PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY, SOLAPUR

NAAC Accredited-2015
'B' Grade (CGPA 2.62)

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Syllabus: PHYSICS

(Applied Electronics/ Materials Science/Condensed Matter Physics)

Name of the Course: M.Sc. Part-I

(Syllabus to be implemented from w.e.f. June 2020)

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY

Syllabus of M.Sc. Physics (Choice Based Credit System)

1) **Title of the course:** M.Sc. in Physics (Applied Electronics/Materials Science/Condensed Matter Physics)
2) **Duration of the course**: Two years.
3) **Pattern:** Choice Based Credit System (CBCS)
4) **Eligibility:** For M. Sc. in Physics following candidates are eligible.
   (i) B.Sc. with Physics at principal level.
5) **Intake Capacity:** 20

M. Sc. program in Physics consists of 100 credits. Credits of a course are specified against the title of the course.

A Four Semester M.Sc. Physics Course

Semester	No. of Papers/ Practicals / Seminar	Marks	Credits
Semester I			
• Theory Papers	04	400	16
• Practical Papers	04	200	08
• Seminar/Tutorial	01	25	01
Semester II			
• Theory Papers	04	400	16
• Practical Papers	04	200	08
• Seminar/ Tutorial	01	25	01
Semester III			
• Theory papers	04	400	16
• Practical Papers	04	200	08
• Seminar/ Tutorial	01	25	01
• Skill Course	--	--	04*
Semester IV			
• Theory papers	04	400	16
• Project	04	200	08
• Seminar/ Tutorial	01	25	01
Total marks and credits for M.Sc. Course	**2500**		**100**

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

M.Sc. Physics Choice Based Credit System (CBCS)
Course Structure

M.Sc. Part-I Physics (Applied Electronics) w.e.f. 2020-21

M.Sc. PHYSICS SEMESTER-I								
Paper Code	**Title of the Paper**	**Semester Examination**			**L**	**P**	**T**	**Credits**
		Theory	**IA**	**Total**				
	Hard Core Theory							
HCT 1.1	Mathematical Physics	80	20	100	4	--	--	4
HCT 1.2	Solid State Physics	80	20	100	4	--	--	4
HCT 1.3	Analog and Digital Electronics	80	20	100	4	--	--	4
	Soft Core-Theory (Any one)							
SCT 1.1	Classical Mechanics	80	20	100	4	--	--	4
SCT 1.2	Fundamentals of Nanoelectronics							
	Practical							
HCP1.1	Practical-1: (Based on HCT 1.1)	40	10	50	--	2	--	2
HCP1.2	Practical-2: (Based on HCT 1.2)	40	10	50	--	2	--	2
HCP1.3	Practical-3: (Based on HCT 1.3)	40	10	50	--	2	--	2
SCP1.1/ 1.2	Practical-4: (Based on SCT 1.1/1.2)	40	10	50	--	2	--	2
	Seminar / Tutorial	---	25	25	--	--	1	1
Total for Semester-I		**480**	**145**	**625**	**--**	**--**	**--**	**25**
M.Sc. PHYSICS SEMESTER-II								
Code	**Title of the Paper**	**Semester Examination**			**L**	**P**	**T**	**Credits**
		Theory	**IA**	**Total**				
	Hard Core Theory							
HCT 2.1	Quantum Mechanics	80	20	100	4	--	--	4
HCT 2.2	Electrodynamics	80	20	100	4	--	--	4
	Soft Core Theory (Any One)							
SCT 2.1	Statistical Physics	80	20	100	4	--	--	4
SCT 2.2	Electronic Instrumentation							
	Open Elective Theory (Any one)							
OET 2.1	Fundamentals of Electronics	80	20	100	4	--	--	4
OET 2.2	Conventional & Non conventional Energy							
	Practical (Hard and Soft core)							
HCP 2.1	Practical-5: (based on HCT 2.1)	40	10	50	--	--	2	2

