UNIVERSITY OF DELHI

NETAJI SUBHAS INSTITUTE OF TECHNOLOGY

CHOICE BASED CREDIT SYSTEM

SCHEME OF COURSES

FOR

M.TECH.
(NANO TECHNOLOGY)

TABLE OF CONTENTS

PREAMBLE

I. INTRODUCTION

Higher education is very important for the growth and development of any country. It is a living organ and requires continuous changes to ensure the quality of education. National Knowledge Commission and University Grants Commission have recommended many academic reforms to address the challenges of today's networked globalized world. People are coming together with the help of new technologies which is resulting towards new aspirations, expectations, collaborations and associations. The concept of "work in isolation" may not be relevant and significant anymore. The UGC guidelines on adoption of Choice Based Credit System may be an important step to revamp the processes, systems and methodologies of Higher Educational Institutions (HEIs). The teacher centric mode be changed to learner centric mode. Class room teaching and learning be made effective; relevant and interesting. Concepts and theories be explained with examples, experimentation and related applications.

A culture of discussions, arguments, interpretations, counter-interpretations, re-interpretations, opposing interpretations must be established. Research should not only be confined to redefinition, extension and incremental change. Innovation & creativity should become an epicentre for all research initiatives. The most important capital is the human capital and thus the ultimate objective is to develop good human beings with utmost integrity & professionalism for this new world.

The Choice Based Credit System supports the grading system which is considered to be better than conventional marks system. It is followed in many reputed institutions in India and abroad. The uniform grading system facilitates student mobility across the institutions within and across the countries and also enable potential employers to assess the performance of the students. The Choice Based Credit System makes the curriculum interdisciplinary and bridge the gap between professional and liberal education.

II. CHOICE BASED CREDIT SYSTEM

The Indian Higher Education Institutions have been moving from the conventional annual system to semester system. Currently many of the institutions have already introduced the choice based credit system. The semester system accelerates the teaching-learning process and enables vertical and horizontal mobility in learning. The credit based semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching. The choice based credit system provides a 'cafeteria' type approach in which the students can take

courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an interdisciplinary approach to learning. It is desirable that the HEIs move to CBCS and implement the grading system.

A. Types of Courses

Courses are the subjects that comprise the M.Tech. Programme.

1. A course may be designed to comprise lectures, tutorials, laboratory work, field work, outreach activities, project work, vocational training, viva, seminars, term papers, assignments, presentations, self-study etc. or a combination of some of these components.

2. The learning objectives and learning outcomes of each course will be defined before the start of a semester.

3. Courses are of two kinds: Core and Elective.

   i. **Core Course (CC)**: This is a course which is to be compulsorily studied by a student as a core requirement to complete the requirement of M.Tech. Nano Technology

   ii. **Elective Course**: An elective course is a course which can be chosen from a pool of subjects. It is intended to support the discipline of study by providing an expanded scope, enabling exposure to another discipline/domain and nurturing a student's proficiency/skill. An elective may be of following types:

      a) **Discipline Centric Elective (ED)**: It is an elective course that adds proficiency to the students in the discipline.

      b) **Open Elective (EO):** It is an elective course taken from other engineering disciplines that broadens the perspective of an Engineering student.

4. Each course contributes certain credits to the programme. A course can be offered either as a full course (4 credits) or as a half course (2 credits). A full course is conducted with 3 hours of lectures and either 1 hour of tutorial or 2 hours of practical work per week. A half course is conducted with 2 hours of lectures.

5. A student of Postgraduate programme has to accumulate about 40% credits from the Core Courses and the remaining credits from the Elective Courses to become eligible for the award of degree/ diploma/ certificate programmes.

6. A course (full/half) may also be designed without lectures or tutorials. However, such courses may comprise Field work, Outreach activities, Project work, Vocational Training, Seminars, Self-study etc. or a combination of some of these.

7. A Project work/Dissertation is considered as a special course involving application of the knowledge gained during the course of study in exploring, analyzing and solving complex problems in real life applications. A candidate completes such a course on his own with an advisory support by a teacher/faculty member.

B. Examination and Assessment

The following system will be implemented in awarding grades and CGPA under the CBCS system.

1. **Letter Grades and Grade Points:** A 10-point grading system shall be used with the letter grades as given in Table 1 below:

Table1:Grades and Grade Points

Letter Grade	Grade point
O (Outstanding)	10
A+ (Excellent)	9
A (Very Good)	8
B+ (Good)	7
B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
Ab (absent)	0

2. **Fail grade:** A student obtaining Grade F shall be considered failed and will be required to reappear in the examination. If the student does not want to reappear in an elective subject (that is ED, EO *but not CC courses*) then he/she can re-register afresh for a new elective subject.
3. **Non-credit course:** For non-credit courses, 'Satisfactory' or "Unsatisfactory' shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA. However, a student must get satisfactory to get the degree.
4. **Fairness in Assessment:** The CBCS promotes continuous evaluation system where end semester examinations weightage should not be more than 60%. The Departments should design their own methods for continuous evaluation. They

have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi & teaching, learning methods. In this regard, the checks and balances be implemented which enable Departments would effectively and fairly carry out the process of assessment and examination.

5. **Computation of SGPA and CGPA:** The following procedure be used to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):

   i. The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses under gone by a student, i.e.

$$SGPA(S_i) = \frac{\sum C_i \times G_i}{\sum C_i}$$

   Where C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course.

   ii. The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme, i.e.

$$CGPA = \frac{\sum C_i \times S_i}{\sum C_i}$$

   Where S_i is the SGPA of the i_{th} semester and C_i is the total number of credits in that semester.

   iii. The SGPA and CGPA shall be rounded off to two decimal points and reported in the transcripts.

   iv. CGPA shall be converted into percentage of marks, if required, by multiplying CGPA with 10.

III. PROGRAMME STRUCTURE

1. The M.Tech. Nano Technology programme spans 4 semesters, normally completed in 2 years.

2. The courses offered in each semester are given in the **Semester-wise Course Allocation.**

3. The discipline centric subjects under CC and ED categories are listed for each discipline separately.

4. A course may have pre-requisite courses that are given in the **Semester-wise Course Allocation**. A student can opt for an elective only if he/she has fulfilled its pre-requisites.

5. A student has to register for all electives before the start of a semester.

IV. COURSE CODIFICATION

The codes for various Postgraduate Programme are as follows:

i. Department of Electronics and Communication Engineering:
   1. Signal Processing-ECSP
   2. Embedded System and VLSI-ECES

ii. Department of Computer Engineering:
   1. Information System-COIS

iii. Department of Instrumentation and Control Engineering:
   1. Process Control-ICPC
   2. Industrial Electronics-ICIE
   3. Mechatronics-ICMT

iv. Department of Biotechnology:
   1. Biochemical Engineering -BTBC
   2. Bioinformatics-BTBF

v. Manufacturing processes and Automation Engineering:
   1. CAD CAM-MACD
   2. Manufacturing process and Automation Engineering.-MAMP
   3. Production Engineering-MAPE
   4. Engineering Management-MAEM
   5. Nano Technology-MANT

The codes for Departmental core subjects and Domain-specific Electives are specific to each Discipline. The first two characters are derived from Departmental codes listed above.

For Ist semester, the codes are:

NTC01	CC

NTC02	CC
NTD**	Elective
NTD**	Elective
NTD**	Elective
EO***	Open Elective

For IInd semester, the codes are:

NTC03	CC
NTC04	CC
NTD**	Elective
NTD**	Elective
NTD**	Elective
EO***	Open Elective

For IIIrd semester, the codes are:

NTC05	Seminar
NTC06	Major Project
NTD**	Elective
NTD**	Elective
NTD**	Elective

For IVth semester, the codes are:

NTC07	Dissertation

V. EVALUATION SCHEME

The courses are evaluated on the basis of continuous assessments, mid-semester exams and end-semester exams. The weightage of each of these modes of evaluation for the different types of courses are as follows.

Type of Course	Continuous Assessment (CA), Theory	Mid Semester Exam (MS), Theory	End-semester Exam (ES), Theory	Continuous Assessment (CA), Lab	End-semester Exam(ES), Lab
CC/ED/EO Theory with/ without Tutorial	25	25	50	Nil	Nil
CC/ED/EO Theory with Practical	15	15	40	15	15
Major Project and Dissertation	Nil	Nil	Nil	40	60

VI. EVALUATION AND REVIEW COMMITTEE

The Committee of Courses and Studies in each department shall appoint one or more Evaluation-cum-Review Committees (ERC), each committee dealing with one course or a group of courses. This ERC consists of all faculty members who are likely to teach such courses in the group. Normally Head of the department shall be ERC Chairman.

The ERC has the following functions-

(i) To recommend appointment of paper setters/examiners of various examinations at the start of each semester.

(ii) To prepare quizzes, assignments, test papers etc. for Continuous Assessment (CA), Mid-Semester examination (MS) and End Semester (ES) examination and to evaluate them. Normally, each concerned faculty member, who is also a member of ERC, will do this job for his/her class. However, in exceptional

circumstances any part of the work may be entrusted to some other member of the ERC.

(iii) To consider the individual representation of students about evaluation and take remedial action if needed. After scrutinizing, ERC may alter the grades awarded upward/downward. The decision of the ERC shall be final.

(iv) To moderate assignments, quizzes etc. for courses given by each of the concerned faculty members for his/her class with a view to maintain uniformity of standards.

(v) To review and moderate the MS and ES results of each course with a view to maintain uniformity of standards.

(vi) To lay guidelines for teaching a course.

VII. ATTENDANCE, PROMOTION AND DETENTION RULES

1. A student should normally attend all the classes. However, a student will be allowed to appear in the examination if he/ she has put in a minimum of 75% attendance separately in each course for which he / she has registered. A relaxation up to a maximum of 25% may be given on the production of satisfactory evidence that (a) the student was busy in authorized activities, (b) the student was ill.
2. A student should submit the evidence to the fact 1(a) and / or 1(b) above within seven working days of resuming the studies. Certificates submitted later will not be considered.
3. No relaxation in attendance beyond 25% is permitted in any case.
4. A student may re-register for a course if he/ she want to avoid a decrement in the grades.
5. There shall be no supplementary examinations. A student who has failed in a course will have to re-register for the course in a subsequent year.
6. If the student does not want to reappear in an elective course (that is, ED, EO, but not CC courses) then he/she can re-register afresh for a new elective course.

VIII. DECLARATION OF RESULTS

1. The M.Tech (NT) programme consists of 82 credits. A student will be awarded the degree if he/she has earned all 82 credits.
2. CGPA will be calculated on the basis of the best 78 credits earned by the student.
3. The candidate seeking re-evaluation of a course shall apply for the same on a prescribed proforma along with the evaluation fee prescribed by the university from time to time only for the End Semester Examination within seven days from the date of declaration of result.

4. The Institution/University may cancel the registration of all the courses in a given semester if

   i. The student has not cleared the dues to the institution/hostel.

   ii. A punishment is awarded leading to cancellation of the student's registration.

IX. CURRICULUM MODIFICATION

The curriculum will be updated regularly within a period of 5 to 10 years since last revision, to keep pace with the advancements in the field of Nano Technology.

X. CENTRAL ADVISORY COMMITTEE

There shall be a Central Advisory Committee consisting of the following—

a) Dean, Faculty of Technology, Chairman
b) Dean PGS
c) Head of Institution
d) Heads of Departments running MTech Courses

SEMESTER-WISE COURSE ALLOCATION

M.TECH. NANO TECHNOLGY (Full Time) SEMESTER I

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION (MARKS)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTC01	CC	Fundamental Physics and Chemistry of Materials	3	0	2	4	15	15	40	15	15	100
NTC02	CC	Introduction to Nanotechnology	3	0	2	4	15	15	40	15	15	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
EO***	EO	Open Elective#	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			24						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

M.TECH. NANO TECHNOLGY (Full Time) SEMESTER II

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION (MARKS)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTC03	CC	Micro Electro Mechanical Systems	3	0	2	4	10	20	40	15	15	100
NTC04	CC	Measurement and Microscopic Techniques at Nanoscale	3	0	2	4	10	20	40	15	15	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	EO	Open Elective#	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			24						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

M.TECH. NANO TECHNOLGY (Full Time) SEMESTER III

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION (MARKS)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTC05	CC	Seminar	0	0	4	2	100	-	-	-	-	100
NTC06	CC	Major Project	-	-	-	6	-	-	-	40	60	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	30	20	50	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	100	-	-	100
		TOTAL	$			20						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

.

