NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

(Deemed to be University Under Section 3 of the UGC Act, 1956)
Kumaracoil, Thuckalay

DEPARTMENT OF NANOTECHNOLOGY

B.Tech. NANOTECHNOLOGY

CURRICULUM AND SYLLABI

REGULATION 2021

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, KUMARACOIL

Regulation : 2021

Curriculum and Syllabi

DEPARTMENT OF NANO TECHNOLOGY

B. Tech. NANOTECHNOLOGY

Vision of the University

To be recognized by the Government and society at large as an institution able to deliver excellence with relevance in the field of higher education and research focusing on the needs of the nation in tune with the technological revolution to cope with the knowledge explosion and global competence.

Mission of the University

To develop the institution as a Centre of Excellence, keeping pace with the advances in the field, so as to provide quality higher education to the students and instill in them high standards of discipline and ethics so that they become enlightened individuals in the service of humanity and to carry out focused research in the frontier areas of science and technology.

Faculty of Nano Technology

Department of Nano Technology

Vision of the Department

To develop professionals with strong technical and research backgrounds by contributing to the society through applications of nanotechnology for the betterment of the nation.

Mission of the Department

The Nanotechnology department is committed to continually improve the educational environment by providing quality education in both theoretical and applied foundations of nanotechnology to create highly skilled engineers, capable of doing research to produce quality publications and encouraging technology transfer.

Description of the programme

Programme Educational Objectives-PEO	
PEO-01	**Engineering knowledge:** Acquire basic fundamental engineering knowledge in electronics, physics, mechanical, graphics, mathematics, biological sciences and material sciences.
PEO-02	**Logical skills:** Problem solving ability to link various disciplines and explore the interdisciplinary aspects of nanomaterials and their applications.
PEO-03	**Material synthesis and characterization:** Use critical knowledge generated for synthesizing materials and characterize it with available advanced tools.
PEO-04	**Design development:** To design and develop novel nanomaterials and substrates suitable for advanced applications through research projects.
PEO-05	**Knowledge dissemination:** To generate quality publication, planning of pilot studies relevant to modern industry based startups and incubation centers.
PEO-06	**Societal impact:** To identify the challenges in the society and to find solution with modern materials and application in terms of health, environment, energy, etc.

Graduate Attributes-GA	
GA-1	**Innovative Engineering Solutions** Develop creative and innovative solutions to complex engineering problems, incorporating the latest technologies and approaches to address current and future challenges.
GA-2	**Global Perspective in Engineering** Understand and apply engineering solutions in a global context, recognizing the diversity of global issues, standards, and the impact of engineering decisions on different cultures and communities.
GA-3	**Sustainable Development and Green Engineering** Design and implement engineering solutions that prioritize sustainability, resource efficiency, and environmental protection, contributing to a sustainable future.
GA-4	**Social Responsibility and Community Engagement** Demonstrate a commitment to social responsibility by engaging with and contributing to local communities, understanding societal needs, and addressing
GA-5	**Adaptability and Lifelong Learning** Exhibit a proactive approach to continuous learning and adaptability, keeping pace with technological advancements and industry changes, and engaging in professional development activities.

GA-6	**Entrepreneurship and Innovation** Foster an entrepreneurial mindset, identifying opportunities for innovation and creating value through new technologies, products, and processes that meet market needs.
GA-7	**Interdisciplinary Collaboration** Work effectively in interdisciplinary teams, integrating knowledge from various fields to develop comprehensive solutions to complex engineering problems.
GA-8	**Ethical Leadership and Integrity** Lead with integrity and ethical principles, ensuring transparency, fairness, and respect in all professional and personal interactions.
GA-9	**Digital and Data Literacy** Utilize advanced digital tools and data analytics techniques to solve engineering problems, optimize processes, and make informed decisions based on data-driven
GA-10	**Safety, Health, and Risk Management** Prioritize safety, health, and risk management in engineering practices, ensuring the well-being of individuals and communities while minimizing potential risks and
GA-11	**Effective Communication and Negotiation Skills** Communicate ideas, solutions, and technical information effectively to a variety of audiences, and engage in negotiation to resolve conflicts and reach consensus.
GA-12	**Impact Assessment and Policy Making** Assess the impact of engineering projects on society and the environment, and contribute to policy-making processes that promote sustainable and responsible

Programme Outcome –PO	
PO-A	By the end of the program, the student will have 1) In-depth knowledge in optics, electronics, physical, mechanical and biological techniques.
PO-B	2) the student will have a cross linking or inter disciplinary knowledge and problem solving skills for different research challenges.
PO-C	3) the student will be capable of chemical and green synthesis routes, can handle software and modern instrumentation for characterization.
P0-D	4) can design practical platforms with novel nanomaterials and chip based sensors, implants and MEMS.
PO-E	5) can write projects, publications, patents, proposals and design novel tools and materials for research sectors.
PO-F	6) can work in any sector related to energy, space, environment and health to develop novel technologies towards existing challenges

Mapping of Graduate Attributes and Programme Educational Objectives (PEO)

GAs / PEOs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10	GA-11	GA-12
PEO-01	**HA**	**HA**	**HA**									
PEO-02					**HA**						**HA**	
PEO-03			**HA**			**HA**						
PE0-04	**HA**		**HA**			**HA**			**HA**			
PEO-05				**HA**			**HA**	**HA**		**HA**		**HA**

H-Highly Associated A-Associated Not – Not Associated

Mapping of Graduate Attributes and Programme Outcomes (PO)

Gas / PEOs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10	GA-11	GA-12
PO-A	**HA**											
PO-B		**HA**										
PO-C			**HA**									
P0-D				**HA**								
PO-E					**HA**	**HA**	**HA**					**HA**
PO-F								**HA**	**HA**	**HA**	**HA**	

H-Highly Associated A-Associated Not – Not Associated

Mapping of Programme Educational Objective (PEOs) and Programme Outcomes (POs)

PEO / PO	PEO-01	PEO-02	PEO-03	PEO-04	PEO-05	PEO-06	PEO-07	PEO-08	PEO-09	PEO-10	PEO-11	PEO-12
PO-A	H											
PO-B		H										
PO-C			H									
P0-D				H								
PO-E					H							
PO-F						H						

H-Highly Associated A-Associated Not – Not Associated

Duration of the programme: 4 Years/ 8 Semesters

Total credits: 163

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, KUMARACOIL
DEPARTMENT OF NANO TECHNOLOGY
B.Tech. NANO TECHNOLOGY
CURRICULUM & SYLLABUS
REGULATION - 2021
SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	EG3101	Technical English	3	1	0	4
2.	MA3101	Engineering Mathematics – I	3	1	0	4
3.	BS3101	Engineering Physics	3	0	0	3
4.	BS3102	Engineering Chemistry	3	0	0	3
5.	CS3101	Fundamentals of Computing and Python Programming	3	0	0	3
PRACTICALS						
6.	CS3171	Fundamentals of Computing and Python Programming Laboratory	0	0	4	2
7.	BS3171	Physics and Chemistry Laboratory	0	0	4	2
TOTAL			**15**	**2**	**8**	**21**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	EG3102	Communicative English	3	0	0	3
2.	MA3102	Engineering Mathematics – II	3	1	0	4
3.	BE3101	Basic Electrical and Electronics Engineering	3	0	0	3
4.	NT3201	Introduction to Nanotechnology	2	1	0	3
5.	NT3202	Synthesis of Nanomaterials	2	1	0	3
PRACTICALS						
6.	BE3171	Basic Electrical and Electronics Engineering Laboratory	0	0	2	1
7.	NT3271	General Synthesis Methods	0	0	4	2
TOTAL			**13**	**3**	**6**	**19**

B. Tech. NANO TECHNOLOGYCURRICULUM & SYLLABUS
REGULATION - 2021
SEMESTER - I

EG3101 TECHNICAL ENGLISH 3 1 0 4

OBJECTIVES:

To develop the linguistic, communicative and critical thinking competencies of First Year Engineering students.

To enhance the understanding of the complex grammatical structures of the English language to students.

To improve the language proficiency of students in English with emphasis on Vocabulary, Grammar, Listening, Speaking, Reading, and Writing skills.

To introduce the students to the basic phonetics of English and make them grasp the various sounds of the English language to improve their pronunciation.

Course Outcome		**Cognitive Skill**
CO-01	The students will be able to grasp the basics of English tense forms and how eight of these tense forms transform into passive forms, learn how to form words with prefixes and suffixes and write instructions using imperatives.	U, A
CO-02	The students will be able to expand the given compound nouns in a meaningful manner, learn how to write definitions for technical terms, use punctuation marks appropriately in sentences and learn the art of changing words from one form to another.	R, A
CO-03	The students will be able to frame questions using interrogatives, generate question tags from statements in the positive or negative. They will also be able to skim and scan given passages for comprehension.	U, An
CO-04	The students will learn the fundamentals of subject and verb agreement in English and find commonly committed errors in English and learn how to correct them.	U, A
CO-05	The students will gain knowledge of converting pictorial representations like Pie Chart, Flow Chart, Bar Chart, Tree Diagram and Tabular Column into text matter.	U, A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

(Increase or reduce the columns based on the program Outcome of the department) *

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L	PO-M
CO-01	M	L	L	M	L	L	L	M	M	S	S	M	
CO-02	S	M	M	M	M	M	M	M	S	S	S	M	
CO-03	M	M	L	M	M	L	M	M	S	S	M	M	
CO-04	L	N	N	M	L	M	L	L	S	S	M	M	
CO-05	S	M	S	S	M	M	S	S	S	S	S	M	

1. S-Strong, M-Medium, L-Low, N-Not relevant

UNIT-I **9**

Word formation with prefixes and suffixes **–** Articles – Conjunctions **–** Prepositions – Expansion of Abbreviations and Acronyms – Writing Checklists **–** Writing Instructions.

UNIT-II **9**

Tense **–** Voice **–** Punctuation **–** Expansion of Compound Nouns – Writing Recommendations – Paragraph Writing – Types, Structures and Features of a Paragraph – Creating Coherence-– Organizing Principles of Paragraphs in Documents.

UNIT-III **9**

Discourse Markers **–** Gerunds and Present Participles – Relative Pronouns – Conditional Clauses – Definitions of Technical Terms – Transcoding: Bar Chart - Flow Chart - Pie Chart - Tree Diagram - Tabular Column.

UNIT –IV **9**

Concord – Clauses – Phrases – Numerical Adjectives – CV/Resume Writing – Virtual Communication**:** E-Mail Writing – Essay Writing: Basic Format of an Essay - Types – Examples.

UNIT-V **9**

Basic Phonetics**:** Phonemes – Vowels, Diphthongs and Consonants – Classification**:** Pure Vowels/Monophthongs – Vowel Glides /Diphthongs.

L: 45 + T: 15, TOTAL: 60 HOURS

EXTENSIVE READING:

Shiv Khera, *You Can Win*, Milan, Delhi, 2004

NOTE:

The book given under Extensive Reading is meant for inculcating the reading habit of the students. They need not be used for testing purposes.

COURSE OUTCOMES:

On completion of the course, students will be able to

- learn grammatical items in a better manner for improving their grammatical competence.
- Develop their writing skills.
- Enhance their language proficiency.

MA3101 ENGINEERING MATHEMATICS - I 3 1 0 4

AIM:
To impart the fundamental knowledge of Engineering Mathematics to the students in order to achieve a well-founded knowledge about the principles of Mathematics

OBJECTIVES:
The course objective is to develop the required skill of the students in the area of Engineering Mathematics with special mphasis on the characteristic equation of matrices, differential calculus, Beta and Gamma functions and to develop basic knowledge to the students in double and triple integration.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Understand the characteristic equation and find eigen values and Eigen vector of a real matrix. Compute the eigen value and eigen vector using properties. Verify Cayley Hamilton theorem and its applications. Apply orthogonal transformation of a symmetric matrix.	U, A, E, R
CO-02	Define the definitions and formula for curvature, radius of curvature, circle of curvature. Apply the formula and solve problems using the required formulas also find the evolute of the curves.	U, A, E, An
CO-03	Know about the differentiation formulae and apply on partial derivatives, total derivatives and Jacobians. Verify the functions be maximum or minimum and Lagrange's multiplier method. Express the Taylor's expansion for two variables.	U, A, E, R
CO-04	Know the Fundamental concepts of improper integrals, Beta and gamma function and their properties. Develop the skill in the relation between Beta and Gamma Functions. Calculate definite integral values using Beta and Gamma Functions.	U, A, An, E
CO-05	Evaluate the double and multiple integrals and can apply these concepts to find areas of regions on a plane or in space. Graph Cartesian and polar equations. Convert Cartesian coordinates into polar coordinates.	U, A, An, E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-k	PO-L	PO-M
CO-01	S	M	S	M	S	S	S	S	M	S	S	M	
CO-02	S	M	M	M	S	S	M	S	M	M	M	M	
CO-03	S	M	M	M	S	S	M	M	M	S	S	M	
CO-04	S	M	S	M	S	M	S	S	M	S	S	M	
CO-05	S	M	S	M	S	M	S	S	M	S	S	M	

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT-I MATRICES **9**

Characteristic equation - Eigen values and Eigen vectors of a real matrix - Properties of eigen values and eigen vectors (without proof)- Cayley Hamilton theorem (statement only), verification and its applications - Orthogonal and Symmetric matrices and their properties(excluding proof)- Orthogonal transformation of a symmetric matrix to diagonal form.

UNIT-II DIFFERENTIAL CALCULUS **9**

Curvature - Cartesian co-ordinates and parametric form -Centre and radius of curvature, Circle of curvature - Evolutes.

UNIT-III FUNCTIONS OF SEVERAL VARIABLES **9**

Partial derivatives - Total derivatives - Jacobians - Properties - Maxima and minima for functions of two variables - Lagrange Multiplier method- Taylor's expansion.

UNIT-IV IMPROPER INTEGRALS **9**

Evaluation of improper integrals- Beta and Gamma functions - Properties - Relation between Beta and Gamma functions - Evaluation of integrals using Beta and Gamma functions.

UNIT-V MULTIPLE INTEGRALS **9**

Evaluation of double and triple integrals - Area enclosed by plane curves as double integral in cartesian and polar co-ordinates - Change of order of integration- Transformation of Cartesian coordinates into polar coordinates.

L: 45 + T: 15, TOTAL: 60 HOURS

OUTCOMES:

At the end of the course, the students will be familiar with various concepts of calculus which are essential for engineering. They also become acquainted with the basic ideas of multiple integrals and their usage.

TEXT BOOKS:

1. Grewal B.S., "Higher Engineering Mathematics"- 40th Edition , Khanna Publishers,

Delhi 2007

REFERENCES:

1. M. Immaculate Mary, K. Uma Samundesvari," Engineering Mathematics - I" Revised Edition, R.K Publishers, 2016.
2. Veerarajan T, "Engineering Mathematics (for first year)", Fourth Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2007.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", Seventh Edition, Wiley India, 2007.
4. P. Kandasamy, K. Thilagavathy, K. Gunavathy" Engineering Mathematics" Vol, 1, S. Chand & Company Ltd. 2002.
5. B.V. Ramana, "Higher Engineering Mathematics" Second Edition Tata McGraw-Hill, Publishing Company Ltd., New Delhi, 2006.
6.

BS3101 ENGINEERING PHYSICS 3 0 0 3

OBJECTIVES

The course objective is to provide basic ideas about the principles of physics related to properties of matter, wave optics, heat, quantum concepts and materials. engineering problems.

Course Outcome - Cos		**Cognitive Skill**
CO-01	Students will be able to understand and apply knowledge about the properties of materials.	R, U, A
CO-02	Students will be able to understand the types of oscillations and the wave nature of light in interference, diffraction and polarization phenomenon.	R, U, A, E
CO-03	Students will be able to state and explain the various laws of thermodynamics, understand entropy and its application.	R, U, A, An, E
CO-04	Students gain basic knowledge about quantum mechanics and will be able to solve time dependent and time independent Schrodinger equation for simple potentials.	R, U, A, E, S
CO-05	Students will be able to know the different types of crystal structures and also gain basic knowledge about nanomaterials and biomaterials.	R, U, A, E

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO - B	PO - C	PO-D
CO-01	S	S	S	S
CO-02	S	S	S	M
CO-03	S	S	S	S
CO-04	S	M	S	S
CO- 05	S	S	M	M

S-Strong, M-Medium, L-Low, N-Not Relevant

Unit I: Properties of Matter **9**

Elasticity – Poisson's ratio – Stress-strain diagram – factors affecting elasticity – bending of beams – cantilever depression – Young's Modulus- theory and experiment of Young's modulus determination (uniform and non-uniform bending) –Shear Modulus – twisting couple – hollow cylinder – torsion pendulum – determination of rigidity modulus - Bulk Modulus - applications of elastic behaviours of materials.

Unit II: Oscillations and Wave optics **9**

Oscillations - Rectilinear motion - Oscillations or Vibrations - Simple Harmonic Motion - Damped Harmonic motion - Real oscillatory system - Forced or Driven oscillation. Wave optics -Interference of light – Photons - Young's Double Slit Experiment - Huygens's Principle - Diffraction - Diffraction Grating - Polarization.

Unit III: Thermal Physics **9**

Transfer of heat energy (conduction, convection and radiation) - thermal expansion of solids and liquids – expansion joints – bimetallic strips-Thermal conductivity- Forbe's and Lee's disc methods (theory and experiment)- thermal insulation in buildings -Laws of thermodynamics- heat exchanger -solar power- applications of solar power (solar water heater, photo voltaic cell).

Unit IV: Quantum Physics **9**

Matter waves- de-Broglie wavelength - Schrodinger's wave equation-time independent and time dependent equations- physical significance of wave function- uncertainty principle and its application- energy and momentum operators-particle in a one dimensional box-scanning electron microscope- transmission electron microscope-scanning tunnelling microscope.

Unit V: Material Physics **9**

Single crystalline, polycrystalline and amorphous materials- Single crystals: unit cell, crystal systems, Bravais lattices, directions and planes in a crystal, miller indices – inter planar distances. Introduction and applications of Metallic glasses, Shape Memory Alloys (SMA),

Nanomaterials, Biomaterials.

TOTAL: 45 HOURS

TEXT BOOKS

1. Engineering Physics I by Bindhu B, Sagi Rani C, Meenadevi V N, Ganapathi Raman R, RK Publishers 2015.
2. Engineering Physics II by Bindhu B, GeethaKumari R, Sugirtha Suni N Y, RK Publishers2016.
3. Engineering Physics by R K Gaur and S L Gupta, Dhanpat Rai Publications 2011.
4. A Text Book Oscillations, Waves & Acoustics by Dr. M. Gosh, Dr. D. Battacharya, S. Chand, Revised Edition.

REFERENCES:

1. Engineering Physics by Rajendran V, McGraw-Hill, New Delhi, 2013
2. Engineering Physics by Arumugam M, Anuradha Publications, 2014.
3. Principles of Physics by Halliday D, Resnick R and Walker J, Wiley 2015.
4. Physics for scientist and Engineers by Serway R A and Jewett J W, Cengage Learning 2010.
5. Engineering Physics by Bhattacharya D K and Poonam T, Oxford University Press 2015.
6. Engineering Physics by Pandey B K and Chaturvedi, Cengage Learning India 201

BS3102 ENGINEERING CHEMISTRY 3 0 0 3

AIM:

To have a thorough knowledge of the basics of chemistry particularly engineering topics to engineering students.

OBJECTIVES:

To make the students conversant with the principles of the following topics:(i) Use of free energy in chemical equilibria (ii) Water chemistry (iii) Periodic properties (iv) Spectroscopic techniques and applications and (v) Organic reactions and synthesis of a drug molecule.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Students will be able to access the quality and utility of suitable water for industrial as well as domestic applications.	A,U
CO-02	To develop awareness and usage of conducting polymers as an engineering material.	A, R, S
CO-03	To understand the uses of various fuels in economic way.	U, S, A
CO-04	To identify the electrolytic cell and electrochemical cells with different types of batteries.	R, U, E
CO-05	To get basic knowledge about thermodynamically aspects and its applications to engineering.	An, E, U

Mapping of Course Outcome with Programme Outcome

PO CO	PO -A	PO -B	PO -C	PO -D	PO -E
CO-01	S	S	M	M	S
CO-02	M	S	M	S	S
CO-03	S	M	S	S	S
CO-04	S	M	M	S	S
CO-05	S	M	M	M	S

S- Strong, M- Medium, L-Low, N- NotRelevant

UNIT I USE OF FREE ENERGY IN CHEMICAL EQUILIBRIA 9

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

UNIT II WATER CHEMISTRY 9

Water as a universal solvent – hard and soft water – reasons for hardness – disadvantages of hard water in washing and industrial purposes - estimation of hardness by EDTA method, problems; boiler feed water – characteristics- softening methods - external conditioning – demineralization (ion exchange) process, desalination by reverse osmosis method- internal conditioning (phosphate, calgon and carbonate conditioning methods); stages in domestic water treatment – disinfection by chlorination, ozone and UV treatments.

UNIT III PERIODIC PROPERTIES 9

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.

UNIT IV SPECTROSCOPIC TECHNIQUES AND APPLICATIONS 9

Principles of spectroscopy and selection rules. Electronic spectroscopy. Fluorescence and its applications in medicine. Vibrational and rotational spectroscopy of diatomic molecules. Applications. Nuclear magnetic resonance and magnetic resonance imaging, surface characterization techniques. Diffraction and scattering.

UNIT V ORGANIC REACTIONS AND SYNTHESIS OF A DRUG MOLECULE 9

Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

TOTAL: 45 HOURS

TEXT BOOKS

1. University chemistry, by B. H. Mahan
2. Chemistry: Principles and Applications, by M. J. Sienko and R. A. Plane
3. Fundamentals of Molecular Spectroscopy, by C. N. Banwell
4. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
5. Physical Chemistry, by P. W. Atkins
6. Organic Chemistry: Structure and Function by K. P. C. Volhardt and N. E. Schore, 5th Edition.

CS3101 FUNDAMENTALS OF COMPUTING AND PYTHON PROGRAMMING 3 0 0 3

AIM:

To explore the basics of algorithmic problem solving and to understand python programming.

OBJECTIVES

- To know the basics of algorithmic problem solving
- To read and write simple Python programs.
- To develop Python programs with conditionals and loops.
- To define Python functions and call them.
- To use Python data structures –- lists, tuples, dictionaries.
- To do input/output with files in Python.

Course Outcome – Cos		Cognitive Skill
CO-01	Study and understand the concepts of computer basics and Internet	U, R
CO-02	Able to develop C programs with operators, branching and looping statements	A
CO-03	Able to write C programs with arrays, structures, union and functions and analyze the string functions using example programs	A, An
CO-04	To develop programs which use pointers for array processing and parameter passing	A
CO-05	Understand memory management and files. Evaluate the file operations in simple programs	U, E

.

Mapping of Course Outcome with Programme Outcome

PO CO	PO	PO	PO	PO	PO	PO	PO
	-A	-B	-C	-D	-E	-F	-G
CO-01	S	S	S	M	N	M	L
CO-02	M	N	S	L	S	M	N
CO-03	S	L	M	N	N	M	S
CO-04	S	M	L	S	L	S	N
CO-05	M	S	L	L	N	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I ALGORITHMICPROBLEMSOLVING 9

Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion). Illustrative problems: find minimum in a list, insert a card in a list of sorted cards, guess an integer number in a range, Towers of Hanoi.

