Appendix-29
Resolution No. 24-10

Bachelor of Science (Prog.) in Applied Life Sciences

Agrochemicals and Pest Management

SEMESTER-VII

ZOOLOGY

DISCIPLINE SPECIFIC CORE COURSE: **ALS-ZOO DSC 07**

INSECT BEHAVIOUR

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	Practicals/ Practice		
Insect Behaviour ALS ZOO DSC 07	4	2	Nil	2	Appeared in Sem-VI	NA

Learning Objectives:

- This syllabus provides a comprehensive overview of insect behavior, its underlying mechanisms, and its relevance to various fields.
- Insect behaviour is a scientific study of the behaviour of insects in their natural habitat and in relation to their interactions with other living organisms and the environment.
- Study of orientation, feeding and oviposition behaviour of insects has immense applications in pest management in an effective, economical and eco-friendly manner.
- Behavioural studies can be conducted easily by the undergraduate students in the laboratory and can later be extrapolated in the investigative field projects.

Course Outcomes:

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

- Learn about the concept of insect behaviour and its applications
- Gain knowledge about importance of insect behaviour in natural habitat.
- Understand the complexities of insect behavior and its applications in the real world.
- Understand the difference between various types of pests and their host plants, extent of damage caused by them.

Theory **30h**

Unit 1: Introduction to insect behaviour **5 h**

Scope and importance of studying insect behavior. Types of behaviour: Innate, Learned, Fixed Action patterns (FAPs) and Complex behaviours (Altruism).

Unit 2: Mechanism of sensory perception and Orientation behaviour of insects **10 h**

Sensory perception in insects: mechanoreceptors, hygroreceptors, thermoreceptors, photoreceptors. Visual Communication, Acoustic communication, Tactile communication and Chemical communication, Neuronal and hormonal basis of Insect behaviour, Orientational responses: Kinesis and Taxis.

Unit 3: Feeding behavior of insects

Types of feeding habits with special emphasis on phytophagous insects, Insect-plant relationships, Foraging behaviour of Honey bees. **8 h**

Unit 4: Reproductive behavior

Locating mates, Courtship, Sexual differences in mating behavior, Mate selection and rejection, Genetic quality and mate choice, Aggregation signal, Sex pheromones. **7 h**

Practicals

(Laboratory periods 15 classes of 4 hrs each)

1. To study the various tools and techniques/methods used to study of the behaviour of insects in the laboratory and field conditions.
2. To observe the insects in the wild.
3. To distinguish between beneficial and destructive insects (pests).
4. To study the geotaxis behaviour of soil insects.
5. To study the phototaxis behaviour larvae of phytophagous insects.
6. To study the stridulation, swarming, habituation, courtship behaviour of insects (at least two videos for each behaviour).
7. Construction of ethogram by using suitable data to study insect behaviour.
8. Visit to forest, wildlife park, sanctuary, zoological park to study and record the behaviour of insects and prepare a short report.

Suggested Readings:

1. V.B. Awasthi. Principle of Insect Behaviour. Scientific Publication; 2nd Edition.
2. Mathews, W. Robert and Methews, R. Janice. Insect Behaviour. Springer, 2nd Edition.

3. Alcock, John. Animal Behaviour. Sinauer Associates. 11th Edition.

Additional Resources:

1. UGC INFONET / DU E-Resources & SciFinder Web Version registration
2. Viji, C. P., Phani Kumar, K. and Sudhavan Vani, V. Insect Ecology and Behaviour.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SCIENTFIC ELECTIVE COURSE: **ALS- ZOO DSE 06**

SOCIAL AND BENEFICIAL INSECTS

Credits 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	Practicals/ Practice		
Social and Beneficial Insects **ALS ZOO DSE 06**	4	2	Nil	2	Appeared in Sem-VI	NA

Learning Objectives:

The learning objectives of this course are as follows:

- to acquaint students of the social organization found in insects.
- to apprise them of beneficial aspects of insects.
- to impart knowledge about the techniques involved in culturing and rearing of bees, silkworms and lac insect.

Learning Outcomes:

By studying this course, students will be able to:

- identify different types of social and beneficial insects.
- differentiate the various castes and their role in the social life of insects.
- acquire skill for mass rearing of beneficial insects and their products.

Theory **30h**

Unit 1: Social Insects **7h**

Characteristics and systematic position. Social organization: caste determination, communication, social parasitism and symbioses, social insect pathogens. Life cycle, social organization and types of ants, bees, wasps and termites.

Unit 2: Apiculture **7h**

Habit and habitat of honey bee (Apis), bee keeping techniques, bee pasturage, artificial bee hives. Economic importance of bee. Bee enemies, bee diseases and their control.

Unit 3: Sericulture and Lac Culture **11 h**

Life cycle of silkworm Bombyx mori. Types of silkworm species and their salient features. Rearing techniques of mulberry, muga, eri and tassar silkworms. Enemies and diseases of silkworms and their management.

Habit, habitat and biology of *Laccifera lacca*. Host trees of lac insect, pruning, inoculation and lac harvesting. Enemies of lac insect and their control

Unit 4: Ecological aspects of beneficial insects **5h**

Ecological role of insects: pollination, weed control, improving soil fertility and as scavengers. Medicinal use of insects and insect products. Entomophagy.

PRACTICALS **60 h**

1. Study of life cycle of ants, bees, termites, silk worm and lac insect through museum specimens/photographs.
2. Study of different nests build by ants, bees and termites.
3. Construction and maintenance of artificial bee hives and study of equipments related to apiculture.
4. Rearing techniques of mulberry, muga, eri and tassar silkworms.
5. Study of different types of enemies and diseases of silkworms.
6. Study of lac culture technique: pruning, inoculation, cropping and harvesting.
7. Study of economically important insect products.

Essential/Recommended readings:

1. Watson, J. A. L., Okot-Kother, B. M. and Noiroh C. (1985) Caste differentiation in social insects. Pergamon Press.
2. Dunston AP. (2007) The Insects: Beneficial and Harmful Aspects.Kalyani Publishers., New Delhi.
3. Brian, M. V. (1983) Social insects: ecology and behavioural biology. Chapman and Hall, London, New York.
4. D. B. Tembhare (2017) Modern Entomology. Himalaya Publishing House.

5. Dokuhon, Z.S. (1998) Illustrated Textbook on Sericulture. Oxford & IBH publishing Co., Pvt. Ltd. Calcutta.
6. Shukla, G.S. and Upadhyay, V.B. (2014) Applied and Economic Zoology, Rastogi Publications.

Suggested Readings:

1. Maxwell F.G. and Jennings P.R. (Eds). (1980) Breeding Plants Resistant to Insects. John Wiley & Sons, New York.
2. Encyclopedia of Social Insects (2021) Springer International Publishing.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SCIENTFIC ELECTIVE COURSE: **ALS ZOO DSE-07**

BASICS OF CHRONOBIOLOGY

Credits 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	Practicals / Practice		
Basics of chronobiology ALS ZOO DSE 07	**4**	**2**	**Nil**	**2**	**Appeared in Sem-VI**	NA

Learning Objectives

The learning objectives of this course are as follows:

- to understand the cyclic physiological phenomena.
- to learn about the unique phenomena of seasonal migration and hibernation.
- to expose the students to clock dysfunctions.
- to make the students aware of the various aspects of chronobiology and its application in therapeutics and medicine
- to enable the students to learn about their own rhythms of sleep and body temperature
- Summarize the importance of various biological rhythm in nature.

Learning Outcomes

By studying this course, students will be able to

- Understand the concepts of biological significance of biological rhythms
- Acquaint with the patterns of animal behaviour and importance of circadian rhythms.
- Observe the adaptations in various animals.
- Develop an overview of the principles of chronobiology.
- Molecular mechanisms underlying the generation of circadian time
- study about the applications of chronobiology in medicine, pharmacology and therapeutics.

- **Theory** **30h**

UNIT- 1: Introduction to Chronobiology **12 h**

Milestone and scope of chronobiology; Types and properties of Rhythms – Ultradian rhythms, Circadian rhythms, Infradian rhythms; Lunar rhythm; Circannual rhythm. Characteristics of circadian rhythms, Temperature compensation; Masking and synchronization; Zeitgebers- Photic and non-photic Zeitgebers.

UNIT- 2: Biological clock system **8 h**

Characteristics, Input, time generation and output components; Central and peripheral clocks; Suprachiasmatic nucleus; Molecular mechanisms underlying the generation of circadian time in Drosophila.

UNIT- 3: Circannual rhythm and Photoperiodism **10 h**

Circannual rhythms; Photoperiodism and regulation of seasonal breeding animals in vertebrates; Pineal as photoreceptive structure in non-mammalian vertebrates. Seasonal Migration in birds; Role of melatonin and serotonin.

UNIT- 4: Circadian rhythms and human health. **10 h**

Circadian clock and sleep-wake cycle; Jet Lag, Shift work ; Sleep and Chronotypes; Consequence of clock dysfunction- Sleep Disorders, Depression, Anxiety, Stress, Cancer; Obesity, Immune Disorders; Chronopharmacology, Chronomedicine and Chronotherapy.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of characteristics of circadian rhythms from a given dataset.
2. Ambulatory blood pressure monitoring and biological rhythm analysis.
3. Using periodically assembled data study of body temperature rhythm.
4. Study of circadian functions in humans (daily eating, sleep and temperature patterns).
5. Human chronotypes-MCTQ questionnaire and analysis.
6. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Essential/recommended readings

1. Binkley, S. (2020). Biological clocks: Your owner's manual. CRC Press.

2. Jay. C. Dunlap, Jennifer. J. Loros, Patricia J. DeCoursey (ed). 2004, Chronobiology Biological Timekeeping: J, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
3. Koukkari, W. L., & Sothern, R. B. (2007). Introducing biological rhythms: A primer on the temporal organization of life, with implications for health, society, reproduction, and the natural environment. Springer Science & Business Media.

SUGGESTED readings

1. Palmer, J. D. (2002). The living clock: The orchestrator of biological rhythms. OxfordUniversity Press.
2. Dunlap J. C, Loros J. J, DeCoursey P. J. (2004) Chronobiology Biological Time keeping. Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
3. Saunders D. S. (2002). Insect Clocks. III Edition, Barens and Noble Inc. New York, USA

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 08**

NON-INSECT PESTS AND THEIR CONTROL

Credits 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	Practicals / Practice		
Non-insect pests and their control ALS ZOO DSE 08	4	2	Nil	2	Appeared in Sem-VI	NA

Learning Objectives:

The learning objectives of this course are as follows:

- to introduce students with various types of non-insect pests in agriculture and household.
- to give an understanding of their behaviour and the damage they cause to crops
- to acquaint with various plant economic losses caused by non-insect pests.

Learning Outcomes:

By studying this course, the students will be able to:

- recognize major non-insect pests in Indian subcontinent.
- identify the specific life stage of the pest which causes significant loss to crop plants and adopt appropriate measures to control them.

Theory **30h**

Unit 1: Introduction to non-insect pests and their management **8 h**

Introduction, habit and habitat and economic importance of non-insect pests and their management. Major mite pests of cultivated and plantation crops, Economic importance along with their management strategies. Study of Red spider mite (*Tetranychus neocaledonicus*) and Cereal rust mite (*Abacarus hystrix*), its damage on different crops and control measures.

Unit 2: Damage to crops by Molluscs and and their control **7 h**

Important species of snails and slugs as pest in India. Description of their nature of damage on agricultural crops, fruits, vegetables and ornamental plants in coastal area. Study of *Helix* sp and Indian slug species (*Macrochlymus indica*)**.** Strategies for their management.

Unit 3: Nematodes as pests of crops and their control **7 h**

Habitat, general characteristics and management of major phyto-nematodes. Study of Root-knot nematode (*Meloidogyne incognita*) and cyst nematode (*Heterodera rostochiensis)*, its impact on crops and control measures.

Unit 4: Damage to crops by the pests and their management **8 h**

Study of important bird pests of agricultural crops and their control: Rose ringed parakeet (*Psittacula krameri*) and blue rock pigeon (*Columba livia*); damage caused by them and their management. Status of rodents as pest in India. Important species of rodents. Study of Indian mole-rat (*Bandicota bengalensis*), palm ***squirrel*** (*Funambulus palmarum*) and Indian fruit bat (*Pteropus giganteus*) with its nature of damage and control measure.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Identification, life cycle and damage caused by following mites *with specimen/Photograph:*
Red spider mite (*Tetranychus neocaledonicus*), Cereal rust mite (*Abacarus hystrix),* Broad mite (*Polyphagotarsonemus latus*)

2. Identification and damage caused by of the following molluscan *with specimen/Photograph:*
Common snail, *Helix* spp and Indian slug (*Macrochlymus indica*)

3. Identification and damage caused by of the following nematode *with specimen/Photograph:*
Root-knot nematode (*Meloidogyne incognita*), cyst nematode (*Heterodera rostochiensis)* and Wheat-gall nematode (*Anguina tritici*)

4. Identification and damage caused by of the following Birds *with specimen/Photograph:*
Rose ringed parakeet (*Psittacula krameria*) and blue rock pigeon (*Columba livia*)

5.Identification and damage caused by of the following mammals *with specimen/Photograph:*
Indian mole-rat (*Bandicota bengalensis*), Commonrat (*Rattus rattus*), palm ***squirrel*** (*Funambulus palmarum*), Indian fruit bat (*Pteropus giganteus*) and common monkey (*Macaca mulatta*)

6. To visit any agriculture Institute and make a project report on main agriculture crops pest and its management.

Essential/recommended readings

1. Dhaliwal, G.S. (2009). *An Outline of Entomology* (2nd Ed.). Kalyani Publishers.
2. Atwal A.S. &Dhaliwal G.S. (2015) *Agricultural pests of south Asia and their management* (8th ed.). Kalyani Publishers.

Suggested readings

1. Devasahayam H.L (2011) *Practicals Manual of Entomology: Insects and Non-insect Pests*. New India Publishing Agency.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 09**

MODERN TOOLS AND TECHNIQUES FOR ENTOMOLOGICAL RESEARCH

Credits 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	Practicals/ Practice		
Modern tools and Techniques for Entomological research **ALS ZOO DSE 09**	4	2	Nil	2	Appeared in Sem-VI	

Learning Objectives:

The learning objectives of this course are as follows:

- To understand modern techniques used in biotechnology for research, diagnostics, and industrial applications.
- To learn the principles, applications, and limitations of bioinstrumentation methods.
- To gain hands-on experience in the operation and maintenance of advanced instruments.
- To develop critical thinking to select and apply suitable techniques for solving specific biological problems.
- To learn to interpret experimental data and troubleshoot issues in instrumentation.

Learning Outcomes:

By studying this course, students will be able to:

- Gain a better understanding of diverse cellular processes and cellular interactions.
- Explain the principles and working mechanisms of advanced instruments in biotechnology.
- Demonstrate proficiency in operating instruments such as spectrophotometers, chromatographs, and PCR machines.
- Design experiments using advanced techniques like chromatography, electrophoresis, and mass spectrometry.
- Analyze experimental data generated by advanced bioinstrumentation.

- to apply biotechnological tools to solve problems in diagnostics, genomics, proteomics, and drug discovery.

Theory: **30h**

UNIT-1: Overview of Basic instruments used in Entomology laboratory **4 h**

Microscopes: Principles and applications of various microscopes, Laminar-Flow Hood, Autoclave, Centrifuge, Hamocytometer, Incubator, Cryostorage Container, pH meter. 2 h

UNIT-2: Spectroscopic Techniques **8 h**

Principles and Applications: UV-Visible spectroscopy, Fluorescence spectroscopy, Advanced Techniques: Infrared (IR) spectroscopy, Atomic Absorption Spectroscopy (AAS), and Nuclear Magnetic Resonance (NMR). Applications: Structure determination, protein folding studies and biomolecular interactions.

UNIT-4: Chromatography and Electrophoresis 6 h

Chromatography: Principles, instrumentation, and applications of HPLC, Gas Chromatography (GC), and Ion Exchange Chromatography. Electrophoresis: Polyacrylamide Gel Electrophoresis (PAGE), Agarose Gel Electrophoresis, 2D Gel Electrophoresis. Applications in genomics and proteomics. Mass Spectrometry (MS): Principles, instrumentation, and applications.