M.TECH. NANO TECHNOLGY (Full Time) SEMESTER IV

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION (MARKS)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTC07	CC	Dissertation	0	0	-	14	-	-	-	40	60	100
		TOTAL	-	-	-	14						

SEMESTER-WISE COURSE ALLOCATION-PART-TIME

M.TECH. NANO TECHNOLGY (Part Time) SEMESTER I

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTC01	CC	Fundamental Physics and Chemistry of Materials	3	0	2	4	15	15	40	15	15	100
NTC02	CC	Introduction to Nanotechnology	3	0	2	4	15	15	40	15	15	100
EO***	EO	Open Elective#	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			12						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

M.TECH. NANO TECHNOLGY (Part Time) SEMESTER II

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTC03	CC	Micro Electro Mechanical Systems	3	0	2	4	10	20	40	15	15	100
NTC04	CC	Measurement and Microscopic Techniques at Nanoscale	3	0	2	4	10	20	40	15	15	100
EO***	EO	Open Elective#	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			12						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

M.TECH. NANO TECHNOLGY (Part Time) SEMESTER III

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			12						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

M.TECH. NANO TECHNOLGY (Part Time) SEMESTER IV

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			12						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

M.TECH. NANO TECHNOLGY (Part Time) SEMESTER V

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTC06	CC	Major Project	-	-	-	6	-	-	-	40	60	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
NTD**	ED	Elective#	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			14						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

M.TECH. NANO TECHNOLGY (Part Time) SEMESTER VI

CODE	Type	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	CA	ES	
NTD**	ED	Elective#	-	-	-	4	-	-	100	-	-	100
NTC05	CC	Seminar	0	0	4	2	100	-	-	-	-	100
NTC07	CC	Dissertation	0	0	-	14	-	-	-	40	60	100
		TOTAL	$			20						

The LTP allocation evaluation scheme and pre-requisites for elective(s) are given in Table 2-3.
$ The actual weekly load will depend upon the elective(s) chosen by the student.

TABLE 2 A: DESCIPLINE CENTRIC ELECTIVES WTH TUTORIAL							
LTP Allocation			**Evaluation Scheme**				
L	**T**	**P**	**CA**	**MS**	**ES**	**CA**	**ES**
3	**1**	**0**	**25**	**25**	**50**	**-**	**-**
Code	**Name of Elective**		**Pre-Requisites**				
NTD01	Nano-Manufacturing		None				
NTD02	Nano-Structures		None				
NTD03	Nano Electronics		None				
NTD04	Fabrication of Nano Materials		None				
NTD05	Nano Biotechnology		None				
NTD06	Nano Electronic Devices		None				
NTD07	Micro Electro Mechanical System		None				
NTD08	Measurement and Microscopic Techniques at Nano scale		None				
NTD09	Embedded systems		None				
NTD10	Mechatronics		None				
NTD11	Smart Materials, Machines and Processes		None				
NTD12	Cell and Molecular Biology		None				
NTD13	Nano composites		None				
NTD14	Carbon Nanotube Electronics and Devices		None				
NTD15	Design of Experiments		None				
NTD16	Nano photonics		None				
NTD17	Industrial Nanotechnology		None				

TABLE 2B: LIST OF DOMAIN SPECIFIC ELECTIVES PART B: WITH PRACTICAL							
LTP Allocation			**Evaluation Scheme**				
L	**T**	**P**	**CA**	**MS**	**ES**	**CA**	**ES**
3	**0**	**2**	**15**	**15**	**40**	**15**	**15**
Code	**Name of Elective**		**Pre-Requisites**				
NTD31	Quantum Physics at Nano scale		None				
NTD32	Nano materials		None				
NTD33	Chemistry of Nano materials		None				
NTD34	Quantum Computation and Communications		None				
NTD35	Solid State Technology		None				
NTD36	Synthesis and Characterization Techniques for Nano materials		None				
NTD37	Green Manufacturing Technology		None				
NTD38	Nano medicine		None				
NTD39	Nano scale Magnetic Materials and Devices		None				

TABLE 3 : LIST OF OPEN ELECTIVES (EO*)**

LTP Allocation			Evaluation Scheme				
L	**T**	**P**	**CA**	**MS**	**ES**	**Int**	**Ext**
3	**1**	**0**	**30**	**20**	**50**	**-**	**-**

Code	Name of Elective	Pre-Requisites
EO001	Technical Communication	None
EO002	Disaster Management	None
EO003	Basics of Finance Management	None
EO004	Basics of Human Resources Management	None
EO005	Project Management	None
EO006	Basics of Corporate Law	None
EO007	Biological computing	None
EO008	Basic of social science	None
EO009	Entrepreneurship	None
EO010	Social work	None
EO011	IP and Patenting	None
EO012	Supply Chain Management-Planning and logistics	None
EO013	Organization Development	None
EO014	Industrial Organisation and Managerial Economics	None
EO015	Global Strategy and Technology	None
EO016	Engineering System Analysis and Design	None
EO017	Biology for Engineers	None
EO018	Energy, Environment and Society	None
EO019	Public Policy and Governance	None

DETAILED SYLLABUS CORE COURSES

Course No	Title of the Course	Course Structure	Pre-Requisite
NTC01	Fundamental Physics and Chemistry Of Materials	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Describe the bonding scheme and its general physical properties, as well as possible applications.
- Describe its physical origin, as well as strength.

COURSE CONTENT

Structure of materials: Structure of Crystals, lattice, bonding in Solids: Bonding in elemental and multi-elemental solids, Cohesive energies, Atomic radius, diffraction and reciprocal lattice, Elastic scattering from ordered and disordered materials, Order and disorder in solids, defects in solids. Physical Properties of Materials: Phonons, Specific heat of Solids and enharmonic effects, Diffusion, Vaporization. Phase diagrams, Structural Phase transitions. Electrical and Thermal Properties: Optical properties of Materials: Magnetic Properties of Materials.Classses of Materials: Semiconductors, Metals and Alloys, Ceramics, Dielectric and Ferroelectric materials Optical Materials, Thin Films and Interfaces and Multi-layers.

SUGGESTED READING

Joel L. Gersten, “The physics and Chemistry of Materials”, Wiley.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTC02	**INTRODUCTION TO NANOTECHNOLOGY**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Describe and explain Nanotechnology.
- Describe Nano materials based on their dimensionality.
- Explain the importance of reduction in materials dimensionality, and its relationship with materials properties.
- understand how basic nanosystems work;

COURSE CONTENT

Introduction to nanotechnology, carbon nanostructures, organic compounds and polymers, bulk nanostructured materials, self-assembly, nanostructured ferromagnetism, catalysts, optical and vibration spectroscopy, biological materials, quantum wells, wires & dots, nano machines and devices.

SUGGESTED READING

Charles P. Poole Jr. & Frank J. Owens, "Introduction to nanotechnology", John Wiley & Sons (Asia) Pte Ltd.
Michael Kohler, "Nanotechnology: Introduction to Nano structuring Techniques", John Wiley & Sons (Asia) Pte Ltd.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTC03	Micro Electro Mechanical Systems	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Be introduced to the field of micro/nano systems
- Gain a knowledge of basic approaches for micro/nanosystem design
- Understand materials science for micro/nanosystem applications
- Understand state of the art micro machining and packaging technologies
- Develop experience on micro/nano systems for photonics and optical applications
- Develop experience on micro/nano systems for power and energy applications
- Development experience on micro/nano systems for clinical/bio medical applications
- Have a good vision to the future of micro/nano technology

COURSE CONTENT

Micro and Nano sensors: Thermal sensors, Radiation sensors, Magnetic sensors, Mechanical sensors.Micro and Nano actuators: Electrostatic actuators, Comb drives, Magnetic actuators, Piezoelectric actuators, Thermal actuators, Hydrolic actuators, Multilayer bonded devices, Micro simulators. Fludics, Micro Total analysis systems, Integrated Optics: Wave guides, Assembly and Packaging. MEMS, NEMS.

SUGGESTED READING

Danny Banks, "Microengineering, MEMS and Interfacing: A Practical Guide", Taylor & Francis and CRC Press.
Henry Balts, Christofer Hierold, Jan G. Korvink and Osamu Tabata, "Enabling Technology for MEMS and Nanodevices", Wiley & Sons.

Course No	Title of the Course	Course Structure	Pre-Requisite

NTC04	Measurement and Microscopic Techniques at Nano scale	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand various optical Probe Techniques used at nano scale.
- Understand basics of modern laser systems.
- Have knowledge of Optical Monitoring of biological tissues.
- Familiar with Optical Imaging.

COURSE CONTENT

Optical Probe Techniques: Introduction/review of basic optical and photophysical properties of molecules: absorption fluorescence, excited state interactions (e.g. quenching, resonance energy transfer, fluorescence depolarisation). The concept of a molecular probe and the modification of molecular optical properties by the environment.

Basic introduction to modern laser systems, single and two-photon laser induced fluorescence, measurement of excited state dynamics (e.g. lifetimes and depolarisation dynamics, FRET (fluorescence resonant energy transfer).

Optical Monitoring: An introduction to the history and development of optical techniques using predominantly near infrared wavelengths, to monitor biological tissue. The basic principles of optical spectroscopy, including the Beer-Lambert law, and techniques such as fluorescence will be covered. A description of a number of different instruments will be given including the photo-plethysmograph, pulse oximeter and near infrared spectrometer.

Optical Imaging: The principles of modeling of light transport in tissue will be introduced as a way of predicting where the light that is detected has traveled (the so called "Forward Problem"). The extension of this modeling to 2D and 3D through the use of the Finite Element Method will then be discussed. The problem of reconstructing an image of the optical properties of the tissue will then be highlighted (the so called "Inverse Problem"), and possible approaches to solving this extremely difficult task outlined. Examples of the applications of both the forward model and image reconstruction will be given and in particular the applications to cerebral monitoring. Scanning Probe and Nano-Electrochemical Techniques:

SUGGESTED READING

H. Hopster & H. P. Oepen, “Magnetic Microscopy of Nanostructures” Springer.

DETAILED SYLLABUS FOR DISCIPLINE CENTRIC ELECTIVES

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD01	**NANO MANUFACTURING**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand the fundamentals specifically associated with manufacturing at the micro- and nano-scale.
- Select appropriate industrially viable processes and equipment, and in designing manufacturing tools for specific industrial products.
- Understand silicon technology used by INTEL-IBM.
- Explain various lithographic methods.
- Understand importance of nano factories

COURSE CONTENT

Silicon Technology: the INTEL-IBM Approach to Nanotechnology, Patterning, Masks, and Photolithography,
Etching Silicon. Methods of Deposition of Metal and Insulating Films. Lateral Resolution (Linewidths) Limited byW avelength of Light, now 65nm. Optical and X-ray Lithography. Electron-beam Lithography.
Sacrificial Layers, Suspended Bridges, Single-electron Transistors. Heat Dissipation and the RSFQ Technology. Scanning Probe (Machine) Methods: One Atom at a Time. Scanning Tunneling Microscope (STM) as Prototype Molecular Assembler. Moving Au Atoms, Making Surface Molecules. Assembling Organic Molecules with an STM. Atomic Force Microscope (AFM) Arrays. Cantilever Arrays by Photolithography. Nanofabrication with an AFM. Imaging a Single Electron Spin bya Magnetic-resonance AFM.Chemical methods in Nano manufacturing, Nano and Micro Machining, Nano-milling, Concept of Nano Factories.

SUGGESTED READING

C. N. R. Rao, “Nanomaterials Chemistry Recent Developments and New Directions”, John Wiley & Sons (Asia) Pte Ltd.
Edward L. Wolf, “Nanophysics and Nanotechnology”, John Wiley & Sons (Asia) Pte Ltd.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD02	**NANO STRUCTURES**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Explain what are the basic principles and properties of the most important systems structured at the Nano scale: structural, electronic, magnetic, optical, chemical.
- Implement simple models to describe the physical properties of nanostructures;
- Present a few applications and to be able to search for scientific informations related to the physics of nanostructures in the scientific literature.

COURSE CONTENT

Magnetic Nanostructures, AMR and GMR Layers and Multilayers for Magnetic Field Sensors, Self-assembled nanostructures in Nature and Industry, Synthetic Self-Assembled Materials, Examples of Nanoscale Materials in Nature. Nanocrystal Self-assembly. Structural Characterization of Nanoarchitectures. Fabrication of Nanoarchitectures Using Lithographic Techniques. Chemical and Photochemical Reactivities of Nano-architectures. Properties of Semiconductor Nanomaterials. Optical, Electronic, Magnetic Properties of Nanomaterials. Electrochemical Properties of Nanoparticle Assemblies. Epitaxy of Nanostructures.

SUGGESTED READING

G. Carotenuto, “Self-Assembled Nanostructures”, Springer.

D. Shi, B. Aktas, L. Pust & F. Mikailov, “Nanostructured Magnetic Materials and Their Applications”, Springer.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD03	**NANO ELECTRONICS**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Familiar with certain nanoelectronic systems and building blocks such as: low-dimensional semiconductors, heterostructures, carbon nanotubes, quantum dots, nanowires etc.
- Understand role of miniaturized electrical and electronic devices.
- Understand process of nanostructuring and extension of conventional devices by Nanotechnology.

