

**BHARATHIAR UNIVERSITY, COIMBATORE 641 046**  
**UNIVERSITY DEPARTMENT**  
**M.Sc., NANOSCIENCE AND TECHNOLOGY**  
(For the candidates admitted from the academic year 2018-19 onwards)  
**Overview, Curriculum and Syllabus**

**Duration:** 2 Years  
**Level:** Post-Graduation  
**Type:** PG. Degree  
**Eligibility:** Any undergraduate Science Degree recognized by UGC

**VISION:** To achieve excellence in the field of Nanoscience and Technology through academic and research programmes and to participate in the interdisciplinary programmes offered in the University.

**MISSION :As a Department, We are committed to,**

- Provide knowledge and skill in Nanoscience and Technology through post-graduate and doctoral programmes.
- Undertake research in emerging areas of physical, chemical and biological sciences with nanoscience and technology and transform the findings for the benefit of the society.
- Solve the environmental issues through the post graduate and research programmes.
- Provide required knowledge in physical, chemical and biological sciences to understand nanoscience and technology for research.

**Programme Educational Objectives(PEOs)**

- I. To prepare students to outshine in academics and research in different motifs of Nanoscience and Nanotechnology through post graduate education.
- II. To provide students with a solid foundation in their respective core subjects such as Physics, Chemistry and Biotechnology in addition to Nanoscience and Technology.
- III. To provide students with a depth knowledge in Synthesis and Characterization of novel nanomaterials with multiple applications.
- IV. To train students with good theoretical and practical knowledge so as to comprehend, analyze, design, and create products and solutions for the real life problems.
- V. To instruct students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate nanotechnology to address biomedical applications and environmental issues.
- VI. To provide students with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career.

**PROGRAMME OUTCOMES (POs):** On successful completion of the M.Sc.Nanoscience and Technology programme:

1. The Post Graduates will demonstrate knowledge on the physics/ chemistry/biotechnology and basics of nanoscale science and technology for their multifunctional applications.
2. Post Graduates will demonstrate an ability to synthesis and characterize the nanomaterials.
3. Post Graduates will project their skill in Lithography and nanofabrication.
4. Post Graduates will have expertise in processing of nanomaterials, MEMS and bio MEMS as per needs and specifications.
5. Post Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks including material science, physics, chemistry and nanobiotechnology.
6. Post Graduates will demonstrate skills to use synthesis, processing and imaging equipments to analyze samples.
7. Post Graduates will be able to propagate their knowledge to address problems of social relevance such as energy, environment and medicine through their specific electives.
8. Post Graduates will show the understanding of impact of nanomaterials on the society including environment, health and ecosystem.
9. Post graduates will be able to plan and execute their own innovative ideas in the form of projects, product design and development.
10. Post Graduates will develop confidence for self education and ability for life-long learning.

**Career Opportunities :**M.Sc.Nanoscience and Technology graduates have plethora job opportunities in the following fields;

- Research Scientist and formulation scientist
- Nanomaterial Product developer
- Government agencies for regulatory monitoring
- Patent examiner
- Entrepreneurship
- Consultancy organizations in pharmaceuticals, Energy, Material Science, Medical, Agriculture, Environment Protection.
- Job in Scientific Research Organizations.
- Enroll for higher degree through research in India or abroad
- Healthcare industry

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**M.Sc., NANOSCIENCE AND TECHNOLOGY**  
(For the candidates admitted from the academic year 2018-19 onwards)  
**SCHEME OF EXAMINATION-(CBCSPATTERN)**

Sem	Paper	Subject	Credit	
I	Core-I	Fundamentals of Nanoscale Science and Technology	4	
	Core-2	P	Classical Mechanics	4
		C	Organic Chemistry – I	4
		B	Biochemistry	4
	Core-3	P	Quantum Mechanics	4
		C	Inorganic Chemistry – I	4
		B	Microbiology	4
	Core-4	P	Mathematical Physics	4
		C	Physical Chemistry – I	4
		B	Cell and Molecular Biology	4
	Elective-1		Analog and Digital Electronics	4
			Analytical Chemistry	4
			Biostatistics	4
Supportive-1	Offered from Other Departments	2		
II	Core-5	Synthesis and Fabrication of Nanomaterials	4	
	Core-6	Properties of Nanomaterials	4	
	Core-7	P	Statistical Mechanics and Thermodynamics	4
		C	Organic Chemistry – II	4
		B	Immunology	4
	Core-8	P	Nuclear and Particle Physics	4
		C	Physical Chemistry – II	4
		B	Pharmaceutical Biotechnology	4
	Elective-2	Advanced Materials Science / Environmental Biotechnology	4	
	Core-9	Practical-I	4	
Supportive-2	Offered from other Department	2		
Online Course-1	Online Course from Swayam, MOOCm NPTEL <i>etc.</i>	2		
III	Core-10	Modern Instrumental Methods for Materials Analysis	4	
	Core-11	Nanobiotechnology	4	
	Core-12	Micro and Nanofabrication	4	
	Core-13	P	Electromagnetic Theory	4
		C	Inorganic Chemistry – II	4
		B	Toxicology	4
	Elective -3	Nanodevices and Applications	4	
	Core-14	Practical – II	4	
Core-15	Mini Project and Study Tour	2		
Supportive-3	Offered from other Departments	2		
IV	Online Course-2	Online Course from Swayam, MOOCm NPTEL <i>etc.</i>	2	
	Core-16	IPR and Biosafety (Self Study)	2	
	Core-17	Project and Viva-Voce	12	
<b>Total</b>			<b>90</b>	

[P-Core papers for B. Sc. Physics Major; C-Core papers for B. Sc. Chemistry Major and B-Core papers for B. Sc. Biology/ Biotechnology Students]

[Online Courses have an extra Credit (Other Than 90 credits). Two online courses are mandatory and the students also can do more than two courses based on their ability. All these courses will entered in the consolidated mark statement and will not be included for grading]

**BHARATHIAR UNIVERSITY, COIMBATORE 641 046**  
**UNIVERSITY DEPARTMENT**  
**M.Sc., NANOSCIENCE AND TECHNOLOGY (Physics Based)**  
(For the candidates admitted from the academic year 2018-19 onwards)  
**SCHEME OF EXAMINATION-(CBCS PATTERN)**

Sem	Code	Subject	Class Hours	University Examination			
				Internal	External	Total	Credit
I	13A	Fundamentals of Nanoscale Science and Technology	4	25	75	100	4
	13B	Classical Mechanics	4	25	75	100	4
	13C	Quantum Mechnics	4	25	75	100	4
	13D	Mathematical Physics	4	25	75	100	4
	1EA	Analog and Digital Electronics	4	25	75	100	4
	1GS..	Offered from Other Departments	2	12	38	50	2
II	23A	Synthesis and Fabrication of Nanomaterials	4	25	75	100	4
	23B	Properties of Nanomaterials	4	25	75	100	4
	23C	Statistical Mechanics and Thermodynamics	4	25	75	100	4
	23D	Nuclear and Particle Physics	4	25	75	100	4
	2EA	Advanced Materials Science	4	25	75	100	4
	23P	Practical-I	4	25	75	100	4
	2GS..	Offered from other Department	2	12	38	50	2
	Online Course-1	Online Course from Swayam, MOOCm NPTEL <i>etc.</i>	2	50	-	50	2
III	33A	Modern Instrumental Methods for Materials Analysis	4	25	75	100	4
	33B	Nanobiotechnology	4	25	75	100	4
	33C	Micro and Nanofabrication	4	25	75	100	4
	33D	Electromagnetic Theory	4	25	75	100	4
	3EA	Nanodevices and Applications	4	25	75	100	4
	33P	Practical – II	4	25	75	100	4
	37V	Mini Project and Study Tour	2	50	-	50	2
	3GS..	Offered from other Departments	2	12	38	50	2
	Online Course-2	Online Course from Swayam, MOOCm NPTEL <i>etc.</i>	2	50	-	50	2
IV	43A	IPR and Biosafety (Self Study)	2	12	38	50	2
	47V	Project and Viva-Voce	12	75	225	300	12
<b>Total</b>			<b>90</b>			<b>2250</b>	

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**BHARATHIAR UNIVERSITY, COIMBATORE 641 046**  
**UNIVERSITY DEPARTMENT**  
**M.Sc., NANOSCIENCE AND TECHNOLOGY (Chemistry Based)**  
(For the candidates admitted from the academic year 2018-19 onwards)  
**SCHEME OF EXAMINATION-(CBCSPATTERN)**

Sem	Code	Subject	Class Hours	University Examination			
				Internal	External	Total	Credit
I	13A	Fundamentals of Nanoscale Science and Technology	4	25	75	100	4
	13E	Organic Chemistry – I	4	25	75	100	4
	13F	Inorganic Chemistry – II	4	25	75	100	4
	13G	Physical Chemistry – I	4	25	75	100	4
	1EB	Analytical Chemistry	4	25	75	100	4
	1GS..	Offered from Other Departments	2	12	38	50	2
II	23A	Synthesis and Fabrication of Nanomaterials	4	25	75	100	4
	23B	Properties of Nanomaterials	4	25	75	100	4
	23E	Organic Chemistry – II	4	25	75	100	4
	23F	Physical Chemistry – II	4	25	75	100	4
	2EA	Advanced Materials Science	4	25	75	100	4
	23P	Practical-I	4	25	75	100	4
	2GS..	Offered from other Department	2	12	38	50	2
	Online Course-1	Online Course from Swayam, MOOCm NPTEL <i>etc.</i>	2	50	-	50	2
III	33A	Modern Instrumental Methods for Materials Analysis	4	25	75	100	4
	33B	Nanobiotechnology	4	25	75	100	4
	33C	Micro and Nanofabrication	4	25	75	100	4
	33E	Inorganic Chemistry – II	4	25	75	100	4
	3EA	Nanodevices and Applications	4	25	75	100	4
	33P	Practical – II	4	25	75	100	4
	37V	Mini Project and Study Tour	2	50	-	50	2
	3GS..	Offered from other Departments	2	12	38	50	2
Online Course-2	Online Course from Swayam, MOOCm NPTEL <i>etc.</i>	2	50	-	50	2	
IV	43A	IPR and Biosafety (Self Study)	2	12	38	50	2
	47V	Project and Viva-Voce	12	75	225	300	12
<b>Total</b>			<b>90</b>			<b>2250</b>	

[Online Courses have an extra Credit (Other Than 90 credits). Two online courses are mandatory and the students can do more than two courses too.]

**BHARATHIAR UNIVERSITY, COIMBATORE 641 046**  
**UNIVERSITY DEPARTMENT**  
**M.Sc., NANOSCIENCE AND TECHNOLOGY (Biotechnology Based)**  
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**SCHEME OF EXAMINATION-(CBCSPATTERN)**

Sem	Code	Subject	Class Hours	University Examination			
				Internal	External	Total	Credit
I	13A	Fundamentals of Nanoscale Science and Technology	4	25	75	100	4
	13H	Biochemistry	4	25	75	100	4
	13I	Microbiology	4	25	75	100	4
	13J	Cell and Molecular Biology	4	25	75	100	4
	1EC	Biostatistics	4	25	75	100	4
	1GS..	Offered from Other Departments	2	12	38	50	2
II	23A	Synthesis and Fabrication of Nanomaterials	4	25	75	100	4
	23B	Properties of Nanomaterials	4	25	75	100	4
	23F	Immunology	4	25	75	100	4
	23G	Pharmaceutical Biotechnology	4	25	75	100	4
	2EB	Environmental Biotechnology	4	25	75	100	4
	23P	Practical-I	4	25	75	100	4
	2GS..	Offered from other Department	2	12	38	50	2
	Online Course-1	Online Course from Swayam, MOOCm NPTEL <i>etc.</i>	2	50	-	50	2
III	33A	Modern Instrumental Methods for Materials Analysis	4	25	75	100	4
	33B	Nanobiotechnology	4	25	75	100	4
	33C	Micro and Nanofabrication	4	25	75	100	4
	33F	Toxicology	4	25	75	100	4
	3EA	Nanodevices and Applications	4	25	75	100	4
	33P	Practical – II	4	25	75	100	4
	37V	Mini Project and Study Tour	2	50	-	50	2
	3GS..	Offered from other Departments	2	12	38	50	2
Online Course-2	Online Course from Swayam, MOOCm NPTEL <i>etc.</i>	2	50	-	50	2	
IV	43A	IPR and Biosafety (Self Study)	2	12	38	50	2
	47V	Project and Viva-Voce	12	75	225	300	12
<b>Total</b>			<b>90</b>			<b>2250</b>	

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## Course Code and Title :13A-Fundamentals of Nanoscale Science and Technology

CourseType: Core

Semester :I

Credits: 4

**Preamble:**This course is the introductory course for the M. Sc. Nanoscience and Technology and is designed to introduce students to the interdisciplinary aspects of nanoscience by integrating important components of the broad research field. This integrated approach will cross the traditional disciplines of physics, chemistry and biotechnology. Fundamental properties of materials at the nanoscale, synthesis of nanoparticles, characterization tools, self-assembly, and nanoscale devices and systems will be covered.

**Prerequisite:**Basic knowledge in science(physics, chemistry, biology and mathematics)

**Course Objectives:** Through this course the students will:

- Understand the relationship between the size and properties for various materials.
- Understand unique interactions and effects occurring at the nanoscale.
- Evaluate appropriate applications for nanoscale processes, materials, or systems.
- Understand the most prominent fabrication approaches for nanoscale materials.
- Understand how quantization in nanomaterials impacts electrical, optical, and magnetic properties *etc.*
- Understand the most prominent metrology & characterization approaches for nanoscale materials.
- Understand how nanomaterials are applicable to, and particularly useful for, electronics, energy devices, and medicine/medical devices.
- Develop/refine ability to present details of a chosen nanoscience phenomenon, technique, tool, material, or device/system by writing a clear review and delivering concise presentation to the class.

**Course Outcomes:**On completion of this course, students will be able to:

- CO1:** Describe fundamentals of nano science and nanotechnology
- CO2:** Classification of nanostructures and their properties
- CO3:** Different types of nanomaterials
- CO4:** Utilization of nanomaterials in diverse applications.
- CO5:** Applications in different areas.

### Unit-I – Generic Methodologies for Nanotechnology

Introduction and classification- Classification of nanostructures-  
Nanoscale architecture; Summary of the electronic properties of atoms and solids- The isolated atom-  
Bonding between atoms - Giant molecular solids - The free electron model and energy bands -  
Crystalline solids- Periodicity of crystal lattices- Electronic conduction; Effects of the nanometre  
length scale- Changes to the system total energy- Changes to the system structure  
- How nanoscale dimensions affect properties.

### Unit-II - Carbon Nanostructures

Introduction; carbon molecules – nature of the carbon bond – new carbon structures; carbon clusters –  
small carbon clusters- discovery of C<sub>60</sub> – structure of C<sub>60</sub> – crystal – alkaline doped C<sub>60</sub> –  
superconductivity in C<sub>60</sub> – large and smaller fullerenes – other buckyballs; carbon nanotubes –

fabrication– structure– electricalproperties– vibrationalproperties–  
mechanicalproperties;applicationsofcarbonnanotubes–fieldemissionandshielding–computers – fuel  
cells– chemicalsensors–catalysis– mechanicalreinforcement.

