, Research, Security, Agriculture and Space.

Learning outcome

After successful completion of the course, students will be able to: Understand and explain the physical principles governing radioactive decay and nuclear interactions. Analyze the behavior of nuclear radiation as it passes through matter and interpret relevant parameters such as range, attenuation, and energy loss. Select and apply appropriate radiation detection techniques and interpret experimental data using statistical analysis. Demonstrate an understanding of signal processing techniques and recognize real-world applications of nuclear science in medicine, industry, and other sectors.

Suggested Readings:

1. Radiation Detection and Measurement by G. F. Knoll (3^{rd} Ed. John Wiley & Sons, Inc.,2000)
2. Physics & Engineering of Radiation Detection by S. N. Ahmed (Academic Press 2007)
3. Techniques for Nuclear and Particle Physics Experiments by W.R. Leo (Springer-Verlag 1987)
4. Nuclear Physics, Principles and Applications by J.S. Lilly (John Wiley & Sons, Inc., 2002).
5. Radiation Detection: Concept, Method and Devices by Douglas S. McGregor and J. Kenneth Shultis, (Taylor and Francis 2020)

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-DSE4115

Course Name: Technique in Theoretical Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Technique in Theoretical Physics DSE	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

The course will introduce to the students' basic concepts of finite and infinite groups. Examples from various fields will be considered. Techniques for solving integral equations will be learnt. Introduction to Green functions and its construction will be studied.

Contents:

Unit I (10 hours)
Introduction of finite discrete Group: subgroups, classes, cosets, factor groups, normal subgroups, direct product of groups; Examples: cyclic, symmetric, matrix groups, regular n-gon. Mappings: homomorphism, isomorphism, automorphism. Representations: reducible and irreducible representation, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations.

Unit II (15 hours)
Continuous Group: Review of the continuous groups: Lie groups, rotation and unitary groups. Representation of SO(2), SO(3), SU(2), SU(3), Tensors. Applications: point groups, translation and space groups, representation of point groups; introduction to symmetry group of the Hamiltonian.

Unit III (10 hours)
Integral Equations: Conversion of ordinary differential equations into integral equations, Fredholm and Volterra integral equations, separable kernels, Fredholm theory, eigen values and eigen functions.

Unit IV (10 hours)
Green function: Boundary Value Problems: boundary conditions: Dirichlet and Neumann; self-adjoint operators, Sturm-Liouville theory, Green's function, eigenfunction expansion.

Course Learning Outcomes

The understanding of the classification of finite groups will be achieved. Upon completion of this course, students should be able to use these concepts in various fields, particularity in crystallography. Students will be able to learn the different analytical techniques for solving integral equations and construct Green's functions for many important boundary value problems.

Suggested Readings:

1. Elements of Group Theory for Physicists, A.W. Joshi (John Wiley, 1997).
2. Groups and Symmetry,M. A. Armstrong(Springer, 1988).

3. Advanced Method of Mathematical Physics, R. S. Kaushal & D. Parashar (Narosa, 2008).
4. Group Theory and Its Applications to Physical Problems, M. Hamermesh (Dover, 1989).
5. Chemical Applications of Group Theory, F. Albert Cotton (John Wiley, 1988).
6. Mathematical Methods for Physicists,G. Arfken, H. Weber, & F. Harris (Elsevier, 2012).
7. Linear Integral Equations, W. V. Lovitt (Dover, 2005).
8. Introduction to Integral Equations with Applications, A. J. Jerri (Wiley-Interscience, 1999).

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-DSE4216

Course Name: Theoretical Techniques in the Quantum World

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Theoretical Techniques in the Quantum World DSE	4	3	1	0	QM I and II.

Duration: 60 Hours (45L+ 15T)

Course Objectives

To introduce students to a simple and elegant class of quantum mechanical systems with supersymmetry, and to explore what it can teach us about the geometry of low-dimensional surfaces.

Contents:

Supersymmetry in Quantum Mechanics (15 Hours)
Supersymmetry in zero dimensions. Supersymmetry algebra in quantum mechanics and its implications for the spectrum of quantum mechanical systems. Spontaneous breaking of supersymmetry. The Witten index. Supersymmetric actions.

Path Integrals (15 Hours)
Path integrals in quantum mechanics. The partition function and the Witten index as a path integral. Instantons, tunneling, and the dilute gas approximation. Zero modes and determinants.

Morse Theory (15 Hours)
Singular homology and homology groups. Differential forms and de Rham cohomology. Betti numbers. de Rham's theorem. Hodge operators. Harmonic forms. Sigma models. Supersymmetry and Morse theory.

Learning Outcomes
Students will learn about supersymmetry in its simplest setting: ordinary quantum mechanics. They will also learn about its relation to Morse theory and the topology of low-dimensional surfaces, a beautiful example of the synergy between physics and mathematics. Students keen on specialising in theoretical high-energy physics and string theory will find this course particularly useful.

Suggested Readings:

1) Geometry, Topology and Physics, Mikio Nakahara, Taylor & Francis (CRC Press), 2nd Edition, 2003.
2) Mirror Symmetry, Kentaro Hori et al., American Mathematical Society, Clay Mathematics Monographs, Volume 1, 2003.

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-SEC4271

Course Name: Workshop skills

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Workshop skills SEC	2	0	0	2	

Duration: 60 hours

Course objective:

The aim is to teach them how to handle machines that can be useful for precise cutting in lab accessories, useful for experiments.

Content:
Hands-on experience:
Unit-I:
- Lathe machine (Plane turning, step turning, taper turning)
- Drill machine

Unit-II:
- Plate cutting
- Hand tools (hacksaw, drilling, tapping, filing)

Learning outcome:
The student will be confident and skilled for handling lab useables and small repairs.

(Not more than seven students at a time due to space constraint and safety.)

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-SEC4272

Course Name: Computational Physics

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Computational Physics SEC	2	0	0	2	

Duration: 60 hours

Course Objective

This is an introductory course where students will learn the various numerical methods to solve physics problems through a programming language(Python).

Prerequisite: Basic knowledge of Python

Content:

Unit-I:

- Numerical Integration: Simpson, Trapezoidal, Gauss Quadrature
- Random number, Monte Carlo Integration

Unit-II:

- Differential equations: Euler method, Runge-Kutta
- Application to Physics problems: Schrodinger Equation using iterative method

Course Learning Outcomes

A student having taken the course would be expected to be proficient in numerical methods using a programming language (Python). In addition, it is also expected that the student would be able to use the same to solve problems involving Integration and Differential equations.

Suggested reading:

1. Lab manual for Computational Physics, Department of Physics and Astrophysics, University of Delhi 2025.
2. https://www.python.org/doc/
3. Monte Carlo Simulation in Statistical Physics: An Introduction, Binder, Kurt, Heermann, Dieter (5th Ed., Springer, 2010)
4. Numerical Analysis, Richard L. Burden, J. Douglas Faires, Annette M. Burden (10th Ed., Cengage Learning, 2016)

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-SEC4273

Course Name: Amateur Astronomy

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Amateur Astronomy SEC	2	0	0	2	

Duration: 60hours.

Course objective:
The student can make cost effective telescopes to enjoy their astronomy skills.
Content:
Unit-I: Designing of an optical telescope.
Unit-II:

- Projection of sun and counting the sun spots
- Identification of celestial objects.

Outcome:
The students will participate actively in designing telescopes and conducting measurements for celestial objects

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-SEC4274

Course Name: Magnet design and simulation

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Magnet design and simulation SEC	2	1	0	1	

Duration: 45 (15L +30P) hours

Course Objectives:

To impart foundational knowledge on the principles and engineering design of magnetic systems used in accelerators, beamlines, and scientific instrumentation. To classify and analyze the operation of various types of magnets (dipole, quadrupole, sextupole, etc.). To equip students with simulation and analytical skills necessary for magnet design. To understand the thermal, structural, and magnetic field considerations during the design of static and dynamic magnetic systems.

Course Content (3 hours/week)

Unit-I:

- **Introduction to Magnet Design:** Magnetic field and flux density basics**,** B-H curves, permeability, hysteresis**,** Classification: dipole, quadrupole, sextupole, solenoid.
- **Magnetic Materials and Core Selection**: Soft and hard magnetic materials, Laminated cores, yoke design, material properties (μr, saturation), Magnetization curves and losses.
- **Dipole Magnet Design:** Principle of uniform magnetic field generation, Pole face shaping, air gap design,Analytical expression for magnetic field and flux in C-type and H-type cores.
- **Quadrupole Magnet Design:** Field gradient, pole tip profile, Rotational symmetry and mechanical tolerances, Equations of motion for charged particles in quadrupole fields. **Sextupole and Higher Order Multipoles**: Field expansion, nonlinear field components, Correction of chromatic aberrations using sextupoles, Applications in beam focusing and correction.
- **Magnetic Circuit and Reluctance**: Ampere's Law and magnetic equivalent circuits, Calculation of magneto-motive force (MMF), reluctance, flux, Application to closed and open magnetic paths.
- **Coil and Conductor Design**: Current density, number of turns, cross-section, Insulation, cooling channels, bus bars, Power supplies and magnet energization.

Unit-II:

- **Thermal and Structural Considerations**: Joule heating, eddy currents, thermal management, Mechanical stresses, Lorentz forces, Cooling methods: water, oil, cryogenic.

- **Fringe Fields and Field Mapping:** Edge field effects, shielding, Field mapping using Hall probes and rotating coils, Magnetic center alignment.
- **Field Quality and Tolerances**: Harmonic analysis, Measurement techniques, Effect of geometric errors.
- **Pulsed Magnets and Eddy Currents**, Pulsed dipoles and kickers, Skin effect, rise time, and decay time, Eddy current suppression and laminated cores.
- **Superconducting Magnet Design (Introductory):** Benefits of superconductors in magnet design**,** Cryostat and quench protection basics**,** Applications in large accelerators.
- **Overview of Indian and Global Magnet Projects:** Magnet design at RRCAT, VECC, IUAC, CERN, BNL, and KEK**,** Industry-academia collaborations**,** Indigenous magnet manufacturing and QA practices.

Skill Development Lab & Simulation

- **Tools & Platforms: FEMM** (Finite Element Method Magnetics) – Free 2D simulation,
- **Opera/TOSCA** – Commercial (if available),
- **COMSOL Multiphysics** – 2D/3D magnetostatics module, Python/Matlab for analytical calculations.

Lab Activities:

	Lab Exercise	**Tool**	**Description**
1	Introduction to FEMM	FEMM	Create geometry, assign boundary conditions
2	2D Dipole Simulation	FEMM	Compute field lines and flux density in dipole geometry
3	Analytical Calculation of Dipole Field	Python/Manual	Compare with FEMM result
4	Quadrupole Field Simulation	FEMM	Compute field gradient, plot field contours
5	Pole Tip Shaping	FEMM	Investigate effects of different profiles
6	Magnetic Circuit Calculation	Python/Excel	Calculate MMF and reluctance
7	Sextupole Design Simulation	FEMM	Design and visualize higher-order field
8	Eddy Current Loss Estimation	FEMM/COMSOL	Pulsed magnet simulation
9	3D Magnet Design Overview	COMSOL	Field distribution visualization (if available)
10	Comparison of Magnetic Materials	FEMM	Simulate using different B-H curves
11	Cooling Analysis	Manual/Excel	Power loss and cooling requirement estimation
12	Simulation of Field Mapping	FEMM	Simulate rotating coil/Hall probe path

Course Learning Outcomes:

Upon successful completion of this course, students will be able to: Describe the design principles and physical function of static magnets used in beam control and steering. Compute magnetic field distributions, gradients, and forces analytically for simple geometries. Use electromagnetic simulation software (e.g., FEMM, Opera, COMSOL) for modeling 2D/3D magnet systems. Analyze key design constraints including saturation, eddy current losses, and cooling requirements.

Suggested Reading:

1. Design of Permanent Magnet Multipole Devices, Klaus Halbach & Richard F. Holsinger, (Volume:10553, Technical Report, Lawrence Berkeley Laboratory, LBL, 1976).
2. Field Computation for Accelerator Magnets, Stefan Russenschuck (3rd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, 2018).
3. Iron Dominated Electromagnets, Jack T. Tanabe (2nd Edition, World Scientific Publishing, 2005).
4. Magnet Design: Theory and Practice, W. T. Norris, (on behalf of the IEE) (1st Edition, Peter Peregrinus Ltd., 1983).
5. FEMM Documentation and Online Tutorials, David Meeker (Distributed via FEMM Software Website, Version 4.2 or latest, 2015).

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-SEC4275

Course Name: Data Interpretation and Simulation

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Data Interpretation and Simulation SEC	2	1	0	1	

Duration: 45hours (15L+30P)

Course Objectives

To develop the ability to interpret, analyze, and present scientific data using modern computational tools. To provide hands-on experience with ROOT (CERN), Origin, and Python for data analysis and visualization. To introduce basic simulation techniques for modeling physical phenomena and experimental processes. To enhance skills required for scientific reporting and reproducible research in experimental/theoretical physics.

Course Contents

Unit I: Data Handling and analysis with Python (8 Hours)

- Types of data: experimental, simulated, observational
- Basic statistics: mean, median, standard deviation, error bars
- Introduction to GNUPlot: plotting, curve fitting, peak analysis
- Data import/export, managing datasets, graphical presentation
- Basics of Python: variables, loops, functions
- NumPy, Pandas, and Matplotlib for data handling and visualization
- Linear regression, curve fitting using SciPy
- Plotting histograms, scatter plots, error bars, etc.

Unit II: Introduction to ROOT (CERN) and Simulation Techniques (7 Hours)

- Overview of ROOT and its architecture
- Working with histograms, trees, and graphs
- Data fitting, statistical tools, multi-plotting
- ROOT scripting (C++ and PyROOT) basics
- Concept of numerical simulation
- Monte Carlo method basics
- Simulation of physical processes (radioactive decay, random walk, detector response)
- Visualization of simulation output

Laboratory Work (2 Hours/week)

Hands-on assignments based on:

- GNUPlot: Curve fitting, interpolation, error analysis
- Python: Reading and visualizing experimental data, statistical analysis
- ROOT: Creating histograms, performing fits, simulating data

- Mini project involving data analysis and basic simulation of a physical phenomenon (e.g., particle interaction, decay process, or signal response)

Course Learning Outcomes

Upon successful completion of this course, students will be able to: Interpret and statistically analyze experimental and simulated data using scientific software. Visualize and fit data using tools such as Python, GNUPlot, and ROOT. Simulate basic physical systems and analyze outcomes in comparison to real datasets. Generate scientific plots and reports suitable for publications or thesis work.

Suggested Reading

1. Data Reduction and Error Analysis for the Physical Sciences, Bevington & Robinson
2. Think Stats: Exploratory Data Analysis in Python, Allen B. Downey
3. ROOT User's Guide – CERN Documentation (https://root.cern/manual/)
4. Mark Newman's Computational Physics
5. Python Documentation – https://docs.python.org

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-SEC4276

Course Name: Electronic circuit and simulation

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Electronic circuit and simulation SEC	2	0	0	2	

Duration: 60hours.

Course objective :

The students will get the opportunity to build and test different electronic circuits using softwares

Content:
Unit-I: Labview training.
Unit-II: Pspice training.

Course Learning Outcome:
The student will be able to engineer different electronic circuits for real world utilization

MASTER of SCIENCE in PHYSICS

Semester II

Course Code: PH-SEC4277

Course Name: Strategies for Scientific Dialogue in Research

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Strategies for Scientific Dialogue in Research SEC	2	1	0	1	

Duration: 45 hours

Course Objectives:

The course is designed to develop and strengthen students' ability to communicate scientific ideas clearly and effectively, both in written and oral formats. It aims to expose students to cutting-edge research through seminars delivered by faculty members and invited experts. Emphasis is placed on cultivating skills in scientific literature review, critical analysis, and academic discourse. The course also prepares students for academic presentations, thesis defenses, and professional scientific interactions. Recognizing that many students produce excellent research but struggle to present it effectively, this course seeks to bridge that crucial gap.

Course Learning Outcomes:

Upon successful completion of the course, students will be able to: Comprehend and effectively communicate recent research developments in physics and allied disciplines. Summarize and synthesize scientific literature with clarity, coherence, and critical insight. Prepare and deliver well-structured, confident, and audience-appropriate scientific presentations. Engage thoughtfully in scholarly discussions and respond competently to academic queries.
This course will be particularly beneficial for students planning to undertake project work or a dissertation in the third and fourth semesters.

Course Structure and Activities:

UNIT -I (15 Hours)

Lecture Attendance & Research Exposure:

- ➢ Students must attend a minimum of 10 research lectures organized by the department. These may include:
  3. Presentations by department faculty on their current research.
  4. Lectures by invited national or international experts.
- ➢ Students will submit comprehensive summaries (approx. 400–500 words) of at least five selected lectures, highlighting key concepts, methods, and findings.

UNIT -II (30 Hours)

Seminar Preparation and Delivery (20 Hours):

- ➢ Students will be assigned a research topic or paper, drawn from current research themes or courses offered in the M.Sc. syllabus.
- ➢ They will receive study materials, including relevant papers, reviews, or resources from the faculty.
- ➢ Each student must prepare a written synopsis (~800–1000 words) on the assigned topic.
- ➢ Students will then present a seminar (15–20 minutes) based on their understanding, followed by a Q&A session.

The course is structured in the spirit of a Dissertation under the DSE category, but with lower credit weightage and, accordingly, reduced academic rigor. As such, the number of hours assigned is indicative rather than prescriptive, intended to reflect the approximate level of effort expected.

Assessment and Evaluation:

Component

i) Participation in Departmental Lectures
ii) Written Summaries of Attended Lectures
iii) Written Review of Assigned Research Topic
iv) Seminar Presentation (Content, Clarity, Delivery)

The Evaluation will be conducted by:

i) A three-member departmental committee for the overall course.
ii) A two-member subcommittee for seminar presentation evaluation.

Notes for Implementation:

- ➢ Attendance at department seminars will be tracked.
- ➢ Students may optionally include key questions or insights from each attended lecture.
- ➢ Emphasis will be placed on communication skills, depth of understanding, organization of content, and response to questions.
- ➢ This course encourages peer learning and academic engagement beyond the classroom.

General Electives (GEC) courses

General Electives (GE) courses to be offered to other departments					
PH-GEC1 Radiation Safety	66	3	0	1	4
PH-GEC2 Introductory Astronomy	69	3	0	1	4
PH-GEC3 Complex System & Networks	71	3	0	1	4
PH-GEC4: Physics for Biological Systems	73	3	0	1	4
PH-GE5: Physics Education	75	3	0	1	4

SELECTION OF GENERAL ELECTIVE COURSES: Guidelines

SEMESTERS I to IV: Students may opt for four General Elective courses in lieu of Department-Specific Elective (DSE) courses—one General Elective course in each of the four semesters—adding up to a total of 16 credits.

- ❖ Certain General Elective Courses may have prerequisites. Students should keep this in mind while opting for General Elective courses.
- ❖ Allotment of General Elective Courses will be based on the choices indicated by the student, performance of the student in earlier semester(s) and availability of seats.

<u>Open electives (GE papers) to be offered to other departments</u>

MASTER of SCIENCE in PHYSICS

Semester I /II/III/IV

Course Code: PH-GEC0001

Course Name: Radiation Safety

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Radiation Safety GEC	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

This course is aimed to introduce the student to practical aspects of nuclear radiation with an understanding of basic quantities and doses, the role of fundamental processes involved in the interaction of X- rays, gamma-rays, charged particles and neutrons with matter, the principles underlying the operation of nuclear detection/dosimetry instruments, areas of applications, awareness of the need and methods for safety protocols for radioactive material and environmental safety.

Contents:

Unit I (8 Hours)

Basics of Radiation: Origin of radiation, binding energy and Q-value, stable and unstable isotopes, radioactive decay (alpha, beta, neutron and electromagnetic transitions), mean life and half life, nuclear reactions, concept of cross sections and attenuation co-efficients, Neutron flus, kinematics of nuclear reactions. Slowing down and moderation. Basic idea of different units of activity, radiation quantities: exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, quality factor, radiation and tissue weighting factors, KERMA, Annual Limit of Intake (ALI) and Derived Air Concentration (DAC).

Unit II (15 Hours)

Devices for radiation measurement and survey:Radiation interaction with matter,

Introduction to types of radiation detectors: semiconductor, scintillator and gas detectors (Geiger-Muller counters, ionisation chamber and proportional counters) Principles of radiation counting statistics, dead time and calibration standards.

Types of Radiation Dosimeters: thermoluminescence, radiographic films, calorimetry, semiconductor diodes; Relation between detection and dosimetry; exposure measurements with free air chamber.Interaction ofionising and non-ionising radiation at the cellular level.

Application of Nuclear techniques: Medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Art & Archaeology, Art, Crime detection, Oil &Mining, Water assessment, Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

Unit III (12 Hours)

Radiation Protection Standards: Classification of radioactive sources, Radiation dose to individuals from natural radioactivity in the environment and man-made sources, Basic concept of radiation protection standards: historical background, International Commission of Radiological Protection and its recommendations, the system of radiological protection, justification of practice, optimization of protection and individual limits, radiation and tissue weighting factors, committed equivalent dose, committed effective dose, concept of collective dose, potential exposures, dose and dose constraints, system of protection for invention-categories of exposures-Occupational, Public and Medical exposures, Permissible levels for neutron flux, factors governing internal exposure-Radionuclide concentration in air and water –ALI, DAC and contamination levels, effects of inhaled radionuclides on biological systems, impact on humans and society.

Unit IV (10 Hours)

Regulations, Monitoring, & Radioactive Waste Management: Evaluation of external radiation hazard-effect of distance, tome and shielding, shielding calculation, personnel and area monitoring-internal radiation hazards, radio toxicity of different radio nuclides and the classification of laboratories, control of contamination-bioassay and air monitoring, chemical protection, Radiation accidents and disaster monitoring, Sources & classification of Radioactive waste, permissible limits for disposal of waste, general method of disposal, storage management of radioactive waste in facilities. Responsibilities of operator, regulatory bodies, and government.

Course Learning Outcomes

A knowledge of the principle of operation of various radiation detectors, understanding of radiation dose calculation and permissible doses for different levels of users, and radiation effects, an understanding of instrumentation in practical situations, awareness about the management of radioactive material, and adherence to safety protocols,

Suggested Readings

1. Nuclear and Particle Physics, W. E. Burcham and M. Jobes (Pearson Education, 1995)
2. Radiation detection and measurement, G. F. Knoll (4th Ed., Wiley, 2010)
3. Thermoluninescense Dosimetry, Mcknlay, A. F., Bristol, Adam Hilger (Medical Physics Hand book 5)
4. Fundamental Physics of Radiology, W. J. Meredith and J. B. Massey (John Wright and Sons, 1989)
5. An Introduction to Radiation Protection, A. Martin and S. A. Harbisor (John Willey & Sons, 1981)
6. Medical Radiation Physics, W. R. Hendee (Medical Publishers Inc., 1981)
7. Nuclear Physics : Principles and applications, John Lilley (Wiley, 2001)
8. Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (2nd Ed., Elsevier, 2014)

9. Techniques for Nuclear and Particle Physics Experiments, W.R. Leo (2^{nd} Ed., Springer, 2013)
10. IAEA Publications : (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b)Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).
11. AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities.
12. AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources.

MASTER of SCIENCE in PHYSICS
Semester I/II/III/IV
Course Code: PH-GEC0002
Course Name: Introductory Astronomy

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Introductory Astronomy GEC	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives
Since this course is an open elective, with students from diverse background opting for it, the primary objective is to impart a basic knowledge about the oldest branch of physical science through a conceptual mode, relying less on mathematics and more on physical understanding. Since exciting new developments have been taking place in the astronomy of 20-th and 21-st centuries, with India playing crucial roles, the idea is to enable students to have a flavour of both historical and modern aspects so that they acquire a perspective of their place in the universe..

Contents:
Unit I (7 Hours)
Antiquity of astronomy: Planets and stars in Egyptian and Babylonian civilizations; Possible reference to stars and planets in Indus Valley Civilization; stars and constellations in Rig Veda as well as in other vedic literature; reference to Halley's comet in a Babylonian clay tablet; Far Eastern astronomy - comets and Crab supernova; reference to cosmic objects in mythologies, classic literature and science fictions.
Early astronomical measurements: Measurement of Earth's radius by Eratosthenes; Lunar and solar motion studies by Hipparchus - equinoxes and solstices, lunar and solar eclipses; Aryabhatta I and his seminal contributions to astronomy - relative motion, spinning Earth, eclipses, etc.; Varahamihira, Brahmagupta and other siddhantic astronomers of India; symbiotic relation between mathematics and astronomy; evidence of the precession of equinox from vedic literature; Jai Singh and his Jantar Mantar.

Unit II (10 Hours)
Solar system: geocentric model - Ptolemy, Tycho Brahe and Samanta Chandrasekhar; retrograde motion of Mars and theory of epicycles; Copernicus and the heliocentric model; Kepler's laws of planetary motions - a formulation based on a set of mathematical laws for the first time in physical sciences; Galileo's pioneering work - length and time measurements, telescope, lunar craters, moons of Jupiter, rings of Saturn, corroboration of Copernican model, Pisa tower and equivalence principle.
Laws of gravitation- motion of the Moon around the Earth, falling bodies, Newton's genius; Halley's comet and laws of gravity; importance of gravity as a force in astronomy; Physics of the Sun; Thermonuclear reactions; discovery of Neptune and Pluto; asteroid belt, meteors and comets; Tidal forces and the oceanic tides; precession of equinox and change of seasons;

dating Rig veda using the precession of equinox; Distances - parallax method; standard candles - Cepheid variables and Henrietta Leavitt, Type Ia Supernovae; Spectroscopy - atomic spectra, emission and absorption lines, their widths and Doppler shifts.

Unit III (18 Hours)

Stellar population and Hertzsprung-Russell diagram; Meghnad Saha, ionized element, Saha equation and birth of astrophysics; Wilson-Bappu effect and stellar distances; Stellar structure and evolution- evolution of low mass stars and high mass stars; white dwarfs - Fowler, Chandrasekhar and Eddington; Chandrasekhar's mass limit; Baade and Zwicky - supernova and neutron stars; supernova explosion; pulsars.

Milky Way and other galaxies: Shapley-Curtis debate; measurement of Doppler shift in emission lines by Humason, Slipher and Hubble; Cepheid variable and distances of galaxies; Classification of galaxies - spirals, ellipticals, irregulars, dwarfs, lenticulars, etc.; Hubble's law and birth of cosmology as a scientific discipline; big bang and steady state models; Hoyle-Narlikar cosmology;radio source counts, evolution of radio-sources and setback to steady-state theory; angular resolution, radio interferometry and large baselines; detection of apparent superluminal motion; radio telescopes in India - Govind Swarup and his collaborators

Unit IV (6 Hours)

The Universe: Penzias, Wilson and the cosmic microwave background; corroboration of thermal history in big bang cosmology as predicted by Gamow and his collaborators; Big bang model, singularity and Raychaudhuri equation; clusters of galaxies; Zwicky and the dark matter; the observed large scale structure; Vera Rubin and the evidence of dark matter from galactic rotation curves; Type Ia supernovae and accelerating universe; the puzzle of dark energy; new astronomy - X-ray and gamma ray astronomy, gravitational waves, neutrino astronomy, thirty metre telescope and the square kilometre array; discovery of exoplanets.

Course Learning Outcomes

A historical perspective of the development of Astronomy. Conceptual understanding of basic principles involved. A flavour of current developments in this field and India’s role in them. Appreciation of laws of nature that are discovered on Earth but which explain successfully distant cosmic objects and the universe as a whole

Suggested Readings

1. The Physical Universe, Frank Shu (University Science Books, 1982)
2. Cosmology: The Science of the Universe, Edward Harrison (Cambridge University Press, 2000)
3. From Black Clouds to Black Holes, J. V. Narlikar (World Scientific, 1985)
4. Archeoastronomy- Introduction to the Science of Stars and Stones, Giulio Magli (Springer, 2016)

MASTER of SCIENCE in PHYSICS

Semester I

Course Code: PH-GEC0003

Course Name: Complex System & Networks

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Complex System & Networks GEC	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Objectives:

This course deals with the interdisciplinary subject of complex systems, that include, among others, living organisms, ecosystems and human societies. The course emphasizes a unifying theme – complex networks – that cuts across all these systems. It develops the mathematical tools of graph theory and dynamical systems to provide insight into the structure, dynamics and evolution of a variety of complex systems in the physical sciences, life sciences, social sciences and engineering.

Contents:

Unit I (7 Hours)

Overview: Examples of complex systems: organisms, brains, ecosystems, societies, the internet. Components of these systems: molecules, cells, species, agents, computers. Collective phenomena exhibited by these systems. Contrast with other collective phenomena in physics such as phase transitions. Adaptive nature of these systems.

Unit II (10 Hours)

Graph theory and the network structure of complex systems: Complex networks of interaction as a unifying theme underlying complex systems. Undirected, directed and bipartite graphs, hypergraphs. Adjacency matrix of a graph. Graph theoretic measures of network structure. Random graph ensembles, small-world, scale-free, hierarchical and autocatalytic graphs. Network motifs. Nature of graphs that arise in various complex systems

Unit III (14 Hours)

Dynamics of complex systems: Dynamics on a fixed network. Examples of continuous and discrete dynamical systems to be taken from various complex systems such as chemical networks, metabolic networks, ecological food webs, genetic regulatory circuits, neural networks, social and economic networks, epidemiological networks. Fixed point and limit cycle attractors of these systems. The influence of network structure on dynamics.

Unit IV (14 Hours)

Evolution of complex systems: How networks change over time. Preferential attachment model of scale free networks. The origin of life puzzle. Model of autocatalytic network evolution and self-organization of a complex network. Community assembly models in ecology. Evolution of biological and social networks. Crashes and recoveries in complex systems. Robustness and fragility of complex systems.

Course Learning Outcomes

Being able to appreciate that complex networks of interacting components underlie many complex systems studied under different disciplines. Learning the similarities and differences between complex systems from the perspective of network structure.Learning certain mathematical methods of graph theory and dynamical systems.Being able to apply these methods to characterize the structure of various complex systems and to model certain phenomena exhibited by them.

Suggested Readings

1. Networks: An Introduction, M. E. J. Newman (Oxford University Press, 2010).
2. Origins of Order, Stuart Kauffman (Oxford University Press, 1993).
3. Handbook of Graphs and Networks: From the Genome to the Internet, S. Bornholdt and H.-G.Schuster (Wiley-VCH, 2003).
4. Dynamics of Complex Systems, Yaneer Bar Yam (Perseus Books, 1997)

Prerequisites for the course: Students should have taken Mathematics as a subject in high school (Class XI and XII).

MASTER of SCIENCE in PHYSICS

Semester I/II/III/IV

Course Code: PH-GEC0004

Course Name: Physics of Biological Systems

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Physics of Biological Systems GEC	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

This open elective course will introduce students to selected biological phenomena from the point of view of physics, emphasizing quantitative regularities. It will enable students from non-biology backgrounds to gain an overview of living systems, and those from biology backgrounds to perform mathematical modelling of certain biological processes.

Pre-requisites: Any branch of Science in Bachelors.

Contents:

Unit I (10 Hours)

Length and time scales in biology: Types, sizes and roles of biomolecules - metabolites, proteins, RNA, and DNA. Ranges of cell sizes and interdivision time scales,. Ranges of organism sizes and lifetimes, Scaling laws in biology, Complexity of living systems, Timeline of life on Earth, Time scales in biological evolution. Experimental techniques.

Unit II (14 Hours)

Cellular dynamics: Dynamical systems, coupled ordinary differential equations, Phenomena and models of intracellular chemical dynamics. Reaction-diffusion systems, Ecological interactions: Predator-prey model.

The brain: Dynamics of a single neuron, Neural networks, Learning, Memories as attractors of neural network dynamics.

Unit III (9 Hours)

Information in living systems: Probability, entropy and information, Applications of Information theory in genetics. Brownian motion of colloids.

Unit IV (12 Hours)

Random walk in d=1,2,3 and Self-avoidance, classification and conformations of polymers and related Scaling, structures of DNA, simulation methods and related experiments.

Course Learning Outcomes

Gain knowledge of structures and processes in living systems at multiple length and time scales, including at the level of molecules, cells, multi-cellular organisms and ecosystems. Appreciate that life is a consequence of physical processes at the molecular level. Learn certain mathematical methods of dynamical systems, probability and information theory. Also, to learn a few techniques for numerical simulations of proteins or biopolymers. Be able to apply these methods to model certain biological phenomena

Suggested Readings

1. Physics in Molecular Biology, Kim Sneppen and Giovanni Zocchi (CUP 2005).
2. Biological Physics: Energy, Information, Life, Philip Nelson (W. H. Freeman &Co, NY, 2004).
3. Biophysics: Searching for Principles, William Bialek (Princeton University Press, 2012).
4. Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, 2013).
5. An Introduction to Systems Biology, Uri Alon (Chapman and Hall/CRC, 2013).
6. Mathematical Biology: I. An Introduction, J. D. Murray (3rd Ed., Springer, 2004).

MASTER of SCIENCE in PHYSICS

Semester I/II/III/IV

Course Code: PH-GEC0005

Course Name: Physics Education

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Physics Education GEC	4	3	1	0	

Duration: 60 Hours (45L+ 15T)

Course Objectives

This Discipline Specific Elective Course will develop pedagogic knowledge for teachinglearning of physics informed by global best praxis. It will delineate procedural and content knowledge for meaningful laboratory work; and design of appropriate technology enhanced active learning environments.

Contents:

Unit I (5 Hours)

Foundations of Teaching-Learning of Physics: Goals of physics teaching. Beliefs and Epistemological Expectations and how they impact teaching-learning of physics. Theoretical models of student learning. Structure of knowledge. Difference between novice learners and experts. Theories of cognition. Constructivist and social theories of learning. Guided Enquiry and Active Learning. Engendering cognitive change.

Unit II (12 Hours)

Effective Teaching-Learning Strategies: Models of Classroom. Traditional instructor centred environment vs Active engagement student centred environment. Physics Education Research (PER): What works and what does not work. Designing Lecture based effective instruction methods: Concept Tests; Peer Instruction; Interactive Lecture demonstrations; Just in Time Teaching; Interactive Tutorials; Cooperative Problem Solving. Modeling. Problem Solving. Enhancing learning through peer, group and collaborative work. Cognitive Apprenticeship. Research-based curricula: Developing hands-on activities. Developing Interactive worksheets/Tutorials.