UNIT-4: Molecular Biology Techniques **10 h**

Polymerase Chain Reaction (PCR): qPCR, RT-PCR, and digital PCR. DNA Sequencing: Sanger sequencing and Next-Generation Sequencing (NGS). CRISPR-Cas9 Technology: Gene editing and applications. Biosensors: Principles, components, and applications in diagnostics.

Practicals **60 h**

(Laboratory periods:15classes of 4 hours each)

1. Chromatography Techniques: Separation of biomolecules using Chromatography.

2. Electrophoresis techniques: SDS-PAGE for protein separation.

3. Amplification of DNA. Gel documentation and analysis of PCR products.

4, Imaging Techniques: Demonstration of SEM/TEM.

5. Biosensors: Demonstration of glucose biosensors and ELISA techniques.

Project related to topics covered in theory/ project report based on visit to labs/ institutions/industry.

Essential/recommended readings

1. Principles and Techniques of Biochemistry and Molecular Biologyby Keith Wilson and John Walker, 7th Edition (2010), Cambridge University Press.
2. Biophysical Chemistry: Principles and Techniques by Upadhyay, Upadhyay, and Nath, Revised Edition (2020), Himalaya Publishing.

3. IntroductiontoSpectroscopybyDonaldL.Paviaetal,5th Edition (2015), Cengage Learning.
4. Bioinstrumentation by John G. Webster,1st Edition (2004), Wiley-Interscience.

Suggested readings

1. Fundamentals of Analytical Chemistry by Douglas A. Skoog et al., 9th Edition (2013), Cengage Learning.
2. Molecular Biology of the Gene by James D. Watson etal., 7th Edition (2013), Pearson.
3. Chromatography: Principles and Instrumentation byB.K. Sharma, Revised Edition (2007), Goel Publishing House.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Science (Prog.) in Applied Life Sciences

Agrochemicals and Pest Management

SEMESTER-VIII

ZOOLOGY COMPONENT

DISCIPLINE SPECIFIC CORE COURSE: **ALS ZOO DSC 08**

CONCEPT OF 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	Practicals/ Practice		
Concept of Evolutionary Biology **ALS ZOO DSC 08**	**4**	**2**	**Nil**	**2**	**Appeared in Sem-VII**	**NA**

Learning Objectives:

- The learning objectives of this course are as follows:
- To understand evolutionary forces leading to the variations and diversification of species.
- To learn about deciphering evidences ranging from fossil records to molecular data and to establish phylogenetic relationships of species.
- To gain knowledge of the processes and patterns of biological evolution.
- To get acquainted with origin and evolution of man.
- To acquire problem solving and high order analytical skills by attempting numerical problems as well as performing simulation studies of various evolutionary forces in action.

Learning Outcomes:

By studying this course, students will be able to:

- To gain knowledge about the relationship of the evolution of various species and the environment they live in.

- To apply the knowledge gained on populations in real time, while studying speciation, behaviour and susceptibility to diseases.
- To have a better understanding of the variations and genetic drift to ensure that conservation efforts for small, threatened populations are focused in right direction.
- To predict the Practicals implications of various evolutionary forces acting on the insect population in the field of human health, agriculture and wildlife conservation.

Theory **30 h**

Unit- 1 Origin of life and Historical Review of Evolutionary Concepts. **8 h**

Lamarckism, Darwinism, Neo-Darwinism**,** Chemogeny, RNA world, biogeny, origin of photosynthesis, endo-symbiotic theory

Unit- 2: Evidences of Evolution **4 h**

Palaeontological Evidences: geological time scale, Origin and Evolution of Insects; Molecular Evidences: neutral theory of evolution, molecular clock

Unit-3: Causes and Mechanism of Organic Evolution **9 h**

Variations: Heritable variations and their role in evolution. Natural selection, types of natural selection, artificial selection, kin selection, adaptive resemblances, sexual selection, frequency dependent selection. Natural selection (concept of fitness, selection coefficient), genetic drift (founder's effect, bottleneck phenomenon), migration and mutation (genetic load).

Unit-4: Species, Speciation and Extinction **5 h**

Speciation micro-evolutionary changes (inter-population variations, clines, Ring species, races), species concept, isolating mechanisms. **4 h**

Mass extinctions (events, causes and effects), Detailed explanation of K-T extinction

Practicals **60 hrs**

(Laboratory periods: 15 classes of 4 hrs each)

1. Study of fossils (types, forms and dating) from models/pictures.
2. Study of homology, analogy and homoplasy from suitable specimens.
3. Study of different modes of speciation and adaptive radiation/macroevolution using suitable examples.

4. Study of variations in a sample human population: (a) Continuous variation: Height/Weight in relation to age and sex (b) Discontinuous variation: Ability/Inability to taste Phenylthiocarbamide (PTC).

5. Study of Hardy-Weinberg Equilibrium: statement, assumptions, derivation of the equation and its verification by chi square analysis.

6. Demonstration of role of natural selection and genetic drift in changing allelic frequencies using simulation studies.

Suggested Readings:

1. Roberts, A. (2018) Evolution: the human story, Dorling, Kindersley Ltd.
2. Hall, B.K. and Hallgrimson, B. (2013). Evolution. V Edition, Jones and Barlett Publishers.
3. Campbell, N.A. and Reece J.B. (2011). Biology. IX Edition. Pearson, Benjamin, Cummings. 4. Barton N.H., Briggs D.E.G., Eisen J.A., Goldstein D.B. and Patel N.H., (2007) 1st Ed. Evolution, Cold Spring Harbor Laboratory Press.

Additional Resources:

1. Futuyma, Douglas and Mark, Kirkpatrick (2017) 3rd Ed. Evolutionary Biology, Oxford University Press.
2. Zimmer C. and Emlen D. J., (2013) 1stEd. Evolution: Making Sense of Life, Roberts & Co.
3. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition, Wiley Blackwell.
4. Ridley, M. (2004). Evolution. III Edition, Blackwell publishing.
5. UGC INFONET / DU E-Resources & SciFinder Web Version registration

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 10**

MEDICAL AND VETERINARY PESTS

Credits 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	Practicals/ Practice		
Medical and Veterinary pests **ALS ZOO DSE 10**	**4**	**2**	**Nil**	**2**	**Appeared in Sem-VII**	**NA**

Learning Objectives:

The learning objectives of this course are as follows:

- This course offers an insight about the various types of human diseases.
- This course offers an insight about the various types of Farm Animal diseases
- The students will understand the concepts of pathogens and pathological basis of diseases including infectious diseases caused by viruses, prokaryotes, protozoans, helminthes, vector-borne and zoonotic diseases.
- Vector biology, medical importance and management of the medically important insects and Veterinary Insect Pests

Learning Outcomes

Upon completing this course, students will be able to:

- Identify and describe the importance of medical and veterinary pests: Recognize and describe the biology, ecology, and behavior of various pests, including insects, arachnids, and rodents.
- Understand the role of pests in disease transmission: Explain the role of pests in transmitting and maintaining diseases, and understand the impact of pest-borne diseases on human and animal health.
- Apply integrated pest management principles: Design and implement integrated pest management strategies that incorporate multiple control methods, including chemical, biological, physical, and cultural controls.

- Use surveillance data for pest management decision-making: Collect and analyze surveillance data to inform pest management decisions, and understand the importance of monitoring pest populations and activity.
- Select and apply appropriate pest control methods: Choose and apply effective pest control methods, including chemical, biological, physical, and cultural controls, and understand their advantages and limitations.
- Understand the importance of personal protective equipment (PPE) and other prevention methods: Recognize the importance of PPE and other prevention methods in preventing pest-borne diseases, and understand how to use them effectively.
- Communicate effectively about pest management: Communicate effectively with various stakeholders, including the public, healthcare professionals, and animal owners, about pest management strategies and risks.

Theory **30 h**

Unit-1: Introduction **4 h**

Definitive host, Intermediate host, Parasitism, Ecto- & Endoparasites of skin, Symbiosis, Commensalism, Reservoir, Zoonosis.

Unit- 2: Medically important insect pests **8 h**

Mosquitoes: Anopheles, Culex, Aedes. Rat Flea, Head and body louse, Bed bug, Sand fly Insect, Endoparasites (*Dermatobia hominis and Calliphoridae*)

Unit- 3: Transmission and control of various pathogens and insect vectors **12 h**

Plasmodium vivax, Trypanosoma gambiense; Wuchereria bancrofti, Dengue virus**.** Control of insect vectors of public health. Management of vector borne diseases by Integrated Vector Management.

Unit-4: Veterinary Insect Pests, their life cycle, transmission and control of diseases **6 h**

Flies, Mosquitoes, Ticks, Fleas, Lice and Mites

Practicals **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Field collection of immature stages of mosquitoes and preparation of temporary slides.
2. Study of ~~few~~ available pathogens of arthropod-borne diseases. Malaria, Culex, Dengue
3. Study of different mosquitoes through photographs

4. Study of life history stages of medically important arthropods by using slides/ photographs: Flies, Ticks, Fleas, Lice and Mites
5. Visit any Vector borne disease lab or carry out a survey of breeding places of Vectors and make a report on your visit/ survey

Suggested Readings:

1. Mullen, Gary R. and Durden, Lance A. (2019). Medical and Veterinary Entomology. Elsevier ; 3rd Edition. ISBN 978-0-12-814043-7
2. Ramnik. Sood (2009) Medical Laboratory Technology Methods and Interpretations, 6th edition; Jaypee Brothers Medical Publishers, ISBN-13: 978-8184484496.
3. Robbins, Basic Pathology, 9th edition (2012), Kumar, Abbas, Fausto and Mitchell; Saunders Publication, ISBN-13: 978-1437717815

Additional Resources:

1. UGC INFONET / DU E-Resources & Sci Finder Web Version registration
2. Arora, D.R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 11**

LOCUSTS AND THEIR MANAGEMENT

Credits 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	Practicals/ Practice		
Locusts and their Management **ALS ZOO DSE 11**	**4**	**2**	**Nil**	**2**	Appeared in Sem-VII	**NA**

Learning Objectives:

The learning objectives of this course are as follows:

- The course aims to apprise the students of locust as one of the most dangerous pests of agricultural crops.
- To focus on identification of locust, reasons of their swarming and migratory nature which gives immense economic loss leading to national emergency of food and fodder.
- To provide knowledge about the control, monitoring and management strategies of locust.

Learning Outcomes:

By studying this course, students will be able to:

- learn about the importance of locust as serious pest that cause damage to the agro-ecosystems affecting the economy.
- learn about the habit, habitat, behaviour, morphology and different phases of locust.
- learn about the biology of locust and various methods of its control.

Theory: **30 h**

Unit 1: Introduction to Locusts **7 h**

Introduction, historical background, locust plague and upsurges, Systematic position of locusts and grasshoppers; habitat, behaviour and morphology of locusts. Difference between locusts and grasshoppers.

Unit 2: Distribution, life cycle of Locusts in India **6 h**

Locusts in India, distribution, life cycle of different species: *Schistocerca gregaria, Patanga succincta, Locusta migratoria;* damage caused by them.

Unit 3: Breeding of Locusts **5 h**

Breeding seasons and breeding areas, swarming. Biological phases: solitary, transient and gregarious. Changes in their behavior, color and structure. Biotic theory of periodicity.

Unit 4: Locust management **12h**

National and international organizations - LWO, SALO, CALO, FAO, NLCC, IRLCO-CSA (International Red Locust Control Organization for Central and Southern Africa), swarm monitoring. Control methods- Mechanical and traditional, regulatory practices,Chemical methods: ULV Sprays, dusting, baits, IGRs; advantages and disadvantages of different chemical control methods, biological practices: biopesticides, predators, parasitoids; Integrated Pest Management; Plant quarantine. Socio-Economic importance: Impact on the health of fauna and humans; on agriculture.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Comparative study of different species of locusts through specimens /photographs.
2. Study of mouthparts, wings and legs of locust through specimens /photographs.
3. Study of sexual dimorphism in locust through specimens/photographs.
4. Study the life stages of the locust through specimens/slides/photographs.
5. Study of different tools used in the management of locust.
6. Study of different host plants of locust.
7. Visit to different institutes/stations/laboratories (submit a Report on visit/current status of locusts in India).

Essential/recommended readings

1. Ritchie, J. M., &Dobson, H. (1995).*Desert Locust, control operations and their environmental impact*. NRI bulletin 67, Hopps the printers Ltd.
2. Atwal, A. S.; &Dhaliwal, G. S. (2015). *Agricultural pest South Asia and their management* (8th Ed.). Kalyani publishers.
3. Pradhan, S. (2016). *Agricultural Entomology and Pest Control*. ICAR publication.
4. Pandey & Kumari R. (2021) *Locust in Indian Agriculture*. Notion press India.

Suggested readings

1. Rachadi, Tahar (2010). *Locust control handbook*. CTA publication, AJ Wagningen, The

Netherlands.
2. Krall, S; Peveling, R & Diallo, D. Ba. (1997).*New strategies in Locust Control*. Pirahauser Basel springer.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 12**

PATHOGENS OF INSECTS IN PEST MANAGEMENT

Credits 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	Practicals / Practice		
Pathogens of Insects in Pest Management **ALS ZOO DSE 12**	**4**	**2**	**Nil**	**2**	**Appeared in Sem-VII**	NA

Learning Objectives:

The learning objectives of this course are as follows:

- to provide knowledge about the basic pathogens infecting insects.
- To understand Epizootiology, symptomatology and etiology of diseases caused by various agents.
- To promote use of environmentally friendly pest Control

Learning Outcomes:

By studying this course, students will be able to:

- Describe the nature and diversity of pathogens infecting insects, including viruses, bacteria, fungi, protozoa, and nematodes.
- Identify and classify different insect pathogens based on their biology, morphology, and mode of action.
- Assess the potential of entomopathogens as biological control agents in sustainable pest management.
- Advocate the use of insect pathogens as alternatives to chemical pesticides in promoting environmentally friendly pest control:

Theory **30 h**

Unit 1: Introduction to Insect Pathogens **6 h**

History of insect pathology, Classification of Insect Pathogens, infection of insects by bacteria, fungi, viruses, protozoa, rickettsia , spiroplasma and nematodes.

Unit 2: Etiology of Diseases and Defense systems **10 h**

Epizootiology, symptomatology and etiology of diseases caused by the Insect Pathogens and the controlling factors. Defense mechanisms in insects against pathogens.

Unit 3: Control of Pests **10 h**

Exploitation of Bacteria (Bacillus thuringiensis) and Viruses (Nuclear Polyhedrosis Viruses) for control of pests: Management and mass production techniques.

Unit 4: Sustainable Pest Control **4 h**

Safety and registration of microbial pesticides. Role of insect pathogens in Sustainable Pest Control.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Equipments used in insect laboratory.
2. Identification of different groups of insect pathogens and symptoms of infection.
3. To study symptomatology and etiology of diseases caused by bacteria, fungi, viruses, protozoa, rickettsia, spiroplasma and nematodes with the help of photographs.
4. Isolation, culturing and testing pathogenicity of different groups of pathogens.
5. Testing Koch's postulates. Estimation of pathogen load.
6. Extraction of pathogens from live organisms and soil.

Essential/recommended readings

1. Boucias DG & Pendland JC. 1998. Principles of Insect Pathology. Kluwer Academic Publisher, Norwel.
2. Nitesh Kumar Maru, Ashwani Kumar, and Sunil Zachariah. Insect pathology: Text Book and Practicals Manual**.** Scientific Publisher, New Delhi.
3. Steinhaus EA. 1984. Principles of Insect Pathology. Academic Press, London.

Suggested readings

1. Yoshinori Tanada and Harry K. Kaya. **Insect Pathology** Academic Press.London.
2. Burges HD & Hussey NW. (Eds). 1971. Microbial Control of Insects and Mites. Academic Press, London.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 13**

Insect Toxicology

Credits 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	Practicals/ Practice		
Toxicology of Pests **ALS ZOO DSE 13**	**4**	**2**	**nil**	**2**	**Appeared in Sem-VII**	NA

Learning Objectives:

Learning objectives of this course are as follows:

- To impart knowledge about the biological effects of toxic chemicals on insects.
- To emphasize on factors affecting toxicity of insecticides and synergistic substances which can be used to increase their efficacy.
- To enable students to understand the development of resistance in insects to insecticides.

Learning Outcomes:

By studying this course, students will be able to:

- learn about the principles of insecticide toxicity
- understand the safe use of toxic insecticides as well as treatments for insecticide poisoning.
- acquire Practicals skills of pest management in public buildings like termite proofing, rodent control.