HCP 2.2	Practical-6: (based on HCT 2.2)	40	10	50	--	**--**	2	2
SCP 2.1/2.2	Practical-7: (based on SCT 2.1/2.2)	40	10	50	--	**--**	2	2
	Practical (Open Elective) Any One							
OEP 2.1	Practical -8: (based on OEP 2.1/2.2)	40	10	50	--	**--**	2	2
OEP 2.2	Practical-4: (based on OEP 2.2)							
	Seminar / Tutorial	---	25	25	--	1	**--**	1
Total for Semester-II		**480**	**145**	**625**	**--**	**--**	**--**	**25**

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
School of Physical Sciences
M.Sc. Physics Choice Based Credit System (CBCS)
Course Structure

M.Sc. Part-I Physics (Materials Science) w.e.f. 2020-21

M.Sc. PHYSICS SEMESTER-I								
Paper Code	Title of the Paper	Semester Examination			L	P	T	Credits
		Theory	IA	Total				
	Hard Core Theory							
HCT 1.1	Mathematical Physics	80	20	100	4	--	--	4
HCT 1.2	Solid State Physics	80	20	100	4	--	--	4
HCT 1.3	Analog and Digital Electronics	80	20	100	4	--	--	4
	Soft Core-Theory (Any one)							
SCT 1.1	Classical Mechanics	80	20	100	4	--	--	4
SCT 1.2	Elements of Materials Science							
	Practical							
HCP1.1	Practical-1: (Based on HCT 1.1)	40	10	50	--	2	--	2
HCP1.2	Practical-2: (Based on HCT 1.2)	40	10	50	--	2	--	2
HCP1.3	Practical-3: (Based on HCT 1.3)	40	10	50	--	2	--	2
SCP1.1/ 1.2	Practical-4: (Based on SCT 1.1/1.2)	40	10	50	--	2	--	2
	Seminar / Tutorial	---	25	25	--	--	1	1
Total for Semester-I		**480**	**145**	**625**	**--**	**--**	**--**	**25**
M.Sc. PHYSICS SEMESTER-II								
Code	**Title of the Paper**	**Semester Examination**			**L**	**P**	**T**	**Credits**
		Theory	**IA**	**Total**				
	Hard Core Theory							
HCT 2.1	Quantum Mechanics	80	20	100	4	--	--	4
HCT 2.2	Electrodynamics	80	20	100	4	--	--	4
	Soft Core Theory (Any One)							
SCT 2.1	Statistical Physics	80	20	100	4	--	--	4
SCT 2.2	Analytical Techniques							
	Open Elective Theory (Any one)							
OET 2.1	Fundamentals of Electronics	80	20	100	4	--	--	4
OET 2.2	Conventional & Non conventional Energy							
	Practical (Hard and Soft core)							
HCP 2.1	Practical-5: (based on HCT 2.1)	40	10	50	--	--	2	2
HCP 2.2	Practical-6: (based on HCT 2.2)	40	10	50	--	--	2	2
SCP 2.1/2.2	Practical-7: (based on SCT 2.1/2.2)	40	10	50	--	--	2	2

	Practical (Open Elective) Any One							
OEP 2.1	Practical -8: (based on OEP 2.1/2.2)	40	10	50	--	--	2	2
OEP 2.2	Practical-4: (based on OEP 2.2)							
	Seminar / Tutorial	---	25	25	--	1	--	1
Total for Semester-II		**480**	**145**	**625**	**--**	**--**	**--**	**25**

Punyashlok Ahilyadevi Holkar Solapur University, Solapur

School of Physical Sciences

M.Sc. Physics Choice Based Credit System (CBCS)