Unit III (12 Hours)

Evaluating Conceptual Learning: Formative and Summative evaluation. Designing examinations. Types of questions: MCQ, Representation-translation questions, ranking tasks, context-based reasoning problems, estimation problems, qualitative questions, essay questions. Domain knowledge content surveys and concept probes (Mechanics, Electricity and Magnetism, Vectors, Quantum Mechanics etc).

Unit IV (16 Hours)

Learning in the Lab: Students understanding of nature of scientific investigation and its influence on lab work. Student's perception of concepts of statistics, errors of observation, reliability and validity of observations; graphical representation of data and impact on performance. Developing Procedural and Conceptual Knowledge (PACK) in the Laboratory. Learning to design open-ended experiments and verify hypotheses. Assessment of performance.

Technology Enhanced Learning Environments: Appropriate use of technology. Developing Demonstration experiments and hands-on activities for conceptual learning. Sensor based Data Acquisition Laboratories. Integrating Simulations, Visualization, Video, Modeling for conceptual learning. Designing Technology Enhanced Active Learning. Future of classroom.

Course Learning Outcomes

Understanding theoretical framework of how students learn; familiarity with range of effective strategies for teaching-learning; evaluating and enhancing student's conceptual understanding of physics and problem solving abilities; developing effective learning in the lab and open-ended investigations; designing technology enhanced active learning environments;. Designing effective assessment and evaluation tools for student learning; developing innovative teaching-learning resources and curricula.

Suggested Readings

1. Teaching Introductory Physics, Arnold Arons (John Wiley and Sons, Inc., 1997)
2. Teaching Physics with the Physics Suite, Edward F. Redish (John Wiley and Sons Inc., 2003)
3. Teaching and Learning in the Science Laboratory, Dimitris Psillos and Hans Niedderer (Editors) (Kluwer Academic Publishers, 2002)
4. Understanding Basic Mechanics, Frederick Reif (John Wiley and Sons Inc., 1995)
5. Peer Instruction, Eric Mazur (Prentice Hall. 1997)
6. Physics by Inquiry. Vol. I and II., Lillian C. Mc Dermott (John Wiley and Sons Inc., 1996)
7. Workshop Physics. The Physics Suite. Priscilla, W. Laws (John Wiley and Sons Inc., 2004)
8. Real Time Physics Active Learning Laboratories. The Physics Suite, David R. Sokoloff, Ronld K. Thornton, Priscilla W. Laws (John Wiley and Sons Inc., 2004)
9. Activity Based Tutorials. The Physics Suite, Michael C. Wittmann, Richard N. Steinberg, Edward F. Redish and the University of Maryland Physics Education Research Group (John Wiley and Sons Inc., 2004)
10. Tutorials in Introductory Physics, Lillian C. Mc Dermott, Peter S. Shaffer and the Physics Education Research Group (John Wiley and Sons Inc., 2003)
11. Modelling in Physics and Physics Education, Proceedings of the GIREP Conference 2006. Ed van den Berg, Ton Ellermeijer and Onne Slooten. GIREP 2006.
12. Five Easy Lessons: Strategies for Successful Physics Teaching, Randall D. Knight.

Prerequisites for the course: Students should have taken Physics as one of the subjects in their Graduation (B.Sc.).

UNIVERSITY OF DELHI
MASTER OF ZOOLOGY
(MSZOOL)
(Academic Year 2025)

PROGRAM BROCHURE

Syllabus under NEP2020 Frame work
For the First Year of M.Sc. Zoology to be effective from 2025

CONTENTS

Department of Zoology, University of Delhi

1. About the Department

The Department of Zoology, established in 1947, has consistently upheld its commitment to excellence in teaching and research in animal sciences. In 1963, it was recognized as the Centre for Advanced Studies (CAS) in Endocrinology and Cell biology, a status it continues to enjoy to this day. The Department's dedication to excellence is further demonstrated by its state-of-the-art Central-Instrument Facility (CIF), funded by the University, DST-Purse and DST-FIST grants, DBT, ICAR and ICMR extramural grants.

Over its 78-year history, the Department of Zoology has achieved significant milestones. It has produced post-graduate students and awarded doctoral degrees. The academic training provided to the Department’s M.Sc. students prepares them for doctoral programs at leading institutes globally. The Department’s alumni have made significant contributions in diverse fields, serving as faculty and scientists at renowned universities and research institutes worldwide, and as distinguished officers in government services and biotechnology industries.

The current research and teaching in the Department include diverse aspects of Zoology with a balance of organismic and reductionist biology. It offers teaching and interdisciplinary research programs in the diverse areas such as, Reproductive Biology, Molecular Endocrinology, Genomics, Metagenomics, Cancer Biology, Animal Physiology, Entomology, Fish Biology, Immunology, Developmental Biology, Cell Biology, and Radiation Biology. The faculty members have been publishing scientific papers in peer-reviewed high-impact research journals.

The Department of Zoology, a world-class center of excellence in Zoology education, and advanced research training, envisions promoting self sustainability and innovation in students through skill development. The Department is committed to impart a holistic understanding of Zoology, thereby 'redefining Zoology' for the modern student, enhancing their employability, and fostering an interest in and innovative solutions for biodiversity conservation and the promotion of a physiologically and mentally healthy society. To further strengthen its academic and research capabilities, the Department is currently undertaking major renovations of its teaching and research laboratories. The M.Sc. curriculum has also been revised in alignment with the National Education Policy (NEP) 2020 to better reflect the Department’s evolving vision and mission.

With a rich history, the Department of Zoology remains unwavering in its commitment to advance scientific excellence and societal relevance.

II. Introduction to NEP 2020

National Education Policy (NEP) 2020

The courses are restructured to promote interdisciplinary learning, research-driven education, and flexible curriculum design. Emphasis is placed on skill development, critical thinking, and experiential learning, aligning with global standards and industry needs. The revised framework encourages academic mobility, while integrating modern pedagogical approaches and digital tools. This reform, in line with the NEP 2020, aims to enhance student employability, innovation, and holistic understanding of the subject.

Definitions:

(i) ‘Academic Programme’ means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/Centre.

(ii) ‘Course’ means a segment of a subject that is part of an Academic Programme.

(iii) 'Programme Structure' means a list of courses (Core, Elective, General Elective, Skill-based Course) that makes up an academic programme, specifying the syllabus, credits, hours of teaching, evaluation and examination scheme, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University rules, eligibility criteria for admission.

(iv) 'Core Course" means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course.

(v) 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre.

(vi) PG 'General Elective' means an elective course which is available for students of all programs other than students of same department. Students of other Department will opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

(vii) 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course.

(viii) 'SGPA' means Semester Grade Point Average calculated for individual semester.

(ix) 'CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(x) 'Grand CGPA' is calculated in the last year of the two-year course by clubbing together the CGPA of two years, i.e., four semesters. This cumulative grade point average, presented in the form of a Transcript, is a comprehensive reflection of the student's academic performance throughout the program. To benefit the student, a formula for converting the Grand CGPA into percentage marks is provided in the Transcript, aiding in their future academic and career pursuits.

Programme Objectives (POs):

The M.Sc. Zoology program is designed to provide students with an in-depth and interdisciplinary understanding of animal and human life. It covers a wide range of topics, from cellular and molecular processes to recent advances in Zoology, from organismic to reductionist biology. The course is structured to build strong foundational knowledge through core subjects such as Comparative Animal Physiology, Genetics and Cytogenetics, and Principles of Gene Manipulation. It also offers flexibility through a range of elective courses that address current and emerging areas in Zoology—including Animal Behaviour, Chronobiology, Metabolic Diseases, and One Health. This interdisciplinary approach opens up diverse learning opportunities and excites students about the breadth of knowledge they will gain.

The program places a strong emphasis on both theoretical learning and practical skill development. With dedicated laboratory sessions and a specialized skill-based course, students are ensured hands-on training in modern biological techniques. By integrating traditional zoological studies with cutting-edge scientific advancements, the program aims to cultivate critical thinking, scientific inquiry, and research competencies. This approach instills confidence in students, preparing them for careers in academic research, teaching, biotechnology, healthcare, environmental management, and public policy, and laying a strong foundation for pursuing doctoral studies and other advanced scientific careers.

Programme Specific Outcomes (PSOs):

The M.Sc. Zoology program will equip students with advanced knowledge and practical expertise in the biological sciences, with a specific focus on animal physiology, genetics, molecular biology, and ecological health. Upon successful completion of the program, students will be able to critically analyze and interpret complex biological phenomena, understand the genetic and cellular basis of life, and apply molecular tools in gene manipulation. Through elective courses, they gain specialized insights into emerging areas such as Animal behavior, Chronobiology, Metabolic disorders, and the One Health approach, enabling them to address real-world challenges in human, animal, and environmental health. The program also fosters proficiency in laboratory techniques, data analysis, and scientific communication through intensive hands-on-training. Thereby, students are well-prepared for careers in research, teaching, biotechnology, public health, and conservation, and are equipped to pursue doctoral studies or professional roles requiring interdisciplinary and research-oriented skills.

Selection of Elective Courses:

Elective courses in Zoology-

The number of seats in each elective course would be limited and will be announced before the commencement of the course in each year. The selection of elective papers in 1st and 2nd Semesters shall be based on merit criteria decided by the Academic committee of the Department.

Eligibility for Admissions:

This course is open to students who have studied Zoology, Biological Sciences or Life Science in B.Sc. based on an entrance test. Please refer to the rules of University of Delhi for seats and the procedure for admission.

'Assessment of Students' Performance and Scheme of Examination:

Examinations shall be conducted at the end of each semester as per the Academic Calendar notified by the University of Delhi. English shall be the medium of instruction and examination.

III. M.Sc. Zoology Programme

First Year of the two-year **M.Sc. Zoology** program is divided into two semesters. The **Details of the papers are as follows**

SEM.	Discipline Specific Core (DSC) (4x3=12 credits)	Discipline Specific Elective(DSE)/ General Elective Course (GE) DSE and GE (4x2=8 Credits) 2 DSE or 1 DSE+1 GE	SKILL BASED COURSE /SPECIALISED LAB (2 Credits)	Dissertation	TOTAL CREDITS
I	**[DSC-1]** Comparative Animal Physiology **[DSC-2]** Genetics and Cytogenetics **[DSC-3]** Principles of Gene Manipulation	**[DSE-1 & 2]** 1. Animal Behaviour 2. Chronobiology 3. Life Style and Metabolic Diseases 4. One Health: Principles and Applications [GE-1] 1. Endocrine Disruptors and Neural Pathways	Specialized Laboratory course in Zoology Part I	NIL	22
II	**[DSC-4]** Developmental Biology **[DSC-5]** Metabolism: Concepts and Regulation **[DSC-6]** Immunology	**[DSE-3 & 4]** 1. Cancer Biology 2. Neurobiology 3. Biology of Parasitism 4. Pharmacognosy and Basics of Traditional Medicine [GE-2] 1. Animal Models in Research	Specialized Laboratory course in Zoology Part II	NIL	22

Course Credit Scheme

Sem.	Discipline Specific Core(DSC)			Discipline Specific Elective(DSE)/ General Elective Course (GE)			Skill Based Course			Total Credits
	No.of papers	Credits (L+P)	**Total Credits**	No.of papers	Credits (L+T)	**Total Credits**	No.of papers	Credits (L+P)	**Total Credits**	
I	3	9L+3P	**12**	2	6L + 2T	**8**	1	2P	**2**	**22**
II	3	9L+3P	**12**	2	6L + 2T	**8**	1	2P	**2**	**22**
Total Credits	6	18L+6P	**24**	4	12L+4T	**16**	2	4P	**4**	**44**

For each Discipline Specific Core Courses, there will be 3 lecture hours of teaching (3 credit) and practical will be two hours (1 credit) every week.

For Discipline Specific Elective Courses and General Elective Courses (4 credit each), there will be 3 lecture hours of teaching and 1 Tutorial every week.

For Skill Based Courses (2 credit), there will be four hours of practical every week.

Semester wise Details of M.Sc. Zoology Course-Semester I

Paper Codes: The first two letters (MS) in a paper code defines as M.Sc.course, the ZOOL defines as a course of Zoology and the last letter as C, E, GE and SBC defines as core, elective, general elective, skill based course, respectively. The First numeral defines the semester and the remaining two numerals defines stream and thepaper number.

SemesterI				
Number ofcorecourses	**Creditsineachcorecourse**			
Course	Theory	Practical	Tutorial	Credits
MSZOOLC-101 Comparative Animal Physiology	3	1	-	4
MSZOOLC-102 Genetics and Cytogenetics	3	1	-	4
MSZOOLC-103 Principle of Gene Manipulation	3	1	-	4
3 Core courses	9	3	-	12
Total credits in core courses	**12**			
Number of elective courses Astudent hastochoose two DSE or one DSE and one GE fromthefollowingoptions	**Creditsineach Electivecourse**			
	Theory	Practical	Tutorial	Credits
Discipline specific elective (DSE) **MSZOOLE-104** Animal Behaviour	**3**	-	**1**	**4**
MSZOOLE-105 Chronobiology	**3**		**1**	**4**
MS ZOOLE-106 Life Style and Metabolic Diseases	**3**		**1**	**4**
MS ZOOLE-107 One Health: Principles and Applications	**3**		**1**	**4**
General elective (GE-1) **MS ZOOLGE-108** Endocrine Disruptors and Neural Pathways	**3**		**1**	**4**
Total credits from 2 elective courses	**8**			
Credits in skill based Course	Theory	Practical	Tutorial	Credits
Skill based course (SBC) **MSZOOLS-109** Specialized Laboratory course in Zoology Part I	-	2	-	2
Total credits in 1 Skill based course	**2**			

Discipline Specific Core-1 (DSC-1): MS ZOOLC-101

Comparative Animal Physiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- To develop a comprehensive understanding of how physiological processes, vary across different animal species and how these processes are adapted to diverse environments.
- To understand the modifications/adaptations found in different physiological systems of various organisms.
- The course also has a strong lab component, where students will develop skills in designing and conducting physiological experiments, recording accurate observations, and analyzing data.

Learning Outcomes

By studying this course, students will be able to:

- Develop a comprehensive understanding of the physiology of invertebrate and vertebrate animals.
- Understand how different physiological environments have shaped the physiology of animals across the animal kingdom
- Appreciate how different environmental conditions (e.g., temperature, oxygen availability, salinity) have shaped the physiological adaptations of various animal groups.

SYLLABUS OF DSC-1: Comparative Animal Physiology

MS ZOOLC-101

Unit 1. Internal transport and gas exchange **9 h**

Circulation: Systems of circulation, peripheral circulation, regulation of heart beat and blood pressure; Respiration: Transport and exchange of gases, neural and chemical regulation of respiration, gas transfer in air and water, gas exchangers, regulation of body pH.

Unit 2. Adaptations to stress **12 h**

Basic concepts of stress; Osmoregulation: Osmoregulation in aquatic and terrestrial environments, extra-renal osmoregulatory organs; Thermoregulation: Heat balance in animals, adaptations to temperature extremes, torpor, aestivation and hibernation, counter current heat exchangers; Bioluminiscence

Unit 3. Sensing the environment and coordination **13 h**

Sensory perception: Photoreception, chemoreception, mechanoreception; Chromatophores: Types, functional modifications and regulation, behavioural significance; Feeding: Modes, habits and patterns of feeding, behavioral adaptation

Unit 4. Muscle physiology **11 h**

Muscle structure and energetics, muscle adaptations; Electric organs: electroplaxes, electric discharge, and functional significance

Practical **30 h**

1. Study the concentration of pigment in isolated scales of dark-adapted fish.
2. Study the dispersal of pigment in isolated scales of light-adapted fish.
3. Examine the relative activity of enzymes in the fore, mid, and hindgut of a typical insect and correlate the enzyme activity with the different gut regions.
4. A comparative study of age-related variability in plethysmographic measurements
5. Observe and compare the inherent rhythmicity of the different parts of the heart.
6. Determine the effects of application of parasympathetic or sympathetic agonists/antagonists.
7. Assessing physical and chemical modifiers of heart rate in frog.
8. Determine the response of the heart to direct electrical stimulation / vagal stimulation.
9. Determine the threshold concentration of sucrose for eliciting feeding behavior in housefly.

Essential/Recommended Readings

1. Comparative Animal Physiology, Prosser,C.L.& Brown Jr.,F.A.(ed.), Saunders. (latest edition)
2. Eckert: Animal Physiology 5th Ed by Randall, David, Burggern, Warren, French, Kathleen (latest edition)
3. Animal Physiology; Hill,R.W, Wyse,G.A. and Anderson,M. Oxford University Press (latest edition)

Suggested Readings

1. Animal Physiology: Adaptation and Environmental, Nelson K. S. (ed.) Cambridge University Press, Cambridge, UK
2. General and Comparative Animal Physiology, Hoar W. S. (ed.), Prentice Hall, India
3. Comparative Physiology (Handbook of Physiology): Vol. 1, 2, Dantzler, W.H. (ed.) Oxford University Press, New York, USA.
4. Latest research papers published in Comparative Biochemistry and Physiology – Part A and Part B, Journal of Comparative Physiology – Part A and Part B, Journal of Experimental Biology

Discipline Specific Core-2 (DSC-2): MS ZOOLC-102

Genetics and Cytogenetics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- Genetics and Cytogenetics course includes understanding of chromosome structure, function and their role in inheritance and disease.
- This course will provide a comprehensive understanding of principles of Genetics with a better understanding to analyze complex traits and further implement their use in breeding and selection studies.
- The modern genetic tools for genetic manipulations will be employed to investigate and address genetic diseases.
- Hands-on experience of the students using model organisms will further strengthen their understanding for Genetics.
- By this comprehensive understanding, students can appreciate role of Genetics and Cytogenetics in various fields including disease, medicine, agriculture, biotechnology etc.

Learning Outcomes

- Genetics and Cytogenetics course will open up several avenues for students in terms of research and employability.
- By observing genetic mutations in *Drosophila*, the students can correlate phenotype with genotype, understand genetic interaction and their molecular basis.
- Students will be able to set hands on genetic crosses to understand recessive and dominant, segregation, pattern of inheritance and finally evaluating statistical significance by counting the progeny as statistical analysis provides crucial insights into many biological processes.
- Students will learn how genetic information is passed on in eukaryotes and prokaryotes, how genes work together in a complex manner in biological system and any alteration can lead to major phenotypic change.
- Students will be able to implement modern genetic tools in understanding and mitigating human genetic diseases through genetic counseling, gene therapy etc.

SYLLABUS OF DSC-2: Genetics and Cytogenetics

MS ZOOLC-102

Unit 1. History of genetics and genetic mapping **8 h**

Mendel's principles and its extension: incomplete dominance, co-dominance, penetrance, expressivity, epistasis and pleiotropy; Allelic series, Testing gene mutations for allelism; Fine structure of gene; Methods of gene mapping: Mapping in *E.coli* and its phage, recombination, 3-point test cross; Genetic and physical maps.

Unit 2. Genemutations and regulation of gene expression **12 h**

Types of gene mutations, methods for detection of induced mutations; Transposable elements and their applications; Chromosome structure: Nomenclature, polytene and lampbrush chromosomes and their relevance; Chromosomal abnormalities, Prokaryotic gene regulation:*lac* and *trp* operons of *E. coli;* Eukaryotic gene regulation: Chromatin organization and gene expression, transcription factors, enhancers and silencers, non-coding genes.

Unit 3. Analysing inheritance patterns **13 h**

Inheritance: independent assortment, linkage; Linkage disequilibrium; Pedigree analysis in humans; Complex pattern of inheritance, metric traits or continuous traits, partitioning of phenotypic variance, additive variation; Heritability, artificial selection, breeding value.

Unit 4. Sex determination, dosage compensation and human genetics **12 h**

Sex determination and mechanisms of dosage compensation: Human, *Drosophila* and *C. elegans*; Genetic basis of diseases in humans (Syndromes/Cancer/Infertility); Gal4-UAS system

Practical **30 h**

1. Study of mutant phenotypes of *Drosophila*.
2. Demonstration of law of segregation and independent assortment using *Drosophila* mutants
3. Study of autosomal and sex- linked inheritance using *Drosophila* mutant lines
4. Statistical analysis of genetic crosses
5. Empirical assessment of dosage compensation using *white apricot (w^a)* mutation in *Drosophila*
6. Targeted expression of genes using Gal4 - UAS System in *Drosophila*
7. Preparation and detailed observation of polytene chromosome from *Drosophila* salivary gland.
8. Study of transcriptional activity in polytene chromosome of *Drosophila* upon heat shock.
9. Preparation and study of metaphase chromosomes: Chromosome banding (C, G, H banding).
10. Simulation of genetic crosses using DrosophiLabprogram/Classic Genetics Simulator

Essential/Recommended Readings

1. Snustad and Simmons (Latest edition): Principles of Genetics, John Wiley & Sons, USA
2. Griffiths, J.F., Gilbert, M., Lewontin, C. and Miller, W. H. (Latest edition): Modern Genetic Analysis: Integrating Genes and Genomes, Freeman and Company, New York, USA
3. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., Killian, D. (Latest edition) Concepts of Genetics. United Kingdom: Pearson.

Suggestive Readings

1. Herron, Jon C., Freeman, Scott. (Latest edition): Evolutionary Analysis: Pearson Education.
2. Brooker, R. J. (Latest edition). Genetics: Analysis and Principles. United Kingdom: McGraw-Hill Education.
3. Latest research papers published in Genetics, Molecular Genetics, Journal of Genetics, Trends in Genetics

Discipline Specific Core-3 (DSC-3): MS ZOOLC-103

Principles of Gene Manipulation

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- Major objective of this core paper is to introduce to the students, contemporary molecular techniques for manipulation of genome that could assist them towards advanced understanding of biological processes in broad range of host organism.
- Lectures will specifically address the historical and standard techniques, gradual evolution and context-dependent applications of molecular techniques for their extended use.
- The student should be able to understand standard and system-specific gene manipulation approaches ranging from bacteria to mammals.

Learning Outcomes

- After successful completion of the course, the students will be able to design and comprehend experimental strategies for alteration of genes and gene products in different organisms.
- Proper understanding of the principles of recombinant DNA techniques will enable the student to design and develop modern recombinant drug molecules and vaccines, thus increasing their employability in the future.

SYLLABUS OF DSC-3: Principles of Gene Manipulation

MS ZOOLC-103

Unit 1. Basic recombinant DNA techniques: **11 h**

Nucleic acid isolation and basic analysis, cutting and joining DNA molecules, restriction modification systems, enzymes used in recombinant DNA technology; Restriction maps and mapping techniques; Nucleic acid probes, blotting techniques, DNA fingerprinting, Gel shift assay; Polymerase chain reaction: methods and applications.

Unit 2. Basic biology of vectors and cloning strategies **12h**

Plasmids, phages, single stranded DNA vectors, high-capacity vectors, expression vectors; Gene cloningstrategies: methods of transforming bacteria with rDNA methods of selection and screening of transformed bacteria; Construction of genomic and cDNA libraries.

Unit 3. Sequencing methods **11 h**

Principles of DNA sequencing, automated sequencing methods; Synthesis of oligonucleotides, primer designing; Directed evolution; Protein engineering.

Unit 4. Manipulating genes in animals **11 h**

Gene transfer to animal cells; Genetic manipulation of animals: transgenic animals, gene knockouts, gene silencing; Genome editing: gene therapy, CRISPR-Cas.

Practical **30 h**

1. Primer designing
2. Polymerase Chain Reaction
3. DNA gel electrophoresis
4. Purification of DNA from an agarose gel
5. Vector and insert ligation
6. Preparation of competent cells and storage
7. Transformation of *E. coli* with recombinant plasmids
8. Calculation of transformation efficiency
9. Plasmid DNA isolation: minipreps
10. DNA quantification and assessment of DNA quality
11. Restriction enzyme digestion
12. Confirmation of ligation in plasmid by different methods

Essential/Recommended Readings

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA (Latest edition).
2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R.M., (Latest edition), Blackwell Publishing, West Sussex, UK.

Suggestive Readings

1. Molecular Biotechnology: Principles and application of recombinant DNA, Bernard R. and Jack, ASM Press, Herndon, USA (Latest edition).
2. Latest research papers published in Nature Biotechnology, Nature Protocols, Gene Therapy

Discipline Specific Elective-1 (DSE-1): MS ZOOLE-104

Animal Behavior

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

CREDIT	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- To understand the adaptive significance of behavior in different environments.
- To discover how animals communicate, seek food, escape predators, and live together.

Learning Outcomes

- By studying this course, students will have a deep understanding of how and why animals behave the way they do.
- Students will be able to explain the role of brain, hormones, genes, and environment in shaping behavior, and how behavior evolves in response to ecological pressures.

SYLLABUS OF DSE-1: Animal Behaviour

MS ZOOLE-104

Unit 1. Concepts, genetics and physiology of behaviour **14 h**

Understanding animal behaviour from arthropods to vertebratesOntogenetic and phylogenetic approaches: Genetics of behaviour; Interactive theory of behaviour; Experience and development of behaviour; Tracing the evolutionary development of behaviour; Physiological basis of behaviour; Homeostasis: Behavioural strategies for maintaining internal balance; Time management: allocation of time to various activities and its adaptive significance.

Unit 2. Cognition, communication, navigation and foraging **16 h**

Problem-solving abilities and decision-making processes; Comparative cognition across species; Information use and signaling: visual, auditory, chemical and tactile; Evolution and function of signaling systems, sensory exploitation and signal receivers; Locomotion strategies, migration patterns and orientation mechanisms; Risk assessment and food selection; Optimal foraging theory.

Unit 3. Parental care and defense mechanisms **7 h**

Parental investment: Nesting behaviours and territoriality; Anti-predator behaviour: Camouflage, mimicry, and escape strategies; Diversity of anti-predator adaptations.

Unit 4. Reproductive behaviour and conservation **8 h**

Sexual selection and reproductive strategies, mate choice and competition; Role of animal behaviour in protecting biodiversity; Human – wildlife interface; Extinction; Reserve design: captive breeding and reintroductions.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Breed, M.D., & Moore, J. (2021). *Animal Behavior* (Latest edition). Academic Press.
2. Kappeler,PM. (2021). Animal Behavior: an Evolutionary perspective, (Latest edition)Springer
3. Rubenstein, D.R., &Alcock, J. (2019). Animal Behavior (Latest edition). Oxford University Press.
4. Goodenogh, J., McGuire,B. and Jakob,E. (2010). Perspectives on Animal Behavior (Latest edition). Wiley publications.

Suggestive Readings:

1. McFarland, D. (1999) Animal Behavior (Latest edition). Longman press
2. Latest research papers published in Animal Behaviour and Cognition, Journal of the Experimental Analysis of Behaviour, Ethology, ecology and Evolution

Discipline Specific Elective -2 (DSE-2): MS ZOOLE-105

Chronobiology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

CREDIT	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning Objectives

- To enable students to understand the importance of internal timing in regulating daily and seasonal processes in organisms.

Learning Outcomes

At the end of the course, the students should be able to

- Conceptualize how species profitably inhabit the temporal environment and space out their activities at different times of the day and seasons.
- Understand the molecular, cellular and systems levels of the generation and coordination of internal timing?
- Develop a critical viewpoint and to interpret observations from experiments on biological rhythms regulating daily and seasonal biology.
- Plan studies on biological rhythms in both human and non-human species.
- Understand the consequences of the disruption of internal rhythms on work performance and health in the modern world.

SYLLABUS OF DSE-2: Chronobiology

MS ZOOLE-105

Unit 1. Introduction of Chronobiology and Neural mechanisms of sleep **13 h**

History and milestones; Clock, rhythm and calendar; The biological timing system: Concepts and methods; Types of rhythms.Sleep mechanism; Brain rhythm and sleep; Rapid Eye Movement (REM), Non REM; Influence of sleep on memory.

Unit 2. Rhythm characteristics and factors **7 h**

Free running rhythm; Entrainment and masking in the natural and artificial environment: Zeitgebers: Photic and non-photic, Parametric and non-parametric entrainment, Phase shift, Phase response curves (PRC) and phase transition curves (PTC); Proximate and ultimate factors; Circannual control of seasonal processes; Photoperiodism: Concepts and photoperiodic time measurement models, Seasonal processes and photoperiodic control mechanisms.

Unit 3. Organization of the circadian system in multicellular organisms 12 h

Concept of central and peripheral clock systemsRetinal and pineal clocks; Melatonin: Input and output of the clock system; Anatomy of the circadian clock: suprachiasmatic nucleus (SCN).

Unit 4. Circadian timing , Biological clock, Life style and health 13 h

Genes and proteins involved in circadian rhythm generation; Molecular feedback loops: Transcription, translation, posttranslational mechanisms; Circadian timing in diverse organisms (*Drosophila*, zebrafish, birds, and mammals). Role of Biological clocks in human health and diseases; Clock dysfunction and lifestyle-related disorders; Chronotherapy.

Tutorial 15 h

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. (Latest edition). Oxford University Press.
2. Physiology in Sleep (Latest edition) By John Orem. Academic press

Suggestive Readings

1. Insect Clocks ((Latest edition) : D.S. Saunders, C.G.H. Steel, X. Afopoulou (ed.) R.D. Lewis. 2002 Barens and Noble Inc. New York, USA
2. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
3. Circadian Medicine: Christopher Colwell (ed.) Wiley-Blackwell (Latest edition)
4. Circadian Physiology: Roberto Refinetti, CRC Press (Latest edition) 2016
5. Latest research papers published in Chronobiology International, Journal of Biological Rhythms, Journal of Pineal Research

Discipline Specific Elective (DSE-3): Lifestyle and Metabolic Diseases

MS ZOOLE-106

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning Objectives

- Understand the biological and environmental foundations of metabolic disorders.
- Explore the role of gut health, diet, physical activity, and circadian rhythms in metabolic regulation.
- Analyze environmental and lifestyle risk factors influencing chronic diseases.
- Evaluate public health strategies and interventions for metabolic health promotion.

Learning Outcomes

By studying this course, students will be able to:

- Describe key metabolic disorders and their underlying mechanisms.
- Explain the impact of gut microbiota, nutrition, sleep, and stress on metabolism.
- Assess lifestyle and environmental interventions for preventing and managing metabolic disorders.
- Propose evidence-based public health and community approaches for metabolic disease prevention.

SYLLABUS OF DSE-3: Lifestyle and Metabolic Diseases

MS ZOOLE-106

Unit 1. Foundation of metabolic health and disorder **12 h**

Introduction to metabolism and metabolic homeostasis; Overview of major metabolic disorders: Obesity, Type 2 Diabetes, Non-alcoholic fatty liver disease (NAFLD), polycystic ovary syndrome (PCOS); Metabolic Syndrome: Role of insulin resistance, inflammation, and oxidative stress.

Unit 2. Gut health, microbiota, and the gut-brain axis **11 h**

The human gut microbiota; Gut dysbiosis and its association with metabolic disorders; Gut-brain axis: links to mood, appetite, immunity, and metabolic balance; Role of diet, antibiotics, and environmental factors in shaping the microbiome; Maintenance of gut health: Probiotics, prebiotics, synbiotics, postbiotics, and Fecal Microbiota Transplantation (FMT).

Unit 3. Environment and health **11 h**

Nutrition and personalized diets; Physical activity:, metabolic benefits, and behavioural strategies; Sleep hygiene, circadian rhythm, and metabolic health; Stress, cortisol, and metabolic implications; Environmental risk factors: pollution, endocrine-disrupting chemicals, microplastics, , air quality; Role of digital health tools and lifestyle tracking in metabolic diseases.

Unit 4. Public health approaches and ccommunity health frameworks **11 h**

Global burden of metabolic disorders (WHO, Sustainable development goals); Workplace, school-based, and community lifestyle programs; Policy frameworks and health promotion strategies; Climate change, metabolic stress, and sustainability; Life-course approach to Non-Communicable Disease prevention; Challenges in global health implementation and intervention scaling.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Lustig, R. (2021): Metabolical: The Lure and the Lies of Processed Food, Nutrition, and Modern Medicine. Harper Wave.
2. Rippe, J. M. (2019): Lifestyle Medicine. CRC Press.
3. Walker, M. (2017): Why We Sleep: Unlocking the Power of Sleep and Dreams. Scribner.
4. Sonnenburg, J., &Sonnenburg, E. (2015): The Good Gut: Taking Control of Your Weight, Your Mood, and Your Long-Term Health. Penguin Press.
5. World Health Organization (Various Years): Global Status Reports on Noncommunicable Diseases (WHO Publications).

Suggested Reading

1. Latest research papers published inNature Metabolism, The Lancet Diabetes & Endocrinology, Frontiers in Nutrition.

Discipline Specific Elective-4 (DSE-4): MS ZOOLE-107

One Health: Principles and Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- Interpretation of one health and significance of different players of one health.
- Develop a systems thinking in understanding disease emergence, transmission and mitigation.
- Provide knowledge of drivers of one health and understanding the necessity of multi-faceted strategies in controlling drivers.
- Impact of environmental changes, policy, governance, and community engagement on infectious disease prevention and control.
- Comparative account of immune mechanisms of humans, animal and insects

Learning Outcomes

By studying this course, students will be able to:

- Understand 'One health' approach and its applications.
- Understand the emergent need of one health application in mitigating diseases.
- Explain the role of distinct drivers of one health?
- Demonstrate comprehensive knowledge of risk factors, mode of transmission, and appropriate strategies to alleviate them.
- Discuss drivers of disease emergence and re-emergence.
- Understand and appreciate the complexity of prevalence of antimicrobial resistance.
- Deploy good practices in surveillance, data collection, management and its analysis.
- Understand the principles of effective communication and its relevance in public health and disease mitigation.

SYLLABUS OF DSE-4: One Health: Principles and Applications

MS ZOOLE-107

Unit 1: Foundations of one health **6 h**

Introduction to one health, Overview of infectious, emerging and re-emerging infectious diseases; Drivers and factors in disease emergence: Anthropogenic and environmental drivers, microbial evolution and adaptation.

Unit 2: Disease emergence, transmission, immune response **16 h**

Zoonoses: emergence and spillover mechanisms, reservoirs, vectors, and environmental drivers; Food- and water-borne diseases, Case studies: COVID-19, cholera, tuberculosis; Immune responses in humans and reservoir hosts; Immunoprophylaxis and immune modulation strategies; Role of insect vectors in zoonotic disease transmission and immune interactions.