UNIT II DATA, EXPRESSIONS, STATEMENTS 9

Python interpreter and interactive mode; values and types: int, float, boo lean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; modules and functions, function definition and use, flow of execution, parameters and arguments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.

UNIT III CONTROLFLOW, FUNCTIONS 9

Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained

conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search.

UNIT IV LISTS, TUPLES, DICTIONARIES 9

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: selection sort, insertion sort, merge sort, histogram.

UNIT V FILES, MODULES, PACKAGES 9

Files and exception: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file.

TOTAL: 45 HOURS

TEXT BOOKS:

1. Allen B. Downey, ``Think Python: How to Think Like a Computer Scientist '', 2nd edition,Updated for Python 3, Shroff /O'Reilly Publishers, 2016 (http://greenteapress.com/wp/thinkpython/)

2. Guido van Rossum and Fred L. Drake Jr, —An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd.,2011.

REFERENCES:

1. John V Guttag, —Introduction to Computation and Programming Using Python ', Revised and expanded Edition, MIT Press ,2013
2. Robert Sedgewick, Kevin Wayne, Robert Dondero, —Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd.,2016.
3. Timothy A. Budd, —Exploring Python||, Mc-Graw Hill Education (India) Private Ltd.,, 2015.
4. Kenneth A. Lambert— Fundamentals of Python: First Programs ||, CENGAGE Learning,2 012. Charles Dierbach, —Introduction to Computer Science using Python: A Computational Problem Solving Focus, Wiley India Edition,2013.
5. Paul Gries, Jennifer Campbell and Jason Montojo, —Practical Programming: An Introduction to Computer Science using Python 3||, Second edition, Pragmatic Programmers, LLC,2013.

BS3171 PHYSICS & CHEMISTRY LABORATORY 0 0 4 2

OBJECTIVES

The course objective is to teach students, the importance of physics through involvement in experiments and to have knowledge of the world due to constant interplay between observationsand hypothesis.

Course Outcome – Cos		**Cognitive Skill**
CO-01	The students will be able to analyses the physical principle involved in various instruments and also relate the principle to new applications.	R, U, A, An, E
CO-02	Various experiments in the areas of optics, properties of matter and ultrasonics will nurture the students in all branches of engineering.	R, U, A,An, E
CO-03	The students will be able to think innovatively and also improve the creative skills that are essential for engineering.	R, U, A, An, E
CO-04	The students will be able to gain knowledge of new concept in the solution of practical oriented problems and theoretical problems.	R, U, A, An, E
CO-05	The students will be able to understand measurement technology, usage of new instruments and real time applications in engineering studies.	R, U, A, An, E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-k	PO-L	PO-M
CO-01	S	S	S	S									
CO-02	S	S	S	M									
CO-03	S	S	S	S									
CO-04	S	M	S	S									
CO-05	S	S	M	M									

S- Strong, M- Medium, L-Low, N- Not Relevant

List of experiments: Physics Laboratory (Any Five Experiments)

1. Determination of velocity of ultrasonic waves and compressibility of the given liquid by Ultrasonic interferometer. (Real and Virtual Lab)
2. Determination of rigidity modulus by Torsional pendulum. (Real and Virtual Lab)
3. Determination of coefficient of viscosity by Poiseulli's method.
4. Determination of Youngs modulus by non-uniform bending method. (Real and VirtualLab)
5. Determination of LASER parameters using LASER diode. (Real and Virtual Lab)
6. Determination of band gap of the semi-conductor. (Real and Virtual Lab)
7. Determination of wavelength of mercury spectrum by diffraction grating. (Real andvirtual lab)
8. Determination of wavelength of light by Newton's rings. (Real and Virtual Lab)

9. Determination of angle of the prism using spectrometer. (Real and Virtual Lab)

CHEMISTRY LAB (Any FIVE experiments)

Course Outcomes

The student at the end of the course will

CO1 learn and apply basic techniques used in chemistry laboratory for small/large scale water analyses/purification.

CO2 be able estimate the ions/metal ions present in domestic/industry waste water.

CO3 utilize the fundamental laboratory techniques for analyses such as titrations, separation/purification and spectroscopy.

CO4 able to analyze and gain experimental skill.

List of Experiments

1. Determination of conductance of solutions
2. Potentiometry - determination of redox potentials and emfs
3. Synthesis of drug
4. Determination of Chloride content
5. Determination of hardness of water sample
6. Determination of Alkalinity of water sample
7. Virtual lab experiments

CS3171 FUNDAMENTALS OF COMPUTING AND PYTHON PROGRAMMING LAB 0 0 4 2

OBJECTIVES:

- ✓ To write, test, and debug simple Python programs.
- ✓ To implement Python programs with conditionals and loops.
- ✓ Use functions for structuring Python programs.
- ✓ Represent compound data using Python lists, tuples, dictionaries.
- ✓ Read and write data from/to files in Python.

LIST OF PROGRAMS:

1. Compute the GCD of two numbers.
2. Find the square root of a number (Newton‘s method)
3. Exponentiation (power of a number)
4. Find the maximum of a list of numbers
5. Linear search and Binary search
6. Selection sort, Insertion sort
7. Merge sort
8. First n prime numbers
9. Multiply matrices
10. Programs that take command line arguments (word count)
11. Find the most frequent words in a text read from a file
12. Simulate elliptical orbits in Pygame
13. Simulate bouncing ball using Pygame

PLATFORM NEEDED: Python 3 interpreter for Windows/Linux

TOTAL: 45 HOURS

B.Tech. NANO TECHNOLOGYCURRICULUM & SYLLABUS

REGULATION - 2021

SEMESTER – II

EG3102 COMMUNICATIVE ENGLISH 3 0 0 3

- To widen and expand students' knowledge of English vocabulary
- To develop skills of students in the areas of vocabulary, grammar, listening, speaking, reading, and writing
- To develop the knowledge, skills and strategies the student must possess to become proficient readers
- To make the students learn the importance and purpose of communication skills and overcome the communication barriers by gaining confidence
- To make the students understand how to apply technical information and knowledge in practical documents

Course Outcome - COs		**Cognitive Skill**
CO-01	Use English Language effectively in spoken and written forms.	R, U
CO-02	Comprehend the given texts and respond appropriately.	U, A
CO-03	Communicate confidently in various contexts and different cultures.	A, S
CO-04	Acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.	U, A
CO-05	The students will be able to understand the English Phonemes by studying the symbols, thereby improving their pronunciation. They will also learn about Word stress and intonation.	U, R

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-k	PO-L	PO-M
CO-01	M	L	L	M	M	M	M	L	S	S	S	M	
CO-02	L	L	L	M	L	L	M	M	M	S	S	M	
CO-03	M	M	L	M	M	L	M	M	M	S	M	M	
CO-04	L	N	N	M	L	M	L	L	M	S	M	M	
CO-05	N	N	N	L	N	L	L	N	S	S	S	M	

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT – I VOCABULARY AND GRAMMAR **9**

Parts of Speech – Sentence Structures – Technical Vocabulary – Synonyms – Antonyms – Homonyms – Homophones – Misspelled Words – One word Substitutes – Odd Words Out – Changing words from one form to another – Common Errors in English – Correction of Errors in Sentences.

UNIT – II LISTENING and READING **9**

Reading Comprehension – Skimming – Scanning – Predicting the Content – Comprehension Questions – Inductive Reading – Close Reading – Note Making – Précis Writing.

UNIT – III SPEAKING **9**

Introducing Oneself **–** Exchanging Personal Information **–** Small Talk : Family, Friends, Studies, Profession **–** Speaking **:** Greeting , Taking Leave **–** Product Description **–** Completing information **–** Gap Exercises **–** Presentation / Public Speaking Skills – Group Discussion – Debate – Role Play.

UNIT – IV TECHNICAL WRITING **9**

Report Writing – Characteristics of a Report – Categories of Reports – Letter Writing (Formal Letters) **:** Job Application Letter with Resume – Letter Seeking Permission – Letter of Invitation – Letter Declining an Invitation – Letter of Complaint – Letter of Requisition.

UNIT – V TECHNICAL COMMUNICATION **9**

The Theory of Communication – Definition and Scope – Nature, Importance and Types – Different Communication Models – Barriers to Communication – Effective Communication (Verbal / Non-verbal).

TOTAL: 45 HOURS

EXTENSIVE READING:

Can Field Jack, *Chicken Soup for the Soul*, Westland, Chennai, 1999.

NOTE:

The book given under Extensive Reading is meant for inculcating the reading habit of the students. They need not be used for testing purposes.

REFERENCE BOOKS:

1. Communication Skills. Oxford University Press.
2. Wood, F. T. (2007). Remedial English Grammar. Macmillan.
3. Zinsser, William. (2001). On Writing Well. Harper Resource Book.
4. The Four Skills for Communication – Josh Sreedharan – Foundation Books
5. Communicative English – E. Sureshkumar and P. Sreehari – Orient Black swan

MA3102 ENGINEERING MATHEMATICS – II 3 1 0 4

Aim: To impart the fundamental knowledge of Engineering Mathematics to the students in order to achieve a well founded knowledge about the principles of Mathematics.

Objective: To develop basic knowledge to the students in differential equations and vector calculus. This subject is further broadened to the functions of complex variables and complex integration. A thorough knowledge about Laplace transforms is also covered to aid the students solve the differential equations.

Course Outcome - COs		**Cognitive Skill**
CO-01	The students will be able to solve ordinary differential equations	An, E, S
CO-02	The students will be able to solve complex variables	E
CO-03	The students will be able to synthesize complex integration	S
CO-04	The students will be able to solve Vector Calculus	E, S
CO-05	The students will be able to Synthesize Laplace transforms	S

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-k	PO-L	PO-M
CO-01	M	S	M	S	S	N	M	M	S	S	M	M	M
CO-02	S	M	L	N	L	M	S	L	L	S	M	M	S
CO-03	S	L	S	S	L	L	S	S	M	M	S	S	M
CO-04	S	L	M	S	N	L	S	S	M	S	S	M	S
CO-05	S	L	M	M	M	L	N	S	M	M	M	S	N
CO-06													
CO-07													
CO-08													
CO-09													
CO-10													

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9

Linear differential equations of second order with constant and variable coefficients- Cauchy's and Legendre's linear equations – Method of variation of parameters.

UNIT II: COMPLEX VARIABLES 9

Functions of a complex variable – Analytic function – Necessary conditions- Cauchy-Riemann equations in cartesian and polar co-ordinates - Sufficient conditions (excluding proof) –Properties of analytic function – Harmonic and its conjugate – Construction of analytic function by Milne Thomson method – Conformal mappings w = z + c, cz , 1/z and Bilinear transformation.

UNIT III: COMPLEX INTEGRATION 9

Statement and applications of Cauchy's integral theorem and Cauchy's integral formula – Laurent's expansion – Singular points – Residues – Cauchy's Residue theorem – Evaluation of real definite integral using contour integration (excluding poles on the real axis) -

$\int_0^{2\pi} f(\cos\theta, \sin\theta)\, d\theta$ and $\int_{-\infty}^{\infty} \frac{f(x)}{g(x)}\, dx$

UNIT IV: VECTOR CALCULUS 9

Gradient, Divergence and Curl – Directional derivative – Irrotational and solenoidal vector fields – Vector integration – Green's theorem in a plane, Gauss divergence theorem and stokes' theorem (excluding proofs) – Simple applications involving cubes and rectangular parallelopipeds.

UNIT V: LAPLACE TRANSFORMS 9

Laplace transform –Existence condition– Transforms of elementary functions – Basic properties – Transforms of derivatives and integrals – Transform of Periodic functions. Inverse Laplace transform – Convolution, Initial and Final value theorems (statement only) – Solutions of linear ordinary differential equation of second order with constant coefficients using Laplace transform techniques.

L: 45 + T: 15 = TOTAL 60 HOURS

Outcomes:

At the end of the course, the students will be familiar to solve differential equations using Laplace Transform method, which is easier to handle the problems that is being investigated. They'll also become acquainted with the basic ideas of complex variable theory so as to enable the students to apply them with confidence in application areas such as heat conduction, elasticity, fluid dynamics and flow of electric current.

TEXT BOOKS:

1. Grewal B.S., "Higher Engineering Mathematics"- 40th Edition, Khanna Publishers, Delhi 2007.

REFERENCES:

2. M. Immaculate Mary, K. Uma Samundesvari, Engineering Mathematics – II" First Edition, Anuradha Publications, ,2013.

3. Erwin Kreyszig, “Advanced engineering Mathematics”, Seventh Edition, Wiley India, 2007.
4. Veerarajan T, “Engineering Mathematics (for first year)”, Tata McGraw- Hill Publishing Company Ltd., New Delhi,2007.
5. P. Kandasamy, K. Thilagavathy, K. Gunavathy” Engineering Mathematics” S. Chand & Company Ltd. 2002.
6. B.V. Ramana, ”Higher Engineering Mathematics” Second Edition Tata McGraw-Hill,Publishing Company Ltd., New Delhi, 2006.

BE3101 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING L T P C
3 0 0 3

AIM :

To understand the basic concepts of AC and DC circuits, measuring instruments, electronic devices and Communication system.

OBJECTIVES:

- To understand the basic solutions of AC and DC circuits.
- To study the basic principle and operation of AC and DC machines.
- To study the fundamental operations of measuring instruments.
- To study the layout of power system
- To understand the fundamental operation and characteristics of Electron devices
- To understand the implementation of Boolean expression using logic gates.
- To become familiar with basic concepts of Communication system.

UNIT: 1 – ELECTRICAL CIRCUITS 9

Ohms Law, Kirchhoff’s laws, Mesh and Nodal Analysis for DC Circuits.
Introduction to AC Circuits, Faraday’s Law of Electromagnetic Induction, Lenz law, Inductor, Capacitor, Power factor, Waveforms and RMS value, Average Value, Peak factor and Form factor, Single phase circuits- Series and Parallel, Three phase balanced circuits. Fundamentals of wiring and earthing.

UNIT: II – ELECTRICAL MEASUREMENTS, MACHINES AND POWER SYSTEM 9 Operating principles of Moving coil and Moving iron instruments (Ammeter and voltmeter), Dynamometer type watt meter and Energy meter, Errors in Measurements. Construction, Principle of operation and Applications of DC Generators, DC Motors, Single phase transformers. Structure of power system.

UNIT- III SEMICONDUCTOR DEVICES 9

Introduction to Semiconductors, PN Junction diode-Zener diode and its characteristics-Half wave and Full wave Rectifiers-Bipolar Junction transistor - CB, CE, CC Configuration and characteristics-JFET and MOSFET construction, operation, characteristics (CS only) and uses.

UNIT-IV DIGITAL ELECTRONICS **9**

Number systems-binary arithmetic--Boolean algebra-laws and theorems-Simplification of Boolean expression- logic gates –Implementation of Boolean expression using logic gates-standard forms of Boolean expression.

UNIT – V COMMUNICATION SYSTEMS **9**

Block diagram of basic communication system-need for modulation-Types of modulation-Principles of Amplitude and Frequency modulation – pulse analog and digital modulation-AM and FM transmitter and receiver (Block diagram description only) –Satellite Communication Radar Systems-Data transmission and MODEM.

TOTAL: 45 HOURS

REFERENCES:

1. Muthusubramanian R, Salivahanan S and Muraleedharan K A, "Basic Electrical, Electronics and Computer Engineering", Tata McGraw Hill, Second Edition, (2006).
2. V.N. Mittle "Basic Electrical Engineering", Tata McGraw Hill Edition, New Delhi, 1990.
3. V.K. Mehta "Principles of Power System", S. Chand & Company Ltd, New Delhi, 2001.
4. R.S. Sedha," Applied electronics" S. Chand&Co.,2006.

NT3201 INTRODUCTION TO NANOTECHNOLOGY 2 1 0 3

OBJECTIVE: The objective of this course to introduce the nanoscience to the students from its history to current technology. The effect of confinement and the electronic level changes, intermolecular forces, optical properties, electronic and magnetic properties, mechanical properties and many other drastic changes through size reduction seen in nanomaterials.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Learn the basics and laws concerning nanomaterials	U
CO-02	Learn the types of nanoscale materials	U, An, A
CO-03	Learn the different properties of electronic and magnetic materials.	U, An, A
CO-04	Learn the properties and features of nanomaterials.	U, An, A
CO-05	Learn the various applications of nanomaterials.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: NANOTECHNOLOGY BASICS 9

Background to nano technology - Scientific revolutions - Basic principles of nano scale materials- Nano sized metals and alloys, semiconductors, ceramics. Comparison with respective bulk materials; Organic semiconductors, carbon nanotubes; Zero, One and Two-dimensional nanostructures – Self-assembly.

UNIT II: OPTICAL AND ELECTRONIC PROPERTIES 9

Length Scales involved and effect on properties: Optical Properties-Surface Plasmon Resonance, Quantum Size Effects- Electrical conductivity-Surface Scattering, Change of electronic structure, Ballistic conductivity -Ferroelectrics and dielectrics.

UNIT III: CHEMICAL AND THERMAL PROPERTIES **9**

Chemical properties- Size effects on structure and morphology- phase transition in nanocrystals-effect of nanoscale materials on chemical reactivity. Thermal properties- Melting points and lattice constants- Glass Transition Temperatures- – Glass Transition Temperatures – Melting-Point Depression– Thermal Conductivity in Nanostructures

UNIT IV: MECHANICAL AND MAGNETIC PROPERTIES **9**

Mechanical Properties- Grain Size effects on strength of materials, Hall-Petch relationship, Super plasticity – Single Domain Magnetic nanoparticles – Uniaxial and Shape anisotropic - Super para magnetism- Giant Magnetic Resistance (GMR).

UNIT V: NANOMATERIALS BASED DEVICES **9**

Renewable energy: Solar Cells and its various types - Photovoltaic diodes –High energy density batteries. , Light Emitting Diodes, OLED displays–White lasers.

TOTAL: 45 PERIODS

TEXTBOOKS:

1. Ratner, M. A., & Ratner, D. (2003). *Nanotechnology: A gentle introduction to the next big idea*. Upper Saddle River, NJ: Prentice Hall. Wilson, M. (2002). *Nanotechnology: Basic science and emerging technologies*. Boca Raton: Chapman & Hall/CRC.
2. Ravichandran K., Swaminathan K., Praseetha P.K., Kavitha K. (2019). Introduction to Nanotechnology, Jazym Publishers.
3. Poole, C. P., & Owens, F. J. (2003). *Introduction to nanotechnology*. Hoboken, NJ: J. Wiley.

REFERENCE BOOKS:

1. Guozhong Cao, "Nanosrtuctures and nanomaterials: Synthesis, properties and applications", Imperial College Press, 2004.
2. Joel. I. Gersten, "The Physics and Chemistry of Materials", Wiley, 2001.
3. S. Edelstein & R. C. Cammarata, "Nanomaterials: Synthesis, properties and applications", Institute of Physics Pub., 1998.
4. S.Yang&P.Shen, "Physics and chemistry of nanostructured materials", Taylor & Francis, 2000.
5. "Encyclopedia of nano science and nanotechnology", Vol.1, 2, 6,7,10.

NT3202 SYNTHESIS OF NANOMATERIALS L T P C
2 1 0 3

OBJECTIVE: The objective of this course is to understand the basic concepts of nanostructured materials, principle behind the various methods used to synthesize/prepare nanomaterials, understanding the various processes involved in the preparation of the nanomaterials.

Course Outcome - COs		**Cognitive Skill**
CO-01	Describe the various types of methods available for nanomaterial synthesis	U
CO-02	Explain the concepts in the formation of nanoparticles	U, An
CO-03	Explain the template and powder synthesis of nanomaterials	U, An
CO-04	Understand the methods in the synthesis of mesoporous and carbon allotropes	U, An
CO-05	Understand the evaporation and condensation methods of nanomaterial synthesis	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	S	M	N	M	S
CO-02	S	S	M	N	M	S
CO-03	S	S	M	N	M	S
CO-04	S	S	M	N	M	S
CO-05	S	S	M	N	M	S

S-Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: NUCLEATION **9**

Fundamentals of homogeneous nucleation - Subsequent growth of nuclei - Synthesis of metallic nanoparticles - Synthesis of semiconductor nanoparticles - Synthesis of oxide nanoparticles. Heterogeneous Nucleation - Fundamentals of heterogeneous nucleation - Synthesis of nanoparticles.

UNIT II: PYSICAL METHODS **9**

Top down and bottom-up approaches–Mechanical alloying and mechanical ball milling. Mechano chemical process – melt quenching and annealing – Inert gas condensation technique – Arc plasma and laser ablation.

UNIT III: CHEMICAL METHODS **9**

Sol-gel technique – solvothermal methods-control of grain size – co-precipitation hydrolysis – nonchemical method - combustion technique – colloidal precipitation - template assisted

process –-Core-Shell Nanoparticle.

UNIT IV: SYNTHESISOF NANOWIRES AND NANORODS 9

Spontaneous Growth - Evaporation (dissolution)-condensation growth - Fundamentals of evaporation (dissolution) - condensation growth - Evaporation-condensation growth - Dissolution-condensation growth. Vapor (or solution) - liquid-solid (VLS or SLS) growth - Fundamental aspects of VLS and SLS growth.

UNIT V: NANOPOROUS MATERIALS 9

Porous Materials: Classification – Preparation of porous materials: soft template and hard template methods – Zeolites, mesoporous materials, nanomembranes - Carbon nanotubes and graphene - hybrid nanocomposites- nano sponge.

TOTAL: 45 HOURS

TEXT BOOKS

1. Cushing, B. L., Kolesnichenko, V. L., & O'Connor, C. J. (January 01, 2004). Recent Advances in the Liquid-Phase Syntheses of Inorganic Nanoparticles. *Chemical Reviews, 104,* 9, 3893.
2. Ajayan, P. M., Schadler, L. S., & Braun, P. V. (2003). *Nanocomposite science and technology*. Weinheim: Wiley-VCH.

REFERENCE BOOKS

1. Cao, G. (2004). *Nanostructures &nanomaterials: Synthesis, properties & applications*. London: Imperial College Press.
2. Zhang, J. Z. (2003). *Self-assembled nanostructures*. New York: Kluwer Academic/Plenum Publishers.
3. Cushing, B. L., Kolesnichenko, V. L., & O'Connor, C. J. (January 01, 2004). Recent Advances in the Liquid-Phase Syntheses of Inorganic Nanoparticles. *Chemical Reviews, 104,* 9, 3893.
4. Inoue, A., & Hashimoto, K. (2001). *Amorphous and nanocrystalline materials: Preparation, properties, and applications*. Berlin: Springer.

BE3171 BASIC ELECTRICAL AND ELECTRONICS ENGINEERING LABORATORY 0 02 1

AIM:

To understand the electric circuit connection, measurement of electrical parameters, Characteristics of electron devices and its applications.

OBJECTIVES:

- To make basic electrical connection
- To measure the electrical parameters
- To obtain the characteristics of Electron devices
- To verify the operation of logic gates.

I. Electrical Engineering Lab

1 Study of Symbols, Cables and Earthing.
2 Residential house wiring using switches, fuse, indicator, lamp and energy meter.
3 Fluorescent lamp wiring.

4 Stair case wiring / Lamp control from three different places/ Doctor Room control/ Go down control
5 Measurement of electrical quantities – voltage, current, power & computation of power factor in RLC circuit.
6 Measurement of energy using single phase energy meter.
7 Fan Wiring.