COURSE CONTENT

Miniaturization of electrical and electronic devices, Moore's Law, Quantamical Aspects, Nano defects, Nano layers, Nanoparticles, Selected solidstates with Nanocrystalline structures, Nanostructuring, Extension of conventional devices by Nanotechnology. CMOS-MEMS Acoustic Devices, CMOS based Sensors, Circuit and System Integration

SUGGESTED READING

W. R. Fahrner, "Nanotechnology and Nano Electronics: Materials, Devices, Measurement Techniques", Springer.

Serge Luryi, Jimmy Xu, Alex Zaslavsky, "Future Trends in Microelectronics: Upto the Nanocreek", Wiley & Sons.

Henry Balts, Oliver Brand, Garry K. Fedder, Christoffer Hierold, Jan G. Korvink and Osamu Tabata, "CMOS-MEMS: Advanced Micro and Nanosystems, Volume 2", Wiley & Sons.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD04	**FABRICATION OF NANO MATERIALS**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand various methods used for production of carbon nanotubes.
- Describe Fabrication Control and Properties of Nanocrystalline composites.
- Familiar with fabrication of Multilayer Ultrathin Films Through Layer-by-Layer Assembly of Delaminated Nanosheets.

COURSE CONTENT

Multiwall Carbon Nanotubes Produced by Underwater Electric Arc, Synthesis of Polyaniline Nanotubes in the Channels of Anodic Alumina Membrane Electrical Properties of Single-Walled Carbon Nanotube Fiber Under Electron Irradiation, Localization of Charge Carries and Magneto-Transport in Nanocomposites Based on carbon Nanotubes, Fabrication Control and Properties of Nanocrystalline Copper, Synthesis and Processing of Silver Doped Copper Nanopowders, Nanoporous Gold as a Metallic Actor Material Palladium Nanoparticles Generation Within Microcellular Polymeric Foam, Empirical Modeling of the Nanocrystallization Process During Devitrification of an Al-based Metallic Glass, Numerical Modelling of Frequency and Field Dependent Relaxation Time in Soft Magnetic Amorphous Ribbons Hierarchical Nano-Structured Design of Metal-Oxide Catalysts, Formation of Nanostructural Oxide Fibers Silicon Carbonitride Nanopowders Synthesized by Laser Pyrolysis for Plastic Nanocomposites Synthesis of Ormosil Particles by Non-Hydrolytic Sol-Gel Chemistry Grain Boundary Microanalysis in A12030-SiC Nanocomposites, A Neutron Powder Diffraction Study of FeCo-SiO2 Nanocomposites, Acidity Characterization of Nanocyrstalline H-ZSM-5 Zeolites by 31P MAS NMR of Adsorbed Phosphine Oxide Probes, Fabrication of Multilayer Ultrathin Films Through Layer-by-Layer Assembly of Delaminated MnO2 Nanosheets and Polyelectrolytes, Generation of Nanostructured Materials from Thin Films of Block Copolymer Assembles

SUGGESTED READING

Yannick Champion and Hans Jorg Fecht, “Nano Architectured and Nanostructured Materials: Fabrication Control and Properties”, Wiley.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD05	**NANO-BIOTECHNOLOGY**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Account for interaction of biomolecules with surfaces of different chemical and physical species.
- Account for production and the applications of various types of nano-structured materials.
- Analyse applications within the field of bioelectronics and account for the basic principles they are based on.
- Use basic principles of micro fluidics to solve biotechnical and bio analytical problems
- Example on methods for diagnostics and biosensing

COURSE CONTENT

Introduction: Biological molecules, self-assembly and the construction of macromolecular structures, e.g. cell membranes. An overview of molecular interactions in biological systems what information is needed at the molecular level to understand the relationship between e.g. structure and function. Physical principles involved in the probing of biological assemblies and systems at the molecular level. Bio-sensors and bio-electronics, Enzyme-based assays; Antibody-based assays, Nucleic-acid based techniques, e.g. Polymerase Chain Reaction (PCR), Synthesis of the above onto a 'lab-on-a-chip', Tethered membranes.
Imaging and targeted drug delivery: This section will address the novel nanoscale imaging and drug delivery agents now arising at the research level. Stem cell research: This section will examine some of the techniques arising from nanotechnology processing that may contribute to such aspects of tissue engineering as better stem cell scaffolds.

SUGGESTED READING

Brian R. Equins, "Chemical Sensors and Biosensors", Wiley & Sons.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD06	**NANO ELECTRONIC DEVICES**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand basic properties of liquid crystals and their display and non-display applications at nanoscale.
- Familiar with working of Electronic, optical, liquid crystal and magnetic devices.
- Understand importance of molecular properties of the organic materials in the current production and research level electronic devices.

COURSE CONTENT

Electronic, optical, liquid crystal and magnetic devices in which the device dimensions (at the nanoscale) play the key role in dictating their functionality. Spintronic devices (including spin valves and MRAM devices), nanoscale semiconductor electronic devices (including CMOS at sub-15nm gate length, III-V and wide-bandgap devices),solid state devices for quantum computation (including Josephson junctions and quantum dots) and nanoscale photonic devices (including photonic bandgap materials). The basic properties of liquid crystals and their display and non-display applications at nanoscale. The importance of molecular properties of the organic materials in the current production and research level electronic devices.

SUGGESTED READING

Kimberly S. Gehar Forlag, “Nanophysics, Nanoclusters and Nanodevices”, Nova Science Publishers.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD07	**MICRO ELECTRO MECHANICAL SYSTEMS**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Be introduced to the field of micro/nanosystems
- Gain a knowledge of basic approaches for micro/nanosystem design
- Understand materials science for micro/nanosystem applications
- Understand state of the art micro machining and packaging technologies
- Develop experience on micro/nano systems for photonics and optical applications
- Develop experience on micro/nanosystems for power and energy applications
- Development experience on micro/nanosystems for clinical/bio medical applications
- Have a good vision to the future of micro/nano technology.

COURSE CONTENT

Micro and Nano sensors: Thermal sensors, Radiation sensors, Magnetic sensors, Mechanical sensors.Micro and Nano actuators: Electrostatic actuators, Comb drives, Magnetic actuators, Piezoelectric actuators, Thermal actuators, Hydrolic actuators, Multilayer bonded devices, Micro simulators. Fludics, Micro Total analysis systems, Integrated Optics: Wave guides, Assembly and Packaging. MEMS, NEMS.

SUGGESTED READING

Danny Banks, “Microengineering, MEMS and Interfacing: A Practical Guide”, Taylor & Francis and CRC Press.

Henry Balts, Christofer Hierold, Jan G. Korvink and Osamu Tabata, “Enabling Technology for MEMS and Nanodevices”, Wiley & Sons.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD08	**MEASUREMENT AND MICROSCOPIC TECHNIQUES AT NANOSCALE**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand various optical Probe Techniques used at nano scale.
- Understand basics of modern laser systems.
- Have knowledge of Optical Monitoring of biological tissues.
- Familiar with Optical Imaging

COURSE CONTENT

Optical Probe Techniques: Introduction/review of basic optical and photophysical properties of molecules: absorption fluorescence, excited state interactions (e.g. quenching, resonance energy transfer, fluorescence depolarisation). The concept of a molecular probe and the modification of molecular optical properties by the environment.

Basic introduction to modern laser systems, single and two-photon laser induced fluorescence, measurement of excited state dynamics (e.g. lifetimes and depolarisation dynamics, FRET (fluorescence resonant energy transfer).

Optical Monitoring: An introduction to the history and development of optical techniques using predominantly near infrared wavelengths, to monitor biological tissue. The basic principles of optical spectroscopy, including the Beer-Lambert law, and techniques such as fluorescence will be covered. A description of a number of different instruments will be given including the photo-plethysmograph, pulse oximeter and near infrared spectrometer.

Optical Imaging: The principles of modeling of light transport in tissue will be introduced as a way of predicting where the light that is detected has traveled (the so called "Forward Problem"). The extension of this modeling to 2D and 3D through the use of the Finite Element Method will then be discussed. The problem of reconstructing an image of the optical properties of the tissue will then be highlighted (the so called "Inverse Problem"), and possible approaches to solving this extremely difficult task outlined. Examples of the applications of both the forward model and image reconstruction will be given and in particular the applications to cerebral monitoring.Scanning Probe and Nano-Electrochemical Techniques:

SUGGESTED READING

H. Hopster & H. P. Oepen, “Magnetic Microscopy of Nanostructures”, Springer.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD-09	**EMBEDDED SYSTEM**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems..
- Become aware of the architecture of the ATOM processor and its programming aspects (assembly Level)
- Become aware of interrupts, hyper threading and software optimization.
- Design real time embedded systems using the concepts of RTOS.
- Analyze various examples of embedded systems based on ATOM processor.

COURSE CONTENT

Programming Concepts: Review of C programming data structures, arrays, stacks, queues, project management. Real Time Operating Systems: OS services and structures process and memory management Inter process communication Example RTOS:

Application specific instruction set processor and digital signal processor: RISC and CISC architectures with focus on designing the datapath and control path. Sample DSP archituctures Motorola 56XX series, Analog Devices:

Microcontroller Architectures: 8 bit microcontroller, focusing on AVR RISC microcontrollers 32 bit focusing on ARM microcontroller.

Embedded controller components: Timers/counters, UMRT, Watchdog Timers ADC, DAC RTC Digital I/O Peripheral devices: LCD Character and graphics displays switches touch screen keyboard Communication protocols: 12C, SPI CAN bus RS232, RS485, Ethernet 31luetooth, IrDA IEEE802.11 etc.

Memory Subsystems: Common memory types memory hierarchy and cache storage subsystems.

Interfacing communication basics I/O addressing Interrupts DMA Bus architectures like ISA PCI compact PCL Communication Software protocols like TCP/IP .

SUGGESTED READING

R.J.A. Buhr, D.L.Bailey, “An Introduction to Real-Time Systems”, PHI.

C.M.Krishna, Kang G. Shin, “Real Time Systems”, McGraw Hill.

Raymond J.A.Buhr, Donald L. Bailey; “An Introduction to Real Time Systems”, PHI.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD10	**MECHATRONICS**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand the mechanisms of commonly used actuators and how to select a proper set of sensors and actuators for a practical mechatronic system.
- Identification of key elements of mechatronics system and its representation in terms of block diagram
- Understanding the concept of signal processing and use of interfacing systems such as ADC, DAC, digital I/O
- Development of PLC ladder programming and implementation of real life system
- Explain the concepts of mechatronic systems, adoptive control, man-machine interface and mechatronic design.
- Summaries the concepts of mechanical and electronic actuation systems.
- Explain the working of stepper and servo motors.
- Write the programme for programmable logic controllers and discuss case studies of mechatronic systems.
- The students will be able to feel the importance of this subject as mechanical engineering students. They will be able to understand the need of the subject for industries. To some extent they will be able to design the basic circuit of a mechatronic system.

COURSE CONTENT

Introduction to Mechatronics, Hydraulic and Pneumatic actuator systems, operational characteristics and performance of hydraulic based actuation systems including linear devices rotary devices, flow control valves pressure control valves, I.P and P-1 converters ancillary.

SUGGESTED READING

1. Andrew Parr, “Hydraulic and Pneumatic”, (HB), Jaico Publishing House.
2. Bolton. W. “Pneumatic and Hydraulic Systems”, Butterworth – Heineman.
3. Lawrence J.Kamm, “ Understanding Electro-Mechanical Engineering, An Introduction to Mechatronics”, Prentice-Hall.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD11	**SMART MATERIALS, MACHINES AND PROCESSES**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Learnt about development of actuators and sensors and their integration into a smart structure
- Gain knowledge about measurement, Signal Processing and control strategies
- Learnt the issue Design, Analysis and manufacturing of embedding sensors and actuators, sensor fusion and incorporation of basic intelligence to such systems will be addressed
- Get knowledge about application areas of smart materials

COURSE CONTENT

Characteristics of smart materials like piezoelectric, shape memory alloys electro-rheological materials Magnetostrictive materials etc. Modelling and applications for sensing, actuation and control. Adaptive control applications in structures for vibration suppression, detection and control of damage in composite structures, use for actuation, valves, suspensions, clutches brakes etc.
Health monitoring and fault diagnosis of machines and structures like computer controlled manufacturing machines, aerospace structures etc. Monitoring of parameters like temperature, cracks, wear, speed, thermal deflections, vibrations and process parameters. Diagnostics of faults using expert systems, artificial neural networks, fuzzy logic, wavelet transforms etc. Practical Courses shall be undertaken based on the theoretical topics covered in the theory courses.