Unit 3: Antimicrobial resistance (AMR), environment, surveillance, diagnosticsand analysis 15 h

Drivers of AMR in humans, animals and environment; Environmental factors: climate change, urbanization, land use; One health approaches to AMR mitigation; One health surveillance:Types and goals, integrated disease surveillance systems (human, animal, environment); Diagnostic methods: microbiology, molecular, serology, genomics; Data management.

Unit 4: Policy, Governance, Communication and Future Challenges 8 h

One health governance: Global and National strategies, multi-sectoral coordination and communication mechanisms; Policy development; Community engagement; Emerging threats: bioterrorism, climate-driven diseases, Operational and Governance challenges, Technology and strategic innovations; Issues beyond infectious diseases: pollution, food security, sustainable development goals; Case studies.

Tutorial 15 h

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Ronald Atlas and Stanley Maloy (Latest edition): One Health: People, Animals, and the Environment. ASM Press
2. Yamada, A., et al. (Latest edition) Confronting Emerging Zoonoses: The One Health Paradigm. 2014. (Eds) Springer, New York, NY
3. Mackenzie, J.S., et al (Latest edition) One Health: The Human-Animal-Environment Interfaces in Emerging Infectious Diseases. Springer, New York, NY
4. Zinsstag, Z., et al (Latest edition) One Health: The Theory and Practice of Integrated Health Approaches. CABI Digital Library

Suggestive Readings

1. Rabinowitz, Peter M. et al (2009) Human-Animal Medicine: Clinical Approaches to Zoonoses, Toxicants and Other Shared Health Risks. Saunders: Elsevier Press, New York
2. David Quammen (2012) Spillover: Animal Infections and the Next Pandemic. 2012. WW Norton and Company. New York
3. Natterson- Horowitz, et al (2013) Zoobiquity: The Astonishing Connection Between Human and Animal Health. Vintage Press
4. WHO: One health initiative
5. Latest research papers published in Nature Microbiology, Applied and Environmental Microbiology, One Health

General Elective-1 (GE-1): MS ZOOLGE-108

Endocrine Disruptors and Neural Pathways

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	4	Nil	Nil	B.Sc.	Nil	Zoology

Course Objectives:

- To enable students to understand how exposure to environmental toxicants and hazardous chemicals in our day-to-day lives can affect human health, with major emphasis on endocrine dysfunction and mental health.
- To make the students understandrequirement of sustainable development of chemicals involved in domestic, agriculture and health sector.

Learning Outcomes

By studying this course, students will be able to:

- The students would understand the environmental toxicants and their effect on hormone action in brain, sex differentiation, behavior, and cognition.
- Know the harmful effects of Plastics and plasticizers on reproductive and metabolic health.
- The students would be able to conceptualize and understand the endocrine effects ofBisphenol A on human physiology.
- Understand the emergent need of discontinuation of plastics and other endocrine disrupting chemicals.
- The students would understand how plastics and alcohol use during pregnancy can affect the brain differentiation during gestation and childhood.
- Understand the effect of drug consumption during adolescence on brain.
- A key outcome is that the students would understand the requirement of sustainable development of chemicals in domestic, agriculture and health sector.

SYLLABUS OF GE-1: Endocrine Disruptors and Neural Pathways

MS ZOOLGE-108

Unit 1. Introduction to the endocrine system **8 h**

Human endocrine system, Types of hormones and their functions in regulation of human physiology.

Unit 2. Endocrine disruptors **11 h**

Historical perspective of endocrine disrupting chemicals (EDCs), Types of EDCs such as Atrazine, Bisphenol A (BPA), Dioxins, Perchlorate, Per- and polyfluoroalkyl substances (PFAS), Phyto and xenoestrogens, Polybrominated diphenyl ethers (PBDE), phthalates, Polychlorinated biphenyls (PCBs), Triclosan, and their sources; Mechanisms of action of endocrine disruptors

Unit 3. EDCs and the nervous system **11 h**

Impact of alcohol, drugs, plastic (BPA) and smoking on neuronaldevelopment and function, Neurodevelopmental disorders and neurological dysfunction associated with EDCs such as autism, dementia, Alzheimer's, Parkinson's, attention-deficit/hyperactivity disorder (ADHD), and learning disability.

Unit 4. Plastics:Endocrine diseases,sexual differentiation of brain and behaviour **15 h**

Impact of BPA, plasticizers, xenoestrogens on gonadal development, sex determination, puberty onset, brain development and behaviour. Impact of plastics (bisphenol isoforms, phthalates) and polyvinyl chloride (PVC) on the development and progression of obesity, metabolic dysfunction, PCOS/PCOD, diabetes, cancer, infertility, puberty, and endometriosis.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Heather B. Patisaul and Scott M. Belcher: Endocrine Disruptors, Brain, and Behavior (2017, Oxford University Press)
2. Philippa D. Darbre (Editor) Endocrine Disruption and Human Health (2021, Academic Press)

Suggestive Readings

1. Kabir, E. R., Rahman, M. S., & Rahman, I. (2015). A review on endocrine disruptors and their possible impacts on human health. Environmental toxicology and pharmacology, 40(1), 241–258. https://doi.org/10.1016/j.etap.2015.06.009
2. Schug, T. T., Johnson, A. F., Birnbaum, L. S., Colborn, T., Guillette, L. J., Jr, Crews, D. P., Collins, T., Soto, A. M., VomSaal, F. S., McLachlan, J. A., Sonnenschein, C., &Heindel, J. J. (2016). Minireview: Endocrine Disruptors: Past Lessons and Future Directions. Molecular endocrinology (Baltimore, Md.), 30(8), 833–847.
3. Latest research papers published in Frontiers in Endocrinology, Journal of Endocrinology, Trends in Endocrinology and Metabolism

Skill Based Course-1 (SBC-1): Specialized Laboratory Course in Zoology Part I
MSZOOLS-109

Course title and Code	Credits	Credit distribution of the course			Eligibility Criteria	Prerequisite of the Course (if any)
		Lecture	Tutorial	Practical		
MSZOOLS-109	2	0	0	2	B.Sc.	Nil

1. Learning Objectives

- Apply observational and experimental techniques (e.g., ethograms, maze learning tasks, mirror tests) to study animal cognition, learning, and social behavior.
- To enable students to understand the rhythmic regulation of internal timing in regulating daily and seasonal processes in organisms.
- Understand key lifestyle contributors (diet, sleep, stress, and activity) to metabolic disease development.
- Develop hands-on expertise in environmental and microbiological techniques, gain proficiency in applying epidemiological models and analyzing infectious disease transmission.
- Learn to collect, analyze, and interpret data.
- Gain hands-on experience with dataset analysis using bioinformatics tools.

2. Learning Outcomes

By the end of the course, students will be able to:

- Students will critically evaluate the role of genes, environment, and evolution in shaping behaviors like courtship in Drosophila or foraging in birds using behavioral ecology principles
- Develop a critical viewpoint and interpret observations from experiments on biological rhythms regulating daily and seasonal biology.
- Identify and understand the complex relationships between lifestyle patterns and metabolic diseases.
- Develop practical skills in isolating and profiling antimicrobial resistance in bacteria from environmental samples, and applying simulation tools to model infection dynamics within the One Health framework.

3. Main Course Structure

Module 1 **30h**

Section A: Animal Behaviour

1. Genetic basis of courtship behavior in *Drosophila.*
2. Evaluate learning and problem-solving using simple maze.
3. Testing self-recognition in fish.
4. Ethogram of *Macacamuleta*, foraging behaviour of birds.

Section B: Chronobiology

5. Ambulatory blood pressure monitoring and circadian analysis.
6. Quantifying oscillations: phase, period and amplitude.
7. Analysis of actograms.
8. Experiments demonstrating the photoperiodic clock.

Module 2 **30h**

Section A: Lifestyle and Metabolic Diseases

1. Meta-analysis of gut microbiota datasets using online tools. Compare the gut microbiome compositions in healthy vs. disease states.
2. Design and analyze a survey assessing risk factors for obesity, type 2 diabetes, and PCOS/PCOD.
3. To investigate Myeloperoxidase (MPO) activity in ovarian and/or uterine tissues of normal, high-fat diet-induced, and PCOS-induced rats/mice as a biochemical marker of inflammation.
4. To evaluate and compare the antioxidant capacity of serum and/or tissue homogenates from normal, high-fat diet-fed, and PCOS-induced rats/mice using the Ferric Reducing Antioxidant Power (FRAP) assay.

Section B: One Health: Principles and Applications

5. *E.coli* sampling from water sample for assessment of Antimicrobial Resistance (AMR) prevalence in the environment.
6. Morphological characterization of microbes.
7. Simulation of infection transmission.
8. One health puzzle to mimic the decision-making process in disease control.

4. **Teaching Methodology/Activities in the classroom:** Following methods will be used:

- **Lab Demonstrations & Hands-on Experiments**: Engage students with practical demonstrations using previously recorded data and real laboratory techniques to reinforce theoretical concepts.
- **Field-Based Learning**: Provide experiential learning opportunities through field visits and on-site investigations.
- **Group Discussions & Role-Playing**: Foster critical thinking and communication skills through collaborative discussions and simulated real-world scenarios.
- **Simulation Software**: Utilize digital tools to model biological and epidemiological processes, enhancing understanding of complex systems.
- **Data Analysis**: Teach analytical skills by working with real datasets, including interpretation and presentation of results.
- **Case Studies**: Apply knowledge to real-life scenarios, encouraging problem-solving and decision-making.

5. **Assessment Pattern for each Unit/practical. Component of Attendance in the Assessment of 1 credit theory course**

Continuous assessment throughout the semester, practical records and end-semester practical-based examination.

6. **Mapping with the next suggestive course**

- Advanced courses in Molecular Pathophysiology of Lifestyle Diseases, Translational Microbiome Research, Nutritional Genomics and Personalized Medicine, Applied Ethology, Sleep can enhance skills and employment opportunities.
- Additional certifications in Geographic Information System (GIS), data analysis tools, or entomology can further expand employment opportunities.

7. **Prospective Job Roles after a particular course**

This course prepares students for a wide range of entry-level roles in public health, research, laboratory science, data analysis, health communication, and program support. Graduates can contribute to disease surveillance, outbreak response, laboratory diagnostics, health education, and research in both human and animal health sectors.

Students can find employment in the following roles:

1. Clinical & Laboratory Roles: Clinical Research Assistant, Biomedical Technician, Laboratory Assistant, Field Investigator (disease tracking, outbreak response), Lifestyle Disease Health Coach
2. Public Health Sector: Public Health Program Coordinator, Infection Prevention Support (hospital or community settings), Mosquito/Insect Control Program Assistant (vector identification and control)
3. Science Communication & Education
4. Data analysts in biomedical and public health sector

Employment Sectors:

- Government health departments,
- NGOs and non-profit organizations
- Hospitals and healthcare facilities, Research institutions and academic labs
- International organizations (e.g., WHO, FAO, OIE)

8. Essential Reading

1. Breed, M.D., & Moore, J. *Animal Behavior* (Latest edition). Academic Press.
2. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. (Latest edition). Oxford University Press.
3. Hu, F. B. Obesity Epidemiology. Oxford University Press
4. Laboratory manuals for biochemical techniques.
5. One Health Cases: CABI Digital Library
6. One Health Puzzle: Life Sciences Learning Center: University of Rochester Medical centre

9. Suggestive Reading

1. McFarland, D. (1999) Animal Behavior (Latest edition). Longman press
2. Circadian Physiology: Roberto Refinetti, CRC Press (Latest edition) 2016
3. WHO and NIH reports on lifestyle-related non-communicable diseases.
4. WHO: One health initiative

Semester wise Details of M.Sc. Zoology Course- Semester II

SemesterII				
Numberofcorecourses	**Creditsineachcorecourse**			
Course	Theory	Practical	Tutorial	Credits
MSZOOLC-201 Developmental Biology	3	1	-	4
MSZOOLC-202 Metabolism: Concepts and Regulation	3	1	-	4
MSZOOLC-203 Immunology	3	1	-	4
Core course 3 (total number)	9	3	-	12
Total credits in core course	**12**			
Number of elective courses	**Credits in each elective course**			
A student has to choose two discipline specific elective or one discipline specific elective and one general elective from the following options:	Theory	Practical	Tutorial	Credits
Discipline specific elective **MSZOOLE-204:** Cancer biology **MSZOOLE-205:** Neurobiology **MS ZOOLE-206:** Biology of Parasitism **MS ZOOLE-207:** Pharmacognosy and Basics of Traditional Medicine **General elective** **MS ZOOLGE-208:** Animal Models in Research	 3 3 3 3 3	-	 **1** **1** **1** **1** 1	 4 4 4 4 4
Total credits in 2 elective courses	**8**			
Credits in Skill based course	Theory	Practical	Tutorial	Credits
Skill based course: **MSZOOLS-209** Specialized Laboratory course in Zoology Part II	-	2	-	2
Totalcreditsin1Skill based course	**2**			

Discipline Specific Core-4 (DSC-4): MS ZOOLC-201

Developmental Biology

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	Nil	Zoology

Learning objectives

The learning objectives of this course are as follows:

- This course aims to understand how organisms develop from a single cell to multicellular organism.
- A fundamental concept of development like cell differentiation, organogenesis and involvement of multiple molecular and genetic mechanisms in the process will enable a clear understanding of such complex phenomena.
- Additionally, they will explore how alteration in any of normal developmental process can lead to serious diseases like birth defects, tumor pathogenesis, neurodegenerative disorders etc.
- Hand-on training using different model organisms with significant homology with Human will further strengthen and connect theoretical understanding of students.

Learning outcomes

- A key learning outcome of developmental biology is to understand how organisms develop from a zygote into complex multicellular organisms.
- Students will have a clear understanding of genetic regulation during development from embryogenesis to the adult.
- Students will connect with how developmental mechanisms are conserved across species and how evolution has shaped the developmental pathway.
- By understanding the fundamental biology of development, targets for intervention in various diseases can be identified, leading to new therapeutic strategies.

SYLLABUS OF DSC-4: Developmental Biology

MS ZOOLC-201

Unit 1. Overview of developmental biology **16 h**

Cell division, cell differentiation, signaling, patterning; Evolution of developmental patterns; Early embryonic development in invertebrates and vertebrates model organisms: Structure of the gametes; Cleavage and gastrulation; Axes and germ layers; Morphogenesis: cell adhesion, neural tube formation, cell migration.

Unit 2. Axis specification **8 h**

Role of maternal genes, patterning of early embryo by zygotic genes- gap genes, pair–rule genes, segment polarity genes, homeotic selector genes- bithorax and antennapedia complex.

Unit 4. Organogenesis and regeneration **14 h**

Development and patterning of vertebrate limb, homeobox genes in patterning, signaling in patterning of the limb; Insect imaginal discs–organizing center in patterning of the leg and wing, the homeotic selector genes for segmental identity; insect compound eye; Regeneration: Epimorphic regeneration of the Salamander limb; Morphallaxis regeneration in Hydra.

Unit 4. Medical implications **7 h**

Embryonic stem cells and their application; Gene expression and human disease – inborn errors; Teratogenesis, environmental impact on human development; Aging and senescence.

Practical **30 h**

1. Study of life cycle and developmental stages of *Drosophila melanogaster*.
2. Study of homeotic gene mutations and their effect on patterning.
3. Study of life cycle and developmental stages of zebrafish.
4. Study of life cycle and developmental stages of *C. elegans*.
5. Study of developmental stages of chick embryo.
6. Identification and study of larval and pupal wing, leg and eye antennal imaginal discs of *Drosophila*.
7. Mounting and observation of impact of cell death on wing patterning using *Drosophila* mutants.
8. Study of targeted gene expression of developmental genes using Gal4/UAS system in *Drosophila*.
9. Study and observation of ectopic expression of *eyeless* gene in *Drosophila*.

Essential/Recommended Readings

1. Developmental Biology: Scott F Gilbert [Latest edition].
2. Essentials of Developmental Biology: JMW Slack [Latest edition].
3. Principles of Development: Louis Wolpert [Latest edition].

Suggested Readings

1. Developmental Biology: Michael Barresi and Scott Gilbert [latest edition].
2. Key Experiments in Practical Developmental Biology: Jennifer Knight, Cambridge University Press
3. Latest research papers published in Developmental Biology, Developmental Cell, Genes and Development

Discipline Specific Core-5 (DSC-5): Metabolism: Concepts and Regulation

MS ZOOLC-202

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- To equip students with an in-depth understanding of how essential biomolecules are metabolized by biological systems and how these processes are regulated.
- To appreciate the interconnectedness of various metabolic processes and their adaptation during altered physiological states.
- To understand the principles of bioenergetics involved in metabolic processes.
- To explore the roles, mechanisms, and regulatory aspects of enzymes involved in metabolic processes.

Learning Outcomes

By studying this course, students will be able to:

- Understand carbohydrate, lipid, amino acid and nucleotide biosynthesis and degradation pathways, including their key enzymes, regulation and physiological relevance.
- Integrate and interpret the interplay between hormonal control and metabolismduring altered physiological states such as fasting and exercise.
- Apply the concept of metabolic reprogramming in specialized tissues and pathological conditions, and evaluate the use of enzymes and receptors as diagnostic and therapeutic targets.
- Demonstrate problem-solving in biochemical contexts by applying the acquired knowledge to interpret laboratory data, clinical case studies, and metabolic pathway maps.

SYLLABUS OF DSC-5: Metabolism: Concepts and Regulation

MS ZOOLC-202

Unit 1. Foundation of Metabolism **20 h**

Laws of thermodynamics and biological energy, ATP as energy currency, high-energy intermediates, biological oxidation-reduction reactions, NAD^{+}/FAD and their roles, mitochondrial function, electron transport and oxidative phosphorylation; Glycolysis and gluconeogenesis, TCA cycle, pentose phosphate pathway, glycogen metabolism; Fatty acid oxidation and synthesis, cholesterol metabolism, ketone body formation and utilization.

Unit 2. Enzymes and their regulation **8 h**

Enzymes: properties, classification and catalytic mechanisms; Mechanisms of chymotrypsin and lysozyme action; Enzyme kinetics: Michaelis-Menten kinetics, interpretation of K_m and V_{max}, turnover number; Inhibition of enzyme activity; Regulation of enzyme activity; Allostery.

Unit 3. Metabolism and Regulation of Proteins and Nucleotides **7 h**

Amino acid degradation. Biosynthesis of non-essential amino acids. Purine and pyrimidine degradation. Purine biosynthesis (de novo and salvage pathways), pyrimidine biosynthesis.

Unit 4. Integration of metabolism, hormonal control and metabolic reprogramming **10 h**

A broad outline of metabolic pathways and their linkage; Integration of metabolism and hormone action; Metabolism during fasting, starvation and exercise; Metabolic basis of specialized tissue function and diagnostics; Regulation of metabolism at molecular, cellular and organismic levels; Enzymes and receptors as drug targets.

Practical **30 h**

1. Preparation of a 'Good' buffer.
2. Preparation of molecular models of biomolecules using ball-and-stick.
3. Titration of an amino acid, an acidic dye and an organic acid to determine the pKa value.
4. Verification of Beer's Law.
5. Estimation of sugar(s), amino acid(s), vitamin(s), nucleotide/nucleic acid by appropriate biochemical methods.
6. Characterization of a purified protein/ enzyme for homogeneity by SDS-PAGE.
7. Determination of enzyme activity.
8. Kinetic characterization of enzyme(s).
9. Enzyme inhibition study.
10. Determination of activation energy of an enzyme-mediated reaction.
11. In gel staining of an enzyme activity (Zymogram).

Essential/Recommended Readings

1. J. M. Berg, J. L. Tymoczko, G. J. Gatto, Jr., LubertStryer (2015) Biochemistry, (Latest edition), W. H. Freeman and Company, New York, NY.
2. D.J. Voet, J.G. Voet, C.W. Pratt, (2016) Principles of Biochemistry, (Latest edition), John Wiley & Sons, Inc.
3. Lehninger by D. Nelson, and M. Cox, (2017) Principles of Biochemistry, (Latest edition), M.W.H. Freeman and Company, New York.

Suggestive Readings

1. P. J. Kennelly, K. M. Botham, O. Mcguinness, V. W. Rodwell, P. A. Weil (2022) Harper's Illustrated Biochemistry, 32nd Edition, McGraw-Hill.
2. Latest research papers published in Biochemistry, Journal of Biological Chemistry, Trends in Biochemical Sciences

Discipline Specific Core-6: MS ZOOLC-203

Immunology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	0	1	B.Sc.	Nil	Zoology

Course Objectives

- This course is centered on the foundational principles of the immune system's structure, function, and regulatory mechanisms.
- It provides students with a basic understanding of innate and adaptive immunity, the coordination of immune responses, and the regulation of immune functions.
- The course also explores how immune processes are linked to health and disease.
- In addition, students will receive hands-on training in basic immunological techniques.
- By the end of the course, students will have a solid grasp of these foundational principles, preparing them for further academic or professional pursuits in the life sciences.

Learning Outcomes

The students opting for this course will

- Have a clear understanding of the basics of immunology.
- Be able to identify and describe the major components of innate and adaptive immunity.
- Describe key immunological concepts of antigen recognition by innate and adaptive immune cells.
- Explain the basics of MHC and antigen presentation.
- Understand mechanisms leading to the effector mechanisms of humoral and cellular immune responses.
- Describe the development, activation and regulation of lymphocytes and their functions.
- Perform basic immunological experiments important for future research and higher studies in the field.

SYLLABUS OF DSC-6: Immunology

MS ZOOLC-203

Unit1. Cells and tissues of the immune system **10 h**

Briefoverview of the immune system; Concepts of innate and acquired immune responses and their crosstalk; Active and passive immunity, natural, artificial and herd immunity; Primary and secondary immune responses; Lymphatic system and lymphoid tissue: Anatomy and functional significance of thymus, bone marrow, spleen, lymph node, gut-associated lymphoid tissue, mucosa-associated lymphoid tissue (GALT/MALT).

Unit 2. Innate immunity and effector mechanisms **10 h**

Innate immune receptors andpatternrecognition; Effector functions of innatememory; Inflammation; Innate regulation: complement system, cytokines, NK and NKT cells.

Unit 3. Adaptive immunity **20h**

Antigen presentation**:** Antigen, antigenicity, superantigen; Antigen processing cells; Structure of major histocompatibility complex (MHC), antigen processing and presentation; Basic structure of antibody, antigen-antibody interactions, antibody diversity; Structure of T-cell receptors (TCRs), CD3 and accessory molecules of T-cells, T-cell co-receptors, antigen recognition by T-cells, adhesion molecules and their role in T-cell functioning; Effector mechanisms of humoral and cell mediated immunity.

Unit 4. Immunity in health and disease **5 h**

Hypersensitivity, autoimmunity, immunodeficiency diseases, immunity to microbes, tumour-immunology, vaccines.

Practical **30 h**

1. Identificationofprimaryandsecondarylymphoid organs.
2. Isolationoflymphocytesandviabilitycount.
3. Differential cell staining of blood cells.
4. Isolationofmacrophages.
5. Study of phagocytosis and phagocytic index.
6. Demonstration of immunization protocols to raise antibodies.
7. Study of antigen-antibody interaction using immuno-diffusion.

Essential/Recommended Readings

1. Kuby Immunology: Published by W.H. Freeman and Company (Latest edition)
2. Roitt’s Essential Immunology: Published by Wiley-Blackwell (Latest edition)
3. BIOS Instant Notes in Immunology: Published by Taylor and Francis (Latest edition)
4. Basic Immunology: Abul K Abbas & Andrew Litchman. Published by Saunders Publication. (Latest edition)
5. Immunology: Understanding the Immune System. Klaus D. Elgert. Wiley-Blackwell (Latest edition)

Suggestive Readings:

1. Cellular & Molecular Immunology: Abul K. Abbas, Andrew H. Lichtman and Shiv Pillai. Published by Saunders Publication
2. Janeway’s Immunobiology: Published by Garland Science/ Google Books.
3. Latest papers published in Nature, Cell, Current Opinions in Immunology, Trends in Immunology.

Discipline Specific Elective DSE-5: MS ZOOLE-204

Cancer Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Course Objectives:

- This course provides an in-depth exploration of cancer biology, focusing on the molecular mechanisms underlying cancer development, the role of immune system in tumor progression, and the impact of epigenetic modifications.
- Students will gain insights into the hallmarks of cancer, tumor microenvironment, metastasis, and therapeutic strategies, with an emphasis on current research and clinical applications.
- The programme provides research-led teaching in fundamental cancer biology, clinical oncology and the latest advances in modern therapeutics including immunotherapy and precision medicine.

Learning Outcomes:

- Upon successful completion of this course, students will gain foundational knowledge of cancer types, global epidemiology, and the multistage process of carcinogenesis. They will be able to understand the molecular mechanisms underlying the hallmarks of cancer, and distinguish the roles of oncogenes and tumor suppressor genes in tumor initiation and progression.
- The course equips students to interpret major signaling pathways involved in cancerand to evaluate their relevance in targeted therapy. Students will develop an understanding of cancer immunology, including immune surveillance, tumor antigens, immune checkpoint regulation, and modern immunotherapeutic approaches.
- Additionally, students will analyze the impact of epigenetic modifications in cancer development and treatment strategies. The course also covers the tumor microenvironment and mechanisms of metastasis and therapeutic resistance.
- Finally, through journal clubs and case studies, students will enhance their ability to critically assess current cancer research and apply this knowledge to translational and clinical contexts.

Syllabus of DSE-5: Cancer Biology

MS ZOOLE-204

Unit 1: Introduction to cancer biology **8 h**

Definitions, types of cancer; Epidemiology and global burden; Multistage model of carcinogenesis: Clonal evolution of tumors; Causes and risk factors of cancer, infection-associated cancers; Cancer and the cell cycle, apoptosis; Hanahan & Weinberg framework: Self-sufficiency in growth signals, resisting cell death, sustained angiogenesis, immune evasion and metabolic reprogramming.

Unit 2: Oncogenes, tumor suppressor genes, molecular signaling and epigenetic control 15h

Proto-oncogenes vs oncogenes: Ras, Myc, HER2; Tumor suppressors: p53, RB, PTEN; Mechanisms of gene mutation, amplification, deletion, gene rearrangement; DNA repair pathways and genomic instability; RTK/PI3K/AKT/mTOR and MAPK pathways; Wnt/β-catenin and Hedgehog signaling; Notch signaling and cell fate decisions; Signaling crosstalk and pathway convergence; DNA methylation and demethylation; Histone modifications and chromatin remodeling; Role of epigenetic silencing in tumor suppressors; Non-coding RNAs: miRNAs, lncRNAs; Epigenetic therapies: DNMT and HDAC inhibitors.

Unit 3: Tumor microenvironment, metastasis, cancer immunology and immunomodulation 15 h

Components of the Tumor microenvironment **(**TME: CAFs, endothelial cells, immune cells, ECM, exosomes; Angiogenesis and hypoxia in tumor progression; Mechanisms of invasion and metastasis; Epithelial-mesenchymal transition (EMT); Immune surveillance and immunoediting; Tumor antigens and their presentation; Tumor-infiltrating immune cells; Role of cytokines and tumor-associated macrophages; Immune checkpoints: CTLA-4, PD-1/PD-L1; Current immunotherapies and resistance mechanisms; CAR-T cells and cancer vaccines.

Unit 4: Cancer therapeutics, stem cells and resistance 7 h

Chemotherapy and radiation: mechanisms, role of cancer stem cells; Targeted therapies and precision oncology; Resistance mechanisms: primary, acquired, adaptive; Emerging modalities: RNA-based therapeutics and nanoparticle delivery.

Tutorial 15 h

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics by Lauren Pecorino, (Latest edition), 2021
2. Cancer Biology by Raymond W. Ruddon, (Latest edition), 2007
3. The Biology of Cancer by Robert A. Weinberg, (Latest edition), 2023
4. Cancer Immunotherapy Principles and Practice by Lisa Butterfield, (Latest edition), 2021
5. Key review articles from Nature Reviews Cancer, Cell, Cancer Cell

Suggestive Readings

1. Latest research papers published in Nature Reviews Cancer, Trends in cancer, Seminars in Cancer, BBA reviews on cancer

Discipline-Specific Elective-6 (DSE-6): MS ZOOLE-205

Neurobiology

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning Objectives

- This course aims to provide a broad introduction to the nervous system, scientific concepts underlying the study of neural phenomena, and principles underlying cellular, molecular, developmental, sensory, motor, and cognitive neurobiology.

Learning Outcomes

At the end of the course, the students should be able to

- Conceptualize how different cell types in the brain are involved in the complex transmission of information essential for the regulation of physiological processes.
- Understand the cellular and molecular mechanisms involved in multifaceted functions regulated by the central nervous system.
- Develop a critical viewpoint and interpret observations from brain behavior and cognition experiments.
- Understand the consequences of the disruption of brain physiology on health in the modern world.

Syllabus of DSE-6: MS ZOOLE-205

Neurobiology

Unit 1. Organization of the nervous system and chemical transmission 7 h

Brain structure, Neurons and glia, Neuronal system: limbic and extrapyramidal, Transmission of nerve impulse, Types of synapses, Excitatory and inhibitory post-synaptic potential, Chemical transmission, neurotransmitters and neuropeptides; Blood-brain barrier.

Unit 2. Glial Cell Biology 8 h

Glial cells: Structure, types and function; Importance of astrocytes in glutamate metabolism and blood-brain barrier; Microglial phenotypes,role of oligodendrocyte and microglial cells in brain health; Glial–neuronal interplay in CNS.

Unit 3. Developmental Neuroscience 15 h

Neural Induction, Signaling molecules that pattern the anterior-posterior axis in vertebrates, Neuronal determination and differentiation, Neuronal death during development, Neurotrophic factors: Neurotrophins and their receptors, intracellular-signaling pathways for neuronal survival, axon growth, pathfinding and nerve patterns; Directional guidance of nerve growth cones; Synapse formation and elimination; Refinement of synaptic connections; Rearrangement of developing neuronal connections; Denervation and regeneration of synaptic connections; Regeneration of central and peripheral axons in mammalian nervous system.

Unit 4. Cognitive neuroscience, brain aging and neurodegeneration 15 h

Learning, memory, motivation, sleep, perception, attention, consciousness, control, logic, language, molecular mechanisms involved in behavioural and cognition, Applications and methods in behavioural neuroscience; Age-associated structural alterations, functional changes and neuroplasticity, Neurodegeneration: Stroke, Epilepsy, Alzheimer's disease, Huntington disease, Parkinson's disease.

Tutorial 15 h

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Eric Kandel: Principles of Neural Science (Latest edition, McGraw-Hill)
2. Longstaff: Neuroscience (Latest edition, Viva Books)
3. Shepherd: Neurobiology (Latest edition, Oxford Univ Press)
4. Squire et al: Fundamental Neuroscience (Latest edition, Academic Press)

Suggestive Readings

1. Latest research papers published in Nature Neuroscience, Molecular Neurobiology, Glia

Discipline Specific Elective-7 (DSE-7): MS ZOOLE-206

Biology of Parasitism

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Learning Objectives

- This course provides a comprehensive overview of the biological foundation of parasitic lifestyles, with an emphasis on host responses and the strategies parasites use to evade host defense mechanisms.
- Students will have a unique opportunity to study various parasites that infect humans, plants, and animals, deepening their understanding of parasite biology.
- The curriculum specifically addresses host specificity and the evolutionary dynamics of host-pathogen interactions. Additionally, students will gain essential knowledge in the transmission, epidemiology, diagnosis, clinical manifestations, pathology, treatment, and control of parasites.
- This program is carefully designed to equip students with the practical knowledge and skills needed for successful career in parasitology, public health, and related fields.

Course Outcomes

The students who participate in this course will have:

- Idea of some important pathogens that impact health of humans, animals and plants in the country.
- Detailed knowledge of the evolutionary dialogue critical for establishing host-parasite relationship.
- Understanding of the different strategies employed by the parasites to successfully establish infection in a host.
- Idea of the different strategies host uses to contain parasitic infection.

Syllabus of DSE-7: Biology of Parasitism

MS ZOOLE-206

Unit 1. Host-parasite interaction **5 h**

Animal associations and evolution of host – parasite relationship, Immune response and self-defense mechanisms, immune evasion and biochemical adaptations of parasites; Zoonosis.

Unit 2. Blood parasites **16 h**

Malaria: Life cycle and epidemiology, mode of infection, detection, immunity and immune evasion mechanisms: Coordinated switching for antigenic variation by malaria parasites, drug targets and mechanisms of drug resistance, malaria vaccines; Leishmaniasis: Life cycle and epidemiology, Sand fly biology in the life cycle of Leishmania, role for sand fly gut microbiota in Leishmania development and transmission, detection, protective and pathologic immune responses in leishmaniasis, immune evasion mechanisms, drug targets and mechanism of drug resistance, vaccine strategies; Filariasis: Life cycle and epidemiology, pathology, role of host immunity in protection and pathology, Wolbachia in disease prognosis, drug targets and mechanisms of drug resistance, vaccine strategies.

Unit 3. Gastro-intestinal and other parasites **14 h**

Amoebiasis: Lifecycle and epidemiology, pathology, virulence factors and their role in immunity and immune evasion mechanisms, trogocytosis and its role, drug targets and mechanisms of drug resistance, vaccine strategies; *Schistosoma*, Ancylostoma, Trichinella and Dracanculus : Life cycle and epidemiology, mode of infection, detection, immunity and immune evasion mechanisms, drug targets and mechanisms of drug resistance, vaccine strategies.

Unit 4. Beyond humans **10 h**

Parasites of veterinary importance; Parasitic insects, mites and ticks; parasites of insects and their significance; Nematode parasites of plants, morphology, biology, lifecycle and infection of crop plants by major plant parasitic nematodes, host parasite interactions.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential readings

1. Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA (Latest Edition)
2. Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwell, U. K. (Latest Edition)
3. Parasitology: A Conceptual Approach, Eric S. Loker, Bruce V. Hofkin (Latest Edition)

Suggestive readings

1. Latest research papers published in Cell Host & Microbes, Plos Neglected and Tropical Diseases, Int J of Parasitology, Trends in Parasitology, Virulence, Gut Pathogens

Discipline Specific Elective-8 (DSE-8): MS ZOOLE-206

Pharmacognosy and Basics of Traditional Medicine

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B.Sc.	Nil	Zoology

Course Objective

- The alternative medical system known as Ayurveda first emerged on the Indian subcontinent.
- The idea that conventional and traditional medical procedures might complement one another to improve patient care is becoming increasingly accepted.
- After completing this course, students will know how to combine the traditional knowledge of Ayurveda with the most recent scientific findings.