II. Electronics Engineering Lab

1. Study of Electronic components and equipment – Resistor, colour coding, Measurement of AC signal parameter (peak-peak, rms period, frequency) using CRO.
2. Characteristics of PN Junction diode
3. Characteristics of Zener diode
4. Voltage Regulator using Zener diode
5. Measurement of ripple factor of HWR and FWR.
6. Study of logic gates AND, OR, EX-OR and NOT, NAND and NOR.
7. Generation of Clock Signal.
8. Soldering practice – Components, Devices and Circuits – Using general purpose PCB.

TOTAL: 30 HOURS

NT3271 GENERAL SYNTHESIS METHODS LABORATORY L T P C
0 0 4 2

OBJECTIVES:
To understand different synthesis methods and biological synthesis of nanomaterials.

Course Outcome - COs		**Cognitive Skill**
CO1	Understand the different synthesis methods	U
CO2	Learn the Various methods for thin film fabrication	U, An
CO3	Learn the biological synthesis of nanomaterials	U, An
CO4	Learn the method to synthesize multicomponent nanoparticles	U,An, A
CO5	Understand the basic characterization techniques	U

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S

CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Syllabus
List of Experiments:

1. Introduction to General laboratory safety and hazardous signs.
2. Solution 1: Preparation of solution using percentage by weight (w/v).
3. Solution 2: Preparation of solution using percentage by volume (v/v).
4. Solution 3: Preparation of molar solution.
5. Preparation of Phosphate Buffer solution having pH 2 (acid) using Henderson-Hasselbalch equation.
6. Preparation of Phosphate Buffer solution having pH 7 (neutral) using Henderson-Hasselbalch equation.
7. Preparation of Phosphate Buffer solution having pH 9 (base) using Henderson-Hasselbalch equation.
8. Measure the conductivity of different molar concentrated solution.
9. Simple oxidation and reduction of Methylene Blue in solution.
10. Simple oxidation and reduction experiments: Metal based.
11. Beer lamberts law and demonstration. (Variation of concentration).

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DEPARTMENT OF NANOTECHNOLOGY
B.TECH. NANOTECHNOLOGY
CURRICULUM & SYLLABUS,
REGULATION - 2021

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MA3202	Numerical Methods and Transforms	3	1	0	3
2.	NT3203	Quantum Mechanics for Nanotechnology	3	1	0	3
3.	NT3204	Materials Science	3	1	0	3
4.	NT3205	Medical Instrumentation Systems	3	1	0	3
5.	NT3206	Nano Characterization Techniques	3	1	0	3
6.	BS3201	Environmental Studies	2	0	0	2
PRACTICAL						
6.	NT3272	Basic Characterization Laboratory I	0	0	2	1
7.	NT3273	Synthesis of Nanomaterials Laboratory	0	0	2	1
8.	NT3274	Electronics and Related Devices Laboratory	0	0	2	1
TOTAL			17	5	6	20

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA3206	Random Processes	3	0	0	3
2	EC3202	Electron Devices	3	0	0	3
3	NT3207	Thin Film Technology	3	0	0	3
4	NT3208	Impedance and Electrochemistry	3	0	0	3
5	NT3209	Chemical Reaction Engineering	3	0	0	3
6	NT3210	Advanced Molecular Biology	3	0	0	3
PRACTICAL						
7.	NT3275	Basic Characterization Laboratory II	0	0	2	1
8.	NT3276	Chemical Engineering Laboratory	0	0	2	1
9.	NT3277	Thin Film Laboratory	0	0	2	1
10.	NT32P1	Internship	0	0	4	2
TOTAL			18	0	10	23

SEMESTER III

NT3203 QUANTUM MECHANICS FOR NANOTECHNOLOGY 3 1 0 3

OBJECTIVES

- Study the basics of quantum mechanics to understand the properties of matter at nanoscale.
- Understanding the one dimensional and three-dimensional harmonic oscillators and its related problems.
- Learn the advanced computation process, q-bit related concepts.

Course Outcome – Cos		**Cognitive Skill**
CO-01	To study the basics of quantum mechanics to understand the properties of matter at nanoscale.	U, A, E
CO-02	To solve the Schrodinger's equations and apply the same for the nanotechnology.	U, A, E
CO-03	Able to understand the concepts behind the free particle's theory	U, A, E
CO-04	To Understand the one dimensional and three-dimensional harmonic oscillators and its theories.	U, A, E
CO-05	To learn the Concept of quantum computation.	U, A, E

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Introduction **9**

Scale of quantum mechanics – Black body radiation – Planck's constant – Photoelectric effect – Compton Effect, experimental verification of Compton Effect – Bohr's theory of hydrogen spectrum – Bohr's explanation of the spectrum of the atomic hydrogen.

Unit II: Dual Nature of Matter **9**

Dual nature of light and matter – Matter waves – de Broglie wavelength – Experimental evidences for matter waves - Heisenberg uncertainty – Postulates of quantum mechanics:

wave functions, physical interpretation of the wave function, normalized and orthogonal wave functions.

Unit III: Schrodinger Wave Equation **9**

Schrodinger equation: Time dependent and time independent, solution of the Schrodinger equation – Applications of Schrodinger's equation: The free particle – Particle in box – A particle in one dimensional, infinitely deep potential – A particle in three dimensional, infinitely deep potential well.

Unit IV: Applications of Schrodinger Wave Equation **9**

Finite potential well – tunneling effect – Quantum harmonic oscillators: one dimensional and three-dimensional harmonic oscillators – Density of quantum states for nanostructures: 0D, 1D and 2D structures.

Unit V: Quantum Mechanics Based Devices **9**

Concept of quantum computation, Quantum Q-bits –Quantum devices: tunnel diode, metal-insulator-metal (MIM) diode, Quantum dot transistor – Single electron devices.

TOTAL: 45 HOURS

REFERENCES

1. SatyaPrakash, Swati Saluja, "Quantum Mechanics", KedarNath ram Nath& Co. Publishers, Meerut.
2. David J. Griffiths "Introduction to Quantum Mechanics", Pearson Educational International, London.
3. Vladimir V. Mitin, Dmitry I. Sementsov and Nizami Z. Vagidov, "Quantum Mechanics for Nanostructures", Cambridge University Press.
4. Dae Mann Kim, "Introductory Quantum Mechanics for Applied Nanotechnology", Wiley VCH Publishers, Germany.

NT3204 MATERIALS SCIENCE 3 1 0 3

OBJECTIVES

To Understand electrical properties of materials, the properties and applications of semi conducting materials, general properties and applications of magnetic and dielectric materials, the behavior of materials on exposure to light, general properties and application of modern engineering and familiarized with the concepts of Nano Science and Technology.

Course Outcome		**Cognitive Skill**
CO-01	to study the basics of mechanical properties of materials	U, A, E
CO-02	to understand the electronic properties of materials	U, A, E
CO-03	able to understand the optical properties of materials	U, A, E
CO-04	to understand the dielectric properties of materials	U, A, E
CO-05	to learn the magnetic properties of materials	U, A, E

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: mechanical properties of materials **9**

Stress Strain diagram for different engineering materials – Ductile and brittle material – Tensile strength – Hardness – Impact strength – Fatigue – Creep – Fracture – Factors affecting mechanical properties.

Unit II: Electronic Properties of Materials **9**

Concept of energy band diagram for materials - conductors, semiconductors and insulators, electrical conductivity effect of temperature on conductivity, intrinsic and extrinsic semiconductors - Hall effect –Superconducting materials.

Unit III: Optical Properties of Materials **9**

Reflection, refraction, absorption and transmission of electromagnetic radiation in solids. Photonic materials: LED and LCD materials – Photo conducting materials – Nonlinear optical materials (elementary ideas) and their applications.

Unit IV: Dielectric Properties of Materials **9**

Dielectric materials: Various polarization mechanisms in dielectrics (elementary ideas) and their frequency and temperature dependence – Dielectric loss – Piezo electric and ferro electric materials and their applications

Unit V: Magnetic Properties of Materials **9**

Magnetic materials: Origin of magnetism, Ferrites– perovskites, dia, para, ferro, ferri, antiferro & superpara Magnetic materials - Giant Magneto Resistance (GMR).

TOTAL 60 HOURS

TEXT BOOKS

1. Kasap, S. O. (2006). *Principles of electronic materials and devices*. Boston: McGraw-Hill.
2. Van, V. L. H. (2008). *Elements of materials science and engineering*. Pearson.
3. Vijaya, M. S., &Rangarajan, G. (2004). *Materials science*. New Delhi: Tata McGraw-Hill.

REFERENCE BOOKS

1. Hummel, R. E. (1992). *Electronic properties of materials*. Berlin: Springer-Verlag.
2. Raghavan, V. (2004). *Materials science and engineering: A first course*. New Delhi: Prentice-Hall of India.

3. Wadhwa, A. S., &Dhaliwal, H. S. (2008). *A textbook of engineering material and metallurgy*. New Delhi: University Science Press.
4. Wilson, M. (2004). *Nanotechnology: Basic science and emerging technologies*. Boca Raton: Chapman & Hall/CRC.

NT3205 MEDICAL INSTRUMENTATION SYSTEMS 3 1 0 3

OBJECTIVES

- To study about bio-potential recording and different types of electrodes.
- To study the operational principles of various bio potential recording devices.
- To understand various biochemical measuring instruments and patient monitoring equipment.
- To familiarize with special medical equipment and their working principle.
- To gain knowledge about various electric shock hazards and patient safety.

Course Outcome		**Cognitive Skill**
CO-01	Understand the fundamentals of biomedical instrumentation about various types of electrodes.	U, An
CO-02	Familiarise with various bio potentials and the method of recording the bio signals.	U, R, An
CO-03	Understand the instrumentation of various biochemical measuring instruments and patient monitoring equipment.	U, An
CO-04	Gain knowledge about special medical equipment and their working principle.	E, U
CO-05	Understand electric shock hazards and the safety precautions.	U, An

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-K	PO-L	PO-M
CO-01	S	M	S	M	S	L	M	L	S	S	M	M	S
CO-02	S	M	S	M	S	L	M	L	S	S	M	M	S
CO-03	S	M	S	M	M	L	M	L	S	S	M	M	S
CO-04	S	M	S	M	S	L	M	L	S	S	M	M	S
CO-05	M	M	M	M	S	L	M	L	L	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: BIOPOTENTIAL ELECTRODES 9

Origin of bio potential and its propagation – Electrode-electrolyte interface – Electrode-skin interface – Skin contact impedance – motion artifacts – half-cell potential – polarization – non-polarizable electrode – Surface, needle and microelectrodes – Electrodes for ECG, EEG, EMG.

UNIT II: BIO-POTENTIAL RECORDING 9

Biological amplifiers – ECG – Einthoven's triangle, standard 12 lead system – EEG – 10-20 electrode system, unipolar, bipolar and average mode – EMG– unipolar and bipolar mode – Recording of ERG, EOG, EGG, GSR and PCG.

UNIT III: BIOCHEMICAL MEASUREMENT AND PATIENT MONITORING 9

Blood gas analyzer (pH, pO_2, pCO_2, $pHCO_3$) – auto analyzer – Blood cell counters – Blood glucose sensor – Patient monitoring systems – bed side monitors, central monitors – Central consoling controls – Radio Telemetry (single, multi) – Portable and Landline Telemetry unit.

UNIT IV: SPECIAL INSTRUMENTS 9

Foetal monitoring Instruments – Baby warmer – Baby Ventilator – Endoscopy unit – Principles of measuring blood pressure – body temperature – blood volume and flow in arteries, veins and tissues – cardiac output measurement – Infusion pumps.

UNIT V: ELECTRIC SHOCK HAZARDS AND PATIENT SAFETY 9

Electric shock Hazards – Effects of electric current on human body - leakage currents – safety codes for Electrical Equipment– Electrical Safety Analyser – Testing of Biomedical Equipment– grounding.

TOTAL: 45 Hours

TEXT BOOKS:

1. Leslie Cromwell, "Biomedical Instrumentation and measurement", Prentice hall of India, New Delhi, 2007.
2. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi, Third Edition, 2013.

REFERENCES:

1. John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2005.
2. Joseph J.carr and John M. Brown, "Introduction to Biomedical equipment technology", John Wiley and sons, New York, Fourth Edition, 2001.

NT3206 NANO CHARACTERIZATION TECHNIQUES 3 1 0 3

OBJECTIVES

The objective of this course is to make students familiar with the important concepts in characterization of nanomaterials by different methods.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Understanding the principle & procedure of Scanning Probe Microscope to characterize the Nanomaterials. To analysis the particle size and surface area.	U
CO-02	To understand the principle & procedure to characterize the nanomaterials using the various spectrometer. To analyze the various applications of nanomaterials based on specific characteristics.	U, An
CO-03	Understanding the structural and thermal characterization of nanomaterials using X-ray diffractometer and TG/DTA.	U, An
CO-04	To identify the specific electrical characterization of nanomaterials to use the nanomaterials for specific applications.	U, An

CO-05	To identify the specific magnetic characterization of nanomaterials for specific applications.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	N	S	N	N	N	L
CO-02	N	S	N	N	N	L
CO-03	N	S	N	N	N	L
CO-04	N	S	N	N	N	L
CO-05	N	S	N	N	N	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNITI: SIZE CHARACTERIZATION 9

Particle size: Dynamic Light scattering & Disc centrifuge method – Surface area: Nitrogen Adsorption analysis – BET surface area. SPM: AFM - STM – MFM. Compositional analysis and composition mapping using EDAX.

UNITII: SPECTROSCOPY 9

Introduction to absorption and emission of radiation –IR Spectroscopy; Characterization of metal oxides and metal sulphides- Fourier transformation and interferometers - Raman spectroscopy –Applications to CNT and Graphene- UV-Vis Spectroscopy- Applications to Silver and Gold.

UNITIII: STRUCTURAL AND THERMAL CHARACTERIZATION 9

Bravais lattice – Miller indices – Crystal systems - Space lattice- - Atomic scattering factor – X- ray diffraction -Bragg Equation- Debye Scherrer Equation–Particle Size Evaluation. Thermalanalysis– TG – DTA – DSC

UNITIV: ELECTRICAL CHARACTERIZATION 9

Polarizability- types- Factors affecting polarizability- Measurement of dielectric constant – dielectric loss –- Hall effect – Hall coefficient measurement – electrical conductivity – four probe measurement

UNITV: MAGNETIC CHARACTERIZATION 9

Classification of Magnetic Materials- Magnetic susceptibility – magnetic hysteresis loop – vibrating sample magnetometer – Introduction to SQUID magnetometer – Applications to magnetic materials

T: 15 + L: 45 = TOTAL: 60 HOURS

TEXT BOOKS

1. Willard, H. H., Merritt, L. L., & Dean, J. A. (1965). *Instrumental methods of analysis*. Princeton, N.J: Van Nostrand.
2. Kalantar-zadeh, K., & Fry, B. N. (2008). *Nanotechnology-enabled sensors*. New York: Springer.

REFERENCE BOOKS

1. Elzey, S. R. (2010). *Characterization of nanomaterials: Environmental, health, and*

safety studies. Saarbrucken, Deutschland: LAP Lambert Academic Pub.

2. Ezawa, Z. F. (2000). *Quantum Hall effects: Field theoretical approach and related topics*. Singapore: World Scientific.
3. Lakowicz, J. R. (1983). *Principles of fluorescence spectroscopy*. New York: Plenum Press.
4. Mattox, D. M. (2010). *Handbook of physical vapor deposition (PVD) processing*. Norwich, N.Y: William Andrew.
5. Cao, G. (2004). *Nanostructures &nanomaterials: Synthesis, properties & applications*. London: Imperial College Press.

BS3201 Environmental Studies 2 0 0 2

OBJECTIVES

- To understand the basic concepts in environmental science
- To gain the knowledge about structure and natural cycles of environment.
- To get an idea about control methods of pollution.
- To know the information about conservation methods of forest and wild life.

Course Outcome - COs		Cognitive Skill
CO-01	Student will be able to demonstrate a general understanding of interdisciplinary nature of environmental uses and able to characterize natural resources.	U, A, An
CO-02	Students will be able to explain the effects of air, water, soil, noise and thermal pollution environment and suggest ways to reduce them.	R, E, A
CO-03	Students will be able to explain the effects of air, water, soil, noise and thermal pollution environment and suggest ways to reduce them.	R, U, A
CO-04	Students will be able to understand the effects of human population and know about the awareness programme.	R, A, E
CO-05	Students apply systems concept and methodologies to analyse and understand interaction between social and environmental process.	R, A, An

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-k	PO-L	PO-M
CO-01	S	M	S	M	M	S	S	S	M	S	S	M	S
CO-02	M	M	S	M	S	S	S	S	M	S	S	M	M
CO-03	M	M	S	M	S	S	S	S	M	S	S	M	M

CO-04	M	M	S	S	M	S	S	S	M	S	S	M	L
CO-05	M	M	S	S	L	S	M	S	M	S	S	L	M

S-Strong, M-Medium,L-Low,N-Not relevant

Unit I: NATURE OF ENVIRONMENT STUDIES AND NATURAL RESOURCES 9

Environment studies- definition – scope and importance- need for public awareness- Methods to create environmental awareness- Natural resources- Forest resources- energy resources- food resources- water resources – land resources - mineral resources.

Unit II: ECO SYSTEMS AND BIO-DIVERSITY 9

Concept and component of eco systems- producer, consumer, decomposer- structure and function of eco system- food chain and food web- energy flow model- aquatic eco system forest eco system- desert eco system- pyramid of biomass- ocean eco system- grass land eco system- Bio diversity in India- value of bio diversity- biodiversity threatens- biodiversity protection- In-situ and Ex-situ conservation.

Unit III: ENVIRONMENTAL POLLUTION 9

Meaning of environmental pollution- air pollution- acid rain – global warming- water pollution- water pollution control- soil pollution- urban waste and soil pollution- marine pollution- noise pollution- thermal pollution- solid and hazardous waste management- waste disposal methods- solid waste and India- natural disaster and disaster management.

Unit IV: HUMAN POPULATION AND ENVIRONMENT 9

Population growth- distribution of population- factors affecting variation in population theories of population- future of human population- family welfare programme- HIV and AIDS- environment and human health- human rights- value education- women and child welfare.

Unit V: SOCIAL ISSUES AND THE ENVIRONMENT 9

Unsustainable to sustainable development- sustainable development in India- water conservation, watershed management and water harvesting- environmental ethics- role of engineer in environmental protection.

TOTAL: 30 HOURS

TEXT BOOKS

1. Cunnigham & Saigo: 'Environmental science: A global concern' 4th Ed. W.c. Brown Publishers. USA. 1997
2. Chauhan A.S, 'Environmental studies' 2nd revised ed.2004, Jain Brother publishers, New Delhi

REFERENCES:

Benny Joseph: 'Environmental Science and Engineering', 2006, Tata McGraw- Hill Publication. 2. Siddique K.A.: Elements of Ecology and Environmental Pollution, 1st Ed. 2002, Kushal Publication, Varanasi. M

NT3272 BASIC CHARACTERIZATION LABORATORY- I 0 0 2 1

OBJECTIVES

To know the main investigation techniques for the determination of the mechanical andthermal properties, and of the possible results for the different materials classes.

Course Outcome - COs		**Cognitive Skill**
CO-01	Ability of performing basic characterization of mechanical, thermal and morphological properties of materials.	U, A
CO-02	Understanding of the main investigation techniques for the determination of the nature and the microstructure of materials, along with their results.	U, A
CO-03	Understanding of the main investigation techniques for the determination of the mechanical and thermal properties, and of the possible results for the different materials classes.	U, A, An
CO-04	Preparation of the Carbon nanotubes by the CVD process	U, A, An
CO-05	Preparation of the ZnO thin films by using spin coating technique	U, A

List of Experiments

1. Crystallinity and average particle size determination by X-Ray powder diffraction technique
2. Particle size analysis by Centrifugal Sedimentation and Dynamic Light Scattering techniques
3. Identification and quantification of compounds by UV-Vis Spectroscopy technique
4. FTIR Spectroscopy technique- Identification of chemical bonds
5. Raman Spectroscopy-Structure elucidation of the compounds
6. Weight loss and thermal effects by Thermogravimetric Analysis (TG/DTA)
7. Calculation of Surface area of Nanostructures by BET method
8. Corrosion Rate Determination
9. AC Impedence
10. Atomic Force Microscopy

TOTAL: 45 HOURS

NT3273 SYNTHESIS OF NANOMATERIALS LABORATORY 0 0 2 1

OBJECTIVES

To learn the Various methods for thin film fabrication and to synthesize multicomponent nanoparticles.

Course Outcome - COs		**Cognitive Skill**
CO-01	Understand the different synthesis methods	U
CO-02	Learn the Various methods for thin film fabrication	U, An

CO-03	Learn the biological synthesis of nanomaterials	U, An
CO-04	Learn the method to synthesize multicomponent nanoparticles	U, An
CO-05	Understand the basic characterization techniques	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	S	S	S	M	S
CO-02	M	S	S	S	M	S
CO-03	M	S	S	S	M	S
CO-04	M	S	S	S	M	S
CO-05	M	S	S	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

List of Experiments:

1. Synthesis of Iron Oxide by combustion method
2. Synthesis of ZrO2 by Hydrothermal method
3. Synthesis of BaTiO2 by Ball Milling
4. Synthesis of Silver (Ag) by Bio mimetic Methods
5. Synthesis of Iron Oxide by Co-Precipitation method
6. Synthesis of Nickel oxide (NiO) by Sol Gel based method
7. Synthesis of Zinc Selenide (ZnSe) quantum dots
8. Synthesis of ZrO_2 nano-sized materials
9. Synthesis of Zinc Oxide by Soft chemical method
10. Synthesis of polymer hydrogel
11. Synthesis of multi component ceramic nanoparticles

TOTAL: 45 HOURS

NT3274 ELECTRON DEVICES LAB 0 0 2 1

OBJECTIVES

To get fundamental ideas in semiconductor devices course through hands-on experience by examining the electrical characteristics of various semiconductor devices, such as diodes, BJTs and FETs.

Course Outcome - COs		**Cognitive Skill**
CO-01	To study experimentally the characteristics of diodes, BJT's and FET's.	U
CO-02	To verify practically the response of various special purpose electron devices.	U, An, A
CO-03	To verify practically the response of LED with different wavelengths	U, An, A
CO-04	Characteristics of half and full wave rectifier.	U, An, A
CO-05	Characteristics of regulators.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	S
CO-02	S	M	S	M	M	S
CO-03	S	M	S	M	M	S
CO-04	S	M	S	M	M	S
CO-05	S	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

List of experiments

1. Characteristics of PN junction and Zener diode.
2. Input, Output and Transfer characteristics of CE and CC Amplifier.
3. Characteristics of LDR, Photo-diode and Photo transistor.
4. Transfer characteristics of JFET.
5. Transfer characteristics of MOSFET (with depletion and enhancement mode)
6. Characteristics of LED with three different wavelengths.
7. Half wave rectifier.
8. Full wave rectifier with 2 diodes.
9. Series voltage Regulator.
10. Shunt voltage Regulator.