### Unit-III - Inorganic Nanostructures

Overview of semiconductorphysics-Quantumconfinement-The electronic densityofstates -  
Fabricationtechniques- Physical Processes of semiconductor nanostructures-Thecharacterisation of  
semiconductor nanostructures-Applications.

### Unit-IV - Nanostructured Molecular Materials

Introduction;Buildingblocks-Self-assembly-Principles-MethodstoPrepareandPatternNanoparticles-  
TemplatedNanostructures-LiquidCrystalMesophases-Macromolecularinterfaces -  
Theprinciplesofinterfascience -Analysisofwetinterfaces -  
InterfaceModification-organicthinfilms -Surfaceeffectsonphaseseparation -  
Nanopatterningsurfacesbyself-assembly-nanoscale devices exploitingmacromolecularinterfaces .

### Unit-V -Evolving Interfaces of Nano

Nanobiology - Introduction - Bio-inspirednanomaterials-  
InteractionBetweenBiomoleculesandNanoparticleSurfaces-  
DifferentTypesofInorganicMaterialsUsedforthe Synthesisof Hybrid Nano-bioAssemblies -  
Applicationsof Nanoin Biology -NanoprobesforAnalyticalApplications-  
CurrentStatusofNanobiotechnology-FuturePerspectivesof Nanobiology;  
Nanosensors - Introduction - What is a Sensor? -  
Nanosensors-OrderfromChaos-Characterization-Perception-  
NanosensorsBasedonQuantumSizeEffects-ElectrochemicalSensors-  
SensorsBasedonPhysicalProperties-Nanobiosensors-SmartDust;Nanomedicines-Introduction-  
ApproachtoDevelopingNanomedicines- Various Kinds of Nanosystems in Use - Protocols for  
NanodrugAdministration- Nanotechnology in Diagnostic Applications - Materialsfor Use  
inDiagnosticandTherapeutic Applications- FutureDirections.

### References

1. NanoscaleScienceandTechnology,RobertW. Kelsall,IanW. HamleyandMarkGeoghegan, John Wiley&Sons,Ltd., UK, 2005.
2. IntroductiontoNanotechnology,CharlesP. Poole JrandFrankJ.Owens,WileyInterscience, 2003.
3. Bio-InspiredNanomaterialsandNanotechnology,Edited byYong Zhou,NovaPublishers.
4. Nano:TheEssentials:UnderstandingNanoscienceandNanotecnology,T.Pradeep,ataMcGraw-Hill PublishingCompanyLimited,NewDelhi, 2008.

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### Course Code and Title : 13B – Classical Mechanics

Course Type : Core (for Physics)

Semester : I

Credits: 4

**Preamble :**This course is a broad, theoretical treatment of classical mechanics, useful in its own right for treating complex dynamical problems, but essential in understanding the foundations of quantum mechanics and statistical physics. The main goal of the course is to introduce students to classical mechanics and its applications and to learn the fundamentals. Classical concepts such as momentum,



energy, angular momentum are central to physics and essential for formulating quantum mechanics; one must understand these concepts at the classical level to have any hope of understanding their quantum analogues.

**Prerequisite** :Basic knowledge in Physics, interest and problem solving skills.

### Course Objectives

- The understanding of the history and knowledge of physics and the physics principles that shape our world
- How to develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics
- Skills in formulating and solving physics problems along with critical thinking skills.
- How to use Newton's laws of motion to solve advanced problems involving the dynamic motion of classical mechanical systems
- How to represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulations of classical mechanics

### Course Outcomes

**CO1:** Demonstrate an intermediate knowledge of Newton's Laws

**CO2:** Demonstrate a basic knowledge of equations of motion

**CO3:** Understanding basic mechanical concepts related to discrete and continuous mechanical systems

**CO4 :** Knowledge of planar and spatial motion of a rigid body

**CO5:** Understanding the motion of a mechanical system using Lagrange-Hamilton formalism.

**CO6:** Students acquire knowledge about the concepts and mathematically formulated laws of mechanics, which enables them to understand mechanical phenomena in nature as well as to solve simple problems

**CO7:** Apply advanced Newtonian methods to complex motion problems

### Unit-I - Mechanics of Single and Systems of Particles

Newton's laws of motion - Mechanics of a particle - Equation of motion of a particle - Motion of a particle under constant force and alternating force - Mechanics of systems of particles - Angular momentum of the system - Potential and kinetic energies of the system - Motion in a central force field - Motion of two particles equivalent to single particle - Equation of motion of centre of mass with respect to centre of force - Motion in an inverse-square law force field - Classification of orbits

### Unit-II - Collisions of Particles and Motion of Rigid Body

Elastic and inelastic scattering - Laboratory and centre of mass systems - Relations between different quantities in the laboratory and centre of mass systems - Inelastic scattering in the laboratory frame - Motion of a rigid body and Euler's theorem - Angular momentum and kinetic energy - Inertia tensor - Euler's equation of motion - Free motion of rigid body – Euler's angles

### Unit-III - Lagrangian and Hamiltonian Formulations

Hamilton's variational principle - Lagrange's equations of motion –Conservation theorems and symmetry properties – Cyclic coordinates - Application of Lagrange's equation; Linear harmonic oscillator, particle moving under a central force, Atwood's machine - Hamilton's equations of motion - Application of Hamiltonian's equations of motion; Double pendulum, Particle moving in an electromagnetic field - Phase space - Principle of least action

#### Unit-IV - Canonical Transformations and Poisson Brackets

Canonical transformations – Generating function – Properties of canonical transformations – Poisson brackets – Properties of Poisson brackets – Constant of motion using Poisson brackets – Poisson brackets of canonical variables – Poisson's Theorem – Invariance of Poisson bracket under canonical transformation – Motion as successive canonical transformation (Infinitesimal generators) – Liouville's theorem - The Hamilton–Jacobi equation – Action and angle variables

#### Unit-V: Small Oscillations and Special Theory of Relativity

Small oscillations - Stable and unstable equilibrium - Lagrange's equation of motion for small oscillations - Normal coordinates and normal frequencies - Small oscillations of particles on string - Free vibrations of linear triatomic molecule – Basic postulates of special theory of relativity – Lorentz transformation – Kinematic effects of Lorentz transformation – Relativistic generalisation of Newton's law.

#### References

1. Introduction to Classical Mechanics, R. G. Takwale and P. S. Puranik, Tata McGraw-Hill, New Delhi, 2006.
2. Classical Mechanics by Herbert Goldstein, Charles Poole and John Safko, Pearson Education and Dorling Kindersley, New Delhi, 2007.
3. Classical Mechanics, Gupta Kumar, Sharma, PragatiPrakashan, New Delhi, 2001.
4. Classical Mechanics, John R. Taylor, University Science books, India, 2005.
5. Classical Mechanics, R. Douglas Gregory, Cambridge University press, India, 2008.

#### Tutorial (This portion is not intended for examination)

1. A particle is projected vertically upwards with speed  $u$  and moves in a vertical straight line under uniform gravity with no air resistance, find the maximum height achieved by the particle and time taken for it to return to its starting position.
2. A body of mass  $m$  is suspended from a fixed point by a light spring and moving under uniform gravity. The spring is found to be extended by a distance  $b$ . Find a period of oscillations of the body about this equilibrium position (assume there is a small strain).
3. Find the moment of inertia of a uniform circular disk of mass  $M$  and radius  $a$  about its axis of symmetry.
4. Find the kinetic energy of rotation of a rigid body with respect to the principle axes in terms of Eulerian angles.
5. Find the equation of motion of harmonic oscillator using Hamilton–Jacobi method.
6. Simple pendulum with rigid support, and with variable length

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#### Course Code and Title : 13E - Organic Chemistry - I

Course Type : Core(for Chemistry)

Semester : I

Credits: 4

**Preamble:** The aim of this organic chemistry course is to introduce students to many of the key concepts of organic chemistry through a survey of the basic reactions of selected monofunctional aliphatic and aromatic molecules. Particular emphasis is placed on the underlying mechanistic pathways that are involved together with some of their stereochemical consequences. The application of spectroscopic techniques for the determination of molecular structure is also considered. Hence, the course seeks to establish a sound foundation on which further learning in organic chemistry can build. Practical component:

**Pre-requisite:** Basic knowledge in chemistry in the intermediate level with little knowledge in organic chemistry.

**Course Objectives:**

- To understand the basic concepts about how the organic reactions are carried out and also to make the students understand the mechanism of different organic reactions.
- To learn Huckel's rule for find out aromatic nature of organic molecules.
- An organic reaction mechanism is detailed study of the actual steps by means of which a mechanism takes place in a chemical reaction.
- To understand carbon-carbon bond formation.
- To be able to get familiarized with almost all the basic organic concepts.

**Course Outcomes:** At the end of the course the students should be able to:

**CO1:**Familiar in aromaticity, which helps to predict new structure analysis.

**CO2:**Students are able to write mechanisms of organic reactions.

**CO3:**Students will be able to learn the importance substitution, elimination, and elimination reactions and their applications.

**CO4:**Students will apply the learned fundamental instrumental techniques in the physical characterization of organic molecules.

**CO5:**Students will be handled easily most of the reagents and solvents

**CO6:**To apply all concepts for their new molecules design.

**Unit-I**

*Aromaticity:*Criteria-Huckel's rule—diatropic molecules—Aromaticity of Benzenoids and heterocyclic compounds. Non-benzenoid aromatics— azulene, ferrocene, tropolone, syndones and annulenes (synthesis not required)— Non-aromatic and anti-aromatic systems.

*Study of Organic Reaction Mechanism*—non-kinetic methods— product analysis intermediate criteria (isolation, trapping and detection)— isotopic labelling and crossover experiments— stereochemical evidence— energy profile diagrams— intermediate vs. transition state. Kinetic methods— mechanistic implications of rate law— isotope effects— kinetic and thermodynamic control of reactions— Hammond's postulate— linear free energy relationship— Hammett and Taft equations

**Unit-II**

*Aromatic Electrophilic Substitution* — mechanism, orientation and reactivity of mono and disubstituted benzenes. Specific reactions - Friedel-Craft's alkylation and acylation- Formylations (Gattermann, Gattermann-Koch, Reimer-Tiemann, Kolbe's, Vilsmeier-Haack), Bischler-Napieralski, Hofmann-Martius and Jacobson reactions.

*Aliphatic Electrophilic Substitution*—SE<sup>1</sup>, SE<sup>2</sup> and SE<sup>i</sup> mechanisms—Friedel-Craft's acylation at olefinic carbon— Stork-enamine reaction— decarboxylation of aliphatic acids.

**Unit-III**

*Aliphatic Nucleophilic Substitution* —SN<sup>1</sup>, SN<sup>2</sup>, ion-pair, SN<sup>i</sup> mechanisms—neighbouring group participation — stereochemistry— Reactivity— effect of substrate structure, nucleophile, leaving group, and the reaction medium— ambient nucleophiles (regioselectivity) and ambient substrate— hydrolysis of esters.

*Aromatic Nucleophilic Substitution- SN<sup>1</sup>, SN<sup>Ar</sup> and benzyne mechanisms- structure and reactivity-effect of substrate structure, leaving groups and nucleophile-typical reactions -Bucherer, Rosenmund, Von-Braun, Ziegler, Chichibabin reactions -Von-Richter, Sommelet-Hauser and Smiles rearrangements.*

#### Unit-IV

*Elimination Reactions—E<sub>1</sub>, E<sub>2</sub> and E<sub>1cB</sub> mechanisms- structural and stereochemical factors governing eliminations, Hofmann and Saytzeff rule – Bredt's rule – elimination vs. substitution-pyrolytic degradation eliminations-Chugaev reaction-Hofmann -Cope elimination.*

*Addition Reactions: Electrophilic, nucleophilic and free radical addition to double and triple bonds- hydration, hydroxylation (OsO<sub>4</sub>, KMnO<sub>4</sub>, H<sub>2</sub>O<sub>2</sub>, Woodward & Prevost methods), Michael addition, hydroboration and epoxidation-sharpless asymmetric epoxidation, Skraup synthesis.*

#### Unit -V

*Oxidation— Jones reagent, Pyridinium chlorochromate (PCC), Pyridinium dichromate (PDC), Chromyl chloride, Dicyclohexylcarbodiimide (DCC), DMSO, DMSO-Ac<sub>2</sub>O, DMSO-oxalyl chloride (Swern reaction), Oppenauer oxidation, Sommelet reaction- oxidative cleavage of 1, 2 – diols (lead tetra acetate and periodic acid), Etard reaction, Dichlorodicyanobenzoquinone (DDQ), SeO<sub>2</sub>, ozonolysis, allylic oxidation (SeO<sub>2</sub> & NBS)*

*Reduction— catalytic hydrogenation— typical reactions— catalysts and solvents, catalytic dehydrogenation. Metal hydride reduction— typical reactions and conditions used— LiAlH<sub>4</sub>, NaBH<sub>4</sub> and NaCNBH<sub>3</sub> reductions, hydroboration, 9BBN, tri-n-butyltin hydride (TBH), DIBAL— H, Me<sub>3</sub>SiCN, tritertiarybutoxyaluminum hydride, stereochemistry of reduction of cyclic ketones with metal hydrides. Dissolving metal reductions— Birch reduction, Clemmensen reduction, Wolff-Kishner, Meerwein-Ponndorf-Verley and Rosenmund reduction, McMurray coupling, Cannizzaro reaction, acyloin condensation, Wilkinson's catalyst.*

#### References

1. Advanced organic chemistry- Reactions, mechanism and structure. Jerry March, McGraw Hill Kogakusha Ltd., 1977.
2. Mechanism and Theory in Organic Chemistry, Lowry and Richardson, Harper & Row Publishers, New York 1981.
3. Reactions mechanisms in organic chemistry, Mukerjee and S. P. Singh, McMillan 1976.
4. Organic Chemistry, Vol-I, I.L. Finar, Longmans, 1963.
5. Advanced Organic Chemistry, Jagdamba Singh and L.D.S. Yadav, Pragati Prakasan, 2011-12.
6. Organic Synthesis, 7<sup>th</sup> Edition, Jagdamba Singh and L.D.S. Yadav, Pragati Prakasan, 2011.
7. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge University Press, 1971.
8. Principles of Organic Synthesis, Norman, John Wiley & Sons, 1973.
9. Guidebook to Organic Synthesis, R. K. Mackie and D. M. Smith, Longman, 1982.

**Course Code and Title : 13H – Biochemistry**

**Course Type : Core (for Biotechnology)**

**Semester : I**

**Credits: 4**

**Preamble :** This is a course offered in first semester for the students admitted who in Biotechnology stream. The course has four credits dedicated to provide the students a strong foundation on the principles and concepts of biochemical metabolism.

**Prerequisite:** Basic understanding of Biochemical concepts

**Course Objectives:** On the successful completion of the course the students will get an overall understanding of structure of atoms, molecules and chemical bonds, enzyme kinetics, bio polymers and metabolic reactions in a living system.