Learning Outcomes

- Students will learn about many forms of traditional and alternative medicine.
- Students will learn how to use sophisticated tools in the exploration of natural sources of therapeutic agents.
- Students will be able to understand how the raw natural ingredients are used in the production of herbal medications from the cultivation to the making of the final product.

Syllabus of DSE-8: Pharmacognosy and Basics of Traditional Medicine

MS ZOOLE-207

Unit 1. Modern approach to traditional medicines **8 h**

Introduction to pharmacognosy; Bioactive compounds from plants, animals and minerals. Uses of natural bioactive compounds in traditional and modern medicines. Traditional systems of Medicine. Concept of AYUSH; Origin of Ayurveda and its Vedic basis; Principles of treatment in traditional medicinal system.

Unit 2. Bioprospecting and drug discovery **13 h**

Systematic exploration of natural sources for the identification, extraction and characterization of bioactive compounds; Biological activities of phytocompounds. Good manufacturing practices (GMP) of herbal drugs. Databases of phytocompounds, pharmacopia.

Unit 3. Pharmacology of natural medicines **12 h**

Solubility kinetics and pKa, pH profile, partition coefficient, crystal morphology, polymorphism, powder flow, surface characteristics, dissolution, solubilization techniques. Mechanism of drug action, dose-response and time-plasma drug concentration curves, concept of drug safety and therapeutic index, drug forms; Routes of administration, pharmacokinetics and pharmacodynamics.

Unit 4. Nano phytomedicine and global regulations regarding natural drugs 12h

Herbal nano-formulations an effective way of drug delivery; Biomolecules and nanoparticle interactions, nanoparticles preparation and characterization. Preclinical studies and clinical trials of natural medicines; Concept of BioPiracy; Ethnomedicine in Indian context; Herbal pharmaceutical regulations in India, Europe; WHO approval, and herbal drug dossier preparation.

Tutorial 15 h

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Herbal Medicine Biomolecular and Clinical Aspects (Latest edition) by Iris F. F. Benzie, SissiWachtel-Galor.
2. Traditional Medicine New Research (Latest edition) By Yoshiharu Motoo.
3. Traditional Herbal Medicine Research Methods Identification, Analysis, Bioassay, and Pharmaceutical and Clinical Studies (Latest edition) By Willow J.H. Liu.

Suggestive Readings

1. Herbal Medicine in India: Indigenous Knowledge, Practice, Innovation and Its Value (2019) By Saikat Sen, Raja Chakraborty.
2. Evidence-Based Validation of Herbal Medicine Translational Research on Botanicals (2022) By Pulok Mukherjee.
3. Ayurveda A Comprehensive Guide to Traditional Indian Medicine for the West (2008) By Frank John Ninivaggi.
4. Ayurvedic Medicine: The Principles of Traditional Practice (2013) By Sebastian Pole.
5. Natural Products and Nano-Formulations in Cancer Chemoprevention (2023) By Shiv Kumar Dubey
6. Latest research papers published in Natural Product reports, Phytomedicine, Phytotherapy research

General Elective-2 (GE-2): MS ZOOLGE-208

Animal Models in Research

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
	Lecture	Tutorial	Practical			
4	3	1	0	B. Sc.	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- To demonstrate how model organisms can be raised and bred in laboratories to study their development and behaviour in a controlled and accelerated manner.
- To learn what are model organisms and their characteristic features.
- To illustrate how model organisms can be used to illustrate complex biological mechanisms.
- To study genetic and physiological similarities of model organisms with human.
- To illustrate how research on model organisms has led to many ground breaking discoveries, including the development of vaccines and new therapies for human diseases.

Learning Outcomes

- By studying this course, students will be able to:
- Appreciate the relevance of using animals to study human diseases.
- Elaborate as to how such studies can result in better and deeper understanding of human diseases.
- Discuss examples of how animal models have helped in developing vaccines, drugs and other approaches to manage human diseases.
- Understand the limitations of animals for modeling many human diseases.

Syllabus of GE-2: Animal Models in Research

MS ZOOLGE-208

Unit 1. *Drosophila melanogaster* **12 h**

General introduction about model organisms; characteristic features of model organisms.*Drosophila* culture and maintenance; Basic concepts of Genetics and Developmental Biology using *Drosophila*, Application for research in Biology and Biomedical research, *Drosophila* as an advanced model for generating mutants, genetic modifications, targeted gene expression. Insect cell culture: Pesticide assay, insect bauculovirus system for producing recombinant proteins in insect cells

Unit 2. *Caenorhabditiselegans* **11 h**

Breeding and maintenance introduction of *C.elegans*biology, Application in research, Experimental design using C.elegans to study biological process, Emerging model in Pharmacological Innovation, Aging and Senescence, Chemotaxis and Behavior, Fluorescence Microscopy and Imaging.

Unit 3. *Danio rerio* (Zebrafish) **11 h**

Origin and natural habitat, Zebrafish in research: history and rise as a model organism, Advantages over other vertebrate models, life cycle overview, Embryogenesis and organ development, setting up a zebrafish facility, tank systems and water quality parameters, breeding protocols, behavior analysis, disease models, developmental biology, genetics, cancer, neurodegeneration, infection, environmental toxicology and ecotoxicology studies, micro biome and host-pathogen interaction studies.

Unit 4. *Mus musculus* (Mouse) **11 h**

Establishment of mouse as a model organism; Availability of coat colour and behavior mutations for study. Development of the mouse; Breeding and maintenance of mice; Probing the immune, endocrine, nervous, cardiovascular, physiological systems with mouse model. Application in biological and biomedical research; Toxicology; Drug discovery.

Tutorial **15 h**

Group discussions, Presentations and Assignments

Essential/Recommended Readings

1. Animal Models in Research – Principles and Practice, HarikrishnanVijayakumar Sreelatha, Satish Patel, PerumalNagarajan, Springer Nature
2. Laboratory Animal Medicine, James G. Fox, Lynn C. Anderson, Glen M. Otto, Kathleen R. Pritchett-Corning, Mark T. Whary, Elsevier (Third Edition)
3. *Drosophila* - A Practical Approach, D.B. Roberts, Oxford Science Publications, New York, USA (Second Edition)
4. Biology of *Drosophila*, M. Demerec, John Wiley & Sons, Inc., New York, USA (Facsimile Edition)
5. Fly Pushing – The Theory and Practice of *Drosophila* Genetics, Ralph J. Greenspan, Cold Spring Harbor Laboratory Press, New York, USA (Second Edition)
6. *Drosophila* Protocols, William Sullivan, Michael Ashburner, R. Scott Hawley, Cold Spring Harbor Laboratory Press, New York, USA
7. Zebrafish, Christiane Nusslein-Volhard and Ralf Dahm, Oxford University Press
8. Mouse models in human disease (DOI: 10.1007/978-1-4939-9086-3_1)

Suggestive Readings

1. Biology of *Drosophila*, M. Demerec, John Wiley & Sons, Inc., New York, USA (Facsimile Edition)
2. Nagy A, et al (2003): Manipulating the mouse embryo: A laboratory manual; CSHL Press]
3. Booklet_Mouse_Models
4. Latest research papers published in Journal of Experimental Biology, Laboratory Animal Research, Animal models and Experimental medicine

Skill Based Course-2 (SBC-1): MSZOOLS-209

Specialized Laboratory Course in Zoology Part II

Course title and Code	Credits	Credit distribution of the course			Eligibility Criteria	Prerequisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
MSZOOLS-209	2	0	0	2	B.Sc.	Nil

1. Learning Objectives

- To gain practical expertise in handling cancer cell lines, including culturing, preservation, and revival, as well as designing and interpreting viability and drug sensitivity assays using aseptic laboratory techniques.
- Hands-on experience on techniques and methodologies essential for studying pathophysiology related to central nervous system at morphological, behavioural, cellular and molecular level.
- To develop the ability to identify and understand the morphology, life cycles, and host interactions of key parasites.
- To sensitize students towards the natural sources of medicines and idea of conventional and traditional medical procedures.
- Enabling students to develop skills in designing and conducting experiments, recording accurate observations, and analyzing data.
- To appreciate role of biology in various fields including disease, medicine, agriculture, biotechnology.

2. Learning Outcomes

By the end of the course, students will be able to:

- Students will be able to independently culture, maintain, and assess cancer cell lines.
- Assess brain function and structure by performing cognitive and memory tests and carry out biochemical and molecular investigations of brain tissue
- Accurately identify and characterize major parasites and their vectors using microscopy and morphological features.
- Deploy sophisticated tools in the exploration of natural sources of the therapeutic agents.

3. Main Course Structure

Module 1 **30h**

Section A: Cancer Biology

1. Culturing cancer cell lines and their propagation. Cryopreservation of cancer cells and their revival from the frozen stocks.

2. Testing cancer cell cultures for mycoplasma contamination. Assessing cell viability and counting of cells using Trypan Blue dye exclusion test.
3. Assessing drug sensitivity of cancer cells using MTT assays and calculation of IC50.
4. Immunofluorescence to study cancer-related protein localization.

Section B: Neuroscience

5. Studies on spatial learning and memory in rat/mouse model by Morris-Water/ Radial-Arm Maze Tests, Y-maze.
6. External morphology of rat/mouse brain.
7. Spectrophotometric assay of acetylcholine esterase.
8. Development of mice/rat models of neurodegeneration.

Module 2 **30h**

Section A: Biology of parasitism

1. Study of prepared slides and museum specimens of selected parasites of representative groups of protozoans, helminths and arthropods.
2. Demonstration of in vitro culture of Plasmodium.
3. Studying the life cycle of insect parasitic nematode.
4. Studying the infection of tomato plant by root knot nematode.

Section B: Pharmacognosy and Basics of Traditional Medicine

5. Preparation of crude extracts of phytochemicals.
6. Preliminary screening of phytochemicals (Mayer's test, Dragendorff's test, Wagner's test, Hager's test, Murexide test and Thalleioquin Test).
7. Maceration, digestion and Soxhlet method of extraction.
8. TLC analysis of medicinal plant crude extract.

4. **Teaching Methodology/Activities in the classroom:** Following methods will be used:

- **Lab Demonstrations & Hands-on Experiments**: Engage students with practical demonstrations using previously recorded data and real laboratory techniques to reinforce theoretical concepts.
- **Data Analysis**: Teach analytical skills by working with real datasets, including interpretation and presentation of results.

5. **Assessment Pattern for each Unit/practical. Component of Attendance in the Assessment of 1 credit theory course**

   Continuous assessment throughout the semester, practical records and end-semester practical-based examination.

6. **Mapping with the next suggestive course**

   Students can enhance skills by opting for specialized programs in cancer biology. neurobiology, molecular parasitology, and phytochemistry.

7. Prospective Job Roles after a particular course

This course leverage skill in cell culture, molecular and biochemical assays, animal handling, microscopy, plant and parasite studies, and phytochemical analysis, providing a strong foundation for laboratory-based and applied research careers in biomedical and life sciences
1. Clinical & Laboratory Roles: Clinical Research Assistant, Biomedical Technician, Laboratory Assistant, Molecular Diagnostics Technician
2. Public Health Sector: Vector control
3. Eligible for technical positions in the Aayush sector and also eligible for Aayush NET examination.

Employment Sectors:

- Research institutes
- Hospitals
- Biotech companies
- Pharmaceutical and Herbal medicine companies
- Public health sector
- Agricultural research centers
- Quality control labs

8. Essential Reading

1. Freshney, R. Ian. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. 8th Edition, Wiley-Blackwell, 2021.
2. Matt Carter and Jennifer Shieh, Guide to Research Techniques in Neuroscience
3. Garcia, L. S. (2020). Diagnostic Medical Parasitology. United States: Wiley.
4. Herbal Medicine in India: Indigenous Knowledge, Practice, Innovation and Its Value (2019) By Saikat Sen, Raja Chakraborty.

9. Suggestive Reading

1. Bairoch, Amos. “The Cellosaurus: A Cell-Line Knowledge Resource.” Nucleic Acids Research, Vol. 46, No. D1, 2018, pp. D825–D830.
2. Eric Kandel: Principles of Neural Science (2000, McGraw-Hill)
3. Paniker, C. K. J. (2017). Paniker's Textbook of Medical Parasitology. India: Jaypee Brothers Medical Publishers Pvt. Limited.
4. Traditional Medicine New Research (Latest edition) By Yoshiharu Motoo.

Prof. Rita Singh
(*Head of the Department*)

Annexure-7 & 8

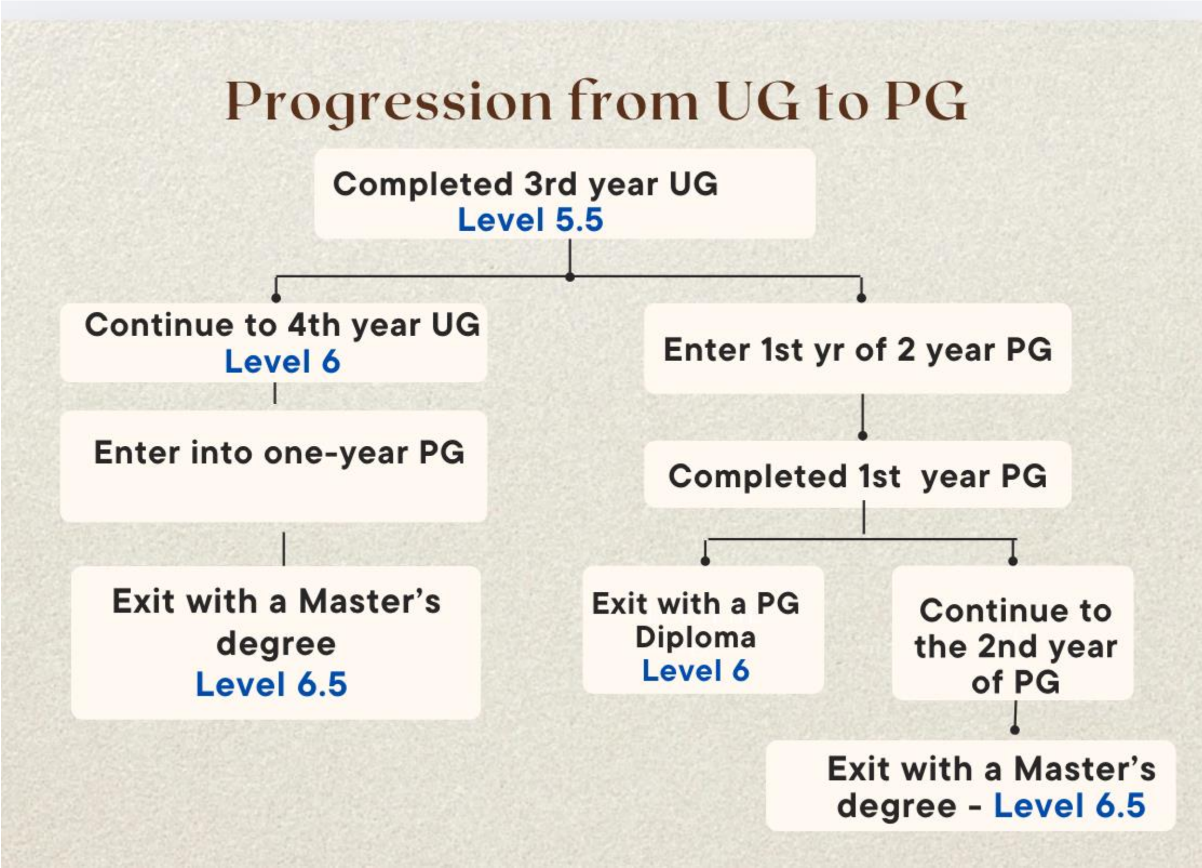
UNIVERSITY OF DELHI

MASTER OF SCIENCE/ MASTER OF ARTS
BY
THE DEPARTMENT OF ENVIRONMENTAL STUDIES

(Effective from academic Year 2025 – 2026)

Revised Syllabus as per PG Curricular Framework 2024 (PGCF-2024) based on NEP-2020 considered by Academic Council on 05 July 2025 and approved by Executive Council on xxx, 2025

PG Curricular Framework 2024 based on NEP 2020



Programme of Study and the corresponding qualification levels

First year UG programme – Level 4.5

Second Year UG Programme – Level 5

Third Year UG Programme – Level 5.5

Fourth Year UG Programme – Level 6

First year of Two Year PG Programme – Level 6

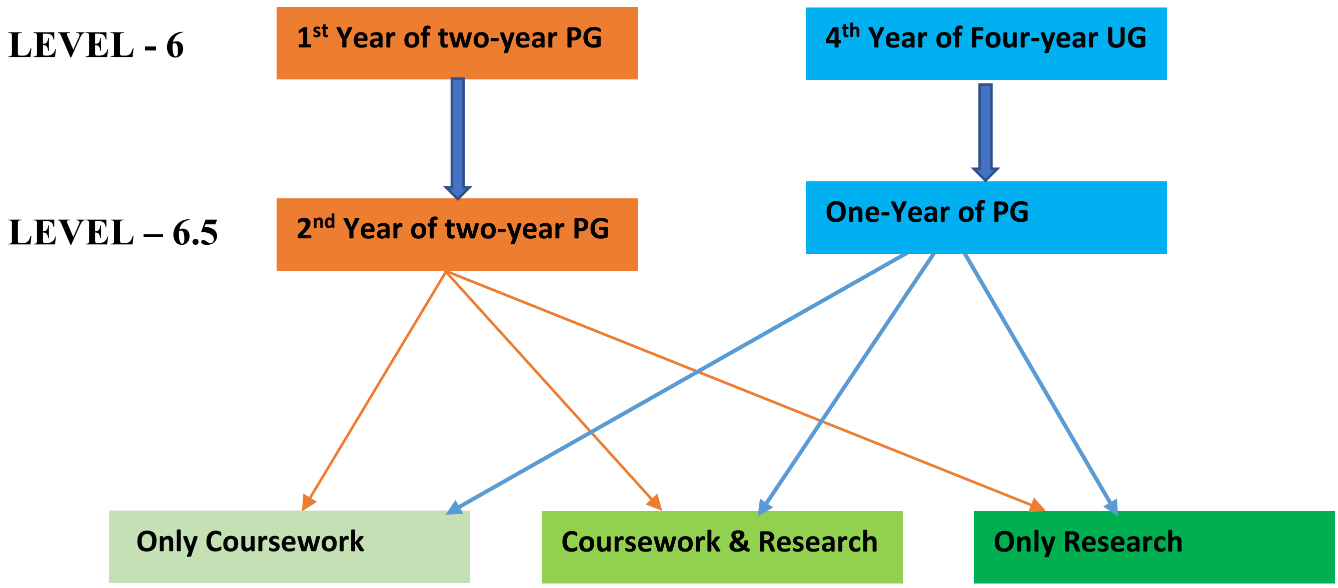
Second Year of Two Year PG Programme – Level 6.5

One year of PG Programme after 4 Year UG – Level 6.5

First year of Two Year PG Programme after 4 Year UG – Level 6.5

Second year of Two Year PG Programme after 4 Year UG – Level 7

Postgraduate Curricular Framework 2024 (based on NEP 2020)



1st Year of PG curricular structure for 2 year PG Programmes (3+2)

Semester	DSC	DSE	2 Credit course	Dissertation/ Academic Project/ Entrepreneurship	Total Credits
Semester- I	**DSC-1** **DSC -2** **DSC - 3** **(12 credits)**	**DSE - 1** **DSE – 2** OR **DSE-1 & GE-1** **(8 credits)**	Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning **(2 credits)**	Nil	**22**
Semester- II	**DSC-4** **DSC -5** **DSC - 6** **(12 credits)**	**DSE- 3** **DSE – 4** OR **DSE-2 & GE-2** **(8 credits)**	Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning **(2 credits)**	Nil	**22**

Details of various courses offered under PGCF for M.Sc. Environmental Science and M.A. Environmental Studies

Programme	Course	Course Code and Title
Semester I		
M.Sc./MA	Discipline-Specific Core (DSC)	**DSC-1:** Fundamentals of Environmental and Ecological Science
		DSC-2: Social, Environmental and Developmental Perspectives on Sustainability
		DSC-3: Integrated Natural Resource Governance for Sustainable Development
	Discipline-Specific Elective (DSE)	Any 2 out of Odd Semester Pool of DSE
	Skill-Based Course (SBC)	Methodologies for Environmental Studies I
Semester II		
M.Sc./MA	Discipline-Specific Core (DSC)	**DSC-4:** Environmental Pollution and Public Health
M.Sc. Environmental Science		**DSC-5:** Natural and Managed Ecosystems
		DSC-6: Ecotoxicology and Environmental Health
M.A. Environmental Studies		**DSC-5:** Global Environmental Challenges and Sustainable Solutions
		DSC-6: Environmental Law, Policy, and Governance
M.Sc./MA	Discipline-Specific Elective (DSE)	Any 2 out of Even Semester Pool of DSE
M.Sc./MA	Skill-Based Course (SBC)	Methodologies for Environmental Studies II

Pool of Discipline-Specific Elective Courses for Odd Semester (M.Sc./M.A. Programme)

Odd Semester DSE Papers (Page 15 onwards)

1. **DSE-1**: Biotechnology in Environmental and Public Health Applications
2. **DSE-2**: Coastal and Marine Environment
3. **DSE-3**: Culture, Environment, and Ecological Imaginaries
4. **DSE-4**: Environmental History and Contemporary Environmental Thought
5. **DSE-5**: Environmental Pollution and Epidemiology of Diseases
6. **DSE-6**: Environmental Microbiology and Microbial Ecology
7. **DSE-7**: Fundamentals of Air Pollution Science
8. **DSE-8**: Gender, Ecology, and Environmental Justice
9. **DSE-9**: Introduction to Environmental Governance
10. **DSE-10**: Remote Sensing and GIS for Environmental Applications
11. **DSE-11**: Technology, Environment, and Society
12. **DSE-12**: Traditional Indigenous Ecological Knowledge

Pool of Discipline-Specific Elective Courses for Even Semester (M.Sc./M.A. Programme)

Even Semester DSE Papers (Page 66 onwards)

Semester I – M.Sc./M.A. Programme

M.Sc./M.A. (Environmental Studies)

DISCIPLINE-SPECIFIC CORE COURSE - (DSC-1):
Fundamentals of Environmental and Ecological Science

Semester I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Environmental and Ecological Science	4	3		1	UG	-

Course Objectives

This course introduces postgraduate students to the interdisciplinary foundations of environmental and ecological sciences. It aims to:

- Provide a systems-based understanding of Earth's environmental processes
- Build foundational ecological, atmospheric, hydrological, and climate science knowledge
- Analyze the causes and consequences of contemporary environmental challenges using scientific and policy frameworks
- Equip students with core field, laboratory, and data-handling skills relevant to environmental analysis
- Cultivate critical thinking around sustainability, biodiversity, and environmental justice issues at both global and Indian scales

Learning Outcomes

By the end of this course, students will be able to:

- Explain fundamental concepts in ecology, atmosphere, hydrology, and environmental systems thinking
- Analyze the scientific basis of air, water, and land interactions using appropriate terminology and models
- Identify drivers of climate change and biodiversity loss using data and global indicators
- Evaluate the implications of environmental change using policy, legal, and sustainability lenses
- Apply basic field and lab skills to monitor and assess environmental quality
- Integrate ecological knowledge into transdisciplinary research and solution-building

Course syllabus (45 hours)

Unit 1: Earth Systems and Ecological Foundations (12 hours)

Earth as an integrated system: lithosphere, hydrosphere, atmosphere, biosphere; Energy flow and thermodynamics in ecosystems; Ecosystem structure and function: food webs, productivity, feedback mechanisms; Organismic interactions: types and ecological outcomes; Gaia hypothesis, ecosystem resilience; Biogeochemical cycles: carbon, nitrogen, phosphorus, sulfur; Global water distribution and hydrological cycle, Freshwater availability; Importance and properties of water.

Unit 2: Atmosphere, Climate, and Hydrosphere Interactions (11 hours)
Atmospheric structure and composition; Air quality standards; Greenhouse gases; Radiative forcing, climate-forcing agents, and atmospheric feedbacks; Climate sensitivity; Atmospheric chemistry–climate interactions; Evidence and indicators of global climate change (IPCC); Water resource challenges; Water use and scarcity; Water management and conservation; Types and sources of water pollution; Water quality indicators; Wastewater treatment; Regulatory frameworks.

Unit 3: Lithosphere, Soils, and Biodiversity (11 hours)
Soil formation, classification (USDA, FAO), profiles, and mineralogy; Soil degradation, erosion, desertification, and nutrient loss; Land use/land cover transitions: agriculture, industry, urbanization; Climate-soil-vegetation feedbacks; Mining impacts; Sustainable soil and land management; Levels and types of biodiversity; Biodiversity patterns, hotspots, endemism; Threats: invasive species, overexploitation, habitat fragmentation; Conservation strategies: in-situ, ex-situ, biosphere reserves, ICCAs.

Unit 4: Environmental Governance and Ecosystem Resilience (11 hours)
Natural resource use and environmental footprints; Energy transitions and circular economy; Environmental Impact Assessment, carrying capacity, environmental auditing; Overview of Indian environmental laws and institutions; Bioprospecting: types, approaches, and significance; Ecosystem services and nature-based solutions.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Compare species diversity between two different habitats using the Simpson's diversity index.
- Assess soil health by measuring pH and conducting soil respiration test
- Determine the trophic state of a local water body
- Monitor and analyze daily fluctuations in urban air quality
- Create a thematic map of green spaces in an urban area using open-source GIS software.
- Investigate the impact of urban surfaces on rainwater runoff by comparing infiltration rates of different surface types
- Calculate and compare the carbon footprint of different transportation modes
- Analyze the urban heat island effect using temperature data collected from various points across a city
- Conduct an energy audit of a classroom/Department
- Analyze local climate trends using 30 years of temperature and precipitation data
- Based on the syllabus

Essential Readings

- Bertrand, P. and Legendre, L., 2021. Earth, Our Living Planet. Springer International Publishing.
- Cunningham, W.P. and Cunningham, M.A., 2016. Principles of Environmental Science. Inquiry & Applications, McGraw-Hill, NY.
- Cunningham, W.P. and Cunningham, M.A., 2017. Environmental Science: A Global Concern, 17th Edition. McGraw-Hill, NY
- IPCC. (2023). *AR6 Synthesis Report: Climate Change 2023*. https://www.ipcc.ch/report/ar6/syr/
- Moore, G.S. and Bell, K.A. (2018). Living with the Earth: Concepts in Environmental Health Science. CRC Press.
- Raven, P.H., Berg, L.R. and Hassenzahl, D.M. (2015). Environment. John Wiley & Sons.

Suggested Readings

- Gadgil, M., & Guha, R. (2013). *This Fissured Land: An Ecological History of India* (2nd ed.). Oxford University Press.
- Glasson, J., Therivel, R., & Chadwick, A. (2013). *Introduction to Environmental Impact Assessment* (4th ed.). Routledge.
- ISRO (2023). *Bhuvan Portal – Remote Sensing Applications*. https://bhuvan.nrsc.gov.in/
- Ministry of Jal Shakti. (2023). *India Water Resources Portal*. https://indiawris.gov.in
- MoEFCC (2023). *National Clean Air Programme (NCAP)*. https://ncap.nic.in/
- NASA Earth Observatory. (2024). *Earth's Energy Budget*. https://earthobservatory.nasa.gov

M.Sc./M.A.
Semester I

DISCIPLINE-SPECIFIC CORE COURSE - (DSC-2): Social, Environmental and Developmental Perspectives on Sustainability

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Social, Environmental and Developmental Perspectives on Sustainability	4	3		1	UG	-

Course Objectives

This course builds a critical understanding of how social, developmental, and environmental dimensions interweave in sustainability debates. It encourages analytical thinking and employability-relevant skills by:

- Exploring philosophical and theoretical foundations in environmental and development thought
- Evaluating colonial and post-colonial trajectories in resource use and governance in India and beyond
- Analyzing the modernity–risk nexus, capitalism, and emerging green critiques
- Assessing equity and justice issues in policy, participation, and sustainability
- Cultivating critical reasoning, stakeholder empathy, interdisciplinary analysis, and communicative competence

Learning Outcomes

By the end of the course, students will be able to:

- Summarize major ethical and theoretical traditions underpinning environmental thought
- Critically discuss development's impact on the environment, including colonial legacies
- Apply social science theories (capitalism, postcolonial, feminist, ecological modernization) to sustainability
- Analyze case studies of governance, activism, and participatory movements in India and globally
- Design communication strategies, policy critiques, and stakeholder assessments

Course Syllabus (45 hours)

Unit 1: Environment and Development: Theories, Critiques, and Paradigms(11 hours)

Development and progress: modernization theory, capitalist realism; Human–nature interface: deep ecology, eco-modernization; Green critiques of industrial capitalism; Postcolonial critiques and South–North environmental disparities; Anthropocene paradigms and the politics of planetary stewardship;

Redefining development: well-being, capabilities, degrowth, circular economies; Post-structural and decolonial perspectives on sustainability discourse.

Unit 2: Historical and Socio-Ecological Transformations in India (11 hours)
Pre-colonial and colonial practices: agriculture, forestry, hydrology; The colonial project: state forest regimes, canal irrigation, commercialization; Impact on communities: dispossession, uprisings, indigenous resistance; Regional comparisons: Gangetic plains, Deccan, Himalayan ecology; Valuing traditional knowledge and indigenous stewardship strategies; Sustainable development paradigms; Case studies on global and Indian strategies for sustainable equity.

Unit 3: Population, Urbanization, Technology, and Risk (12 hours)
Population–resource linkages; Malthusian debates; tragedy of the commons; Urban growth, resource consumption, environmental externalities; Technological systems: electrification, transport, energy – benefits and risks; Environmental risk and ecological modernization theory (Beck, Giddens); Governing environmental risk: frameworks, discourses, communication.

Unit 4: Environmental Governance, Justice, and Participatory Approaches (11 hours)
Environmental law & policy as governance tools; Community management: JFM, Adivasi institutions, co-governance; Principle of free, prior & informed consent; Role of social movements; Disparities and justice: caste, gender, tribal voices in environmental politics; NGO–State–Market relationships; Media and environmental literacy.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Critically analyze and debate opposing perspectives in environmental theory by comparing modernist and deep ecologist worldviews.
- Examine the historical context of resource governance by studying colonial forest policies and evaluating their impact on postcolonial environmental movements.
- Explore institutional designs for managing common pool resources through a simulation exercise based on Ostrom's principles of collective action.
- Integrate environmental science with social critique by developing a case study on the environmental and social risks associated with technological infrastructure failures.
- Investigate equity and agency in environmental governance by creating a stakeholder power relations map for a current environmental issue.
- Critically evaluate mainstream sustainability narratives by writing a policy critique on a specific Sustainable Development Goal or national budgetary approach to environmental issues.
- Based on the syllabus

Essential Readings

- Guha, R. (2014). Environmentalism: A Global History. Penguin, UK.
- Merchant, C. (2020). The Death of Nature. HarperOne.
- Armitage, D., Charles, A. and Berkes, F., 2017. Governing the coastal commons. London: Taylor & Francis.
- Scoones, I. (2015). Sustainable Livelihoods and Rural Development. Practical Action Publishing.
- Sachs, J. (2015). The Age of Sustainable Development. Columbia University Press.

Suggested Readings

- Escobar, A., 2020. Pluriversal politics: The real and the possible. Duke University Press.
- Martinez-Alier, J. (2005). The Environmentalism of the Poor. Edward Elgar.
- Redclift, M.R. and Springett, D. (eds.) 2015. Routledge international handbook of sustainable development. London: Routledge.
- Harper, C. and Snowden, M., 2017. Environment and Society: Human perspectives on environmental issues. Routledge.

M.Sc./M.A. Semester I

DISCIPLINE-SPECIFIC CORE COURSE - (DSC-3): Integrated Natural Resource Governance for Sustainable Development

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Integrated Natural Resource Governance for Sustainable Development	4	3		1	UG	-

Course Objectives

This course provides an integrated understanding of natural resource systems, combining ecological principles with socio-political dynamics of conservation, conflict, and governance. It equips students with analytical, policy, and stakeholder engagement skills by:

- Exploring natural resource cycles and ecological foundations
- Analyzing governance structures and policy instruments for conservation
- Investigating resource-based conflicts, equity issues, and institutional responses
- Evaluating participatory and sustainable management strategies
- Applying tools for scenario analysis, stakeholder mapping, and conflict resolution

Learning Outcomes

Students will be able to:

- Explain biophysical processes and ecosystem services of key natural resources
- Evaluate conflicts over access, control, and use of natural resources
- Analyze legal, institutional, and community-based governance mechanisms
- Develop integrated conservation and management strategies
- Assess the sustainability and equity implications of resource choices

Course Syllabus (45 hours)

Unit 1: Land and Forest Resources: Conservation, Conflict, and Governance (14 hours)

Soil formation, classification, fertility and erosion dynamics; Land degradation: causes, processes and mitigation; Competing land-use demands: agriculture, infrastructure, industry, conservation; Conflicts: land grabs, mining vs. agriculture, pastoral vs. settled land use; Governance tools: land reforms, soil health cards, land use planning, commons regulation; Forest types, ecosystem services, biodiversity values; Governance regimes: state control, joint forest management, CFR (FRA 2006); Conflicts: timber extraction, protected areas vs. people, NTFP access, eco-tourism tensions; Biodiversity management: GMOs, access and benefit-sharing, wildlife corridors; Co-management models: community forestry, sacred groves, biodiversity registers.

Unit 2: Water and Aquatic Resource Governance (9 hours)
Hydrological cycle, aquifer dynamics, water quality concerns; Use conflicts: irrigation vs. drinking water, dams and displacement, transboundary river sharing; Oceans and fisheries governance: common-pool dilemmas, sovereignty disputes; Policy and institutions: river basin authorities, IWRM, groundwater legislation; Community-based water governance: watershed programs, traditional tanks, gendered access.

Unit 3: Energy, Minerals, and Environmental Justice (12 hours)
Genesis and classification of mineral/energy resources; Environmental impacts of extraction: deforestation, pollution, displacement; Mineral resource cycle; Patterns and issues in global non-renewable energy consumption; Fossil fuel resources and environmental impacts; Conflicts: mining in tribal areas, renewable energy land use; Nuclear and geothermal energy, nuclear waste politics; Regulatory frameworks: MMDR Act, CSR in extractives; Transition governance: energy justice, just transitions, fossil vs. renewable trade-offs.