SEMESTER IV

MA3206 RANDOM PROCESSES 2 1 0 3

OBJECTIVES

To have the fundamental knowledge of basic probability concepts, the standard distributions and random variables which can describe real life phenomena. To acquire skills in the basic characteristic features of queuing system and in analyzing queuing models.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Know the basic concepts of probability and Random Variables. Understand the characteristic of density random variable and continuous random variable. Able to compute mean, variance and generate moment generating functions.	R, A, U, E
CO-02	Understand the different distributions ie Binomial, Possion, Uniform, Exponential, gamma and normal distribution and its properties.	
CO-03	Analyse the characteristic of two dimensional Random Variables, the properties of joint distribution, Marginal and conditional distributions and compute covariance, correlation and regression.	R, U, A, E
CO-04	Understand the characteristics and properties of strictly stationary, wide-sense stationary, Ergodic processes, Markov process, binomial, sine wave process and Gaussian processes.	R, U, A, E
CO-05	Analyse the characteristics and properties of Auto correlation, cross correlation, power spectral density and cross spectral density. Able to find cross correlation and Auto correlation function of input and output.	R, A, U, E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	S	S	S	M	S
CO-02	M	S	S	S	M	S
CO-03	M	S	S	S	M	S
CO-04	M	S	S	S	M	S
CO-05	M	S	S	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: PROBABILITY AND RANDOM VARIABLE 9

Axioms of probability - Conditional probability – Independent Events –Total probability- Baye's theorem- Random variable - Probability mass functions - Probability density functions -Distribution functions- Properties – Expectation – Moments - Moment generating function and its properties.

UNIT II: STANDARD DISTRIBUTIONS 9

Binomial, Poisson, Uniform, Exponential, Gamma and Normal distributions and their properties (Problems only) –Central Limit Theorem. (without proof)

UNIT III: TWO DIMENSIONAL RANDOM VARIABLES 9

Joint distributions - Marginal and Conditional distributions –Expectation-Independence-Covariance – Correlation and Regression.

UNIT IV: RANDOM PROCESSES **9**

Definition and Examples - first order, second order, strictly stationary, wide – sense stationary and Ergodic processes - Markov process - Binomial, Sine wave process and Gaussian processes

UNIT V: CORRELATION AND SPECTRAL DENSITIES 9

Auto Correlation - Cross Correlation - Properties – Power spectral density – Cross spectral density –Properties-Relationship between cross power spectrum and cross correlation function- Linear time invariant system - System transfer function –Linear systems with random inputs – Auto correlation and cross correlation functions of input and output – Fundamental theorem of power spectral density.

TOTAL:30+15 = 45 HOURS

TEXT BOOKS:

1. Ross, S., "A First Course in Probability", Fifth edition, Pearson Education, New Delhi, 2002 (Chapters 2 to 8)

2. Peebles Jr. P.Z., "Probability Random Variables and Random Signal Principles", Tata McGraw-Hill Publishers, Fourth Edition, New Delhi, 2002 (Chapters 6, 7 and 8).

REFERENCES:

1. Henry Stark and John W. Woods "Probability and Random Processes with Applications to Signal Processing", Pearson Education, Third edition, Delhi, 2002.
2. Veerarajan. T., "Probabilitiy, Statistics and Random Processes", Tata McGraw-Hill Publications, Second Edition, New Delhi, 2002.
3. Ochi, M.K., "Applied Probability and Stochastic Processes", John Wiley & Sons, New York, 1990.
4. Dougles C. Montgomery and George C. Runger, "Applied Statistics and Probability for Engineers", 3rd Edition, John Wiley & Sons (2004).

EC3202 **Electron Devices** **3 0 0 3**

OBJECTIVES

To acquaint the students with the construction, theory and operation of the basic electronic devices such as PN junction diode, Bipolar and Field effect Transistors, Power control devices, LED, LCD and other Opto-electronic devices

Course Outcomes		**Cognitive Skill**
CO-01	Able to understand the VI characteristics of PN Junction diode.	U
CO-02	Able to understand the equivalent circuit of transistors.	R
CO-03	Able to analyze Field Effect Transistors.	N
CO-04	Able to get the concepts of special semiconductor devices.	
CO-05	Able to apply the concepts of power supplies.	A

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I	PO-J	PO-k	PO-L	PO-M
CO-01	S	M	M	M	S	S	S	S	S	S	M	L	L
CO-02	S	S	S	M	M	M	M	S	S	S	L	L	L
CO-03	M	S	S	S	M	M	M	M	S	S	S	L	L
CO-04	M	S	S	S	M	M	M	M	M	L	S	L	M
CO-05	S	M	S	S	S	L	S	S	S	L	L	L	M

S-Strong, M-Medium, L-Low, N-Not relevant

Unit I: Semiconductor Diode **9**

PN Junction Diode- Current Equations- Energy Band Diagram- Diffusion and Drift Current Densities- Forward and Reverse Bias Characteristics- Transition and Diffusion Capacitances- Switching Characteristics- Breakdown in PN Junction Diodes.

Unit II: Bipolar Junction Transistors **9**

NPN and PNP Operations- Early Effect- Current Equations- Input and Output Characteristics of CE, CB, CC, h- Parameter Model- Hybrid π Model- Multi Emitter Transistor.

Unit III: Field Effect Transistors **9**

JFETs – Drain and Transfer Characteristics-Current Equations-Pinch Off Voltage and its Significance- MOSFET- VI Characteristics of CS and CD - Threshold Voltage -Channel Length

Modulation- D- MOSFET- E-MOSFET- CMOS Device Structure.

Unit IV: Special Semiconductor Devices **9**

Metal-Semiconductor Junction- MESFET, FINFET, PINFET, CNTFET, DUAL GATE MOSFET, Schottky Barrier Diode-Zener Diode-Varactor Diode –Tunnel Diode- GaAs/GaNHEMFET-LASER diode-LDR .

Unit V: Power Devices And Display Devices **9**

UJT, SCR, Diac, Triac, Power BJT- IJPT- Power MOSFET- DMOS-VMOS. LED, LCD, Photo Transistor, Opto Coupler, Solar Cell, CCD.

TOTAL: 45 HOURS

TEXT BOOKS

1. Robert Boylestad and Louis Nashelsky, ―Electron Devices and Circuit Theory‖ Pearson Prentice Hall, 10th edition, July 2008.
2. R.S. Sedha, ― A Text Book of Applied Electronics‖ S. Chand Publications, 2006.
3. Millman and Halkias- Integrated Electronics, Tata McGraw Hill Publication 2001

REFERENCES:

1. Donald A Neaman, ―Semiconductor Physics and Devices‖, Fourth Edition, Tata McGraw Hill Inc. 2012.
2. Salivahanan. S, Suresh Kumar. N, Vallavaraj A, ―Electronic Devices and circuits‖, Third Edition, Tata McGraw- Hill, 2008.
3. Yang, ―Fundamentals of Semiconductor devices, McGraw Hill International Edition, 1978.

NT3207 **THIN FILM TECHNOLOGIES** **3 0 0 3**

OBJECTIVES

For a basic understanding on thin film technology, the course is designed to study the mechanism of formation of thin film, various fabrication methods, physic-chemical characterization and property studies of thin films, and thin film-based applications.

Course Outcome - COs		**Cognitive Skill**
CO-01	At the end of this subject students will come to know about the fundamental of thin film coating techniques.	U
CO-02	After completing this subject student able to understand the various physical vapour deposition method used to thin film coating	U, An
CO-03	After completing this subject student able to understand the various chemical vapour deposition method used to thin film coating.	U, An
CO-04	Students who completed this subject will be able to handle the instruments which used to coat the thin film.	U, An
CO-05	At the end of this subject students will come to know that the difference between the various techniques used to coat the thin film and optimize the techniques based on the materials.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	S	M	M	S	S
CO-02	S	S	M	S	S	S
CO-03	S	S	M	M	S	S
CO-04	S	S	M	M	S	S
CO-05	S	S	M	M	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: THIN FILMS & VACUUM BASICS **9**

Fundamental of Thin film Growth – Island or Volmer Weber growth, Layer or Frank-van der Merwe growth and Island-Layer or Stranski - Krastonov growth – Vacuum science: Primary, secondary, third stage- vacuum chamber

UNIT II: THIN FILM FABRICATION BY PHYSICAL VAPOUR DEPOSITION **9**

Physical Vapour Deposition (PVD) – Thermal evaporation, Laser Beam Evaporation (Pulsed Laser Deposition) – Sputtering Methods: DC sputtering, RF sputtering and Magnetron sputtering – Comparison of evaporation and sputtering

UNIT III: THIN FILM FABRICATION BY CHEMICAL VAPOUR DEPOSITION **9**

Chemical Vapour Deposition – Typical chemical reactions – Reaction kinetics – Transport phenomena – CVD Methods: Metalorganic CVD, Plasma Enhanced CVD and Laser Enhanced CVD.

UNIT IV: THIN FILM FABRICATION BY OTHER TECHNIQUES **9**

Atomic Layer Deposition –Molecular Beam Epitaxy- Superlattices – Sol-Gel films – Electrochemical Deposition – Langmuir-Blodgett Films – Self-Assembly – Doctor Blade Techniques- Spray pyrolysis

UNIT V: APPLICATIONS OF THIN FILMS **9**

Sensors (Thermal and pressure sensors), Glucose biosensors, - Anti-abrasive Coatings, Solar Cells, GMR devices. Magnetic Thin Films – MOSFET **–** Anti Reflection Coating.

Total : 45 HOURS

TEXT BOOKS

1. Guozhong-Cao, *Nanostructures & Nanomaterials: Synthesis, Properties & Applications*, Imperial College Press, London (2003).

2. Elshabini-Riad, A., & Barlow, F. D..*Thin film technology handbook*. New York: McGraw-Hill, (1997).

3. Ohring, M. *The materials science of thin films*. Boston: Academic Press, (1992).

REFERENCE BOOKS

1. Chopra, K. L. *Thin film phenomena*. New York: McGraw-Hill, (1969).

2. Bunshah, R. F., *Handbook of deposition technologies for films and coatings*. Park Ridge, N.J: Noyes Publications, (1994).
3. Dobkin, D. M., &Zuraw, M. K., *Principles of chemical vapor deposition*. Dordrecht; Boston: Kluwer Academic Publishers, (2003).

NT3208 IMPEDANCE AND ELECTROCHEMISTRY 3 0 0 3

OBJECTIVES

Understand impedance and electrochemistry from a fundamental perspective, including development of interpretation models based on a physicochemical description of the system under investigation.

Course Outcome - COs		**Cognitive Skill**
CO-01	Understand the basic concepts and characteristics of electrochemical reactions	U
CO-02	Understand the various concepts and models of electrochemical reactions	U, An
CO-03	Understand and learn the various techniques used to study and evaluate the various electrochemical reactions	U, An
CO-04	Understand the reaction kinetics associated with the electrochemical reactions	U, An
CO-05	Understand the concepts, techniques and applications of impedance spectroscopy	U, An, A

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	N	S	N	N	N	L
CO-02	N	S	N	N	N	L
CO-03	N	S	N	N	N	L
CO-04	N	S	N	N	N	L
CO-05	N	S	N	N	N	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Overview of electrochemical concepts and methods; the electrochemical experiment; electrochemical methods; sign conventions; the three-electrode cell, the potentiostat, electrochemical window, types of electrodes. Redox reactions; cell notation; standard potentials, free energy & equilibrium constants, reference electrodes, liquid junction potentials.

UNIT II: ELECTRIFIED INTERFACE AND ELECTRON TRANSFER KINETICS 9

Electric double layer; Helmholtz and Gouy-Chapman models; the dropping mercury electrode; surface tension; double-layer capacitance; specific and non-specific adsorption; Debye-Hückel theory. Standard rate constant; transfer coefficient; Tafel equation; Marcus

theory; Butler-Volmer equation; Tafel plots; irreversible &quasi-reversible voltammetry.

UNIT III: POTENTIOMETRY AND VOLTAMMETRY 9

Definition of reversibility; charging currents; convection less methods; chronoamperometry; Cottrell equation; linear scan and cyclic voltammetry; polarography; pulse methods; convection methods; rotating disk and ring-disk voltammetry; microelectrodes; general methods and calibration; redox and ion-selective electrodes.

UNIT IV: MASS TRANSFER 9

Modes of mass transfer, diffusion, conduction and migration; Fick's Laws of diffusion, diffusion coefficient; concentration-distance profiles. Electrolyte conductance; IR drop andthe roll of supporting electrolyte.

UNIT V: ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY 9

Origin of constant phase elements behaviour, diffusion effects, Warburg Impedance, passivation and film formation - Variations of EIS: Local EIS, Nonlinear EIS, higher harmonics, noise-based techniques-applications of EIS: Corrosion, biosensors, materials characterization, Batteries and fuel cells.

TOTAL: 45 HOURS

TEXT BOOKS:

1. Allen J. Bard and Larry R. Faulkner, Electrochemical Methods Fundamentals and Applications, 2nd Edition. Wiley.
2. In Barsoukov, E., & In Macdonald, J. R. (2018). *Impedance spectroscopy: Theory, experiment, and applications*, Wiley.
3. Koryta, J., Dvorak, J., &Kavan, L. (1993). Principles of electrochemistry, Wiley

REFERENCES:

1. Mark E. Orazem and Bernard Tribollet, Electrochemical Impedance Spectroscopy, 1st Edition, by, Wiley Inter science.
2. Hamann, C. H., Hamnett, A., &Vielstich, W. (2007). *Electrochemistry*. Weinheim: Wiley-VCH.
3. International Workshop on Impedance Spectroscopy, & In Kanoun, O. (2015). *Lecture notes on impedance spectroscopy: Volume 5*.

NT3209 CHEMICAL REACTION ENGINEERING 3 0 0 3

OBJECTIVES

To impart knowledge on different types of chemical reactors, the design of chemical reactorsunder isothermal and non-isothermal conditions.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Determine the reaction rate of different types of reactions.	U, A
CO-02	Understand the effect of velocity and fluid properties on rate of reactions controlled by mass transfer	U, A
CO-03	Determine the mean residence time and standard deviation using residence time distribution (RTD) data	U, A, An
CO-04	Analyze the performance of non-ideal reactors using tanks-in series and parallel model.	U, A, An
CO-05	Understand the effect of catalyst in various reactor considerations.	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	N	S	N	N	N	L
CO-02	N	S	N	N	N	L
CO-03	N	S	N	N	N	L
CO-04	N	S	N	N	N	L
CO-05	N	S	N	N	N	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: KINETICS OF HOMOGENEOUS REACTION AND INTERPRETATION OFBATCH REACTOR RATE 9

Classification of reactions. Types of rate expressions, Elementary and non- elementary reactions. Activation Energy and Arrhenius theory. Differential and integral methods of analysis of rate data. Interpretation of rate data in constant and variable volume systems. Kinetics of irreversible, parallel and series reactions in constant volume batchreactor.

UNIT II: BASIC THERMODYNAMICS AND FLOW PATTERN 9

Enthalpy, Heat Capacities, Heat of reaction, Entropy, Entropy Changes, Gibbs Energy, Dependence of Gibbs Energy on Temperature and Pressure, characteristic of a fluid, Laminar and turbulent flow, Reynolds number.

UNIT III: DESIGN OF REACTORS 9

Introduction to reactor design – ideal batch reactor – space-time and space velocity – steady state mixed flow reactor – steady state plug flow reactor – holding time and space-time for flow reactors.

UNIT IV: MULTIPLE REACTIONS AND REACTORS **9**

Size comparison of single reactor – multiple reactor system – plug flow reactor in series/parallel – equal size mixed reactors in series – reactors of different types in series – recycle reactor. Distillation and its types

UNIT V: HETEROGENOUS REACTION AND KINETICS **9**

Catalysts and catalysis– the spectrum of kinetic regimes – pore diffusion resistance combinedwith surface kinetics – single cylindrical pore– fluidized bed and porous catalysts – non catalytic system – fluid particle reactions – selection of model – unreacted core model for spherical particles of unchanging size – diffusion through gas film controls – chemical reaction controls.

L: 45 + T: 15 = TOTAL: 45 HOURS

TEXT BOOKS:

1. H. Scott Fogler, 'Elements of Chemical Reaction Engineering', Prentice-Hall of India, New Delhi 2005.
2. O. Levenspiel, 'Chemical Reaction Engineering', III edition, Wiley – Eastern Ltd,New Delhi, 2005.
3. Fundamentals of Fluid Mechanics, 7th edition by Munson, Okiishi, Huebsch and Rothmayer. Wiley & Sons, Inc.

REFERENCES:

1. L.D. Schmidt, "The Engineering of Chemical Reactions", II Edition, Oxford Univ. Press, New York, 2009.
2. J.M.Smith, "Chemical Engineering Kinetics", 3rd edition, McGraw-Hill, New York, 1981.

NT3210 **Advanced Molecular Biology** **3 0 0 3**

OBJECTIVES

• To comprehend cell as the basic unit of life by studying the universal features of cells that distinguish the living and nonliving.

• To understand the internal organization of cells, molecular bases of membrane transport, intracellular membrane traffic, cell communication, cytoskeleton and cell death

Course Outcome - COs		**Cognitive Skill**
CO-01	To comprehend cell as the basic unit of life by studying the universal features of cells that distinguish the living and nonliving	U, A
CO-02	To understand the internal organization of cells, molecular bases of membrane transport, intracellular membrane traffic, cell communication, cytoskeleton and cell death	U, A
CO-03	To perceive about a cell in its social context by studying cell – cell adhesions and cell environment associations through communications	U, A, An
CO-04	To understand the basic shape and forms of the genetic material	U, A, An

CO-05	To understand the governing mechanisms behind regulating the genetic material and cellular reproduction	U, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	N	S	N	N	N	L
CO-02	N	S	N	N	N	L
CO-03	N	S	N	N	N	L
CO-04	N	S	N	N	N	L
CO-05	N	S	N	N	N	L

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Cellular basis of life **9**

Universal features of cells, Role of membrane asymmetry in cellular functions, Membrane proteins and how they support cellular diversity, Cells and laws of thermodynamics; Cell membrane: Membrane Structure, Internal organization of cells,

Unit II: Intracellular compartments and protein sorting **9**

Transport of proteins between intracellular compartments, Types of membrane transport and examples of molecular mechanisms involved in transport; Glycosylation and its significance; Intracellular membrane traffic, membrane and transport from trans-golgi network to cell exterior;

Unit III: Communication between cells and the exterior **9**

Cell signaling: General principles governing cell signaling, Types of cell communication, Negative feedback, Positive feedback, signaling through GPCRs and enzyme-coupled surface receptors; Cytoskeleton, Molecular mechanisms involved in self-assembly and dynamic structure of cytoskeletal filaments, Molecular motors and their significance in intracellular transport, Cell adhesions,

Unit IV: The genetic material **9**

DNA: Structure and function, Chromosome and chromatin, Genetic code, RNA and types of RNA, Proteins and their structure, DNA replication and its regulation, Homologous and site specific recombination, DNA repair, Transcription and its regulation, Translation and its regulation, Gene structure,

Unit V: Genetic regulation **9**

Gene expression regulations: operon, Epigenetics, Types of mutations, Genetic system of mitochondria Gene identification, promoter identification, Molecular biology techniques: Isolation and Quantification of DNA/RNA, PCR, Reverse transcriptase PCR, Real Time PCR, DNA Sequence analysis, hybridization (southern, northern and western) and Sanger sequencing

Total Periods: 45

TEXTBOOKS/REFERENCES:

1. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, "Molecular Biology of the Cell", Fifth and Sixth Editions, Garland Publishing Inc. 2008.
2. Cato T. Laurencin, Lakshmi S. Nair. Nanotechnology and Regenerative Engineering: The Scaffold, Second Edition, CRC Press 2017
3. Gerald Karp, "Cell and Molecular Biology", Fifth Edition, John Wiley, 2008
4. Lewin's Essential Genes, Jocelyn E. Krebs, Benjamin Lewin, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones& Bartlett Publishers, 2013 - Science - 847 pages
5. Molecular Biology of the Gene, Seventh Edition, James D. Watson, Cold Spring Harbor Laboratory; Tania A. Baker, Massachusetts Institute of Technology; Alexander Gann, Cold Spring Harbor Laboratory; Michael Levine, University of California, Berkeley; Richard Losick, Harvard University,2013

NT3275 Basic Characterization Lab II 0 0 2 1

OBJECTIVES

The objective of this course is to characteristic the properties of nanomaterials like morphology, thermal, chemical, structural, optical, electrical properties etc. that forms the important criterion for their application.

Course Outcome - COs		**Cognitive Skill**
CO-01	Ability of performing basic characterization of mechanical, thermal and morphological properties of materials.	U, A
CO-02	Understanding of the main investigation techniques for the determination of the nature and the microstructure of materials, along with their results.	U, A
CO-03	Understanding of the main investigation techniques for the determination of the mechanical and thermal properties, and of the possible results for the different materials classes.	U, A, An
CO-04	Preparation of the Carbon nanotubes by the CVD process	U, A, An
CO-05	Preparation of the ZnO thin films by using spin coating technique	U, A

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	N	S	N	N	N	L
CO-02	N	S	N	N	N	L
CO-03	N	S	N	N	N	L
CO-04	N	S	N	N	N	L
CO-05	N	S	N	N	N	L

S- Strong, M- Medium, L-Low, N- Not Relevant

List of experiments

1. Thermal characteristics by TG/DTA for biomaterials
2. Lattice parameter by X-ray diffractometer.
3. Cyclic voltammeter study by electrochemical workstation.
4. Surface area by BET method.
5. Morphology study by Scanning Electron Microscopy.
6. Topography study by Atomic Force Microscopy.
7. Nature of bond characteristics by FTIR.
8. Bandgap measurement by UV-Vis spectroscopy.
9. Thermal characteristics by TG/DTA for ceramic materials.
10. Corrosion studies of nanomaterials using electrochemical workstation.

NT3276 CHEMICAL ENGINEERING LABORATORY 0 0 2 1

OBJECTIVES

To know the effects of catalyst in various reactor considerations.

Course Outcome - COs		**Cognitive Skill**
CO-01	Determine the reaction rate of different types of reactions	U, A
CO-02	Understand the effects of velocity and fluid properties on rate of reactions controlled by mass transfer	U, A
CO-03	Determine the mean residence time and standard deviation using residence time distribution (RTD) data effects of catalyst in various reactor considerations	U, A, An
CO-04	Analyze the performance of non-ideal reactors using tanks-in series and parallel model	U, A, An
CO-05	Understand the effects of catalyst in various reactor considerations.	U, A

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	N	S	N	N	N	L
CO-02	N	S	N	N	N	L
CO-03	N	S	N	N	N	L
CO-04	N	S	N	N	N	L
CO-05	N	S	N	N	N	L

S- Strong, M- Medium, L-Low, N- Not Relevant

List of Experiments:

1. Determination of pH and pKaby Titration Method
2. Homogeneous Reactions
3. Heterogenous Reactions
4. Reaction Rate Determination
5. Residence Time Distribution
6. Adsorption
7. Kinetics of Amylase
8. Kinetics of a (Solid-Liquid) Esterification Reaction
9. Batch Reactive Distillation
10. Interfacial (Liquid-Liquid) Nitration

TOTAL: 45 HOURS

NT3277 THIN FILM LABORATORY 0 0 2 1

OBJECTIVES

To know the effects of coating techniques and thin film preparation.