Theory **30h**

Unit 1. Introduction to Toxicology **4h**

History of chemical control, Pesticides registration, Pesticide industries and markets.

Unit 2. Principles of Toxicology **10h**

Evaluation of insecticide toxicity: LC50/ LD50, ED50, LT50 etc, Tolerance limits, ADI value, Bioaccumulation; Joint action of insecticides: synergism, potentiation, antagonism, Insecticide compatibility, selectivity and Phytotoxicity, Factors affecting toxicity of insecticides.

Unit 3. Pesticide metabolism **8 h**

Mode of entry of pesticides: I, F, W Insecticides and their metabolism - phase I and phase II pathways, Pest resistance to insecticides; Mechanisms and types of resistance; Diagnosis and treatment of insecticide poisoning, Health hazards: carcinogenic, mutagenic and teratogenic effects.

Unit 4. Pest Management in Residential and Public Places **8 h**

Principles and methods of pest management in residential places and public buildings, Insecticides for domestic use and their safety, Pre and post-construction termite proofing of buildings, Appliances for domestic pest control; Organic methods of domestic pest management.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. To calculate LD50/ED50/LT50 of an insecticide from data provided.
2. To study the equipment used for spraying and dusting of insecticide**s.**
3. Metabolism of insecticides in insects using TLC
4. Pesticide residues analysis of soil samples by soxhlet extraction method
5. Video Demonstration of Gas chromatography/ HPLC.
6 Project Report on visit to IARI, IPFT, Hindustan Insecticides Ltd., FCI complex, etc.

Suggested Readings:

1. Ishaaya, I., & Degheele, (Eds.). (1998). *Insecticides with Novel Modes of Action.* Narosa Publication. House.
2. Matsumura, F. (1985). *Toxicology of Insecticides*. Plenum Press.
3. Perry, A.S., Yamamoto, I., Ishaaya, I., &Perry, R. (1998). *Insecticides in Agriculture and Environment.* Narosa Publication. House.
4. Prakash, A., & Rao, J. (1997). *Botanical Pesticides in Agriculture.* Lewis Publication.

Additional Readings:

1. Greim, H., & Snyder, R. (ed)., (2018). *Toxicology and Risk Assessment: A Comprehensive Introduction.* John Wiley and Sons.
2. Whitford, F. (2002). *The Complete Book of Pesticide Management.* Wiley Interscience, John Wiley and Sons.
3. Chattopadhyay, S.B. (1985). *Principles and Procedures of Plant Protection.* Oxford & IBH.
4. Gupta, H. C. L. (1999). *Insecticides: Toxicology and Uses.* Agrotech. Publication.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE: **ALS ZOO DSE 14**

Application of Biotechnology for Pest Management

Credits 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**	**Practicals / Practice**		
Application of Biotechnology for Pests-Management **ALS ZOO DSE 14**	**2**	**1**	**Nil**	**1**	**Appeared in Sem-VII**	NA

Learning Objectives:

Learning objectives of this course are as follows:

- To provide knowledge about alternative measures to traditional pest management practices against insects.
- To learn about various tools and techniques of biotechnology used for controlling insect pests.

Learning Outcomes:

By studying this course, students will be able to:

- distinguish between various types of pests and the damage they cause to their host plants.
- acquire the skill to use important tools and techniques of biotechnology for management of pests.

Theory **30h**

Unit 1: Introduction to eukaryotic cell culture **4 h**

Introduction to eukaryotic cell culture; Historical background, Biology of animal cell and cell-cell interactions, good laboratory practices, Sterilization methods and techniques. Isolation of the tissue, Initiation of culture: Types of primary culture. Subculture and cell lines;

Unit 2: Media and Buffers **6 h**

Types of culture media, Physicochemical characteristics of medium-Osmolality, Temperature, Viscosity and Surface Tension. Importance of Serum and Serum-free media, Antibiotics and other supplements.

Unit 3: Advanced Cell culture techniques **15 h**

Principles of cryopreservation of cell lines. Methodology of production of chimeric DNA, I*n vitro* transfection of animal cells-chemical method, lipid mediated gene transfer (lipofection), Electroporation. Microbial contaminants (Bacteria, Yeast, Fungi, Mycoplasma and Virus) in cell line. Applications of Animal Cell Culture: Toxicology studies, Vaccine production, Gene therapy, Stem cell therapy, Production of recombinant proteins, Derived benefits from DNA barcode-based molecular taxonomy, Use of biotechnology for insect pest management

Unit 4: Challenges and Technologies for Pest management **5 h**

International project on barcode of life, Host–plant resistance: mechanism of resistance-antibiosis, antixenosis, tolerance, factors mediating resistance. Transgenic mosquito**,** Genetic control through sterile insect techniques.

Practicals **60 h**

(Laboratory periods: 15 classes of 4 hours each)

1. Packing and sterilization of glassware and plasticware for cell culture.
2. Preparation and sterilization of culture medium, buffers and solutions.
3. To study about cytotoxicity and cell viability.
4. Demonstration of Transfection in cell lines using Photographs/Videos.
5. Demonstration of working of the following instruments:

i) Laminar Flow Hood ii) Autoclave iii) Humidified CO_2 Incubator iv) pH Meter.

6. Project report on visit to animal cell culture labs

Essential/recommended readings

1. Freshney, R. IAN. (2021). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (8th Ed.).
2. Masters, John. R. W. (2000). Animal Cell Culture: A Practicals Approach (3rd Ed.).
3. Butler, M. (2003). Animal Cell Culture and Technology. (2nd Ed.).

Suggested readings

1. Davis, John. M. (2011). Animal Cell Culture: Essential Methods.
2. Bhatt, Sheelendra. M. (2011). Animal Cell Culture: Concept and Application.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER VII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VII

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23

Department of Botany
Courses offered in B.Sc. Applied Life Science with Agrochemicals and Pest Management

SEMESTER –VII

(Under UGCF-2022 based on NEP-2020)

Index

*These courses are already approved.

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
		Lecture	Tutorial	Practical/ Practice		
Plant Tissue Culture ALS-DSE 7	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objectives

To give students knowledge of techniques used in plant tissue culture and its applications.

Learning Outcomes

The successful students will be able to:

- learn the basic concepts, principles and processes in plant cell and tissue culture.
- understand the use of tissue culture techniques in plant improvement.
- apply the concepts and principles of plant cell and tissue culture in biotechnological and agricultural fields.
- become an entrepreneur by establishing their own plant tissue culture lab.

Theory; 30 Hours

Unit 1 Introduction **08 Hours**

Historical perspective, Important contributions of Haberlandt, White, Reinert & Steward, Murashige, Skoog, Cocking, Guha & Maheshwari, Morrel & Martin. Terminologies: Cell culture,organ culture, explant, callus, totipotency, plasticity, regeneration, somaclonal variants. Role of nutrients, vitamins, hormones and supplements in nutrient medium. Composition of MS and White medium.

Unit 2 Techniques of Plant Tissue Culture **08 Hours**

Collection of plant material, sterilization of tissue (maintenance of aseptic conditions by use of autoclave and laminar flow chamber), filter sterilization, inoculation. Protoplast isolation (mechanical and enzymatic), culture, purification (viability test) and fusion (spontaneous, induced), selection of fused protoplasts, applications

Unit 3 Micropropagation **05 Hours**

Selection of plant material and suitable explant, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis, difference between somatic and zygotic embryos.

Unit 4 Tissue culture applications **09 Hours**

Anther culture, Production of haploids, triploids and cybrids, artificial seeds (production & advantages), embryo rescue, virus elimination, secondary metabolite production; Cryopreservation; Germplasm conservation. Novel sources of variation.

Practicals **60 Hours**

- To study the equipment used in tissue culture: autoclave and laminar air flow chamber.
- Preparation of Murashige & Skoog's (MS) medium.
- Demonstration of sterilization and inoculation methods using leaf

and nodal explants of tobacco, carrot, *Datura*, *Brassica* etc. (any two).
- Study of anther, embryo and endosperm culture.
- Study of micropropagation, somatic embryogenesis & artificial seeds.
- Isolation of protoplasts.
- Visit to a plant tissue culture laboratory and submission of field report.

Suggested Readings:

- Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
- Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
- Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
- Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
- Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer

Additional Resources:

- Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
- Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
- Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition
- {Elsevier}
- Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
- Trigiano, R. N. (2011). Plant Tissue Culture, Development, and Biotechnology CRC Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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
		Lecture	Tutorial	Practical/ Practice		
Applied Phycology ALS-DSE 5	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objective:

To gain knowledge about diversity, life forms, life cycles, morphology and economic importance of algae.

Learning Outcomes:

On completion of the course the students will be able to understand:

- use of algae for environment, human welfare and industries.
- algal culture techniques and their commercial production

Theory : 30 Hours

Unit 1: Scope of phycology **09 hour**

In emerging research areas, environment and industries. Nutritional value of algae; Common edible algae; Algae as food, feed and fodder with suitable examples. Phycocolloids (Agar-agar, Alginic acid and Carrageenan) and secondary metabolites: Sources and Applications; Pharmaceutical and Nutraceutical uses of algae; Algae in cosmetics; Diatomaceous Earth.

Unit 2: Algae in agriculture and environment **09 hours**

Algae as soil conditioners and biofertilizers; Seaweed liquid extract; Seaweed powder; Algal biorefinery residues. Algae as pollution indicators; wasteland reclamation; Role of algae in wastewater treatment; Ecological importance of Symbiotic associations of algae; Harmful algal blooms; Red tides; Algal toxins.

Unit 3: Algae in biotechnology and research **08 Hours**

Gene sequencing and algal systematics; Algae as a model organism (Chlamydomonas, Chlorella, Acetabularia, Ectocarpus,Porphyra); Bioluminescent forms; Algae in nanotechnology. Biofuels (Bioethanol, Biodiesel, Biohydrogen); Algal Biorefinery.

Unit 4: Algal culture techniques and commercial production **04 Hours** Isolation, purification and sterilisation of algae; Freshwater and marine culture media (BG-11 and Provasoli ES medium); Photobioreactors and large-scale production of microalgae; Seaweed farming.

Practicals **60 hours**

1. Isolation and identification of algal species (any three) in water samples from polluted and non-polluted sources through temporary mounts.
2. Nutritional analysis (protein and carbohydrates) of *Spirulina/ Chlorella/* anyother available edible algae.
3. Study of algal symbiosis (*Azolla* fronds) through sectioning or tease mount.
4. Phycocolloid (Agar-agar/ Alginates/ Carrageenan) extraction (demonstration/ digital resources).
5. Microalgal culture - maintain cultures of species isolated in Experiment 1(any three).
6. Commercial applications of algae through photographs/products (edible, cosmetics, biofuels, pharmaceutical, nutraceutical, phyco-remediation).
7. Study of algae as a model organism (any 2) through digital resources.
8. Project work on any applied aspect of algae/ Visit to any Institute or Industry (Report to be submitted).

Suggested Readings:

1. Bold, H.C. and Wynne, M.J. (1985) Introduction to the Algae: Structure and Reproduction, 2nd edition. Prentice-Hall International INC.
2. Chapman, D.J. and Chapman, V.J. (1980) Seaweeds and their uses. 3rdedn. British Library.
3. Kumar, H.D. (1999) Introductory Phycology, 2nd edition. Affiliated East-West Press, New Delhi.
4. Lee, R.E. (2008) Phycology, 4th edition: Cambridge University Press, Cambridge.
5. Sahoo, D. (2000) Farming the Ocean*:* Seaweed Cultivation and Utilization. Aravali Book International, New Delhi.

Additional Resources:

1. Andersen, R.A. (2005) Algal Culturing Techniques. Elsevier Academic Press.
2. Chapman, D.J. and Chapman, V.J. (1973) The Algae. 2ndedn. Macmillan, London.
3. Fleurence, J. and Levine, I. (2016) Seaweed in Health and Disease Prevention. Academic Press publications.
4. Sahoo, D (2010). Common seaweeds of India. IK International Pvt Ltd.
5. Sahoo, D. and Seckbach, J. (2015) The Algae World. Vol 26 Cellular Origin, Life in Extreme Habitats and Astrobiology. Springer, Dordrecht.
6. Van den Hoek, C. Mann, D.G. and Jahans H.M. (1995) Algae: An Introduction to Phycology. Cambridge University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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 and Environmental Microbiology ALS-DSE 6	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objectives:

- To introduce students to the concepts, principles, scope and applications of industrial and environmental microbiology.

Learning Outcomes:

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

- understand how microbiology is applied in manufacturing of industrial products
- know about design of bioreactors
- understand the rationale in medium formulation, design for microbial fermentation, sterilization of medium and air
- comprehend the techniques and the underlying principles in upstream and down-stream processing
- learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
- understand the basic principles of environment microbiology and application of the same in solving environmental problems - waste water treatment and bioremediation
- comprehend the various methods to determine the quality of water

Theory : 30 Hours

Unit 1: Microbes and quality of environment **04 Hours** Introduction and scope of microbes in industry and environment; Distribution and isolation of microorganisms from soil, air and water.

Unit 2: Bioreactors/Fermenters and fermentation processes **08 Hours** Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors:

laboratory, pilot scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit 3: Microbial production of industrial products 10 Hours

Microorganisms generally regarded as safe (GRAS); Downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization; Production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)

Unit 4: Industrial and Environmental Applications 08 Hours

Applications of industrially important enzymes (protease, lipase, and penicillin acylase); Methods of immobilization and its advantages. Water pollution: various sources and control measures; Role of microbes in sewage and domestic wastewater treatment systems. Microorganisms as indicators of water quality: coliforms and faecal coliforms.

Practicals 60 Hours

1. Principles and functioning of instruments: autoclave, laminar air flow, incubators, types of fermenters.
2. Preparation of different culture media (Nutrient medium/ LuriaBertani medium/Potato dextrose medium/Czapek Dox medium).
3. Hydrolysis of casein andstarch by microorganisms.
4. Alcohol production by yeast using sugar/ jaggery.
5. Serial dilution method for isolation of microorganisms from water and soil and study of aero-microflora.
6. To determine the BOD of sewage water.
7. To qualitatively check the enzyme activity (phosphatase/amylase/cellulase) in soil samples.
8. To determine the microbial activity in soil by Triphenyltetrazolium chloride (TTC) assay or by measuring the CO_2 evolution.
9. Determination of coliforms in water samples using eosin methylene blue (EMB) medium.
10. Visit to any educational institute/ industry and a report to be submitted

Suggested Readings:

1. Bertrand, Jean-Claude, Caumette, P., Lebaron, P, Matheron, R., Normand, P., Sime• Ngando, T. (2015). Environmental Microbiology: Fundamentals and Applications. Amesterdam, Netherlands, Springer.
2. Joe, S., Sukesh (2010). Industrial Microbiology. S.Chand& Company Pvt. Ltd. New Delhi, Delhi.

3. Mohapatra.P.K. (2008). Textbook of Environmental Microbiology. I.K. International Publishing House Pvt.Ltd. New Delhi, Delhi.
4. Okafer, Nduka (2007). Modern Industrial Microbiology & Biotechnology. Science Pubishers, Enfield, NH, USA.
5. Pelzar, M.J. Jr., Chan E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. New Delhi, Delhi: McGraw Hill Education Pvt. Ltd., Delhi.