SUGGESTED READING

1. Halpin, J.C., “Primer on Composite Materials, Analysis”, Techomic Publishing Co.

2. Agarwal, B.D., and Broutman L.J., “Analysis and Performance of Fiber Composites”, John Wiley and Sons, New York.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD12	**CELL AND MOLECULAR BIOLOGY**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Describe how gene expression is regulated at different levels, how tissue-specific expression is achieved and exemplify how gene expression can be manipulated and studied experimentally
- Account for the molecular mechanisms regulating and controlling cell division and the cell cycle and exemplify how extracellular signals affect cell division
- Describe the molecular mechanisms behind DNA damage and repair
- Describe and compare different molecular mechanisms to bring about cell death and explain how this is linked to DNA damage
- Explain how molecular defects in a cell can lead to its development into a cancer cell
- Explain and compare different principles of how extracellular signals can reach the cell interior, be amplified, transmitted and terminated, and exemplify how signal routes are integrated and how specificity can be achieved
- Describe the molecular structure and function of extracellular matrices and how cells interact with these and each other
- Explain different principles and molecular mechanisms of how and why cells move
- Account for basic concepts of hereditary and population genetics and master fundamental genetic calculations
- Exemplify and explain methods for how the flow from gene to protein can be achieved and observed experimentally.
- Analyse hereditary data and apply fundamental coupling analyses and genetic calculations
- Apply critical thinking and logical analysis in the assessment and evaluation of issues in cell biology and genetics.
- Reflect on issues of cell biology and genetics and on the ethical principles governing the use and analysis of genetic data

COURSE CONTENT

Origin and evolution of cells. Tools of cell biology-Light microscopy-Electron Microscopy-Subcelluar fractionation, study of the living cells-Fixation and staining: - freeze drying and free substitution. Microtomes & embedding- Chemical basis of staining metachromatia, cytochemical methods.
Prokaryotes & eukaryotes: Molecular composition of cells- Carbohydrates- Lipids- Nucleic acids- Proteins, Cell membranes-Membrane lipids. Cell wall and extra cellular matrix- cytoskeleton- cell membrane (including plasma membrane)-

Endocytosis- Cell-cell interactions. Cell cycle- Mitosis-Meiosis- Regulation of cell cycle- Molecular basis.
Components of dna - purine bases -pyrimidine bases deoxyribose sugar - physical and chemical properties of dna - chemical modifications - introduction of dna nanotechnology- primary, secondary, super secondary, tertiary, quaternary structures - the methods to determine - prediction methods -utilization of genomic databases.Structure and reactions of amino acids - hydrophilic and hydrophobic amino acids - table of standard amino acid abbreviations and side chain properties - nonstandard amino acids- biochemistry of proteins - cellular functions of proteins - introduction to protein based nanotechnology.
Golgi- LysosomesPeroxysomes-Hydrogenosomes & centrosomes. The cell nucleus: Nuclear envelope- Nucleolus- Chromosomes. Prokaryotic nucleoids(bacterial & plastid genomes).Membrane functions; Cell adhesions & cell junctions. Membrane transport- Neurotransmission- Vesicular transport & membrane function(Secretory & endocytic pathways). Membrane proteins-Transport across the membranes.
Cell signaling & cell transduction:- Signalling molecules & their receptors- Functions of cell surface receptors- Pathways of intracellular signal transduction. Signal transduction and cytoskeleton- Development & differentiation- Regulation of programmed cell death. Innate immunity- adaptive immunity- cells of reticulo endothelial system- antigen presenting cells and its pathways - complement system and its pathways- tumor immunology- life cycle of HIV Virus- monoclonal antibodies synthesis and applications

SUGGESTED READING

1. Geoffrey M. Copper, "The Cell A Molecular Approach‖", ASM press, Sinauer Associates, Inc., Washington.

2. Harvey Lodish, Arnold Berk, S.L Zipursky, Paul Matsudaira, David Baltimore and James Danell, "Molecular Cell Biology", W.H Freeman and company.

3. E.D.P. De Robertis, and E.M.F De Robertis, "Cell and Molecular Biology", Lippincott Williams and Wilkins.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD13	**NANOCOMPOSITES**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- describe the main existing materials used in nanocomposites and explain the advantages of disadvantages of these reinforcements and matrices, respectively
- outline state of the art by a literature review in the intersection of nanocomposites and the PhD student's own research area
- understand the relation between composite structure on the micro- or nanoscale, and the macroscale properties, including basic mechanical notions
- explain why these relations are not directly transferrable from the micron to the nanoscale
- use acqueired knowledge in possible role in design of engineered materials, in particular in relation to the PhD students own research projects
- practice and improve critical thinking in analysis of recent publications in the field of nanocomposites in discussion with other course participants
- conduct a limited literature survey on a given topic at the research forefront within the field of the course

COURSE CONTENT

Classification of nanoparticles by size. Stability of nanoparticles in solutions – Stabilizing capability characteristics of polymers – Characteristics of polymer absorption on metal surfaces specifics of polymer surfactants as stabilizers – Mechanism of nanoparticles stabilization by polymers – Stabilization of nanoparticles by electrolytes – Surface proofing as a method of stabilizing nanoparticles by polymers on the problem of matrix confinement

Nanocomposite preparation – Physical methods of incorporating nanoparticles into polymers – Mechanochemical dispersion of precursors jointly with polymers – Microencapsulation of nanoparticles into polymers – Physical deposition of metal nanoparticles on polymers – Formation of 2D nanostructures on polymers – Formation of metal

nanoparticles in polymer matrix voids (pores) – Physical modification and filling of polymers with metal reduction of polymer – Bound metal complexes – Nanocomposites formation by metal containing precursor thermolysis – Nanocomposite formation in monomer – Polymer matrices in thermolysis – Nanocomposites on the base of polymer – Immobilized metalloclusters.

Basic notion of metal containing protein systems – Metal nanoparticles in Immunochemistry, Cytochemistry and Medicine – Biosorption, selective heterocoagulation and bacterial concentration of metal nanoparticles – Sol-gel process

as a way of template – Synthesized nanobioceramics – Biomineralization and bioinorganic nanocomposites – Control of physic-mechanical properties of nanocomposites – Peculiarity of nanocomposites synthesized by solgel methods – Polyolefin based nanocomposites – Polymer matrix structurization in nanocomposites – Physical and mechanical properties of metallopolymer nanocomposites – Nanocomposites in adhesion compounds and Tribopolymers – New trends in Material science connected with metallopolymeric nanocomposites

SUGGESTED READING

1. C. F. Candau and R. H. Ottewill, "An introduction to polymer colloids", Springer Berlin Heidelberg, New York.

2. A. D. Pomogailo and V. S. Savostyanov, "Synthesis and polymerization of metal containing monomers", CRC press.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD14	**CARBON NANOTUBE ELECTRONICS AND DEVICES**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Familiar with structure, types and electronic properties of carbon nanotubes.

COURSE CONTENT

Carbon materials – Allotropes of carbon – Structure of carbon nanotubes – Types of CNTs – Electronic properties of CNTs – Band structure of Graphene – Band structure of SWNT from graphene – Electron transport properties of SWNTs – Scattering in SWNTs – Carrier mobility in SWNTs.

CVD synthesis – Method – Direct incorporation with device fabrication process – SWNT synthesis on metal electrodes – Lowering the synthesis temperature – Controlling the SWNT growth – Location, Orientation, Chirality – Narrowing diameter distributions – Chirality distribution analysis for different CVD processes – Selective removal of the metallic nanotubes in FET devices – Integration.

Schottky barrier heights of metal S/D contacts – High k-gate dielectric integration – Quantum capacitance – Chemical doping – Hysteresis and device passivation – Near ideal, Metal-contaced MOSFETs – SWNT MOSFETs – SWNT band-to-band tunneling FETs.

Assessing the AC response of Top gated SWNT FETs – Power measurement using a spectrum analyzer – Homodyne detection using SWNT FETs – RF characterization using a two tone measurement – AC gain from a SWNT FET common source amplifier – Device simulation of SWNT FETs – SWNT FET simulation using NEGF – Device characteristics at the Ballistic limit – Role of Phonon scattering – High frequency performance limits – Optoelectronic phenomena.

Schottky barrier SWNT-FET modeling – Compact model for circuit simulation – Model of the intrinsic SWNT channel region – Full SWNT-FET model – Applications of the SWNT-FET compact model – Performance modeling for carbon nanotube interconnects – Circuit models for SWNTs – Circuit models for SWNT bundles – Circuit models for MWNTs – Carbon nanotube interconnects – Applications.

SUGGESTED READING

1. Javey, Ali, Kong, Jing (Eds.), "Carbon Nanotube Electronics", Springer.
2. François Léonard, "The Physics of Carbon Nanotube Devices", Elsevier.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD15	**DESIGN OF EXPERIMENTS**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand the importance of statistical design of experiments and benefits in R&D
- Learn the experimental designs most widely used in practice
- Choose an appropriate experimental design based on the study objectives
- Construct and implement the design selected
- Analyze the data collected based on the design used and its underlying assumptions
- Interpret the results of the experiment and report the conclusions

COURSE CONTENT

Objectives, principles, terminologies, guidelines, and applications of design of experiments. Completely randomized design. Randomized block design. Latin square design. Two level and three level full factorial designs. Fractional factorial designs. Robust design. Mixture experiments. Central composite and Box-Behnken designs. Response surface methodology. Multi-response optimization. Analysis of variance. Statistical test of hypothesis. Analysis of multiple linear regression. Use of statistical software packages.

SUGGESTED READING

1. DC Montgomery, "Design and Analysis of Experiments", Wiley.
2. George Box, "Statistics for Experimenters: Design, Innovation, and Discovery" Wiley.
3. C. F. Jeff Wu, Michael S. Hamada, "Experiments: Planning, Analysis, and Optimization", Wiley.
4. Wu & Hamada, "Experiments: Planning, Analysis and Optimization", Wiley.

No Course	Title of the Course	Course Structure	Pre-Requisite
NTD16	**NANOPHOTONICS**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Reflect the fundamental principle of light-matter interaction in nanostructures.
- Digitalize the fundamental light-matter interaction via identifying and analyzing the time and memory requirements in numerical computation and computer visualization.

Compute and visualize electron, photon, and electron-photon interaction (light-matter) in simplified nano optoelectronic and bio systems

COURSE CONTENT

Photons and electrons: similarities and differences,freespace propagation. Confinement of photons and electrons. Propagation through a classicallyforbidden zone: tunneling. Localization under a periodic potential: Band gap. Cooperative effects for photons and electrons.Nanoscale optical interactions, axial and lateral nanoscopiclocalization.Inorganic semiconductors, quantum wells, quantum wires, quantum dots, quantum rings. Manifestation of quantum confinement: Optical properties nonlinear optical properties. Quantum confined stark effect. Dielectric confinement effect, superlattices.Core-shell quantum dots and quantum-dot-quantum wells. Quantum confinedstructures as Lasing media. Organic Quantum-confined structures

Internal reflection and evanescent waves –plasmons and surface plasmon resonance –Attenuated Total reflection – Grating SPR coupling –Optical waveguide SPR coupling-SPR dependencies and materials –plasmonics and nanoparticles

Important features of photonic crystals-Presence of photonic bandgap-anomalous group velocity

Aperture less near field optics-near field scanning optical microscopy (NSOM or SNOM)-SNOM based detection of plasmonic energy transport-SNOM based visualization of waveguide structures-SNOM in nanolithography-SNOM based optical data storage and recovery-generation of optical forces-optical trapping and manipulation of single molecules and cells in optical confinement-laser trapping and dissection for biological systems.

SUGGESTED READING

1. H. Masuhara, S. Kawata and F. Tokunga, “NanoBiophotoics”, Elsevier Science.
2. B. E. A. Saleh and A. C. Teich, “Fundamentals of Photonics”, John Wiley and Sons, NewYork.
3. P. N. Prasad, “Introduction to Biophotonics”, John Wiley and Sons.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD17	**INDUSTRIAL NANOTECHNOLOGY**	**L-T-P:** 3-1-0	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand the advantages of nano electrical devices, electronic devices and nanoelectromechanical systems.
- Understand important role of Nanoparticles in bone substitutes and dentistry.
- Familiar with use of Nanocatalyts in production of Smart materials.
- Familiar with use of Nanotechnology in Agriculture and Nanofibre production.

COURSE CONTENT

Advantages of nano electrical and electronic devices –Electronic circuit chips – Lasers - Micro and NanoElectromechanical systems – Sensors, Actuators, Optical switches, Bio-MEMS –Diodes and Nano-wire Transistors - Data memory –Lighting and Displays – Filters (IR blocking) – Quantum optical devices – Batteries - Fuel cells and Photo-voltaic cells – Electric double layer capacitors – Lead-free solder – Nanoparticle coatings for electrical products

Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery – Nanorobotics in Surgery – Photodynamic Therapy - Nanosensors in Diagnosis– Neuro-electronic Interfaces – Protein Engineering – Drug delivery – Therapeutic applications -

Nanocatalyts – Smart materials – Heterogenous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays

Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology – Potential of nano-fertilizers - Nanotechnology in Food industry - Packaging, Food processing - Food safety and biosecurity – Contaminant detection – Smart packaging

Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application – Polymer nanofibers - Nylon-6 nanocomposites from polymerization - Nano-filled polypropylene fibers - Bionics– Swim-suits with shark-skin-effect,Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes)

SUGGESTED READING

1. Mark A. Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson.
2. Bharat Bhushan, "Handbook of Nanotechnology", Barnes & Noble, Springer.
3. Neelina H. Malsch, "Biomedical Nanotechnology", CRC Press.
4. Udo H. Brinker, Jean-Luc Mieusset, "Molecular Encapsulation: Organic Reactions in Constrained Systems", Wiley Publishers.
5. P. J. Brown and K. Stevens, "Nanofibers and Nanotechnology in Textiles", Woodhead Publishing Limited, Cambridge.
6. Y-W. Mai, "Polymer Nano composites", Woodhead publishing.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD31	**QUANTUM PHYSICS AT NANOSCALE**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand fundamental concepts of Quantum and Statistical Physics.
- Understand fundamental concepts of Solid State Physics.
- Describe principles of Semiconductor Devices.
- Explain working and use of single electron transistors (SETs).
- Gain knowledge of Magnetism and Superconductivity.
- Describe Basic Atomic and Molecular Physics.