**Course Outcomes:** On the successful completion of the course, students will be able to

- CO1 :** the students will get an overall understanding of structure of atoms, molecules and chemical bonds, enzyme kinetics, bio polymers and metabolic reactions in a living system
- CO2 :** the student with a firm foundation in the biochemical aspects of cellular functions which forms a base for their future research.
- CO3 :** the study of identification and quantitative determination of the substances, studies of their structure, determining how they are synthesized metabolized and degraded in organisms, and elucidating their role in the operation of the organism.
- CO4 :** Interpretation of subject knowledge with the bio molecules and the process of energy metabolism
- CO5 :** Understanding the analytical techniques and its basic principles
- CO6 :** Demonstration of how basic biomolecules involved in life process in living cells

**Unit-I**

Structure of atoms, molecules and chemical bonds; Classes of organic compounds and functional groups. Covalent and Noncovalent interactions- Vander Waals, Electrostatic, Hydrogen bonding and hydrophobic interactions, Thermodynamics, kinetics, dissociation and association constants: Enzymes and coenzymes; Respiration and photosynthesis. Chemical foundations of Biology- pH, pK, acids, bases and buffers, Henderson-Hasselbalch equation, biological buffers solutions. Energy metabolism (concept of free energy); Principles of thermodynamics; energy rich bonds; weak interactions; coupled reactions and oxidative phosphorylation; group transfer; biological energy transducers; bioenergetics.

**Unit -II**

*Sugars-* classification and reactions. Polysaccharides: classification, occurrence, isolation, purification, properties and biological reactions. Structural features of homoglycans, heteroglycans and complex carbohydrates. Methods for compositional analysis.  
*Proteins:* Amino acids and peptides- classification, chemical reactions and physical properties. Peptide bond, Primary structure of proteins, structural comparison at secondary and tertiary levels (Ramchandran map), conformation of proteins and polypeptides (secondary, tertiary, quaternary and domain structure), Purification and criteria

homogeneity:protein folding-biophysical and cellular aspects.

*Lipids*: Classification, structure and functions. Triglycerides; Phospholipids; Steroids and terpenes. Glyco and lipoproteins-structure and function. Role of lipids in biomembranes.

*Nucleic acids*: Structure of double stranded DNA (B, A, C, D, T and Z DNA). The biological significance of double strandedness, sequence dependent variation in the shape of DNA. Physical properties of double stranded DNA. Types of RNAs and their biological significance. DNA bending, DNA supercoiling. Conformational properties of polynucleotides, secondary and tertiary structural features and their analysis.

### Unit -III

Enzyme kinetics (negative and positive cooperativity); Regulation of enzymatic activity; Enzyme catalysis in solution. kinetics and thermodynamic analysis, effects of organic solvents on enzyme catalysis and structural consequences. Active sites; Coenzymes: activators and inhibitors, kinetics of enzyme inhibitors, isoenzymes, allosteric enzymes; Ribozyme, hammerhead, hairpin and other ribozymes, strategies for designing ribozymes. Abzyme: structure and drug targets (enzymes and receptors); Prodrug delivery using enzymes; Bioluminescence

### Unit -IV

Silk fibroin, coiled coils, collagen triple helix and hemoglobin. Denaturation and renaturation of proteins. Lysozyme-structure, enzymic activity, mechanism of lysozyme action. Analytical techniques: separation techniques, small and macro biomolecules, Protein-Protein and protein-ligand interactions. Physical and chemical methods for immobilization of small and macro molecules.

### Unit-V

Glycolysis and TCA cycle; Glycogen breakdown and synthesis; Gluconogenesis; interconversion of hexoses and pentoses: Co-ordinated control of metabolism; Biosynthesis of purines and pyrimidines; Oxidation of lipids; Biosynthesis of fatty acids; Triglycerides; Phospholipids; Sterols.

### References

1. Biochemistry, Christopher K. Mathews, Kensal E. van Holde, Kevin G. Ahern, 3<sup>rd</sup> Edition, Pearson Education, 2000.
  2. Principles of Biochemistry, Abraham White, Philip Handler, Emil L. Smith., McGraw-Hill International book Company, 8<sup>th</sup> Edition, 1973.
  3. Principles of Biochemistry, Lehninger, Nelson, Cox, CBS publishers and distributors, New Delhi, 2004.
  4. Fundamentals of Biochemistry, Donald Voet, Akif Uzman, Judith G. Voet, Charlotte W. Pratt, John Wiley and Sons, New York, 2008.
  5. Biochemistry, Geoffrey L. Zubay, WCB publishers, 1998.
  6. Harper's Biochemistry, R.K. Murray, D.K. Granner, P.A. Mayes and V.W. Rodwell, 24<sup>th</sup> edition, Stamford, 1996.
  7. Biochemistry (6<sup>th</sup> Ed.)-J.M Berg; J.L. Tymoczko and L. Stryer, WH Freeman and Company, NY.
-

### Course Code and Title : 13C – Quantum Mechanics

Course Type : Core (for Physics)

Semester : I

Credits: 4

**Preamble :** This course develops concepts in quantum mechanics such that the behaviour of the physical universe can be understood from a fundamental point of view. We will discuss analytic solutions to the Schrodinger equation for a variety of potentials in one, two and three dimensions. The role of symmetries as the underlying principle of Quantum Mechanics will be emphasized throughout the course. The use of symmetry principles and operators methods will be discussed.

**Prerequisite:** Basic knowledge in General Physics and Mathematics

#### Course Objectives

- How to perform calculations on simple systems using the Schrödinger equation; we introduce Heisenberg's principle of uncertainty, the concept of spin and the Pauli principle.
- To understand the central concepts and principles in quantum mechanics, such as the Schrödinger equation, the wave function and its statistical interpretation, the uncertainty principle, stationary and non-stationary states and time evolution of solutions
- Be able to solve the Schrödinger equation on their own for simple systems in one to three dimensions, both analytically and by using robust numerical methods.
- Relating the knowledge of mathematics to the formalism of quantum mechanics

#### Course Outcome

**CO1:** Pinpoint the basic of quantum mechanics starting from Eigen functions and values

**CO2:** Understand and explain the differences between classical and quantum mechanics

**CO3:** Understand the idea of wave function and the uncertainty relation

**CO4:** Able to solve Schrodinger equation for simple potentials

**CO5:** Spot, identify and relate the eigenvalue problems for energy, momentum, angular momentum and central potentials explain the idea of spin

**CO6:** General experience with non-relativistic quantum mechanics that is useful for further studies in theoretical physics, as well as nanotechnology

#### Unit-I - General Formalism of Quantum Mechanics

Linear Vector Space- Linear Operator- Eigen Functions and Eigen Values- Hermitian Operator- Postulates of Quantum Mechanics- Simultaneous Measurability of Observables- General Uncertainty Relation- Dirac's Notation- Equations of Motion; Schrodinger, Heisenberg and Dirac representation- momentum representation.

#### Unit-II - Energy Eigen Value Problems

Particle in a box – Linear Harmonic oscillator- Tunnelling through a barrier- particle moving in a spherically symmetric potential- System of two interacting particles-Rigid rotator- Hydrogen atom

#### Unit-III - Angular Momentum

Orbital Angular Momentum-Spin Angular Momentum-Total Angular Momentum Operators- Commutation Relations of Total Angular Momentum with Components-Ladder operators- Commutation Relation of  $J_z$  with  $J_+$  and  $J_-$  - Eigen values of  $J^2$ ,  $J_z$ - Matrix representation of  $J^2$ ,  $J_z$ ,  $J_+$  and  $J_-$  - Addition of angular momenta- Clebsch Gordon Coefficients – Properties.

#### Unit-IV - Approximate Methods

Time Independent Perturbation Theory in Non-Degenerate Case-Ground State of Helium Atom  
Degenerate Case-Stark Effect in Hydrogen – Spin-orbit interaction-Variation Method & its  
Application to Hydrogen Molecule- WKB Approximation.

#### Unit-V: Many Electron Atoms

Indistinguishable particles – Pauli principle- Inclusion of spin – spin functions for two-electrons-  
The Helium Atom – Central Field Approximation - Thomas-Fermi model of the Atom - Hartree  
Equation- Hartree -Fock equation.

#### References

1. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, Tata McGraw Hill, 2010.
2. Quantum Mechanics, G. Aruldas, Prentice Hall of India, 2006.
3. Introduction to Quantum Mechanics, David J.Griffiths, Pearson Prentice Hall, New Delhi, 2005.
4. Quantum Mechanics, L.I Schiff, McGraw-Hill, 1968.
5. Quantum Mechanics, A. Devanathan, Narosa Publishing, New Delhi, 2005.
6. Principles of Quantum Mechanics, R.Shankar, Springer, 2005

#### Tutorial: (This portion is not intended for examination purpose)

1. Plotting of harmonic oscillator wave functions
2. Problems involving matrix representations of an operator
3. Alpha emission
4. Kronig-Penney Square-well periodic Potential

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### 13F : Inorganic Chemistry – I

Course Type : Core (for Chemistry)Semester : I

Credits: 4

**Preamble:** The aim of this course is to provide a core for future studies in inorganic chemistry and allied subjects, in the following areas; Homocyclic and Heterocyclic Ring Compounds; Reactions in Non-aqueous Solvents; Nuclear Chemistry; Experimental methods; Nuclear Reactions.

**Pr-requisite:** Basic knowledge in chemistry in the intermediate level with little knowledge in inorganic chemistry.

#### Course Objectives:

- To enhance the level of understanding of structure, bonding and reaction mechanism involved in inorganic complexes.
- To learn inorganic homocyclic and heterocyclic ring compounds.
- To enable students to apply the concepts of non-aqueous solvents and acids-bases theory.
- To analyze and interpret nuclear reactions.



**Course Outcomes:** At the end of the course the students should be able to:

- CO1:** Students will be able to analyze how structure and bonding, reactivity influence the functions and to design & develop new systems.
- CO2:** Students will be able to use various inorganic solvents for modern biomaterials synthesis.
- CO3:** Students will know how to synthesize inorganic materials and analyze them using various analytical instruments.
- CO4:** Students will be Identified the structure and bonding aspects of simple nuclear reactions.

### Unit-I

*Homocyclic and Heterocyclic Ring Compounds* - Borazines, phosphonitrilic compounds, sulphur-nitrogen compounds, organohalosilanes, silanols, siloxanes, silylamines (silazenes) Isopoly and heteropoly acids of vanadium, chromium, molybdenum and tungsten

### Unit -II

*Reactions in Non-aqueous Solvents:* Classification of solvents – properties of ionizing solvents – a general study of the typical reactions in liquid ammonia, sulphur dioxide, anhydrous hydrogen fluoride, hydrogen sulphide and hydrocyanide – a comparative study, organophosphorus compounds, alkyl lithium compounds.  
*Acids and Bases* - Lowry-Bronsted theory - Lewis concept – Hardness and softness of acids and bases.

### Unit-III

*Nuclear Chemistry* - The nucleus – subatomic particles and their properties – binding energy -  $n$ : prations in stable and metastable nuclei – Different types of nuclear forces – Liquid drop model and Shell model.  
Modes of radioactive decay – Theory of alpha decay, beta decay and gamma radiation. Orbital electron capture, nuclear isomerism – Internal conversion.

### Unit-IV

*Experimental Methods* - Cloud chamber, nuclear emulsion, bubble chamber, proportional counters, G M counter, Scintillation and Cherenkov counters  
*Particle Accelerators* - Linear accelerators – cyclotron, synchrotron, Betatron and Bevatron.

### Unit-V

*Nuclear Reactions* -  $Q$ -value, coulombic barrier – nuclear cross section – different types of nuclear reactions - projectile capture – particle emission, spallation, fission and fusion – Product distributions – theories of fission, use of fission products, fissile and fertile isotopes - U-233, U-235, Pu-239, Th-232 – Stellar energy – Synthesis of new elements.  
*Radioisotopes* - Applications – isotopes as tracers – neutron activation analysis and isotopic dilution analysis – uses in structure and mechanistic studies – carbon dating

### References

1. Advanced Inorganic Chemistry, F.A. Cotton and G. Wilkinson, C. A. Murillo, M. Bochmann, John Wiley & Sons, VI Edition, 2003-04.
2. Modern Aspects of Inorganic Chemistry, H.J. Emeleus and A.G. Sharpe, John Wiley & Sons, 1973.
3. Source book on Atomic Energy, S. Glasstone, Krieger Pub. Co., 1979.

4. Advanced Inorganic Chemistry, Gurdeep Raj and Mehra Harish, Goel Publishing House, 1976.
  5. Chemistry in Non-aqueous solvents, Harry H. Sisler, Reinhold, 1961
  6. Nuclear and Radiochemistry, G. Friedlander, J. W. Kennedy and J. M. Miller, John Wiley, 1964.
  7. Inorganic Chemistry, J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Pearson Education Inc., 1993.
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### Course Code and Title : 13I – Microbiology

**Course Type : Core (for Biotechnology)**

**Semester : I**

**Credits: 4**

**Preamble :** The course offered in the first semester to make students to deal with the microscopic living structures. Understanding the elemental knowledge of microorganisms and its life process is the prime focus.

**Prerequisite:** Acquire knowledge on basics of microorganisms

#### Course Objectives:

- To acquaint students with the basic laboratory techniques and tools of microbiology.
- To introduce the fundamental characteristics of various microorganisms.
- To develop lab skills, including collection and analysis of data, the ability to draw valid conclusions and apply these conclusions within a larger framework.
- To develop a heightened sense of understanding in students about the microscopic world around them.

**Course Outcomes:** On the successful completion of the course, students will be able to

- CO1 :** the students will get an overall understanding of basic history and classification of microorganisms
- CO2 :** learning the techniques to obtain auxenic culture and cultivation of microorganisms using range of media
- CO3 :** to get equipped with the theoretical understanding of growth parameters and study the kinetics of growth
- CO4 :** to provide information on various types of sterilization techniques and standard procedures involved to achieve contamination free environment.
- CO5 :** Understanding the growth physiology of microorganisms and its metabolic process
- CO6 :** to provide basic information on conversion and synthesis of macromolecules and their role in metabolism

#### Unit-I

History of Microbiology-

History of Microbiology. Principles of classification of microbes; morphological, metabolic and molecular criteria for the classification, A brief introduction to major group of bacteria. Ultrastructure of bacteria.

#### Unit -II

Microbial Cultivation-

Nutritional types requirements of bacteria. Cultivation of bacteria: Pure culture techniques different media. Culture media and preparation:-  
Preservation of cultures aerobic and anaerobic culture techniques. Batch and synchronous cultures. Growth curve and factors influencing growth

#### Unit-III

Control of Microbial growth-Principles and techniques:-Physical and Chemical methods. Disinfection- Method of action of disinfectants. Methods of testing disinfectants.

#### Unit IV

Microbial physiology-Staining characteristics, Gram staining, AFB staining, fluorescent staining, serological characteristics:- surface antigen, capsular antigen & flagellar antigen, Cultural characteristics, Photosynthetic microorganisms, cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria. Bacterial aerobic respiration, Bacterial anaerobic respiration: introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria. Mechanism of oxygen toxicity. Bacterial transport system-ABC, Sec pathway, PTS, role of permeases in transport, different permeases in E. coli.

#### Unit V

Microbial Diversity-General properties of fungi, fungal classification, economic importance of fungi, Mycoplasma, Actinomycetes, Archeobacteria (extremophiles) and microbial algae.