Course Outcome - COs		**Cognitive Skill**
CO-01	To come to know to coat the thin film by dip coating method.	U, A
CO-02	Understand the concept of spin coating and prepare the thin film by spin coating unit.	U, A
CO-03	Understand the basic principle Chemical bath deposition and coat the thin film.	U, A, An
CO-04	Understand the electroplating concept and make the electrode using same techniques.	U, A, An
CO-05	To coat the thin film by spray pyrolysis method.	U, A

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	N	S	N	N	N	L
CO-02	N	S	N	N	N	L
CO-03	N	S	N	N	N	L
CO-04	N	S	N	N	N	L
CO-05	N	S	N	N	N	L

S- Strong, M- Medium, L-Low, N- Not Relevant

List of Experiments:

1. Preparation of CdS thin film using chemical bath deposition.
2. Preparation of PVA gel and coating a thin film by spin coating.
3. Preparation of graphite thin film using Doctor Blade slurry technique.
4. Preparation of ZnO thin film using dip coating.
5. Preparation of ZnS thin film using chemical bath deposition.
6. Preparation of PVA thin film using spin coating
7. Preparation of CuO thin film using Spray pyrolysis technique.
8. Preparation of hydrophobic Langmuir Blodgett film using self-assembly.
9. Preparation of Copper thin film by electrochemical deposition method.
10. Preparation of Aluminum metal thin film by DC sputtering techniques

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B.TECH. NANOTECHNOLOGY
CURRICULUM & SYLLABUS
REGULATION - 2021

SEMESTER V

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MS3201	Professional and Business Ethics	2	0	0	2
2.	NT3211	Nanomedicine	3	0	0	3
3.	NT3212	Nanomaterials for Energy Conversion and Storage Devices	3	0	0	3
4.	NT3213	Solid State and Surface Science	3	0	0	3
5.	NT32XX	Elective - I	3	0	0	3
PRACTICAL						
6.	NT3278	Advanced Microscopy Lab	0	0	4	2
7.	NT3279	Simulation Laboratory	0	0	4	2
8.	NT3280	Sensor Laboratory	0	0	4	2
TOTAL			15	0	12	21

SEMESTER VI

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	AI32D1	Fundamentals of Artificial Intelligence	3	0	0	3
2.	NT3214	Nano biomaterials	3	0	0	3
3.	NT3215	Carbon Based Materials	3	0	0	3
4.	NT3216	Lithography and Nano Fabrication	3	0	0	3
5.	NT32XX	Elective-II	3	0	0	3
6.	NT32XX	Elective-III	3	0	0	3
7.	NT3281	Surface Characterization Laboratory	0	0	4	2
8.	NT3282	Advanced Nanomaterials Preparation Laboratory	0	0	4	2
9.	NT32P2	Project Work - I	0	0	6	3
TOTAL			18	0	14	25

SEMESTER V

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MS3201	Professional and Business Ethics	2	0	0	2
3.	NT3211	Nanomedicine	3	0	0	3
4.	NT3212	Nanomaterials for Energy Conversion and Storage Devices	3	0	0	3
5.	NT3213	Solid State and Surface Science	3	0	0	3
6.	NT32XX	Elective – I	3	0	0	3
PRACTICAL						
7.	NT3278	Advanced Microscopy Lab	0	0	4	2
8.	NT3279	Simulation Laboratory	0	0	4	2
9.	NT3280	Sensor Laboratory	0	0	4	2
TOTAL			15	0	12	21

MS3201 PROFESSIONAL AND BUSINESS ETHICS 2 0 0 2

Course Description: The course on Professional and Business Ethics is designed to cultivate ethical awareness and instil moral and social values in BE students. It aims to help students recognize legal and ethical issues in business decision-making, enhance analytical problem-solving skills, and foster ethical decision-making abilities. The course explores the relationship between ethics and business, examines moral and cultural values in the workplace, and encourages critical thinking and research on topics relevant to business ethics.

Course Objectives:

1. To Recognize legal and ethical issues in business decision-making.
2. To Understand and apply ethical rules and constraints.
3. To Enhance analytical problem-solving skills and ethical decision-making abilities.

Course Outcomes:

Subject Code: **MS3201** Subject Name: **PROFESSIONAL AND BUSINESS ETHICS 2 0 0 2**		
Course Outcome - COs		**Cognitive Skill**
CO-01	To Understand the basics of Human Values, Morals and ethics	R, U
CO-02	To remember the ethics theories and issues	U
CO-03	To Understand the function of Engineering as experimentation and case study	A
CO-04	Able to Understand the Safety and risk assessment, risk benefit analysis and professional rights	A,U
CO-05	Ability to understand the Multinational corporations and institutions	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO - I	PO-J	PO-k	PO -L	PO-M
CO-01	S	L	M	N	L	S	M	L	M	N	N	N	
CO-02	M	S	L	L	S	L	L	N	L	N	N	L	
CO-03	L	S	M	S	M	M	L	M	N	M	L	N	
CO-04	S	M	L	M	N	S	N	L	N	N	N	M	
CO-05	S	M	L	M	S	N	L	M	L	M	L	N	

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Human Values (9 hours)

Morals, Values, and Ethics -Integrity and Work Ethic - Service Learning and Civic Virtue - Respect for Others and Living Peacefully - Caring, Sharing, and Honesty - Courage, Valuing Time, and Co- operation - Commitment, Empathy, and Self-Confidence - Character and Spirituality

Unit II: Engineering Ethics (9 hours)

Senses of 'Engineering Ethics' and Moral Issues - Types of Inquiry and Moral Dilemmas - Moral Autonomy and Ethical Theories - Models of Professional Roles - Self-Interest, Customs, and Religion

Unit III: Engineering as Social Experimentation (9 hours)

Engineering as Experimentation - Engineers as Responsible Experimenters - Codes of Ethics and Legal Perspectives - Case Study: The Challenger Incident

Unit IV: Safety, Responsibilities, and Rights (9 hours)

Safety, Risk, and Risk Assessment - Risk-Benefit Analysis and Risk Reduction - Case Studies: Three Mile Island and Chernobyl - Collegiality, Loyalty, and Respect for Authority - Conflicts of Interest and Occupational Crime - Professional and Employee Rights - Intellectual Property Rights (IPR) and Discrimination

Unit V: Global Issues (9 hours)

Multinational Corporations and Environmental Ethics - Computer Ethics and Weapons Development - Engineers as Managers, Consultants, and Expert Witnesses - Sample Codes of Ethics from Professional Organizations.

Total: 45 hours

TEXTBOOKS:

1. Mike Martin and Roland Schinzinger, "Ethics in Engineering," McGraw-Hill, New York, Latest edition: 4th edition (2022).
2. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics," Prentice Hall of India, New Delhi, Latest edition: 2nd edition (2021).

REFERENCES:

1. Charles D. Fleddermann, "Engineering Ethics," Pearson Education/Prentice Hall, New Jersey, Latest edition: 4th edition (2022).

2. Charles E Harris, Michael S. Protchard, and Michael J Rabins, "Engineering Ethics - Concepts and Cases," Wadsworth Thompson Learning, United States, Latest edition: 2nd edition (2023).
3. John R Boatright, "Ethics and the Conduct of Business," Pearson Education, New Delhi, Latest edition: 8th edition (2021).
4. Edmund G Seebauer and Robert L Barry, "Fundamentals of Ethics for Scientists and Engineers," Oxford University Press, Oxford, Latest edition: 2nd edition (2022).

NT3211	**NANOMEDICINE**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:
To make the students understand the different types of cancers and applications of nanomaterials in tissue engineering and gene therapy

Course Outcome - COs		**Cognitive Skill**
CO-01	A proper understanding on the nanomedicinal procedures applied for diagnosis and therapy of cancers	U
CO-02	Students will gain knowledge on the polymer-based drug delivery vehicles to be used in various ailments	U, An, A
CO-03	Candidates can understand clearly the different types of drug delivery vehicles and their applications	U, An, A
CO-04	Students can construct nanomaterials that will assist in drug targeting and imaging after understanding the principles behind	U, An, A
CO-05	Candidates will gain knowledge on the applications of nanomaterials in tissue engineering and gene therapy	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	S
CO-02	S	M	S	M	M	S
CO-03	S	M	S	M	M	S
CO-04	S	M	S	M	M	S
CO-05	S	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Nano-oncology **9**

Liposomes- Antibodies- Tumour targeting invivo- Dendrimers- Synthesis -Nanoscale containers- Gene transfection- Nanoscafold systems- Biophotonics and their applications in

cancer – cancer theranostics

Unit II: Polymeric Nanofibers **9**

Implications in Neuro science, tissue engineering and cancer therapy. Poly electrolyte multilayers- coated colloids- smart capsules. Chitosan, Colloids, collagen assembly of bionanotechnology. Micro emulsions in nanotechnology

Unit III: Drug Delivery Systems **9**

Microfabricated drug delivery systems – Microneedles- Micropumps-Microvalves-Implantable microchips – Controlled Drug Delivery system – microencapsulation - Transdermal Drug Delivery Systems**.**

Unit IV: Nanoparticles for Targeting **9**

Targeted Nano particles for drug delivery system - Bacterial nanoparticles- Virus Based Nanoparticles - Modification by bioconjugation –– use in biomedical Imaging, Genetic vaccines, neosomes

Unit V: Tissue Engineering **9**

Nanoparticles and Micro–organism, Nanomaterials for regeneration of bone and cartilage Scaffolds - Nanocomposites for tissue engineering - Electrospinning in tissue engineering - Stem cell Tissue Engineering.

Total Periods 45

TEXT BOOKS

1. Goodsell, D. S. *Bionanotechnology: Lessons from nature*. Hoboken: Wiley-Liss, (2004).
2. Nalwa, H. S. *Encyclopedia of nanoscience and nanotechnology*. Stevenson Ranch, Calif: American Scientific Publishers, (2004).
3. Rosenthal, S. J., & Wright, D. W. *Nanobiotechnology protocols*. Totowa, N.J: Humana Press., (2005).

REFERENCE BOOKS

1. A.M. Hillery, Drug Delivery and Targeting, CRC Press, 2002.
2. Vladimir P. Torchilin, Nanoparticles as Drug carriers, Imperial College Press, 2006.
3. Ed. John P. Fisher, Antonios G. Mikos and Joseph D. Bronzo, Tissue Engineering,2007.
4. Jan J. Dubowski and Stoyan Tanev", Photon-based Nanoscience and Nanobiotechnology" edited by Springer Publications. 2005.
5. The Handbook of Nanomedicine, Kewal K. Jain, Humana Press, 2008.
6. M. Salzman "Drug Delivery: Engineering Principles for Drug Therapy,"

NT3212 NANOMATERIALS FOR ENERGY CONVERSION AND STORAGEDEVICES 3 0 0 3

OBJECTIVES

To make the students understand Nanotechnology for sustainable energy-Energy conversion process, Fuel Cell Technology and Microfluidic Systems

Course Outcome - COs		Cognitive Skill
CO-01	A proper understanding on sustainable energy-Energy conversion	U
CO-02	Students will gain knowledge on Renewable Energy Technology	U, An, A

CO-03	Candidates can understand clearly the Fuel Cell Technology	U, An, A
CO-04	Students can understand Microfluidic Systems	U, An, A
CO-05	Candidates will gain knowledge on Hydrogen storage methods - metal hydrides	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	S
CO-02	S	M	S	M	M	S
CO-03	S	M	S	M	M	S
CO-04	S	M	S	M	M	S
CO-05	S	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Introduction 9

Nanotechnology for sustainable energy-Energy conversion process, indirect and direct energy conversion-Materials for light emitting diodes-batteries advanced turbines-catalytic reactors-capacitors-fuel cells.

Unit II: Renewable Energy Technology 9

Energy challenges, development and implementation of renewable energy technologies-nanotechnology enabled renewable energy technologies - Energy transport, conversion and storage- Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro-Si-composite structure, various techniques of Si deposition.

Unit III: Fuel Cell Technology 9

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems -thin film and microfabrication methods – design methodologies - micro-fuel cell power sources.

Unit IV: Microfluidic Systems 9

Nano-electromechanical systems and novel microfluidic devices – nano engines – driving mechanisms - power generation - microchannel battery - micro heat engine (MHE) fabrication - thermocapillary forces - Thermocapillary pumping (TCP) - piezoelectric membrane.

Unit V: Hydrogen Storage Methods 9

Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity hydrogen reaction kinetics - carbon-free cycle- gravimetric and volumetric storage capacities- hydriding /dehydriding kinetics -high enthalpy of formation - and thermal management during the hydriding reaction.

Total Periods :45

TEXTBOOKS

1. L. R. Martinez and N. Omar, Emerging Nanotechnologies in Rechargeable Energy Storage Systems, 1st Edition, Elsevier (2017).
2. G. A. Nazri and G. Pistoia, Lithium Batteries, Springer, 2009.
3. Nanomaterials for solid state hydrogen storage-Robert A. Varin, springer 2007.

REFERENCES

1. Handbook of Hydrogen Storage: New Materials for Future Energy Storage edited by Michael Hirscher, Wiley-2010.
2. Allen Bard and Larry R. Faulkner, Electrochemical Methods, John Wiley & Sons Inc, 2001.
3. Introduction to carbon capture and sequestration, The Berkeley lectures on energy-vol 1, Berendsmit, imperial college press, 2014

NT3213 SOLID STATE AND SURFACE SCIENCE 3 0 0 3

OBJECTIVES

The course is designed to study the fundamentals of solid state physics, material synthesis, property studies with special emphasize on semiconductor materials, and applications of solid state material in various technology fields.

Course Outcome - COs		Cognitive Skill
CO-01	Understand basic elements of crystal structure of condensed matter	U
CO-02	Understand accurate description of lattice dynamics and thermal properties of crystalline solids	U, An, A
CO-03	Understand origin of energy bands in solids with focus on semiconductors	U, An, A
CO-04	Describe and understand basics of transport properties across solids	U, An, A
CO-05	Understand the surface kinetics and thermal properties of nanostructures	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT: I INTRODUCTION **9**

Crystalline and Amorphous Solids, Classification of Crystalline Solids- **Molecular Solids:** Non – Polar, Polar and Hydrogen-Bonded. **Ionic Solids, Covalent Solids or Network Solids, Metallic Solids.** Basic Crystallography - Crystal lattice, unit cell and crystal systems, crystal planes and Miller indices, Reciprocal lattice. Diffraction- Bragg's law- X-ray diffraction methods- Rotation, Laue and powder methods

UNIT II: ELECTRONIC PROPERTIES IN SOLIDS **9**

Free electron theory, Electrical Conductivity, Molecular Orbital Theory, Conductivity, Photoconductivity, Doped Semiconductors, *p-n* Junction, Field-Effect Transistors, Metal Oxide Semiconductor Field-Effect Transistors (MOSFETs), Bands in Compounds – GaAs, Bands in d-block Compounds.

UNIT III: DEFECTS AND NONSTOICHIOMETRY **9**

Point Defect – Intrinsic, Anion Frenkel defect in fluorite, Concentration of defects, Extrinsic defects, Ion Migration (Schottky defects), Ion Migration (Frenkel Defects), Electronic Defects, Extended Defects, Crystallographic Shear Planes.

UNIT IV: OPTICAL PROPERTIES OF SOLIDS **9**

Spectrum of a "Blacklight", Interaction of light with atoms, Describing electrons in multi-electron systems, LASER, Phosphors in Fluorescent Lights, Phosphor Material Composition, Up conversion, Energy Bands, Band structure of copper, Refractive Indices, Optical Fibers, Rayleigh Scattering, Photonic Crystals

UNIT V: THERMODYNAMICS AND KINETICS AT SURFACES **9**

Interactions at the surface, Physisorption, Chemisorption, Diffusion, dynamics and reactions of atoms/molecules on surfaces, Generic reaction mechanism on surfaces, Adsorption isotherms, Kinetics of adsorption, Use of temperature desorption methods.

T: 15 + L: 45 = TOTAL: 60 PERIODS

TEXT BOOKS

1. Azároff, L. V. (1960). *Introduction to solids*. New York: McGraw-Hill.
2. West, A. R., & West, A. R. (1988). *Basic solid state chemistry*. Chichester [West Sussex: Wiley.
3. Kittel, C. (1966). *Introduction to solid state physics*. New York: Wiley.
4. Pillai, S. O. (2005). *Solid state physics*. New Delhi: New Age International.
5. Shriver, Atkins, *Inorganic Chemistry* (3rd ed, 1999), W.H. Freeman and Company

REFERENCE BOOKS

1. Callister, W. D. (2006). *Materials science and engineering: An introduction*. Hoboken, NJ: John Wiley &Sons.
2. Ropp, R. C. (2003). *Solid state chemistry*. Amsterdam: Elsevier.
3. Ehrenreich, H., & Turnbull, D. (1991). *Semiconductor heterostructures and nanostructures*. Boston, Mass: Academic Press.
4. Ashcroft, N. W., &Mermin, N. D. (1976). *Solid state physics*. New York: Holt, Rinehart and Winston.
5. Bhattacharya, D. K., & Sharma, R. (2007). *Solid state electronic devices*. New Delhi: Oxford University Press.

NT3278 ADVANCED MICROSCOPY LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVES

The course is designed to analyze various microscopic techniques.

Course Outcome - COs		Cognitive Skill
CO-01	To analyze the performance of atomic force microscopy	A
CO-02	To demonstrate the performance of scanning tunneling microscopy	An, A
CO-03	To demonstrate the function of field emission microscopy	An, A
CO-04	To study the performance of scanning electron microscopy	An, A
CO-05	To demonstrate the performance of fluorescence microscopy	An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M

CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

1. Optical Microscopy
2. Scanning Tunneling Microscopy
3. Atomic Force Microscopy
4. Magnetic Force Microscopy
5. Scanning Electron Microscopy
6. Fluorescence Microscopy
7. Transmission Electron Microscopy
8. Field Emission Microscopy

NT3279 SIMULATION LABORATORY 0 0 4 2

OBJECTIVES

To familiarize the MATLAB software.

Course Outcome - COs		**Cognitive Skill**
CO1	Understanding the Computational modeling of nanoparticles.	U, An
CO2	Understanding the Modeling of the electronic structure of molecules, crystals, and surfaces. Simulates electrical transport in nano-devices.	U, An
CO3	understanding the electron density and band structure of semiconductor	U, An
CO4	Understanding the Basic Image processing operations.	U, An
CO5	Understanding the Image Enhancement and Image segmentation techniques.	U, An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

1. Computational modeling of nanoparticles.
2. Modeling of the electronic structure of molecules, crystals, and surfaces. Simulates electrical transport in nano-devices.
2. Density functional theories of nanoparticles
3. Hydrogen storage interactions of nanoparticles
4. Response Surface Methodology (RSM) optimization studies.
5. Finite element analysis of Nano-sized magnetic materials.
6. Basic Image processing operations.
7. Image Enhancement.
8. Image segmentation.

NT3280 Sensors Lab 0 0 4 2

OBJECTIVES

To familiarize with various types of Sensors & Transducers and their working principles

Course Outcome - COs		**Cognitive Skill**
CO-01	Know the various types of error in instruments	R
CO-02	Obtain the knowledge about various types of Sensors & Transducers and their working principle	R, U
CO-03	Understand the various types of transducers like Resistive, Capacitive and Inductive	R, U, A
CO-04	Students will be able to analyze and understand various sensors based on its classification and working principle.	U, An, E
CO-05	Students will be able to to identify the problem use the appropriate sensors with resistive, capacitive inductive or any other modern sensor technologies like fiber optic MEMS, nano, etc for multidisciplinary applications.	U, An, E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

1. Characteristics of strain gauge
2. Characteristics of Load cell

3. Characteristics of thermistor.
4. Characteristics of RTD
5. Characteristics of Thermocouple
6. Loading effect of Potentiometer
7. Characteristics of Synchros
8. Characteristics of LVDT
9. Characteristics of Piezo-electric Transducer
10. Characteristics of Hall-effect

Noorul Islam Centre for Higher Education
B.E./ B.Tech. Programmes
Regulation - 2021

SEMESTER VI

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	AI32D1	Fundamentals of Artificial Intelligence	3	0	0	3
2.	NT3214	Nanobiomaterials	3	0	0	3
3.	NT3215	Carbon Based Materials	3	0	0	3
4.	NT3216	Lithography and Nano Fabrication	3	0	0	3
5.	NT32XX	Elective-II	3	0	0	3
6.	NT32XX	Elective-III	3	0	0	3
7.	NT3281	Surface Characterization Laboratory	0	0	4	2
8.	NT3282	Advanced Nanomaterials Preparation Laboratory	0	0	4	2
9.	NT32P2	Project Work - I	0	0	6	3
TOTAL			18	0	14	25

AI32D1 FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE 3 0 0 3

OBJECTIVES

- Understand the basic concepts of intelligent agents.
- Develop general-purpose problem-solving agents, logical reasoning agents, and agents that reason under uncertainty.
- Employ AI techniques to solve some of today's real world problems.

Course Outcome – COs		**Cognitive Skill**
CO-01	Explain autonomous agents that make effective decisions in fully informed, partially observable, and adversarial settings.	U
CO-02	Choose appropriate algorithms for solving given AI problems	A
CO-03	Design and implement logical reasoning agents	R, A
CO-04	Design and implement agents that can reason under uncertainty	R, A
CO-05	Understand the basic areas of artificial intelligence including problem solving, knowledge representation, reasoning, decision making, planning, perception and action.	U

R-Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G
CO-01	L	L	L	M	L	M	M
CO-02	M	M	S	M	M	M	L
CO-03	M	M	M	M	M	S	S
CO-04	S	M	S	L	L	M	S
CO-05	M	M	L	L	M	M	S

S-Strong, M-Medium, L-Low, N-Not relevant

UNIT I: AI AGENTS **9**

Introduction to AI – Agents and Environments – Concept of rationality – Nature of environments –Structure of agents – Problem solving agents–Search algorithms – Uninformed search strategies.

UNIT II: PROBLEM SOLVING **9**

Heuristic search strategies–heuristic functions - Local search and optimization problems – Local search in continuous space – Search with non-deterministic actions – Search in partially observable environments – Online search agents and unknown environments.

UNIT III: THEORY OF GAME PLAYING **9**

Game theory – Optimal decisions in games – Alpha-beta search – Monte-Carlo tree search –Stochastic games– Partially observable games. Constraint Satisfaction Problems – Constraint propagation – Backtracking search for CSP – Local search forCSP– Structure ofCSP.

UNIT IV: KNOWLEDGE BASED LOGICAL AGENTS **9**

Knowledge-based agents – Propositional logic – Propositional theorem proving – Propositional model checking– Agents based on propositional logic. First-order logic – Syntax and semantics – Knowledge representation and engineering – Inferences in first-order logic–Forward chaining– Backward chaining–Resolution.

UNIT V: KNOWLEDGE REPRESENTATION **9**

Ontological engineering–Objects and categories–Events–Mental objects and Modal logic–Reasoning systems for categories – Reasoning with default information. Classicalplanning–Algorithmsforclassicalplanning–Heuristicsforplanning– Hierarchical planning–non-deterministic domains–Time, Schedule, and Resources–Analysis.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Stuart Russel and Peter Norvig, "Artificial Intelligence: A Modern Approach", Fourth Edition, PearsonEducation,2020.

REFERENCES

1. Dan W. Patterson, "Introduction to AIand ES", Pearson Education,2007.
2. Kevin Night, Elaine Rich and Nair B., "Artificial Intelligence", McGraw Hill,2008.
3. Patrick H. Winston, "Artificial Intelligence", Third edition, PearsonEdition,2006.
4. Deepak Khemani, "Artificial Intelligence", Tata McGraw Hill Education, 2013.
5. Artificial Intelligence by Example: Develop machine intelligence from scratch using real artificial intelligence use cases -byDennisRothman,2018.