Unit 4: Integrated Governance: Institutions, Innovation, and Equity (10 hours)
Principles of integrated governance: resilience, equity, subsidiarity; Conflict transformation: legal mechanisms, participatory approaches, negotiation tools; Institutions: CPCB, MoEFCC, state bodies, customary governance, green tribunals; Tools: payment for ecosystem services, sustainability assessments, conflict mapping; Case studies: Forest Rights Act, Narmada dam, REDD+, SDG implementation models.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Analyze connections between soil management practices and land-use conflicts by mapping conflict zones and evaluating soil restoration strategies.
- Simulate complex stakeholder dynamics in forest conflicts through role-playing Joint Forest Management, tribal, conservationist, and industrial perspectives.
- Develop water sharing and fisheries conflict resolution strategies by creating mediation plans incorporating Integrated Water Resource Management and traditional practices.
- Assess the multidimensional impacts of mining activities by constructing an impact matrix for a hypothetical project, considering economic, ecological, and social factors.
- Design a cross-sectoral resource management strategy using real-world data to propose landscape-level conservation and governance approaches.

Essential Readings

- Barnes, G. and Child, B. eds., 2014. Adaptive Cross-scalar Governance of Natural Resources. New York, NY: Routledge.
- Blaikie, P. & Brookfield, H. (2015). Land Degradation and Society. Routledge.
- Evans, J. and Thomas, C., 2023. Environmental Governance. Routledge.
- Frey, U. (2020). Sustainable Governance of Natural Resources: Uncovering Success Patterns with Machine Learning. Oxford University Press.
- Valenzuela, J.R. and Eggert, 2020. Natural Resource Governance, Grievances and Conflict. Springer Fachmedien Wiesbaden.

Suggested Readings

- Beevers, M.D., 2018. Peacebuilding and Natural Resource Governance After Armed Conflict: Sierra Leone and Liberia. Springer.
- Faure, M., Mascini, P. and Liu, J., 2017. Environmental Governance and Common-Pool Resources: A Comparison of Fishery and Forestry. Routledge.
- Grant, J., Compaoré, W. and Mitchell, M. eds., 2014. New Approaches to the Governance of Natural Resources: Insights from Africa. Springer.
- Le Billon, P., 2013. Fuelling war: Natural resources and armed conflicts. Routledge

Skill-Based Course for
Semester – I (M.Sc./M.A. Programme)

M.Sc./M.A. (Environmental Studies)
Semester I

SKILL-BASED COURSE - (SBC-I): Methodologies for Environmental Studies I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Methodologies for Environmental Studies I	2	1		1	UG	-

Course Objectives

- Equip students to formulate rigorous environmental research questions, hypotheses, and mixed-method study designs.
- Build foundational competence in descriptive and introductory inferential statistics for environmental datasets.
- Develop skill in constructing and evaluating deterministic, stochastic, and simulation models of ecological processes.

Learning Outcomes

By the end of the course, students will be able to:

- Classify data and choose appropriate measures of central tendency and dispersion.
- Apply normal and binomial distributions, t-tests, χ^2 and one-way ANOVA to real environmental data
- Interpret statistical power in the context of ecological and epidemiological studies.
- Translate conceptual system diagrams into calibrated simulation models and critically appraise model uncertainty.

Course Syllabus – Theory (15 hours)
Unit 1: Research Design and Methods (5 hours)
Environmental research questions and hypothesis formulation; Types of research: Different criteria with examples and case studies; Quantitative, qualitative and mixed-method approaches; Sampling strategies: probabilistic and non-probabilistic; Participatory rural appraisal (PRA), stakeholder mapping; Ethics in environmental research and data sovereignty

Unit 2: Environmental Statistics I (5 hours)
Types of data: nominal, ordinal, interval, ratio; Descriptive statistics and data visualization; Probability distributions: normal, binomial; Inferential statistics: Parametric tests – t-test, chi-square, ANOVA

Unit 3: Simulation and Environmental Modelling (5 hours)
Types of models: deterministic, stochastic, empirical, simulation; Conceptualizing models: systems thinking and flow diagrams; Case models: eutrophication, air pollution dispersion, climate sensitivity; Model calibration, validation, and uncertainty analysis; Introduction to participatory modelling

Suggested Practicals/Applied Exercises/Field Component (30 hours)
- Compute central tendencies, visualize data distributions of environmental variables
- Compute and visualise summary statistics (histograms, boxplots, etc.) for the environmental dataset.
- Perform *t*-tests and one-way ANOVA on environmental data and interpret post-hoc comparisons.
- Create an interview guide and perform pilot interviews
- Develop a research plan that integrates quantitative and qualitative tools, sampling strategy
- Based on the syllabus

Essential Readings

- Crawley, M.J., 2012. The R book. John Wiley & Sons.
- Gotelli, N.J. and Ellison, A.M., 2004. A primer of ecological statistics (Vol. 1, pp. 1-640). Sunderland: Sinauer Associates.
- Quinn, G.P. and Keough, M.J., 2002. Experimental design and data analysis for biologists. Cambridge university press.
- Sokal, R.R. and Rohlf, F.J., 2012. Biometry, 4^{th} ed. Stony Brook University.
- Zar, Jerrold H. 2018. Biostatistical analysis. Pearson Education India.
- Zuur, A.F., Ieno, E.N. and Smith, G.M., 2007. Analysing ecological data (Vol. 680). New York: Springer.

Suggested Readings

- Bolker, B.M., 2008. *Ecological Models and Data in R,* Princeton University Press.
- Ellison, A.M., 2010. Repeatability and transparency in ecological research. Ecology, 91(9), pp.2536-2539.
- Mangel, M. and Hilborn, R., 2013. The Ecological Detective: Confronting Models with Data (MPB-28). Princeton University Press.
- McDonald, J.H., 2014. *Handbook of Biological Statistics*, 3rd ed., Sparky House.

Pool of Discipline-Specific Elective Courses for Even Semester (M.Sc./M.A. Programme)

Odd Semester DSE Papers

1. **DSE-1**: Biotechnology in Environmental and Public Health Applications
2. **DSE-2**: Coastal and Marine Environment
3. **DSE-3**: Culture, Environment, and Ecological Imaginaries
4. **DSE-4**: Environmental History and Contemporary Environmental Thought
5. **DSE-5**: Environmental Pollution and Epidemiology of Diseases
6. **DSE-6**: Environmental Microbiology and Microbial Ecology
7. **DSE-7**: Fundamentals of Air Pollution Science
8. **DSE-8**: Gender, Ecology, and Environmental Justice
9. **DSE-9**: Introduction to Environmental Governance
10. **DSE-10**: Remote Sensing and GIS for Environmental Applications
11. **DSE-11**: Technology, Environment, and Society
12. **DSE-12**: Traditional Indigenous Ecological Knowledge

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE – (DSE-1):

Biotechnology in Environmental and Public Health Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-1: Biotechnology in Environmental and Public Health Applications	4	3	-	1	UG	-

Course Objectives

- Introduce students to the fundamentals of environmental biotechnology and its role in addressing environmental health issues,
- Explore the interconnections between biotechnology, ecosystem health, and public health,
- Develop understanding of microbial processes, bioremediation, and emerging biotechnologies in disease prevention and environmental restoration,
- Foster critical evaluation of biotechnological interventions in urban and rural environmental management.

Learning Outcomes

- Understand the scope and applications of environmental biotechnology in the health and environment interface.
- Analyse biotechnological solutions for waste management, water treatment, and pollutant degradation.
- Evaluate the health risks associated with environmental contaminants and the role of microbes in mitigation.
- Apply case-based learning to understand the role of biotechnology in tackling public health challenges.

Course syllabus – Theory (45 hours)

Unit I: Life Sciences in Environmental and Public Health (11 hrs)

Environment–health interactions, One Health approach: convergence of human, animal, and environmental health, Environmental determinants of health: air, water, soil, food, housing, Emerging Environmental and public health issues: AMR, pandemics, urban heat, etc, Case Study: climate change and health

Unit II: Molecular Tools in Disease Surveillance (11 hrs)

Basics of molecular biology relevant to public health, Genetic markers and biomarkers in pollution and health assessment, Environmental DNA and pathogen detection, Genomic surveillance of vector-borne and waterborne diseases, Wastewater-based epidemiology for community health monitoring, Case Study: wastewater surveillance in Indian cities

Unit III: Microbial and Ecological Applications in Environmental Health (12 hrs)

Environmental microbiology and public health: Role of microbes in transmission and prevention of infectious diseases; Microbial communities in air, water, and soil as determinants of health. Microbial applications in disease prevention and control**;** Use of beneficial microbes in reducing disease-causing pathogens; Role of microbiota in gut and health, Antimicrobial resistance (AMR): Emergence, transmission through environment, and health implications, Bio-toilets and rural hygiene solutions

Unit IV: Climate, Ecosystem Health, Innovation and Policy Interface (11 hrs)

Health impacts of climate change and ecosystem degradation, Traditional ecological knowledge and community-based interventions, Public health frameworks, environmental policies and SDGs, Role of life sciences in achieving One Health and sustainable development

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Microscopic observation of environmental microbial cultures
- Isolation and growth of pollutant-degrading bacteria
- Water quality testing for coliform and other health indicators
- Soil microbial diversity and pollutant exposure assay
- Survey/report on environmental determinants of health in a local community, PCR.
- Reading and discussion: Case study on bio-toilets in rural India.
- Case study on life science-based environmental health intervention (e.g., algal treatment of arsenic, probiotics in water purification, decentralised composting systems, etc).

Essential Readings

- Rittmann, B.E. & McCarty, P.L. (2001). Environmental Biotechnology: Principles and Applications.
- Vallero, D.A., 2015. Environmental biotechnology: a biosystems approach. Academic press.
- WHO Reports on Water, Sanitation and Health
- MoEFCC (India). National Environmental Health Profile Reports
- Pierik, R. & Verweij, M. (2009). Health Impact Assessment and Public Health Ethics.

Suggested Readings

- UNEP. Environmental Biotechnology for Pollution Control
- Wang, L.K., Ivanov, V., Tay, J.H. and Hung, Y.T. eds., 2010. Environmental biotechnology (Vol. 10). Springer Science & Business Media.
- IPCC Reports (Health and Vulnerability sections)
- National Health Policy 2017 – Govt. of India
- The Lancet Commission Reports on Pollution and Health

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-2) : Coastal and Marine Environment

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OFTHE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-2: Coastal and Marine Environment	**4**	**3**	**-**	**1**	UG	**-**

Course Objectives

The course is designed to

- Develop an advanced understanding of the physical, chemical, and biological processes governing coastal and marine environments, with a focus on their structure, function, and dynamics.
- Equip students with practical and analytical skills for the use of modern field, laboratory, and geospatial techniques such as GIS and remote sensing.
- Cultivate an understanding of the key challenges facing coastal and marine environments, including climate change, pollution, habitat degradation, biodiversity loss, and resource
- exploitation, and the capacity to propose nature-based sustainable solutions. Understand the role being played by climate change in modifying the ocean processes and the ocean-atmosphere interactions.

Learning Outcomes

At the end of the course, the students should be able to

- Demonstrate advanced understanding of the physical, chemical, and biological processes that shape coastal and marine environments, including their structure, function, and dynamics.
- Apply quantitative and qualitative research methods, including fieldwork, laboratory analysis, GIS, and remote sensing, for environmental assessment, monitoring, and spatial planning in coastal and marine contexts.
- Critically evaluate natural and anthropogenic impacts on coastal and marine systems, including pollution, habitat loss, climate change, and resource exploitation, and propose evidence-based management solutions.
- Demonstrate familiarity with global scientific concepts and research findings in the domain of climate change-driven oceanic processes.

Course syllabus - Theory (45 hours)

Unit I – Overview of Coastal and Marine Environment (14 Hours)

Bathymetry, structure, function, and classification; Opening and closing of the Ocean, Mapping Ocean floor, Active and Passive Margins, Physical andchemical properties, coastal features, zonation and ecological characteristics; ecosystem services; classification frameworks.

Unit II – Physical and Geological Processes (12 Hours)

Seafloor spreading, Patterns of Paleomagnetism, Coastal geomorphology and landforms; Classification of sediments, Sediment dynamics; Oceanic processes;Sea surface temperature, Ekman Transport, Gyres, Upwelling, Downwelling, Watermasses, Waves and Tides, Oozes, CCD, Marine geology; Paleoceanography, Coastal hazards; Karsts and carbonate systems.

Unit III – Chemical and Biological Oceanography (10 hours)

Composition, sea water Salinity and properties of seawater, Conservative and Non-conservative constituents, Ocean stratification, marine biogeochemical cycles- carbon and nitrogen, marine biodiversity, sea grasses, mangroves, habitats, salt marshes, estuaries and biogeographic zones.

Unit IV – Coastal and Marine Environmental Issues (9 Hours)

Eutrophication, harmful algal blooms, hypoxia, and Oxygen Minimum zones, Coastal erosion, sea-level rise, and climate change impacts, Marine and coastal biodiversity loss, habitat degradation, factors affecting marine communities.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Construction and interpretation of T-S (Temperature-Salinity) diagrams.
- Seawater and marine sediment sampling techniques.
- Analysis of nutrients, dissolved oxygen, pH, and other chemical parameters associated with seawater.
- Assessment of chlorophyll content in seawater.
- Sediment sampling and grain size analysis.
- Mapping of land use/land cover, habitats, and geomorphological features in coastal zones
- Use of remote sensing data for coastal change detection and habitat assessment

Essential Readings

- Garrison Tom S. Essentials of Oceanography 5th ed. Belmont, Brooks/Cole, Cengage Learning. 2009.
- Alan P. Trujillo and Harold V Thurman. Essentials of Oceanography, Prentice Hall. 2013.
- Lalli M.C. and Parsons T.R. Biological Oceanography: An Introduction, Elsevier. 2012.
- Frank J. Millero. Chemical Oceanography, CRC Press. 2014.

Suggested Readings

- Dijkstra, H. A. (2008). Dynamical oceanography (Vol. 1, No. 4). Berlin: Springer.
- Miller, C. B. (2009). Biological oceanography. John Wiley & Sons. Abel, D. C., & McConnell, R. L. (2009). Environmental oceanography: topics and analysis. Jones & Bartlett Publishers.
- Knauss, J. A., & Garfield, N. (2016). Introduction to physical oceanography. Waveland Press. Grasshoff, K., Kremling, K., & Ehrhardt, M. (Eds.). (2009). Methods of seawater analysis. John Wiley & Sons.

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE- (DSE-3)

Culture, Environment, and Ecological Imaginaries

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-3: Culture, Environment, and Ecological Imaginaries	4	3		1	UG	-

Course Objectives

- Examine how diverse cultures conceptualize nature, landscape, and the human–environment relationship
- Analyze environmental transformations through the lenses of cultural adaptation, political ecology, and environmental history
- Explore the environmental implications of religious beliefs, myths, rituals, and customary practices
- Critically assess the impact of modern development, colonial legacies, and capitalism on cultural-ecological systems
- Understand how cultural narratives shape contemporary discourses on sustainability, risk, and resilience

Learning Outcomes

By the end of the course, students will be able to:

- Interpret ecological practices and landscape transformations through cultural and symbolic frameworks
- Analyze historical and contemporary modes of human adaptation across ecological regions
- Identify how cultural perceptions of environment influence conservation, land use, and development
- Reflect on the role of myth, memory, ritual, and tradition in environmental knowledge and resilience
- Engage critically with concepts such as "sacred landscapes," "ecological cosmologies," and "cultural adaptation" in policy and practice

Course Syllabus – Theory (45 hours)

Unit 1: Culture, Nature, and Environmental Knowledge Systems (13 hours)
Concept of culture, material culture, and environmental adaptation; Technology and symbolic interaction with nature; Traditional ecological knowledge (TEK) and biocultural diversity; Nature–culture dualism and its critiques; Environmental meanings in mythology, cosmology, and oral traditions; Ecological transitions: hunting-gathering, pastoralism, swidden agriculture; Spiritual landscapes; Gender, caste, and ethnicity in environmental labor and resource use.

Unit 2: Environmental Adaptation, Identity, and Governance (12 hours)
Market integration and industrial transformation; Climate adaptation in cultural context; Political ecology of land, forest, and water in colonial and post-colonial India; Customary law, community governance, and commons management; Sacred groves, shrine forests, and cultural conservation regimes; Cultural framings of scarcity, degradation, and disaster risk; Religion and ecological stewardship.

Unit 3: Development, Displacement, and Cultural Transformation (10 hours)
Development discourses and redefinition of nature; Cultural dislocation and ecological change under dams, mines, and urbanization; Environmental culture in organizations and green business ethics; Commodification of landscapes and ecological tourism; Post-development, degrowth, and regenerative movements.

Unit 4: Landscapes, Memory, and Ecological Representation (10 hours)
Landscapes as cultural texts and memory-scapes; Environmental aesthetics and ecological storytelling; Cultural change, nostalgia, and place attachment; Literary and visual representations of nature; Art, folklore, and music in environmental resistance.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Analyze a ritual or belief system that reflects an ecological ethic
- Use narrative, symbols, or GIS to explore cultural meanings of place
- Examine a conflict between cultural practices and conservation or development policy
- Deconstruct environmental symbolism in film, photography, or media
- Assess adaptive cultural strategies across ecological zones or communities

Essential Readings

- Anderson, A. (2019). Media, Culture and the Environment. Routledge.
- Milton, K. (2003). Environmentalism: The View from Anthropology. Routledge.
- Rocheleau, D., Thomas-Slayter, B. and Wangari, E., 2013. Feminist political ecology: Global issues and local experience. Routledge.
- Sahlins, M.D., 2013. Culture and environment: The study of cultural ecology. In Theory in anthropology (pp. 367-373). Routledge.

Suggested Readings

- Dennett, D.C., 2001. The evolution of culture. The Monist, 84(3), pp.305-324.
- Krüger, F., Bankoff, G., Cannon, T., Orlowski, B. and Schipper, E.L.F. eds., 2015. Cultures and disasters: understanding cultural framings in disaster risk reduction. Routledge.
- Gold, A. G., & Gujar, B. R. (2002). In the Time of Trees and Sorrows: Nature, Power, and Memory in Rajasthan. Duke University Press.

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE – (DSE-4:

Environmental History and Contemporary Environmental Thought

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-4: Environmental History and Contemporary Environmental Thought	4	3	-	1	UG	-

Course Objectives

- Explore major trends in environmental history from ancient to modern times
- Analyze the co-evolution of societies and ecosystems
- Understand historical roots of environmental degradation, conservation, and sustainability discourses
- Critically examine ideologies, and cultural constructs shaping environmental thinking
- Evaluate transformations in water, land, forests, disease ecology, and technology through historical processes

Learning Outcomes

By the end of the course, students will be able to:

- Analyze ecological transitions across civilizations
- Identify key environmental events that influenced develoment at global and local levels
- Examine the origins and trajectories of ecological thought and public concern about the environment
- Contextualize modern environmental challenges and movements in long-term historical patterns

Course Syllabus – Theory (45 hours)

Unit 1: Foundations of Environmental History and Ecological Thought (14 hours)

Definitions, scope, and methodologies of environmental history; Environmental thought across time: natural theology, romantic ecology, Gaia theory; Relationship with economic, social, and cultural histories; Foundational thinkers: Lynn White, Rachel Carson, Ramachandra Guha, Alfred Crosby; Human–nature relationships: from sacred landscapes to extractive frontiers; Environmental impacts of colonial expansion: forest policies, agrarian restructuring, ecological imperialism; Global movement of species, crops, pathogens, technologies.

Unit 2: Empire, Landscapes, and Ecological Transformation (11 hours)

Case studies: spice trade, tea plantations, malaria ecology, cartographic reordering; Cultural meanings of wilderness, commons, enclosures; Landscapes of control: plantations to protected areas; Industrial capitalism and ecological consequences; Urban growth: waterworks, pollution, sanitation; Changing perceptions of environmental risks; Anti-industrial resistance: Luddite and Gandhian ecological thought.

Unit 3: Environmental Movements and Contemporary Ecological Thought (10 hours)
From conservation to environmental justice; Movements for forests, water, and biodiversity: Chipko, Narmada, Bishnoi, Climate Strikes; Ecofeminism, Indigenous philosophies, deep ecology; Global green politics; Historical roots of environmental reform movements.

Unit 4: Environmental History of Inequality, Climate Futures, and the Anthropocene (10 hours)
Ecological marginality: caste, race, gender, and class; Resource access, institutional power, and governance; Historical trajectories of global environmental change; Anthropocene, planetary boundaries, and climate governance; Futures of environmental history and contemporary debates.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Develop a cross-regional environmental chronology focusing on key socio-ecological events
- Trace the environmental history of a landscape (e.g., river, forest, wetland) using maps and reports
- Critically engage with historical environmental narratives in literature or visual media
- Curate a thematic exhibit or digital archive on historical environmental change
- Analyze contrasting approaches to nature in pre-colonial and colonial societies

Essential Readings

- Hughes, J.D., 2016. What is environmental history?. John Wiley & Sons.
- Richards, J.F., 2003. The unending frontier: an environmental history of the early modern world (Vol. 1). Univ of California Press.
- Gadgil, M. and Guha, R., 2013. Ecology and equity: The use and abuse of nature in contemporary India. Routledge.
- Guha, R., 2014. Environmentalism: A global history. Penguin UK.

Suggested Readings

- Hughes, J.D., 2009. An environmental history of the world: humankind's changing role in the community of life. Routledge.
- Merchant, C., 2007. American environmental history: An introduction. Columbia University Press.

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE – (DSE-5)

Environmental Pollution and Epidemiology of Diseases

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-5: Environmental Pollution and Epidemiology of Diseases	4	3	-	1	UG	-

Course Objectives

The course is aimed to:

- Introduce the scientific basis and sources of environmental pollution affecting human health,
- understand the fundamental concepts of epidemiology in the context of environmental exposure,
- explore the linkages between pollution and disease burden across populations, and
- provide exposure to environmental health data collection, analysis, and risk communication.

Learning Outcomes

After the course, students will be able to:

- Describe the types, sources, and health impacts of major pollutants,
- Examine basic epidemiological methods used in environmental health studies,
- Analyse case studies linking pollution exposure with acute and chronic diseases, and
- Conduct and interpret basic environmental health surveys and risk assessments.

Course syllabus – Theory (45 hours)

Unit I – Environmental Pollution and Human Exposure (11 hours)

Types of pollution: air, water, soil, noise, chemical, and radioactive. Pollutants of concern: PM2.5, NOx, SOx, VOCs, heavy metals, pesticides, plasticisers. Pathways of exposure: inhalation, ingestion, dermal contact. Bioaccumulation and biomagnification

Unit II – Principles of Environmental Epidemiology (10 hours)

Basic concepts: incidence, prevalence, risk factors, population-at-risk. Types of studies: cross-sectional, cohort, case-control. Exposure-response relationships and dose-response curves. Confounders and bias in environmental health studies

Unit III – Pollution-linked Diseases (12 hours)

Respiratory: asthma, bronchitis, COPD, Waterborne: cholera, typhoid, arsenicosis, fluorosis, Soil and food-related: pesticide toxicity, mycotoxicosis, heavy metal poisoning, Emerging diseases and climate-sensitive diseases (dengue, heat stroke, leptospirosis)

Unit IV – Risk Assessment and Public Health Response (12 hours)

Steps in health risk assessment: hazard identification, dose-response, exposure assessment, risk characterization, Risk management and communication, Disease surveillance systems (IDSP, NVBDCP, ICMR), Policies and regulations in environmental health (WHO, CPCB, MOHFW, SDG 3 & 6)

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Conduct an environmental health survey in a community
- Case study analysis of an epidemic linked to pollution (e.g., Minamata, Bhopal, Delhi smog)
- Data analysis of air or water quality and correlating with health indicators
- Prepare an exposure pathway diagram,
- Visit to a local PHC/UHC or environmental monitoring agency
- Design a public awareness campaign on pollution-related diseases.

Essential Readings

- Friis, R. H. (2012). Essentials of Environmental Health.
- Burt, J. E., & Barber, G. M. (1996). Elementary Statistics for Geographers.
- WHO (2006). Preventing Disease Through Healthy Environments.
- Kondo, M. C. et al. (2018). Health impact of urban environmental exposures: A systematic review.
- CPCB/ICMR Reports on Environmental Health and Pollution

Suggested Readings

- Balakrishnan, K. et al. (2020). Air Pollution and Health in India: A Review.
- ICMR-NIREH. (2021). Environmental Health Risk Assessment Manual.
- Baird, C., & Cann, M. (2012). Environmental Chemistry (Chapters on pollutants).
- Kjellstrom, T. et al. (2007). Comparative Quantification of Health Risks: Global and Regional Burden of Disease Attributable to Selected Major Risk Factors.
- Indian Ministry of Health Reports and NDMA Guidelines on pollution-linked emergencies

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-6):
Environmental Micobiology and Microbial Ecology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-6: Environmental Micobiology and Microbial Ecology	4	3	-	1	UG	-

Course Objectives

- Understand microbial diversity and ecological roles in natural and managed ecosystems
- Gain proficiency in classical and molecular techniques for microbial identification and analysis
- Examine microbial functions in biogeochemical cycles, plant-microbe interactions, and ecosystem processes
- Explore microbial adaptations and their applications in bioremediation and environmental sustainability.
- Analyze policy, ethical, and legal frameworks related to microbial resources and biosafety.

Learning Outcomes

At the end of the course, the students should be able to

- Understand interactions of microorganisms with abiotic and biotic environment
- Microorganisms and biogeochemical cycles
- Microorganisms in terrestrial, aquatic and extreme environments
- Culture-based characterization of microbial communities
- Molecular characterization: PCR, real-time PCR, molecular fingerprints
- Statistical methods in microbial ecology

Course Syllabus – Theory (45 hours)

Unit I – Microbial Function in Ecosystems (12 Hours)

Microbial diversity and ubiquity in ecosystems: roles of microorganisms in biogeochemical cycles (nitrogen fixation, methane metabolism, phosphate mobilization, sulfur cycling); photosynthesis in microorganisms and diversity of pigments; microbial ecological niches and metabolic specialization: functional roles in ecosystems including production, decomposition, and nutrient mobilization; symbiotic and mutualistic relationships; microbial applications in biodegradation and bioremediation.

Unit II – Interactions of Microorganisms with Abiotic and Biotic Environment (14 Hours)

Microbial networks and ecological interactions; plant-microbe interactions including mycorrhizal associations. PGPR and rhizosphere dynamics; microbial interactions with animals and humans; microbe-microbe interactions including competition and quorum sensing; microbial decomposition and nutrient recycling; effects of abiotic factors such as temperature, pH, and moisture on microbial activity; extremophiles and microbial adaptations to extreme environments.

Unit III – Methods in Microbial Ecology (10 Hours)

Traditional microbial isolation techniques; characterization of microbial species using morphological and biochemical tests; aseptic techniques and culture maintenance; molecular tools for studying microbial diversity (PCR, 16S and 18S rRNA sequencing, metagenomics); functional gene analysis and metatranscriptomics; use of bioinformatics in microbial ecology; environmental sampling and experimental design; statistical approaches in microbial ecological studies.

Unit IV – Intellectual Property Rights and Microorganisms (9 Hours)

TRIPS agreement and microbial patentability; Convention on Biological Diversity (CBD) and benefit-sharing frameworks; legal and ethical considerations in microbial resource utilization; case studies on biopiracy and access-benefit sharing; emerging doctrines such as the rights of nature; global inequities in microbial biotechnology and environmental justice.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

Environmental sampling: collection of samples from soil, water, air and niche habitats__

- Aseptic media preparation, isolation and characterization of microbes on prepared media
- DNA extraction from tissue and environmental samples
- Metagenomics: understanding microbial diversity and function by analyzing all DNA sequences in a sample
- Metatranscriptomics: understanding microbial gene expression and functional potential through analyses of RNA sequencing from microbial communities
- Bioinformatics: handling, assembling and annotating large datasets.

Essential Reading

- Environmental Microbiology and Microbial Ecology. Barton, L.L., McLean, R.J.C. (2019). Wiley-Blackwell
- Soil Biology and Ecology: The Basics. Popoviciu, D.R., Bentham Science (2024)
- Metagenomics: methods and protocols. Streit, W.R., Daniel, R., Springer Nature (2023)
- Are ecological processes that select beneficial traits in agricultural microbes nature's intellectual property rights? Kothamasi, D., Vemeylen, S., Deepika, S. Nature Biotechnology (2023) 41:1381 – 1384
- Journal Research articles related to lectures delivered in the classroom

Suggested Readings

- Microbial Ecology, Larry L. Barton, Diana E. Northup, Wily-Blackwell (Publisher)
- Microbial Ecology: Fundamentals and Applications, Ronald M Atlas and Richard Bartha
- Intellectual Property and Biotechnology, Biological Inventions, Mathew Rimmer. Edward Elgar (Publisher)
- Rau, N. et al., 2009. Evaluation of functional diversity in rhizobacterial taxa of a wild grass (*Saccharum ravennae*) colonizing abandoned fly ash dumps in Delhi urban ecosystem. Soil Biology and Biochemistry, 41(4), pp.813-821.

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-7):

Fundamentals of air pollution science

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-7: Fundamentals of Air Pollution Science	4	3	-	1	UG	-

Course Objectives

The course is designed to

- Understand the environmental effects of air pollution
- Understand the dispersion of air pollutants
- Learn about air pollution monitoring methods and control technologies

Learning Outcomes

At the end of the course, the students should be able to

- Evaluate the emergent issues of air pollution in India and worldwide
- Evaluate the impact of air pollution on the atmospheric environment
- Measure air pollutants and select the appropriate control technologies for the target pollutants

Course syllabus – Theory (45 hours)

Unit 1- Basics of Air Pollution (11 hours)

Types and sources of air pollution; Air pollution hot spots; Criteria pollutants, and NAAQs; Air pollution monitoring methods; Objectives of the air pollution monitoring programme; Government initiatives to tackle air pollution; Indoor air pollution.

Unit II - Air pollution meteorology (11 hours)

Meteorological parameters; Temperature profile of the atmosphere; Lapse rate; Atmospheric stability; Plume behaviour; Dispersion of air pollutants; Gaussian plume model; Meteorological data acquisition and use in air quality forecasting

Unit III - Air pollution control technologies (11 hours)

Technologies for controlling the gaseous and particulate pollution; Vehicle emission control technologies; Urban planning and traffic interventions for air quality; Pollution control in thermal power plants, cement and other industries; Role of green infrastructure and urban vegetation; Case studies.

Unit IV- Impacts of air pollution on the environment and health (12 hours)
Inter-relation of air pollution and climate change; Air pollution impacts on human health; Impacts on atmospheric chemistry and radiative forcing; Air pollution and mortality/morbidity statistics; Agricultural and ecological effects; Transboundary air pollution and regional agreements; Policy responses: WHO air quality guidelines, UNEP reports; Case studies

Suggested Practicals/Applied Exercises/Field Component (30 hours)
- To study the meteorological parameters
- To study mixing height and atmospheric stability
- To study the concentration of particulates in the ambient air
- Monitoring air pollutants using low-cost sensors
- Study and interpret the data from the continuous ambient air quality monitoring system
- Air quality Index- calculation and interpretation
- Based on the syllabus

Essential Readings

- Seinfeld, J.H., Pandis, S.N., (2016). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. Wiley publication.
- Vallero, D. A., (2014). Fundamentals of air pollution. 5th edition. Academic Press, USA.
- Tiwari, A., Williams, I., (2018). Air Pollution: Measurements, Modelling and Mitigation. 4th Edition. CRC Press.
- De N.N., (2000). Air Pollution Control Engineering. McGraw-Hill.

Suggested Readings

- Jeremy, C., Tiwary, A., Colls, J. (2009). Air pollution: measurement, modeling and mitigation, 3rd Edition, USA: CRC Press.
- Guidelines for Ambient Air Quality Monitoring. CPCB India.
- Lutgens, F.K., Tarbuck, E.J., Tasa, D., (2013). The Atmosphere: An Introduction to Meteorology. Pearson.

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE – (DSE-8)

Gender, Ecology, and Environmental Justice

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-8: Gender, Ecology, and Environmental Justice	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives

- Develop a globally relevant understanding of gender–environment relationships
- Critically examine how ecological degradation, climate crises, and environmental governance intersect with gender, class, race, and coloniality
- Explore global and local feminist ecological knowledge systems, policy frameworks, and justice-based movements
- Investigate the role of women in environmental conservation, and activism

Learning Outcomes

By the end of the course, students will be able to:

- Analyze the interlocking systems of gender, race, class, and environment using critical and intersectional theories
- Apply feminist and decolonial ecological frameworks to case studies of climate, conservation, and development
- Critique dominant environmental discourses and policies through gender-justice and equity lenses
- Assess contributions of feminist movements, and eco-justice actors in global environmental governance
- Design and communicate gender-responsive, socially inclusive environmental policies

Course Syllabus – Theory (45 hours)

Unit 1: Theorizing Gender, Ecology, and Environmental Thought (14 hours)
Genealogies of gender, race, and environmental thought; Ecofeminism: radical, spiritual, materialist, and posthuman approaches; Feminist political ecology: access, control, knowledge, and everyday struggles; Queer ecologies and intersectional environmentalism; Decolonial and Indigenous feminist critiques of development and conservation. Women's knowledge in agriculture, forest management, and water governance; Gendered labour and care work in ecological transitions.

Unit 2: Gendered Knowledge, Resource Politics, and Justice (11 hours)
Land tenure, land grabs, and feminization of land struggles; Indigenous women and ecological stewardship; Global political economy of extraction and environmental harm; Gendered dimensions of climate vulnerability and resilience; Migration, conflict, urbanization, and displacement; UNFCCC Gender Action Plan.

Unit 3: Environmental Movements, Activism, and Climate Justice (11 hours)
Women-led environmental movements: Chipko, Narmada, Standing Rock; Feminist campaigns against mining, nuclear projects, and toxics; Gender and corporate accountability; Feminist storytelling in climate justice and environmental resistance; Just transitions: renewable energy, carbon markets, reparative frameworks.

Unit 4: Governance, Policy, and the Future of Environmental Justice (9 hours)
Gender mainstreaming in environmental governance; Gender-responsive budgets and institutional reforms; International instruments: CEDAW, IUCN Gender & Environment Hub; Ethics of care; Future directions for gendered environmental justice and global sustainability.