#### References

1. Microbial Physiology and Metabolism by Caldwell D.R. 1995 Brown Publishers.
2. Microbial Physiology by Moat A.G. and Foster J. W. 1999. Wiley.
3. Prokaryotic Development by Brun. Y.V. and Shimkets L.J. 2000. ASM Press.
4. Advances in Microbial Physiology. Volumes. Edited by A.H. Rose. Academic Press, New York.
5. Applied Microbial Physiology by Rhodes.
6. Principles of bacteriology, virology and immunology Vol I Topley and Wilson
7. Zinser, Microbiology
8. Microbiology, Prescottt, Harley and Klein
9. Foundations in Microbiology Talaro and Talaro
10. Text book of Microbiology, R Ananthanarayanan C K J Panicker
11. Microbiology, Pelczar, Chan and Kreig.

### Course Code and Title : 13D – Mathematical Physics

Course Type : Core (for Physics)

Semester : I

Credits: 4

**Preamble :** The intent of the course has been to cover a number of intermediate and advanced topics in applied mathematics that are needed by science and engineering majors. The course was originally designed for postgraduate level students enrolled in Physics, Applied Physics, Nanoscience and Technology and other engineering departments. This emphasizes the development of rigorous logical thinking for solving different kinds of problems that occur in mathematical applications. The material we cover includes intermediate topics in Matrices, Linear algebra, Special differential equations, Fourier series, Fourier and Laplace transforms, theorem and Applications of these transformations. We have used an organization that can develop fundamental pedagogical knowledge for solving real, physical problems.

**Prerequisite:** Under Graduate level, differential and integration Calculus – Use theorems and Logics

**Course Objectives:** The objective of this course is to develop a working knowledge of Mathematical Physics at the post-graduate level and to use this knowledge to explore various applications.

**Course Outcomes:** On the successful completion of the course, students will be able to

**CO1:** Learn the types and properties of Matrices and find the rank of matrices.

**CO2:** Solve linear homogeneous and non-homogeneous equations and Use Cramer's rule and Check the Eigen values and vectors of matrices.

**CO3:** Find the solutions of linear and non-linear second order differential equations and apply power series and extended power series methods for identical equations.

**CO4:** Understand and validate the properties and generating functions of Legendre, Bessel and Hermite's polynomial functions

**CO5:** Represent first and second translational properties Laplace transforms, derivatives and theorems.

**CO6:** Verify Laplace and Inverse Laplace transformation of given functions

**CO7:** Identify and use the Fourier series expansions and theorems and Solve problems relevant to periodic functions.

### Unit-I - Matrices and Determinants

Properties of matrix addition and multiplication – different types of matrices and their properties – Rank of a Matrix and some of its theorems – solutions to linear homogeneous and non homogeneous equations – Cramer's rule - eigenvalues and eigenvectors of matrices – differentiation and integration of a matrix

### Unit-II - Solving Differential Equations

Homogeneous linear equations of second order with constant coefficients and their solutions – ordinary second order differential with variable coefficients and their solution by power series and Frobenius methods - extended power series method for indicial equations

### Unit-III - Special Differential Equations and their Solutions

Legendre's differential equation: Legendre polynomials - Generating functions – Recurrence Formulae – Rodrigues's formula – orthogonality of Legendre's polynomial; Bessel's differential equation: Bessel's polynomial - generating functions – Recurrence Formulae – orthogonal properties of Bessel's polynomials – Hermite differential equation– Hermite polynomials – generating functions – recurrence relation.

### Unit-IV - Laplace Transforms

Laplace transforms: Linearity property, first and second translation property of LT – Derivatives of Laplace transforms – Laplace transform of integrals – Initial and Final value theorems; Methods for finding LT: direct and series expansion method, Method of differential equation; Inverse Laplace transforms: Linearity property, first and second translation property, Convolution property – Application of LT to differential equations and boundary value problems

### Unit-V - Fourier Series and Integrals

Fourier series definition and expansion of a function – Dirichlet's conditions – Assumptions for the validity of Fourier's series expansion and its theorems – Complex representation of Fourier series - Problems related to periodic functions – graphical representation of FS – Fourier integrals - convergence of FS – some applications of Fourier transforms

### References

1. Mathematical Physics, B. D. Gupta, 3<sup>rd</sup> Edition, Vikas Publishing House PVT.LTD, 2006.
2. Mathematical Physics, B.S. Rajput, 17<sup>th</sup> Edition, PragatiPrakasam, 2004.
3. Advanced Engineering mathematics, Erwin Kreyszig, 7<sup>th</sup> Edition, Wiley Eastern Limited Publications, 1993.
4. Mathematical methods for physics, G. Arfken, 4<sup>th</sup> edition, 1992.
6. Special Function for scientist and engineers, W.W.Bell, D. Van Nostrand Company Ltd, London,1968.

### Tutorial: Mathematical Physics (This portion is not intended for examination purpose)

1. Fourier Transformation (FT) of Gaussian functions.
  2. Applications of FT of dirac delta function.
  3. Solution of time dependent problems by FT.
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### CourseCode andTitle :13G–Physical Chemistry-I

CourseType:Core(for Chemistry)

Semester :I

Credits: 4

**Preamble:** Physical chemistry is the study of macroscopic, atomic, subatomic, and particulate phenomena in chemical systems in terms of the principles, practices, and concepts of physics such as motion, energy, force, time, quantum chemistry, analytical dynamics and equilibrium. The students pursuing this course would have to develop in depth understanding of various aspects of the subject. Physical chemistry courses are instilled in with the knowledge of chemistry and the fundamentals used for its applicability in the career. Students are imparted with the analytical, evaluative and interpreting skills so as to help in solving problems.

**Prerequisite :**Higher Secondary Level, Degree Level – Molecular symmetry, kinetic theory, Classical mechanics, electrochemistry.

### Course Objectives

- To understand the basics of molecular symmetry, point symmetry, rate of the reaction and type of the chemical reaction.
- To understand the basics of various catalytic reactions.

**Course Outcomes:** After learning this course the students can able

- CO1:** To understand the fundamental concepts and techniques used in group theory.
- CO2:**To understand molecular symmetry and its application in character table
- CO3:**To explain the Raman and IR active compounds
- CO4:**To understand and analyze the various chemical kinetics
- CO5:**To explain rate of the reaction.
- CO6:**To solve kinetics and equilibrium problems
- CO7:**To understand enzyme catalysis to find the mechanism of reaction.

### Unit-I

Molecular symmetry and group theory – Point symmetry – Schönflies and Herman-Mauguin notations – identification of point groups of simple molecules – postulates of group theory – group multiplication table – orthogonality and irreducible representations – application of the orthogonality theorem to obtain their irreducible representations of the point groups  $C_{2v}$  and  $C_{3v}$  only – character table (explanation) different areas of the character tables.

### Unit-II

Application of the group theoretical methods to find the total number of vibrations of simple molecules such as  $H_2O$  and  $NH_3$  – Selection rules with regard to Raman and IR activities and electronic transitions – splitting of orbitals in  $O_h$ ,  $T_d$  and  $D_{4h}$  symmetries – hybridization as applied to methane and water – simplification of MO calculation employing symmetry adopted linear combination molecular orbital procedure – application to butadiene.

### Unit-III

*Chemical Kinetics* – The Arrhenius equation – thermodynamic treatment of Arrhenius equation – significance of reaction coordinate – application of Arrhenius equation – Unimolecular and bimolecular processes – potential energy surface – Kinetic isotopic effect – Principles of microscopic reversibility – Steady State Approximation – third order and termolecular reactions – Applications of Arrhenius equation to solution kinetics – Factors affecting reaction rates in solution.

Chain reactions and explosions – Homogeneous catalysis, Acid-base catalysis – salt effects – acidity functions – Zuckerman-Hammett hypothesis – Bunnett criterion.

### Unit-IV

*Enzyme catalysis* – Mechanism of single substrate reaction – influence of  $P^H$  and temperature – fast reactions – Kinetics of polymerization in solution – Heterogeneous catalysis adsorption and free energy relation at interfaces – Gibbs adsorption isotherm – Physical adsorption – Chemisorption – Potential energy diagram and Lennard-Jones plots – Langmuir and BET isotherms – Measurement of surface area – Semiconductor catalysis – Langmuir-Hinshelwood and Langmuir-Rideal – Eley mechanisms

### Unit-V

Fast Reactions – Study by stop-flow techniques, relaxation methods. Flash photolysis, magnetic resonance methods. Kinetic theory of gases Postulates – Maxwell distribution of molecular velocities – Expressions for most probable velocity, average velocity, root mean square velocity. Collision diameter, Collision frequency, Mean free path. Transport properties of gases – Thermal conductivity, Viscosity, Diffusion – principle of equipartition of energy.

### References

1. F. A. Cotton, Chemical Applications of Group Theory
2. Ramakrishnan and Gobinathan, Group Theory in Chemistry
3. Raman, Group Theory
4. K.J. Laidler, Chemical Kinetics, Tata McGraw Hill
5. Gurdeep Raj, Chemical Kinetics, Goel Publishing House.
6. P.W. Atkins, Physical Chemistry
7. W.J. Moore, Physical Chemistry, Longmans

8. A.A.FrostandR.G.Pearson, Kineticsand Mechanism, WileyEastern, Pvt.Ltd.

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**Course Code and Title: 13J – Cell and Molecular Biology**

**Course Type: Core (for Biotechnology)**

**Semester: I**

**Credits: 4**

**Preamble:** A Nanoscience and Technology (with biotechnological) student needs to have some basic definition of cell, concepts of cell theory, structure and organization of membranes, molecular events of electron transport chain, structure and types of DNA & RNA, basic mechanisms of gene regulation, different stages of cell cycle (M Phase and Interphase), cell division (Mitosis and Meiosis) and cell differentiation (Gametogenesis and Fertilization). The main objective of this course is to introduce the basic mechanisms of cell cycle and gene regulation used in biotechnological applications. Based on this course aims to giving adequate exposure in the concepts of cell theory, structure and functions of cytosol, mitochondria, chloroplast, endoplasmic reticulum, mechanisms of DNA Replication, transcription, translation and cell differentiation of gametogenesis and fertilization.

**Prerequisite:** Higher Secondary Level, Degree Level – Cell theory, cell division and cell cycle.

**Course Objectives:**

- To gain a thorough understanding of the basic concepts of cell and molecular biology relevant to nanoscience and nanotechnology.
- To understand the (i) organization of biological systems such as viruses, prokaryotic and eukaryotic cells.
- To understand the structures and types of nucleic acids (DNA & RNA) and basic mechanisms of cell division.

**Course Outcomes:** On the successful completion of the course, students will be able to,

- CO1:** The structure and function of the eukaryotic cell and its organelles.
- CO2:** The genetic information flow in the eukaryotic cell; including nucleic acid structures, the definition of a gene, the organization of the genome, the replication, the formation of RNA (transcription), the processing of pre mRNA and the protein synthesis (translation).
- CO3:** The cell cycle and the cell division and account for how these are regulated.
- CO4:** How cells can communicate and the central intracellular signal transduction pathways.
- CO5:** Cell motility and regulation of cell form and movement; including cytoskeleton organization and generation of force and cell motility.
- CO6:** Understand and apply the principles and techniques of molecular biology which prepares students for further education and/or employment in teaching, basic research, or the health professions.
- CO7:** Various levels of gene regulation and protein function including signal transduction and cell cycle control.
- CO8:** Related properties of cancerous cells to mutational changes in gene function.

**Unit-I**

Definition of cell: Structure and function of cells in prokaryotes and eukaryotes; Structure and organization of Membrane - Model membranes, Glyco conjugates and proteins in membrane systems. Intra cellular matrix: structure and biogenesis - Cytosol, mitochondria, chloroplast,

endoplasmic reticulum, peroxisome, lysosomes, endosomes, cytoskeleton .Extra cellular matrix – cell to cell and cell matrix adhesion – selectins, Integrins, cadherins, gap junctions.

### **Unit-II**

Molecular events of electron transport chain: Hydrogen and electron carriers, ATP synthase, Oxidative phosphorylation, photosynthesis and photorespiration. Protein synthesis and post translational modification of proteins vesicular transport and import into cell organelles. Response to stress – active transport, passive - mediated transport, thermodynamics of transport, transport channels and pumps, Neurotransmission, neuromuscular junction.

### **Unit -III**

Oxidative reactions in microbodies: Peroxisomes and Glyoxysomes. Nucleus, The nucleosome, the supranucleosomal structures; Nucleic acid structure and types: DNA (Double helix structure) and RNA; DNA replication; transcription and translation. Gene regulation: prokaryotic gene regulation- Operon concept; lac operon and tryptophan operon; Eukaryotic gene regulation: transcriptional and translational regulations.

### **Unit-IV**

Cell cycle: Different stages of cell cycle - M Phase and Interphase, factors and genes regulating cell cycle. Mechanism of cell division: Mitosis: Prophase, Metaphase Anaphase and Telophase. Meiosis: Different phases of meiosis. Significance of meiosis, post reductional meiosis & chiasmaterminalization. Comparison of Mitosis and Meiosis. Cell signaling – types of cell signaling - G protein mediated, Tyrosine kinase mediated signaling.

### **Unit-V**

Cell differentiation; gametogenesis and fertilization; life cycle and molecular biology of some pathogens – AIDS virus, tuberculosis, malaria parasite, hepatitis virus, filarial parasite and kalazar parasite. Biochemistry and molecular biology of Cancer, tumour suppressor and oncogenes.

### **Techniques (Self Study)**

Radiolabeling techniques: Properties of different types of radioisotopes normally used in biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.

### **References**

1. Molecular cell Biology, Darnell, Lodish, Baltimore, Scientific American Books, Inc., 1994.
  2. Molecular and cellular Biology, Stephen L.Wolfe, Wadsworth Publishing Company, 1993.
  3. Molecular Cloning: a Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York, 2000.
  4. Introduction to Practical Molecular Biology, P.D.Dabre, John Wiley & Sons Ltd., New York, 1998.
  5. Molecular Biology LabFax, T.A. Brown, Bios Scientific Publishers Ltd., Oxford, 1991.
  6. Molecular Biology of the Gene, J.D.Watson, N.H.Hopkins, J.W.Roberts, J.A. Steitz and A.M.Weiner, 4<sup>th</sup> Edition, The Benjamin/Cummings Pub. Co., Inc., California, 1987.
  7. Genes VI, Benjamin Lewin, 6<sup>th</sup> Edition, Oxford University Press, U.K., 1998.
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**Course Code and Title : 1EA – Analog and Digital Electronics**

**Course Type : Elective (for Physics)**

**Semester : I**

**Credits: 4**

**Preamble:** This course deals with semiconductor device characteristics, Op-Amp characteristics and their applications and digital principles

**Pre-requisite:** Basic knowledge in physics or applied science.

**Course Objectives**

- To understand the basics of number systems, digital logic levels, functionality of digital components and
- operation of digital electronics circuits.
- To construct and analyse various digital electronic circuits

**Course Outcomes:** After learning this course the students can able to understand

**CO1:**the fundamental concepts and techniques used in digital electronics.

**CO2:**binary number systems and its application in digital electronics

**CO3:** the functionality of logic gates

**CO4:** and analyze the various digital logic functions

**CO5:** the design Karnaugh map to simplify the Boolean functions

**CO6:** and design various combinational circuits to solve problems

**CO7:**the design of various timer and sequential circuits

**CO8:** and analyze the interface between digital and analogue electronics

**CO9:** the basic concepts of molecular device structure and analyse their operation

**Unit-I - Operational Amplifiers**

The ideal Op-Amp-inverting, non-inverting and differential amplifiers-CMRR; Op-Amp IC building blocks-emitter coupled differential amplifier, active load, level shifting and output stage; Op-Amp characteristics-open-loop input output characteristics, frequency response and slew rate; Op-Amp applications-adder, subtractor, integrator, differentiator, comparator, voltage-to-current converter, current-to-voltage converter and logarithmic amplifier.