Course Structure

M.Sc. Part-I Physics (Condensed Matter Physics) w.e.f. 2020-21

M.Sc. PHYSICS SEMESTER-I								
Paper Code	Title of the Paper	Semester Examination			L	P	T	Credits
		Theory	IA	Total				
	Hard Core Theory							
HCT 1.1	Mathematical Physics	80	20	100	4	--	--	4
HCT 1.2	Solid State Physics	80	20	100	4	--	--	4
HCT 1.3	Analog and Digital Electronics	80	20	100	4	--	--	4
	Soft Core-Theory (Any one)							
SCT 1.1	Classical Mechanics	80	20	100	4	--	--	4
SCT 1.2	Energy Studies							
	Practical							
HCP1.1	Practical-1: (Based on HCT 1.1)	40	10	50	--	2	--	2
HCP1.2	Practical-2: (Based on HCT 1.2)	40	10	50	--	2	--	2
HCP1.3	Practical-3: (Based on HCT 1.3)	40	10	50	--	2	--	2
SCP1.1/ 1.2	Practical-4: (Based on SCT 1.1/1.2)	40	10	50	--	2	--	2
	Seminar / Tutorial	---	25	25	--	--	1	1
Total for Semester-I		**480**	**145**	**625**	**--**	**--**	**--**	**25**
M.Sc. PHYSICS SEMESTER-II								
Code	**Title of the Paper**	**Semester Examination**			**L**	**P**	**T**	**Credits**
		Theory	**IA**	**Total**				
	Hard Core Theory							
HCT 2.1	Quantum Mechanics	80	20	100	4	--	--	4
HCT 2.2	Electrodynamics	80	20	100	4	--	--	4
	Soft Core Theory (Any One)							
SCT 2.1	Statistical Physics	80	20	100	4	--	--	4
SCT 2.2	Electronic Instrumentation							
	Open Elective Theory (Any one)							
OET 2.1	Fundamentals of Electronics	80	20	100	4	--	--	4
OET 2.2	Nuclear Techniques							
	Practical (Hard and Soft core)							
HCP 2.1	Practical-5: (based on HCT 2.1)	40	10	50	--	--	2	2
HCP 2.2	Practical-6: (based on HCT 2.2)	40	10	50	--	--	2	2
SCP 2.1/2.2	Practical-7: (based on SCT 2.1/2.2)	40	10	50	--	--	2	2

	Practical (Open Elective) Any One							
OEP 2.1	Practical -8: (based on OEP 2.1/2.2)	40	10	50	--	--	2	2
OEP 2.2	Practical-4: (based on OEP 2.2)							
	Seminar / Tutorial	---	25	25	--	1	--	1
Total for Semester-II		**480**	**145**	**625**	**--**	**--**	**--**	**25**

Evaluation Scheme:

Each theory paper will have 100 marks out of which 80 marks will be for Term End examination and 20 marks for Internal Assessment. The candidate has to appear for internal evaluation of 20 marks and external evaluation (University Examination) of 80 marks for each theory paper.

Each practical paper will have 50 marks out of which 40 marks will be for Term End examination and 10 marks for Internal Assessment. The candidate has to appear for internal evaluation of 10 marks and external evaluation (University Examination) of 40 marks for each practical paper.

Internal Evaluation:

- In case of theory papers internal examinations will be conducted by department / school.
- In case of practical papers, 5 marks shall be for day-to-day journal and 5 marks shall be for internal test, which will be conducted by the department / school.

External Evaluation (End of Term University Examination):

I) Nature of Theory question paper:

1) Each Theory paper is of 80 marks.
2) Each Theory paper will be of 3 hours.

II) Nature of Practical question paper: (End of Term Examination)

Sem-I and II: Practical examination (Performing of Experiments) will be conducted for 40 marks and is of two hours duration. VIVA will be for 10 marks.

Department of Physics (Applied Electronics)

Programme Objectives: Applied Electronics

The main objective to initiate M.Sc Physics (Applied Electronics) was to give an exposure to the student on recent trends in consumer Electronics Apart from this students are encouraged to appear for various competitive examinations, PSU and join research Institutions.

Programme Specific Outcomes:

This programme is so designed that students can venture in the academic, research & private institutions/Organizations. Owing to the syllabus content many students have been placed in these organizations.

Alumni of these programmes have been placed in various PSU, Research institutions, academic institution and private electronics related industries.

Programme relevance to the

Local Development Needs: Various pass out student are working in and around Solapur region at various U.G. & P.G. Colleges as teaching faculty members and imparting knowledge.

National Development Needs:

Alumni of the programme are working in private electronic industries pertaining to embedded design solutions. Also students are engaged in research activities of National Level.

Regional Development Needs:-

Global Development Needs: Institution has ventured MOUs with premier institutions like CEERI Pilani, NRCP and KBCNMU Jalgaon.