Suggested Practicals/Applied Exercises/Field Component (30 hours)
- Visualize gender-climate vulnerability for a community or region
- Critically assess a national environmental policy (e.g., climate plan, forest rights) for gender equity
- Analyze representations of gender and environment in documentaries or social campaigns
- Propose an initiative that integrates gender equity and environmental sustainability in a specific sector
- Write or deconstruct eco-feminist stories from oral traditions, Indigenous epistemologies, or digital media
- Based on the syllabus

Essential Readings

- Alston, M. and Whittenbury, K. eds., 2012. Research, action and policy: Addressing the gendered impacts of climate change. Springer Science & Business Media.
- Buckingham, S., 2020. Gender and environment. Routledge.
- Cuomo, C., 2002. Feminism and ecological communities. Routledge.
- MacGregor, S. ed., 2017. Routledge handbook of gender and environment. Taylor & Francis.

Suggested Readings

- Gaard, G., 2017. Critical ecofeminism. Lexington Books.
- Haraway, D.J., 2016. Staying with the trouble: Making kin in the Chthulucene. In Staying with the Trouble. Duke University Press.
- Sachs, C.E., 2018. Gendered fields: Rural women, agriculture, and environment. Routledge.

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE – (DSE-9)

Introduction to Environmental Governance

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-9: Introduction to Environmental Governance	4	3	-	1	UG	-

Course Objectives

- Introduce the evolution, principles, and frameworks of environmental governance at multiple levels,
- Explain the roles of institutions, policies, stakeholders, and legal mechanisms in governing natural resources and ecosystems,
- Foster critical understanding of participatory, Decentralised, and inclusive models of governance,
- Equip students with analytical tools to evaluate governance structures in the context of environmental justice, equity, and sustainability.

Learning Outcomes

At the end of the course, students will be able to:

- Understand key concepts, actors, and mechanisms involved in environmental governance.
- Examine how power, institutions, and norms influence environmental decision-making.
- Evaluate national and global governance systems through real-world case studies.
- Recommend policy or governance interventions for sustainable and equitable outcomes.

Course syllabus – theory (45 hours)

Unit I – Concepts and Frameworks of Environmental Governance (12 hours)
Definition and significance of environmental governance, Core principles: transparency, accountability, participation, equity, rule of law, Governance vs. government: new institutionalism, decentralisation, Environmental governance and sustainable development, Theories of governance: adaptive, polycentric, collaborative governance

Unit II – Governance Actors and Institutions (11 hours)
Key actors: state, judiciary, civil society, indigenous communities, media, corporations, Role of Panchayati Raj Institutions and Urban Local Bodies, Public-Private Partnerships (PPP) in environmental governance, Environmental Tribunals, especially National Green Tribunal (NGT), Policy instruments: command-and-control regulations, market-based incentives, voluntary codes, certifications

Unit III – Environmental Governance in India (12 hours)
Constitutional and legislative provisions: Art. 48A, 51A(g); EPA 1986; FRA 2006, Institutional framework: MoEFCC, CPCB, SPCBs, Forest Departments, Implementation challenges: gaps, coordination issues, political economy, corruption Case studies: Forest Rights Act implementation, Coastal Regulation Zone norms, Environmental Impact Assessment Notification 2006

Unit IV – Global Environmental Governance (10 hours)
Global commons and transboundary environmental challenges, Global institutions: UNEP, IPCC, WTO, World Bank, GEF, Major Multilateral Environmental Agreements (MEAs): UNFCCC and the Paris Agreement, CBD, Basel Convention, Minamata Convention, Governance of climate change, biodiversity, pollution control, Emerging issues: climate justice, environmental diplomacy, geoengineering governance

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Institutional Mapping: Local/state environmental governance bodies,
- Case Study Analysis: Governance success/failure (e.g., Aravalli Hills restoration, Delhi CNG policy)
- Stakeholder Analysis: Contested environmental issues (e.g., mining project, dam construction),
- Governance Audit: Preparation of a report on a local environmental issue (e.g., water pollution, waste management),
- Policy Drafting Exercise: Alternative policy framework for local waste or water governance,
- Legal Brief: Landmark NGT judgment or PIL (e.g., Sterlite, Vizag gas leak) ,
- Document Review: Content and critique of a State Action Plan on Climate Change (SAPCC

Essential Readings

- Lemos, M. C. & Agrawal, A. (2006). Environmental Governance. Annual Review of Environment and Resources.
- Evans, J. and Thomas, C., 2023. Environmental governance. Routledge.
- Ostrom, E. (1990). Governing the Commons.
- Government of India. (2006). National Environment Policy.
- Baviskar, A. (2004). In the Belly of the River.

Suggested Readings

- UNDP. Environmental Governance for Sustainable Development
- World Bank. (2003). World Development Report: Sustainable Development in a Dynamic World
- IPCC Sixth Assessment Report (Summary for Policymakers)
- NGT Compendium of Landmark Judgments (MoEFCC)

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE10):
Remote Sensing and GIS for Environmental Applications

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-10: Remote Sensing and GIS for Environmental Applications	4	3	-	1	UG	-

Course Objectives

- Provide foundational and applied knowledge of geospatial technologies for environmental analysis
- Develop competence in remote sensing data acquisition, image processing, and spatial analysis
- Equip students with hands-on GIS tools for solving real-world environmental problems
- Explore global satellite missions, sensors, and cloud-based platforms for environmental monitoring
- Apply geospatial techniques in sustainable resource management, climate assessment, and biodiversity conservation

Learning Outcomes

By the end of this course, students will be able to:

- Explain the principles of remote sensing and geographic information systems
- Analyze spatial and spectral data from satellite and airborne sources
- Apply GIS for spatial modeling and visualization of environmental patterns and processes
- Utilize tools like QGIS, ArcGIS, and Google Earth Engine for environmental decision-making
- Integrate RS-GIS into climate change, land use, biodiversity, and pollution studies

Course Syllabus – Theory (45 hours)

Unit 1: Principles of Remote Sensing and Data Acquisition (11 hours)

Electromagnetic spectrum: interactions with atmosphere and surface; Remote sensing platforms and sensors: Landsat, Sentinel, MODIS, IRS, LiDAR; Resolution types: spatial, spectral, radiometric, temporal; Image acquisition and pre-processing: radiometric and geometric corrections; Global data sources: USGS Earth Explorer, Bhuvan, Copernicus, NOAA.

Unit 2: GIS Fundamentals, Spatial Analysis, and Data Management (11 hours)

GIS concepts: raster and vector models; Spatial reference systems and projections; Data input, digitization, attribute tables, georeferencing; Spatial analysis: buffering, overlay, spatial interpolation; Database creation, metadata, and spatial data quality.

Unit 3: Image Processing, Classification, and Cloud-Based Analytics (11 hours)

Digital image enhancement and classification: supervised, unsupervised; Vegetation indices: NDVI, SAVI; Change detection and temporal analysis; Accuracy assessment and ground truthing; Visual and digital interpretation; Introduction to Google Earth Engine and cloud-based geospatial platforms.

Unit 4: Environmental Applications, Modeling, and Decision Support (12 hours)
Land use/land cover change and urban sprawl; Forest degradation, biodiversity, and conservation planning; Wetland and watershed mapping; Pollution zoning: air and water; Natural hazard monitoring: drought, floods, fires; GIS-based environmental modeling: erosion, runoff, climate vulnerability; Drone and GPS integration; EIA, carrying capacity analysis; Ethics and limitations in geospatial data use.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Land cover classification using Sentinel or Landsat data – Detect and classify vegetation and built-up areas
- Watershed delineation using DEM data – Apply GIS hydrological tools
- Change detection analysis of urban growth – Monitor land use transitions over time
- Pollution mapping using spatial interpolation – Visualize pollutant spread from sampling data
- GIS-based suitability analysis for conservation sites – Perform multi-criteria decision analysis
- Based on the syllabus

Essential Readings

- Burrough, P. A., McDonnell, R. A., & Lloyd, C. D. (2015). Principles of geographical information systems (3rd ed.). Oxford University Press.
- Jensen, J. R. (2013). Remote sensing of the environment: An earth resource perspective (2nd ed.). Pearson.
- Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2015). Remote sensing and image interpretation (7th ed.). Wiley.
- Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic information systems and science (4th ed.). Wiley.

Suggested Readings

- Bolstad, P. (2016). GIS fundamentals: A first text on geographic information systems (5th ed.). XanEdu Publishing.
- Campbell, J. B., & Wynne, R. H. (2011). Introduction to remote sensing (5th ed.). Guilford Press.
- Google Earth Engine Tutorials. https://developers.google.com/earth-engine
- QGIS Documentation Team. (2023). QGIS User Guide. https://docs.qgis.org

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC CORE COURSE - (DSC-11):
Technology, Environmental and Society

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-11: Technology, Environmental and Society	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives

- Analyze the historical and contemporary relationships between technological advancement, society, and the environment
- Critically assess the social and ecological consequences of technology adoption across sectors
- Examine the role of innovation in driving sustainability transitions and addressing environmental challenges
- Explore environmental policy frameworks and their interaction with technological choices
- Understand the contribution of social and environmental movements to responsible and equitable technology development

Learning Outcomes

By the end of the course, students will be able to:

- Articulate the reciprocal influences of technology, environmental change, and social systems
- Distinguish between types and scales of technologies and their implications for ecological sustainability
- Evaluate technological innovations in key environmental domains (e.g., energy, transport, water)
- Interpret policy frameworks and assess how they shape technology transitions
- Critically reflect on environmental movements and community-led alternatives to dominant technological paradigms

Course Syllabus – Theory (45 hours)

Unit 1: Technology, Society, and Environmental Change (14 hours)

Historical human–technology–nature interactions; Industrial revolutions and environmental transformations; Technology as an agent of ecological risk and adaptation; Comparative tech trajectories: Global North vs Global South; Technological dualism and environmental justice critiques; Cultural and ecological dimensions of technological change. Typologies of technology: green, disruptive, appropriate, soft and hard; Lifecycle assessment and design-for-environment; Technology adoption barriers; Environmental externalities of legacy and lock-in technologies.

Unit 2: Technological Systems, Innovation, and Sustainability (11 hours)

Case studies: decentralized solar, bio-digesters, electric mobility; Material flow and end-of-life challenges in tech systems; Sectoral innovations: agriculture, water, mobility, waste; Bioeconomy and circular technologies; Green technologies for pollution control and resource efficiency; Emerging tech: AI, IoT, climate-tech, risk modeling; Frugal innovation and climate-smart adaptation technologies.

Unit 3: Governance, Policy, and Socio-Technical Transitions (10 hours)
Policy instruments: regulatory, fiscal, voluntary; Socio-technical transitions and Multi-Level Perspective (MLP); Environmental costs: mining, digital waste, rebound effects; Governance of emerging technologies: uncertainty, ethics, risk; Innovation systems for low-carbon pathways; Policy–technology integration for just transitions.

Unit 4: Technology Movements, Justice, and Corporate Responsibility (10 hours)
Media and civil society in shaping tech narratives; Environmental justice movements and technology critiques; Corporate shifts: CSR to ESG to Steward Leadership; Appropriate technology revival: ethics, scale, purpose; Community-led innovation and decentralized systems; Role of academia and media; Global critiques of greenwashing and techno-solutionism.

Practicals/Tutorials/Activities/Applied Exercises/Field Component (30 hours)

- Analyze the lifecycle and environmental footprint of a chosen technology
- Map the governance landscape for EV adoption in India or any region
- Assess technology deployment in a contested landscape (e.g., hydropower, waste incineration)
- Case study analysis of community resistance to a large infrastructure project; stakeholder assessment
- Draft an "appropriate technology" proposal addressing water, waste, or mobility
- Based on the syllabus

Essential Readings

- Atkinson, J. and Crowe, M. eds., 2006. Interdisciplinary research: Diverse approaches in science, technology, health and society. John Wiley & Sons.
- Dove, M. and Kammen, D., 2015. Science, society and the environment: Applying anthropology and physics to sustainability. Routledge.
- Golden, J.M., 2016. Dawn of the metal age: Technology and society during the Levantine Chalcolithic. Routledge.
- Gross, M. and Mautz, R., 2014. Renewable energies. Routledge.
- Harper, C. and Snowden, M., 2017. Environment and society: Human perspectives on environmental issues. Routledge.
- Perkins, J.H., 2017. Changing energy: the transition to a sustainable future. Univ of California Press.

Suggested Readings

- Brownsword, R., 2019. Law, technology and society: reimagining the regulatory environment. Routledge.
- Jasanoff, S. (2004). States of Knowledge: The Co-Production of Science and the Social Order. Routledge.
- Narayanan, A., Sharma, R.S. and Mishra, V., 2025. Unmasking the Masks of Profits: Analyzing Corporate Social Responsibility Through an Environmental Justice Framework. In Integrating Environmental Sustainability and Corporate Social Responsibility: A Move Beyond Profit: Corporate Social Responsibility for Environmental Sustainability (pp. 65-94). Cham: Springer Nature Switzerland.
- Odum, H.T., 2007. Environment, power, and society for the twenty-first century: the hierarchy of energy. Columbia University Press.
- Smil, V., 2007. Energy in nature and society: general energetics of complex systems. MIT Press.

M.Sc./M.A. Odd Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE – (DSE-12)

Traditional Indigenous Ecological Knowledge

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-12: Traditional Indigenous Ecological Knowledge	4	3	-	1	UG	-

Preamble

A "traditional environment knowledge" cover key topics definition and principles of Traditional Ecological Knowledge (TEK), its application in different ecosystems, indigenous knowledge systems related to plants, animals, weather patterns, land management practices, cultural beliefs tied to the environment. Methods for documenting and preserving TEK, and ethical considerations for studying and applying indigenous knowledge, often focusing on the interconnectedness between humans and their environment. The course is designed to deliver a foundational framework and overall understanding of Traditional Ecological Knowledge (TEK) in sustainability science and in the larger sustainability context and conservation movements. The course will make an effort to amalgamate theory and practical hands on experience techniques for alleviating and preserving indigenous knowledge in the scenario of socio-cultural transitions between knowledge systems. The students will focus on narratives of environmental knowledge, and how it can be integrated with social beliefs and subsequently to cater environmental management. Traditional versus scientific knowledge will also be explored.

Course Objectives

- Know the meaning of "traditional environment knowledge" and its significance in the contemporary world.
- Aware of the concept of "traditional environment knowledge" in sync with cultural beliefs and ecosystem interconnectedness to ecosystem services.
- Will be acquainted about the traditional indigenous knowledge of the elements of earth.

Learning Outcomes

- Understand the significance of our indigenous environmental knowledge system.
- In the scenario of globalization- how indigenous environmental knowledge will play a key role to conserve natural resources.
- Enhanced ability to communicate and understand the tacit balance between nature, culture, and biological diversity
- Comprehensively aware about the socio-cultural heritage and how TEK can augment and sensitize the youth in sync to government programs.

Course Syllabus – Theory (45 hours)

Unit- 1: (12 hours)

Introduction: Concept, Meaning and Definition, Approaches of Traditional Ecological Knowledge, Identification, Documentation, and Validation of Traditional Ecological Knowledge, Significance of Indigenous Traditional Ecological Knowledge. Sacred groves as living repositories of Traditional Ecological Knowledge – their ecological, and cultural significance in maintaining biodiversity, microclimate regulation, and ecosystem services. Sacred groves in traditional forest and land stewardship. Sacred groves as community-conserved areas and potential for ecotourism and environmental education.

Unit- 2: (9 hours)

Indigenous Traditional Ecological Knowledge (I-TEK) its linkages to Ecosystem Services, sustainability and Nature based Solutions (NbSs). Case study- Crop cultivation, and community based environment friendly practices.

Unit- 3: (12 hours)

Traditional Knowledge System and Practice: Studies related to agro-ecosystem, Land use and soil fertility, water conservation, and Forest products. Case Study related to traditional Indian water management and irrigation methods- aquifers, traditional baoli and various irrigation types. Historical practices of metallurgy and Indian metal carvings. Historical architectural influences in terms of energy efficiency. Traditional textile technology in terms of fiber, fabric, colour (use of natural colours) and weaving.

Unit- 4: (12 hours)

Traditional Knowledge System Community rights: Socio-cultural Heritage, Role of organizations/institutions, transitions of Intellectual Property Rights (IPRs). Policy Implications and way Forward- recognizing the importance of Traditional Ecological Knowledge, Integrating Inter-generational transitions of Traditional Ecological Knowledge, Policy framework and initiatives taken uplift Traditional Ecological Knowledge with respect to India. Addressing the challenges of Indigenous Traditional Ecological Knowledge (I- TEK) through SWOT- (Strength, Weakness, Opportunities and Threats) analysis.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Conduct biodiversity assessments (flora/fauna checklists), and measure environmental parameters like soil moisture and canopy cover etc.
- Simulate a community meeting to resolve resource-sharing rights using traditional frameworks.
- Conduct a SWOT analysis of a selected traditional ecological practice (e.g., shifting cultivation, pastoralism etc.).
- Developing a fact sheet of documenting observations, interviews, photos, and reflections on traditional ecological knowledge of any selected area.
- Write a short policy brief recommending measures to integrate TEK into environmental planning and role of IPR in protecting indigenous knowledge: benefits versus exploitation scenario.

Essential Readings

- Basham A.L. (ed.). A Cultural History of India. OUP, 1997.
- Berkes, F. (2012). Sacred ecology (3rd ed.). New York, NY: Routledge.
- Ramakrishnan, P. S. (1998). Conserving the sacred: From species to landscapes. New Delhi: UNESCO & Oxford & IBH Publishing.
- Melissa N. and Shilling D. (2018). Traditional Ecological Knowledge: Learning from Indigenous Environmental Sustainability. Cambridge University Press.
- Sen, G. (Ed.). (1997). India: A National Culture? New Delhi: Sage Publications.

- Sillitoe, P. (2007). Local science vs global science: Approaches to indigenous knowledge in international development. New York, NY: Berghahn Books.
- Raygorodetsky, Gleb (2011). *Why Traditional Knowledge Holds the Key to Climate Change.* UN University.
- Gadgil, M., Berkes, F., and Folke, C. (1993). Indigenous knowledge for biodiversity conservation. Ambio, 22, 151–156.
- Hughes, JD and Chandran, MDS (1998). Sacred groves around the Earth: An overview. In: PS Ramakrishnan, KG Saxena, and UM Chandrashekara (Eds.), Conserving the sacred: For biodiversity management (pp. 69–86). New Delhi: Oxford and IBH Publishing.
- Millennium Ecosystem Assessment (MEA). (2005). Ecosystems and human well-being: Synthesis. Washington, DC: Island Press.

Suggestive Readings

- Agarwal, A., and Narain, S. (1997). Dying wisdom: Rise, fall and potential of India's traditional water harvesting systems. New Delhi: Centre for Science and Environment.
- Kumar B B (2001). Indigenous knowledge and sustainable development. New Delhi: Concept Publishing Company.
- Brush, S. B. (1996). *Indigenous Knowledge of Biological Resources and Intellectual Property Rights: The Role of Anthropology.* American Anthropologist, 98(3), 653–686.
- UNESCO. (2009). Learning and knowing in indigenous societies today. Paris: UNESCO.
- Ministry of Environment, Forest and Climate Change (MoEFCC). (2014). National biodiversity action plan: Addendum 2014 to NBAP 2008. Government of India.

Semester – II

Details of various courses offered under PGCF for M.Sc. Environmental Science and M.A. Environmental Studies

Programme	Course	Course Code and Title
Semester I		
M.Sc./MA	Discipline-Specific Core (DSC)	**DSC-1:** Fundamentals of Environmental and Ecological Science
		DSC-2: Social, Environmental and Developmental Perspectives on Sustainability
		DSC-3: Integrated Natural Resource Governance for Sustainable Development
	Discipline-Specific Elective (DSE)	Any 2 out of Odd Semester Pool of DSE
	Skill-Based Course (SBC)	Methodologies for Environmental Studies I
Semester II		
M.Sc./MA	Discipline-Specific Core (DSC)	**DSC-4:** Environmental Pollution and Public Health
M.Sc. Environmental Science		**DSC-5:** Natural and Managed Ecosystems
		DSC-6: Ecotoxicology and Environmental Health
M.A. Environmental Studies		**DSC-5:** Global Environmental Challenges and Sustainable Solutions
		DSC-6: Environmental Law, Policy, and Governance
M.Sc./MA	Discipline-Specific Elective (DSE)	Any 2 out of Even Semester Pool of DSE
M.Sc./MA	Skill-Based Course (SBC)	Methodologies for Environmental Studies II

Pool of Discipline-Specific Elective Courses for Even Semester (M.Sc./M.A. Programme)

Even Semester DSE Papers (Page 66 onwards)

Semester II – M.Sc./M.A. Programme

M.Sc./M.A. (Environmental Studies)
Semester II

DISCIPLINE-SPECIFIC CORE COURSE - (DSC-4): Environmental Pollution and Public Health

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Cred its	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-4: Environmental Pollution and Public Health	4	3		1	UG	-

Course Objectives
- Examine contemporary environmental pollution and exposure pathways affecting human health
- Build interdisciplinary knowledge spanning environmental chemistry, toxicology, epidemiology, and public health
- Analyze environmental health risks using global standards and data-driven approaches
- Train students in emerging methods of environmental health surveillance, modelling, and policy response

Learning Outcomes
By the end of the course, students will be able to:
- Evaluate environmental pollutants in relation to their health effects across exposure routes and life stages
- Use global and Indian monitoring standards to interpret pollutant data from air, water, soil, and food systems
- Analyze exposure-disease relationships including both communicable and non-communicable outcomes
- Apply tools for environmental epidemiology, pollution risk mapping, and vulnerable population profiling

Course Syllabus – Theory (45 hours)

Unit 1: Pollution Types, Exposure Pathways, and Health Risk Fundamentals (12 hours)
Types of pollutants: physical, chemical, biological, and emerging contaminants (e.g., microplastics, PFAS); Exposure routes; Dose-response concepts, exposure burden, DALYs, vulnerable populations; Basics of toxicokinetics and environmental toxicology; Vector ecology: mosquitoes, rodents, ticks – disease ecology and seasonality; Climate change and vector expansion; Zoonotic diseases: Nipah, COVID-19, leptospirosis, One Health frameworks; Mental health effects of pollution and ecological stress.

Unit 2: Air, Water, Soil, and Food Pollution and Related Health Impacts (12 hours)
Air pollutant composition (inorganic and organic) and sources; Respiratory and cardiovascular impacts; Air quality monitoring and standards (national/international); Health thresholds, AQI, meteorological monitoring and biological effects; Drinking water quality (WHO, BIS standards), contaminants, and treatment; Waterborne pathogens and diseases; Soil and heavy metal exposure: arsenic, lead, mercury, cadmium; mycotoxins.

Unit 3: Radiation, Noise, Indoor, and Occupational Environmental Health Risks (11 hours)
Types of radiation: UV, X-rays, ionizing and non-ionizing; Health impacts from nuclear disasters, EMF, mobile towers; Noise pollution and auditory/other health effects; Indoor air pollution: biomass fuels, household chemicals, building-related illness; Ventilation: standards and health impacts; Occupational exposure and workplace health (ILO guidelines); Urban health: slums, waste, sanitation; Public health challenges in cities and climate-sensitive disease patterns.

Unit 4: Environmental Health Governance, Surveillance, and Risk Communication (10 hours)
Indian regulatory framework: Air Act, Water Act, EP Act, Biomedical Waste Rules; E-waste and hazardous waste rules; National/international frameworks: EPA, CPCB, WHO; Community health assessments and Environmental Health Indicators (EHIs); Climate-resilient health systems, disaster preparedness, environmental surveillance; Role of digital tools, citizen science, and health communication in environmental health.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Analyze global and national case studies on various pollutants and their health effects
- Examine the success and challenges of various national/international policies in combating pollution and improving health.
- Develop profile exposure hotspots of targeted pollutants using open-source data (e.g., AQI, CPCB)
- Evaluate physical, chemical, and microbial parameters of drinking water quality
- Survey and map noise levels in different urban zones
- Assess indoor air quality, evaluate risk factors, and develop household improvement plans
- Prepare documentaries on pollution and health issues of the selected site
- Based on the syllabus

Essential Readings

- Goodsite, M.E., Johnson, M.S. and Hertel, O. eds., 2021. Air pollution sources, statistics and health effects. New York, NY: Springer.
- McGranahan, G. and Murray, F. eds., 2012. Air pollution and health in rapidly developing countries. Routledge.
- Moreira, D. and Vilhena, M. eds., 2009. Air pollution and turbulence: modeling and applications. CRC Press.
- Pope III, C.A. and Dockery, D.W., 2025. Particles of Truth: A Story of Discovery, Controversy, and the Fight for Healthy Air. MIT Press.
- Taylor, D., 2014. Toxic communities: Environmental racism, industrial pollution, and residential mobility. In Toxic communities. New York University Press.

Suggested Readings

- Fuller, R., Landrigan, P.J., Balakrishnan, K., Bathan, G., Bose-O'Reilly, S., Brauer, M., Caravanos, J., Chiles, T., Cohen, A., Corra, L. and Cropper, M., 2022. Pollution and health: a progress update. The Lancet Planetary Health, 6(6), pp.e535-e547.
- Garg, S., Kumar, P., Mishra, V., Guijt, R., Singh, P., Dumée, L.F. and Sharma, R.S., 2020. A review on the sources, occurrence and health risks of per-/poly-fluoroalkyl substances (PFAS) arising from the manufacture and disposal of electric and electronic products. Journal of Water Process Engineering, 38, p.101683.
- Landrigan, P.J., Fuller, R., Acosta, N.J., Adeyi, O., Arnold, R., Baldé, A.B., Bertollini, R., Bose-O'Reilly, S., Boufford, J.I., Breysse, P.N. and Chiles, T., 2018. The Lancet Commission on pollution and health. The lancet, 391(10119), pp.462-512.
- Prüss-Üstün, A., Wolf, J., Corvalán, C., Bos, R. and Neira, M., 2016. Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks. World Health Organization.

Semester II – M.Sc. Environmental Science

M.Sc. (Environmental Science)
Semester II

DISCIPLINE-SPECIFIC CORE COURSE - (DSC-5): Natural and Managed Ecosystesms

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Natural and Managed Ecosystems	**4**	**2**		**2**	**UG**	**-**

Course Objectives

This course explores how ecosystems are structured, function, and respond to natural and anthropogenic changes. It emphasizes ecological theories, mechanisms of community assembly, and the functioning of terrestrial and aquatic ecosystems. Through conceptual frameworks and hands-on practice, students will:

- Develop foundational knowledge in systems ecology and plant community dynamics
- Understand biotic interactions (competition, facilitation, invasion, allelopathy, defense) shaping ecosystems and causes of biodiversity loss
- Examine the role of biodiversity in ecosystem processes and resilience
- Explore ecological perspectives on human-modified ecosystems
- Acquire field and laboratory skills in vegetation and soil ecological assessment

Learning Outcomes

By the end of this course, students will be able to:

- Explain the organization and dynamics of ecosystems and ecological communities
- Analyze the processes driving competition, facilitation, and community structure
- Apply theoretical frameworks (e.g., niche theory, assembly rules, ecosystem energetics)
- Assess human-mediated impacts on ecosystem patterns and biogeochemistry
- Conduct ecosystem-level field investigations with robust ecological design

Course Syllabus – Thoery (30 hours)

Unit 1: Ecosystem Foundations and Community Dynamics (8 hours)

Concepts of ecosystems: components, boundaries, scales; Ecosystem energetics: energy capture, productivity, trophic levels; Nutrient cycles: N, P, S cycles, inputs, transformations, and loss; Food chains, food webs, trophic cascades; Functional responses and efficiencies in energy and matter flow; Community structure: niche, dominance, stratification, species diversity; Development and dynamics: succession, r/K strategies.

Unit 2: Plant Strategies, Interactions, and Community Assembly (8 hours)

Plant strategies: CSR framework (Grime), Tilman's R* theory; Plant competition: resource limitation, light, water, nutrients; Plant facilitation: Stress gradient hypothesis, context dependency; Community assembly rules and coexistence theory; Plant defense theories: optimal defense, carbon:nutrient balance, induced vs. constitutive defense; Allelopathy: chemical interactions, roles in community assembly.

Unit 3: Invasion Ecology, Ecosystem Types, and Disturbance Regimes (7 hours)

Invasive species: linkages with ecosystem processes; Ecological consequences of invasion; Case studies: Lantana, Prosopis juliflora, Wattles; Ecosystem types: forests, grasslands, wetlands, deserts, rivers, lakes, oceans; Managed ecosystems: agri-ecosystems, plantations, aquaculture, urban systems; Disturbance regimes: fire, grazing, drought, flooding; Biodiversity–function relationships: stability, productivity, redundancy.

Unit 4: Ecosystem Services, Human Influence, and Restoration (7 hours)

Biodiversity and ecosystem services: provisioning, regulating, supporting, cultural; Ecosystem fragmentation and connectivity; Human-mediated plant community transformation (agriculture, plantations, invasive species); Managed ecosystems: agroecosystems, aquaculture, community forests, urban greens; Ecosystem restoration and nature-based ecological management.

Suggested Practicals/Applied Exercises/Field Component (60 hours)

- To analyze vegetation community structure using quadrat and transect methods, calculating density, frequency, abundance, and basal area.
- To assess key soil properties influencing plant growth by measuring pH, texture, moisture, organic carbon, and major nutrients (nitrate, phosphate, sulfate).
- To estimate primary productivity and biomass using non-destructive techniques, including leaf area index (LAI) measurement and above-ground to below-ground biomass correlations.
- To investigate plant-plant interactions by designing and conducting basic experiments on resource competition or facilitation under varying plant densities.
- To explore species-area relationships and biodiversity patterns by constructing species-area curves and calculating Shannon and Simpson diversity indices.
- To examine the link between plant functional traits and community structure by observing and documenting key traits (e.g., height, specific leaf area, dispersal mode, defense mechanisms) and relating them to species abundance.
- Based on the syllabus

Essential Readings

- Singh JS, Singh SP, and Gupta SR (2017) Ecology, Environmental Science and Conservation. S. Chand Publishing.
- Rockwood, L.L. (2015). Introduction to population ecology. John Wiley & Sons.
- Grime, J. P. (2001). Plant Strategies, Vegetation Processes, and Ecosystem Properties. Wiley.
- Gurevitch, J., Scheiner, S. M., & Fox, G. A. (2020). The Ecology of Plants (3rd ed.). Sinauer.
- Inderjit. 2005. Invasive plants: Ecological and Agricultural Aspects. Birkhäuser Verlag AG, Switzerland.
- Weil RR and Brady NC. 2017. The nature and properties of soils. 15TH ed. Pearson.

Suggested Readings

- Loreau, M. (2014). From Populations to Ecosystems: Theoretical Foundations for a New Ecological Synthesis. Princeton.
- Reid, W. V. et al. (2005). Millennium Ecosystem Assessment: Synthesis. Island Press.
- IPBES (2022). Global Biodiversity and Ecosystem Services Report. https://ipbes.net
- Allen, S. E. (1989). Chemical Analysis of Ecological Materials. Blackwell.
- Inderjit, Simberloff D, Kaur H, Kalisz S and Bezemer TM. 2021. Novel chemicals engender myriad invasion mechanisms. New Phytologist (Tansley Review), 232: 1184-1200.
- Inderjit, Wardle DA, Karban R and Callaway RM. 2011. The ecosystem and evolutionary contexts of allelopathy. Trends in Ecology & Evolution, 26: 655-662.

M.Sc. (Environmental Studies)
Semester II

DISCIPLINE-SPECIFIC CORE COURSES - (DSC-6): Ecotoxicology and Environmental Health

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Ecotoxicology and Environmental Health	4	2		2	UG	-

Course Objectives

- Develop an integrated understanding of toxic substances, their pathways, and their ecological and human health impacts
- Equip students with advanced tools for toxicity testing, biomonitoring, and health risk assessment
- Build knowledge of international conventions and policy instruments governing toxic exposure and environmental health
- Promote critical thinking about exposure justice, chemical safety, and sustainable remediation technologies

Learning Outcomes

By the end of this course, students will be able to:

- Identify and analyze major classes of environmental toxicants and their fate in ecosystems
- Evaluate toxicant impacts at biochemical, molecular, and ecosystem levels
- Conduct environmental health assessments using epidemiological and toxicological data
- Interpret and apply global treaties and safety standards (WHO, IARC, Stockholm, Minamata)
- Design field-based toxicity and health risk assessments using bioassays and exposure indicators

Course syllabus (30 hours)
PART A: ECOTOXICOLOGY

Course Syllabus – Theory (30 hours)

Part A: Ecotoxicology
Unit 1: Foundations and Fate of Environmental Toxicants (6 hours)
Scope and principles of ecotoxicology; Major pollutant classes: heavy metals, organics, endocrine disruptors, nanomaterials; Environmental entry routes (soil, water, air), bioavailability, transport; Environmental fate: bioaccumulation, biomagnification, biotransformation; Global movement: grasshopper effect, long-range transport.

Unit 2: Toxic Effects and Ecotoxicological Responses (9 hours)
Molecular and biochemical responses: oxidative stress, detoxification enzymes (CYP450, GST); Genetic toxicity: DNA damage, epigenetics, mutation assays; Sub-lethal and chronic effects in organisms; Ecotoxicity at population, community, and ecosystem levels; Tools: Adverse Outcome Pathways (AOP), omics approaches; Bioassays (LC_{50}, NOEC, EC_{50}), test organisms and endpoints; Biomarkers, bioindicators, eDNA, biosensors; Field biomonitoring and data quality.

Part B: Environmental Health
Unit 3: Foundations of Environmental Health and Hazard Pathways (8 hours)
Environmental health and toxicology: key concepts and risk assessment; Occupational and community exposures; Classification of toxicants: carcinogens, mutagens, teratogens, neurotoxins; Environmental stressors: chemical, physical, biological, psychosocial; Sources and exposure pathways: solid/hazardous waste, industrial emissions, pesticides, sewage, air pollution.

Unit 4: Environmental Disease Burden and Public Health Interventions (7 hours)
Major disease types: waterborne (cholera, hepatitis), airborne (asthma, COPD), vector-borne (malaria, dengue), foodborne (toxins, parasites); Effects of radioactive exposures; Climate-related health risks: heat, cold, altitude; Preventive strategies: surveillance, sanitation, public awareness, ecological interventions, resilience building.