COURSE CONTENT

Introduction to Quantum and Statistical Physics: Electrons as waves, wave mechanics, Schrödinger's equation and particle in a box; Heisenberg's Uncertainty Principle. Introduction to the operator formalism – bras, kets, expectation values; spin and the exclusion principle. Boltzmann distribution; indistinguishable particles – Fermi-Dirac and Bose-Einstein distributions.
Introduction to Solid State Physics: Crystal structure; free electron theory of metals; band theory of solids; metals and insulators; semiconductors: classification, electrons and holes, transport properties; size and dimensionality effects – quantum wells, wires and dots.
Principles of Semiconductor Devices: The p-n junction and the bipolar transistor; metal-semiconductor and metal-insulator-semiconductor junctions; field-effect transistors, MOSFETs, CMOS; heterostructures, high electron mobility devices, HEMTs; Quantum Hall Effect; Introduction to single electron transistors (SETs): quantum dots, single electron effects, Coulomb blockade.
Introduction to Magnetism and Superconductivity: Basic magnetic phenomena: para-magnetism, ferromagnetism, ferromagnetism, anti-ferromagnetism; nano-magnetism; giant and colossal magneto-resistance; ferro-fluids. Basic superconductivity phenomena; flux quantization and Josephson effects.
Basic Atomic and Molecular Physics: Revision of the hydrogen atom, spectroscopic series. The helium atom and the exchange interaction. Many electron atoms, spin-orbit coupling, spectroscopic notation. Interaction of atoms with external fields and radiation - Stark and Zeeman Effects, selection rules, lasers. NMR and ESR. Molecular spectra -electronic, vibration and rotation. Bonding and anti- bonding orbitals.

SUGGESTED READING

Edward L. Wolf, "Nanophysics and Nanotechnology", John Wiley & Sons (Asia) Pte Ltd.
D. K. Ferry, "Quantum Mechanics: An Introduction for Device Physists & Electrical Engineers", informa- Taylor & Francis group.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD32	**NANO MATERIALS**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand the general physics and chemistry of nanomaterials
- Understand processing techniques for nanomaterials – both chemical and physical approaches
- Understand the important applications and properties of nanomaterials
- Describe and explain nanotechnology.
- Describe nanomaterials based on their dimensionality.
- Explain the importance of reduction in materials dimensionality, and its relationship with materials properties.

COURSE CONTENT

Introduction, charastistics, fabrication and applications of Zero Dimensional nanomaterials-Nano particles, One dimensional nanomaterials-Nanowires and Nanorods, Two dimensional nanostructures: Films, Special nanomaterials Nanostructures fabricated by Physical Techniques, Characterization and Properties of Nanomaterials, Applications of Nanomaterials. Physical and chemical techniques for synthesis of nanoparticles. Nanocrystalline materials, Semiconductor Nano crystals, Nano Composites.

SUGGESTED READING

Guozhong Cao, “Nanostructures and Nano-materials: Synthesis properties and Applications”, World Scientific Publishing Co. Pte. Ltd.
Luis M. Liz-Marzan and Prashant V. Kamat, “Nanoscale Materials”, Kluwer Academic Publishers.
Kenneth J. Klabunde, “Nanoscale Materials in Chemistry”, Wiley & Sons.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD33	**CHEMISTRY OF NANOMATERIALS**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Describe co-precipitation technique and compare it with other solution based techniques.
- Describe sol-gel technique and compare it with other solution based techniques.
- Describe microemulsion synthesis technique and compare it with other solution based techniques.
- Describe mesocrystals and their formation using self-assembly principles.

COURSE CONTENT

Molecular Machines, Nanomaterials for Optoelectronics, Non-aqueous Sol-gel Processed for the Synthesis of Oxidic Nano-particles, Recent Results on Nano-crystals Peptide Nanotubes and Related Aspects, Photo/Electrochemistry, Nanowires and Nanotubes, Growth of Nano-particles, Nanoscale Electronic Phase Separation in Oxides Nano-electrodes: Batteries Molecular Electronics.

SUGGESTED READING

C. N. R. Rao, "The Chemistry of Nanomaterials", John Wiley & Sons (Asia) Pte Ltd.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD34	**QUANTUM COMPUTATION AND COMMUNICATIONS**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Provide a comprehensive introduction to the emerging area of quantum information science.
- Acquaint the student with the practical applications and importance of some basic notions of quantum physics such as quantum two state systems (qubits), entanglement and decoherence.
- Arm a student with the basic concepts, mathematical tools and the knowledge of state of the art experiments in quantum computation & communication to enable him/her embark on a research degree in the area.
- Demonstrate the greater power of quantum computation through the simplest quantum algorithm (the deutsch algorithm)
- Work through the mathematics underlying schemes such as dense coding, teleportation, entanglement swapping as well their simple variants.
- Know the basic quantum logic gates
- Construct circuits for arbitrary multi-qubit unitary operations using universal quantum gates
- Describe the important quantum algorithms such as shor's algorithm & grover's algorithm.

COURSE CONTENT

Introduction to the quantum information (the basic notions such as quantum cryptography, quantum algorithms, teleportation). The qubit and its physical realization, Single qubit operations and measurements, The Deutsch algorithm, Quantumno-cloning. Quantum Cryptography: The BB84 quantum key distribution protocol, elementary discussion of security. Pphysical implementations of kilometers. Quantum Entanglement: State space of two qubits; Entangled states; Bell's inequality; Entanglement based cryptography; Quantum Dense Coding. Quantum Teleportation; Entanglement Swapping; Polarization entangled photons & implementations; von-Neumann entropy. Quantification of pure state entanglement. Quantum Computation: Tensor product structure of the state space of many qubits; Discussion of the power of quantum computers. The Deutsch-Jozsa algorithm; Quantum simulations. Quantum logic gates and circuits; Universal quantum gates; Quantum Fourier Transform; Phase Estimation; Shor's algorithm; Grover's algorithm. Decoherence & Quantum Error Correction: Decoherence. Errors in quantum

computation & communication;Quantumerror correcting codes. Elementary discussion of entanglement concentration & distillation. Physical Realization of Quantum Computers: Ion trap quantum computers. Solid state implementations (Kane proposal as an example). NMR quantum computer.
SUGGESTED READING Sandor Imre, Ferenc Balazs, Quantam, "Computing and Communications", Wiley & Sons. Stig Stenholm and Kalle-Antti Suominen, "Quantam Approach to Informatics", Wiley & Sons.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD35	**SOLID STATE TECHNOLOGY**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Familiar with Vibrational and Thermal properties of Nanostructures.
- Have an overview of Band theory, Bloch's theorem, etc.

COURSE CONTENT

Crystals of Inert gases – van der Waal-London interaction – Cohesive Energy - Ionic crystals – Madelung Energy - Covalent crystals – Metals – Hydrogen bonded solids – Analysis of Elastic strains – Dilation and Stress components - Elastic Compliance and Stiffness constants – Evaluation of Bulk Modulus and Compressibility - Elastic Waves in Cubic Crystals.

Overview of Reciprocal lattice, Brillouin zone – Crystals with monoatomic basis – Two atoms per primitive basis – Quantization of Elastic waves – Phonon momentum – Elastic properties – Phonon Heat Capacity – Planck distribution – Density of states – Debye T^3 law – Einstein's model of Density of states - Thermal expansion – Heat conduction by Phonons – Vibrational and Thermal properties of Nanostructures

Overview of Band theory, Bloch's theorem – Boundary conditions (counting states) – Types of solids : Band picture – Cohesion – Rigid band model and Density of States – Fermi statistics of electrons – Statistics of carriers in Semiconductor – Electronic specific heat - Imaging techniques for Nanostructures – Electronic structure of 0D and 1D systems – Electrical transport in 0D, 1D

Boltzmann equation – Electrical conductivity – Calculation of relaxation time – Impurity scattering – Ideal resistance – Carrier mobility – General transport coefficients – Thermal conductivity – Thermo-electric effects – Wiedmann-Franz Law - Magneto-resistance - Optical reflectance – Excitons – Raman Effects in Crystals - Energy Loss of Fast particles in Solid

Holes, Equations of motion, Effective mass – Silicon and Germanium – Intrinsic carrier concentration and Intrinsic conductivity – Impurity conductivity – Donor and Acceptor states – Semi-metals – Superlattices – Bloch oscillator - Zener tunneling - p-n Junction diode – V-I Characterstics - Bipolar Transistors – Circuit arrangements – Junction Field-Effect transistor –Metal-Semiconductor Junctions – Schottky Barrier Diode – Rectifying Metal-N/P semiconductor junction – MOSFET and MESFET.

SUGGESTED READING

1. C. Kittel, "Introduction to Solid State Physics", Wiley India Pvt. Ltd.
2. J. M. Ziman, "Principles of the Theory of Solids", Cambridge University Press.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD36	**SYNTHESIS AND CHARACTERIZATION TECHNIQUES FOR NANOMATERIALS**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Fabricate/synthesize nanostructures by either approach.
- Discuss various physical methods of synthesis of nanomaterials.
- Enunciate various chemical methods of synthesis of nanomaterials.
- Discuss various biological methods of synthesis of nanomaterials and their mechanisms of formation.
- Develop nanostructures on substrates and pattern them to desired shape using lithographical etching techniques.
- Study of structure, composition and analysis of synthesized nanomaterials by various characterization techniques.

COURSE CONTENT

Size Effects – Fraction of Surface Atoms – specific Surface Energy and Surface Stress – Effect on the Lattice Parameter – Phonon Density of States – the General Methods available for the Synthesis of Nanostrutures – precipitative – reactive – hydrothermal/solvothermal methods – suitability of such methods for scaling – potential Uses

Solution growth techniques of 1D-2D nano structures:- Synthesis of metallic, semiconducting and oxide nanoparticles – homo- and hetero-nucleation growth methods – template-based synthesis (electrochemical, electrophoretic, Melt and solution, CVD, ALD) – Gas Phase Synthesis of Nanopowders: – Vapor (or solution) – liquid – solid (VLS or SLS) growth – the Need for Gas/vapor State Processing – Main Stages of Gas Phase Synthesis – Applicability of the methods.

Thermodynamics of Phase Transitions – triggering the Phase Transition – fundamentals of nucleation growth – Controlling Nucleation & Growth – Size Control of the Nanometric State –Aggregation – Stability of Colloidal Dispersions – Spontaneous Condensation of Nanoparticles: Homogeneous Nucleation – Spinodal decomposition – Other undesirable Post-Condensation Effects – Nanoparticles' morphology

Magnetic Moment in clusters/Nanoparticles – Magnetic Order – coercivity – Magnetocrystalline Anisotropy – thermal activation and Superparamagnetic effects – Electronics and Optoelectronics:- Quantum Confinement of Superlattices and Quantum Wells – Dielectric Constant of Nanoscale Silicon – Doping of a Nanoparticle – Excitonic Binding and Recombination Energies – Capacitance in a Nanoparticle –

Diffusion in Nanocrystalline Materials –Diffusion In Grain Boundaries Of Metals – Nanocrystalline Ceramics – Correlation Between Diffusion and Crystallite Growth –

Other properties: – brief overview of optical properties – mechanical properties including superplasticity phenomena – reactivity of nanoparticles Fundamentals of the techniques – experimental approaches and data interpretation – applications/limitations of Xray characterization: – X-ray sources – wide angle, extended x-ray absorption technique – Electron microscopy: SEM/TEM – high resolution imaging – defects in nanomaterials – Spectroscopy: – electron energy-loss mechanisms – electron filtered imaging – prospects of scanning probe microscopes – optical spectroscopy of metal/semiconductor nanoparticles.
SUGGESTED READING 1) C. N. R. Rao, A. Mu¨ller, A. K. Cheetham, "The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Volume 1", Wiley-VCH, Verlag GmbH, Germany. 2) C. Bre´chignac P. Houdy M. Lahmani, "Nanomaterials and Nanochemistry", Springer Berlin Heidelberg, Germany. 3) Guozhong Cao, "Nanostructures & Nanomaterials Synthesis, Properties G;Z: Applications", World Scientific Publishing Private, Ltd., Singapore. 4) Zhong Lin Wang, "Characterization Of Nanophase Materials", Wiley-VCH, Verlag GmbH, Germany.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD37	**GREEN MANUFACTURING TECHNOLOGY**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- Understand the fundamentals and applications of Green Manufacturing.
- Know about government initiative and motivation of Green Manufacturing.
- Know about Material and solid waste management.