NT3214 NANOBIOMATERIALS **3 0 0 3**

OBJECTIVES

To gain an understanding of the application of materials in biological systems, especially prosthetic applications.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Study, understand various Engineering materials.	U, A
CO-02	Understand the structure of metals and alloys.	U
CO-03	Analyze and study the body response to biomaterials	An
CO-04	Study and remember the degradation of biomaterials	R, U

CO-05	Study the applications of biomaterials.	An, E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: PROPERTIES 9

Introduction and Historical background – Mechanical Properties of materials: Yield Strength – Tensile Strength – Plastic deformation – Brittleness– Hardness– Toughness – Creep, Viscous Flow, Fatigue – Glass transition – Surface Properties: Surface Energy, Critical Surface Tension, Hydrophobic interaction.

UNIT II: MATERIALS USED IN MEDICINE 9

Metals and Alloys: Stainless steel – Ti based alloys, Shape memory alloys – Synthetic Polymers: PE, PVC, PTFE, Nylon-6, Poly Urethane, PMMA, PLA, PGA – Hydrogels: Biodegradable materials (Bioresorbable materials) – Ceramic Materials: Al2O3, Hydroxyapatite – Bioactive glass – Natural materials: Collagen, Gelatin.

UNIT III: BODY RESPONSE TO BIOMATERIALS 9

Proteins – Cells – Tissues – Inflammation, wound healing and foreign body response – Immunne system – Innate immunity – Specific Acquired immunity – Systemic toxicity and hyper sensitivity – Blood coagulation – Tumorigenesis – Infection.

UNIT IV: DEGRADATION OF BIOMATERIALS 9

Introduction to the degradation of biomaterials - Degradation mechanisms - Factors influencing the degradation - Degradation of metals and ceramics - Mechanical breakdown of biomaterials - Pathogenic calcification - Assessment methods - Biocompatibility considerations- Strategies for controlling and mitigating.

UNIT V: APPLICATIONS OF BIOMATERIALS 9

Biomaterials for Drug Delivery – Nanoparticles in Cancer Treatment – Biosensing Materials – Artificial blood vessels – Artificial heart valves – Orthopedic applications – Dental implants – Testing of biomaterials.

Total Periods: 45

TEXT BOOKS

1. Ratner, B. D. *Biomaterials science: An introduction to materials in medicine*. Amsterdam: Elsevier Academic Press, (2004).
2. Park, J. B., &Bronzino, J. D. *Biomaterials: Principles and applications*. Boca Raton: CRC

Press, (2002).

REFERENCE BOOKS

1. Ajayan, P. M., Schadler, L. S., & Braun, P. V. *Nanocomposite science and technology*. Weinheim: Wiley-VCH, (2003).
2. Lanza, R. P., Langer, R. S., &Vacanti, J. *Principles of tissue engineering*. San Diego, CA: Academic Press, (2000).

NT3215 CARBON BASED MATERIALS 3 0 0 3

OBJECTIVES

To understand the mechanism behind the formation of carbon allotropes and its preparation techniques. To find the possible application using various carbon allotropes.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Study, understand various carbon materials and their chemical nature, electronic configuration.	U, A
CO-02	Understand the structure of fullerenes and various synthesis methods.	U
CO-03	Analyze and study the concepts single-walled carbon nanotubes and multiwalled carbon nanotubes and Structure.	An
CO-04	Study and remember the basic concept Graphene Oxide structure and properties.	R, U
CO-05	Study the applications of all carbon based nanomaterials.	An, E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F	PO-G	PO-H
CO-01	S	S	S	M	N	M	M	S
CO-02	M	N	S	S	S	M	N	L
CO-03	S	L	M	N	N	M	S	N
CO-04	N	M	L	S	L	S	N	S
CO-05	S	S	L	L	N	M	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION **9**

Carbon - atomic structure – Different hybridization – Chemical structure and Nature of carbon allotropes: Diamond, Graphite, Graphene, Carbon clusters, Carbon Nanostructures: carbon nanotubes, Diamond like carbon, carbon, and aerogel - porous carbon, activated carbon, carbon black, CNT, Nanotube Peapods and Graphene.

UNIT II: FULLERENES **9**

The structure of fullerenes; Synthesis (CVD and Arc Discharge), and purification of fullerenes; different sized fullerenes - doped fullerenes; Electrical and magnetic properties – electronic structure of fullerene – fullerene functionalization.

UNIT III: CNT **9**

Single-walled carbon nanotubes and Multiwalled carbon nanotubes, Structure – Zigzag, armchair, chiral, single and multiwall CNT - Synthesis and purification of carbon nanotubes: CVD, Arc Discharge, High Pressure Carbon Monoxide, Laser Ablation - mechanism of growth – electron transport – mechanical property – electronic structure of CNT.

UNIT IV: GRAPHENE **9**

Graphene Oxide structure and properties – Hummer's method - electronic structure – electron transport –Graphene Oxide Reduction – reduced Graphene Oxide - few layer graphene - Micromechanical Exfoliation – from SiC ––Graphene growth on surfaces (CVD) – grapheme &graphene oxide functionalization.

UNIT V: APPLICATIONS **9**

Electrode materials for supercapacitors-Graphite-based materials for energy storage applications-Carbon nanotubes (CNTs) and aerogels for hydrogen storage-Advanced materials for thermal protection systems: C-C composites-Fuel cells: Materials and advancements in energy conversion-Structural stability in demanding environments: Carbon fiber composites-Diamond-like films and their applications in abrasives

Sensors and biosensors utilizing graphene and graphene oxides.

T: 15 + L: 45 = TOTAL: 60 PERIODS

TEXT BOOKS

1. Langa, F., Nierengarten, J.-F., & Royal Society of Chemistry (Great Britain). *Fullerenes: Principles and applications*. Cambridge: Royal Society of Chemistry, (2007).
2. Gaponenko, S. V., *Optical properties of semiconductor nanocrystals*. Cambridge, UK: Cambridge University Press, (1998).
3. Shonaike, G. O., &Advani, S. G., *Advanced polymeric materials: Structure property relationships*. Boca Raton, FL: CRC Press, (2003).

REFERENCE BOOKS

1. Dresselhaus, M. S., Dresselhaus, G., &Eklund, P. C., *Science of fullerenes and carbon nanotubes*. San Diego: Academic Press, (1996).
2. Goddard, W. A., *Handbook of nanoscience, engineering, and technology*. Boca Raton: CRC Press, (2003).
In Nalwa, H. S., *Nanostructured Materials and Nanotechnology: Concise Edition*. (Referex Mechanical Engineering and Materials.) San Diego: Academic Press [Imprint.] (2001).

NT3216 LITHOGRAPHY AND NANOFABRICATION 3 0 0 3

OBJECTIVES

To understand the uses of clean room for the nanofabrication and to study the different lithographic methods used to fabricate nanomaterials, the various phenomena involved in these processes.

Course Outcome - COs		**Cognitive Skill**
CO-01	To study the basics of lithography techniques which used to fabricate the nanomaterials-based devices.	U, R
CO-02	To understand the procedure of various optical lithography techniques which used to fabricate the MEMS devices.	U, An, R
CO-03	Understanding the source, experimental set up and applications of various electron beam lithography to fabricate the nanomaterials-based devices.	U, An, R
CO-04	Understanding the source, experimental set up and applications of various ion beam lithography to fabricate the nanomaterials-based devices.	U, An, R
CO-05	To identify the various techniques based on soft lithography to fabricate the nanomaterials-based devices.	U, An, R

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	M	S	M	M	S	S
CO-02	M	S	M	M	S	S
CO-03	M	S	M	M	S	S
CO-04	M	S	M	M	S	S
CO-05	M	S	M	M	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: LITHOGRAPHY BASICS 9

Advanced Lithography Techniques- Clean Room Contamination: Types and Sources- Nanoparticle Contamination in Clean Rooms- Airborne Particulate Cleanliness Classes- Next-generation Clean Room Design and Technologies- Pattern Transfer: Additive and Subtractive Techniques- Emerging Photoresist Materials and Advances- Advanced Photomask Technologies: EUV Masks- Molds in Lithography: 3D Printing Applications-

Sub-Resolution Assist Feature Enhancement- Advanced Illumination Techniques: Off-Axis and Beyond- Optical Proximity Correction: Machine Learning Approaches

UNIT II: OPTICAL LITHOGRAPHY 9

Optical projection lithography - Optical immersion lithography - Optical interferometric lithography - Holographic lithography - MOPL (Mask less Optical Projection Lithography) - ZPAL (Zone Plate Array Lithography) - EUVL (Extreme Ultraviolet Lithography) - Etching: Isotropic & Anisotropic etching.

UNIT III: ELECTRON BEAM LITHOGRAPHY 9

Electron beam exposing system- SEBL Scanning electron-beam lithography- Mask less (ML2) EBL: parallel direct-write e-beam systems-E-beam projection Lithography (EPL) - SCALPEL Scattering with Angular Limitation Projection E-beam lithography- PREVAIL Projection reduction exposure with variable axis immersion lenses.

UNIT IV: ION BEAM LITHOGRAPHY 9

Ion beam Lithography- Focused Ion beam Lithography (FIB) - Ion Projection Lithography (IPL) - Projection Focused Ion Multibeam (PROFIB) - Masked Ion Beam Lithography (MIBL) - atom lithography – NEMS by X-ray Lithography

UNIT V: SOFT LITHOGRAPHY 9

Nano imprint lithography (NIL) - hot embossing- UV-NIL- Soft Lithography- Molding/Replica molding: Printing with soft stamps- Edge lithography -Dip-Pen Lithography-set up and working principle. Etching techniques - Reactive Ion etching – laser ablation.

Total Periods: 45

TEXT BOOKS

1. NATO Advanced Research Workshop on Nanolithography: a Borderland Between STM, EB, IB, and X-Ray Lithographies, Gentili, M., Giovannella, C., Selci, S., & North Atlantic Treaty Organization., *Nanolithography*. Dordrecht: Kluwer Academic, (1994).
2. Weddige, E., *Lithography*. Scranton, Pa: International Textbook Co. (1966).

REFERENCE BOOKS

1. Bucknall, D. G., *Nanolithography and patterning techniques in microelectronics*. Cambridge: Woodhead Pub. (2005).
2. Howerton, H., *Introduction to Nanolithography*. New Delhi: World Technologies. (2011).
3. Li, X. *Catalytic approaches to nanolithography*. Enschede: Twente University Press, (2003).
4. ASHRAE journal, Setember 2014,
5. Nanofabrication: Fundamentals and applications, Ampere A Tseng, World Scientific, 2008.
6. Clean Rooms: Facilities and Practice, M. Kozicki, S. Hoenig, P. Rabin son; Van Nostrand Reinhold (VNR) publications, New York, 1991.

NT3281 SURFACE CHARACTERIZATION LABORATORY 0 0 4 2

OBJECTIVES

To analyse and understand the physics behind various nano characterization tools

Course Outcome - COs		**Cognitive Skill**
CO1	To learn and understand the physics behind various nano characterization tools	U
CO2	To understand the interaction of electromagnetic radiation with matter using various spectroscopic techniques.	U, An
CO3	To understand the mechanism behind the surface morphological techniques and surface conductivity.	U, An
CO4	To learn the instrumental techniques to measure particle size, surface area, porosity, and contact angle.	U, An
CO5	To apply physical and chemical methodologies to measure thermal and mechanical properties of materials.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

(Any EIGHT experiments will be taken)

1. Surface Area Analysis of oxide nano materials
2. Study of Surface functional groups using FTIR ATR mode
3. Contact angle measurement of hydrophobic surfaces
4. Non-Contact mode AFM imaging of thin films
5. MFM imaging of spin coated magnetic oxide thin films
6. STM imaging of HOPG surface
7. SEM imaging of TiO_2 nano tube
8. Corrosion studies with electro chemical workstation

NT3282 ADVANCED NANOMATERIALS PREPARATION LABORATORY 0 0 4 2

OBJECTIVES

The objective of this course is to analyze the characteristic properties of nanomaterials like morphology, thermal, chemical, structural, optical, electrical, mechanical properties etc that forms the important criterion for their application.

Course Outcome - COs		**Cognitive Skill**
CO1	To learn and understand Preparation of carbon foam from Carbohydrates	U
CO2	To understand the interaction of electromagnetic radiation with matter using various spectroscopic techniques.	U, An
CO3	To understand the reinforcement of rubber/plastics with Nanosilica/carbon black and study of their mechanical and thermal properties	U, An
CO4	To learn the preparation of nanoceramic powders	U, An
CO5	To learn Titanium based solar cell solar cell assembly and conversion efficiency measurement	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

(Any EIGHT experiments will be taken)

1. Preparation of carbon foam from Carbohydrates
2. Particle size and specific surface area analysis of nano particles.
3. Preparation of nano fluids and thermal conductivity measurements.
4. Reinforcement of rubber/plastics with Nanosilica/carbon black and study of their mechanical and thermal properties
5. Extraction of herbs using Soxhlet apparatus and identification of major components/ functional groups
6. Extraction of Nanosilica from rice husk and its particle size & surface area analysis
7. Reduction of Nanosilica to silicon using different techniques/materials and

characterization of silicon
8. Preparation of carbon black using vegetable oils and characterization
9. Titanium based solar cell solar cell assembly and conversion efficiency measurement
10. Conversion of hydrophilic silica to hydrophobic silica and angle of contact measurement.
11. Homogenisation of nano particles in fluids and slurrys
12. Preparation of nanoceramic powders

OPEN ELECTIVES

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	NT32D1	Nanomaterials Synthesis & Characterisation	3	0	0	3
2.	NT32D2	Nano Engineering Applications	3	0	0	3

NT32D1 NANOMATERIALS SYNTHESIS & CHARACTERISATION 3 0 0 3

OBJECTIVES:
To learn the fundamental principles of characterizing nanomaterials for their morphology, structure, chemistry and functionality through diverse methods of microscopy, spectroscopy, scattering and diffraction.

Course Outcome – Cos		**Cognitive Skill**
CO-01	To understand various chemical synthesis (Bottom-up) of diverse types of nanomaterials (0D, 1D and 2D)	U
CO-02	To understand various physical methods (Top-down) of fabricating nanomaterials and nanostructures	U, An, A
CO-03	Decipher information on the various class of nanomaterials based on composition, shape and size (1D, 2D, 3/0D nanostructures)	U, An, A
CO-04	To understand the application potential of nanomaterials based on their unique properties and importance of selecting appropriate synthesis methods that will suit the specific application.	U, An, A
CO-05	To learn the fundamental principles of characterizing nanomaterials for their morphology, structure, chemistry and functionality through diverse methods of microscopy, spectroscopy, scattering and diffraction.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit 1: Synthesis of nanomaterials: **9**

Basic chemistry concepts, Inorganic, organic synthesis and analytical chemistry methods, concepts of precipitation reaction, mechanisms of nanocrystal growth, LaMer theory, Oswald ripening, coalescence, Nanoprecipitation reaction, synthesis of zero- dimensional metal, metal oxides, semiconductor nanoparticles by nanoprecipitation routes, high-pressure homogenization

Unit 2: Bottom-up synthesis approaches **9**

Micro-emulsion route of synthesis, basic concepts of surfactant, emulsion, micelles, reverse micelles, critical micellar concentration, micro-emulsions: Sol-gel method, hydrolysis and condensation, Self- assembly, Kinetically Confined Synthesis of Nanoparticles. Template-based synthesis; Synthesis of one dimensional nano systems by different routes – VLS and SLS methods, Synthesis of two dimensional nano systems

Unit 3: Top-down approaches: **9**

Fundamentals of nano–thin film Growth; Vapor phase deposition methods - Physical and chemical vapor phase methods; Langmuir-Blodgett Films; Electrochemical Deposition; laws of electrolysis and deposition

Unit 4: Characterization: **9**

Structure, Morphology and Surface, Crystal structure, Lattice parameters, nanoparticle size by Debye-Scherrer's formula. Working principles of the Scanning electron microscope and Transmission electron Microscope, particle size Dynamic Light scattering, Elemental analysisusing energy dispersive X-ray analysis, Atomic absorption and Inductively coupled Plasma. Fundamental working principles of scanning probe microscopy (STM) Atomic Force Microscopy, confocal fluorescence microscopy

Unit 5: Spectroscopy **9**

Fundamentals of spectroscopy, vibrational and rotational spectroscopy, Nanomaterials analysis using UV-VIS, Infrared & Raman spectroscopy, Surface enhanced Raman spectroscopy using nanotechnology. FTIR and NMR spectroscopy, Basic principles and applications of Mass spectrometry, chromatography and High-pressure Liquid chromatography in nanomaterial or nanomedicine characterization.

Total : 45 Hours

REFERENCES

1. Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013.

2. G. Cao, Nanostructures and Nanomaterials – Synthesis, Properties and

Applications, Imperial College Press 2006.
3. Elements of X-ray Diffraction, B. D. Cullity and S. R. Stock (Pearson)4. Physical Principles of Electron Microscopy, R.F. Egerton (Springer)
5. Scanning Probe Microscopy and Spectroscopy, D. A. Bonnell (Wiley)8
6. Fundamentals of Molecular Spectroscopy, C. N. Banwell (McGraw Hill)
7. Nanostructured materials: Processing, Properties and Potential Applications, Editedby Carl. C. Koch, Noyes Publications, 2002.
8. Materials Science and Engineering – An Introduction, William D Callister, 12th Edition, John Wiley (Available in Amazon India, Rs. 287

NT32D2 Nano Engineering Applications 3 0 0 3

OBJECTIVES

- To understand the basics of energy conversion and storage at nanoscale(phenomena to devices)
- Introduce the fabrication and characterization technologies of Solar cells,batteries, thermo-electric and piezo-electric devices.

Course Outcome – Cos		**Cognitive Skill**
CO-01	To understand the basics of energy conversion and storage at nanoscale (phenomena to devices)	U
CO-02	Introduce the fabrication and characterization technologies of Solar cells, batteries, and thermo-electric and piezo-electric devices.	U, An, A
CO-03	Applications of electrochemical analysis techniques in characterizing energy storage devices	U, An, A
CO-04	To understand the Reaction mechanisms and fundamentals	U, An, A
CO-05	To learn the fundamental principles of Electrochemical analysis techniques	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit 1: Concepts in Energy conversion 9

Semiconductor junctions, Shockley–Queisser limit, electrical and optical characteristics; Energy conversion at nanoscale, charge carrier dynamics at nanoscale in energy conversion

devices

Unit 2: Energy conversion devices **9**

Solar cells: I-V, EQE, CV, and VOC decay, wafer, thin films and excitonic solar cells; carrier transport and loss mechanisms, recombination models; anti-reflective coating, surface texturing; photodetectors and LEDs.

Unit 3: Thermo-electric and piezo-electric devices **9**

Thermo-electric and piezo-electric materials and devices, fabrication and characterizations.

Unit 4: Energy storage devices

Positive and negative electrodes of batteries and electrochemical capacitors, advanced batteries with nanoscale materials, Reaction mechanisms and fundamental understanding, cycle-life, capacity, energy and power density assessments, safety concerns and solutions.

Unit 5: Electrochemical analysis techniques **9**

Electrochemical methods: potentiostatic and galvanostatic, cyclic voltammetry, chronoamperometry, chronopotentiometry and electrochemical impedance spectroscopy.

Total number of classes: 45

TEXT BOOKS/REFERENCES:

1. Jenny Nelson, "The Physics of Solar Cells", First Edition, Imperial College Press, 2003.
2. Stephen Fonash, Solar Cell Device Physics - 2nd Edition, Academic Press, 2010
3. L. R. Martinez and N. Omar, Emerging Nanotechnologies in Rechargeable Energy Storage Systems, 1st Edition, Elsevier (2017).
4. G. A. Nazri and G. Pistoia, Lithium Batteries, Springer, 2009.
5. Allen Bard and Larry R. Faulkner, Electrochemical Methods, John Wiley & Sons Inc,2001

Noorul Islam Centre for Higher Education
B.E./ B.Tech. Programmes
Regulation - 2021
SEMESTER VII

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MS3202	Principles of Management	2	0	0	2
2.	NT3217	Concepts in Nano-magnetism and their applications	3	0	0	3
3.	NT32XX	Elective - IV	3	0	0	3
4.	NT32XX	Elective - V	3	0	0	3
5.	****	Open Elective-II	3	0	0	3
PRACTICAL						
6.	NT3283	Biotechnology lab	0	0	2	1
7.	NT32P3	Project Work - II	0	0	6	3
TOTAL			14	0	8	18

SEMESTER VIII

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	NT32XX	Elective VI	3	0	0	3
2.	****	Open Elective - III	3	0	0	3
PRACTICAL						
4.	NT32P4	Project Work - III	0	0	20	10
TOTAL			6	0	20	16

Total credits: 162

MS3202 PRINCIPLES OF MANAGEMENT 2 0 0 2

(Common to all Branches)

OBJECTIVES

Knowledge on the principles of management is essential for all kinds of people in all kinds of organizations. After studying this course, students will be able to have a clear understanding of the managerial functions like planning, organizing, staffing, leading and controlling. Students will also gain some basic knowledge on international aspect of

management.

Subject Code: **MS3202**	Subject Name: PRINCIPLES OF MANAGEMENT	
Course Outcome - COs		**Cognitive Skill**
CO-01	To Explore the relationship between ethics and business across different culturaltraditions.	R, U
CO-02	To Explain the connection between ethics, morals, and values in the workplace.	U
CO-03	To Formulate an ethical philosophy and relate it to current practices	A
CO-04	To Assess the ethical implications of business activities and competing demands onbusinesses.	A,U
CO-05	To Critically analyse real-world contexts and conduct research projects on topics relatedto business ethics	A

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO - I	PO-J	PO-k	PO -L	PO-M
CO-01	S	L	M	N	L	S	M	L	M	N	N	N	
CO-02	M	S	L	L	S	L	L	N	L	N	N	L	
CO-03	L	S	M	S	M	M	L	M	N	M	L	N	
CO-04	S	M	L	M	N	S	N	L	N	N	N	M	
CO-05	S	M	L	M	S	N	L	M	L	M	L	N	

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit1: Historical Development **9**

Definition of Management – Science or Art – Management and Administration – Development of Management Thought – Contribution of Taylor and Fayol – Functions of Management – Types of Business Organization.

Unit II: Planning **9**

Nature & Purpose – Steps involved in Planning – Objectives – Setting Objectives – Process of Managing by Objectives – Strategies, Policies & Planning Premises- Forecasting – Decision-making.

Unit III: Organizing 9

Nature and Purpose – Formal and informal organization – Organization Chart – Structure and Process – Departmentation by difference strategies – Line and Staff authority – Benefits and Limitations – De-Centralization and Delegation of Authority – Staffing – Selection Process - Techniques – HRD – Managerial Effectiveness.

Unit IV: Directing **9**

Scope – Human Factors – Creativity and Innovation – Harmonizing Objectives – Leadership – Types of Leadership Motivation – Hierarchy of needs – Motivation theories – Motivational Techniques – Job Enrichment – Communication – Process of Communication – Barriers and Breakdown – Effective Communication – Electronic media in Communication.