Suggested Practicals/Applied Exercises/Field Component (60 hours)
- Estimate heavy metals in water/soil using AAS
- Measure oxidative enzyme activity in exposed plants/animals
- Assess physiological responses to environmental contaminants in plants and microbes
- Conduct ecotoxicity assays using a model organism
- Determine enzyme polymorphism in response to eotoxicants
- Analyse eDNA from polluted habitats and compare with pristine habitats
- Assess air quality and risk of associated diseases
- Determine the water quality of potable water
- Assess the density of selected microbes prevalent in air, soil and water
- Determine the lung capacity of the selected population exposed to different air quality
- Bsaed on the syllabus

Essential Readings

- Bradley, N., Harrison, H., Hodgson, G., Kamanyire, R., Kibble, A. and Murray, V. eds., 2014. Essentials of Environmental Public Health Science: A Handbook for Field Professionals. Oxford University Press (UK).
- Landrigan, P. J., & Etzel, R. A. (Eds.). (2013). Textbook of children's environmental health (2nd ed.). Oxford University Press.
- Newman, M. C. (2019). Fundamentals of ecotoxicology: The science of pollution (5th ed.). CRC Press.
- Sparling, D. W. (2017). Basics of Ecotoxicology. CRC Press.
- Walker, C. H., Sibly, R. M., Hopkin, S. P., & Peakall, D. B. (2016). Principles of Ecotoxicology (4th ed.). CRC Press.

Suggested Readings

- Hauser-Davis, R. A., & Parente, T. E. (Eds.). (2018). Ecotoxicology: Perspectives on key issues. CRC Press.
- Warner, L.M. and Schwarzer, R., 2024 Handbook of Concepts in Health, Health Behavior and Environmental Health. Singapore: Springer Nature Singapore.
- Moore, G.S. and Bell, K.A., 2018. Living with the Earth: Concepts in environmental health science (4th ed.). CRC Press.
- Rawat, D., Mishra, V. and Sharma, R.S., 2016. Detoxification of azo dyes in the context of environmental processes. Chemosphere, 155, pp.591-605.
- Suter, G. W. (2016). Ecological Risk Assessment (2nd ed.). CRC Press.
- Van Gestel, C.A., Jonker, M., Kammenga, J.E., Laskowski, R. and Svendsen, C. (eds.) (2016). Mixture Toxicity: Linking Approaches from Ecological and Human Toxicology. CRC Press.

Semester II – M.A. Environmental Studies

M.A. (Environmental Studies)
Semester II

DISCIPLINE-SPECIFIC CORE COURSE - (DSC-5): Global Environmental Challenges & Sustaianable Solutions

M.Sc. (Environmental Studies)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Global Environmental Challenges & Sustainable Solutions	4	3		1	UG	-

Course Objectives

- Understand complex global environmental challenges within scientific, economic, legal, and geopolitical frameworks
- Examine international treaties, institutions, and governance mechanisms shaping global responses
- Evaluate sustainable technological and policy innovations across sectors
- Explore ethics, equity, and environmental justice in global decision-making
- Cultivate critical thinking and applied skills through simulations, debates, and real-world case studies

Learning Outcomes

Upon completion, students will be able to:

- Analyze major global environmental problems and their interlinkages
- Critically interpret international environmental law, treaties, and negotiations
- Evaluate the role of global institutions in promoting sustainability
- Recommend integrated policy solutions based on ethics and equity
- Apply frameworks and tools to simulate environmental governance scenarios

Course Syllabus – Theory (45 hours)
Unit 1: Climate Change, Governance Mechanisms, and Environmental Security (12 hours)

Scientific and policy dimensions of climate change; Carbon markets, REDD+, methane regulation; Food vs Fuel debate, NDCs, climate finance, carbon trading; Emerging debates: loss & damage, adaptation vs. mitigation, climate migration; Ecological impacts of war and terrorism; Case studies: Ukraine, Vietnam, Iraq; Nuclear winter, chemical/biological warfare; ENMOD, Geneva Conventions; UNEP post-conflict assessments; Resource security, water diplomacy, energy conflicts.

Unit 2: Global Waste, Hazardous Trade, and Environmental Justice (11 hours)
Global waste flows and environmental injustice; Basel, Bamako, Stockholm, Rotterdam Conventions; Governance of e-waste, plastics, mercury, POPs; Key institutions: UNEP, GEF, Interpol, WTO; Circular economy, Extended Producer Responsibility (EPR), green tariffs; Global campaigns, trade–environment disputes, and case-based perspectives on toxic waste governance.

Unit 3: Biodiversity Conservation, Genetic Resources, and Ethical Governance (11 hours)
CBD, CITES; Biopiracy, GMOs, IPRs, access and benefit-sharing (ABS); Regulatory bodies: IUCN, WIPO, TRIPS, FAO; Synthetic biology, CRISPR, biosafety and ethics; Indigenous knowledge, seed sovereignty, and public trust in biodiversity governance.

Unit 4: Energy Transitions, Corporate Sustainability, and Global Pathways (11 hours)
Global energy transitions: renewables, nuclear safety, and sustainability; Case studies: EU Green Deal, India Solar Mission, Brazil biofuels; Life Cycle Assessment (LCA) and decarbonization strategies; Corporate environmental frameworks: CSR, ESG, CDP, GRI, ISO 14001; Global partnerships: UNGC, IEA, IRENA, WBCSD; Net-zero pledges, green recovery, circular business models.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Negotiation simulation on global climate finance allocation
- Policy critique of e-waste regulation in an emerging economy
- Case study analysis of a transboundary toxic-waste dispute
- Biodiversity and biopiracy debate featuring stakeholder perspectives
- Techno-economic assessment of solar vs. nuclear energy in India
- Corporate ESG report design for a real or hypothetical company
- Based on the syllabus

Essential Readings

- Brauch, H.G., Behera, N.C., Chourou, B., Dunay, P., Grin, J., Kameri-Mbote, P., Liotta, P.H., Mesjasz, C. and Spring, Ú.O. eds., 2008. Globalization and environmental challenges: reconceptualizing security in the 21st century (Vol. 3). Berlin: Springer.
- Harris, F. ed., 2012. Global environmental issues. John Wiley & Sons.
- Hite, K.A. and Seitz, J.L., 2021. Global issues: an introduction. John Wiley & Sons.
- Klein, N. (2014). This Changes Everything: Capitalism vs. the Climate. Simon & Schuster.
- Middleton, N., 2024. The global casino: an introduction to environmental issues. Routledge.
- Spaargaren, G., Mol, A.P. and Buttel, F.H. eds., 2006. Governing environmental flows: global challenges to social theory. MIT Press.

Suggested Readings

- Chasek, P. S. (2018). Global Environmental Politics. Routledge.
- Harwell, M.A., 2012. Nuclear winter: the human and environmental consequences of nuclear war. Springer Science & Business Media.
- Kareiva, P. M., et al. (2015). Improving Global Environmental Management with Standard Corporate Reporting. PNAS, 112(23), 7375–7382.
- Kaur, H., Rawat, D., Poria, P., Sharma, U., Gibert, Y., Ethayathulla, A.S., Dumée, L.F., Sharma, R.S. and Mishra, V., 2022. Ecotoxic effects of microplastics and contaminated microplastics–Emerging evidence and perspective. Science of the Total Environment, 841, p.156593.
- Russo, M. V. (2008). Environmental Management: Readings and Cases. Houghton Mifflin.
- Welford, R. (2016). Corporate Environmental Management 3: Towards Sustainable Development. Earthscan.

M.A. (Environmental Studies)
Semester II

DISCIPLINE-SPECIFIC CORE COURSE - (DSC-6):
Environmental Law, Policy, and Governance

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Environmental Law, Policy, and Governance	4	3		1	UG	-

Course Objectives

This course provides an interdisciplinary and critical foundation in environmental law, policy instruments, and governance frameworks. It addresses formal legal systems and the evolving landscape of environmental governance across scales, with emphasis on participatory processes, justice, and institutional accountability.

Students will:

- Understand foundational legal concepts and statutory mechanisms for environmental protection
- Analyze institutions and tools of environmental governance from local to global levels
- Examine environmental movements, power structures, and stakeholder roles in shaping outcomes
- Engage with real-world legal cases, treaties, and governance innovations
- Develop competencies in legal reasoning, policy critique, and institutional assessment

Learning Outcomes

Upon successful completion, students will be able to:

- Describe the evolution of environmental law and the principles guiding regulation
- Analyze Indian constitutional, legislative, and institutional frameworks for environmental protection
- Interpret international environmental agreements and India’s role in global governance
- Evaluate the effectiveness and equity of environmental governance mechanisms
- Apply legal and governance insights to assess contemporary environmental issues

Course Syllabus (45 hours)

Unit 1: Foundations of Environmental Law and Regulation (12 hours)

Definitions and scope of environmental law; Legal bases: constitutional, statutory, judicial, customary; Core principles: sustainable development, polluter pays, precautionary principle, public trust, equity; Regulatory tools: command-and-control, incentive-based, liability laws, ESG compliance; Role of EIA and environmental audit in regulatory frameworks; Constitutional foundations: Articles 14, 19(1)(g), 21, 32, 48A, 51A(g); PILs and judicial activism.

Unit 2: Legislative and Institutional Frameworks in India (11 hours)

Environmental statutes: Water Act (1974), Air Act (1981), Environment Protection Act (1986), Forest laws (1927, 1980), Wildlife Protection Act (1972), Biodiversity Act (2002); Waste management rules: hazardous, biomedical, e-waste, plastic; Environmental institutions: CPCB, SPCBs, NGT, NEAA; Innovations in environmental law: legal personhood for nature, ecocide legislation; National Environmental Policy (2006), NAPCC and SAPCCs; Centre–state roles in environmental governance.

Unit 3: Global Environmental Law and Multilateral Governance (11 hours)

Milestones: Stockholm (1972), Rio (1992), Johannesburg (2002), Paris (2015), Glasgow (2021); Major MEAs: CBD, UNFCCC, Kyoto, Montreal, Basel, CITES, Nagoya Protocol; CBDR; Institutions: UNEP, UNFCCC, IPCC, WTO; Environmental trade disputes and climate litigation; Carbon markets, loss and damage mechanisms; Rights of nature and their position in Indian and global frameworks.

Unit 4: Environmental Governance, Justice, and Political Ecology (11 hours)

Regulatory effectiveness: monitoring, enforcement, compliance challenges; Community-based natural resource governance: JFM, FRA; Decentralized and participatory models: Panchayati Raj, urban local bodies, river basin authorities; Role of civil society, media, green tribunals, and corporate governance. Environmental justice: caste, class, livelihood, procedural equity; Grassroots movements: Chipko, Narmada, Bhopal, Silent Valley; Indigenous and gendered perspectives; Political ecology: development conflicts, access, and governance failures.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- To analyze a landmark environmental case by identifying key legal principles and assessing their impact on current environmental governance.
- To draft a simplified Public Interest Litigation (PIL) addressing a local environmental issue, focusing on relevant constitutional and statutory provisions.
- To evaluate the effectiveness of a specific environmental policy by analyzing its implementation challenges and proposing evidence-based improvements.
- To compare two major multilateral environmental agreements, examining their objectives, mechanisms, and India's commitments under each.
- To conduct a structured debate on a current environmental controversy, critically examining the balance between development needs and environmental protection.
- Based on the syllabus

Essential Readings

- Divan, S., & Rosencranz, A. (2022). Environmental Law and Policy in India (3rd ed.). Oxford University Press.
- Singh, G. (2024). Environmental Law (3rd ed.). Eastern Book Company
- Cullet, P., 2017. Differential Treatment in International Environmental Law. Routledge.
- Bodansky, D., Brunnée, J., & Rajamani, L. (2017). International Climate Change Law. Oxford University Press.
- McInerney-Lankford, S., Darrow, M., & Rajamani, L. (2010). Human Rights and Climate Change. World Bank.

Suggested Readings

- Bell, S., McGillivray, D., Pedersen, O.W., Lees, E. and Stokes, E. (2017). Environmental Law. Oxford University Press.
- Lazarus, R.J. (2023). The Making of Environmental Law. University of Chicago Press.
- Elliott, L. and Schaedla, W.H. (eds.) (2016). Handbook of Transnational Environmental Crime. Edward Elgar Publishing.
- Chasek, P. and Downie, D.L. (2020). Global Environmental Politics. Routledge.

Skill-Based Course for
Semester II (M.Sc./M.A. Programme)

M.Sc./M.A. (Environmental Studies)
Semester II

SKILL-BASED COURSE - (SBC-II): Methodologies for Environmental Studies II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Methodologies for Environmental Studies II	2	1		1	UG	-

Course Objectives

- Advance student proficiency in correlation, regression, non-parametric and time-series techniques for environmental analytics.
- Integrate spatial data (RS/GIS/GPS) with statistical outputs to address land-use change, hazard mapping, and conservation problems.
- Cultivate critical competence in digital image processing and thematic map creation for decision support.

Learning Outcomes

By the end of the semester, students will be able to:

- Choose and justify Pearson/Spearman correlations, simple–multiple linear regression, or logistic regression, for diverse datasets.
- Execute non-parametric tests (Mann-Whitney U, Kruskal-Wallis, Wilcoxon)
- Acquire, preprocess, and classify multispectral imagery; calculate NDVI and change-detection maps in QGIS/ArcGIS.
- Integrate GPS ground truth with raster and vector layers to validate land-cover and hazard maps.

Course syllabus – Theory (15 hours)

Unit 1: Environmental Statistics II (5 hours)

Correlation and Regression: Types and applications; Non-parametric tests: Mann-Whitney U, Kruskal-Wallis, Wilcoxon signed-rank; Comparison of parametric and non-parametric methods; Time series analysis in environmental datasets

Unit 2: Remote Sensing Principles & Digital Image Processing (5 hours)
Remote Sensing: definition, principles, satellites and sensors; Aerial photography to satellite remote sensing; Digital image processing and image interpretation; Applications of Remote Sensing for Environmental Studies

Unit 3: GIS, GPS and Environmental Applications (5 hours)
GPS principles and applications; Geographic Information System: concepts, database generation and analysis; Case studies: (a) Land-use/land-cover change, Forest degradation, Urban sprawling; (b) Mining Hazards/Impacts; (c) Forest Fire/Coal Fire Monitoring

Suggested Practicals/Tutorials/Applied Exercises/Field Component (30 hours)

- Investigate relationships between environmental variables
- Compare linear vs. logistic models using environmental data.
- Analyse abundance of target species across disturbance gradients with Mann-Whitney U and Kruskal-Wallis tests.
- Perform supervised classification (maximum-likelihood) of Landsat 8 imagery and assess accuracy with ROC curves.
- GIS mapping of invasive species distributions
- Based on the syllabus

Essential Readings

- Borcard, D., Gillet, F. and Legendre, P., 2011. Numerical ecology with R (Vol. 2, p. 688). New York: Springer.
- Burrough, P.A., McDonnell, R.A. and Lloyd, C.D., 2015. Principles of geographical information systems. Oxford University Press.
- Coops, N.C. and Tooke, T.R., 2017. Introduction to remote sensing. Learning Landscape Ecology: A Practical Guide to Concepts and Techniques, pp.3-19.
- Jensen, J.R., 2015. Remote sensing of the environment: An earth resource perspective 2/e. Pearson India.
- Zar, Jerrold H. 2018. Biostatistical analysis. Pearson Education India.

Suggested Readings

- Dale, M.R. and Fortin, M.J., 2014. Spatial analysis: a guide for ecologists. Cambridge University Press.
- Lillesand, T., Kiefer, R.W. and Chipman, J., 2015. Remote sensing and image interpretation. John Wiley & Sons.
- O’Sullivan, D. & Unwin, D. 2010. Geographic Information Analysis, 2nd ed. John Wiley & Sons.
- Wickham, H. and Grolemund, G., 2017. R for data science (Vol. 2). Sebastopol, CA: O'Reilly.

Pool of Discipline-Specific Elective Courses for Even Semester (M.Sc./M.A. Programme)

Even Semester DSE Papers (Page 66 onwards)

13. **DSE-13**: Atmospheric Aerosols
14. **DSE-14**: Bioremediation and Rhizosphere Engineering for Sustainable Development
15. **DSE-15**: Design Thinking for Nature-Positive Development
16. **DSE-16**: Ecological Genomics: Genes, Ecosystems, and Environmental Change
17. **DSE-17**: Energy and Environment
18. **DSE-18**: Environmental Behaviour and Psychology
19. **DSE-19**: Restoration Ecology and Nature-Based Engineering
20. **DSE-20**: Environmental Geosciences
21. **DSE-21**: Fundamentals of Environmental Politics
22. **DSE-22**: Invasion Biology
23. **DSE-23**: Sustainable Finance and ESG Reporting
24. **DSE-24**: Tropical Field Ecology

M.Sc./M.A. Even Semester

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE-13)

Atmospheric Aerosols

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-13: Atmospheric Aerosols	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives

The course is designed to

- Understand the sources and chemical composition of aerosols
- Learn about aerosol measurement methods
- Understand their role in atmospheric phenomena

Learning Outcomes

At the end of the course, the students should be able to

- Evaluate the importance of aerosols in the atmosphere
- Understand the aerosol measurement methods
- Evaluate the environmental and climatic effects of aerosols

Course syllabus – Theory (45 hours)

Unit 1- Introduction to atmospheric aerosols (12 Hours)

Climate and aerosols; Sources and aerosol types; Production rates and budget; Characteristics of ambient aerosols; Physical properties of aerosols; Optical and chemical characteristics of aerosols; Thermodynamics of aerosols; Impact of meteorology on aerosol characteristics: Atmospheric boundary layer, temperature, wind, relative humidity; Formation and sinks of aerosols.

Unit II - Measurements of Aerosols (11 Hours)
Mass concentration, number concentration, and size distribution; Scattering, absorption, and extinction coefficients; Methods for determination of particulate matter bound carbonaceous aerosols, ionic species, and metals; Optical properties: Aerosol optical depth (AOD), Single scattering albedo (SSA), and asymmetry parameter (g); Fine mode fraction; Remote sensing of aerosols.

Unit III - Aerosol radiative forcing and aerosol-cloud interactions (11 Hours)
Radiation; Radiative transfer: Equation, Beer-Lambert law, effect of surface albedo in radiative transfer, definition of radiative forcing; Aerosol radiative forcing: Estimation, sensitivity to AOD, SSA and g, role of surface reflectance, short wave vs long wave, comparison; Clouds; Uncertainty in aerosol-cloud interactions and precipitation.

Unit IV- Aerosol impacts on climate and air quality (11 Hours)
Direct radiative forcing: Tropospheric aerosols, black carbon aerosol, aerosol vertical profile and aerosol radiative forcing, aerosol impact on surface temperature, stratospheric aerosols; Indirect radiative forcing: Cloud albedo effect, semi-direct effects; Aerosols and Indian summer monsoon; Aerosol impacts on air quality and aquatic systems; Case studies.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Study the $PM_{2.5}$ mass concentration in the ambient air
- Analyse the size distribution of aerosols
- Examine the optical properties of aerosols
- Study the $PM_{2.5}$-bound inorganic ions
- Study the ambient carbonaceous aerosols
- Based on the syllabus

Essential Reading

- Seinfeld, J.H., Pandis, S.N., (2016). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. Wiley publication.
- Ramachandran, S., (2018). Atmospheric Aerosols: Characteristics and Radiative Effects. CRC press.
- Gelencser, A., (2004). Carbonaceous Aerosols. Springer.

Suggested Reading

- Lutgens, F.K., Tarbuck, E.J., Tasa, D., (2013). The Atmosphere: An Introduction to Meteorology. Pearson.

M.Sc./M.A. Even Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-14): Bioremediation and Rhizosphere Engineering for Sustainable Development

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-14: Bioremediation and Rhizosphere Engineering for Sustainable Development	4	3	-	1	UG	-

Course Objectives

- Develop a foundational understanding of bioremediation processes and rhizosphere ecology
- Examine microbial and plant-based technologies for detoxifying pollutants and restoring contaminated soil and water
- Equip students with knowledge of rhizospheric interactions and microbiome engineering for sustainability
- Strengthen skills in ecological risk assessment, and nature-compatible remediation

Learning Outcomes

By the end of this course, students will be able to:

- Describe the principles and applications of bioremediation and rhizosphere engineering
- Analyze microbial and plant-assisted strategies for removing environmental pollutants
- Evaluate the effectiveness of bioremediation techniques in different environmental settings
- Design rhizosphere-based interventions to enhance soil health, and carbon sequestration
- Integrate biotechnological tools in sustainable development

Course Syllabus – Theory (45 hours)

Unit 1: Principles and Strategies of Bioremediation (10 hours)

Definition and scope of bioremediation; Microbial degradation pathways: aerobic, anaerobic, co-metabolism; Biostimulation, bioaugmentation, intrinsic bioremediation; In situ vs. ex situ approaches: landfarming, biopiles, bioventing, biosparging; Biosurfactants and genetically engineered microorganisms (GEMs)

Unit 2: Phytoremediation and Plant-Based Strategies (10 hours)

Phytoremediation mechanisms: phytoextraction, phytostabilization, phytodegradation; Hyperaccumulator species and transgenic plants; Role of endophytic microbes in enhancing phytoremediation; Monitoring tools and ecological safety concerns

Unit 3: Rhizosphere Microbiome and Soil Health Engineering (12 hours)
Structure and dynamics of the rhizosphere; Microbial interactions: PGPR, mycorrhizae, nitrogen fixers, quorum sensing; Rhizoengineering for nutrient cycling, pollutant breakdown, and stress tolerance; Rhizosphere-mediated carbon sequestration and climate resilience; Innovations in microbial consortia and biofertilizers

Unit 4: Integrated Applications and Sustainable Development Goals (13 hours)
Role of bioremediation in water treatment and sanitation; Land reclamation and brownfield restoration; Green wastewater treatment systems (constructed wetlands, root zone tech); Bioremediation in circular economy: resource recovery from waste; Biomarker assays and gene expression in contaminated systems; Monitoring efficacy: bioindicators, microbial community profiling (NGS, qPCR).

Suggested Practicals/Applied Exercises/Field Component (30 hours)
- Isolation and purification of heavy metal-tolerant microbes
- Characterization of heavy metal-tolerant microbes
- Identification and selection of ecotoxicant tolerant plant species through field surveys
- Examination of key characteristics of plants with high phytoremediation potential
- Evaluation of phytoremediation efficiency of selected plant species
- Assess rhizosphere microbial density and diversity of selected plant species from contaminated habitats
- Understand and design in situ microbial treatment processes
- Enhancement plant growth and stress tolerance using PGPR
- Detection of pollutant-degrading genes using PCR-based tests
- Based on the syllabus

Essential Readings
- Hlihor, R.M., Apostol, L.C. and Gavrilescu, M., 2017. Environmental bioremediation by biosorption and bioaccumulation: principles and applications. Enhancing Cleanup of Environmental Pollutants: Volume 1: Biological Approaches, pp.289-315.
- King, R.B., Sheldon, J.K. and Long, G.M., 2023. Practical Environmental Bioremediation: The Field Guide. CRC Press.
- Mackova, M., Dowling, D. and Macek, T. eds., 2006. Phytoremediation and Rhizoremediation (Vol. 9). Springer Science & Business Media.
- Russell, D.L., 2024. Remediation Manual for Contaminated Sites. CRC Press.

Suggested Readings
- Atlas, R.M. and Philp, J., 2005. Bioremediation. Applied microbial solutions for real-world environmental cleanup (pp. xi+-366).
- Cole, G.M., 2018. Assessment and Remediation of Petroleum Contaminated Sites. CRC Press.
- Glick, B.R. and Patten, C.L., 2022. Molecular biotechnology: principles and applications of recombinant DNA. John Wiley & Sons.
- Mishra et al., 2025. Innovative sustainable solutions for detoxifying textile industry effluents using advanced oxidation and biological methods. Journal of Environmental Management, 380, p.124804.
- Sharma et al., 2011. Functionally diverse rhizobacteria of *Saccharum munja* (a native wild grass) colonizing abandoned morrum mine in Aravalli hills (Delhi). Plant and soil, 341, pp.447-459.
- Willey, N. (ed.) 2008. Phytoremediation: Methods and Reviews (Vol. 23). Springer Science & Business Media.

M.Sc./M.A. Even Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-15): Design Thinking for Nature-Positive Development

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-15: Design Thinking for Nature-Positive Development	4	3	-	1	UG	-

Course Objectives

- Introduce design thinking as a human-centered and systems-based approach to solving environmental challenges
- Foster creativity, empathy, and iterative thinking in building nature-positive solutions
- Apply principles of regenerative and circular design for sustainable innovation
- Enable students to ideate, prototype, and test interventions that benefit both people and the planet

Learning Outcomes

By the end of this course, students will be able to:

- Understand the principles and stages of design thinking in an environmental context
- Apply co-creation and ideation tools to generate innovative, ecologically sound solutions
- Prototype, test, and iterate sustainable interventions using feedback loops
- Evaluate solutions based on ecological performance, equity, and social adoption potential

Course Syllabus – Theory (45 hours)

Unit 1: Foundations of Design Thinking and Nature-Positive Development (11 hours)

What is design thinking? Origins and evolution; Nature-positive and regenerative development: concepts and principles; The five stages: Empathize, Define, Ideate, Prototype, Test; Environmental design ethics and the precautionary principle; Design for equity, circularity, and net-positive outcomes

Unit 2: Empathizing with Stakeholders and Systems Thinking (10 hours)

Ecosystem mapping and stakeholder analysis; Systems thinking tools: causal loops, feedback, leverage points; Community-driven innovation and social learning; Working across cultures and knowledge systems (indigenous, informal, expert)

Unit 3: Defining Challenges and Ideating Solutions (12 hours)

Problem framing techniques: HMW (How Might We) questions; Ecological constraints and opportunity spaces; Ideation methods: brainstorming, SCAMPER, blue ocean, 10x thinking; Co-creation sessions with users and experts; Tools: idea canvases, SWOT, design briefs

Unit 4: Prototyping and Testing Nature-Based Interventions (12 hours)
Nature-based solutions and biomimicry in prototyping; Feedback collection, iteration, and scenario testing; Rapid prototyping labs: green walls, waste-to-product ideas, urban cooling; Metrics: ecological footprint, biodiversity impact, social acceptance; Pitching nature-positive solutions and developing a Theory of Change.

Suggested Practicals/Applied Exercises/Field Component (30 hours)
Empathy Mapping with local stakeholders – Identify user needs and values

- Design Challenge Framing using systems maps – Define complex eco-social problems
- Nature-Based Prototyping Sprint – Build and test small-scale green infrastructure solutions
- Storytelling and Pitch Workshop – Communicate design vision and ecological impact
- Design Audit of an Urban/Natural Space – Redesign a space for regenerative performance
- Based on the syllabus.

Essential Readings

- Birkeland, J., 2020. Net-positive design and sustainable urban development. Routledge.
- Boy, G.A. ed., 2017. The handbook of human-machine interaction: a human-centered design approach. CRC Press.
- Kanaani, M. ed., 2022. The Routledge Companion to Ecological Design Thinking: Healthful Ecotopian Visions for Architecture and Urbanism. Taylor & Francis.
- Lee, H., 2013. Creating cultural events: the role of design within culture-led regeneration strategies. Lancaster University (United Kingdom).
- Manzini, E., 2015. Design, when everybody designs: An introduction to design for social innovation. MIT Press.
- Primrose, S.B., 2020. Biomimetics: nature-inspired design and innovation. John Wiley & Sons.

Suggested Readings

- Brown, T. (2009). Change by design: How design thinking creates new alternatives for business and society. Harper Business.
- Cross, N., 2023. Design thinking: Understanding how designers think and work. Bloomsbury Publishing.
- Raworth, K. (2018). Doughnut economics: Seven ways to think like a 21st-century economist. Chelsea Green.
- Walsh, E.A. and Moore, S.A., 2014. Regenerative Design. Architecture Beyond Criticism: Expert Judgment and Performance Evaluation, p.252.

M.Sc./M.A. Even Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-16): Ecological Genomics: Genes, Ecosystems, and Environmental Change

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-16: Ecological Genomics: Genes, Ecosystems, and Environmental Change	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives
- Integrate genomics into the study of ecosystem structure and functions
- Explore how gene(s) shape patterns and processes in biodiversity
- Analyze relationships between genomes and organisms' roles in nutrient cycling, and primary production
- Examine how environmental changes influence functional genes, symbiotic networks, and ecosystem services
- Equip students with cutting-edge tools of environmental metagenomics, transcriptomics, and genomics

Learning Outcomes

By the end of the course, students will be able to:
- Apply ecological genomics to study environmental responses and ecosystem functioning
- Analyze gene–environment interactions across different scales of biological organization
- Evaluate roles of genes and genomes in ecosystems resilience using molecular tools
- Interpret high-throughput datasets using bioinformatics platforms to derive ecological inferences
- Design genomics-based frameworks for biodiversity monitoring, restoration, and climate adaptation

Course Syllabus – Theory (45 hours)

Unit 1: Foundations and Tools in Ecological Genomics (14 hours)

Scope and principles of ecological genomics; Genotype × environment interactions; Evolutionary and functional genomics; Tools and technologies: NGS, transcriptomics, eDNA, functional annotation; Linking genomics with ecological theory; eDNA metabarcoding for biodiversity monitoring; Molecular indicators of pollution and disturbance; Policy and ethical considerations in environmental genomics.

Unit 2: Genomic Insights into Ecosystem Structure and Function (12 hours)

Genetic diversity and ecosystem multifunctionality; Genomic basis of plant-microbe-soil interactions; Molecular underpinnings of productivity, herbivory, symbiosis, and decomposition; Genomics of resilience, redundancy, and stability; Ecological genomics in selecting resilient genotypes.

Unit 3: Genomics of Biogeochemical and Ecological Processes (11 hours)
Microbial genomics in carbon, nitrogen, sulfur, and phosphorus cycling; Metagenomic profiling of soils, sediments, and extreme and polluted environments; Functional gene markers; Genomic gradients across latitudes, elevations, and urban-rural interfaces; Landscape genomics and host-microbiome co-evolution.

Unit 4: Environment, Epigenetics, and Mental Health in a Changing Ecological Landscape (8 hours)
Epigenetics and environmental regulation; Gene–environment interactions and mental health; Green space, biodiversity, and epigenetic health; Genomic signals of environmental shifts; Transgenerational epigenetic effects and trauma ecology; Ecological justice and epigenomic vulnerability

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- DNA/RNA Extraction and Metagenomics Setup – Extract nucleic acids from soil/water and prepare for sequencing
- Functional Gene Analysis – Identify nitrogen cycling genes using PCR and sequence data
- Landscape Genomics Mapping – Analyze gene–environment associations using GIS layers and SNP datasets
- Microbial Community Profiling – Use QIIME or MG-RAST to analyze environmental microbiomes
- Case Simulation – Interpret ecosystem functioning from a metagenomics dataset (e.g., rhizosphere or estuarine)
- Comparative genomics of selected microbial species from two ecologically distinct habitats
- Based on the syllabus

Essential Readings

- Allendorf, F. W., Funk, W. C., Aitken, S. N., Byrne, M., Luikart, G., & Antunes, A. (2022). *Conservation and the genomics of populations* (3rd ed.). Oxford University Press.
- Ussery, D.W., Wassenaar, T.M. and Borini, S., 2009. Computing for comparative microbial genomics: bioinformatics for microbiologists (Vol. 8). Springer Science & Business Media.
- Van Straalen, N.M. and Roelofs, D., 2012. An introduction to ecological genomics. OUP Oxford.
- Weissensteiner, M.H., Suh, A. and Kraus, R.H.S., 2019. Avian genomics in ecology and evolution: From the lab into the wild. Springer

Suggested Readings

- Cox, C.B., Moore, P.D. and Ladle, R.J., 2016. Biogeography: an ecological and evolutionary approach. John Wiley & Sons.
- Freeland, J.R., 2020. Molecular ecology. John Wiley & Sons.
- Gregory, T.R. ed., 2011. The evolution of the genome. Elsevier.
- Martin, F. (2013). The Ecological Genomics of Fungi. Wiley.

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M.Sc./M.A. (Semester I/II)

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-17)

Energy and Environment

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-17: Energy and Environment	4	3	-	1	UG	-

Course Objectives

The course is designed to

- Examine advanced relationships between energy systems and environmental sustainability.
- Analyze technological, ecological, and policy aspects of renewable energy with a focus on bioenergy systems
- Provide a comparative understanding of renewable and non-renewable energy systems.
- Explore the scientific, technological, environmental, and policy dimensions of bioenergy.
- Develop critical thinking about sustainable energy transitions in India and globally.

Learning Outcomes

At the end of the course, the students should be able to

- Identify and classify various energy sources and explain their roles in development.
- Analyze the environmental implications of fossil-based and renewable energy systems.
- Evaluate bioenergy technologies and their integration in circular economy models.
- Interpret and critique national/international energy policies and SDG linkages.

Course Syllabus – Theory (45 hours)

Unit 1: Fundamentals of Energy Systems and Non-Renewable Resources (12 hours)
Core energy concepts and forms; Solar radiation principles; Energy-development interlinkages (GDP, HDI, energy poverty); Global and Indian energy consumption trends; Fossil fuel classification and extraction technologies; Unconventional reserves (shale, gas hydrates); Environmental costs and mitigation (pollution, GHGs); Energy policies and missions (India and global); Renewable and nuclear governance; Carbon markets, SDGs, and international frameworks.

Unit 2: Renewable and Nuclear Energy Systems (10 hours)
Principles and systems: solar, wind, hydro, geothermal, tidal, OTEC; Intermittency, economics, and grid integration; Nuclear energy: fission/fusion, reactor types, waste risks; Global case studies: Chernobyl, Fukushima; Emerging clean energy technologies.

Unit 3: Bioenergy Systems and Biomass Conversion Technologies (12 hours)
Biomass sources: residues, MSW, algae, energy crops; Biofuel generations (1st to 4th); Conversion pathways—thermochemical (gasification, pyrolysis), biochemical (AD, fermentation), bioelectrochemical (MFCs, MECs); Products: biogas, bioethanol, biodiesel, biohydrogen; Sustainability considerations, nutrient recovery, and CCUS.