M.SC-I, SEME. I, PHYSICS (APPLIED ELECTRONICS)

HCT - 1.1: MATHEMATICAL PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT1. 1 (60 lectures, 4 credits)

Course Objectives:

The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics.

Mathematical technique is an important tool that every physist would like to utilize.

Upon completion of the course, the student should be able to understand basic theory of:

- Operator and Matrix Analysis
- Functions of complex variables
- Elements of distribution theory
- Fourier Series

Learning Outcomes:

Successful students should be able to:

- Apply methods of functions of complex variables for calculations of integrals
- Expand functions in Fourier Series
- Work with vectors
- Work with Operators
- Work with Integral Transforms

Unit I: Calculus of Residues (15)

COMPLEX VARIABLE AND REPRESENTATIONS: Algebraic Operations, Argand Diagram: Vector Representation, Complex Conjugate, Euler's Formula, De Moiver's Theorem, The n^{th} Root or Power of a complex number.

ANALYTICAL FUNCTIONS OF A COMPLEX VARIABLE : The Derivative of f(Z) and Analyticity, Harmonic Functions, Contour Integrals, Cauchy's Integral Theorem, Cauchy's Integral Formula,

Zeros, Isolated Singular points, Evaluation of Residues, Cauchy's Residue theorem.

Unit II: Operator and Matrix Analysis (15)

Vector Space and its dimensionality, Vector Spaces and Matrices, Linear independence; Bases; Dimensionality, linear dependence, Inner product Hilbert space, linear operators.

Matrix operations, properties of matrices, Inverse, Orthogonal and unitary matrices; Independent elements of a matrix Diaglonization; Complete orthogonal sets of functions, special square matrices, Eigen values and eigenvectors; Eigen value problem.

Unit III: Ordinary Differential Equations (14)

First-Order homogeneous and non homogeneous equations with variable coefficients. The superposition principle, Second-order homogeneous equations with constant coefficient. Second-order non homogeneous equations with constant coefficients.

Unit IV: Fourier Series, Integral Transforms and Laplace transform (16)

Fourier Series: Fourier's theorem; Cosine, Sine and complex Fourier series, Applications to saw tooth and square waves and full wave rectifier. FS of arbitrary period; Half wave expansions; Partial sums Fourier integral and transforms; cosine since complex forms, Parsevals relation, Application to Gaussian distribution, box and exponential functions; FT of delta function.

Laplace transforms: Laplace transforms of common functions, First and second shifting theorems; inverse LT by partial fractions; LT of derivative and integral of a function.

Reference Books:

1. Introduction to Mathematical Physics by C. Harpcr, Prcnticc - Hall of India Ltd. N.Delhi 1993,(Chapters 2,4,6,9)
2. Mathematical Physics by A.G. Ghatak, I.C.Goyal and S.J.Chua, McMillan India Ltd. New Delhi 1995 (Chapters 4, 7,9,10)
3. Matrices and Tensors for Physicists,by A W Joshi
4. Advanced Engineering Mathematics, by E Keryszig
5. Mathematical Method for Physicits and Engineers, by K F Reily, M P Hobson and S J Bence
6. Mathematics for Physicists by Mary L B
7. Mathematical Methods for Physics, by G Arfken

M.SC-I, SEME. I, PHYSICS (APPLIED ELECTRONICS)

HCT - 1.2: SOLID STATE PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT 1.2 (60 lectures, 4 credits)

Course objectives: The course offers an introduction to solid state physics, and will allow the student to employ classical and quantum mechanical theories needed to understand the physical properties of solids. Prominence is put on building models able to explain several different phenomena in the solid state.

The course carries an understanding of how solid state physics has contributed to the existence of a number of important technological developments of importance in our lives now and in the future.

Learning outcomes:

The student is able to

- Explain mechanical properties of matter, and connect these to bond type.
- Explain how diffraction of electromagnetic waves on solid matter can be used to obtain lattice structure.
- Explain simple theories for conduction of heat and electrical current in metals.
- Classify solid state matter according to their band gaps.
- Understand how electrons and holes behave in semiconductors, and explain how they conduct current.
- Explain and give simple models for dielectrics.
- Know the basic physics behind superconductors

Unit I: Crystal Structure (15)

Basic Structures, Bravais systems in 2D and 3D, Bonding in solids, Reciprocal Lattice, Diffraction by X-ray and structure factor, Point defects and dislocations, Specific Heat: Lattice vibration, Phonons, Einstein and Debye's theories.