COURSE CONTENT

Green Manufacturing: Fundamentals and Applications - basic definitions and issues surrounding green manufacturing at the process, machine and system - government motivations for green manufacturing - traditional manufacturing to green manufacturing -economic issues- surrounding green manufacturing - the areas of automotive, semiconductor and medical areas as well as in the supply chain and packaging areas Green Manufacturing.
Green manufacturing sustainability processes, requirements, and risk - The sustainable lean and green audit process. International green manufacturing standards and compliance. Green rapid prototyping and rapid manufacturing. Green flexible automation. Green collaboration processes . Alternative energy resources. Globally green manufacturing supply chains and logistic networks. Sustainable green manufacturing system design.
Material and solid waste management - Energy management -chemical waste management and green chemistry - Climate change and air emissions management - Supply water and waste water management - Environmental business management. Material flows in chemical manufacturing-Industrial parks-Assessing opportunities for waste exchanges and by product synergies-Life cycle concepts-Product shewardship and green engineering-Regulatory, social and business environment for green manufacturing.- Metrics and analytical tools.- Green supply chains.- Present state of green manufacturing. green plastics manufacturing

SUGGESTED READING

1. T. David Allen and David R. Shonnard, “Green engineering”, Prentice Hall NJ.
2. David Dornfeld, “Green manufacturing fundamental and applications”, Prentice hall.
3. G. Sammy Shinga, “Green electronics design and manufacturing”, Prince publications.
4. James clark, “Green chemistry”, Blackwell publishing.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD38	**NANOMEDICINE**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (COs)

On Completion of the course the student will be able to

- understand how nano technological approaches can be used in biomedical therapies
- understand biomaterials and interaction of biomaterials with cells, body fluids and tissues
- understand basic stem cell biology and corresponding requirement for tissue engineering
- understand the need, obstacles and solutions for polymeric, lipidous and solid nanosized drug delivery systems
- understand the toxicological aspects of nanosized surfaces and particles
- find, refer and evaluate available information

COURSE CONTENT

Nanodiagnostics -Rationale of Nanotechnology for Molecular Diagnostics - Nanoarrays for Molecular Diagnostics . NanoProTM System -Nanofluidic/Nanoarray Devices to Detect a Single Molecule of DNA-SelfAssembling ProteinNanoarrays - Fullerene Photodetectors for Chemiluminescence DetectiononMicrofluidicChips Protein Microarray for Detection of Molecules with Nanoparticles Protein Nanobiochip. Nanoparticles for Molecular Diagnostics -Gold Nanoparticles - Quantum Dots for Molecular Diagnostics Magnetic Nanoparticles -Use of Nanocrystals in Immunohistochemistry -Imaging Applications of Nanoparticles.
Nanobarcodes Technology -Nanobarcode Particle Technology for SNP Genotyping - Qdot Nanobarcode for Multiplexed Gene Expression Profiling -BiobarcodeAssay for ProteinsSingle-Molecule Barcoding System for DNA Analysis Nanoparticle-Based Colorimetric DNA Detection Method .
Nanobiotechnology for Drug Discovery -Gold Nanoparticles for Drug Discovery -Use of Quantum Dots for Drug Discovery -Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules -Role of AFM for Study of Biomolecular Interactions for Drug Discovery Nanoscale Devices for Drug Discovery -Nanotechnology Enables Drug Design at Cellular Level Nanobiotechnology-Based Drug Development Dendrimers asDrugs- Fullerenes as Drug Candidates – Nanobodies. Nanobiotechnology in Drug Delivery.
Development of nano medicines – Nano Shells – Nano pores – Tectodendrimers – Nanoparticle drug system for oral administration – Drug system for nasal

administration – Drug system for ocular administration – Nanotechnology in diagnostic application. Cancer Therapy -- Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems - Active Targeting Strategies in Cancer with a Focus onPotential Nanotechnology Applications -Pharmacokinetics of Nanocarrier-Mediated Drug and Gene Delivery - Multifunctional Nanoparticles for Cancer Therapy- Neutron Capture Therapy of Cancer.
SUGGESTED READING 1. Kewal K. Jain, "The Handbook of Nanomedicine" Humana Press. 2. Zhang, "Nanomedicine: A Systems Engineering Approach", Pan Stanford Publishing. 3. Robert A. Freitas Jr., "Nanomedicine Volume IIA: Biocompatibility", Landes Bioscience Publishers.

Course No	Title of the Course	Course Structure	Pre-Requisite
NTD39	**NANOSCALE MAGNETIC MATERIALS AND DEVICES**	**L-T-P:** 3-0-2	None

COURSE OUT COMES (CO)

On Completion of the course the student will be able to

- Have knowledge of Antiferromagnetic materials, ferromagnetic and antiferromagnetic interfaces.
- Familiar with Mesoscopic magnetism.
- Understand the principles of magnetic recording.

COURSE CONTENT

Antiferromagnetic materials – Domains and the magnetization process – Coercivity of fine particles – Super paramagnetism in fine particles – Exchange anisotropy - Induced anisotropy in thin films – Electron transport in magnetic multi-layers – Spin polarized electron tunneling – Interlayer exchange coupling.
Two-spin channel model - Two terminal spin electronics – Three terminal spin electronics - Spin tunneling - Study of ferromagnetic and antiferromagnet interfaces – Photoemission Electron Microscopy - X-ray Absorption Spectroscopy - X-ray Magnetic Linear Dichroism (XMLD) - X-ray Magnetic Circular Dichroism (XMCD) - Temperature dependence of X-ray Magnetic Dichroism.
Mesoscopic magnetism - Particulate nanomagnets – Geometrical nanomagnets – Fabrication techniques scaling – Characterization using various techniques – Imaging magnetic microspectroscopy – Optical Imaging – Lorentz Microscopy – Electron Holography of Magnetic Nanostructures –Magnetic Force Microscopy.
Principles of magnetic recording - Magnetic digital recording - Perpendicular recording - Magneto-Optic recording - Magnetic media – Kerr effect – Faraday effect. Biomedical applications of magnetic nanoparticles - Diagnostic applications - Therapeutic applications - Physiological aspects - Toxic effects.

SUGGESTED READING

1. Hans P.O., and Hopster H., “Magnetic Microscopy of Nanostructures”, Springer.
2. Bland J.A.C., and B. Heinrich.B., “Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism”, Springer.

SYLLABUS OF OPEN ELECTIVES

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO001	Technical Communication	L-T-P : 3-1-0	**None**

COURSE OUTCOMES (COs)

- The course will improve writing and documentation skills of students with emphasis on the importance of effective communication with focus on choice of words, formation of proper sentence structures and writing styles.
- This will enhance the students capability to prepare technical documents and correspondence.
- The course will equip the student with good communications skills for placements, preparing SOPs and CVs.
- The course will sensitize the students towards research ethics, copyright and plagiarism.

COURSE CONTENT

- Definition of communication, meaning, importance & process of communication, objectives, types, C's of communication, barriers to communication
- human & non -human communication, distinctive features of human languages
- Business correspondence-definition, meaning and importance of business communication, business letters- purchase, enquiry, quotation, order, followup, acceptance-refusal
- Emphasis on (i) paragraph writing, its kinds, coherence & cohesion
  (ii)writing a paragraph/thesis: selection of topic and its development

  (iii) writing reports, manuals, notices, memos, agendas, minutes

  (iv)Interviews, speeches, presentations,
- Research ethics, methodologies, copyright, plagiarism

SUGGESTED READING

1. Mike Markel, "Technical Communication", Bedford/St. Martin's.
2. John M. Lannon and Laura J. Gurak, "Technical Communication", Pearson.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO002	Disaster Management	L-T-P : 3-1-0	**None**

COURSE OUTCOMES (COs)

- Demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations. Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

COURSE CONTENT

Unit -I: Introduction

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.

Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Unit -II: Disaster Prone Areas In India

Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

Unit -III: Disaster Preparedness And Management

Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Unit -IV: Risk Assessment

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

Unit -V: Disaster Mitigation

Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

SUGGESTED READING

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies", New Royal book Company, Lucknow.

2. Sahni, Pardeep et al. (Eds.), "Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.

3. Goel S. L., "Disaster Adminastration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO003	Basics of Finance Management	L-T-P : 3-1-0	**None**

COURSE OUTCOMES (COs)

- To provide a theoretical framework for considering corporate finance problems and issues and to apply these concepts in practice.
- Enhance knowledge and understanding of financial management.
- How managers should organize their financial transactions effectively and with integrity and how to give everybody the ability and confidence to tackle common financial problems in practice.
- Provide adequate preparation for future finance classes.

COURSE CONTENT

Unit I

Nature, scope and objectives of financial management, Time value of money, Risk and return (including Capital Asset Pricing Model).

Unit II

Long term investment decisions: The Capital Budgeting Process, Cash Flow Estimation, Payback Period Method, Accounting Rate of Return, Net Present Value (NPV), Net Terminal Value, Internal Rate of Return (IRR), Profitability Index.

Unit III

Financing Decisions: Sources of long-term financing, Estimation of components of cost of capital, Methods for calculating Cost of Equity, Cost of Retained Earnings, Cost of Debt and Cost of Preference Capital, Weighted Average Cost of Capital (WACC). Capital Structure- Theories of Capital Structure (Net Income, Net Operating Income, MM Hypothesis, Traditional Approach). Operating and Financial leverage. Determinants of capital structure

Unit IV

Dividend Decisions: Theories for Relevance and irrelevance of dividend decision for corporate valuation-Walter's Model, Gordon's Model, MM Approach, Cash and stock dividends. Dividend policies in practice.

Unit V

Working Capital Decisions: Concepts of Working Capital, Operating & Cash Cycles, sources of short term finance, working capital estimation, cash management, receivables management, inventory management.

SUGGESTED READING

1. Khan, M.Y. and P.K. Jain, "Financial Management: Text and Problems", Tata McGraw Hill.

2. Srivastava, Rajiv, and Anil Mishra, "Financial Management", Oxford University Press, UK.

3. Chandra, P., "Financial Management-Theory and Practice", Tata McGraw Hill.

4. Horne, Van; James C., John Wachowicz, "Fundamentals of Financial Management", Pearson Education.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO004	Basics of Finance Management	L-T-P : 3-1-0	**None**

COURSE OUTCOMES (COs)

This course is designed to provide students with an understanding of human resource management (HRM) functions within organizations, including an appreciation of the roles of both HRM specialists and line managers in designing and implementing effective HRM policies and practices.

COURSE CONTENT

Unit - I

Evolution and growth of human resource management (with special reference to scientific management and Human relations approaches).Role of HR in strategic management. Nature. objectives, scope, and functions of HR management.

Unit - II

Challenges of HR (the changing profile of the workforce - knowledge workers, employment opportunities in BPOs, IT and service industries, Flexi options), Workforce diversity (causes, paradox, resolution of diversity by management).

Unit III

HRD; Human resource management as a profession. Concepts of line-staff in the structure of human resource department and the role of human resource manager.

Unit - IV

Manpower planning -objectives, elements, advantages, process. Job design - (simplification, rotation, enlargement, enrichment and approaches}.Job analysis.Job evaluation.

Unit - V

Recruitment (factors affecting, sources, policy, evaluation). Selection(procedure, tests, interviews). Placement and Induction.

SUGGESTED READING

1. K. Aswathappa, "Human Resource and Personnel Management", Tata McGraw-Hill, New Delhi.

2. T.N. Chhabra, "Human Resource Management", Dhanpat Rai and Co. Delhi.

3. Saiyadain S. Mirza, "Human Resource Management", Tata Mc-GrawHill, India.

4. N.K. Chadha, "Human Resource Management-issues, case studies, experiential exercises", Sri Sai Printographers, New Delhi.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO005	Project Management	L-T-P : 3-1-0	**None**

COURSE OUTCOMES (COs)

In this comprehensive course, student will learn the fundamentals of project management: how to initiate, plan, and execute a project that meets objectives and satisfies stakeholders. This course provides a step-by-step guide to planning and executing a project and to develop a manageable project schedule.

COURSE CONTENT

Unit-I

Objectives of Project Planning, monitoring and control of investment projects. Relevance of social cost benefit analysis, identification of investment opportunities. Pre-feasibility studies.

Unit-II

Project Preparation: Technical feasibility, estimation of costs, demand analysis and commercial viability, risk analysis, collaboration arrangements; financial planning; Estimation of fund requirements, sources of funds.Loan syndication for the projects.Tax considerations in project preparation and the legal aspects.

Unit-III

Project appraisal: Business criterion of growth, liquidity and profitability, social cost benefit analysis in public and private sectors, investment criterion and choice of techniques. Estimation of shadow prices and social discount rate.

Unit-IV

Project review/control-Evaluation of project. PERT/CPM .resource handling/leveling.

Unit-V

Cost and Time Management issues in Project planning and management, success criteria and success factors, risk management.