Unit V: Controlling **9**

System and process of Controlling – Requirements for effective control – The Budget as Control Technique – Information Technology in Controlling – Use of computers in handling the information – Productivity – Problems and Management – Control of Overall Performance – Direct and Preventive Control – Reporting – The Global Environment – Globalization and Liberalization – International Management and Global theory of Management.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Harold Kooritz & Heinz Weihrich "Essentials of Management", Tata McGraw-Hill, 1998
2. Joseph L Massie "Essentials of Management", Prentice Hall of India, (Pearson) Fourth Edition, 2003.

REFERENCES:

1. Tripathy PC And Reddy PN, "Principles of Management", Tata McGraw-Hill, 1999.
2. Decenzo David, Robbin Stephen A, "Personnel and Human Reasons Management", Prentice Hall of India, 1996
3. JAF Stomer, Freeman R. E and Daniel R Gilbert Management, Pearson Education, Sixth Edition, 2004.
4. Fraidoon Mazda, "Engineering Management", Addison Wesley, 2000.

NT3217 CONCEPTS IN NANOMAGNETISM AND ITS APPLICATIONS 3 0 0 3

OBJECTIVES

- Make sure they get the foundations of nanomagnetism and how it is used.
- Explore the potential impacts of magnetism at the macro- and nanoscales.
- Educate students on the use of magnetic nanoparticles in healthcare, the environment, and energy storage.

Course Outcome - COs		**Cognitive Skill**
CO1	Make sure they get the foundations of nanomagnetism and how it is used.	U
CO2	Explore the potential impacts of magnetism at the macro- and nanoscales.	U, An
CO3	Educate students on the use of magnetic nanoparticles in healthcare, the environment, and energy storage.	U, An
CO4	To modify the magnetic properties of materials based on nanoparticles.	U, An
CO5	Educate the students on the applications of nanomagnetism applications of nanomagnetism	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Magnetostatics and Electrons in Magnetism 9

Introduction - History - Magnetism and hysteresis, Magnetic dipole moment, Magnetic fields, Maxwell's equations, Magnetostatic energy and forces. Orbital and spin moments, Magnetic field effects – Zeeman effect, Theory of electronic magnetism, Magnetism of electrons in solids.

Unit II: Magnetism of Localized Electrons on the Atom 9

Atomic Origins of Magnetism - The hydrogenic atom and angular momentum, The many-electron atom, Paramagnetism, Ions in solids; crystal-field interactions.

Unit III: Ferromagnetism and Antiferromagnetism **9**

Ferromagnetism: Mean field theory, Exchange interactions, Band magnetism, Collective excitations, Anisotropy Ferromagnetic phenomena – Antiferromagnetism: Molecular field theory of Antiferromagnetism, Ferrimagnets, Frustration, Amorphous magnets, Spin glasses,Magnetic models

Unit IV: Micromagnetism and Nanoscale Magnetism **9**

Micromagnetic energy, Domain theory, Reversal, Pinning and Nucleation, Characteristic length scales, Super paramagnetism, Thin films, Thin-film heterostructures, Wires and needles, Small particles, Bulk nanostructures, Magnetic interactions: a tool to modify the magnetic properties of materials based on nanoparticles.

Unit V: Applications of Nanomagnetism **9**

Magnetic storage and recording, Magnetic resonance Imaging, Hyperthermia, Ferrofluid, Biosensors. Biomedical applications of magnetic nanoparticles -Diagnostic applications - Therapeutic applications - Physiological aspects – Toxic effects.

TEXT BOOKS:

1. J. M. D. Coey, Magnetism and Magnetic Materials, Pearson Education, 2010.
2. B. D. Cullity, C. D. Graham, Introduction to Magnetic Materials, John Wiley & Sons, Inc,2009.
3. Bland. J.A.C, and B. Heinrich. B, —Ultra thin Magnetic Structures III –Fundamentals of Nanomagnetism‖ Springer ,2004.
4. Nicola. A.S, —Magnetic Materials: Fundamentals and Device Applications‖ Cambridge University Press ,2003.

REFERENCE BOOKS:

1. R. C. O'Handley, Modern Magnetic Materials: Principles and Applications, John Wiley &
2. Sons, Inc, 2000.
3. C Binns, Nanomagnetism: Fundamentals and Applications, Elsevier, 2014.
4. David Jiles, Introduction to Magnetism and Magnetic Materials, Chapman and Hall, 1991.

NT3283 BIOTECHNOLOGY LAB 0 0 2 1

OBJECTIVES

- Make sure that the students get the foundations of biotechnology in practical terms.
- Explore the potential impacts of biotechnology at the nanotechnology interface.

Course Outcome - COs		**Cognitive Skill**
CO1	To make sure that the students get the foundations of biotechnology in practical terms.	U
CO2	To explore the potential impacts of biotechnology at the nanotechnology interface.	U, An
CO3	To educate students on the use of biotechniques in healthcare, the environment, and nanomedicine.	U, An
CO4	To understand the easy handling of biomaterials.	U, An
CO5	To educate the students on the applications of biotechnology in medicine and nanomaterials	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	L	M	S	S	S	M
CO-02	L	M	S	S	S	M
CO-03	L	M	S	S	S	M
CO-04	L	M	S	S	S	M
CO-05	L	M	S	S	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

Experiments:

1. Observation of Polytene chromosomes from Chironomous larva
2. Cell division in plant cells (*Allium cepa*)
3. Extraction of DNA from human cells
4. Methylene Blue DNA Staining
5. Isolation of DNA from onion
6. Gel Electrophoresis (Agarose; Polyacrylamide)
7. Estimation of DNA purity and Quantification
8. Separation of amino acids by Thin Layer Chromatography
9. Antibacterial activities of silver and zinc nanoparticles, against bacterial cultures performed by standard disc diffusion method.
10. Toxicity assessment of metal nanoparticles on plant growth

ELECTIVES

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	NT32A1	Entrepreneurship in Nanotechnology	3	0	0	3
2.	NT32A2	Intellectual Property Rights	3	0	0	3
3.	NT32A3	Pharmacokinetics & Therapy	3	0	0	3
4.	NT32A4	Piezoelectric Materials for Nanotechnology	3	0	0	3
5.	NT32A5	Nanoscale Devices	3	0	0	3
6	NT32A6	Nanorobotics	3	0	0	3
7	NT32A7	Imaging Techniques for Nanotechnology	3	0	0	3
8	NT32A8	Microelectronics and VLSI	3	0	0	3
9	NT32A9	Toxicology and Healthcare	3	0	0	3
10	NT32B1	Drug Delivery Systems	3	0	0	3
11	NT32B2	Industrial Nanotechnology	3	0	0	3
12	NT32B3	Polymer Nanocomposites	3	0	0	3

NT32A1 ENTREPRENEURSHIP IN NANOTECHNOLOGY 3 0 0 3

OBJECTIVES

- This course is designed to provide an overview of entrepreneurship in the field of nanotechnology.
- The course will cover topics such as the commercialization of nanotechnology, intellectual property, funding opportunities, and market analysis.
- Students will also learn about the ethical considerations and societal impacts of nanotechnology entrepreneurship.

Course Outcome - COs		**Cognitive Skill**
CO1	Understand the basics of nanotechnology and its commercialization	U
CO2	Understand the key characteristics of nanotechnology entrepreneurship	U, An
CO3	Identify the intellectual property issues and funding opportunities in nanotechnology entrepreneurship	U, An
CO4	Develop business models and conduct market analysis for nanotechnology startups	U, An
CO5	Analyse ethical considerations and societal impacts of nanotechnology entrepreneurship	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Introduction to Nanotechnology Entrepreneurship 9

Overview of Nanotechnology - Introduction to Entrepreneurship - Importance of Nanotechnology Entrepreneurship - Key Characteristics of Nanotechnology Entrepreneurship - Case Studies in Nanotechnology Entrepreneurship

Unit II: Commercializing Nanotechnology 9

Intellectual Property in Nanotechnology - Patents, Copyrights, and Trademarks - Trade Secrets - IP Enforcement and Litigation - IP Strategies for Nanotechnology Startups – IP Ownership and Assignment - Technology Transfer - Licensing Agreements - Spin-Off Companies

Unit III: Funding Opportunities **9**

Sources of Funding for Nanotechnology Startups - Venture Capital - Angel Investors - Government Grants and Contracts – Crowdfunding - Initial Public Offerings (IPOs) - Private Equity - Accelerators and Incubators - Corporate Partnerships and Strategic Alliances

Unit IV: Market Analysis in Nanotechnology Entrepreneurship **9**

Market Analysis and Research - Target Market Identification - Competitor Analysis - SWOT Analysis - Business Model Development - Market Segmentation - Customer Personas - Marketing Mix (Product, Price, Promotion, Place) - Sales Strategy and Pipeline Management -Metrics and Key Performance Indicators (KPIs).

Unit V: Ethical Considerations and Societal Impacts **9**

Ethical Considerations in Nanotechnology - Societal Impacts of Nanotechnology - Environmental Impacts of Nanotechnology - Responsible Innovation in Nanotechnology - Global Perspectives on Nanotechnology Entrepreneurship

TEXTBOOKS:

1. Sparks, S. (2017). Nanotechnology: business applications and commercialization. CRC press.
2. Tsuzuki, T. (2013). Nanotechnology commercialization. CRC Press.
3. Ganguli, P., & Jabade, S. (2017). Nanotechnology intellectual property rights: research,design, and commercialization. CRC Press.

REFERENCES:

1. Helwegen, W., & Escoffier, L. (Eds.). (2012). Nanotechnology commercialization for managers and Scientists. CRC press.
2. Mandal, P., &Vong, J. (Eds.). (2017). Entrepreneurship in Technology for ASEAN. Springer Singapore.
3. Ries, E. (2011). The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses. Currency.
4. Farris, P. W., Bendle, N., Pfeifer, P. E., &Reibstein, D. (2010). Marketing metrics: The definitive guide to measuring marketing performance. Pearson Education.

NT32A2 INTELLECTUAL PROPERTY RIGHTS **3 0 0 3**

OBJECTIVES

- Understand the basic concepts and principles of intellectual property law
- Identify the different types of intellectual property and their legal protections
- Understand the requirements for obtaining and maintaining intellectual property rights
- Analyze the legal and policy issues surrounding intellectual property, including its impact on innovation, competition, and society
- Evaluate the legal strategies and best practices for protecting and enforcing intellectual property rights

Course Outcome - COs		Cognitive Skill
CO1	Analyze and compare the legal requirements and protections for each type of intellectual property	U
CO2	Evaluate the strengths and weaknesses of different legal strategies for protecting and enforcing intellectual property rights	U, An
CO3	Understand the legal and policy debates surrounding intellectual property, including its impact on innovation, competition, and society	U, An
CO4	Analyze and apply legal precedent and case law to real-world scenarios involving intellectual property	U, An
CO5	Communicate effectively about intellectual property law and policy, including through written assignments, oral presentations, and class discussions.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Introduction to Intellectual Property **9**

Overview of Intellectual Property and its importance in the modern economy - Types of Intellectual Property: Patents, Copyrights, Trademarks, Trade Secrets - Differences between Intellectual Property and Physical Property - Historical background and evolution of Intellectual Property

Unit II: Patents **9**

Definition and purpose of patents - Patentable subject matter and criteria for patentability - Patent application process and requirements - Patent prosecution, including office actions and appeals - Enforcement and infringement of patents - Case study: Apple v. Samsung

Unit III: Copyrights **9**

Definition and purpose of copyrights - Copyrightable subject matter and criteria for copyrightability - Copyright ownership and duration - Copyright registration process and requirements - Fair use and other exceptions to copyright infringement - Case study: Google

v. Oracle

Unit IV: Trademarks **9**

Definition and purpose of trademarks - Trademarkable subject matter and criteria fortrade markability - Trademark registration process and requirements - Trademark infringement and enforcement - Trademark licensing and assignment - Case study: Nike v. Adidas

Unit V: Trade Secrets and Emerging Intellectual Property Issues **9**

Definition and purpose of trade secrets - Trade secret protection and enforcement - Intellectual property issues related to emerging technologies, such as artificial intelligence and blockchain - International Intellectual Property issues, including global treaties and agreements - Current events and controversies in Intellectual Property law -IP-related agreements: The Berne Convention, The Paris Convention, The Madrid Protocol, The Trans-Pacific Partnership

Total Hours: 45 Hours

TEXTBOOKS:

1. Bently, L., & Sherman, B. (2014). Intellectual property law (4th ed.). Oxford University Press.
2. Nard, C. A., & Cross, J. T. (2013). The law of intellectual property (4th ed.). Aspen Publishers.
3. Chisum, D. S. (2017). Understanding intellectual property law (3rd ed.). LexisNexis.
4. Merges, R. P., & Duffy, J. F. (2012). Patent law and policy: Cases and materials (5th ed.). Foundation Press.
5. Keller, B. P., & Cunard, J. P. (2015). Copyright law: A practitioner's guide (3rd ed.). Bloomberg BNA.

REFERENCE BOOKS:

1. Dinwoodie, G. B., & Janis, M. D. (Eds.). (2016). Trademark law and theory: A handbook of contemporary research. Edward Elgar Publishing.
2. Sandeen, S. K., & Rowe, E. A. (2012). Trade secrets law. West Academic.
3. Vaidhyanathan, S. (2017). Intellectual property: A very short introduction. Oxford University Press.

NT32A3 Pharmacokinetics & Therapy 3 0 0 3

OBJECTIVES

- Students should be able to identify which specific drugs belong to each major drug class,
- To have an understanding of the indications, clinical effect, mechanism of action and adverse effects of each drug classes on humans.
- To demonstrate ability to describe functional outcome of drugs in therapeutic interactions

Course Outcome - COs		**Cognitive Skill**
CO1	Be able to articulate the drug-intrinsic and extrinsic factors that determine drug molecule movement across biological membranes	U, An
CO2	To demonstrate understanding in concepts that determine dosage, absorption, distribution, and excretions of drugs	U, An
CO3	To demonstrate ability to describe functional outcome of drugs in therapeutic interactions	U, An
CO4	To demonstrate understanding of chemotherapy that includes various drugs and their cell response	U, An, A
CO5	To understand the immunological responses and ways to quantify and describe different drugs	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	S	M	M	M
CO-02	S	S	S	M	M	M
CO-03	S	S	S	M	M	M
CO-04	S	S	S	M	M	S
CO-05	S	S	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Introduction to pharmacology 9

Body compartments and their volumes, principles of pharmacokinetics, movement of drug molecules across biological membranes via diffusion, features of drug absorption, distribution, metabolism, and elimination, model systems in pharmacokinetics.

Unit II: Drug metabolism 9

Molecular mechanisms of drug action, principles of pharmacodynamics, drug toxicity and poisoning, membrane transporters and drug response, concepts in drug agonism and antagonism

Unit III: Pharmacotherapy **9**

Neuropharmacology, muscarinic and nicotinic drug systems, adrenergic, serotonergic, and dopaminergic agonists and antagonism, pharmacotherapies in neural disorders

Unit IV: Chemotherapy **9**

Cellular and molecular mechanism of actions and resistance of antimicrobial agents such as ßlactams, aminoglycosides, quinolones, Macrolide antibiotics. Antifungal, antiviral, and anti-TB drugs, Drugs used in Protozoal Infections, Drugs used in the treatment of Helminthiasis, Chemotherapy of cancer

Unit V: Immuno and chronotherapies **9**

Inflammation and immune response. Allergic or hypersensitivity reactions. Pharmacotherapy of asthma and COPD. Immunosuppressants and Immunostimulants, Prokinetics, antiemetics, anti-diarrheals and drugs for constipation and irritable bowel syndrome. applications of chronotherapy in various diseases like cardiovascular disease, diabetes, and peptic ulcer

TEXT BOOKS:

1. Goodman and Gilman's 'The Pharmacological Basis of therapeutics' 13th Edition, McGraw Hill Malcolm Rowland, Thomas Tozer, "Clinical Pharmacokinetics and Pharmacodynamics, Concepts and Applications", 4th Edition, Wolters Kluver
2. The Pharmacological basis of therapeutics- Goodman and Gill man„s
3. Principles of Pharmacology. The Pathophysiologic basis of drug therapy by David E Golan et al.
4. Basic and Clinical Pharmacology by B.G -Katzung 4. Pharmacology by H.P. Rang and M.M. Dale.
5. A Complete Textbook of Medical Pharmacology by Dr. S.K Srivastava published by APC Avichal Publishing Company.

NT32A4 PIEZOELECTRIC MATERIALS FOR NANOTECHNOLOGY 3 0 0 3

OBJECTIVES

- To learn the basics of piezoelectric materials and its characteristics.
- To understand the applications of piezoelectric materials in engineering and biology.

Course Outcome - COs		**Cognitive Skill**
CO1	Make sure they get the foundations of Piezoelectric Materials	U
CO2	Explore the potential impacts of Piezoelectric Characteristics	U, An
CO3	Educate students on the Piezoelectric Devices	U, An
CO4	To know the Engineering Applications of Piezoelectric Materials	U, An
CO5	Educate the students on the Biological Applications of Piezoelectric Materials	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Piezoelectric Materials **9**

Piezoelectric Materials – Principles of Piezoelectricity, Perovskite, Piezoceramic Materials, Piezoelectric Polymers – Piezoelectric Composites.

Unit II: Piezoelectric Characteristics **9**

Dielectric Constant – Dielectric Loss – Curie Temperature – Remnant Polarization – Coercive electric field – d_{33} measurement.

Unit III: Piezoelectric Devices **9**

Pressure sensor - Piezoelectric vibrators – Surface Acoustic Wave (SAW) devices – Piezoelectric transformer – Piezoelectric actuators – Ultrasonic motors.

Unit IV: Engineering Applications **9**

Energy Harvesting – Gas Lighter – Electronic Buzzer and Tweeter - Piezoelectric Micro Pump – Ultrasonic Cleaner - Non-destructive Testing (NDT) of Materials Using Ultrasonics.

Unit V: Biological Applications **9**

Introduction – Blood Pressure Monitor – Piezoelectric Heartbeat Monitor – Piezoelectric Pump: Drug Delivery and Biomedical Analyses - Ultrasonic Imaging.

REFERENCES:

1. Ferroelectric Devices, Kenji Uchina, Marcel Dekker, Inc. (2000).
2. M. S. Vijaya, Piezoelectric Materials and Devices, CRC Press (2013).
3. Kenji Uchino, Advanced Piezoelectric Materials, Woodhead Publishing (2010).

TEXT BOOKS:

1. Walter Heywang , Karl Lubitz , Wolfram Wersing, Piezoelectricity: Evolution and Future of a Technology, Springer Link (2008).
2. B. Jaffe, W.R. Cook, H. Jaffe, Piezoelectric Ceramics, Academic Press, New York, 1971.

NT32A5 NANOSCALE DEVICES **3 0 0 3**

OBJECTIVES

- To learn the basics of nanoscale devices in engineering.
- To understand their importance relevant to advanced applications

Course Outcome - COs		**Cognitive Skill**
CO1	Make sure they get the foundations of bulk nanostructured materials	U
CO2	Explore the potential impacts of gas sensing materials gas sensor materials	U, An
CO3	Educate students on the tools for nanolithography, immersion lithography, Electron and ultraviolet (EUV) photolithography	U, An
CO4	To know the Engineering Applications of Single Electron Transistors and manipulation Single Electron	U, An
CO5	Educate the students on the microfabrication and VLSI technology	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Bulk Nanostructured Materials **9**

Quantum wells, wires and Dots – Size and dimensionality effects, Carbon nanotubes (CNTs)- Single walled carbon nanotubes (SWNTs), Multi walled carbon nanotubes (MWNTs), Graphenes, Fullerenes- Structure and Properties, Metal/oxide nanoparticles, Nano rods, Nanowires, Nanotubes, and Nano fibres, Semiconductor Quantum Dots Excitons, Magnetic Nanoparticles- Nanostructured Ferromagnetism, Polymer nanoparticles, Core Shell Structures, Nano crystals, Single electron tunnelling – Applications.

Unit II: Gas Sensing Materials Gas Sensor Materials **9**

Criteria for the choice of materials, Experimental aspects – materials, properties, measurement of gas sensing property, sensitivity; Discussion of sensors for various gases, Gas sensors based on semiconductor devices.

Unit III: Nanolithography **9**

Top-down approach to nanolithography; Tools for nanolithography, immersion lithography, Electron and ultraviolet (EUV) photolithography, phase shifting masses, x ray lithography including plasma xray sources, Ebeam lithography, focused ion beams. Nanosphere lithography – Molecular self assembly, soft lithography, Stereo-lithography, nanoscale 3D shapes – NEMS design, molecular manipulation by STM and AFM - LB flim resists - nanopattern synthesis – Nano scratching.

Unit IV: Semiconductor Nanodevices **9**

SEMICONDUCTOR NANODEVICES-I: Single Electron devices- Nano scale MOSFET – Resonant Tunnelling Transistor – Single Electron Transistors manipulation Single Electron Dynamics Mechanical Molecular Nano robotics Nano devices and Nano computers: Theoretical Models, Molecular Devices Micro and Optical Fibres DNA Based nano devices.

Unit V: Microfabrication and VLSI Technology **9**

Micro fabrication techniques, MEMS, Microfulidic devices, MOS transistor, NMOS, PMOS, CMOS, VLSI design issues, VLSI design techniques, BIOSENSORS: Principles- DNA based biosensors – Protein based biosensors – materials for biosensor applications- fabrication of biosensors - future potential.

REFERENCES:

1. VLSI Technology, S M Sze
2. VLSI fabrication, by S K Gandhi
3. ULSI Devices, Wiley New York, by C.Y. Chang and S.M. Sze.
4. Handbook of Semiconductor Manufacturing Tech by R. D. Doering and Y. Nishi.
5. Semiconductors, 2nd edition, Cambridge University Press, by R.A. Smith.
6. Fundamentals of Modern VLSI Devices, Y Taur, and T. H. Ning.
7. Nitride Semiconductors and Devices (Springer Series) by Hadis Morkoç
8. Physical Properties of III-V Semiconductor Compounds: InP, InAs,GaAs, GaP, InGaAs, andInGaAsP by Sadao Adachi
9. Handbook of Compound Semiconductors: Growth, Processing, Characterization, and Devices (Materials Science and Process Technology Series) by Paul H. Holloway and Gary E. McGuire

NT32A6	NANOROBOTICS	3	0	0	3

OBJECTIVES

- To learn the basics of Nanorobotics.
- To understand their importance relevant to advanced applications

Course Outcome - COs		**Cognitive Skill**
CO1	Make sure they get the foundations of Actuation Methods for Nanorobotic Manipulation & Assembly	U
CO2	Explore the potential impacts of dielectrophoretic based nanomanipulation	U, An
CO3	Educate students on the concepts of AFM based nanorobotic system enhanced by augmented reality- Hardware & software setup	U, An
CO4	To know the CAD models and CAD models of nanostructures	U, An
CO5	Educate the students on the Medical applications of nanorobots, Cancer targeted therapy using nanorobots	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Actuation Methods for Nanorobotic Manipulation & Assembly 9

Interaction forces in nanomanipulation- Electro kinetic based actuation- Electro kinetic manipulation of carbon nanotubes- Graphene, nanoparticles- Biological entities- Biological entities- Optical tweezers- Manipulation of biological entities & chemical entities- Piezoelectric enabled actuators.