Unit II: Energy bands and Semiconductors (20)

Energy bands:

Metal, Insulator and Semiconductor, Bloch theorem, Electron in periodic potential -1D, Tight and loose band approach, Brillion's Zones, Fermi surfaces.

Semiconductors:

Direct and indirect band gap semiconductors, Effective mass, Hall effect and thermoelectric power, Intrinsic and Extrinsic carrier concentration.

Unit III: Dielectrics **(10)**

Electronic, Ionic, Orientational polarizations, Clausius-Mossotti equation, Dipole theory of ferroelectricity, Internal field in solids, Classification of magnetic materials,

Unit IV: Superconductors **(15)**

Basic concept, Meissner effect, Types I and II, Thermal properties of superconductor, Thermodynamics of superconductors, London equation, Josephson tunneling and its theory, BCS theory.

Reference Books:

1. Introduction to Solid State Physics 4 th Ed. C.Kittel,
2. Solid State Physics by N.W.Ashoroff &N.D.Mermin
3. Solid State Physics S.O.Pillai (New age international limited Publications)
4. Solid State Physics by Saxena and Gupta(Pragati Editions)
5. Solid State Physics by Rita John (Mc Graw Hill)

M.SC-I, SEME. I, PHYSICS (APPLIED ELECTRONICS)

HCT - 1.3: ANALOG & DIGITAL ELECTRONICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT1. 3 (60 lectures, 4 credits)

Course Objectives:

- To understand the fundamentals analog and digital electronics.
- To understand the differential amplifier and its types.
- To understand the building blocks of operational amplifiers 741, characteristics, parameters.
- To understand applications of operational amplifiers as multivibrators, Instrumentation amplifier, comparators, voltage regulator, power supplies.
- To understand the digital devices like flip flops, MUX and DEMUX ,shift registers, counters
- To understand the architecture, instruction set and different modes of addressing of 8085 microprocessor.

Learning Outcomes: After completion of this course, the students should be able…

- To design analog circuits using Op amp 741.
- To design digital circuits using combinational sequential logic.

To write the simple assembly language programs using microprocessor

Unit I: Operational Amplifiers (15)

Differential amplifier Circuit Configurations, Dual Input Balanced Output Differential amplifier, DC analysis, AC analysis, Inverting and Non Inverting Inputs, Constant Current Bias Circuit.

Block diagram of a typical Op-Amp, Open loop configuration, Inverting and Non-inverting amplifiers, Op-amp with negative feedback, Voltage Series Feedback, Effect of feedback on closed loop gain, Input resistance, Output resistance, Bandwidth and Output offset voltage, Voltage follower.

Practical Op-amp, Input Offset Voltage, Input bias current- input offset current, total output offset voltage, CMRR frequency response.

Unit II: Applications of Op amps (15)

DC and AC amplifier, Summing, Scaling and Averaging Amplifiers, Instrumentation amplifier, Integrator and Differentiator.

Oscillator: Principles, Oscillator types, Frequency stability, Response, Phase Shift oscillator, Wein Bridge Oscillator, LC Tunable Oscillator, Multivibrators, Monostable and Astable, Comparators,

Unit III: Combinational & Sequential Logic Circuits (15)

Combinational logic:

The transistor as a switch, OR AND NOT gates- NOR And NAND gates Boolean algebra- Demorgans theorems, Multiplexers and Demultiplexers

Sequential Logic:

Flip- Flops: RS Flip- Flop, JK Flip- Flop, JK master slave Flip-Flops Flip-Flop,
D Flip- Flop, Shift registers Synchronous and Asynchronous counters.

Unit IV: Microprocessors (15)

Architecture of 8085, Signals and timing diagram of 8085, Demultiplexing Address and Data bus, Instruction Set, Addressing modes, Assembly Language Programming of 8085 (Sum /Subtraction, Multiplication & Division of 4 & 8 bit numbers) .