Additional Resources:

1. Alef K, and Nannipieri P (1995). Methods in Applied Soil Microbiology and Biochemistry, First Edition Academic Press, USA.
2. Atlas, Bartha. (1997). Microbial Ecology: Fundamentals and Applications. San Fransisco, SF. Pearson.
3. Casida, J.R. (2016). Industrial Microbiology. New Delhi, Delhi, New Age International Publishers.
4. Hurst C.J., Crowford R.L., Garland J.L. and Lipson D.A. (2007). Manual of Environmental Microbiology, American Society of Microbiology, USA.
5. Patel, A.H. (2008). Industrial Microbiology, Bangalore, India: McMillan India Limited.
6. Sharma, P.D.(2005). Environmental Microbiology. Meerut, UP: Alpha Science International, Ltd.
7. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016). Principles of Fermentation Technology. Amesterdam, NDL:Elsevier Publication.
8. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology (9th edition). San Francisco, SF: Pearson Benjamin Cummings.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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
		Lecture	Tutorial	Practical / Practice		
Natural Resource Management **ALS-DSE 7**	4	2	0	2	**VI Sem**	**Nil**

Course Learning Objectives:

Natural Resources are materials from earth which support life and significantly meet the needs of people. The paper aims to describe the different types of natural resources and their management. Students will study about the importance of each natural resource and how and why they are threatened in current times. They will also be taught about sustainably using our resources

Learning outcomes: At the end of this course, students will be able to:

- understand the different resources available in nature
- learn the importance of each resource along with the threats to these resources
- gain an in-depth understanding of management of these resources and restoration of natural ecosystems
- study the importance of sustainable practices
- gain an insight into various initiatives taken the world over to save our natural resources.
- understand the concept of clean energy and management of waste

Theory 30 Hours

Unit 1: Natural Resources and Sustainable Utilization **05 Hours**

Definition, fundamental concepts and types, Concept, Goals, Approaches (economic, ecological, socio-cultural)

Unit 2: Land and Water Resources **10 Hours**

Forests (definition, threats, management); Agricultural practices and their impact; Soil degradation (causes, management and remediation/restoration strategies), Freshwater, Marine, Estuarine, Wetlands – Threats and Management

Unit 3: Biological Resources and Energy **05 Hours**

Biodiversity – Levels, Significance, Threats, Management, Clean energy strategies – Solar, Wind, Hydro, Tidal, Geo-thermal, Bio-energy

Unit 4: Climate Change, Contemporary practices and National and International Initiatives **10 Hours**

Impact, adaptation and mitigation (Land, Soil, Water, Biodiversity, Air), EIA, GIS, Energy Audits, Waste Management, Ecosystem Restoration, Carbon footprint, International Solar Alliance; Ramsar Convention; Basel Convention; Carbon Neutral Goals; Net- zero Coalition; Clean Development Mechanism; CAMPA (Compensatory Afforestation Fund Management and Planning Authority); Carbon Credits; REDD+ project, Renewable Energy Certificates

Practicals: **60 Hours**

- Comparison of pH (pH meter) and salinity (Electrical Conductivity) of various soil samples.
- Comparison of field capacity of various soil samples.
- Comparison of pH (pH meter) and TDS (TDS meter) of various water samples.
- Comparison of salinity (titrimetric method) of various water samples.
- Calculation and comparison of BOD and COD of various water samples from given data.
- Comparison of species diversity in various communities by Shannon-Wiener Index.
- Measurement of dominance of woody species by DBH method in the college campus.
- Project (any one of the following):
  a. Rainwater harvesting (site visit)
  b. Ecological restoration (site visit)
  c. Energy audit
  d. Seed germination and seedling growth in garden and contaminated soils
  e. Composting
  f. Any other
- Field visit/s to any degraded ecosystem (landfill, polluted water body, invaded forest) or any ongoing restoration project site.

Suggestive readings:

- Vasudevan, N. (2006). Essentials of Environmental Science. New Delhi, India: Narosa Publishing House.
- Singh, J. S., Singh, S.P. and Gupta, S.R. (2006). Ecology, Environment and Resource
- Conservation. New Delhi, India: Anamaya Publications.
- Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. New Delhi, India: Prentice Hall of India Private Limited.

- Jordan III, W. R., Gilpin, M. E., Aber, J. D. (1987). Restoration Ecology: a synthetic approach to ecological research. Cambridge, Great Britain: Cambridge University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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		
Intellectual Property Rights ALS-DSE 8	4	**2**	**0**	**2**	**VI Sem**	Nil

Course learning Objectives

The objective of this course is to impart knowledge of rules, regulations, laws and processes of patents. Besides this, students will have adequate knowledge of copyrights, trademarks and shall be thorough with the importance of traditional knowledge and protection of plant varieties.

Learning outcomes:

After studying this course, the students of Life Sciences will be well-equipped and well informed with the basics of IPR. Especially IPR in India. Students will be informed about the Patents that are integral to research. Students will have working Knowledge of various softwares and will be morally and ethically aware of the rights of the farmers, breeders and researchers.

Theory : 30 Hours

Unit 1: Introduction to Intellectual Property Rights (IPR) 03Hours

Concept and types; economic importance, IPR in India and world, Genesis and scope, some important examples: IPR and WTO (TRIPS, WIPO).

Unit 2: Patents, Copyrights and Trademarks 09 Hours

Objectives, Rights, Patent Act 1970 and its amendments. Procedure of filing and getting Patents, Patent Infringement, Introduction, Work protected under copyright law, Rights, Transfer of copyright, Copy right Infringement, Objectives, Types, Rights, Protection of Goodwill, Infringement, Passing off, Defenses, Domain name

Unit 3: Geographical Indications, Traditional Knowledge Protection and Industrial Design

09 Hours

Objectives, Justification, International Position, Multilateral Treaties, National Level, Position of Govt. of India, Objectives Concept of Traditional Knowledge, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, Need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO at National level, Traditional Knowledge Digital Library (TKDL), Objectives, Rights, Assignments, Infringements, Defenses of Design Infringement

Unit 4: Protection of Plant Varieties, IPR and Biotechnology

09 Hours

Plant Varieties Protection- Objectives, Justification, International Position, Plant varieties Protection in India. Rights of Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues related to farmers, breeders and researchers. National Gene Bank, Benefit sharing. Protection of Plant Varieties and Farmer's Rights Act, 2001, Computer Softwares and Intellectual Property, Database and Data Protection, Domain Name Protection, Patenting Biological/Biotechnological Inventions

Practicals: **60 Hours**

1. Patent search from different website.
2. Trademark search
3. Copyright infringement (Plagiarism check by Urkund and other available software.
4. Geographical Indicators: (Preparation of Inventories)
   Food- Malabar pepper, Basmati rice, Darjeeling Tea, and Requefort cheese.
   Industry- (Mysore agarbatti, Feni Goa, Champagne France).
   Natural Resources- Sandalwood
5. Biopiracy- Neem,Turmeric
6. Industrial designs- Jewelry design, chair design, car design,
7. To prepare IPR e diary.

Suggested Readings:

- M.M.S. Karki (2009) Intellectual Property Rights: Basic Concepts. Atlantic Publishers & Distributors (P) Ltd. ISBN13: 9788126912629.
- Rajeev Babel (2023) Intellectual Property Rights in India | Bloomsbury Publications. Publisher Bloomsburry Publication.
- S.V. Damodar Reddy (2024) Intellectual Property Rights -- Law and Practice. Asia Law House. ISBN: 9788119107483.
- JP Misra (2023) An Introduction to Intellectual Property Rights 3rd Edition. Central Law Publication, India

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Stress Physiology: Concepts and Strategies **ALS-DSE 9**	**4**	**2**	**0**	**2**	**VI Sem**	**Nil**

Course Learning Objectives:

This course explores the physiological, biochemical, and molecular mechanisms by which plants respond to environmental stresses. It covers abiotic and biotic stress factors, their impact on plant growth and development, and adaptive mechanisms to mitigate stress effects. The course also introduces strategies for improving stress tolerance in crops.

Learning Outcomes:

At the end of this course students will be able to:

- Identify different types of plant stresses and their effects on plant physiology.
- Understand the molecular and biochemical responses of plants to stress.
- Analyze plant adaptation and tolerance mechanisms under stress conditions.
- Explore strategies to enhance plant resilience against environmental challenges.
- Apply knowledge of plant stress biology in agricultural and environmental contexts.

Theory : 30 Hours

Unit 1: Introduction to Plant Stress Physiology **02 Hours**

Types (abiotic and biotic), Perception, Acclimation vs Adaptation, Phenotypic plasticity.

Unit 2: Abiotic and Biotic Stress **12 Hours**

Drought stress- Physiological and Biochemical responses, Resistance or Tolerance mechanisms
Salinity- Osmotic and Cytotoxic effects, Ion homeostasis, Salt-tolerant mechanisms: Developmental and Physiological protective mechanisms – exclusion vs tolerance, Osmoprotectants, Ion transporters, Compatible solutes- glycine betaine, proline
Temperature - Cold and heat stress (in brief)
Stress caused by Pathogens, Herbivores, Parasitic plants and Weeds, Susceptibility and Resistance, PR proteins, Pattern-triggered immunity and Effector triggered immunity.

Unit 3: Stress Sensing, Signaling and Tolerance Mechanisms 14 Hours

Hormonal regulation (Abscisic acid, Jasmonic acid, Salicylic acid), Reactive Oxygen Species and Nitrous Oxide, Salt Overly Sensitive pathway, Late embryogenesis abundant proteins (LEA), Antioxidant enzymes (Superoxide dismutase, Catalase, Peroxidase), Osmolytes, Secondary metabolites (Alkaloids, phenolics and terpenoids), Chaperones (Heat Shock Proteins), Cryoprotectants, Phytoalexins

Unit 4: Crop Improvement Strategies 0**2 Hours**

Traditional plant breeding (Mutation breeding, Protected cultivation) and Biotechnological approaches (brief account of stress tolerant genetically engineered plants).

Practicals: 60 hours

- To study the effect of salt stress on seed germination (percentage, plant shoot and root length).
- To study the effect of stress (anyone) on chlorophyll content.
- To determine electrolyte leakage in stressed plants.
- To determine SOD or peroxidase enzyme activity in control and stress plants.
- Study of plant adaptations under stress (Stomatal closure, Leaf curling, Root elongation, Stunted plant growth, Wilting) (through photographs).
- To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile (through photographs).
- Effect of stress on plant membranes (photographs).
- Effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, apple scab, SAR) (through photographs).

Suggested Readings:

- Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
- Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.
- Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.
- Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John wiley & sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER VIII

UNIVERSITY OF DELHI

COURSES OFFERED BY DEPARTMENT OF BOTANY FOR SEMESTER-VIII

Under UGCF-2022 based on NEP-2020 (Effective from Academic Year 2022-23)

Department of Botany

Courses offered in B.Sc. Applied Life Science with Agrochemicals and Pest Management

SEMESTER –VIII

(Under UGCF-2022 based on NEP-2020)

Index

*These courses are already approved.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credit s	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Agriculture Botany and Weed Management ALS-DSC 8	**4**	**2**	**0**	**2**	**Sem VII**	**Nil**

Course Learning Objectives

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

- Explain the role of plants in agricultural systems and the impact of plant characteristics on crop productivity and adaptation.
- Identify major weeds affecting crop production and understand their biological and ecological characteristics.
- Analyze interactions between crops and weeds and their effects on yield and quality.
- Evaluate weed management strategies, both conventional and modern.
- Apply botanical knowledge to solve practical problems in crop and weed management.

Learning Outcomes

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

- Describe plant structures and functions essential for crop growth and development.
- Explain physiological processes and their relevance to crop productivity.
- Critically assess various weed control methods, including herbicide classification and mode of action.
- Design integrated weed management plans suited to specific cropping systems and ecological conditions.

Theory : 30 Hours

Unit 1 Seed Physiology and Physiology of Growth and Yield 09 hours

Seed dormancy, types, factors causing dormancy, mechanism and methods for breaking seed dormancy, seed viability and seed vigour, Principal of growth analysis, source-sink relationship, factors affecting growth, dry matter partitioning and yield, crop simulations and modeling, use of controlled environment for plant growth and development studies.

Unit 2: Plant Hormone and Reproductive Physiology 10 Hours

Role of hormones in plant growth and development, commercial applications of growth regulators, growth retardant and its usefulness, Photoperiodism, flowering response, photo perception, critical photoperiod, photo-induction, phytochrome and its role in flowering, vernalization, physiology of fruit ripening, and senescence.

Unit 3: Biology of Weeds and Weed Management Practices 04 Hours

Ecology of weeds, competition, reproduction of weeds, Mechanical Practices, Cultural Practices, Biological control.

Unit 4: Weed Control Methods 07 Hours

Herbicide classification, Selectivity of herbicides, absorption and translocation of herbicides, Mode of action of herbicides, Detoxification mechanisms of herbicides. Weed resistance to herbicides, weed control in wheat, rice and vegetable crops. Control of five obnoxious weeds.

Practical : 60 Hours

- To study opening and closing of stomata.
- To determine stomatal index of the given leaf.
- To study the effect of ethylene on shelf life of cut flowers.
- To study the effect of cytokinin on leaf senescence.
- To study effect of heavy metals on growth and development.
- To test the viability of weed seeds.
- To evaluate the allelopathic effects of weeds on germination of crop seeds.
- To evaluate effect of herbicides on seed germination and seedling growth of weeds.

Suggested Readings:

1. Taiz, L. & Zeiger, E. 2006 Plant Physiology (5th edition) Sinauer Associates, Inc. Sunderland,
2. M.A.W.G. Hopkins (2009) Introduction to plant physiology, John Wiley and Sons Inc USA.
3. Mandal, R.C. (2010) Weeds, weedicides and weed control: Principle and Practice Agro Botanical Publishers, Delhi
4. Das TK (2011) Weed Science: Basics and Applications JPublisher ai Brothers
5. F. M. Ashton and T. J. Monaco (2002) *Weed Science: Principles and Practices*. John Wiley and Sons. Inc.
6. V. S. Rao (2002) *Principles of Weed Science.* Oxford and IBH Publishers, New Delhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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
		Lecture	Tutorial	Practical/ Practice		
Biofertilizers ALS-DSE 10	4	2		2	7^{Th} Sem	**Nil**

Course Learning Objectives:

The Learning Objectives of this course are as follows:

- To develop an understanding of biological systems used as fertilizers and build skills in handling microbial inoculants.
- To understand the optimum conditions for growth and multiplication of useful microbes such as *Rhizobium*, cyanobacteria, mycorrhizae, *Azotobacter* etc.
- To understand the role of microbes in mineral cycling and nutrition of plants.
- To gain expertise in various methods of decomposition of biodegradable waste, conversion into compost and apply this knowledge and skill in their daily life.

Learning outcomes

On successful completion of this course, a student will be able to:

- visualize and identify different types of microorganisms with a compound microscope.
- understand the classification of microorganisms according to their shape/ structure for morphological identification. Prepare and sterilize different types of culture media.
- isolate of microorganisms from the environmental samples and culture in aseptic conditions.

Theory : 30 Hours

Unit 1: Introduction **08 hours**

Introduction to microbial inoculants or biofertilizers, macro and micro nutrition of plants, chemical fertilizers versus biofertilizers; Role of seaweed liquid fertilizers, Methods and steps in mass multiplication of biofertilizers: stock culture, broth culture, growth medium, fermentation, blending with the carrier, packaging, and quality check, ISI standard specification for biofertilizers; scope of biofertilizers in India.

Unit 2: Microbial Inoculants and Role of Cyanobacteria 09 hours

Study of important microbial inoculants: *Rhizobium*, *Azospirillum*, *Azotobacter*, Actinorhizae; Characteristics, isolation, identification, and crop response, Role of Cyanobacteria (blue-green algae) in rice cultivation; *Azolla* and *Anabaena azollae* association, nitrogen fixation, and factors affecting growth.

Unit 3: Mycorrhizal association 08 hours

Types of mycorrhizal association, taxonomy, occurrence and distribution; Role of Arbuscular mycorrhizal fungi in phosphorus nutrition, growth and yield of crop plants; AMF – methods in isolation (wet sieving and decanting), identification (morphological and molecular methods). Methods of inoculum production (Pot culture and root culture).

Unit 4: Organic farming 05 hours

Introduction to organic farming, recycling of biodegradable municipal (domestic), agricultural and industrial waste; green manuring, bio-composting, vermicomposting and their field application.

Practical: (60 Hours)

1. Study of *Rhizobium* from root nodules of leguminous plants by Gram staining method.
2. Observation of arbuscular mycorrhizal fungi from plant roots.
3. Isolation of arbuscular mycorrhizal spores from rhizosphere soil.
4. Isolation of *Anabaena* from *Azolla* leaf.
5. Study of Earthworm, *Azolla*, AMF: Arbuscules-vesicles through specimen / digital resources.
6. Study of Biocontrol methods and their application -Pheromone trap, *Trichoderma*, *Pseudomonas*, Neem etc. through digital resources.
7. Rapid test for pH, $NO3^{-}$, $SO4^{2-}$, Cl^{-} and organic matter of different composts.
8. Projects on any one of the following topics: *Rhizobium* technology, AMF technology, Organic farming, Bio composting, Vermicomposting, *Azolla* culture etc. (The design of the project should be such that it includes a continuous work ofat least 6 Hours and a dissertation submission).

Essential/recommended readings

- Kumaresan, V. (2005). Biotechnology. New Delhi, Delhi: Saras Publication.
- Sathe, T.V. (2004). Vermiculture and Organic Farming. New Delhi, Delhi: Daya publishers.
- Subha Rao, N.S. (2020). Soil Microbiology, 5th edn. New Delhi, Delhi: Oxford & IBH Publishers.
- Reeta Khosla (2017). Biofertilizers and Biocontrol Agents for Organic Farming, Kojo Press.