SUGGESTED READING

1. Ravi Ravindran, "Operations Research and Management Science Handbook", CRC Press.

2. Harold Kerzner, "Applied Project Management: Best Practices on Implementation", John Wiley & Sons, Inc.

3. Goodpasture, J. C., "Quantitative Methods in Project Management", J Ross Publishing, Boca Raton, Florida, USA.

4. Meredith, J. R. and Mantel Jr., S. J., "Project Management: A Managerial Approach", John Wiley, New York.

5. Clifford Gray, "Project Management", Richard D. Irwin.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO006	Basics of Corporate Law	L-T-P : 3-1-0	**None**

Course outcome

The objective of this Course is to provide in-depth knowledge of the Corporate laws and process related to integrate these aspects of management studies in decision making within an organization; analyze and interpret management information; make decisions based on the information available; communicate information effectively; understand and apply the theoretical aspects of accounting methods used for collecting, recording and reporting financial information; explain and appraise the taxation laws which govern corporations and individuals

Course Content

.**Unit I: Introduction :** Administration of Company Law, characteristics of a company; common seal; lifting of corporate veil; types of companies including private and public company, government company, foreign company, one person company, small company, associate company, dormant company, producer company; association not for profit; illegal association; formation of company, promoters and their legal position, pre incorporation contract and provisional contracts; on-line registration of a company.

Unit II: Documents: Memorandum of association and its alteration, articles of association and its alteration, doctrine of constructive notice and indoor management, prospectus, shelf prospectus and red herring prospectus, misstatement in a prospectus; GDR; book building; issue, allotment and forfeiture of shares, calls on shares; public offer and private placement; issue of sweat capital; employee stock options; issue of bonus shares; transmission of shares, buyback and provisions regarding buyback; share certificate; D-Mat system; membership of a company.

Unit III: Management and Meetings: Classification of directors, additional, alternate and adhoc director; women directors, independent director, small shareholders' director; director identity number (DIN); appointment, who can appoint a director, disqualifications, removal of directors; legal position, powers and duties; key managerial personnel, managing director, manager; meetings of shareholders and board; types of meeting, convening and conduct of meetings, requisites of a valid meeting; postal ballot, meeting through video conferencing, e-voting; committees of board of directors – audit committee, nomination and remuneration committee, stakeholders relationship committee, corporate social responsibility committee; prohibition of insider trading.

SUGGESTED READING

1. Hicks Andrew & Goo S.H., "Cases and Material on Company Law", Oxford University Press.

2. LCB Gowar, "Principles of Modern Company Law", Stevens & Sons, London.

3. A.K. Majumdar, and G.K. Kapoor, "Company Law and Practice", Taxmann, New Delhi.

4. Brenda Hanningan, "Company Law", Oxford University Press, U.K.

5. J.P. Sharma, "An Easy Approach to Corporate Laws", Ane Books Pvt. Ltd., New Delhi.

9. Ramaiya, "A Guide to Companies Act", LexisNexis Butters worth wadhwa.

6. S. Kannal, & V.S. Sowrirajan, "Company Law Procedure", Taxman's Allied Services (P) Ltd., New Delhi.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO007	Biological computing	L-T-P : 3-1-0	**None**

COURSE OUTCOMES (COs)

- To understand computing in context of biological systems
- To understand computing languages needed to solve biological problems
- To acquire computational skills for analysis of biological processes through grid computing
- To gain knowledge of different biological databases and their usage
- To gain innovative insight into DNA computing

COURSE CONTENT

Introduction, Orientation and UNIX,

Python: Introduction to Variables and Control flow, Python II - Parsing In and Output,

Python III - Scripting and Functions, Python IV- Number Crunching and Plotting,

Grid computing, Biogrid, R basics and Visualization, Unix for fast text processing, SQL Database

Biological databases, R for speed, R for fun, Local BLAST, Unit Testing and Code Correctness

DNA computing,

SUGGESTED READING

1. H. Bolouri, R. Paton, "Computations in cells & tissues", Springer.

2. Haubold, Bernhard, Wiehe, Thomas, "Introduction to Computational Biology: An Evolutionary Approach", Springer.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO008	Basic of social science	L-T-P : 3-1-0	**None**

COURSE OUTCOMES (COs)

Sociologyis a major category of academic disciplines, concerned with society and the relationships among individuals within a society. It in turn has many branches, each of which is considered a "social science".

COURSE CONTENT

Unit 1.

The Development of Sociology in the 19th Century

Unit 2. **Sociology as Science:**

a. Science, scientific method and critique.
b. Major theoretical strands of research methodology.
c. Positivism and its critique.
d. Fact value and objectivity.
e. Non- positivist methodologies.

Unit 3. **Religion and Society:**

a. Sociological theories of religion.
b. Types of religious practices: animism, monism, pluralism, sects, cults.
c. Religion in modern society: religion and science, secularization, religious revivalism, fundamentalism.

Unit 4. **Politics and Society:**

a. Sociological theories of power.
b. Power elite, bureaucracy, pressure groups, and political parties.
c. Nation, state, citizenship, democracy, civil society, ideology.
d. Protest, agitation, social movements, collective action, revolution.

Unit 5. **Sociological Thinkers:**

a. Kar l Marx- Historical materialism, mode of production, alienation, class struggle.
b. Emile Durkheim- Division of labour, social fact, suicide, religion and society.
c. Max Weber- Social action, ideal types, authority, bureaucracy, protestant ethic and the spirit of capitalism.
d. Talcolt Parsons- Social system, pattern variables.
e. Robert K. Merton- Latent and manifest functions, conformity and deviance, reference groups.
f. Mead - Self and identity.

SUGGESTED READING

1. Beteille, Andre, "Sociology: Essays in Approach and Method", Oxford University Press, Chap l.

2. Giddens, Anthony, "Sociology", Polity Press, Chap 17.

3. Weber, M., "The Methodology of the Social Sciences", New York: Free Press.

4. Durkheim, E., "The Rules of Sociological Method", London: Macmillan.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO009	Entrepreneurship	L-T-P : 3-1-0	**None**

COURSE OUTCOMES (COs)

This Course Aims at Instituting Entrepreneurial skills in the students by giving an overview of who the entrepreneurs are and what competences are needed to become an entrepreneur.

contents:

COURSE CONTENT

Unit I-Introduction:

Concept and Definitions, Entrepreneur v/s Intrapreneur; Role of entrepreneurship in economic development; Entrepreneurship process; Factors impacting emergence of entrepreneurship; Managerial versus entrepreneurial Decision Making; Entrepreneur v/s Investors; Entrepreneurial attributes and characteristics; Entrepreneurs versus inventors; Entrepreneurial Culture; Women Entrepreneurs; Social Entrepreneurship; Classification and Types of Entrepreneurs; EDP Programmes; Entrepreneurial Training; Traits/Qualities of an Entrepreneurs.

Unit II- Creating Entrepreneurial Venture:

Generating Business idea- Sources of Innovation, methods of generating ideas, Creativity and Entrepreneurship; Challenges in managing innovation; Business planning process; Drawing business plan; Business plan failures; Entrepreneurial leadership- components of entrepreneurial leadership; Entrepreneurial Challenges; Legal issues – forming business entity, considerations and Criteria, requirements for formation of a Private/Public Limited Company, Intellectual Property Protection- Patents Trademarks and Copyrights – importance for startups, Legal Acts Governing Business in India.

Unit III-Functional plans:

Marketing plan– for the new venture, environmental analysis, steps in preparing marketing plan, marketing mix, contingency planning; Organizational plan – designing organization structure and Systems; Financial plan – pro forma income statements, pro forma cash budget, funds Flow and Cash flow statements; Pro forma balance sheet; Break Even Analysis; Ratio Analysis.

Unit IV- Entrepreneurial Finance:

Debt or equity financing, Sources of Finance- Commercial banks, private placements, venture capital, financial institutions supporting entrepreneurs; Lease Financing; Funding opportunities for Startups in India.

Unit V- Enterprise Management:

Managing growth and sustenance- growth norms; Factors for growth; Time management, Negotiations, Joint ventures, Mergers & acquisitions.

SUGGESTED READING

1. Kumar, Arya, "Entrepreneurship: Creating and Leading an Entrepreneurial Organization", Pearson, India.

2. Hishrich., Peters, "Entrepreneurship: Starting, Developing and Managing a New Enterprise", Irwin.

3. Taneja, "Entrepreneurship", Galgotia Publishers.

4. Barringer, Brace R., and R. Duane Ireland, "Entrepreneurship", Pearson Prentice Hall, New Jersy (USA).

5. Hisrich, Robert D., Michael Peters and Dean Shephered, "Entrepreneurship", Tata McGraw Hill, New Delhi.

6. Lall, Madhurima, and ShikhaSahai, "Entrepreneurship", Excel Books, New Delhi.

7. Charantimath, Poornima, "Entrepreneurship Development and Small Business Enterprises", Pearson Education, New Delhi.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO0010	Social work	L-T-P : 3-1-0	**None**

COURSE OUTCOMES(COs)

In this course students will learn about various methods of social work, about community organization, social welfare administration, Problems pertaining to Marriage, Family and caste

COURSE CONTENT

Unit 1.Social work

Philosophy and Methods. Social work: Meaning, Objectives, Scope, Assumptions & Values; History of Social work in U.K. U.S.A.and India, philosophy of Social Work. Democratic (Equality, Justice Liberty & Fraternity) and Humanitarian (Human Rights) Matrix.Social works as a profession.

Unit 2. Methods of Social work

Meaning, Scope Principles, Processes (Psychosocial study, Assessments, treatment-goal formulation and techniques), Evaluation, Follow-up and Rehabilitation. Social Groups work: Meaning,Objective, Principles, Skills, Processes (Study, Diagnosis, treatment and evaluation), Programme, Planningand Development, Role of Social group worker, Leadership Development.

Unit 3 Community organization Meaning, Objective, Principles, Approaches, Roles of Community Organization Worker.

Unit 4 Social Welfare Administration

Meaning Scope, Auspices-Private and Public, Principles, Basic Administrative Processes and Practice decision making communication, planning.organisation, budgeting and finacial control, reporting. Social work Research: Meaning objectives, types, scope, scientific method, Selection and formulation of the problem Research Design Sampling, Sources and Methods of Data Collection, Processing of Data, analysing and interpretation, Report writing. Social Action: Meaning,Scope, approaches (Sarvodays, Antyodaya etc.) and Strategies.

Unit 5 Work in India Problem pertaining to Marriage, Family and caste

Dowry- child Marriage, Divorce, Families with working couples, Disorganised Families, Families with Emigrant Heads of the Households, Gender Inequality, Authoritarian Family structure, Major Changes in Caste systems and problem of casteism. Problems Pertaining of Weaker Sections. Problems of Children, Women Aged. Handicapped and Backward Classes (SCs, STs, and other Backward Classes). **Problems of Deviance:** Truancy Vagrancy and Juvenile Delinquency, Crime, White Colla Crime, Organized Crime,Collective Violence, Terrorism, Prostitution and Sex Related Crimes. Social Vices: Alcohilism. Drug Addiction, Beggary, Corruption and communalism. **Problems of Social Structure :** Poverty, Unemployment, Bonded Labour, Child Labour. **Fields of Soclal work India :** Child Development, Development of Youth, Women's Empowerment, Welfare of aged, Welfare of Physically. Mentally and Social Handicapped, Welfare of backward Classes (Scs, STs and Other Backward Classes) Rural Development Urban Community Development, Medical And Psychiatric Social work, Industrial Social work, Social Security offender Reforms.

SUGGESTED READING

1. Rajni Bedi, "Social Work: An Introductory Text Book", Regal Publications.
2. P. R. Gautam, "Social Work: Methods Practices and Perspectives", Centrum Press.
3. Charles Zastrow, "Introduction to Social Work and Social Welfare: empowering People", Wadsworth Publishing Co Inc.

Course No.	Title of the Course	Course Structure	Pre-Requisite
EO011	IP and Patenting	L-T-P : 3-1-0	**None**

COURSE OUTCOMES(COs)

The objective of this Course is to provide in-depth knowledge of the laws and process related to Trademarks, Copyrights and other forms of IPs with focus on Patents, the Indian and International Patent filing procedure, drafting patent application and conducting prior art searches. Students will be exposed to the technical, management and legal aspects of IP and Patents.

COURSE CONTENT

UNIT I: Introduction: Historical and philosophical background of patents and other intellectual property, Patent System: the Constitution, Congress, Patent Office (PTO), and courts; Analyzing and understanding judicial opinions

UNITII: Comparative overview of patents, copyrights, trade secrets, and trademarks: Legal fundamentals of patent protection for useful inventions**,** Design and plant patents, Legal fundamentals of copyright protection, Similarity and access, Expression vs. ideas and information, merger, Fair use of copyrighted works (e.g., for classroom use), Contributory copyright infringement, Critical differences between patent and copyright protection, Copyright infringement distinguished from plagiarism, Legal fundamentals of trade-secret protection, Legal fundamentals of trademark protection

UNIT III: Requirements and limitations of patentability: New and useful: (A) The legal requirement of novelty (B) First to invent vs. first inventor to file, The legal requirement of non-obviousness.