Unit 4: Circular Economy, Industrial Sustainability, and Societal Dimensions (11 hours)
Waste-to-energy and biochar applications; Circular economy in energy systems; Eco-design and material efficiency; Industrial sustainability: clean technologies, symbiosis, GHG benchmarks; EPR and product stewardship; Access, equity, and gender in decentralized energy; Behavioral change, community participation, and justice-based energy transitions.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Set up and operate a waste-to-bioenergy reactor.
- Determine the moisture content of a biomass sample using the oven-drying method.
- Estimate the total solids in biomass. How does this differ from moisture content determination?
- Calculate the volatile solids in biomass. What do they indicate about the biodegradability of biomass?
- Determine the Chemical Oxygen Demand (COD) of biomass slurry. Why is this important for assessing potential biogas yield?
- Determine the Biological Oxygen Demand (BOD) in biomass samples. What is its relevance to bioenergy systems?
- Quantify cellulose in biomass. Why is this parameter crucial for biofuel production?
- Measure hemicellulose content in lignocellulosic biomass. What is its role in bioenergy conversion?
- Estimate lignin content in biomass. How does lignin affect biomass digestibility?
- Determine the ash content in biomass. What implications does it have for thermochemical conversion?
- Field visits

Essential Readings

- Abraham, A.R., Susanto, H., Haghi, A.K. and Asli, K.H. eds., 2024. Sustainability in Energy and Environment: Engineered Materials and Smart Computational Techniques. CRC Press.
- Ahamed, M.I., Boddula, R. and Rezakazemi, M. eds., 2021. Biofuel cells: materials and challenges. John Wiley & Sons.
- André, M. and Samaras, Z. eds., 2016. Energy and Environment. John Wiley & Sons.
- Ngô, C. and Natowitz, J., 2016. Our energy future: resources, alternatives and the environment. John Wiley & Sons.
- Ristinen, R.A., Kraushaar, J.J. and Brack, J.T., 2022. Energy and the Environment. John Wiley & Sons.
- Twidell, J., & Weir, T. (2021). *Renewable Energy Resources.* Taylor & Francis

Suggested Readings

- Baker, N. and Steemers, K., 2003. Energy and environment in architecture: a technical design guide. Taylor & Francis.
- Chhachhiya, N., Tiwari, A., Sharma, R.S., Rai, P.K., Anand, S. and Mishra, V., 2025. Transformative potential of optimized microbial fuel cell designs and materials for eco-friendly management of hazardous chemical waste. Journal of Water Process Engineering, 69, p.106647.
- Kalogirou, S.A., 2023. Solar energy engineering: processes and systems. Elsevier.
- Meyer, B., 2013. Sulfur, energy, and environment. Elsevier.
- Tan, Z. and Li, Q. eds., 2019. Micro/Nano Materials for Clean Energy and Environment. MDPI.
- Yadav, A., Kumar, P., Rawat, D., Garg, S., Mukherjee, P., Farooqi, F., Roy, A., Sundaram, S., Sharma, R.S. and Mishra, V., 2022. Microbial fuel cells for mineralization and decolorization of azo dyes: Recent advances in design and materials. Science of The Total Environment, 826, p.154038.

M.Sc./M.A. (Semester I/II)

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-18): Environmental Behaviour and Psychology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-18: Environmental Behaviour and Psychology	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives

- Examine environmental perception and behavior and their associated psychological theories and cognitive processes
- Analyze sociocultural and contextual factors shaping pro-environmental behavior
- Understand individual and collective responses to environmental risks, and ecological identity
- Apply behavior-change models and interventions for sustainability and environmental justice and in policy, education, communication

Learning Outcomes

Upon completion, students will be able to:

- Analyze the drivers and barriers of individual and group-based environmental actions
- Explain key psychology theories and cognitive processes of pro-environmental behavior
- Evaluate interventions for promoting sustainability and reducing ecological harm
- Apply psychological insights to environmental campaigns, nudges, and policy instruments

Course Syllabus – Theory (45 hours)

Unit 1: Foundations of Environmental Psychology and Human-Nature Relationships (12 hours)
Evolution and scope of environmental psychology; Theories of place attachment, biophilia, and ecological identity; Environmental attitudes and values; Cognitive dissonance and environmental concern; Nature connectedness, eco-spirituality, and well-being; Environmental risk perception, affective heuristics; Spatial cognition and landscape perception; Information processing, value–action gap.

Unit 2: Perception, Cognition, and Decision-Making in Environmental Contexts (12 hours)
Framing, heuristics, and mental models in climate risk; Eco-anxiety, denial, and psychological distance; Theories of planned behavior, norm activation, and behavioral economics; Barriers to sustainable behavior: habits, norms, structural constraints; Emotions, empathy, identity in motivation; Behaviorally-informed communication strategies and participatory engagement.

Unit 3: Social and Cultural Dimensions of Environmental Behaviour (11 hours)
Role of gender, class, and culture in shaping behavior; Cultural cognition and belief systems; Collective action and community norms; Group identity, intergroup dynamics, and sustainability movements; Social learning and public engagement in climate action; Environmental education and experiential learning.

Unit 4: Institutional Applications and Behavioral Interventions for Sustainability (10 hours)
Urban design and behavior; Workplace and institutional sustainability; Behavioral audit and intervention design; Case studies: recycling, energy use, dietary change, mobility transitions; Integrating behavioral science into sustainability policy and planning.

Suggested Practicals/Applied Exercises/Field Component (30 hours)
- Environmental Value Survey and behavior mapping – Identify underlying values and behavior gaps
- Perception Mapping of green spaces – Understand landscape perception and comfort design
- Climate Risk Communication Analysis – Evaluate message framing and emotional response
- Design a Behavioral Intervention (e.g., nudge for waste segregation) – Apply behavior change tools
- Environmental Identity and Reflection Journal – Explore personal relationship with nature and pro-social behavior
- Based on the syllabus

Essential Readings

- Gifford, R. (2007). Environmental psychology: Principles and practice (5th ed.). Optimal Books.
- Steg, L., van den Berg, A. E., & de Groot, J. I. M. (Eds.). (2019). Environmental psychology: An introduction (2nd ed.). Wiley.
- Di Fabio, A. and Cooper, C.L. eds., 2024. Psychology of sustainability and sustainable development in organizations. Routledge.
- Kals, E., Strubel, I.T. and Hellbrück, J., 2025. Environmental Psychology. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Clayton, S.D. ed., 2012. The Oxford handbook of environmental and conservation psychology. Oxford University Press.

Suggested Readings

- Fleury-Bahi, G., Pol, E. and Navarro, O. eds., 2017. Handbook of environmental psychology and quality of life research (pp. 329-344). Cham, Switzerland: Springer International Publishing.
- Gifford, R., 2016. Research methods for environmental psychology. John Wiley & Sons.
- van Valkengoed, A. and Steg, L., 2019. The psychology of climate change adaptation. Cambridge University Press.
- Koger, S.M., 2011. The psychology of environmental problems: Psychology for sustainability. Psychology press.

M.Sc./M.A. Even Semester
M.Sc. (Semester I/II)

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-19): Restoration Ecology and Nature-Based Engineering

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-19: Restoration Ecology and Nature-Based Engineering	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives
- Build foundational understanding of ecological degradation and ecosystem recovery processes
- Introduce ecological principles, techniques, and design approaches for restoring natural systems
- Equip students with tools to design, assess, and monitor ecological restoration projects
- Explore emerging nature-based engineering solutions for climate resilience, urban planning, and biodiversity conservation
- Integrate sustainability science, indigenous knowledge, and systems thinking in landscape restoration

Learning Outcomes
By the end of this course, students will be able to:
- Understand key drivers of ecosystem degradation and resilience
- Apply ecological principles to restore and rehabilitate degraded ecosystems
- Design site-specific nature-based solutions for soil, water, and biodiversity restoration
- Evaluate effectiveness of restoration interventions through monitoring and adaptive management
- Integrate socio-ecological perspectives in large-scale restoration projects and policy frameworks

Course Syllabus – Theory (45 hours)
Unit 1: Foundations and Principles of Ecological Restoration (12 hours)
Concepts: restoration, rehabilitation, rewilding, reclamation; Historical ecology and reference systems; Causes of ecosystem degradation: land-use change, pollution, overexploitation; Ecological succession and resilience theory; Principles and ethics of ecological restoration (SER guidelines); Definition and principles of Nature-Based Solutions (NbS); Bioengineering techniques: vetiver systems, living walls, green roofs; Natural water retention and flood control systems.

Unit 2: Ecosystem Restoration Across Landscapes (12 hours)
Forest ecosystems: afforestation, enrichment planting, assisted regeneration; Wetlands and rivers: wetland hydrology, riparian buffers, rechanneling; Grasslands and deserts: seed banks, grazing management, dune stabilization; Urban and peri-urban ecosystems: green belts, bioswales, ecological corridors; Coastal and marine ecosystems: mangrove restoration, coral nurseries; Climate-resilient infrastructure: sponge cities, regenerative agriculture; Ecosystem-based adaptation (EbA) and disaster risk reduction.

Unit 3: Planning and Implementing Restoration Projects (11 hours)
Site assessment: soil, hydrology, biota, disturbance history; Restoration goals, reference models, and success indicators; Stakeholder participation and co-design approaches; Planning tools: GIS, spatial modeling, suitability mapping; Project management, timelines, and costing frameworks.

Unit 4: Monitoring, Governance, and Global Restoration Initiatives (10 hours)
Monitoring frameworks: ecological indicators, adaptive management; Use of remote sensing in monitoring; National and global restoration policies: UN Decade on Ecosystem Restoration, Bonn Challenge, Community-based restoration and indigenous stewardship; Legal, institutional, and funding mechanisms for large-scale restoration.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Site Assessment and Baseline Survey – Evaluate biophysical and socio-ecological parameters
- Design a Nature-Based Solution for urban flood control – Apply eco-engineering for resilience
- Vegetation Recovery Monitoring using quadrats and diversity indices – Track post-restoration trends
- Soil Quality Assessment in degraded vs. restored plots – Understand soil function restoration
- Case Study Analysis: Mangrove restoration or forest landscape restoration – Evaluate strategy effectiveness and community involvement
- Based on the syllabus

Essential Readings

- Clewell, A. F., & Aronson, J. (2012). Ecological restoration: Principles, values, and structure of an emerging profession (2nd ed.). Island Press.
- Greipsson, S., 2011. Restoration ecology. Jones & Bartlett Learning.
- Hartmann, T., Slavíková, L. and McCarthy, S., 2019. Nature-based flood risk management on private land: Disciplinary perspectives on a multidisciplinary challenge (p. 228). Springer Nature.
- Howell, E.A., Harrington, J.A. and Glass, S.B., 2012. Introduction to restoration ecology. Washington, DC: Island Press.
- Sharky, B., 2024. Nature-Based Design in Landscape Architecture. Taylor & Francis.
- van Andel, J., & Aronson, J. (2012). Restoration ecology: The new frontier (2nd ed.). Wiley-Blackwell.

Suggested Readings

- Chazdon, R. L. (2014). Second growth: The promise of tropical forest regeneration in an age of deforestation. University of Chicago Press.
- IUCN. (2020). Nature-based solutions for climate change adaptation and disaster risk reduction. IUCN Publications.
- Sang, N. ed., 2020. Modelling Nature-Based Solutions: Integrating Computational and Participatory Scenario Modelling for Environmental Management and Planning. Cambridge University Press.
- Temperton, V.M., Hobbs, R.J., Nuttle, T. and Halle, S. eds., 2013. Assembly rules and restoration ecology: bridging the gap between theory and practice (Vol. 5). Island Press.
- Toft, J.D., 2017. Living Shorelines: The Science and Management of Nature-Based Coastal Protection. CRC Press.
- Sharma, R.S., Karmakar, S., Kumar, P. and Mishra, V., 2019. Application of filamentous phages in environment: A tectonic shift in the science and practice of ecorestoration. Ecology and Evolution, 9(4), pp.2263-2304.

M.Sc./M.A. Even Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE -
(DSE-20): Environmental Geosciences

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OFTHE COURSE

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-20: Environmental Geosciences	**4**	**3**	**-**	**1**	UG	**-**

Course Objectives

The course is designed to

- Provide a comprehensive understanding of the fundamental geological principles as they relate toenvironmental processes, hazards, and resources.
- Equip students with the ability to analyze, assess, and address environmental issuesusing geological methods and knowledge.
- Develop proficiency in identifying, evaluating, and managing geological hazards, such as landslides, earthquakes, floods, and contamination, with an emphasis on risk mitigation andsustainable solutions.
- Foster skills in the exploration, sustainable utilization, and management of earth resources(water, minerals, energy) while considering environmental and societal impacts.

Learning Outcomes

At the end of the course, the students should be able to

- Understand and apply geological principles to evaluate environmental problems and proposesustainable nature-based solutions.
- Identify, interpret, and manage geological hazards and contaminated sites.
- Use advanced field and laboratory techniques for environmental assessment and monitoring.
- Integrate geological knowledge with environmental policy and management strategies.

Course syllabus – theory (45 hours)

Unit 1 – The Earth System (12 hours)

Exploring Earth's Interior, Layered structure of the Earth, Plate Tectonics, Rates and History of Plate Motions, Evolution of Continents, The Grand Reconstruction, Interactions Between Plate Tectonics and Climate Systems; Mantle convection and its role in surface processes, Earth system cycles; Earth's magnetic field; Lithosphere–asthenosphere interactions.

Unit II – Geologic Processes (12 hours)

Igneous, magmatic differentiation and intrusions; Sedimentary, Classification, Burial and Diagenesis; Metamorphism, Causes, types and Grades; Deformation, types, structures andunravelling geologic history; Minerals and Rock-forming Processes, Physical properties of minerals,Minerals as valuable resources; Structural geology; Plate boundaries; Tectonometamorphic terrains.

Unit III – Geologic Records (14 hours)

Geological Time Scale-Relative and absolute age, Principles of Stratigraphy, Reconstructing Geologic History from the Stratigraphic Record, Measuring Absolute Time with Radioactive Clocks, Geobiological Events in Earth's History; Evolution of life and major extinction events; Unconformities and their geological significance, Isotopic dating methods

Unit IV – Internal and Surficial Geosystems (9 hours)

Volcanoes, Eruptive style and landforms; Earthquakes, Patterns of Faulting, Exploring interior with seismic waves; Stream and Glacial Transport, Drainage networkand Landscapes; Mass movement; Coastal processes, Aeolian processes, Tectonics and surface processes

Suggested Practicals/Applied Exercises/Field Component (30 hours)

1. To undertake Particle size analysis
2. To evaluate the Bulk density of the soil
3. To undertake Loss-on-ignition analysis
4. To undertake major minerals identification
5. To identify major rock types
6. To undertake satellite images interpretation
7. To undertake digitization- point, line, polygon data
8. To understand data conversion-vector to raster, raster to vector
9. To prepare land use/land cover maps using visual and digital interpretation
10. A visit to the Geology Museum

Essential Reading

- Bennett, M.R. and Doyle, P. Environmental geology: Geology and the Human Environment.John Wiley and Sons. 1997.
- Jensen, J.R., Remote Sensing of the Environment – An Earth Resources Perspective, Pearson Education, Inc. (Singapore) Pvt. Ltd., Indian edition, Delhi, 2000.
- Jenson, J.R. Introductory Digital Image Processing: Prentice Hall Series, 2018.

- Keller, E.A. (2008). Introduction to Environmental Geology. Prentice Hall, Upper SaddleRiver, New Jersey.
- Montgomery, C. W. (2006). Environmental geology (p. 540). New York: McGraw-Hill.

Suggested Readings

- Kehew, A. E. (2021). Geology for engineers and environmental scientists. Waveland
- Knödel, K., Lange, G., & Voigt, H. J. (2007). Environmental geology: handbook of field methods and case studies. Springer Science & Business Media.
- Merritts, D., De Wet, A., & Menking, K. (1998). Environmental geology: an earth system science approach. Macmillan.
- Valdiya, K. S. (2004). Geology, Environment, and Society. Universities Press.

M.Sc./M.A. Even Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE – DSE(-21)

Fundamentals of Environmental Politics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-21: Fundamentals of Environmental Politics	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives

- Introduce foundational concepts and frameworks in environmental policy and political ecology.
- Explore how environmental policies are shaped by socio-political, economic, and institutional contexts.
- Understand global and national environmental governance systems.
- Enable students to critically evaluate contemporary environmental challenges through a policy and political lens.

Learning Outcomes

After the course, students will be able to:

- Describe the key concepts and actors involved in environmental policy-making.,
- Analyse the role of political ideologies and power structures in shaping environmental outcomes
- Understand the evolution and structure of environmental policies in India and globally,
- Evaluate contemporary environmental issues and governance mechanisms with policy relevance.

Course Syllabus – Theory (45 hours)

Unit I – Understanding Environmental Politics (12 hours)
Definition, scope, and significance of environmental politics, Key stakeholders: state, civil society, corporations, indigenous communities, Political ideologies: Ecocentrism **vs** Anthropocentrism**,** Environmental Justice**,** Ecofeminism**,** Power, equity, and representation in environmental decision-making, Introduction to Political Ecology: concepts and key thinkers, Environmental citizenship.

Unit II – Environmental Policy: Concepts and Processes (11 hours)
Definition and importance of public policy, The policy cycle: Agenda setting, policy formulation, adoption, implementation, evaluation, Policy instruments: Command-and-control Market-based (e.g., carbon pricing), Voluntary instruments (e.g., eco-labels) Role of institutions and stakeholders: State, NGOs, corporations, media, judiciary, Right to Information and public participation in policy processes, Role of science and traditional knowledge in policymaking

Unit III – Introduction to Environmental Politics in India (12 hours)
Historical context of post-independence environmental governance, Growing tension between development and ecological sustainability; Role of the state, judiciary, and institutions. Environmental movements (Chipko Movement, Narmada Bachao Andolan, and anti-mining struggles) and contributions of marginalised communities (women and tribals) in resisting ecological degradation; Role of civil society, NGOs, media, and judicial activism in shaping public discourse and environmental decision-making. Politics of development

Unit IV – Introduction to Global Environmental Politics (10 hours)
Politics and evolution of global environmental discourse: Stockholm (1972) to Paris (2015) Multilateral Environmental Agreements (MEAs): Environmental diplomacy and negotiations.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Policy Analysis: Critical review and presentation on a major Indian environmental policy/law (e.g., Forest Rights Act, Draft EIA 2020),
- Comparative Review: Indian vs international treaty (e.g., CRZ vs Ramsar Convention; EPA 1986 vs UNFCCC),
- Media Content Analysis: Tracking trends and biases in environmental coverage
- Policy Brief Writing: Drafting short policy documents on current environmental issues (e.g., air pollution, water security, waste),
- Institutional Visit: Visit to a local body like municipal council, CPCB/SPCB,
- Mini-Project: "Policy solutions for a local environmental problem" (to be presented)

Essential Readings

- Rosenbaum, W. A. (2013). Environmental Politics and Policy.
- Rangarajan, M. (Ed.) (2007). Environmental Issues in India: A Reader.
- Baviskar, A. (2004). In the Belly of the River: Tribal Conflicts Over Development.
- Guha, R. & Martinez-Alier, J. (1997). Varieties of Environmentalism.
- Government of India. National Environmental Policy (2006) and Draft NEP (2020).

Suggested Readings

- Hajer, M. A. (1995). The Politics of Environmental Discourse.
- Jasanoff, S. (2004). States of Knowledge: The Co-production of Science and Social Order.
- UN Environment Programme: Global Environmental Outlook
- CSE: State of India's Environment (latest)
- IPCC Summary for Policymakers (latest report)

M.Sc./M.A. Even Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE – (DSE-22): Invasion Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-22: Invasion Biology	4	3	-	1	UG	-

Invasion Biology

Preamble:

Biological invasions represent a critical dimension of global change, threatening biodiversity, altering ecosystems, and posing significant socio-economic challenges. Understanding the mechanisms, impacts, and management of invasive species is essential for developing resilient ecological frameworks and informed conservation strategies.

Learning Objective:

The course aims to equip students with a comprehensive understanding of invasion biology by exploring the historical development, ecological theories, invasion processes, and the multifaceted impacts of invasive species. It also emphasizes analytical skills for assessing risks and implementing effective management strategies.

Learning Outcome:

- Students will be able to explain the historical context and key concepts underlying invasion biology.
- Analyze mechanisms of species invasiveness and community invasibility.
- Evaluate the ecological and economic consequences of biological invasions.
- Apply predictive tools and risk assessment methods to real-world invasion scenarios.
- Critically assess and propose context-appropriate management and policy interventions for invasive species control.

Course syllabus – Theory (45 hours)

Unit I (11 hours)

Introduction: Terminology- definition and concepts of invasion biology, Invasion biology in the 21st century. Framing biological invasions, issues of specialization and dissociation and re-association, Invasion research priorities, Critique of invasion Biology (SPRED ecology – SPecies REDistribution), EICAT an IUCN standard for the classification of impacts of alien taxa on the environment.

Process of invasion: Introduction (intentional and accidental)- Pathways and vectors, Establishment and Naturalization- Residence time, Biotic resistance, Propagule pressure, Tens rule, Hybridization, Species traits, Rapid evolution and Spread and subsequent invasion meltdown. Various frameworks proposed time to time for invasive species spread. Invasive species databases e.g. GISD and ILORA

Unit II (11 hours)

Species and Community invasibility: Species traits and invasibility, small-scale, large- scale and non- experimental studies, Enemy release hypothesis (ER), Evolution of Increased Competitive Ability (EICA), Allopathic advantage against resident species (AARS), allelopathy and competition, density dependent fitness in invasive populations, Allee effects, Darwin's naturalization hypothesis etc., Empty niche hypothesis, Intermediate disturbance hypothesis. Fluctuating resource hypothesis, Diversity–invasibility hypothesis, facilitation, mutualism and predator relationships. Hybridization, Epigenetics and evolutionary diversification.

Impacts of global environmental change on invasion process- atmospheric CO_2 concentration, change in temperature, change in nutrients- habitat heterogeneity, nitrogen deposition etc, disturbance regimes, and habitat fragmentation-canopy openings as windows of species invasions. Case studies related to plant and animal invasions.

Unit III (11 hours)

Ecological and economic consequences: Loss of species diversity through biotic homogenization; disruption of native community composition and food web dynamics; alterations in nutrient cycling, water flow patterns, and fire frequency; long-term ecological liabilities ('invasion debt'); and shifts in the overall economic valuation of biodiversity. EICAT an IUCN standard for the classification of impacts of alien taxa on the environment.

Unit IV (12 hours)

Forecasting and evaluating invasion risks: Anticipating the spread of invasive species using Weed Risk Assessment tools and species distribution models such as GARP and MaxEnt; implementing biosecurity protocols and quarantine strategies to prevent introduction and establishment.

Management of invasive species: prevent introductions, detect nascent invasions, identify susceptible environments, rapid management response. Management strategies- Physical removal, Chemical treatments and Bio-controls, advantages and disadvantages of strategies. Capacity building through biological invasion managers, and Citizen Science. Vulnerabilities and contribution of emerging technologies.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- To identify and document the presence and abundance of invasive plant species in a selected study area.
- To assess how an invasive species affects the growth and survival of native plants through competition.
- To compare germination success and seedling growth between invasive and native species.
- To test whether invasive plants release chemicals that inhibit the growth of native species.
- Ecological Niche Modelling (ENM) techniques to predict the potential distribution of invasive plant species based on environmental variables and habitat suitability.
- Based on the syllabus

Essential Readings

- Elton, C (1958). The Ecology of Invasions by Animals and Plants. Methuen Publishing.
- Richardson, DM (Ed.). (2011). *Fifty years of invasion ecology: The legacy of Charles Elton*. Wiley-Blackwell.
- Ramakrishnan, PS (1991). *Ecology of biological invasion in the tropics*. New Delhi: International Scientific Publications.
- Lockwood, JL, Hoopes, MF, and Marchetti, MP (2013). *Invasion ecology* (2nd ed.). Wiley-Blackwell.
- Davis M (2009) Introduction Invasion biology. Oxford University Press.
- Pyšek, P., Richardson, DM, and Rejmánek, M (Eds.). (2020). Encyclopedia of Biological Invasions. University of California Press.
- Simberloff, D (2013). Invasive species: What everyone needs to know. Oxford University Press.

Suggestive Readings

- Blackburn, TM, Pyšek, P., Bacher, S., Carlton, JT, Duncan, RP, Jarošík, V. and Richardson, DM (2011). A proposed unified framework for biological invasions. *Trends in Ecology & Evolution, 26*(7), 333–339.
- Seebens, H., et al. (2017). No saturation in the accumulation of alien species worldwide. *Nature Communications, 8*(1), 14435.
- Catford, JA, Jansson, R, and Nilsson, C (2009). Reducing redundancy in invasion ecology by integrating hypotheses into a single theoretical framework. *Diversity and Distributions, 15*(1), 22–40.
- Blossey, B., and Notzold, R. (1995). Evolution of increased competitive ability in invasive nonindigenous plants: A hypothesis. *Journal of Ecology, 83*(5), 887–889.
- Inderjit, Wardle DA, Karban R and Callaway RM. (2011) The ecosystem and evolutionary contexts of allelopathy. Trends in Ecology & Evolution, 26: 655-662.
- Sharma, GP, Singh, JS, & Raghubanshi, AS (2005). Plant invasions: Emerging trends and future implications. Current Science, 88(5), 726–734.
- Callaway, RM, and Ridenour, WM (2004). Novel weapons: Invasive success and the evolution of increased competitive ability. *Frontiers in Ecology and the Environment, 2*(8), 436–443.
- Vilà, M., Espinar, JL, Hejda, M., Hulme, PE, Jarošík, V., Maron, JL and Pyšek, P. (2011). Ecological impacts of invasive alien plants: A meta-analysis of their effects on species, communities and ecosystems. *Ecology Letters, 14*(7), 702–708.
- Pejchar L., and Mooney H. A. (2009). Invasive species, ecosystem services and human well-being. *Trends in Ecology & Evolution, 24*(9), 497–504.

M.Sc./M.A. Even Semester

DISCIPLINE-SPECIFIC ELECTIVE COURSE - (DSE-23): Sustainable Finance and ESG Reporting

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-23: Sustainable Finance and ESG Reporting	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives

- Develop a robust understanding of sustainability-linked financial instruments
- Explore principles and practices of Environmental, Social, and Governance (ESG) reporting and ratings
- Analyze global frameworks, standards, and regulatory mechanisms for green and ethical finance
- Equip students with applied skills in ESG disclosure, materiality analysis, and impact investing

Learning Outcomes

By the end of the course, students will be able to:

- Explain core concepts in sustainable finance, ESG investing, and climate-risk disclosure
- Analyze ESG metrics, KPIs, and frameworks for sustainability assessment and reporting
- Evaluate ESG performance and sustainability strategies of corporations and institutions
- Apply ESG data for scenario analysis, stakeholder communication, and regulatory compliance

Course Syllabus – Theory (45 hours)

Unit 1: Foundations of Sustainable Finance and Global Instruments (12 hours)

Definitions and trends in sustainable finance; Evolution of responsible investing and ESG integration; Green, blue, social, and SDG-linked bonds; Principles of climate finance; Role of development banks and private equity in sustainability transitions; ESG pillars—environmental risk, social equity, corporate governance; Global ESG standards: GRI, SASB, TCFD, ISSB, CDP.

Unit 2: ESG Frameworks, Standards, and Regulatory Landscapes (12 hours)

ESG data providers: MSCI, Sustainalytics, Bloomberg, LSEG; Double materiality, climate risk disclosure, EU Taxonomy; Regulatory ecosystems: SEBI (India), SEC (US), EU SFDR; Integrating ESG into business models; Materiality mapping, stakeholder engagement, sustainability KPIs; ESG reporting practices and corporate case studies.

Unit 3: Climate Risk, Carbon Finance, and ESG Ethics (11 hours)

Climate-related financial risks; Internal carbon pricing, offsets, carbon credits, and trading schemes; Paris-aligned finance and net-zero strategies; Science-Based Targets (SBTi); Role of financial institutions in climate mitigation; Assurance, auditing, benchmarking ESG performance; Greenwashing, controversies, and ethical considerations in ESG.

Unit 4: ESG Analytics, Decision Tools, and Emerging Markets (10 hours)
ESG score construction and integration challenges; Quantitative and qualitative ESG metrics and dashboards; SDG alignment and materiality tools; ESG performance in emerging and frontier economies; Role of AI, blockchain, and big data in ESG reporting and decision-making.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

1. Materiality Matrix Design for a listed company – Identify ESG priorities for strategic disclosure
2. ESG Scorecard Analysis using Bloomberg/Refinitiv sample data – Evaluate corporate ESG performance
3. Green Bond Case Study Review – Assess environmental impact and compliance
4. Carbon Risk Scenario Analysis – Estimate exposure to climate transition risks
5. Develop a Mini ESG Report for an SME or startup – Synthesize ESG metrics and stakeholder narrative

Essential Readings

- Adams, C., 2017. Understanding integrated reporting: the concise guide to integrated thinking and the future of corporate reporting. Routledge.
- Bednárová, M. and Soratana, K., 2025. Environmental, Social, and Governance (ESG) Investment and Reporting. Springer.
- Bini, L. and Bellucci, M., 2020. Integrated sustainability reporting. Integrated Sustainability Reporting. Springer
- Boustead, R., 2025. ESG Reporting Manual: 500+ Legal Tips and Tricks to Improve Your ESG Reporting. CRC Press.
- Hill, J., 2020. Environmental, Social, and Governance (ESG) investing: A balanced analysis of the theory and practice of a sustainable portfolio. Academic Press.

Suggested Readings

- Clark, G. L., Feiner, A., & Viehs, M. (2015). From the stockholder to the stakeholder: How sustainability can drive financial outperformance. University of Oxford.
- GRI. (2021). Universal Standards 2021. Global Reporting Initiative.
- Haar, G., 2024. Rethink Economics and Business Models for Sustainability. Springer Nature Switzerland.
- Netterstrom, R., 2014. Sustainability Reporting and Communications. Business Expert Press.
- TCFD. (2023). Recommendations of the Task Force on Climate-related Financial Disclosures. https://www.fsb-tcfd.org
- Trites, G., 2024. Beyond Sustainability Reporting: The Pathway to Corporate Social Responsibility. Business Expert Press.
- Wachtel, P., Ferri, G. and Miklaszewska, E. eds., 2023. Creating value and improving financial performance: inclusive finance and the ESG premium. Springer Nature.

M.Sc./M.A. Even Semester

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE-24)

Tropical Field Ecology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-24: Tropical Field Ecology	**4**	**3**	**-**	**1**	**UG**	**-**

Course Objectives

- To prepare students with interests in Ecology and Evolution to the diverse field approaches used to address ecological questions..
- To gain experience with field techniques used in ecological research, including habitat evaluation, sampling, and identifying wildlife populations, using case based approach
- To present the natural history and ecology of tropical forests through practical exercises, lectures, field visits, tutorials, and small group project work.
- To impart fieldwork skills and experience relevant to tropical forest ecology and biodiversity.

Learning Outcomes

At the end of the course, the students should be able to

- prepare students with the scientific methods needed for field ecology and conduct ecological surveys of flora and fauna in forests.
- learn to work effectively in teams and contribute to research project design, execution, analysis, and interpretation of ecological data sets through small-group research projects.
- understand bioacoustics principles and their practical applications with a focus on conservation and applied ecological research.
- prepare students for entry-level jobs in environmental monitoring, rare-plant surveys, undergraduate and high school teaching, project management for nonprofit organizations, and park management

Course Syllabus – Theory (45 hours)

Unit 1- (11 hours)

Paleoecology: historical ecological patterns; Structure, function, and diversity of tropical forests; the ecological, evolutionary and biogeographic processes leading to high diversity in tropical forests; importance of natural history and taxonomy in the study of biodiversity of tropical forests; drivers of change in tropical forests and examples of solutions; major threats to tropical forests, as well as examples of tropical forest recovery following disturbance.

Unit II (12 hours)

Principles of Field-Based Research: Sampling strategies, field data collection methods, biases in data collection; Biodiversity field surveys for vertebrates (Transects/Line transect surveys camera trapping, pugmarks, scat surveys), invertebrates (butterflies, dung beetles, dragonflies), plants (families with high economic, ecological, or ethnobotanical importance), and assessments of ecosystem functioning (seed predation, herbivore predation); examples of large-scale experiments in tropical forests and their importance in tropical forest ecology and conservation.

Unit III (11 hours)

Soil and vegetation assessment in a range of habitats (from coastal sand dunes to rainforests), distribution and dynamics of vegetation; field methods to reconstruct fire history (tree rings analyses) and assess past fire history through forest stand structure. Use of QGIS for species distributions and habitat associations through spatial data in forest and fire ecology; Field ornithology: morphology, ecology, and behavior, taxonomy, field identification of local birds by sight and sound, and field methods (e.g., point counts, mist netting, bird banding).

Unit IV (11 hours)

Introduction to bioacoustics, and the functions of sound in biology; Techniques for Wildlife Recording: Essentials of equipment use, and field recording skills. Bioacoustics applications in real-world conservation: Eco acoustics, passive acoustic monitoring, and machine learning applications for conservation efforts, focused on real-world data analysis and species classification.

Suggested Practicals/Applied Exercises/Field Component (30 hours)

- Field Skills in Ecology: Survey and identify local plants, insects, amphibians, reptiles, birds, and mammals
- Collect ecological data using pitfall traps, mist nets, visual counts, sweep nets, Pollard's walk for butterfly sampling, aural, point counts and transects for bird sampling
- Field monitoring techniques, including radio telemetry, camera traps, acoustic monitoring, and electrofishing
- Orientation: GPS and campus navigation, map and field bearings
- Use of citizen science platforms such as GBIF, iNaturalist, eBird and other global biodiversity databases for species occurrence data
- Bioacoustics: familiarization with wildlife recording equipment and field recording techniques; focal species recordings in the field; Visualizing soundscapes and analyzing sound data

Essential Reading

- *Krebs, C.J. (2013) Ecology* The Experimental Analysis of Distribution and Abundance. New International Edition, 6E, New York
- Molles, M. C. (2016). Ecology: *concepts and applications*. Seventh edition. McGraw-Hill Education.
- Wheater, C. P., Bell, J. R., & Cook, P. A. (2020). *Practical field ecology: a project guide*. 2E. John Wiley & Sons.
- Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management*. John Wiley & Sons.
- Smith, R. L., & Smith, T. M. (2001). Ecology and field biology: hands-on field package. Benjamin Cummings

Suggested Textbooks:

- Real, L. A., & Brown, J. H. (Eds.). (2012). Foundations of Ecology:\Classic Papers with Commentaries. University of Chicago Press.
- Smith, R. L. (2001). Ecology and field biology. 5E. Pearson
- Begon, M., Howarth, R. W., & Townsend, C. R. (2014). Essentials of ecology. John Wiley & Sons.
- Bradbury, J. W., & Vehrencamp, S. L. (2011). Principles of animal communication.2E Oxford University Press