Suggestive readings

- *Azotobacter* - Isolation and characterization - https://youtu.be/1Z1VhgJ2h6U
- *Rhizobium* - Identification and characterization - https://youtu.be/jELlo-pMvc4.
- 3-Days Online Workshop On Arbuscular Mycorrhizal Fungi - Biodiversity, Taxonomy and Propagation 19-2 (2022-01-20 at 02_27 GMT-8) - https://youtu.be/LKzK4IuSRc4.
- Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming. Nadiad, Gujarat: Akta Prakashan.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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
		Lecture	Tutorial	Practical/ Practice		
Environmental Biotechnology and Management **ALS-DSE 11**	**4**	**2**	**0**	**2**	**Sem VII**	**Nil**

Course Learning Objectives:

The course aims to build awareness of:

- various global and regional environmental concerns due to natural causes and/or human activities.
- different types of pollution and their impacts on the environment.
- existing and emerging technologies that are important in the area of environmental biotechnology to fulfill Sustainable Development Goals.

Learning Outcomes:

After completion of course the student will be able to:

- demonstrate awareness about emerging concerns such as climate change, waste management; biodegradation of xenobiotic compounds; bioremediation, etc.
- relate applications of biotechnology for alleviating the environmental concerns
- appreciate the scientific, ethical and/or social issues
- understand the national and international legislations, policies and role of public participation in Environmental Protection

Theory : 30 Hours

Unit 1: Environment **5 hours**

Basic concepts and issues, global environmental problems - ozone layer depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management. Fate of pollutants in the environment, Bioconcentration, Biomagnification.

Unit 2: Microbiology of waste water treatment **7 hours**

Aerobic process - activated sludge, oxidation ponds, trickling filter. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy and sugar industries.

Unit 3: Xenobiotic compounds and their treatment 10 hours

Organic (Bio degradation of petroleum products and pesticides) and inorganic (metals, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, Bioaccumulation and Biosorption of metals, Treatment of toxic compounds: Role of immobilized cells/enzymes, microbial remediation, Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control. Bioindicators and Bioprospecting

Unit 4: Legislations and Policies for Environmental Protection 08 hours

Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Kyoto Protocol- 1997. Environmental ethics, Water Pollution (Prevention and Control) Act-1974, Air Pollution (Prevention and Control) Act- 1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.

Practicals: 60 hours

1. To determine the pH and total hardness of water samples collected from different places (polluted and non-polluted sites)
2. To determine the salinity of water samples (polluted and non-polluted sites)
3. To determine the dissolved oxygen of two water samples.
4. To determine the alkalinity of water samples.
5. To determine the pH and rapid field test of soil samples (Chloride, Nitrate, and Sulphate).
6. To study microbes suspended in air and water samples.
7. A visit to any educational institute/ industry to understand the uses of microbes in environmental management and a report to be submitted for the same.

Suggested Readings:

1. De, A. K. (2022). Environmental Chemistry, 10th Edition, New Delhi. New Age International Pvt. Limited
2. Dennis, A., Seal, K.J., Gaylarde, C.C. (2004). Introduction to Biodeterioration, Cambridge University Press
3. Ahmed, N., Qureshi, F.M., Khan, O.Y. (2006). Industrial and Environmental Biotechnology, Horizon Press
4. Rochelle, P.A. (2001). Environmental Molecular Biology, Horizon Press.
5. Jadhav, H.V., Bhosale, V.M. (2015). Environmental Protection and Laws, Himalaya publishing House Pvt Ltd.
6. Trivedi, P. C. (2006). Biodiversity Assessment and Conservation, Agrobios Publ.
7. Rana, S.V.S. (2015). Environmental Biotechnology, Rastogi Publications, India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

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
		Lecture	Tutorial	Practical/ Practice		
Plant Health & Disease Diagnostics ALS-DSE 12	4	2	0	2	**Sem VII**	**Nil**

Course Learning Objectives:

- understand the challenges and importance of plant pathogen diagnosis
- understand methods for reducing/minimizing risk of the spread of pathogens and pests.
- understand principles and tools for early warning systems to protect plant health.

Learning Outcomes:

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

- diagnose the cause of a plant disease and identify the causal agent
- select appropriate methods and strategy for control and mitigate spread.

Theory : 30 Hours

Unit 1: Introduction to Plant Diseases and Diagnosis **10 Hours**

Definition; History of Plant Pathology, Concept and basic components of disease; Causes and classification of diseases; Disease cycle; Significance of plant diseases, Koch's Postulates; Plant disease symptoms and types (Necrosis, Hypertrophy and Hyperplasia, Hypoplasia); General symptoms of viral, bacterial and fungal plant diseases; Methods of plant disease diagnosis- Histochemical, Serological and PCR techniques.

Unit 2: Plant Disease Epidemiology **05 Hours**

Epidemics and factors affecting the development of epidemics; Epidemic assessment and Disease forecasting; Tools of epidemiology geographic information system (GIS), Global Positioning System (GPS), Geostatistics, Remote sensing.

Unit 3: Plant Diseases **11 hours**

Causal organism, symptoms, disease cycle and management of the plant disease caused by bacteria, virus and fungi: Tobacco Mosaic, Yellow Vein mosaic of Bhendi, Citrus Canker, Angular leaf spot of Cotton, White rust of crucifers, Late & early blight of potato, Rust of wheat, Smut of Cereals.

Unit 4: Management of Plant Diseases **04 Hours**

Concept of integrated disease management (IDM); strategies for IDM- regulatory, cultural, physical, chemical and biological.

Practicals: **60 hours**

1. Preparation of Fungal Medium (Potato Dextrose Agar | Czapek Dox), Study of Instruments (Laminar Air flow, Autoclave, Incubator) & sterilization techniques.
2. Isolation pathogen from an infected plant sample.
3. Symptoms of Citrus canker and Angular leaf spot of Cotton through specimens / photograph.
4. Powdery mildew of pea: Symptoms and study of asexual and sexual stage of causal organism (*Erysiphe polygoni*) with the help of temporary tease /section/permanent slides.
5. Symptoms of Tobacco Mosaic Virus and Yellow Vein Mosaic of Bhinde through specimens / photographs.
6. White Rust of Crucifers - Symptoms and study of asexual and sexual stages of *Albugo candida* from tease /section/permanent slides.
7. Late blight of potato. Symptoms
8. Early blight of potato - Symptoms and study of asexual stage of *Alternaria solani* through temporary tease mounts
9. Black stem rust of wheat: Symptoms on both wheat and barberry. Types of spores of *Puccinia gormenis tritici* wheat and barberry by temporary tease/section mount/permanent slides.
10. Symptoms of Loose and covered smuts of barley.

Suggested Readings:

1. Cooke, B.M., Jones, D.G., Kaye, B. (2007) The Epidemiology of Plant Diseases, 2nd ed. Springer.
2. Madden, L.V., Hughes, G. and Bosch, F van den (2017). The Study of Plant Disease Epidemics, APS Publications.
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and their Allies. (2nd Edition), Medtech Publishers, Delhi.
4. Sharma, P.D. (2014*).* Plant Pathology. Rastogi Publications, Meerut.
5. Singh R.S. (2018*).* Plant Diseases. 10th Edition Medtech, New De

Additional Resources:

1. Agrios G.N. (2005*).* Plant Pathology. 5th Edition, Elsevier.
2. Gupta, V.K. and Sharma, R.C. (2020) Integrated Disease Management and Plant Health, Scientific Publishers, India
3. Kapoor, A.S. and Banyal, D.K. (2012). Plant Disease Epidemiology and Management, AbeBooks.

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
		Lecture	Tutorial	Practical/ Practice		
Protected Agriculture– Hydroponics and Organic Cultivation **ALS-DSE 13**	**4**	**2**	**0**	**2**	**Sem VII**	**None**

Course Learning Objectives

The Learning Objectives of this course are as follows:

- To provide knowledge and expertise of various aspects of hydroponics, aquaponics and organic cultivation to students.
- To make students economically self-reliant by growing and marketing organic herbs, vegetables, microgreens and fruits.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will develop a thorough understanding of the concepts of Hydroponics, Aquaponics and Organic farming.
- Students will be trained in establishing hydroponic facility.
- Students will learn the development of various organic products such as biopesticides, biofertilizers and bio-organic growth promoters.
- Students will understand various government policies in marketing of hydroponic and organic produce.
- Students will understand Good Agricultural Practices associated with protected agriculture.

Theory : 30 Hours

Unit 1: Introduction to Protected Agriculture **02 hours**

Types of Protected Agriculture (hydroponics, aquaponics and organic farming), definition, history, terminology, importance and advantages over traditional agriculture, limitations and challenges.

Unit 2: Plant Growth Requirements and Media formulations **05 hours**

Physical parameters - light (quality and quantity) artificial light, light balancers; pH, conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters- mineral nutrient requirements, deficiencies, toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisic acids); Growth media- types, properties, uses, nutrient formulae, preparation of solutions, solid Media and nutrient film.

Unit 3: Hydroponic growing systems and associated pest & diseases 12 hours

Basic concepts and designs (closed and open systems techniques Nutrient Film Technique (NFT), Deep Water Culture (DWC), Dutch Bucket and other small-scale systems), systems layout. Strengths and weaknesses of various systems, site considerations, componentry, nutrient delivery, pumping Hydroponics associated pest - mites, thrips, whiteflies, leaf miners; Identification and management of diseases -bacterial, fungal and viral diseases; safety practices (Good Agricultural Practices (GAP) and Integrated Pest Management (IPM).

Unit 4: Organic farming and its management, Marketing & Policies 11 hours

Organic farming and associated management practices (nutritional requirements, pest, diseases, weeds); use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas*, neem oil, garlic etc.) in management

Marketing of the produce and government institutes and policies related to protected farming (hydroponics and organic farming).

Practical: 60 hours

- Study of various instruments used in hydroponics.
- Preparation of growth media for hydroponics.
- Estimation of NPK, DO, TDS, pH of growing media.
- Demonstration of different irrigation techniques in hydroponics.
- Demonstration of construction of a sustainable hydroponic unit.
- Perform rapid tests for estimation of NPK in different soil samples (samples from at least three different sites).
- Bulk density and porosity of soilless media e.g. coco-peat, perlite, vermiculite,expanded clay, rockwool (any two media).
- Demonstration of growing a leafy vegetable/fruity vegetable/ medicinal herb/aromatic plant in Hydroponics solution.
- Study of traditional organic inputs and formulation of biofertilizer.
- Preparation of biopesticides, plant health promoters like *Panchgavya, Beejamrut*
- etc.
- Field visit to organic farm/hydroponic farm and submission of visit report.

Essential/recommended reading:

- Schwarz, M. (1995). Soilless Culture Management. Advanced Series in Agricultural Sciences, vol. 24. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-79093-5_2.
- Hasan, M., Sabir, N., Singh, A.K., Singh, M.C., Patel, N., Khanna, M., Rai, T., Pragnya, P. (2018). Hydroponics Technology for Horticultural Crops, Tech.

- Bull.TB-ICN 188/2018. Publ. by I.A.R.I., New Delhi-110012 INDIA.
- Misra S., Misra S., Misra R.L. (2017). Soilless Crop production. Daya Publishing House, Astral International (P) Ltd., New Delhi.
- Palaniappan S. P., Annadurai K. (2018). Organic Farming: Theory & Practice.Scientific Publisher.
- Goddek, S., Joyce, A., Kotzen, B., Burnell, G.M. (2019). Aquaponics Food Production Systems. Springer, Cham.

Suggestive readings:

1. Jones, J. B. (2014). Complete Guide for Growing Plants Hydroponically. CRCPress.
2. Vayas, S.C, Vayas, S., Modi, H.A. (1998). Bio-fertilizers and organic Farming.Akta Prakashan, Nadiad.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credit s	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Intelligent Plant Systems **ALS-DSC-14**	**4**	**2**	**0**	**2**	**VII Sem**	**Nil**

Course Learning Objectives

- The course aims to lay the foundations on plant intelligence and develops understanding of the intelligent adaptively variable behavior of plants.

Learning outcomes

- The students will be learning the concepts of intelligence, distinction between development and intelligent behavior and morphological /adaptive strategies employed by plants to survive.

Theory : 30 Hours

Unit 1: Introduction **03 hours**

An Introduction to Plant Structure (Morphological and Anatomical details).

Unit 2: Plants Intelligence and Sensory Biology **06 hours**

Brief History and Introduction to Plant Intelligence and Memory, Cell to cell communication, Self-recognition, Recognition of Neighbors and Relatives.

Unit 3: Learning in Plants **08 hours**

Habituation learning; Learning by association (Rhizosphere and Mycorrhizae); Adaptive Intelligence (Hydrophytes, Xerophytes, Parasites, Carnivorous plants, Thermogenic plants); Response to water, heat, salt and cold stress; Mechanical and chemical defense against predators with special reference to secondary metabolites.

Unit 4: Intelligent Behavior of Plants **13 hours**

A Guided tour to Plant Movements (Tropic Movements, Movement towards gravity, light, tracking sun movements, prey driven movements, liberation movements); Intelligent response to minerals and light (Seed germination, root cap, response of shoot, leaf morphology and anatomy); Unique pollination and seed dispersal mechanisms; Osmosis; Short and long-distance transport of water and food.

Practicals: **60 hours**

1. Study the structure of plant cell using temporary mount.
2. Study of the cell as an osmotic system (Plasmolysis and De-plasmolysis).
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Extraction and qualitative analysis of alkaloids, flavonoids, tannins and phenols.
5. To study the phenomenon of seed germination (effect of light).
6. To study light sensitivity and etiolation vs. de-etiolation.
7. Morphology and orientation of chloroplasts in leaves growing in light and dark, plasmodesmata connections and plasma membrane receptors. (through photographs or other digital resources).
8. Estimation of total photosynthetic pigments.
9. Study of (a) Root cap (b) Trichomes: non-glandular and glandular (c) Leaf Morphology and Anatomy (d) pulvinus anatomy in *Mimosa pudica* (e) Specialized motor tissue at the base of monocot leaves.
10. (a) Study of morphological and anatomical adaptations of hydrophytes, xerophytes.
    (b). Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants).
11. Pollination types (selected) and associated seed dispersal mechanisms.

Suggested Readings:

1. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
2. Evert, RF., Eichhorn, S.E. (2012). Raven Biology of Plants, 8th edition, New York, NY: W.H. Freeman and Company.
3. Koller, D. (2011). The Restless Plant. Edited by Elizabeth Van Volkenburgh, Haward University Press, Cambridge, Massachusetts, and London, England.
4. Crang, R., Lyons-Sobaski, S., Wise, R. (2018) Plant Anatomy- A Concept based approach to the structure of seed plants, Springer Nature, Switzerland.