UNIT IV: The process of applying for a patent ("patent prosecution"): Anatomy of a patent application, Adequate disclosure, The art of drafting patent claims, Patent searching: (A) Purposes and techniques, Actions for patent infringement, Interpretation of claims, Doctrine of equivalents, Product testing as a possibly infringing use, Doctrine of exhaustion

SUGGESTED READING

Rines, Robert H., "Create or Perish: The Case for Inventions and Patents", Acropolis, Prelim.

.Course No.	Title of the Course	Course Structure	Pre-Requisite
EO012	Supply Chain Management and Logistics	L-T-P : 3-1-0	**None**

Course outcome

Supply chain management consist of all parties (including manufacturer, marketer, suppliers, transporters, warehouses, retailers and even customers) directly or indirectly involved in fulfillment of a customer. The main objective is to acquaint the students with the concepts and tools of supply chain management and logistics as relevant for a business firm.

Course Content

Unit I

Introduction: Concept of supply chain management (SCM) and trade logistics; Scope of logistics; Logistic activities – an Overview; Contribution of logistics at macro and micro levels; SCM and trade logistics; Business view of SCM; Concept, span and process of integrated SCM; Demand management – methods of forecasting; Supply chain metrics (KPIs), performance measurement and continuous improvement; Product development Process and SCM; Strategic role of purchasing in the supply chain and total customer satisfaction; Types of purchases; Purchasing cycle.

Unit II

Managing Relationship: Role of Relationship marketing in SCM; Managing relationships with suppliers and customers; Captive buyers and suppliers; Strategic partnerships; Supplier-retailer collaboration and alliances.

Unit III

Focus Areas of Logistics and Supply Chain management: Transportation-Importance of effective transportation system; Service choices and their characteristics; inter-modal services; Transport cost characteristics and rate fixation; In-company management vs. out-sourcing; World sea borne trade; International shipping- characteristics and structure; Liner and tramp operations; Liner freighting; Chartering-Types, principles and practices; Development in sea transportation-Unitization, containerisation, inter and multimodal transport; CFC and ICD. Air transport: Set up

for air transport and freight rates; Carriage of Goods by sea -Role and types of cargo intermediaries. Warehousing and inventory management: Reasons for warehousing; Warehousing evaluation and requirements; Warehousing location strategies; Inventory management principles and approaches; Inventory categories -EOQ, LT, ICC

Unit IV

IT Enabling Logistics and Supply Chain: Technology in logistics – EDI, bar Coding, RFID etc., data warehousing, electronic payment transfers; Business management systems; TRADITIONAL ERP, SPECIAL ERP, MR, DRP, PDM, EIP, CPFR, WMS, TMS; Re-engineering the supply chain-Future directions.

Unit V

Trends and Challenges in logistics and supply chain management: Third party logistic outsourcing –challenges and future directions.

SUGGESTED READING

1. M Christopher, "Logistics and Supply Chain Management", Prentice Hall.

2. Handfield and Nicholas, Jr., "Introduction to Supply Chain Management", Prentice Hall.

3. Jhon J Coyle, C. Jhon and Langley, Brian J Gibs, "Logistics approach to Supply Chain Management", Cengage Learning.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO013	ORGANISATION DEVELOPMENT	L-T-P: 3-1-0	None

COURSE OUT COMES (COs)

Organisation Development is a growing field of Human Resource Management. It has its foundations in a number of behavioural and social sciences.

COURSE CONTENT

Topics included are

- Organtzattonal Systems and Human Behaviour - Developing a basic knowledge of how organizattons and groups function as systems; introducing and discussing various theoretical approaches and issues.
- Interpersonal and Consulting Skills - Increasing effectiveness as a change agent by providing a variety of opportunities in order to increase self-awareness, practice alternative ways of approaching personal and interpersonal problem-solving and develop basic consulting and interviewing skills.
- Introduction to organization development - introducing some basic theories, models and methods in the field of organization development, especially those relating to the role of consultant and strategies for change.
- Intervention and Change in Organizations - Consolidating and further developing consulting skills and strategies

Action Research Project - Carrying out a change activity in an organization, while also researching the effects and or the process. This provides participants with an opportunity to consolidate and demonstrate skills and knowledge gained in other units of the course.

SUGGESTED READING

1. Dr Mee-Yan Cheung-Judge, Linda Holbeche, “Organization Development: A Practitioner's Guide for OD and HR”, Kogan Page.
2. Donald Brown, “Experiential Approach to Organization Development: Pearson New International Edition”, Pearson.
3. W. Burke, Debra Noumair, “Organization Development”, Pearson.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO014	Industrial organization and managerial economics	L-T-P: 3-1-0	None

COURSE OUT COMES (COs)

This course help students in understanding the basics of management and Industrial organization.

COURSE CONTENT

Unit I: Principles of management, General idea, various functions, scope of engineering. Organisation structure, Types, merits and demerits.

Unit II: Plant location and layout, Factors effecting location, types of layout. Production planning and control, Sequence of planning and control of production. Scheduling , routing, despatching., Methods Study, Methods analysis, time study methods of rating.

Unit III: General idea of personnel management, Industrial psychology, job evaluation and monitoring. Business decision making and forward planning. Demand and demand forcasting of production analysis- prices and pricing decision-profit and capital, management. Analysis of inter-industry relation, macro-economics and business.

SUGGESTED READING

1. Koutsoyiannis A, "Modern Microeconomics", Palgrave Macmillan U.K.

2. Prof. D.N. Kakkar, "Managerial Economics for Engineering", New Age International.

3. Sytse Douma, Hein Schreuder, "Economic Approaches to Organisations", Pearson.

4. Yogesh Maheshwari, "Managerial Economics", PHI Learning.

5. Ruddardutt and K.P.M.Sundharam, "Indian economy", S. Chand Limited.

6. Paul Keat, Philip Young, "Managerial Economics, Global Edition", Pearson.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO015	Global Strategies and Technology	L-T-P: 3-1-0	None

COURSE OUT COMES (COs)

This subject focuses on the specifics of strategy and organization of the multinational company, and provides a framework for formulating successful and adaptive strategies in an increasingly complex world economy.

COURSE CONTENT

Globalization of industries, the continuing role of country factors in competition, organization of multinational enterprises, and building global networks, Analysis of competitive situations from the general management point of view, including fit between key environmental forces and the firm's resources, and changes in these over time. Formulating and implementing strategy based on that analysis. Developing and leveraging a firm's core competencies to gain long-term sustainable advantage.

SUGGESTED READING

1. Mike W. Peng, "Global strategy", South-Western College Pub.
2. Pankaj Ghemawat, "Redefining Global Strategy", Harvard Business Review Press.
3. Cornelis A. de Kluyver, "Fundamentals of Global Strategy", Business Expert Press.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO016	Engineering System analysis and Design	L-T-P: 3-1-0	None

COURSE OUT COMES (CO)

The students will learn about system definitions and role of system analyst. They will learn about system modeling and design. They will be exposed to System Implementation and Maintenance issues.

COURSE CONTENT

Unit 1

System definition and concepts: Characteristics and types of system, Manual and automated systems

Real-life Business sub-systems: Production, Marketing, Personal, Material, finance Systems models types of models: Systems environment and boundaries, Real time and distributed systems, Basic principles of successful systems

Unit 2

Systems analyst: Role and need of systems analyst, Qualifications and responsibilities, Systems Analyst, agent of change.

Various phases of systems development life cycle: Analysis, Design, Development, Implementation, Maintenance

Unit3

Systems Design and modeling: Process modeling, Logical and physical design, Design representation, Systems flowcharts and structured charts, Data flow diagrams, Common diagramming conventions and guidelines using DFD and ERD diagrams. Data Modeling and systems analysis, designing the internals: Program and Process design, Designing Distributed Systems

Unit 4

User Interfaces – Relational Analysis – Database design – program design– structure chart – HIPO – SSADM – Alternate Life cycles – Prototypes.

Unit 5

System Implementation and Maintenance: Planning considerations, Conversion methods, producers and controls, System acceptance Criteria, System evaluation and performance, Testing and validation, Systems qualify Control and assurance, Maintenance activities and issues.

SUGGESTED READING

1) Haryszkiewycz, "Introduction to Systems Analysis and Design", PHI.
2) James A Senn, "Analysis and Design of Information Systems", McGraw Hill.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO017	BIOLOGY FOR ENGINEERS	L-T-P: 3-1-0	None

COURSE OUT COMES (CO)

1. General understanding of organization in biological systems
2. Conceptual knowledge of functioning in biological systems
3. Clarity about relevance of Biology to engineering graduates
4. Understanding human body or any other suitable organism as a study-model for engineering students.
5. Understanding electrical, chemical and magnetic forces, and communication networks in bio system.

COURSE CONTENT

The Biological system – An Introduction; Biomolecules & self-assemblies; Molecular recognition; Bioenergetics; Communication network in biosystem; Mechanics in biology; Storage, preservation and propagation of biological information; Biomaterials in engineering applications; Organisms as factories for biomaterials; Engineering organisms for novel applications

SUGGESTED READING

1. T. Johnson, "Biology for Engineers", CRC Press.
2. Michael Small, "Dynamics of Biological system", CRC Press.
3. Johnny T. Ottesen, MS Olufsen, JK Larsen, "Applied Mathematical Models and Human Physiology", Published by Society for Industrial and Applied Mathematics.
4. Michael Roberts, Michael Jonathan Reiss, Grace Monger, "Advanced Biology", Nelson Thornes.
5. Hermann Remmer, "Ecology: A Textbook", Springer.
6. Colin Ratledge, Bjorn Kristiansen (Ed.), "Basic Biotechnology", Cambridge Univ. Press.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO018	Energy, Environment and Society	L-T-P: 3-1-0	None

COURSE OUT COMES (CO)

1. To be able to assess the energy resources available worldwide
2. To understand the negative impact of conventional energy resource utilization on ecosystem
3. To learn about various types of pollutions and their control strategies
4. To understand renewable energy resources and their socio-economic impact.

COURSE CONTENT

Introduction to Environment, Energy and its impact on society

Universe, Environment and Ecosystem: Origin of earth, atmosphere, Origin of Life, Ecosystem, Biotic and abiotic components, Ecological pyramids, Food chain, Food web, Habitat and Niche, Major ecosystems, Atmosphere, Biodiversity

Pollution: Air Pollution, Water Pollution, Soil Pollution, Noise Pollution

Energy: Different sources of Energy, Renewable sources of energy, Nonrenewable energy, Bioenergy, Bioethanol and Biodiesel

Biofertilizers, Biopesticides and Biopolymers

Environmental Ethics and Morals

SUGGESTED READING

1.Kishore V V N, Editor, "Renewable Energy Engineering and Technology, Principles and Practice", The Energy and Resources Institute (TERI).

2.G. N. Tiwari and M. K. Ghosal, "Fundamentals of Renewable Energy Sources", Narosa Publishing House, N.D.

3.Mital K. M, "Biogas Systems: Principles and Applications", New Age International publishers (P) Ltd.

4.Nijaguna, B.T., "Biogas Technology", New Age International publishers (P) Ltd.

5.D. Yogi Goswami, Frank Kreith, Jan. F .Kreider, "Principles of Solar Engineering", 2nd Edition, Taylor & Francis.

6.Rezaiyan. J and N. P. Cheremisinoff, "Gasification Technologies, A Primer for Engineers and Scientists", Taylor and Francis.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO019	Public Policy and Governance	L-T-P: 3-1-0	None

COURSE OUTCOMES (COs)

Students will be introduced to Public Policy and Administrative governance. They will also learn about Administrative Governance.

COURSE CONTENT

Unit 1 Introduction to Public Policy and Administrative Governance: Introduction to public policy, econometrics for policy research, policy analysis, economics for public decision making.

Unit 2 Public Bureaucracy in Theory and Practice: Benefit cost analysis, public budgeting, revenue and expenditures, managing and leading public service organisations.

Unit 3 Administrative Governance: The Challenge of Policy Implementation, public and non-profit programme evaluation.

Unit 4 Non-state Actors in Policy-making and Administrative Governance: governance in twenty-first century, Social Diversity and the Question of "Difference" in Policy-making and administrative Governance

SUGGESTED READING

1. John Shields and B. Mitchell Evans, "Shrinkingthe State: Globalization and Public administration Reform", Halifax: Fernwood.
2. Beryl Radin, Beyond Machiavelli, "Policy Analysis Reaches Midlife", 2nd edition. Washington, DC: Georgetown University Press.
3. Frank R. Baumgartner, Jeffrey M. Berry, Marie Hojnacki, and David C. Kimball, "Lobbying and Policy Change: Who Wins, Who Loses, and Why", Chicago, IL: University of Chicago Press.
4. Timothy Conlan, Paul Posner, and David Beam, "Pathways of Power: The dynamics of National Policymaking", Washington, DC: Georgetown University press.

******