**Unit-II - Digital Electronics –**

Logic gates-Boolean algebra and De-Morgan's theorem; Boolean laws and theorem-Sum-of-Products and Products-of-Sums method-Karnaugh simplifications; Multiplexers and Demultiplexers; BCD-to-Decimal decoders-Seven-segment decoders; Decimal-to-BCD encoder; Half-adder and Full-adder circuits

**Unit-III - Flip-Flops**

Types of Flip-Flops-RS Flip-Flop, Clocked RS Flip-Flop, D Flip-Flop, J-K Flip-Flop and J-K Master-Slave Flip-Flops; Schmit Trigger; 555 Timer-Astable and Monostable circuits.

**Unit-IV - Registers and Counters**

Types of Registers-Serial in-Serial out, Serial in-Parallel out, Parallel in-Serial out, Parallel in-Parallel out Registers; Types of Counters-Ring Counters, Asynchronous and Synchronous Counters, Shift Counters; D/A and A/D Converters.

### Unit-V - Molecular Electronics

Molecular Scale Electronics – Introduction – Nanosystems – Engineering Materials At the Molecular Level - Molecular Device Architectures – Molecular Rectification – Electronic Switching and Memory Devices – Single Electronic Devices – Optical and Chemical Switches – Nanomagnetic Systems – Nanotube Electronics – Molecular Actuation – Logic Circuits – Computing Architectures – Quantum Computing.

### References

1. Text Book of Electronics, S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
2. Digital Principles and Applications, A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi, 1986.
3. Molecular Electronics From Principle to Practice, Michael C. Petty, John Wiley & Sons. Ltd., 2007.
4. Electronics Principles, Malvino, 6<sup>th</sup> Edition, Tata McGraw-Hill Publishing Co., New Delhi, 2001.
5. Electronics Principles and Applications, A.B. Bhattacharya, New Central Book Agency P.Ltd., Kolkata, 2007.

### Tutorials

1. Suppose a three-variable truth table has a high output for these input conditions: 000, 010, 100 and 110. What is the sum-of-products circuit?
2. A truth table has low outputs for inputs of 0000 to 0110, a high output for 0111, low outputs for 1000 to 1001, don't cares for 1010 to 1111. Show the simplest logic circuit for this truth table.
3. Suppose a truth table has a low output for the first three input conditions: 000, 001 and 010. If all other outputs are high, what is the product-of-sums circuit?
4. A sine wave with a peak of 6 V drives one of the inverters in a 7414. Sketch the output voltage.
5. Examine the logic levels at the input of a 54/74L91 and show how a 1 and then a 0 are shifted into the register.

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### Course Code and Title: 1EB – Analytical Chemistry

Course Type: Elective (for Chemistry)

Semester: I

Credits: 4

**Preamble :** This course content covers all aspects of analytical chemistry such as from classical analytical techniques tools modern sophisticated instrumentation, the Instrumental methods of chemical analysis have become backbone of experimental Chemistry. Method development for new product is one of the essential requirements for the expansion of research in the new product development. This elective course will very well cater the post graduate students to design new analytics and methodology development.

**Pre-requisite:** The master students of the Nanoscience and technology who has completed their under graduation in any branch of chemical-physical sciences or biotechnology can opt this course as elective.

**Course Objectives :**Students will develop the skill necessary to solve analytical problems in a quantitative manner, particularly with the aid of the spreadsheet tools that are so commonly available. Finally, we aim to teach those laboratory skills that will give students confidence in their ability to obtain high-quality analytical data.

**Course Outcomes:** Upon successful completion of this course, the student will be able to:

- CO1:** Demonstrate a mastery of various methods of expressing concentration.
- CO2:** Use a linear calibration curve to calculate concentration.
- CO3:** Describe the various spectrochemical techniques as described within the course.
- CO4:** Use sample data obtained from spectrochemical techniques to calculate unknown concentrations or obtain structural information where applicable.
- CO5:** Describe the various chromatographies described within this course and analyze a given chromatogram.
- CO6:** Demonstrate an understanding of electrochemistry and the methods used to study the response of an electrolyte through current of potential.

#### Unit-I

**Fundamentals of Analytical chemistry:**Applications of quantitative analysis-performance of quantitative analysis - choice of methods for an analysis - errors in chemical analysis - sampling, standardization and calibration.

#### Unit-II

**Separation Techniques:** Solvent extraction - introduction to chromatography - types of chromatography - efficiency of separation - factors affecting resolution.

#### Unit-III

**Electro analytical techniques:**Introduction to electrochemistry-applications of standard electrode potentials- applications of oxidation/reduction titrations- potentiometry -electrogravimetry - coulometry - voltametry.

#### Unit-IV

**Modern analytical techniques:**UV-visible absorption spectroscopy - principles and instrumentation - Raman spectroscopy - raman spectrum- theory- instrumentation- structural characteristics - quantitative analysis - Infra-red Spectroscopy - basic principle-instrumentation – correlation of infrared spectra with molecular structure - Nuclear magnetic resonance spectroscopy - Basic principles of NMR - Instrumentation.

#### Unit-V

**Green Chemistry Principles-** Definition, need of green chemistry, twelve basic principles of green chemistry-planning a green synthesis in a chemical laboratory - solvent - less reactions, selection of appropriate solvent, use of microwaves - fundamentals of closed - vessel heating and sonication. Atom efficient processes and atom efficiency, atom economy (with specific reaction).

**Greener Reactions**–Water as greener solvent- reactions in ionic-liquid, solvent free reaction-solid supported organic synthesis, phase transfer catalyst (PTC), use of microwaves and sonication (any four specific reactions with mechanism).

### References:

1. Fundamentals of analytical chemistry, Douglas A. Skoog, Donald M. West.
  2. Fundamentals of analytical chemistry, Skoog, West, Holler, Crouch.
  3. Instrumental methods of analysis, Hobart H. Willard, Lynne L. Merritt, JR., John A. Dean.
  4. Quantitative chemical analysis, Daniel C. Harrish.
  5. Green Chemistry, V.K.Ahluwalia.
  6. Green Chemistry, P.T. Anastas and J. C. Warner, 1998
  7. Green Chemistry, S. Delvin.
- 

### Course Code and Title : 1EC – Biostatistics

Course Type : Elective (for Biotechnology) Semester : I

Credits: 4

**Preamble::** This paper highlights on vital statistical techniques for analysis of biological data.

**Pre-requisite:** Little knowledge on intermediate level.

**Course Objective:** To expose students to various statistical technique and bio statistical tools used in modern biology and biotechnology research.

Goal: Upon successful completion of the paper the students will get an insight on the usage of various statistical tools and their relevant applications.

**Course Outcomes:** On successful completion of this course, students will be able to:

- CO1: Apply basic statistical concepts commonly used in Health and Medical Sciences;
- CO2: Use basic analytical techniques to generate results;
- CO3: Interpret results of commonly used statistical analyses in written summaries; and
- CO4: Demonstrate statistical reasoning skills correctly and contextually.

### Unit-I

Descriptive statistics and relationship of quantitative variables: Tabulation of data and its graphical representation; Frequency distributions; Measures of central tendency (mean, median mode) and dispersion (range, MD, Variatrion, SD, cv); Probablity (permutation and combination); rank correlation coefficient, concurrent deviation methods, simple regression analysis.

### Unit-II

Theoretical probability distributions: Chi square Test; Probability distributions (Binomial, Poisson, Normal); Population (finite and infinite) and sampling (Methods); students „t“ methods, analysis of frequencies and variance (F-test).

### Unit-III

Design of experiments: Completely randomized design, Randomised Block design; Latin square, factorial design; Central Composite Design (RSM and its applications)

#### Unit-IV

Correlation and Regression: Types of correlation, Simple linear correlation and Multiple regression; Probit analysis; Multivariate statistics.

#### Unit-V

Computers in Statistics: Microsoft excel for statistical functions (Chi-square test; t-test; ANOVA; Correlation and Regression) and Graphical representations; Software for statistics (IRISTAT, SPSS, SYSTAT, Design Expert)

#### References

1. Biostatistical analysis, J.H.Zar, 4th Edition, Pearson Education Inc, 1999.
2. Biostatistics – How it works, Steve Selvin, Pearson Education Inc.
3. An introduction to Biostatistics, Glover and Mitchell, McGraw Hill, 2008.
4. Fundamentals of Biostatistics – Practical approach, N.K.R.Dutta, Kanishka publishers, New Delhi, 2002.
5. An Introduction to Biostatistics, N.Gurumani, 2nd Edition, MJP publishers, Chennai
6. Statistical Methods, S.P.Gupta, Sultan Chand and Sons, 2003.
7. Biostatistics – A foundation for analysis in health Science, W. Daniel, Wiley, 1983.

#### Course Code and Title :23A– Synthesis and Fabrication of Nanomaterials

Course Type :Core

Semester :II

Credits: 4

**Preamble:** This course helps the students to understand the different types of nanomaterials synthesis by both top-down and bottom up approach using various physical, chemical and biological approaches.

**Prerequisite:** Basic knowledge in science (physics, chemistry and biology)

**Course Objectives:** Through this course the students will:

- To learn about bulk synthesis of nanomaterials.
- To know about physical, chemical and biological approaches of nanomaterials synthesis.
- To learn about nanoporous and composite materials and application of nanomaterials.
- To understand the lithographic process for the fabrication of nanodevices.

**Course Outcomes:** On completion of this course, students will be able to:

- CO1:** synthesize nanomaterials using various physical, chemical and biological approaches.
- CO2:** tune the size and shape of the nanomaterials for diverse applications.
- CO3:** understand the functionalization of nanoparticles
- CO4:** form the nanocomposites for tuning their functional properties.
- CO5:** fabricate the device structures using lithographic techniques.

#### Unit-I - Chemical Methods

Sol-Gel Process-Self-assembly-Electrodeposition-Spray Pyrolysis-Flame Pyrolysis-  
Metal Nanocrystals by Reduction-Solvent Thermal Synthesis-Photochemical Synthesis-  
Sonochemical Routes-Reverse Micelles and Microemulsions-Combustion Method-Template Process-  
Chemical Vapor Deposition (CVD)-Metal Organic Chemical Vapor Deposition (MOCVD)

### Unit-II - Physical Methods

BallMilling-InertGasCondensationTechnique(IGCT)–Thermalevaporation–  
PulsedLaserDeposition(PLD)–DC/RFMagnetronSputtering–MolecularBeamEpitaxy (MBE)–Melt  
Spinning process- ICFabricationProcess– Microlithography– Etching – WetCleaning– CMP–  
BackendProcess.

### Unit-III -Biological Synthesis

Introduction-NaturalNanocompositeMaterials-  
BiologicallySynthesizedNanoparticles,NanostructuresandSyntheticNanocomposites-Protein-  
BasedNanostructureFormation-DNA-TemplatedNanostructureFormation- Protein Assembly -  
Biologically InspiredNanocomposites-LyotropicLiquid-CrystalTemplating-Liquid-  
CrystalTemplatingofThinFilms - Block-CopolymerTemplating-Colloidal Templating.

### Unit-IV Nanocomposites

Ceramic/MetalNanocomposites-MetalMatrixNanocomposites-NanocompositesforHardCoatings–  
Polymerbased nanocomposites– nanoscalefillers– processing of polymernanocomposites – Properties  
macromoleculesintroductionintothe layered host lattices – Langmuir-  
Blodgettmetalopolymers films as self-organized hybridnanocomposites.

### Unit -V -LithographicMethods

Introduction–Lithography–Photolithography-Phase-shiftingphotolithography-  
Electronbeam lithography-X-raylithography-Focusedionbeam(FIB)lithography-  
Neutralatomicbeam lithography-NanomanipulationandNanolithography-SoftLithography-  
Assemblyof Nanoparticles andNanowires Other Methods forMicrofabrication.

### References

1. RecentAdvancesintheLiquid-  
phasesynthesesifinorganicnanoparticles,BrainL.Cushing,VladimirL.Kolesnichenko,CharlesJ.O  
Connor,ChemRev.104(2004)3893-3946.
  2. Nanocrystals:Synthesis,PropertiesandApplications,C.N.R.Rao,P.J.ThomasandG.  
U. Kulkarni, Springer(2007).
  3. Nanotechnology-EnabledSensors,KourosKalantar-zadehandBenjaminFry,Springer(2008).
  4. Nanostructures&Nanomaterials:Synthesis,Properties&Applications,GuozhongGao,ImperialC  
ollege Press (2004).
  5. Nanochemistry:AChemicalApproachtoNanomaterials–  
RoyalSocietyofChemistry,Cambridge,UK (2005).
  6. Nanocompositescienceandtechnology,PulickelM.Ajayan,LindaS.Schadler,PaulV.Braun,Wiley-  
VCHVerlag,Weiheim (2003).
  7. EncyclopediaofMaterialsCharacterization,C.RichardBrundle,CharlesA.EvansJr.,Shaun Wilson,  
Butterworth-HeinemannPublishers(1992).
  8. HandbookofMicroscopyforNanotechnology,Ed.ByNanYaoandZhongLinWang,KluwerAcade  
mic Press (2005).
  9. Nanochemistry, G.B.Sergeev, Elsevier (2006).
  10. Nanotechnology:BasicScienceandEmergingTechnologies–  
MickWilson,KamaliKannangara,Geoff Smith, Michelle Simmons,  
BurkhardRaguse,OverseasPress(2005).
  11. HandbookofAnalyticalTechniques,EditedByHelmutGünzlerandAlexWilliams,WileyVCH,  
2002.
-

### Course Code and Title: 23B – Properties of Nanomaterials

Course Type: Core

Semester: II

Credits: 4

**Preamble :**The Properties of Nanomaterials course will give an information about the properties of materials at the nano scale and also a comparison with its bulk counter parts.

**Pre-requisite:** This core course is designed for the masters in Nanoscience and technology those who have acquired basic degree with a knowledge of material science.

**Course Objectives:** This course will provide students to gain a thorough understanding of the structure-property relationships at nanoscale as well as the concepts on various properties and critical evaluation of the promising nanotechnology devices.

#### Course Outcomes:

- CO1:** The student will demonstrate a basic understanding of the length scale that defines nano for metal and semiconductor materials.
- CO2:** The student will demonstrate an understanding of the properties of materials with strong dependence on size.
- CO3:** The student will demonstrate an understanding of approaches to nanomaterials characterization.
- CO4:** The student will demonstrate an understanding of approaches to engineering nanomaterials and nanostructures.
- CO5:** The student will demonstrate an understanding of the challenges on safe nanotechnology.

#### Unit I - Electrical and Mechanical Properties

Introduction - Energy Storage Basics - General Information: Electrical Energy Storage Devices and Impact of Nanomaterials – Batteries – Capacitors - Electrochemical Properties of Nanoscale Materials - Aerogels and Structure-Directed Mesoporous and Macroporous Solids - Nanoparticles - Nanotubes, Nanowires, and Nanorolls.