Additional Resources:

Trewavas A. (2017). The foundations of plant intelligence. Interface Focus 7: 20160098. http://dx.doi.org/10.1098/rsfs.2016.0098.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Annexure-4.11.05
EC dated 12.07.2025

Frameworks for VII and VIII semesters

B.Sc. (H) Applied Life Sciences with Agrochemicals and Pest Management

Semester	DSC Credits 4	DSE Credits 4
VII	DSC 07 (3T+1P)	DSE I (2T + 2P) DSE II (2T + 2P) DSE III (2T + 2P)
VIII	DSC 08 (3T+1P)	DSE IV (2T + 2P) DSE V (2T + 2P) DSE VI (2T + 2P)

VII

- **DSC 07:** Agrochemicals for Insect and Mite Control
- **DSE I**: Research Methodology in Agrochemistry
- **DSE II**: Physical Principles in Agrochemicals
- **DSE III**: Analytical Techniques in Pesticide Analysis

VIII

- ✓**DSC 08**: Agrochemical for Fungi, Nematodes, and Weeds
- ✓**DSE IV**: Environmental health and Agrochemicals
- ✓**DSE V** Introduction to Natural Pesticides: Biopesticides and Plant Toxins
- ✓**DSE VI:** Pesticide Formulation and Application Equipment

SEMESTER –VII

BSc. (Hons)Applied Life Sciences with Agrochemicals and Pest Management

Swami Shraddhanand College

DISCIPLINE SPECIFIC CORE COURSE – 01

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		
Agrochemicals for Insect and Mite Control: DSC 07	**4**	**3**	**0**	**1**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- to familiarize students to different types of classification of pesticides.
- to familiarize with factors that make the organic compound to be considered as pesticide.
- Develop a solid knowledge base regarding the chemistry, classification, and synthesis of agrochemicals—including insecticides and acaricides (pesticides used against mites).
- This entails learning about key chemical classes (such as organophosphates, pyrethroids, carbamates) and their modes of action and effective chemical control strategies

Learning outcomes

The Learning Outcomes of this course are as follows:

- To analyze important aspects attributing pesticidal activity to organic molecules.
- To explain the strategies involved in synthesis of different pesticides.
- To handle pesticides safely in view of human health and environment.
- To help the students to gain an in-depth understanding of both the theoretical and practical aspects of using agrochemicals for pest management

SYLLABUS OF DSC- 07

THEORY COMPONENT-

UNIT 1: **(17 Hours)**

A Structure, properties, uses, structure-activity relationship (QSAR) and toxicity with reference to selective examples each from class of selected examples of pesticides: Discussion on stereochemical aspects of pesticides insecticides, where ever required.

a) Organochlorines
b) Organophosphorus
c) Carbamates

B Structure, uses and toxicity examples each from:Pyrethrins,Pyrethroidsand Neonicotinoids. Discussion on stereochemical aspects of pesticides insecticides, where ever required.

a) Pyrethrins
b) Synthetic Pyrethroids
c) Neonicotinoids pesticides

UNIT 2:(10Hours)

Introduction to Insecticide synergists: Concept, Significance, andimportance,role in resistance management,mode of action,Common insecticide synergists-piperonylbutoxide and MGK-264 (n-octylbicycloheptanedicarboximide), Synergists Work Efficacy, Resistance Management, Reduced Insecticide Use

UNIT3: **(10 Hours)**

Introduction to Synthetic IGRs:Synthetic IGRs- Concept, Significance, andimportance,

Use of Synthetic IGRs- Mimicking Hormones, Disrupting Chitin Synthesis, targeting Specific Life Stages,

Advantages of Synthetic IGRs - Reduced Environmental Impact, Reduced Resistance Development, Compatibility with Integrated Pest Management (IPM),

Examples of Synthetic IGRs: Methoprene, Diflubenzuron, teflubenzuronChlorfluazuron ,Fenoxycarb

UNIT4: **(8 Hours)**

Fumigants and other chemicals for post-harvest storage of agricultural commodities

PRACTICAL COMPONENT (30Hours)

Synthesis of pesticides /analogues/intermediates

1. Preparation of carbamate derivative from phenylisocynate and alcohol/phenol.
2. Preparation of DDT from chlorobenzene and chloral
3. Preparation of other chlorinated hydrocarbons DDE, and Methoxychlor
4. Preparation of organophosphorus Insecticide-Part A –phosphorodichloridite, and Part B -phosphonate
5. Preparation and characterization of oxime ether, Preparation of DDVP.
6. Preparation of acyl phenyl hydrazine
7. Preparation ofof 3,5-dimethylpyrazole
8. Preparation of mosquito repellent Diethyl phthalate in two steps:

   Step-1: Preparation of phthalic anhydride

   Step-2: preparation of Diethyl phthalate
9. Writing the assigned an in-depth analysis of at least three insecticides to be allotted by instructor fromorganochlorines, organophosphorus, carbamates, pyrethroids, and neonicotinoids. It must cover the detailed aspects of: Chemical Structure, Uses, Mode of Action, Toxicity and GHS labelling, Human Health Implications

ESSENTIAL/RECOMMENDED READINGS

1. G.T. (1976). *Chlorinated Insecticides* (Vols. I–II). CRC Press.
2. Buchel, K. H. (Ed.). (1992). *Chemistry of Pesticides*. John Wiley & Sons.
3. Cremlyn, R. J. (1990). *Pesticides: Preparation and Mode of Action*. Wiley.
4. Eto, M. (1979). *Organophosphorus Pesticides: Organic and Biological Chemistry*. CRC Press. *(Note: Corrected to insert a space between "Biological" and "Chemistry".)*
5. Kuhr, R. J., &Dorough, H. W. (1979). *Carbamate Insecticide Chemistry and Biochemistry*. CRC Press.
6. Leahey, J. P. (1985). *The Pyrethroid Insecticides*. Taylor & Francis.
7. Metlosky, G., Nadasy, M., &Andriska, V. (1988). *Pesticide Chemistry*. Elsevier.
8. Perry, U. K., Yamamoto, A. S., Ishaaya, I., & Perry, R. (1998). *Insecticides in Agriculture and Environment: Retrospects and Prospects*. Narosa.

KEYWORDS: QSAR, Stereochemical activity of Pesticides, Insecticide synergists, Synthetic synergists, Fumigants, Pesticide activity

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 01

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		
Research Methodology inAgrochemistry	**4**	**2**	**0**	**2**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Understand Fundamental Concepts of research.
- Develop researchable questions and hypotheses related to pesticide application, efficacy, environmental impact, or health effects.
- Design Appropriate Research Methodologies and Distinguish between qualitative, quantitative, and mixed-method approaches in pesticide research.
- Use statistical tools to analyze pesticide research data. Address Ethical and Regulatory Considerations Describe relevant national and international pesticide regulations.
- Learning computational toxicology
- Develop Scientific Communication Skills. Write research proposals, reports, and scientific papers on pesticide-related topics.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Recall and identify key concepts and terminology related to research methodology.
- Analyze the strengths and weaknesses of different research methodologies in relation to specific research contexts or objectives.
- Apply the principles of a specific research methodology to design a research study or experiment.
- Computer in pesticide development.

SYLLABUS OF DSE- 01

THEORY COMPONENT-

UNIT 1: (8Hours)

Introduction of Research and Writing scientific report:
Meaning and objectives of research, criteria of good research, research methods vs research methodology, selection of research problem, literature review, types of hypotheses. Maintaining a laboratory record; On-line literature searching, Database, Sci-finder, Scopus, Citation Index, Impact Factor.

Planning, preparation, draft, revision and refining; writing project proposal to funding agency, Paper writing for Journals, Conference presentation, preparation of effective slides and presentation. Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism, Acknowledgement,Fellowships/Research Grants, Introduction to guidelines, Insecticides Act 1968 and Insecticides rules 1971

UNIT 2: (8Hours)

Computational tools used in chemical structure designing:
AutoDock, PyMOL, or ChemSketch,Marvin (Chem Axon), Determination of some selected physiochemical properties

UNIT 3: (10Hours)

Computational toxicology

A. Introduction to Toxicity prediction and hazard identification

Applicability domain (AD) of a QSAR mode, brief discussion on the models available for predicting toxicological endpoints, Physicochemical properties associated with toxicity, QSAR approaches and the definition of structural similarity a key aspect of silico prediction.

B. Software and expert systems in relation to the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) initiative and Organization for Economic Co-operation and Development (OECD) principles.

C. Computational models for toxicology,their Limitations of chemical similarity and Read-across for regulatory purposes.

D. Freely available Software for Toxicity prediction:

OECD QSAR Toolbox, EPA's Toxicity Estimation Software Tool (TEST), OPERA, VEGA, ProTox 3.0,SwissADME (Several other available software as per requirement may be used)

UNIT 4: (4 Hours)

Data exploration for the pesticide molecules:
Manually curated database sites for pesticides like ChEMBL, ChEBI, Agrochemical Database @ USDA, chemspider, BRENDA (enzyme data and metabolic information), UniProt (Enzyme database) PubChem etc. to be introduced.

PRACTICAL COMPONENT (60Hours)

For review and data analysis to be carried out for the given pesticides

1 **Utilization of Academic Search Engines and Databases.** Practice using platforms like Google Scholar, Scopus, and PubMed to locate and retrieve relevant research and review articles.

2 Conduct systematic reviews. Choose a topic (e.g., pesticide resistance in insects). Use online databases to find 5–10 relevant papers. Analyze them for research gaps, methods used, and key findings

3 Practice data entry and statistical analysis. Provide sample data (e.g., pesticide residue levels in water). Clean and organize data in Excel or R. Perform correlation or regression analysis. Interpret results.

4 Collection of data, interpretation, and presentation of data through writing short research or review papers

5 Develop skills to write concise and informative titles and abstracts for research manuscripts.

6 Use reference management tools (Zotero, Mendeley, EndNote) to format citations and bibliographies according to various journal styles.

7 Learn how to check for plagiarism using software tools (Turnitin, Grammarly, etc.) and maintain academic integrity.

8 Explore the basics of computational tools used in pesticide design (such as AutoDock, PyMOL, or ChemSketch).

9. Writing the assigned an in-depth analysis ofat least three pesticides to be allotted by instructor for their computational study for physicochemical data and toxicity prediction.

ESSENTIAL/RECOMMENDED READINGS

1. G.R.Chatwal, Instrumental method of chemical analysis.
2. A text of inorganic quantitative analysis by Shree Ramulu.
3. Instrumental methods of chemicals analysis by Willard, Meritt
4. Rastogi S.C. Mendecutta, N.Bioinformatics Methods and application
5. Sharma B.K. Instrumental Methods of chemical analysis
6. Chopra &Kanvar, Analytical agriculture chemistry
7. Robert Brown, Introduction to instrumental Analysis
8. Peter Atkins, Physical chemistry
9. Sivasankari, Bioseparation Principles and Techniques.
10. Practical Research Methods, Catherine Dawson, UBS Publishers Distribution, New Delhi 2002.
11. Research Methodology – Methods and Techniques, C. R. Kothari, Wiley Easter Ltd, New Delhi 1985.
12. Research Methodology – A Step by step Guide for Beginners 2 ndedn. Kumar Ranjit, Pearson Education, Singapore, 2005.
13. Introduction to Research and Research Methodology M. S. Sridhar.
14. The Information Specialist's Guide to Searching & Researching on the Internate& the World Wide Web by Ernest Ackermann, Karen Hartman, Fitrzroy Dearborn Publishers, London.
15. Learning to Use the World Wide Web, Ernest Ackermann, BPB Publications development and formulation development. Use of computer-based equipment for pesticide analysis.

KEYWORDS: Research methodology, Citation Index, Computational tools, QSAR approaches, Silico prediction, REACH, OECD, Computational models for toxicology, Toxicological endpoints, Agrochemical Database, Plagiarism

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE – 02

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Physical Principles in Agrochemicals	**4**	**2**	**0**	**2**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- explain the laws of thermodynamics and their applications in agrochemical formulation and stability.
- Compute and interpret enthalpy, entropy, and Gibbs free energy changes in agrochemical reactions.
- Principles of catalysis and enzyme kinetics, particularly in the context of bio-pesticide action.
- Role of surfactants and micelles in pesticide formulations and critical micelle concentration (CMC).
- Analyze how pKa and pH affect the ionization and solubility of pesticides in different environmental conditions.
- Correlate lipophilicity with pesticide bioavailability, uptake, and systemic activity in target organisms

Learning outcomes

The Learning Outcomes of this course are as follows:

- Define key physicochemical properties of pesticides (e.g., solubility, volatility, vapor pressure, partition coefficient, and degradation rates).
- Describe the fundamental principles of enzyme kinetics

- Define photochemical transformation and its relevance in the environmental fate of pesticides.
- Explain the mechanisms of direct and indirect photolysis of pesticides under natural and artificial light sources

SYLLABUS OF DSE- 02

THEORY COMPONENT-

UNIT 1: **(7Hours)**

Physicochemical Properties of Pesticides: Physicochemical properties (solubility, octanol-water partition coefficient, vapor pressure, soil adsorption coefficient, emulsion stability, half-life, shelf-life etc.) and their testing, Formulation-toxicant interactions.Distribution coefficient of pesticide-its mobility**,** persistence**,** and potential to contaminate environment. Significance ofstudying the physiochemical properties.

UNIT 2: **(7Hours)**

Photochemical transformation of pesticides:Introduction to photochemistry, direct and indirect photolysis, photosensitizers, quenchers, light filters, quantum yield. Photo transformation pesticides and their significance. An overview of broken-down Pesticide and health risk of altered transformed products photochemically.

UNIT 3: **(10 Hours)**

Enzyme Kinetics and Application in Agrochemical Degradation: Factors affecting the enzyme activity- Concentration, pH and temperature. Kinetics of a single-substrate enzyme catalysed reaction, Michealis-Menten Equation, Km, Vmax, L.B Plot, Turnover number, Kcat. Enzyme specificity. Active site, Principles of activation energy, transition state. Interaction between enzyme and substrate- Lock and Key Theory. Kinetics of Enzyme Inhibition- irreversible and reversible, types of reversible inhibitions- competitive and non-competitive. Feedback inhibition.

UNIT 4: (6Hours)

Surface and Colloid Chemistry in Agrochemicals: Critical micelle concentration (CMC), Emulsions, suspensions, and colloidal stability. Adsorption isotherms (Langmuir and Freundlich): application in soil-pesticide interaction. Wettability, contact angle, and spreadability on leaf surfaces.

PRACTICAL COMPONENT (60Hours)

1. To measure the solubility of a pesticide in water at room temperature.
2. To evaluate the lipophilicity of a pesticide by calculating log P using 1-Octanol/Water System.
3. To determine the dissociation constant (pKa) of an agrochemical using UV-Visible Spectroscopy.
4. To study how solubility varies with pH due to ionization of pesticide.
5. Determination of surface tension and contact angle of formulations.
6. Study of adsorption of pesticide on soil using isotherms.
7. Kinetics of pesticide degradation under various pH conditions.
8. To determine the distribution coefficient of a pesticide by studying its adsorption onto soil from an aqueous solution.
9. Writing the assigned an in-depth analysis of at least three pesticides to be allotted by instructor for evaluation of Physical principles by surveying the data from literature.

ESSENTIAL/RECOMMENDED READINGS

1. "Physical Chemistry" – P.W. Atkins
2. "Pesticide Formulation and Adjuvant Technology" – Chester L. Foy
3. "Agrochemical Discovery: Insect, Weed and Fungal Control" – John J. Beck
4. Journal Articles from Pest Management Science**,** Journal of Agricultural and Food Chemistry
5. K.H. Buchel - “Chemistry of Pesticides” Classic text explaining the chemistry, mode of action, and environmental aspects.
6. K.S. Birdi- “Surface Chemistry”
7. B.D. Khosla -Practical Physical Chemistry
8. S.S. Balpande- Laboratory Manual for Soil and Agrochemical Analysis
9. Fundamentals of Enzymology: Nicholas Price & Lewis Stevens

KEYWORDS: Physicochemical Properties of Pesticides, Formulation-toxicant interactions, Photochemical transformation of pesticides, Kinetics of Enzyme, Kinetics of Enzyme

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE – 03

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 Pesticide analysis	**4**	**2**	**0**	**2**	-	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- To understand the principles behind preparing standard solutions, analytical reagents, qualitative reagents, and indicators.
- To Learn to construct standard curves essential for titrimetric and analytical applications.
- To learn the fundamentals and practical applications of separation methods including solvent extraction, thin layer chromatography (TLC), paper chromatography, and column chromatography.
- To gain insight into the applications of instrumental techniques like Ultraviolet-visible (UV-Vis) spectroscopy, infrared (IR) spectroscopy, atomic absorption spectroscopy (AAS), and mass spectrometry (MS)
- To understand how these methods are applied in pesticide formulation analysis and quality control.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Learn chromatography (TLC, paper, and column methods) to effectively isolate and identify agrochemical compounds from environmental and food samples.
- Critically Evaluate Analytical Methods
- Independently prepare reliable standard solutions and reagents required for a variety of analytical and titrimetric analyses in pesticide assessment.
- Analyze complex data sets, making informed decisions about method suitability and analytical outcomes.

SYLLABUS OF DSE- 03

THEORY COMPONENT-

UNIT 1: (6Hours)

Preparation of Solutions for Analytical and Titrimetric Applications:

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation- reduction and complexometric titration.

UNIT 2: (8 Hours)

Chemical analysis in Pesticide formulation: Titrimetric Methods: Acid-base,non-aqueous, iodimetric titration, oxidation-reduction (redox), precipitation and complexometric titrations

UNIT 3: (6 Hours)

General methods of characterization, separation and purification: Agrochemical compounds from soil, food stuff etc, Solvent extraction, Thin layer chromatography, paper chromatography and column chromatography

UNIT 4: (10Hours)

Instrumental analysis in Agro-chemistry:Applications of gas chromatography and liquid chromatography. Applications of Ultraviolet-visible spectroscopy, infrared spectroscopy, Atomic absorption spectroscopy, Mass spectrometry.