Unit II: Nanomanipulation ` 9

Dielectrophoretic based nanomanipulation- Theory- modelling of electro rotation- Dynamic effects of fluid medium- Nanoparticles by dielectrophoretic- Manipulation of CNT- Nanomanipulation by scanning probe- Reducing atomic scale stick- Slip motion (nanomanipulation)- Slip motion by feedback control nanomanipulation

Unit III: Sensing & Fast Imaging System 9

Art of compressive sensing- Compressive sensing based fast imaging system- AFM based imaging- AFM based nanorobotic system- AFM based nanorobotic system enhanced by augmented reality- Hardware & software setup

Unit IV: CAD & Real- Time Nanorobotic Manipulation 9

CAD models and CAD models of nanostructures- Automated manipulation of nanoparticles- Nanorods and nanowires- Limitation of augmented reality system- Real time fault detection & correction- Time random drift compensation with local scan- Interpret on-line fault detection & correction- Implementation & experimental results ion of the data to test the hypothesis

Unit V: Nanorobotic Applications 9

Wireless capsules endoscopy images and video- Energy harvesting nanorobotic- Capsules robot in gastro-intestinal tract- Nanorobots- Cooperative control design for nanorobots- Cooperative control design for nanorobots in drug delivery- Medical applications of nanorobots- Cancer targeted therapy using nanorobots

REFERENCES:

1. Ning Xi, Guangyoung Li, "Introduction to Nanorobotic Manipulation & Assembly" Artech House Press,2012
2. Yi Guo, "Selected Topics in Micro/Nano-robotic for Biomedical Applications", Springer, 2013
3. Klaus D. Sattler, "Hand Book of Nanophysics: Nano medicine & Nanorobotics", CRC Press, 2010.

NT32A7 IMAGING TECHNIQUES FOR NANOTECHNOLOGY 3 0 0 3

OBJECTIVES

- To learn the basics of imaging techniques for nanotechnology
- To understand the impact and recent applications of Microscopy in Nanotechnology research

Course Outcome - COs		**Cognitive Skill**
CO1	Make sure they get the foundations of use of polarized light microscopy, Phase contrast microcopy, Interference Microscopy	U
CO2	Explore the basic design of the scanning electron microscopy and transmission electron microscopy	U, An
CO3	Educate students on the concepts of Radiography and MRI	U, An
CO4	To know the principles of atomic force microscopy	U, An
CO5	Educate the students on the concepts of scanning tunneling microscopy	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F

CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Optical Microscopy **9**

Optical microscopy- Use of polarized light microscopy – Phase contrast microcopy – Interference Microscopy – hot stage microscopy - surface morphology – Introduction to confocal microscopy.

Unit II: Scanning Electron Microscopy and Transmission Electron Microscopy 9

Basic design of the scanning electron microscopy – Modes of operation– Backscattered electrons – secondary electrons- X-rays – typical forms of contrast– Resolution and contrast – enhancement – Specimen Preparation, Replicas Various-application of SEM, Structure of Grain boundaries and interfaces HRTEM use in nanostructures.

Unit III: Radioimaging **9**

General overview of MR Physics, Basic principles of MRI, Discovery of NMR/MRI, Contrast enhanced MRI & Gadolinium, Major components of an MRI, MRI SAFETY

Unit IV: Atomic Force Microscopy **9**

Basic concepts-Interaction force-AFM and the optical lever- Scale drawing- AFM tip on nanometer scale structures- force curves, measurements and manipulations-feed back control-different modes of operation –contact, non contact and tapping mode-Imaging and manipulation of samples in air or liquid environments-Imaging soft samples. Scanning Force Microscopy-Shear force Microscopy-Lateral Force Microscopy-Magnetic Force microscopy.

Unit V: Scanning Tunneling Microscopy **9**

Principle- Instrumentation- importance of STM for nanostructures – surface and molecular manipulation using STM -3D map of electronic structure.

REFERENCES:

1. J.Goldstein, D. E. Newbury, D.C. Joy, and C.E. Lym, ―Scanning Electron Microscopy and X-ray Microanalysis‖, 2003.
2. S.L. Flegler, J.W. Heckman and K.L. Klomparens, ―Scanning and Transmission Electron Microscopy: A Introduction‖, WH Freeman & Co, 1993.
3. Radiographic imaging-Derrick P. Roberts and Nigel L. Smith. Churchill Livingstone, Edinburgh (1994)
4. P.J.Goodhew, J.Humphreys, R.Beanland, ―Electron Microscopy and Analysis‖2001.
5. R.Haynes, D.P.Woodruff and T.A.Talchar, ―Optical Microscopy of Materials‖, Cambridge University press, 1986.

NT32A8 MICROELECTRONICS AND VLSI **3 0 0 3**

OBJECTIVES

- To learn the various lithography techniques and concepts of wafer exposure system
- To design Low power CMOS designs, for digital circuits.
- To gain knowledge on bipolar transistors and MOSFETs

Course Outcome - COs		**Cognitive Skill**
CO1	To know the characteristics of microelectronic sensing systems and semiconductors	U, A, An
CO2	Construct in-depth knowledge of formation and properties of PN junctions and MOSFET	U, A, An
CO3	Designing MOS amplifier CS stage, CG topologies	U, A, An
CO4	Understanding monolithic integrated circuit technologies	U, A, An
CO5	Studying fabrication of CMOS devices and technologies for BiCMOS	U, A, An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	S	S	M	S	M	M
CO-02	S	S	M	S	M	M
CO-03	S	S	M	S	M	M
CO-04	S	S	M	S	M	S
CO-05	S	S	M	S	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Introduction to Microelectronics, Semiconductor Physics and IC technology **9**

The digital Inverter – Microelectronic sensing systems – Pure semiconductors – Generation, Recombination and thermal equilibrium – Doping – carrier transport – Silicon Integrated circuit technology.

Unit II: Physics of PN Junction diode and MOS transistors **9**

Diode fabrication, Device physics: Thermal equilibrium, Internal electro-static fields and potentials, drift-diffusion equations. I-V Characteristics: Forward bias, reverse bias, Diode equation. Avalanche and Zener Breakdown mechanism, Capacitive effect: Junction and diffusion capacitance. DC, AC and transient analysis of Diodes, Structure of MOSFET, operation of MOSFET – I/V characteristics – Channel length modulation – MOS transconductance – Velocity saturation – MOS device models – PMOS transistor – CMOS technology – Comparison of bipolar and MOS devices.

Unit III: CMOS Amplifiers and operational Amplifiers **9**

MOS Amplifier Topologies – Common Source Biasing-Realization of Current Sources - Common-Source Stage - CS Core - CS Stage With Current-Source Load -CS Stage With Diode-Connected Load - CS Stage With Degeneration - CS Core With Biasing - Common-Gate Stage - CG Stage With Biasing - Source Follower - Op-Amp-Based Circuits- Noninverting Amplifier-

Inverting Amplifier -Integrator and Differentiator - Voltage Adder

Unit IV: Introduction to VLSI technology **9**

Introduction to monolithic Integrated Circuit technology – Integrated circuits – Silicon wafer preparation – Czochralski technique of crystal growth – Thermal oxidation – Growth techniques of oxide layer – Properties of oxide – Defects induced due to oxidation

Unit V: MOSFET and MOS Fabrication Technology **9**

Fabrication of CMOS devices – n well process, p - well process, Twin tub process. Technology for BiCMOS – Comparison of bipolar and CMOS devices – Fabrication of BiCMOS - Stick diagrams – nMOS design style – CMOS design style – Layout and design rules- Lambda based design rules – contact cuts – double metal MOS process – rules – ways of decreasing the threshold voltage.

Total Periods 45

TEXT BOOKS:

1. VLSI Technology, S.M. Sze, TMH, Second edition.
2. Basic VLSI design, Douglas A Pucknell, Kamran Eshragian, PHI, Third edition.

REFERENCE BOOKS:

1. Fundamentals of Microelectronics, Behzad Razavi, Wiley edition, 2008

2.Microelectronics, an integrated approach by Roger T Howe, Charles G Sodini, Pearson education, 2004.

3. Microelectronics, Jacob Millman, Arvin Grabel, TMH.
4. VLSI Technology, Design and basics of Microelectronics, R.K. Singh, Katson books, 2005.

NT32A9 TOXICOLOGY AND HEALTHCARE 3 0 0 3

OBJECTIVES

To develop an understanding of the students to synthesize non-toxic, harmless nanomaterialsthat produce no hazard to the environment

Course Outcome - COs		**Cognitive Skills**
CO-01	**Toxicology and toxicological chemistry:** Basic toxins produced, their chemical nature and their measured effects	U, A, An
CO-02	**Nanomaterials and toxicity:** understanding the harmful effects of toxins in our cells and tissues and their remedial measures	U, A, An
CO-03	**Physico-chemical characteristics dependent toxicity** The mechanism of interaction of toxins to cells and mode of entry and their dependence	U, A, An
CO-04	**Effect of nanomaterials on human health:** How the toxins do harm the human health and the different types of diseases that result from it.	U, A, An
CO-05	**Health hazards due to ecological effects:** The methods of diagnosis of such diseases, development of non toxic drugs	U, A, An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Toxicology And Toxicological Chemistry 9

Introduction– Acute and Chronic Effects – Tolerance and Ecological Gradients – Chemical Interactions – Reversible and Irreversible Toxic Effect – Toxicological Chemistry- Mechanistic Toxicology – Descriptive Toxicology – Regulatory Toxicology – Dose Responsive Concept – Toxin Exposure- Quantitative Aspects of Exposure – Interactive Effects of Toxicants

Unit II: Nanomaterials And Toxicity 9

Interaction of Nanomaterials with Biological Systems – Intracellular Trafficking of Nanomaterials – Cellular Metabolism of Nanomaterials: Biodegradation – Elimination – Mechanisms of Nanomaterial Cytotoxicity- Genotoxic Effects of nanomaterials – Cell-Nanoparticle Interaction: Considerations for Toxicity Assessment.

Unit III: Physico-Chemical Characteristics Dependent Toxicity **9**

Dose-dependent toxicity - Size-dependent toxicity -Surface area-dependent toxicity - Concentration-dependent toxicity - Particle chemistry and crystalline structure dependent toxicity - Aspect ratio dependent toxicity - Surface coating and functionalization - Adaptability to nanomaterials inhalation - Comparison studies.

Unit IV: Effect of Nanomaterials on Human Health **9**

Inflammation, DNA damage, nervous system uptake of nanoparticles, interaction with blood cells, cardiovascular malfunction, Adverse health effects on liver, kidneys, spleen, gastro intestinal tract and skin. Positive effects of nanoparticles, as antioxidants and antimicrobial

Unit V: Health Hazards **9**

Environments: e.g. chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers such as PHB-Health: e.g. development of non-toxic therapeutic agents, recombinant live vaccines, gene therapy, diagnostics, monoclonal in E. coli, human genome project.

TEXTBOOKS:

1. Textbook of Toxicology, By Balram Pani, I. K. International Pvt Ltd, New Delhi
2. Monteiro-Riviere, N. A., & Tran, C. L. (2007). Nanotoxicology: Characterization, dosing and health effects. New York (London: Informa Healthcare USA.
3. Peterson, W. P. (2009). *Nanotechnology: Environmental, health and safety issues*. New York: Nova Science.

REFERENCE BOOKS:

1. Cassee, F. R., Mills, N. L., & Newby, D. E. (2011). Cardiovascular effects of inhaled ultrafine and nano-sized particles. Hoboken, N.J: Wiley.
2. In Wexler, P. (2014). Encyclopedia of toxicology. San Diego, California: Elsevier Science & Technology, Boston, Massachusetts: Credo Reference.
3. Monteiro-Riviere, N. A., & Tran, C. L. (2007). *Nanotoxicology: Characterization, dosing and health effects*. New York: Informa Healthcare.
4. Cristina Buzea, Ivan. I. Pacheco Blandino, and Kevin Robbie, (2007) Nanomaterials and nanoparticles: Sources and toxicity, Bio interphases vol. 2, issue 4 (2007) pages MR17 - MR172.

NT32B1 Drug Delivery Systems 3 0 0 3

OBJECTIVES

To develop an understanding of the students to learn the basic principles and techniques of various drug delivery systems.

Course Outcome - COs		**Cognitive Skill**
CO-01	Learn the basic principles and techniques of various drug delivery systems.	U
CO-02	Learn the various methods for targeted nanoparticle for drug delivery	U, An, A
CO-03	Learn the different polymers used as drug carriers.	U, An, A
CO-04	Learn the various Nanoparticle Targeted Systems for Cancer Treatment	U, An, A
CO-05	Learn the advances in smart delivery systems.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Principles of Drug Delivery Systems 9

Modes of drug delivery, Absorption distribution metabolism excretion characteristics of drugs, Kinetics of drug delivery, Controlled drug delivery - site specific drugs, for drug targeting - passive and active targeting, Strategies for site specific drug delivery, and rate-controlled delivery of drugs, Antibody based drug delivery systems, Metabolism-based drug delivery systems.

Unit II: Smart Delivery Systems Fundamentals 9

Evolution of the drug dosage forms: The need of smartness - Smart DDSs - Smart components: Phase transitions - Stimuli and suitable smart DDSs: pH - Redox conditions - Molecule- responsive and imprinted systems – Temperature – Light - Electrical field – Magnetic Field – Ultrasound - Autonomous responsiveness - Smart Drug-eluting Medical Devices.

Unit III: Polymeric Drug Carriers 9

Polymers - classification - polymer micelles as drug carriers- polymers nanotubes, Magnetic nanoparticles as drug carriers, Dendrimers - synthesis – tecto-dendrimers, Nanoscale containers – nano scafold systems; Gene Transfection, Carbon nanotubes in diagnosis and therapy Liposomes for pharmaceutical and cosmetic applications lipid- DNA complexes,

Liposomal peptide and protein drug delivery, Liposomal peptide and protein drug delivery – Liposomal anticancer and antifungal agents

Unit IV: Targeted Nanoparticles for Drug Delivery **9**

Classification of targeted drug delivery systems, Nanoparticles surface modification – Bioconjugation, surface modification– PEGylation, - cell-specific targeting, Controlled drug release, Gold nanoparticles for drug delivery, Multi-functional gold nanoparticles for drug delivery, Virus based-nanoparticles for drug delivery system, Virus based-nanoparticles for targeted drug delivery system

Unit V: Nanoparticle Targeted Systems for Cancer Treatment **9**

Targeted delivery through enhanced permeability and retention, Cancer markers - Folate receptors, targeting through angiogenesis, targeting to specific organs or tumor types - tumor-specific targeting, Combination therapy and Neutron capture therapy, Targeting tumor vasculature for imaging, Delivery of specific anticancer agents: paclitaxel, doxorubicin. Delivery of specific anticancer agents: 5-Fluorouracil

Total: 45 periods

TEXT BOOKS:

1. Vladimir P Torchilin, *"Nanoparticulates as drug carriers"*, Imperial College Press, 2006
2. Deepak Thassu, Michel Deleers, Yashwant Vishnupa, *"Nanoparticulate drug delivery systems",* CRC Press, 2007
3. Irene Brigger, Catherine Dubernet, Patrick Couvreur *"Nanoparticles in cancer therapy anddiagnosis Advanced Drug Delivery",* CRC Press, 2002
4. Tejal Desai, *"BioMEMS and Biomedical Nanotechnology: Therapeuti micro/ nanotechnology",* Volume 3, Springer, 2006.

REFERENCES:

1. Alvarez-Lorenzo, C. and Concheiro, A., 2014. Smart drug delivery systems: from fundamentals to the clinic. Chemical communications, 50(58), pp.7743-7765.
2. Sanchez-Moreno, P., Ortega-Vinuesa, J.L., Peula-Garcia, J.M., Marchal, J.A. and Boulaiz, H., 2018. Smart drug-delivery systems for cancer nanotherapy. Current drug targets, 19(4), pp.339-359.

NT32B2 INDUSTRIAL NANOTECHNOLOGY 3 0 0 3

OBJECTIVES

To apply the nanotechnology concepts for various industries such as agriculture, medicine, textiles, cosmetics, automobile and sports industries to solve unsolved issues.

Course Outcome - COs		**Cognitive Skill**
CO-01	Understand the importance of nanoscience and nanomaterials for finding suitable area.	U
CO-02	Apply the nanotechnology concepts for various industries such as agriculture, medicine, textiles, cosmetics, automobile and sports industries to solve unsolved issues.	U, An, A
CO-03	To gain knowledge over risk assessment, regulatory approaches and potential for regulatory control.	U, An, A
CO-04	To get aware of nanotechnology product and its markets.	U, An, A
CO-05	Apply the nanomaterials for diagnosis and treatment	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO **CO**	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Nanotechnology in Electrical and Electronics Industry 9

Nano electrical and electronic devices: advantageous, Data storage and memory, Micro and nanoelectromechanical systems, Lasers, lighting and displays, Batteries, Fuel cells, Photovoltaic cells, Electric double layer capacitors, Nanoparticle coatings for electrical products.

Unit II: Nanotechnology In Biomedical and Pharmaceutical Industry 9

Nanoparticles in bone substitutes and dentistry, Tissue engineering/regenerative medicine, Scaffolds for tissue engineering, Nanorobotics in surgery, Drug delivery advantages of nanostructured delivery systems, Activation and targeting of nanotechnology-based drug delivery systems, Cancer diagnostics and therapy: why Nanotechnology?, Nanotools for early cancer detection, Nanomedicine for cancer treatment

Unit III: Nanotechnology for Environment Applications 9

Nano techno structured catalysts TiO_2 nanoparticles for water purification: background of TiO_2 as a semiconductor photocatalyst, Photocatalytic mechanism, general pathways, and kinetics, Photocatalytic degradation of specific waterborne pollutants, Nanoparticles for treatment of arsenic, Treatment of arsenic using nanoparticles other than TIO_2 , Nanoscale carbon materials for contaminant separation , Nanostructured metal oxide gas sensors for

air-quality monitoring, The gas-sensing mechanism, integrated solid-state sensors

Unit IV: Nanotechnology in Agriculture and Food Technology 9

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

Unit V: Nanotechnology in Textiles, Cosmetics, and Personal Care Products 9

Nanofiber production techniques: Electrospinning and its applications in textile manufacturing - Controlling morphologies of nanofibers for tailored properties in textiles - Multifunctional polymer nanocomposites for advanced textile applications - Carbon nanotubes and their composites in textile materials -Nano-filled polypropylene fibers for enhanced textile performance - Nanotechnology in textile finishing for improved properties: - Nanotechnology in cosmetic formulations

TEXT BOOKS:

1. Mark A.R., Daniel Ratner, "*Nanotechnology: A Gentle Introduction to the Next Big Idea"*, Pearson
Education, India,2003
2. Bharat Bhushan, *"Handbook of Nanotechnology"*, Springer, Barnes & Noble,2004
3. Eelina H. Malsch, "*Biomedical Nanotechnology"*, CRC Press,2005
4. Kenneth E.G., Craig R.H., Cato T.L., Lakshmi S.N., "*Biomedical Nanostructures*", John Wiley & Sons Inc., 2008

REFERENCE BOOKS:

1. Maqhong Fan, Huang C.P., Alan E.B., "*Environanotechnology*", Elsevier,2010
2. Tian C.Z., Rao Y.S., Keith C.K.L., Zhiqiang H., Tyagi R.D., Irene M.C.L, *Nanotechnologies ForWater Environment Applications*", ASCE publications, 2009
3. Jennifer Kuzma and Peter VerHage, *"Nanotechnology in agriculture and food production"*, Woodrow Wilson International Center,2006
4. Lynn J. Frewer, Willehm Norde, Fischer R. H. and Kampers W. H., "*Nanotechnology in theAgri-food sector"*, Wiley-VCH Verlag,2011
5. P. J. Brown and K. Stevens, "*Nanofibers and Nanotechnology in Textiles"*, Woodhead Publishing Limited, Cambridge, 2007.

NT32B3 POLYMER NANOCOMPOSITES 3 0 0 3

OBJECTIVES

The course is designed to study certain selected topics from the broad area of polymer and polymer nanocomposites, which include various polymer types, synthetic methods and mechanism of formation, polymer characterization, solution properties of polymers, nanocomposites and their application.

Course Outcome - COs		**Cognitive Skill**
CO-01	Study, understand various Engineering materials.	U, A
CO-02	Understand the structure of metals and alloys.	U
CO-03	Analyze and study the advanced engineering materials like ceramic and glasses.	An

CO-04	Study and remember the classifications of composites and polymers.	R, U
CO-05	Study the applications of all smart materials.	An, E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H
CO-01	S	S	S	M	N	M	M	S
CO-02	M	N	S	S	S	M	N	L
CO-03	S	L	M	N	N	M	S	N
CO-04	N	M	L	S	L	S	N	S
CO-05	S	S	L	L	N	M	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

Unit I: Introduction to Polymers **6**

Monomers, Natural and synthetic polymers, glass transition, melting transition, Block and graft polymers. Polymer blends and composites, Rubber and plastics, thermoplastics and thermosets. Biodegradable polymers, biomedical polymers, polymer liquid crystals

Unit II: Synthetic Methods and Mechanism **9**

Different types of polymerizations: addition, condensation and stereo regular polymerization. Kinetics and mechanism of addition, condensation and stereo regular polymerizations. Co-polymerization - Important techniques of polymerization: emulsion, bulk, solution and suspension.

Unit III: Polymer Characterization **9**

Solubility and swelling, molecular weight determination by GPC, viscosity, light scattering and Osmometry. Polymer characterizations by IR, NMR, X-ray analysis etc. Thermal analysis of polymers using DSC, TGA, DTA and DMA.

Unit IV: Polymer Solutions **9**

Introduction to solution properties of polymers - Thermodynamics of liquid mixtures of small molecules- Entropy and heat of mixing in polymer solutions- Flory-Huggins theory of polymer solutions- Flory-Krigbaum theory and its application to polymer solutions- Cluster type theory in polymer solutions- Understanding polymer solubility and phase behavior- Effects of polymer concentration on solution properties- Polymer-solvent interactions and their impact on solution behavior- Practical applications of polymer solutions in various industries.

Unit V: Nano Composites **9**

Introduction to composites, Fabrication of Polymer-carbon nanotubes based composites, their mechanical properties, and industrial possibilities. Epoxy nanocomposites, Silicon rubber, Organically modified clay, Magnetic polymer nanocomposites, Polymer/graphite nanocomposites, Wear resisting polymer Nanocomposites.

TEXT BOOKS:

1. Billmeyer, F. W. (1984). *Textbook of polymer science*. New York: Wiley.
2. Flory, P. J. (1953). *Principles of polymer chemistry*. Ithaca: Cornell University Press.
3. Gowariker, V. R., Viswanathan, N. V., & Sreedhar, J. (1986). *Polymer science*. New York: Wiley.
4. Odian, G. G. (1970). *Principles of polymerization*. New York: McGraw-Hill.

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1. McCrum, N. G., Buckley, C. P., & Bucknall, C. B. (1988). *Principles of polymer engineering*. Oxford [Oxfordshire: Oxford University Press.
2. Pinnavaia, T. J., & Beall, G. W. (2000). *Polymer-clay nanocomposites*. Chichester: Wiley.
3. Lazzari, M., Liu, G., & Lecommandoux, S. (2006). *Block copolymers in nanoscience*. Weinheim: Wiley-VCH.
4. Gerdeen, J. C., Lord, H. W., & Rorrer, R. A. L. (2006). *Engineering design with polymers and composites*. Boca Raton: CRC/Taylor & Francis.