Nanoscale Mechanics - Introduction – Mechanical properties – The Elasticity of Nanomaterials – Elasticity of Bulk Nanomaterials –Plastic Deformation of Nanomaterials - The Physical Basis of Yield Strength – Crystals and Crystal Plasticity – From Crystal Plasticity to Polycrystal Plasticity.

#### Unit II - Nanophotonics

Absorption: direct and indirect bandgap transitions - Emission: photoluminescence and Raman Scattering - Emission: chemiluminescence and Electroluminescence - Shape dependent optical properties - Optical absorption - Optical emission - Surface plasmon resonance (SPR) - Surface enhanced Raman scattering (SERS)

#### Unit III - Nanocatalysis

Introduction to catalysis and nanocatalysis-Catalysts- Types of catalyst- Applications of catalysis – Metal-nanostructured adsorbant – metals – controlled pore size materials – pelletized nanocrystal – nanoparticles as new chemical reagents – metals – metal oxide reactions – nanocomposite polymers – fluids, inks and dyes – block co polymers and dendrimers – nanocrystalsuperlattices.

#### Unit IV - Nanomagnetism

Introduction – fundamental concepts – magnetic materials – dia, para and ferromagnetism - magnetic phenomena in ferromagnetic materials – magnetic anisotropy – magnetic domains – hysteresis small particle magnetism – single domain particles – coercivity of single domain particles – superparamagnetism – the coercivity of small particles - Issue in nanoscale magnetism.

#### Unit V-Nanoelectronics

Introduction to electronics - Basics of nanoelectronics - Single electron transistor – Principle – Coulomb Blockade effect – performance of the single electron transistor – Bioelectronics – molecular processor – DNA analyzer as biochip – DNA computer – Quantum computer.

#### References

1. Nanomaterials : Mechanics and Mechanisms, K. T. Ramesh, Springer 2009.
2. Nanoscale materials in chemistry, Edited by Kenneth J. Klabunde, John Wiley & Sons, 2001.
3. Nanoscopic materials; Size dependent phenomena, Emil Roduner, RSC publishing, 2006.
4. Optical properties and spectroscopy of nanomaterials, J. Z. Zhang, World Scientific, 2009.
5. Nanoelectronics and nanosystems – K. Gosser, P. Glösekötter and J. Dienstuhl, Springer 2008.
6. Principles of Physical Chemistry- Samuel H. Maron, Carl F. Prutton.

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### Course Code and Title : 23C – Statistical Mechanics and Thermodynamics

**Course Type : Core (for Physics)**

**Semester : II**

**Credits: 4**

**Preamble:** The objective of this course is to register the concepts of equilibrium statistical mechanics which evolved out of the desire to explain thermodynamics from fundamental laws of physics governing the behaviour of atoms and molecules. Being a science built on a set of macroscopic observations, thermodynamics offers inefficient ways of incorporating molecular level information. Thus, an approach based solely on thermodynamics is not sufficient if we hope to achieve desired materials properties through manipulation of nanoscale features and/or molecular level architecture of materials. The course is designed for postgraduate level students enrolled in Physics, Applied Physics, Nanoscience and Technology and other engineering departments. This emphasizes the development of thorough consistent thinking for solving different kinds of problems that occur in macroscopic and microscopic systems. The syllabus includes intermediate topics in Microcanonical, Canonical and Grand canonical Ensembles, Bose-Einstein, Fermi-Dirac and Maxwell-Boltzmann Distributions, Heat Capacities, Phase Transitions, Thermodynamics, Microstates and Macro states. We have well pledged team of dedicated staffs who can essentially amplify the academic acquaintance for the enrolled students.

**Pre-requisite:** Under Graduate level knowledge in basic physics, differentiation and integration to solve problems.

**Course Objectives:** The main goal of this course is to acquire fundamental knowledge of classical and quantum statistical mechanics; construct a bridge between macroscopic thermodynamics and microscopic statistical mechanics by using mathematical methods and fundamental physics for individual particles. Problem solving is stressed as a means of imparting physical understanding and intuition. We will study how general principles of statistical mechanics actually work in some simple and complex systems and what powerful notions and ideas have been developed to approach



complex cases. We will explore relationships between macroscopic properties of large systems and microscopic behavior of the particles these systems are comprised of. The richness and complexity of the behavior exhibited by many-particle systems is incredible. In this course, however, we would be able to explore only very few illustrating examples. We will be dealing with elements of statistical thermodynamics, kinetics, and the theory of phase transitions.

**Course Outcome:** On the successful completion of the course, students will be able to

- CO1:** Gain knowledge of the different canonical systems in two energy systems and their partition functions.
- CO2:** Derive the three different distributions on Bose-Einstein, Fermi –Dirac and Maxwell-Boltzmann equations.
- CO3:** Evaluate the spectral density of electromagnetic radiation emitted by a black body in thermal equilibrium at a given temperature T.
- CO4:** Learn the Thermodynamic relations for non-interacting Fermi gas for the Microscopic and Macroscopic system.
- CO5:** Using the thermodynamics properties of Heat capacities of heteronuclear diatomic gas, Heat capacities of solid.
- CO6:** Explain the *law* of Dulong and *Petit* states that the product of the specific heat capacity of a solid element and its mass per mole is constant. The value of the constant may be found from the principle of equipartition of energy.
- CO7:** Describes the relationship between changes in chemical potential for components in a thermodynamic system.
- CO8:** Learn the Gibbs–Duhem equation cannot be used for small thermodynamic systems due to the influence of surface effects and other microscopic phenomena.

### Unit-I -Microcanonical, Canonical and Grandcanonical Ensembles

Microcanonical distribution function – Two level system in microcanonical ensemble – Gibbs paradox and correct formula for entropy – The canonical distribution function – Contact with thermodynamics - Two level system in canonical ensemble – Partition function and free energy of an ideal gas – Distribution of molecular velocities – Equipartition and Virial theorems – The grand partition function – Relation between grandcanonical and canonical partition functions

### Unit -II - Bose-Einstein, Fermi-Dirac And Maxwell-Boltzmann Distributions

Bose-Einstein and Fermi-Dirac distributions – Thermodynamic quantities – Fluctuations in different ensembles – Bose and Fermi distributions in microcanonical ensemble - Maxwell-Boltzmann distribution law for microstates in a classical gas - Physical interpretation of the classical limit – Derivation of Boltzmann equation for change of states without and with collisions – Boltzmann equation for quantum statistics – Equilibrium distribution in Boltzmann equation

### Unit-III - Bose Gas and Fermi Gas

Non-interacting Bose gas and thermodynamic relations – Chemical potential of bosons – Density of states, pressure and energy density of bosons – Black body radiations and Planck's distribution law – Number density of photons and Bose condensation - Thermodynamic relations for non-interacting Fermi gas – Fermi gas at zero temperature – Fermi energy and Fermi momentum – Pressure and energy density – Fermi gas at low temperature – Energy density and heat capacity

#### Unit-IV - Heat Capacities, Ising Model and Phase Transitions

Heat capacities of heteronuclear diatomic gas – Heat capacities of homonuclear diatomic gas – Heat capacities of solids; Dulong and petit law, Einstein temperature and Debye theory – Heat capacities of metals – Heat capacity of Bose gas – One-dimensional Ising model and its solution by variational method – Exact solution for one-dimensional Ising model – Bragg-Williams approximation for Ising model - Phase transitions and criterion for phase transitions– Classification of phase transitions by order and by symmetry – Phase diagrams for pure systems.

#### Unit-V - Thermodynamics, Microstates and Macrostates

Basic postulates of thermodynamics – Fundamental relations and definition of intensive variables – Intensive variables in the entropic formulation – Intensive variables in the entropic formulation - Equations of state – Euler relation, densities - Gibbs-Duhem relation for entropy Thermodynamic potentials and extensivity properties – Maxwell relations – Energy differential and thermodynamic potentials of systems in external magnetic field - Thermodynamic relations – Microstates and macrostates – Ideal gas – Microstate and macrostate in classical systems – Microstate and macrostate in quantum systems – Density of states

#### References

1. An Introductory Course of Statistical Mechanics, Palash B. Pal, Narosa Publishing House, New Delhi, 2008.
2. Elements of Statistical Mechanics, Kamal Singh & S.P. Singh, S. Chand & Company, New Delhi, 1992.
3. Statistical Mechanics an Elementary Outline, Avijit Lahiri, University Press, Hyderabad, 2002.

### 23E: Organic Chemistry – II

**Course Type :** Core (for Chemistry)

**Semester :** II

**Credits:** 4

**Preample:** This course presents the comprehensive chemistry of natural products, terpenoids, proteins and stereochemistry

**Pre-requisite:** Basic knowledge in organic chemistry.

#### Course Objectives:

- To understand the basic concepts about the organic photochemistry reactions.
- To make the students understand the mechanism of different types of intermediate states.
- To learn the Woodward – Hoffmann rules for addition and reagents.
- Learn to apply concerted and stepwise reactions in organic synthesis.
- To learn carbonyl compounds towards organic synthesis.
- To understand the mechanism of stereochemistry reactions.

**Course Outcomes:** At the end of the course the students should be able to:

- CO1:** Learners familiar in synthesis of organic compounds based on photochemistry.
- CO2:** Students will be able to interpret the formation of products using orbital diagram in pericyclic reaction, photochemical reaction.
- CO3:** Students will be able to explain the chemistry of free radicals.
- CO4:** Students gain the knowledge on stereochemistry of organic compounds.

**CO5:** To apply isolation of isomeric compounds.

### Unit-I

**Organic Photochemistry**- Theory of light absorption—electronic excitation - properties & energies of excited states – Jablonski diagram – photo physical processes - fluorescence and phosphorescence - excimers and exciplexes – intersystem crossing – energy transfer - geometry of excited states - quantum efficiency.

**Photochemical reactions of ketones** – Norrish Type I, Norrish Type II – Paterno – Buchi reaction – Photo reduction and oxidation –  $\alpha$ ,  $\beta$ - unsaturated ketones- Photochemistry of olefins, conjugated olefins and aromatic compounds – *cis-trans* isomerisation - di –  $\pi$  methane rearrangement of cyclohexadienones – Barton's reaction.

### Unit-II

**Pericyclic Reactions** – Characteristics – Electrocyclic reactions of 1, 3-dienes and 1, 3, 5-trienes. [2+2] and [4+2] cycloadditions - The Frontier Molecular Orbital approach (FMO) and Correlation diagrams – The Woodward – Hoffmann rules. 1,3 – dipolar addition – Cheletropic reaction.

**Sigmatropic reactions** – [1, 3], [1, 5] and [3, 3] Sigmatropic shifts, Frontier Molecular Orbital approach – Claisen and Cope rearrangements, ene reactions. Theories –Huckel – Mobius approach, Dewar – Zimmermann Approach.

### Unit-III

**Addition Reactions to Carbonyl Compounds**- Mannich, Aldol, Grignard, Claisen & Dieckmann, Stobbe, Perkin, Knoevenagel, Darzen, Wittig, Thorpe, Reformatsky and Benzoin reactions, Friedlander quinoline synthesis, Strecker and Peterson synthesis. Stereo selectivity in carbonyl addition reactions - Cram's rule.

### UNIT-IV

**Molecular Rearrangements**—Wagner–Meerwein rearrangement—Migratory aptitudes—Memory effects – Demjanov, Neber, Baeyer–Villiger, Dienone – phenol, Favorski, Fries and Benzidine, Wolff, Stevens, Lossen and Schmidt rearrangements – Non-cyclic rearrangements – Chapman and Wallach rearrangement, Arndt-Eistert synthesis, Fischer Indole synthesis.

### UNIT-V

**Stereochemistry**: Optical isomerism—concept of chirality- stereochemistry of sulfur and nitrogen compounds – concept of prochirality- enantiotopic and diastereotopic ligands & faces- stereo selective and stereo specific reactions - R, S – nomenclature of compounds having one and more than one chiral centres – axial chirality - (optical isomerism of biphenyls, allenes and spirans) - planar chirality (optical isomerism of ansa compounds and cyclophanes) - helicity (optical isomerism of over – crowded molecules).

### References

1. S. Sankararaman, Pericyclic reactions-A Textbook: Reactions Applications and Theory. Wiley-VCH, 2015.
2. S. Kalaivanai, Organic Photochemistry and Peri Cyclic Reactions, MJP Publishers, 2011.

3. J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6<sup>th</sup> Edition, Wiley, 2007.
  4. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry Part B: Reaction and Synthesis, Springer, 5<sup>th</sup> Edition, 2010.
  5. Advanced Organic Chemistry. Jagdamba Singh and L.D.S.Yadav, PragatiPrakasan, 2011.
  6. E. Eliel and A. H. Wilen, Stereochemistry of Organic Compounds 1<sup>st</sup> Edition, Wiley, 2010.
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**Course Code and Title : 23F – Immunology**

**Course Type :Core (for Biotechnology)**

**Semester : II**

**Credits: 4**

**Preamble:** The course offered to make students to understand the Immunity concepts and its importance in infection free life . Acquire knowledge on Immunity and its life process is the prime focus.

**Prerequisite :**Get equipped with theoretical knowledge of Immune process

**Course Objectives:**

- The students will be able to identify the cellular and molecular basis of immune responsiveness.
- The students will be able to describe the roles of the immune system in both maintaining health and contributing to disease.
- The students will be able to describe immunological response and how it is triggered and regulated.
- The students will be able to demonstrate a capacity for problem-solving about immune responsiveness.
- The students will be able to transfer knowledge of immunology into clinical decision-making through case studies presented in class.

**Course Outcomes:** On the successful completion of the course, students will be able to

- CO1 :** the students will get an overall understanding of basic history and evolution of immunology
- CO2 :** to impart knowledge on infection and involvement of immune response by involving range of immune cells and organs
- CO3 :** to get equipped with the theoretical understanding of antigen and antibody interactions and its structures
- CO4 :** to provide information on various types of vaccines and its immunization schedule
- CO5 :** Understanding the transplantation immunology by studying graft acceptance and rejection mechanisms
- CO6 :** to provide basic information on blood grouping techniques and its role in hypersensitivity reactions
- CO7 :** Help the students to learn techniques involved in immunological concepts and its role in diagnostic immunology

**Unit-I**

Immune System- Introduction to immunology, infections. Organs and cells involved in immune system. Lymphocytes, their subpopulation, their properties and functions, membrane bound receptors.

### Unit-II

Antigens and Immunoglobulins- Concept of haptens, determinants, conditions of antigenicity, antigens and immunogenicity, superantigen. Immunoglobulins: Structure and properties of immunoglobulin classes. Clonal selection theory, hybridoma technology for monoclonal antibodies and designer monoclonal antibodies. Structural basis of antibody diversity. Freund's adjuvants and its significance.

### Unit-III

Antigen – Antibody reactions- Antigen-Antibody reaction by precipitation, agglutination and complement fixation. Complement system: Classical, alternate, lectin pathway of complement activation. Non-specific immune mechanism: - Surface defenses, tissue defenses, opsonization, inflammatory reaction. Tissue metabolites with bactericidal properties (lysozyme, nuclein, histone, protamine, basic peptides of tissues – leukins, phagocytins, lecterins, haemocompounds).