PRACTICAL COMPONENT (60Hours)

1. Extraction of pesticides from water samples using immiscible organic solvents.
2. Extract pesticide residues from soil using a solvent mixture.
3. Extraction from Leafy Vegetables (Spinach/Cabbage)
4. Extract Cleanup using Solid Phase Extraction (SPE)
5. To identify and compare multiple pesticides by determining their **$R_f$values** using **TLC** with suitable **mobile phases** and **visualization methods**. (e.g., Malathion, Carbaryl, Atrazine,
   2,4-D, Endosulfan)
6. Quantitative analysis of Pesticides using UV-Vis spectroscopy
7. To verify Beer-Lambert's law and prepare a calibration curve for a pesticide that absorbs in the UV-visible range (e.g., malathion**,** carbaryl**,** 2,4-D**, or** glyphosate**).**

8. To identify the functional groups**,** present in pesticide samples using Fourier Transform Infrared (FTIR) spectroscopy by analyzing their characteristic absorption bands.
9. To identify the structure of a pesticide for which mass spectra data is provided.

ESSENTIAL/RECOMMENDED READINGS

1. R.J Cremlyn, Agrochemicals: Preparation and mode of Action, 2nd Edition, Wiley Blackwell publishers, New Jersey (1991).
2. S.M Khopkar, Concepts in Analytical Chemistry, 3rd Edition, New Academic Science, New York (2008).
3. Willard, Merittee and Dean, Instrumental methods of Analysis, 5th Edition, Van Nostrand Publishers, Newyork (1974).

KEYWORDS: Analytical Applications, Titrimetric Applications, Chemical analysis in Pesticide formulation, Separation and purification techniques, Instrumental analysis in Agro-chemistry

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER –VIII

BSc. (Hons)Applied Life Sciences with Agrochemicals and Pest Management

Swami Shraddhanand College

DISCIPLINE SPECIFIC CORE COURSE – 02

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		
Agrochemical for Fungi, Nematodes, and Weeds: DSC 08	**4**	**3**	**0**	**1**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Learners will gain knowledge about agrochemicals used for the control of fungi, nematodes and weeds.
- To study interactions of fungi, nematodes, and weed species in agricultural systems.
- To understand how these organisms, affect crop health and yield.
- Understand the biochemical and physiological mechanisms by which these chemicals control pest populations.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Articulate the modes of action for various agrochemical agents and explain how these mechanisms disrupt the life processes of pests.
- Develop strategies for minimizing adverse effects through careful selection, timing, and application of agrochemicals.
- Learners will explain, compare, and critically assess the major classes of agrochemicals (fungicides, nematicides, and herbicides) and their specific modes of action.

SYLLABUS OF DSC- 08

THEORY COMPONENT-

A. FUNGICIDES

UNIT 1: (16Hours)

Preparation, properties, uses, structure-activity relationship and mode of action of selected fungicides: Organophosphorus compounds and dithiocarbamatesPolyhalogenalkanes, sulfenyl compounds, phenols, quinones, carboxamides, carboximides.

Preparation, properties, uses, structure-activity relationship and mode of action of Azoles and other heterocyclics compounds as fungicides.

UNIT 2: (8 Hours)

A comprehensive view, with reference to two suitable examples of fungicides, for each of the followingMode of action

a) Membrane sterol biosynthesis
b) Lipid synthesis, transport, or membrane function
c) Respiration inhibitor
d) Nucleic acid metabolism

B. NEMATICIDES

UNIT 3:(6 Hours)

Preparation, properties, usesand mode of action of selected Nematicides: halocarbons, organophosphorus compounds, carbamates.

C. HERBICIDES

UNIT 4: (15Hours)

Properties, uses, structure-activity relationship and mode of action of phenoxyalkanoic acids, carbamates and substituted phenylureas, sulfonylureas

Properties, uses, structure-activity relationship and mode of action of triazines, pyridinium compounds,imidazolinones and dinitroanilines.,

Herbicide safeners and Synthetic plant growth regulators

A comprehensive view, with reference to suitable examples of herbicides, for each of the followingMode of action

a) Inhibition of Photosynthesis at PS II and PSI
b) Inhibition of Cellulose Synthesis
c) Inhibition of Microtubule Assembly

PRACTICAL COMPONENT (30Hours)

Synthesis of pesticides /analogues/intermediates

1. Preparation of 2,4-dichlorophenoxy acetic acid herbicide or its synthetic analogues (*any one* of the following)
    a) 4-chlorophenoxy acetic acid
    b) 4-methylphenoxy acetic acid
    c) 2-methylphenoxy acetic acid
2. Preparation of ethyl ester or butyl ester of any one of phenoxy acetic acid mentioned in experiment-1.
3. Preparation of 2-naphthoxyacetic acid (BNOA or β-naphthoxyacetic acid)
4. Preparation of Dithiocarbamate fungicide analogous from aromatic/aliphatic amine and separated as sodium /zinc/ manganese salt.
5. Preparation of Zineb (Z)
6. Preparation of urea derivative from phenylisocynate and aniline.
7. Preparation of thiourea derivative from phenylisothiocynate and aniline.
8. Preparation of benzimidazole/2-benzylimidazole /2-Methylbenzimidazole
9. Preparation of Maleic anhydride -an intermediate for agrochemicals
10. Writing the assigned an in-depth analysis of at least three fungicides /Nematicide/Herbicides to be allotted by the instructor. It must cover the detailed aspects of: Chemical Structure, Uses, Mode of Action, Toxicity and GHS labelling, Human Health Implications.

ESSENTIAL/RECOMMENDED READINGS

1. Audus, L.J. (1964), The Physiology and Biochemistry of Herbicides, Academic Press.

2.Bell, C.V. and Alford, D.V. (2000), _Pest and Disease Management Handbook, British Crop Protection Council; Wiley-Blackwell

3.Buchel, K.H. (Ed.) (1992), Chemistry of Pesticides, John Wiley & Sons

4. Copping, L.G., Hewitt, H.G. and Leonard, G.C. (1998), Chemistry and Mode of Action of Crop Protection Agents, Royal Society of Chemistry.

5. Cremlyn, R.J. (1990), Pesticides: Preparation and Mode of Action, John Wiley & Sons, U.K

6. Kearnay, P.C. and Kaufman, D.D. (1975), Herbicides: Chemistry, Degradation and Mode of Action_ (Vols. I, II), Marcel Dekker.

7. Kramer, W.K. and Ulrich, S. (2007), Modern Crop Protection Compounds,
Wiley-VCH Verlag GmbH

8. Metlosky, G.,Nadasy, M. and Andriska, V. (1988), Pesticide Chemistry,
Elsevier

9. Nene, Y.L. and Thapliyal, P.N. (1989), Fungicides in Plant Disease Control,
India Book House

10. Roy, N.K. (2002), Chemistry of Pesticides, CBS Publishers, New Delhi.

11. Unger, T.A. (1996), Pesticide Synthesis Hand Book, William Andrew.

12. Vyas, S.C. (1984),Handbook of Systemic Fungicides, Tata McGraw Hill.

KEYWORDS: Fungicides, mode of action of fungicides, Nematicides, mode of action of herbicides, Herbicide safeners, Synthetic plant growth regulators

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 04

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 health and Agrochemicals	**4**	**2**	**0**	**2**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Understand the mechanisms of pesticide entry and dispersion in environmental compartments.
- Explore the interactions between pesticide residues and soil/water/microbial systems.
- Assess the toxicological and ecological implications of pesticide residues.
- Implications of pesticide persistence on human health**.**
- Impact of Pesticide Residues on Human Health and Society

Learning outcomes

The Learning Outcomes of this course are as follows:

- Describe the environmental pathways of pesticide residues in air, water, and soil.
- Analyze the physicochemical and biological processes governing pesticide degradation and transport.
- Evaluate the impact of pesticide residues on ecosystems, food safety, and public health.
- Persistence of pesticides in environment.
- Propose sustainable practices and policy interventions to mitigate agrochemical pollution.

SYLLABUS OF DSE- 04

THEORY COMPONENT-

UNIT 1: **(6Hours)**

Residues of Agrochemicals in the Atmosphere:

Entry pathways of pesticides into the atmosphere, Fate of Pesticides in the atmosphere, Transport of vapors, Precipitation, Impact of airborne residues, air quality and climate, effect of residues on human health

UNIT 2: **(6 Hours)**

Residues of Agrochemicals in Water system:

Nature and origin of pollution of aquatic systems, Point and Non-Point pollution. Runoff, leaching, and effluent discharge into water bodies, Physicochemical properties influencing aquatic fate (solubility, hydrolysis, photolysis). Dynamics of pesticides in aquatic environment. Toxicological effects on aquatic flora and fauna

UNIT 3: **(6 Hours)**

Pesticides residues in the Soil:

Absorption, Retention, Transport and Degradation of pesticides in the soil, persistence and half-life of various pesticide classes in soil. Effect on microorganisms and Consequent effect on the soil condition, Fertility, nutrient cycle and crop productivity. Interactions between pesticides and soil organic/inorganic matter

UNIT 4: (12Hours)

A Persistence of Pesticides in the Environment:

Low, moderate and high persistent pesticides, Persistent organic pollutants, Physical, chemical, biochemical and environmental factors affecting pesticide of persistence in the environment.

B Pesticide Dissipation and Fate in The Environment:

Various dissipation processes, Role of drift, volatilization, adsorption, desorption, runoff etc.in pesticide dissipation, Leaching and risk of groundwater pollution, Dissipation time (Half-life-DT50, DT90), Rate kinetics (1st order, 2nd order), Behavior and fate of pesticides in soil and crops.

C Impact of Pesticide Residues on Human Health and Society:

Direct and indirect exposure pathways in humans (food, water, air, occupational). Acute and chronic health effects (carcinogenicity, neurotoxicity, endocrine disruption, genotoxicity, skin sensitization, reproductive and developmental toxicity).

PRACTICAL COMPONENT (60Hours)

1. To study degradation of airborne pesticides when exposed to UV radiation.
2. To observe chemical degradation (hydrolysis and photolysis) of pesticides in water
3. To measure how different soils, retain pesticides through adsorption.
4. To determine the degradation rate and persistence of a pesticide in soil.
5. To analyze enzyme activity or nutrient availability in pesticide-treated soil.
6. To study whether washing, peeling, or boiling reduces pesticide residues and protects food quality.
7. Writing the assigned an in-depth analysis of at least three pesticides to be allotted by instructor. It must cover the detailed aspects of: Chemical Structure, Impact on environment and its persistence, Toxicity, Human Health Implications and GHS labelling

ESSENTIAL/RECOMMENDED READINGS

1. Ogwu, M. C., &Izah, S. C. (Eds.). (2023). One health implications of agrochemicals and their sustainable alternatives (Vol. 34). Springer Nature.

2. WHO (World Health Organ.), FAO (U. N. Food Agric. Organ.). (2019). Global situation of pesticide management in agriculture and public health: report of a 2018 WHO-FAO survey WHO, Geneva. https://apps.who.int/iris/handle/10665/329971](https://apps.who.int/iris/handle/10665/329971)

3. Vaz Jr, S. (2019). Sustainable agrochemistry. Springer International Publishing, New York, US.

4. Naeem, M., Juan Francisco Jimenez Bremont, Abid Ali Ansari, &Sarvajeet Singh Gill. Agrochemicals in Soil and Environment.

5. Devi, P. I., Manjula, M., &Bhavani, R. V. (2022). Agrochemicals, environment, and human health. Annual Review of Environment and Resources, 47(1), 399-421.

6. Dowdall, C. M., & Klotz, R. J. (2016). Pesticides and global health: understanding agrochemical dependence and investing in sustainable solutions. Routledge. https://doi.org/10.4324/9781315422695

7. Yassi, A. (2001). Basic environmental health. Oxford University Press.

8. Akpan, G. E., Ndukwu, M. C., Etim, P. J., Ekop, I. E., &Udoh, I. E. (2023). Food Safety and Agrochemicals: Risk Assessment and Food Security Implications. In One Health Implications of Agrochemicals and their Sustainable Alternatives (pp. 301-333). Springer Nature Singapore.

9. Frumkin, H. (Ed.). (2016). Environmental health: from global to local. John Wiley & Sons.

10. Nriagu, J. O. (2019). Encyclopedia of environmental health. Elsevier.

11. Pretty, J. (Ed.). (2012). The pesticide detox: towards a more sustainable agriculture. Routledge.

12.Hamilton, D., & Crossley, S. (Eds.). (2004). *Pesticide residues in food and drinking water: human exposure and risks*. John Wiley & Sons.

13. Horrigan, L., Lawrence, R. S., & Walker, P. (2002). How sustainable agriculture can address the environmental and human health harms of industrial agriculture. Environmental Health Perspectives, 110(5), 445-456.

14.Schnoor, J. L. (Ed.). (1992). *Fate of Pesticides and Chemicals in the Environment*. John Wiley & Sons.

15. Shahamat U Khan. 1980. Pesticides in the Soil Environment (Editor: R. J. Wakeman) Elsevier.

KEYWORDS: Residues of Agrochemicals, Fate of Pesticides in the atmosphere, Toxicological effects, Transport and Degradation of pesticides, Persistence of Pesticides, Pesticide Dissipation in environmental

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE – 05

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Introduction to Natural Pesticides: Biopesticides and Plant Toxins	**4**	**2**	**0**	**2**	-	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Define natural pesticide, including biopesticides and plant toxins.
- Differentiate between biopesticides and synthetic chemical pesticides.
- Identify common examples of biopesticides and plant-derived toxins.
  Analyze the advantages and limitations of using natural pesticides.
- Discuss the environmental and health benefits of biopesticides over synthetic pesticides.
- Evaluate real-world applications and case studies of natural pesticides in modern agriculture.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Demonstrate an understanding of biopesticides and plant toxins in pest control.
- Apply knowledge of natural pesticides to sustainable farming practices.
- Assess the role of biopesticides in reducing chemical pesticide dependency.
- Critically evaluate different biopesticide strategies for pest management.

SYLLABUS OF DSE- 05

THEORY COMPONENT-

UNIT 1: (9Hours)

Isolation, characterization, properties and mode of action of important groups of naturally occurring insecticides (pyrethroids, nicotinoids, rotenoids, limonoids, microbial macrolides).Sources of bio pesticides and extraction (ASE, SFE /solvent extraction)

UNIT 2: **(5 Hours)**

A Bacillus thuringiensis and nuclear polyhedrosis virus based insecticides and other biopesticides.

B Semi chemicals, insect hormones, insect growth regulators, feeding deterrents and repellents etc

UNIT 3 **(4Hours)**

Natural nematicides, fungicides, mollusicides and rodenticides

UNIT 4 **(12Hours)**

A Introduction to Plant Toxins Based on Plant Family

B Classification Plant Toxins Based on Chemical Structure

C Biological Activity and Mode of Action of Plant Toxins

PRACTICAL COMPONENT (60Hours)

1. Extraction by hydrodistillation, isolation of pure compounds, their characterization,
2. Extraction of tobacco leaves
3. isolation of nicotine and its identification,
4. Extraction of neem seed kernels, enrichment of azadirachtin, analysis of azadirachtin and its analysis.
5. To extract azadirachtin, a bio-pesticidal compound, from neem seeds using organic solvents.
6. To extract caffeine from tea leaves by solvent extraction method using dichloromethane.
7. To extract and estimate the amount of **allicin**, a bioactive compound, from fresh garlic using spectrophotometry.
8. Writing the assigned an in-depth analysis of at least three biopesticides to be allotted by instructor from different sources from theory portion. It must cover the detailed aspects of: Source, Chemical Structure, extraction /isolation from natural source, Uses, Advantages and disadvantages with respect to synthetic pesticides, Toxicity, Human Health Implications (if any), GHS labelling.

ESSENTIAL/RECOMMENDED READINGS

1. Alexander, M. (1999). Biodegradation and Bioremediation (2nd ed.). Academic Press.

2. Copping, L.G. (1996). Crop Protection Agents from Nature: Natural Products and Analogues. Royal Soc. Chem., London, 136.

3. Dev, S. &Koul, O. (1997).Insecticides of Natural Origin. Harwood Acad. Publishers.

4. Godfrey, C.R.A. (1995). Agrochemicals from Natural Products Marcel Dekker.

5. Hall, J.C., Hoagland, R.E. &Zablotowicz, R.M (2001). Pesticide Biotransformation in Plants and Microorganisms: Similarities and Divergences. ACS Symposium Series, 777. Washington, DC.

6. Hassal, K.A.(1990). The Biochemistry. Plenum Press.

7. Jacobson, M. (1965).Insect Sex Attractants. John Wiley & Sons.

8. Jacobson, M. (1970). Naturally Occurring Insecticides. John Wiley & Sons.

9. Khan, S.U. (1980). Pesticides in the Soil Environment. Elsevier.

10. Leahey, J.P. (1985). The Pyrethroid Insecticides. Taylor & Francis.

11.Matsumura, F. (1975). Toxicology of Insecticides. Plenum Press.

12. Menzie, C.M (1980). Metabolism of Pesticides. Update III US Fish and Wildlife Service Special Scientific Report.

13. Parmar, B.S. &Devakumar, C (1990). In: Botanical and Biopesticides. Westvill Publ. House.

14. Racke, K.D., Skidmore, M.W., Hamilton, D.J., Unsworth, J.B., Miyamoto, J. &Cohen, S.Z. (1997). Pesticide Fate in Tropical SoilsPure and Appl. Chem., 69(6), 1349–1371.

15. Mtewa, A. G., Egbuna, C., & Rao, G. M. N. (Eds.). (2021). Poisonous plants and phytochemicals in drug discovery / edited by Andrew G. Mtewa, (First edition.). John Wiley & Sons

16. Osman, A. M. G., Chittiboyina, A. G., & Khan, I. A. (2013). Plant toxins. In *Foodborne infections and intoxications* (pp. 435-451). Academic Press.

17. Keeler, R. F., &Tu, A. T. (Eds.). (1991). *Toxicology of plant and fungal compounds*. M. Dekker.

18. Dauncey, E. A., & Larsson, S. (2018). *Plants that kill: A natural history of the world's most poisonous plants*. Princeton University Press.

KEYWORDS: Bio pesticides, Bacillus thuringiensis, Nuclear polyhedrosis virus, Semi chemicals, Insect growth regulators, Natural nematicides, mollusicides and rodenticides

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 06

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		
Pesticide Formulation and Application Equipment	**4**	**2**	**0**	**2**	**-**	**NIL**

Course objectives

The Learning Objectives of this course are as follows:

- Identify various types of pesticide formulations (e.g., emulsifiable concentrates, wettable powders, granules, suspension concentrates) and discuss their specific characteristics, advantages, and limitations.
- Analyze the chemical and physical properties that affect the formulation's stability, efficacy, and compatibility.
- Importance of pesticide Labelling
- Analyze how the choice of formulation impacts the selection and performance of application equipment.
- Describe the function and importance of key components in application equipment, such as nozzles, pumps, and pressure mechanisms.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Classify different pesticide formulations with an explanation of their components and respective functions
- Demonstrate Knowledge of Pesticide Formulation and labelling

- Select suitable pesticide application equipment based on specific crop requirements, target pest types, and environmental conditions.
- Ensure Safety and Compliance assurance requirements.

SYLLABUS OF DSE- 06

THEORY COMPONENT-

UNIT 1: (7 Hours)

Introduction and Types of Pesticide formulations:

A Definition, purpose of formulations, Important formulation terms: Active Ingredient, Inert Ingredient, Phytotoxicity, Adjuvant, Carrier, surfactants, emulsifiers, stabilizers, wetting agents, Spray Mix Terminology: solution, suspension, emulsion

B International codes for the formulation type.Wettable powders, soluble powder, solutions, emulsifiable concentrates, aerosols, dusts and granules. Controlled Release Pesticides, Bait. Advantages and disadvantages of individual pesticide formulation

UNIT 2: (12 Hours)

Key aspects for creating a formulation and Conventional formulation:

A Type of surface, Training and equipment, Runoff or drift, Safety to people, animals, and the environment, Habits of the pest, Consideration of mixed pesticides for their capabilities and incompatibilities

B Dusting, Powders/ Dust Formulations (DP), Granules (GR), Water Dispersible Powders/Wettable powders (WDP/WP), Soluble Concentrates (SC), Emulsifiable concentrates (EC), Ultra Low volume (ULV) with respect to their ingredients, advantages and disadvantages.

UNIT 3: (4 Hours)

Introduction to pesticide Application Equipment:

Overview of pesticide application equipment (with few selected examples), each tailored to type of the formulation.

1. Dusters: Manually and Power Operated Dusters
2. Sprayers: Knapsack Sprayers, Hydraulic Sprayers, Aerial Sprayers (Aircraft or drones)

3. Modern trends in pesticide application with Precision Application Equipment: Technological advancement with GPS-guided sprayers and drone-based application systems
4. Types of nozzles: Function of nozzles with different size and hole diameter available as an attachment with these sprayers.

UNIT 4: (7 Hours)

Understanding pesticide Label and Labeling:

Definition, purpose of Label and Labeling, Common Terms Used in Pesticides Labels, Precautionary Statements, Direction for Use Environmental Hazards, Color coding Information on the label Symbols,Toxicity information/ statements, Pictograms, Labels (GHS) warning statements, Information about type of formulation, Name of pesticide, active and inert material, Name of manufacturer, Quantity

PRACTICAL COMPONENT (60Hours)

1. Preparation of Emulsifiable concentrate (EC) formulation of given organic compound as oil in water emulsion(O/W).
2. Preparation of EC formulation: Emulsifiable concentrate of neem oil.
3. Preparation of standard hard water.
4. To determine the emulsion stability of given EC formulation.
5. Determination of bulk density of pesticidalwettable powder (WP).
6. Preparation of WP formulation.
7. Volumetric determination of acidity/ alkalinity of WP.
8. Preparation of Suspension Concentrate (SC) formulation.
9. Determination of wettability of pesticidal WP / Dust/SP.
10. To draw pictograms and indicate:
    a. Advice, Warning and their meaning
    b. Colour Codes and their meaning
11. Write the colour identification band and warning symbol as per toxicity Data (LD_{50}) following Government of India Recommendations (*see***reference -2**)
12. Each student to be assigned project for designing the label manually for any five pesticides. It must cover the detailed aspects of: Pesticide formulation, Manufacturers name, Quantity of Active and inert ingredient, Pictograms/GHS labelling/Toxicity statement(s), Handling instruction, Any other information required for label

13. Student to be demonstrate / visit to the manufacturing unit for pesticide Application Equipment

ESSENTIAL/RECOMMENDED READINGS

1. Agrochemicals-Pesticide formulations | IUPAC https://agrochemicals.iupac.org
2. Report of the committee on manner of labelling of pesticides as per toxicity Dated 09 August,20I9 Ministry of Agriculture & Farmers Welfare Government of India No. 24-01/2019-ClR.Ihttps://ppqs.gov.in/sites/default/files/public_notice_0.pdf
3. Cardarelli, N.F. (2018). Controlled Release Pesticides Formulations.CRC Press.
4. Foy, C.L., & Pritchard, D.W. (1996). Pesticide Formulation and Adjuvant Technology. CRC Press.
5. Hall, F.R., Berger, P.D., & Collins, H.M. (1995). Pesticide Formulations and Application Systems (Vol. 14).
6. Knowles, D.A. (1998). Chemistry and Technology of Agrochemical Formulations. Springer.
7. Parmar, B.S., &Tomar, S.S. (2004). Pesticide Formulation - Theory and Practice. CBS Publishers & Distributors.
8. Wade, R. (1973). Pesticide Formulation. Dekker, Inc.
9. Wade, V.V., Sugavanam, B., &Khetan, S.K. (1998). Pesticide Formulation. New Age International Publishers.
10. Ware, G.W. (1994). The Pesticide Book (4th ed.). W.H. Freeman: Fresno, CA.

KEYWORDS: Pesticide formulations, Conventional formulation, pesticide application equipment,Pesticide Label and Labeling, Suspension Concentrate formulation

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SKILL ENHANCEMENT COURSE (SEC-1): Advanced Software Utilities for Chemists

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 Software Utilities for Chemists SEC-1	**2**	**1**	**0**	**1**	**12th class with science**	NIL

Course objectives

Course Objectives:

- To develop basic understanding of important software utilities *Gnuplot* and using this tool for presentation of data in graphical form for research purpose.
- To develop basic understanding of software utilities for designing and formatting chemical structures.
- To develop a basic understanding of functioning of a Large Language Model utility; *ChemCrow* for **C**hemists.

Learning outcomes

After completing the course, the students will be able to:

- Develop standard research quality graphs and analyze the graph for understanding acquired data.
- Use software utilities for designing chemical structures in varied representations for example, in research articles and presentations.
- Use Large Language Model utility; *ChemCrow* for applying molecule tool, safety tool, and chemical reaction tool for analyzing chemical reaction and scientific data for literature survey.

THEORY

UNIT 1: Software Utilities for Chemists **(15 Hours)**

Gnuplot Software Utility

Graphical analysis and visualization of computational data. Need and limitations of Graphical analysis. Introduction to *Gnuplot* plotting tool, a command-driven interactive function and data plotting program.

Basic *Gnuplot* commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file. Locations on a graph, Editing and Styling plots (plot ranges, line styles, colours, fonts, terminal types). Use of multiple axes and multiple plots in a single page.

Basics of three-dimensional plots, generating surface and contour plots, plotting data from a file. Understanding colour spaces, defining palettes, creating coloured graphs with palettes. Advanced plotting concepts; Multiplot, Higher math and special occasions, Mathematical Functions and curve fitting. Exporting graphs to file.

Software Utilities for drawing Chemical Structure and ROSHAMBO Utility

Introduction to software utilities for designing molecules species and representation of chemical reaction and ROSHAMBO utility for molecular alignment and 3D similarity scoring.

Large Language Model utility: ChemCrow

Introduction to *ChemCrow*; *General tool*, *Molecule tool*, *Safety tool NameRXN*, *RXNPredict*, *RXNPlanner* tool for using the software for designing chemical structure, literature survey, exploring safety of materials and prediction and planning reactions.

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. Plotting graphs using Gnuplot

(i) Installing Gnuplot and plotting simple 2-D plots: linear, sine, cosine, exponential
(ii) Ideal gas isotherms
(iii) Pressure-volume curves of van der Waals gas (van der Waals isotherms)
(iv) Planck's distribution law
(v) Radial distribution curves for hydrogen like orbitals
(vi) Maxwell-Boltzmann distribution curves as function of temperature and molecular weight
(vii) Data from phase equilibria studies.
(viii) Graphical solution of equations.
(ix) Simulation of pH metric titration curves.
(x) Simple 3D functions such as sin(x)*cos(y)
(xi) Parametric plots in spherical polar coordinates
(xii) Probability density surface as a function of angle for Hydrogen atom

2. Drawing chemical structures of various compounds (aliphatic, aromatic, heterocyclic with different functional groups, using Free, Open Source, Proprietary and Online software utilities i.e. ACD Chemsketch and 3-D viewer, ChemDraw, ChemDraw online & ROSHAMBO utility.
3. Exploring organic name reactions in ChemCrow

Essential/recommended readings

Theory:

1. Janert P. K., (2010) Gnuplot in Action, Manning Publications Co., Greenwich, CT.
2. Phillips L., (2012) Gnuplot Cookbook, Packt Publishing, Birmingham U.K.
3. Moore B.G., Orbital Plots Using Gnuplot, J. Chem. Edu., 77 (6), (2000) 785-789.
4. Atwi R., Wang Y., Sciabola S., and Antoszewski A., ROSHAMBO: Open-Source Molecular Alignment and 3D Similarity Scoring, J. Chem. Inf. Model., 64, (2024) 8098−8104.
5. https://fitzkee.chemistry.msstate.edu/sites/default/files/ch8613/ibm-gnuplot.pdf
6. https://fitzkee.chemistry.msstate.edu/sites/default/files/bootcamp/2022/session-08_gnuplot-tutorial.pdf
7. https://emleddin.github.io/comp-chem-website/Analysisguide-gnuplot.html
8. https://www.acdlabs.com/resources/free-chemistry-software-apps/chemsketch-freeware/
9. https://chemaxon.com/marvin
10. https://www.insilicochemistry.io/tutorials/foundations/gpt-4-for-chemistry#h.kfv6wyq239nc

Practical:

1. Janert P. K., (2010) Gnuplot in Action, Manning Publications Co., Greenwich, CT.
2. Phillips L., (2012) Gnuplot Cookbook, Packt Publishing, Birmingham U.K.
3. Moore B.G., Orbital Plots Using Gnuplot, J. Chem. Edu., 77 (6), (2000) 785-789.
4. Atwi R., Wang Y., Sciabola S., and Antoszewski A., ROSHAMBO: Open-Source Molecular Alignment and 3D Similarity Scoring, J. Chem. Inf. Model., 64, (2024) 8098−8104.
5. https://fitzkee.chemistry.msstate.edu/sites/default/files/ch8613/ibm-gnuplot.pdf
6. https://fitzkee.chemistry.msstate.edu/sites/default/files/bootcamp/2022/session-08_gnuplot-tutorial.pdf

7. https://emleddin.github.io/comp-chem-website/Analysisguide-gnuplot.html
8. https://www.acdlabs.com/resources/free-chemistry-software-apps/chemsketch-freeware/
9. https://chemaxon.com/marvin
10. https://www.insilicochemistry.io/tutorials/foundations/gpt-4-for-chemistry#h.kfv6wyq239nc

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-2): Lab-Based Learning: Analytical Instruments

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		
Lab-Based Learning: Analytical Instruments **SEC-2**	**2**	**1**	**0**	**1**	**12th class with science**	NIL

Course objectives

Course Objectives:

- To learn about the fundamentals of separation techniques employed in organic synthesis and the purification of organic compounds.
- To understand instrumentation (hardware/software) employed in the analysis and identification of organic compounds.
- Hands-on training on 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 the purification of pure compounds from a mixture.
- work independently on sophisticated equipment used in organic synthesis, correlating with the principle and the instrumentation part.

THEORY

UNIT 1: Separation and Analytical Instruments **(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.

UV-VIS Spectroscopy

Basics and applications of UV-vis spectroscopy, Instrumentation of UV-vis spectroscopy, Applications of UV-vis spectroscopy.

Optical Rotation

Importance of optical activity, Instrumentation of Polarimeter, Sample preparation, Recording Optical rotation of organic compounds.

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. To determine the number of organic compounds present in the given mixture by TLC, and calculate their respective R_f values.
2. To determine the relative polarities of a set of given organic compounds by comparing their R_f on TLC.
3. To separate a mixture of two or more non-polar organic compounds by column chromatography using a gradient solvent system (Hexanes/EtOAc).
4. To separate a mixture of two or more medium/high polarity organic compounds by column chromatography using a gradient solvent system (MeOH/DCM).
5. Hands-on training on running a UV-vis spectroscopy and sample preparation.
6. To verify the linear relationship between absorbance and concentration using a coloured organic compound.
7. To investigate the effect of solvent polarity on the keto-enol equilibrium of acetylacetone by analyzing UV-Visible absorption spectra.
8. To study the effect of pH on the UV-Vis spectrum of an indicator (e.g., methyl orange).
9. Hands-on training on running a polarimeter and sample preparation.
10. To measure the optical rotation of a pair of enantiomers.

Essential/recommended readings

Theory:

1. 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
2. Kemp W., 'Organic Spectroscopy', 3rd ed., Palgrave, New York (1991).

3. 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.
4. Silverstein R. M., and Webster F. X., "Spectrometric Identification of Organic Compounds", 6th ed., John Wiley & Sons, New York (1998).
5. Skoog D. A., Holler F. J., and Crouch S. R., "Principles of Instrumental Analysis", 6th ed., Thomson Brooks/Cole, Cengage Learning, New Delhi (2007).

Practical:

1. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy.
2. Donald A. McQuarrie and John D. Simon, Physical Chemistry: A Molecular Approach.
3. J. Michael Hollas, Modern Spectroscopy.
4. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis.
5. Donald L. Pavia, Gary M. Lampman, George S. Kriz, Introduction to Spectroscopy.
6. Vogel, A. I. (2012), Quantitative Organic Analysis, Part 3, Pearson Education.
7. Mann, F. G., Saunders, B.C. (2009), Practical Organic Chemistry, Pearson Education.
8. Furniss, B. S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), Vogel's Textbook of Practical Organic Chemistry, Fifth Edition, Pearson.
9. 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.