### Unit-IV

Expressions of Immune Response- Antigen processing and presentation, MHC restriction, generation of humoral and cell mediated immune response, maturation and activation of B and T lymphocytes, cytokines and their role in immune regulation, Immunological tolerance and regulation. Cell mediated cytotoxicity: Mechanism of T cells and NK cell mediated lysis, ADCC and macrophage mediated cytotoxicity.

### Unit V

Immunity in Medical biology- Transplantation immunology: MHC, typing, types of grafts, grafts rejection, GVH reactions, mechanism of graft rejection, and prevention of graft rejection. Immuno deficiencies and autoimmunity. Hypersensitivity, Tumor immunology, immune hematology – ABO, Rh, and Duffy systems, transfusion reactions, Immune response against parasitic and viral infection.

### Techniques (Self Study):

Histochemical and immunotechniques: Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, *in situ* localization by techniques such as FISH and GISH.

### References:

1. Fundamental immunology, Paul w e (ed)
  2. Principles of bacteriology, virology and immunity Vol I Topley and Wilson.
  3. Essential clinical immunology- Helen chappu and Manselhaeny
  4. Introduction to immunology John w Kimball
  5. Textbook of microbiology, Ananthanarayanan and Jayarampaicker.
  6. Essential immunology Roitt
  7. Basic and clinical immunology stiles, Stobo, Fuden berg wells (eds)
- Microbiology and immunology David J Hantges
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**Course Code and Title : 23D – Nuclear and Particle Physics**

**Course Type :Core (for Physics)**

**Semester : II**

**Credits: 4**

**Preamble:** The objective of introducing this paper is to provide an in-depth knowledge of nuclear structure, nuclear models, nuclear reactions and different elementary particles.

**Pre-requisite:** Basics knowledge in physics or applied physics

**Course Objectives**

- To provide the student to understand, analyse the fundamental principles, concepts pertaining to nuclear and particle physics and to apply for real life problems

**Course outcomes:** After learning this course, the student able

- CO1:**To understand the basic principles, laws, concepts in nuclear and particle physics
- CO2:**To understand and analyse the ground breaking experiments related to nuclear decay and apply for nuclear fission and fusion
- CO3:**To understand various particle interactions and analyse the properties of the particles
- CO4:**To understand the principles of elementary particles and their interactions
- CO5:**To explain the methods used to understand the properties of sub atomic particles through scattering experiments
- CO6:**To apply quantum mechanical concepts to understand nuclear decay
- CO7:**To apply conservation laws to predict type of interaction

**Unit-I**

Nuclear mass and binding energy - mass defect, mass excess, packing and binding fraction – Weizacker's formula based on liquid drop model – Application of semi empirical formula for alpha decay – mass parabola for stability of nuclei against beta decay – Fission process on the basis of liquid drop model – Energy released in fission process – Bohr-Wheeler's model for stability limits of heavy nuclei – Evidences for shell effects – Single particle energy levels for infinite square well, harmonic oscillator and spin-orbit potential – Application of shell model for nuclear spin, parity and magnetic moment

**Unit-II**

Types of nuclear reaction – Conservation laws in nuclear reactions – Energetics of nuclear reactions – Threshold energy of reaction – Reaction induced by alpha particles ( $\alpha$ ), ( $\alpha, n$ ), ( $\alpha, p$ ) - Proton, deuteron and neutron induced reactions ( $p, \alpha$ ), ( $p, n$ ), ( $p, p$ ), ( $p, d$ ), ( $d, \alpha$ ), ( $d, p$ ), ( $d, n$ ), ( $d, d$ ), ( $d, t$ ), ( $n, \alpha$ ), ( $n, p$ ), ( $n, d$ ), ( $n, n$ ), ( $n, t$ ) – Cross section of nuclear reaction – Partial wave method for nuclear scattering and reaction cross sections – Compound nucleus hypothesis – Breit-Wigner one level formula

**Unit-III**

Ground state properties of deuteron – Square well solution of deuteron – Low energy neutron proton scattering – limits of energy for the scattering of different partial waves – Properties of nuclear force – Fine structure of alpha particles and long range alpha particles – Determination of velocities of alpha particles – alpha disintegration energy – WKB approximation for theory of alpha

disintegration – Energetics of beta decay – Origin of continuous beta spectrum – neutrino hypothesis – properties of neutrino

#### Unit-IV

Electrostatic generators – (Vandegraff, tandem, pelletron) – Cyclotron – Linear accelerators – Betatron – Ionization Chamber – Proportional counter – Geiger Muller Counter - Semi conductor detectors and its uses – Scintillation detector

#### Unit-V

Classification of elementary particles – conservation laws – Isospin symmetry and SU(2) group – Symmetry classification of elementary particles – super multiplet of spin  $\frac{1}{2}$  baryons – supermultiplet of spin 0 mesons – meson resonance octet – baryon resonance decuplet – Quark hypothesis – quark structures of mesons and baryons

#### References

1. *Nuclear Physics*, S.N. Ghosal, S. Chand & Company Ltd, 1997.
2. *Nuclear Physics*, D.C. Tayal, Himalaya Publishing House, 1997.
3. *Nuclear Physics*, B.B. Srivastava, *Rastogi Publication*.
4. *Nuclear Physics*, S. B. Patel, New Age International Publisher, 1991.
5. *Nuclear Physics*, V. Devanathan, Alpha Science International, 2006.
6. *Introductory Nuclear Physics*, Kenneth S. Krane, Wiley, 1987.
7. *Nuclear Physics theory and experiment*, R. R. Roy, B.P. Nigam, Wiley, 1967.
8. *Concepts of Nuclear Physics*, Bernard L. Cohen, Tata McGraw-Hill, 1971.
9. *Nuclear Physics*, Irving Kaplan, Addison-Wesley Pub, 1963.
10. *Nuclear Physics*, John Lilley, Wiley, 2006.

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### Course Code and Title :23F-Physical Chemistry-II

Course Type :Core(for Chemistry)

Semester :II

Credits: 4

**Preamble:** Physical chemistry blends the principles of physics and chemistry to study the physical characteristics, or properties, of molecules. By understanding these properties, you learn more about the way in which molecules are put together, as well as how the actual structure of a chemical is impacted by these properties. The students studying this subject would have to develop depth knowledge in quantum mechanics and electrochemistry.

**Prerequisite:** Higher Secondary Level, Degree Level –Classical mechanics, electrochemistry, Mathematical knowledge.

#### Course Objectives

- To understand the basics of quantum mechanics, particle and wave nature of the matters.
- To understand the basics of electrochemical reactions.

**Course Outcomes:** After learning this course the students can able

**CO1:** To understand the fundamental concepts and techniques used in quantum mechanics.

**CO2:** To understand Schrodinger equations and its application in diatomic molecule

**CO3:** To explain the perturbation theory in anharmonic oscillator and He atom

**CO4:** To understand the conductivity of electrolyte and its application in electrochemical reaction.

**CO5:** To understand the concept of electrochemical reaction.

### Unit-I

Quantum chemistry: Failure of classical mechanics and the success of quantum theory in explaining blackbody radiation-heat capacities of solids-photoelectric effect and the H-atom spectrum- De Broglie, matter waves-Heisenberg, uncertainty principle-Schrodinger equation- Born, interpretation of the wavefunction-requirements of the acceptable wavefunction. Algebra of operators- sums and products of operators- commutator- linear operators- eigenfunctions and eigenvalues- correspondence between physical quantities in classical mechanics and operators in quantum mechanics- Hamiltonian operator- quantisation of angular momentum and its spatial orientation-average (expectation) values-postulates of quantum mechanics.

### Unit-II

Particle in a one-dimensional box-quantisation of energy-normalisation of wavefunction- orthogonality of the particle in a one-dimensional box wavefunctions- average position and average momentum of a particle in a one-dimensional box- illustration of the uncertainty principle and correspondence principle with reference to the particle in a one-dimensional box-particle in a three-dimensional box-separation of variables- degeneracy Solving of Schrodinger equation for the one dimensional harmonic oscillator - harmonic oscillator model of a diatomic molecule- illustration of the uncertainty principle and correspondence principle with reference to harmonic oscillator.

### Unit-III

Solving of Schrodinger equation for a rigid rotor- rigid rotor model of a diatomic molecule. Schrodinger equation for the H-atom (or H-like species)- separation of variables-energy levels-radial factors of the H-atom wavefunctions Electron spin and the Pauli principles-antisymmetric nature of the wavefunctions- Slater determinants- approximate wavefunction of many electron atoms. Need for approximation methods- the perturbation theory (first order only) application of the perturbation method of systems such as the anharmonic oscillator and He-atom-the variation method-applications of variation method to systems such as anharmonic oscillator and He-atom.

### Unit-IV

Calculation of heat of solvation, hydration of ionic species-Ionic strength-concentration and activity coefficient - Debye-Huckell limiting law- Electrochemical Method of determining activity coefficient of electrolytic solutions - Electrolytic conductances-Debye-Huckel-Onsager equation- verification-Wien effect and Debye-Falkenhagen effect  
- Thermodynamics of electrochemical reactions - Free energy and emf- Standard and formal electrode potentials-  
Problems based on electrode potentials and their measurements  
- Ion selective electrodes.



### Unit-V

Electrode–Electrolyticinterface–electricaldoublelayer–electrocapillarythermodynamics  
Lippmanequation–Measurementsofdoublayercapacitances–Theoreticalmodelsofdoublayers–  
HelmholtzandGuoy-Chapmanmodels–Potentialofzerocharge–Sternmodel– outer and  
innerHelmholtzplanes– Specific adsorption ofcations,anionsandneutramolecules – abrief outlineof  
electrokineticphenomenon andmemberanepotentials.

### References

1. I.N.Levine -Quantumchemistry,Prentice Hallof IndiaPvtLtd, 1994.
2. R. K. Prasad - Quantumchemistry, WileyEasternLtd, (1992).
3. W.J. Moore- Physicalchemistry, (1962).
4. W. Castellan- Physicalchemistry, (1971).
5. A. K.Chandra-Introductoryquantumchemistry.
6. P. W. Atkins- Physicalchemistry.
7. S. Glasstone- Electrochemistry.
8. GordonM.Barrow-PhysicalChemistry,McGrawHill PublishingCompany Ltd,2007.
9. BockrisandReddy,ModernElectrochemistry(Vol.I&II)

### Course Code and Title : 23G – Pharmaceutical Biotechnology

**Course Type :Core (for Biotechnology) Semester : II Credits: 4**

**Preamble:** The course designed to make students understand the concepts and process involved in pharmaceutical industry. Acquire knowledge on involvement of nanoparticles in pharmaceutical industry is the prime focus.

**Prerequisite:** Get equipped with theoretical knowledge of nanoparticles and its importance in pharmaceutical applications

**Course Objectives:** Pharmaceutical Biotechnology is intended to provide the student with a working knowledge of the preparation, stability and formulation of different protein and peptide drugs such as antisense agents, transgenic therapeutics and gene therapy. Current FDA approved biotechnology drugs such as human insulin, growth hormones and interferons will be discussed

**Course Outcomes:** On the successful completion of the course, students will be able to

- CO1 :** the students will get an overall understanding of pharmacodynamics and drug screening process
- CO2 :** to deal with basic drug design procedures and molecular modification procedures of lead compounds
- CO3 :** to get equipped with the theoretical understanding of active site determination of enzymes
- CO4 :** to provide information on various types of drugs obtained from bacteria, plants, animals and insects and its active principles
- CO5 :** to educate the active animal model systems for drug testing and protein modelling by computer using docking studies
- CO6 :** to provide basic information on drugs derived from natural sources specifically from plants species
- CO7 :** to educate the students to know different nanoparticles used as drug carriers and its applications

### **Unit-I - Biological Systems and Models**

Routes of administration, adsorption enhancement / solubility factor/ bioavailability, site specific delivery; Pharmacodynamics of protein therapeutics; Inter species scaling; Chemical modification of proteins/ therapeutics; Colloidal particulate carrier system; Immuno suppressor in antibody therapy; High throughput screening; Automation; Combinatorial  
Synthesis: Chemistry, Biology, and Biotechnology; Genotyping: Genetic Pre-Disposition, and Heterogeneity; Pharmaco- Genomics.

### **Unit-II: Drug metabolism**

Oxidation, reduction, hydrolysis, conjugation. Need for developing new drugs: Procedure followed in drug design; Molecular modification of lead compounds; Prodrug and soft drugs; Physico-chemical parameters in drug design; QSAR; Active site determination of enzymes; Design of enzyme inhibitors.

### **Unit-III - Pharmacokinetics and Drug Discovery**

Substances derived from bacteria, plants, insects, and animals; Sources of active principles; Assay systems and models (e.g., Knock-out Mice) Protein molecular modeling by computer: Docking studies; Structure based drug designing using software (Insight II LS)

### **Unit-IV - Plants as Pharmaceuticals**

Drugs derived from plants, natural resources of medicine, Antitumor agent - Etoposide, Colchicine, Demecolcine, Irinotecan, Lapachol, Taxol, Vinblastine, Vincristine. Cardiotonic- Convallatoxin, Acetyldigoxin, Adoniside, Antiinflammatory – Aescin, Bromelain, Local anaesthetic – Cocaine, Choleric – Curcumin, Cynarin, Topical antifungal – Thymol, Antihypertensive, tranquilizer – Rescinnamine, Reserpine, Rhomitoxin.

### **Unit-V - Nanoparticles in Drug Delivery**

Polymeric, Lipid nanoparticles for drug delivery, Micelles in Drug Delivery. Quantum Dots, Gold, silica, silver and magnetic nanoparticles for biomedical applications. Carbon nanotubes and their applications. Nanoparticulate Drug Delivery to the Reticuloendothelial System and to Associated Disorders – Delivery of Nanoparticles to the Cardiovascular System – Nanocarriers for the Vascular Delivery of Drugs to the Lungs – Nanoparticulate Carriers for Drug Delivery to the Brain – Nanoparticles for Targeting Lymphatics – Polymeric Nanoparticles for Delivery in the Gastro-Intestinal Tract – Nanoparticulate Carriers for Ocular Drug Delivery – Nanoparticles and Microparticles as Vaccines Adjuvants

### **References**

1. Industrial Pharmaceutical Biotechnology, Heinrich Klefenz, Wiley-Vch Publication, Germany, 2002.
2. Pharmaceutical Biotechnology, Daan Crommelin, Robert D Sindelar, 2002, Taylor and Francis Publications, New York, 2002.
3. Hand book of Pharmaceutical Biotechnology, Jay P Rho, Stan G Louie, 2003, Pharmaceutical products press, New York, 2003
4. Theory and practice of industrial pharmacy, Lachman L Lieberman, HA, Kanig, J, 1986, 3<sup>rd</sup> edition, Varghese publishing & Co, New Delhi, 2000.
5. Remington's Pharmaceutical sciences, Joseph Price Remington, 18<sup>th</sup> edition, Mack publishing & Co., Easton, 1980.

6. Nanoparticles as Drug carriers, Vladimir P Torchilin, Imperial College Press, USA, 2006
  7. Nanomedicine, ParagDiwan and AshishBharadwaj, pentagon press, India, 2006.
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### Course Code and Title : 2EA – Advanced Materials Science

Course Type : Elective (for Physics and Chemistry)      Semester : I      Credits: 4

**Preamble:** The course intends to present new, relevant and advanced topics within modern materials science and engineering. Special lectures will be given on current research topics such as semiconductor low-dimensional structures and photonic crystals. This course aims to establish fundamental concepts in condensed matter physics with special focus on materials science, and applies the physics learned previously (in particular quantum mechanics, classical mechanics, electromagnetism and statistical mechanics) to these real-world materials.

**Prerequisite:** Basic knowledge in Materials Science

#### Course Objectives

- To learn the fundamental principles underlying and connecting the structure, processing, properties, and performance of materials systems.
- To study some of the basic properties of the condensed phase of matter especially solids.
- Have an understanding of the magnetic properties of condensed matter;
- Knowledge of the optical properties of solids and the relation to their electronic properties;
- Will study the physical principles for different types of electric and magnetic phenomena in solid materials (like e.g. ferroelectricity, superconductivity, paramagnetism, diamagnetism, ferromagnetism etc) and in relevant cases relate this to macroscopically measured physical quantities.

#### Course Outcome

**CO1:** Will be able to demonstrate advanced knowledge and skills in materials science

**CO2:** Know the fundamental science and engineering principles relevant to materials

**CO3:** Understand the relationship between nano/microstructure, properties and processing and design of materials.

**CO4:** Will be able to solve theoretical problems in materials science

**CO5:** Gain knowledge and understanding of the properties of condensed materials.

**CO6:** Apply key analysis techniques to typical problems encountered in the field

#### Unit-I-Theory of Semiconductors

Intrinsic and extrinsic semiconductors - Free carrier concentration in semiconductors – Fermi level and carrier concentration in semiconductors – Mobility of charge carriers – Effect of temperature on mobility – electrical conductivity of semiconductors – Hall Effect in semiconductors – Junction properties.

#### Unit –II - Theory of Dielectrics, Piezoelectrics and Ferroelectrics

Dipole moment – Polarization – the electric field of a dipole – local electric field at an atom – Clausius –Mosotti equation - Dielectric constants and its measurements - Polarizability – The Classical theory of electronic polarizability – dipolar polarizability – Ferro electricity – Dipole theory of ferroelectricity – Piezoelectricity.

### Unit-III - Magnetic Properties of Materials

Terms and definitions used in magnetism – Classification of magnetic materials – theory of diamagnetism – Langevin theory of paramagnetism - Weiss theory – Paramagnetic susceptibility of a solid – Quantum theory of paramagnetism – Determination of susceptibility of para and dia magnetism using Gouy method - Ferromagnetism – Spontaneous magnetization in ferromagnetic materials – Quantum theory of ferromagnetism– Weiss Molecular field – Curie-Weiss law – Ferromagnetic domains – The Domain Model – Domain theory – Antiferromagnetism – Ferrimagnetism – Structure of Ferrite.

### Unit-IV - Superconductivity

Sources of superconductivity – The Meissner effect – Thermodynamics of superconducting transitions – Origin of energy gap – London equations –London Penetration depth – Type I and Type II Superconductors - Coherence length – BCS theory – Flux quantization – Theory of DC and AC Josephson effect – Potential applications of superconductivity.

### Unit –V - Optical and Thermal Properties of Materials

Absorption processes- Photoconductivity – Photoelectric effect – Photovoltaic effect – Photoluminescence – Colourcentres – Types of colourcentres – Generation of colourcentres. Classical lattice heat capacity – Quantum theory of lattice heat capacity: average thermal energy of a harmonic oscillator, Einstein Model and Debye Continuum model – Anharmonic effects: thermal expansion and Phonon collision process.

### References

1. Solid State Physics: Structure and Properties of Materials, A.M.Wahab, 2<sup>nd</sup> Edition, Narosa Publishing house, New Delhi, India, 2007.
2. Elementary Solid State Physics: Principles and Applications, M.A.Omar, 4<sup>th</sup> Edition, Pearson Education Pvt. Ltd., Delhi, India, 2004.
3. Introduction to Solid State Physics, C. Kittel, 7<sup>th</sup> Edition, John –Wiley & Sons Pvt Ltd., New Delhi, 1996.
4. Elements of Solid State Physics, J.P.Srivastava, 2<sup>nd</sup> Edition, Printice Hall of India, New Delhi, 2001.
5. Solid State Physics, S.O.Pillai, 4<sup>th</sup> Edition, New Age International Publishers, New Delhi, 2001.
6. Solid State Physics, Ashcroft and Mermin, 1<sup>st</sup> Edition, Eastern Press Pvt Ltd, Bangalore, 2003.
7. Introductory to Solid State Physics, H.P.Myers, 2<sup>nd</sup> Edition, Taylors and Francis Ltd, London, 1998.

### Tutorials:

1. In an intrinsic semiconductor, the effective mass of an electron is  $0.07 m_0$  and that of hole is  $0.4 m_0$ , where  $m_0$  is the rest mass of the electron. Calculate the intrinsic concentration of charge carriers at 300 K. (Given the energy gap = 0.7 eV)

2. If a sample of silicon is doped with  $3 \times 10^{23}$  arsenic atoms and  $5 \times 10^{23}$  atoms of boron. Determine the electron and hole concentrations if the intrinsic charge carriers of silicon are  $2 \times 10^{16}/\text{m}^3$
  3. The polarizability of  $\text{NH}_3$  molecule in the gaseous state, from the measurement of dielectric constant is found to be  $2.42 \times 10^{-39} \text{ Fm}^2$  at 309 K and  $2 \times 10^{-39} \text{ Fm}^2$  at 448 K, respectively. Calculate for each temperature the polarizability due to permanent dipole moment and due to deformation of molecules.
  4. The magnetic field intensity in a piece of ferric oxide is  $10^6$  ampere/metre. If the susceptibility of the material at room temperature is  $1.5 \times 10^{-3}$ , calculate the flux density and magnetization of the materials.
  5. The critical temperature for mercury with isotopic mass 199.5 is 4.185K. Calculate its critical temperature when its isotopic mass changes to 203.4
  6. The penetration depths for lead are 396 Å and 1730 Å at 3 K and 7.1K, respectively. Calculate the critical temperature for lead.
  7. Diamond (atomic weight of carbon = 12) has Young's modulus of  $10^{12} \text{ Nm}^{-2}$  and a density of  $3500 \text{ kg/m}^3$ . Compute the Debye temperature for diamond.
  8. A photon of wavelength 1400 Å is absorbed by cold mercury vapour and two other phonons are emitted. If the wavelength of one of them is 1850 Å, what is the wavelength of the other photon?
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### Course Code and Title: 2EB – Environmental Biotechnology

Course Type: Elective (for Biotechnology)

Semester: II

Credits: 4

**Preamble:** A Nanoscience and Technology (with biotechnological) student needs to have some basic definition of energy and environment. Non – conventional energy sources from hydroelectric, tidal, ocean, thermal energy, solar energy collectors, nuclear energy and bioenergy. Definition, causes, effects and control measures of pollutions. Sources and management problems such as ozone depletion, acid rain and green house effects. The main objective of this course is to introduce the principles of conservation and application of biotechnology. Waste water treatment, characterization and its significance. Treatment schemes for waste waters of dairy, distillery, tannery, sugar, antibiotic industries. Based on this course aims to giving adequate exposure in the fate and life cycle of nanomaterial in environment, environmental and health impacts of nanomaterials.

**Prerequisite:** Higher Secondary Level, Degree Level – Environmental pollution, Waste water treatment and environmental problems such as acid rain and green house effect.

#### Course Objectives:

- To understand the environmental problems and control measures of pollutions, green house effect and acid rain.
- To understand the application of industrial ecology to nanotechnology such as environmental and health impacts of nanomaterials.
- To gain a thorough understanding of the basic knowledge of environmental biology applications related to nanoscience and nanotechnology.

#### Course Outcomes:

- CO1:** Understand the existing and emerging technologies that are important in the area of environmental biotechnology.
- CO2:** Understand the biotechnological solutions to address environmental issues including pollution, mineral resource winning, renewable energy and water recycling.
- CO3:** Understand the microbial processes and growth requirements underlying the activated sludge process, nitrification, denitrification, enhanced phosphorus removal, and anaerobic digestion.
- CO4:** Understand the bases for microbial metabolism of environmental contaminants.
- CO5:** Identify the ever-increasing complexity and interrelated nature of current environmental problems as well as the advantages of biotechnological treatment of liquid, solid and gaseous waste.
- CO6:** Use skills to tackle the problems and apply scientific principles to invent biotechnologies such as biological treatment, bioremediation and biosorption that would provide solutions to the real-life problems.

### **Unit-I**

Energy and environment: Non-Conventional energy sources: hydroelectric, wind, tidal ocean, thermal energy, geothermal, solar energy collectors, hydrogen, magneto hydrodynamic, nuclear energy, chemical energy, bio-energy (energy from biomass). Environmental pollution: Definition, causes, effects and control measures of Air pollution, water pollution, Soil pollution, Marine pollution and Noise pollution. Solid waste: Sources and management (composting, vermiculture and methane production).

### **Unit-II**

Global environmental problems: ozone depletion, green house effect and acid rain, principles of conservation and application of biotechnology, remote sensing and GIS, ecological modeling, bioindicators and biosensors for detection of pollution. Environmental acts-Ecoplanning and sustainable development: Indian standards IS: 2490, IS: 3360, IS: 3307, IS: 2296, ISO: 14000 series, MINAS for industries and ecomarks, public liability insurance act, EIA guidelines and assessment methods, environmental priorities in India and agenda 21 and carbon credit.

### **Unit-III**

Waste water characterization and its significance: COD, BOD, Inorganic constituents, solids, biological components. Biochemistry and microbiology of inorganic phosphorus and nitrogen removal. Waste water treatment: waste water collection, physico-chemical properties of waste water, physical, chemical and biological treatment processes. Activated sludge, oxidation ditches, trickling filter, rotating discs, rotating drums, oxidation ponds.

### **Unit-IV**

Anaerobic digestion, anaerobic filters, up flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar, antibiotic industries. Xenobiotics- Ecological considerations, degradative plasmids; hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides, biopesticides and bioremediation of contaminated soils and wastelands.

### **Unit-V**

Application of industrial ecology to nanotechnology: Fate and life cycle of nanomaterial in environment, environmental and health impacts of nanomaterials, toxicological threats, ecotoxicology, exposure to nanoparticle – biological damage, threat posed by nanomaterials to humans, environmental reconnaissance and surveillance. Corporate social responsibility for nanotechnology, Nano materials in future - implications.

### References

1. Environmental Biotechnology, Alan Scragg, Pearson Education Limited, England, 2005.
  2. Environmental Biotechnology, S.N. Jogdand, Himalaya Publishing House, Bombay, 1996.
  3. Wastewater Engineering – Treatment, Disposal and Reuse, Metcalf and Eddy, Inc., Tata McGraw Hill, New Delhi, 2004.
  4. Environmental chemistry, A.K. De, Wiley Eastern Ltd, New Delhi, 2003.
  5. Introduction to Biodeterioration, D. Allsopp, C. Gaylarde and k.J. Seal, ELBS/Edward Arnold, 2004.
  6. Environmental Science, WP Cunningham & BW Saigo., 5<sup>th</sup> edition, McGraw Hill, 1999.
  7. Biotechnology for Wastewater Treatment, P Nicholas Cheremisinoff, Prentice Hall Of India, 2001.
  8. Biotechnological Methods of Pollution Control, SA Abbasi and E Ramaswami, Universities Press, 1999.
  9. Environmental Biotechnology, Concepts and Applications, Hans-Joachim Jordening and Josef Winter, Winter-VCH, 2005
  10. Biology of wastewater Treatment, N F Gray, McGraw Hill, 2004.
  11. Environmental Biotechnology: Principles and Applications, Bruce Rittmann and Perry McCarty, McGraw Hill, 2001.
  12. Enviro-nanotechnology by Mao Hong fan, Chin-pao Huang, Alan E Bland, Z Honglin Wang, Rachid Sliman, Ian Wright. Elsevier, 2010.
  13. Nanotechnologies, Hazards and Resource efficiency by M. Steinfeldt, Avon Gleich, U. Petschow, R. Haum. Springer, 2007.
  14. Nanotechnology: Health and Environmental risk by Jo Anne Shatkin. CRC press, 2008.
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### Course Code and Title : 23P – Practical - I

Course Type : Practical

Semester : II

Credits: 4

**Preamble:** This course provides the hands on experience to understand the concepts learned through the core papers from their respective subjects in addition to nanoscience.

**Prerequisite:** Basic knowledge in science (physics, chemistry, biology and mathematics)

**Course Objectives:** Through this course the students will improve their practical knowledge in their core subjects in addition to nanoscience.

**Course Outcomes:** On completion of this course, students will be able to:

**CO1:** Understand the core concepts in physics, chemistry and biology related to nanoscience.

**CO2:** Have strong laboratory skills.

**CO3:** Enhance the present day requirements in research in their respective core subjects.

**CO4:** Create the knowledge of theories involved in their core subjects using practical experiments.

**First Half**

1. Study the forward and reverse characteristics of a Zener diode.
2. Construction of adder, subtracter, differentiator and integrator circuits using the given OP – Amp.
3. Study the static and drain characteristics of a JFET.
4. Study the characteristics of UJT.
5. Construction of a single FET amplifier with Common Source configuration.
6. Qualitative analysis of simple organic compounds and two component mixtures. Organic estimations based on functional groups.
7. Analysis of two component and three component mixtures separation and characterization with emphasis on characterization by derivatives.
8. Preparation of simple organic compounds and their identification by spectroscopic methods.
9. Semimicro qualitative analysis of common cation and anion containing the following less familiar elements: Tl, W, Sc, Te, Mo, Ce, Th, Ti, Zr, V, Be, U, Li and Cs.
10. Simple inorganic preparations including some complex compounds.
11. Preparation and analysis of metal complexes, characterisation by spectroscopic, magnetic, thermal and x-ray diffraction methods.
12. Determination of protein by Lowry method using BSA
13. Enzyme assay determination of specific activity of enzyme.
14. Determination of molecular weight of a protein by SDS-PAGE
15. Separation of peripheral mononuclear cells from the blood.
16. Hematology: RBC and WBC total counts

### **Second Half**

1. Michelson Interferometer Experiment
2. Hall effect in semiconductor
3. Determination of the refractive index of the given samples.
4. Determination of the diameter of the given circular aperture (Three holes)
5. Determination of the particle size of the given materials using He-Ne LASER.
6. XRD analysis of the given XRD spectra
7. Determination of thickness by the envelope method and calculate the band gap of the given transmittance spectra.
8. Determination of the wavelength of the given LASER using Vernier Caliper/steel scale and grating elements.
9. Polymer synthesis in bulk
10. Polymer synthesis by suspension method
11. Polymer synthesis by emulsion method
12. Preparation of polyurethane foams
13. Suspension copolymerization
14. IR and NMR spectra of polymers
15. Photopolymerization
16. Introduction to plant tissue culture-induction of callus and suspension cultures
17. Extract the genomic DNA from plants by CTAB method and resolve in the agarose gel
18. Plant genomic DNA isolation from a medicinal plant
19. Isolation of microorganisms from various environments.
20. Cultivation of bacteria, antinomycetes, fungi and archaea



21. Staining techniques and microscopy
22. Biochemical observations of bacteria
23. Blood typing
24. Double immunodiffusion

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