Reference Books:

1. OP Amp amplifiers by Ramakant Gaikwad
2. Integrated Circuits by K.R.Botkar
3. Modern Digital Electronics by R.P.Jain
4. Digital Principle and Application by Malvino &Leeach
5. Digital Fundamentals by Floyd
6. 6)8085 Microprocessor by Ramesh Gaonkar

M.SC-I, SEME. I, PHYSICS (APPLIED ELECTRONICS)
SCT - 1.1: CLASSICAL MECHANICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 1.1 (60 lectures, 4 credits)

Course Objectives:

- To focus on understanding of the motion and equation of motion of macroscopic bodies.
- To learn to use the functional mathematical notations that's allows precise understanding of fundamental properties of classical mechanics.
- To study the demerits and to overcome them for further development in classical mechanics.

Learning Outcomes:

- Provides the difference between the equation of motion of the one body and many bodies systems as well as the basic formulations such Lagrangian and Hamilton, canonical transformation etc.
- Students can understand how to apply these formulations to the systems to obtain their equation of motions.
- Further, the problems solved during the course will be helpful for SET/NET.

Unit I: Mechanics of Particles and Rigid Bodies (15)

Mechanics of Particle and system of Particles using vector algebra and vector calculus, Conversion laws, work-energy theorem, open systems (with variable mass), Gyroscopic forces; dissipative systems, Jacobi integral, gauge invariance, integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations.

Unit II: Lagrangian Formulation and Motion Under Central Force (15)

Constrainsts, Generalised co-ordinates, D Alemaberts Principle, Lagranges equations of motion, Central Force, definition and characteristics, Reduction of Two-bod problem into equivalent One-body problem, General analysis of orbits, Keplers laws and equations, Artificial satellites, Rutherford Scattering.

Unit III: Variational Principle (15)

Introduction to Calculus of variation, Variational technique for many independent variables, Eulers Lagrange differential equation, Hamilton's principle, Deduction f Lagrange's equation of motion from Hamilton's principle.

Hamilton, Generalized momentum, Constant of motion, Hamilton's canonical equations of motion, Deduction of canonical equations from Variations principle.

Applications of Hamilton's equations of motion, Principle of least action, Proof of principles of least action, Problems.

Unit IV: Canonical Transformations and Hamilton's - Jacobi Theory (15)

Canonical Transformations, Condition for Transformation to be Canonical, Illustration of Canonical Transformation, Poisson's Brackets, Properties of Poisson's Brackets, Hamilton's Canonical equations in terms of Poisson's Brackets.

Hamilton's - Jacobi Theory, Solution of harmonic oscillator problems by HJ Method, Problems.

Texts and Reference Books:

1. Classical Mechanics, By Gupta, Kumar and Sharma (Pragati Prakashan2000).
2. Introduction to Classical Mechanics, by R.G. Takwale and P S Puranik(Tata McGraw Hill 1999).
3. Classical Mechanics, by H Goldstein (Addison Wesley 1980).
4. Classical Mechanics, by N C Rana and P S Joag(Tata McGraw Hill 1991).
5. Mechanics, by A Sommerfeld (Academic Press 1952)

M.SC-I, SEME. I, PHYSICS (APPLIED ELECTRONICS)
SCT - 1.2: Fundamentals of Nanoelectronics
Choice Based Credit System (CBCS)
(w. e. f. June 2020-21)

COURSE CODE: SCT 1.2 (60 lectures, 4 credits)

Course Objectives:

- To introduce the students to nanoelectronics, nanodevices and molecular electronics.
- To recognize quantum mechanics behind nanoelectronics.
- To define the principle and the operation of nanoelectronic devices.
- To explain the application of nanoelectronic devices.
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Learning Outcomes:
Students are able to:

- Explain the fundamental science and quantum mechanics behind nanoelectronics.
- Explain the concepts of a quantum well, quantum transport and tunnelling effects.
- Differentiate between microelectronics and nanoelectronics.
- Describe the superposition of eigenfunctions and probability densities.
- Describe the spin-dependant electron transport in magnetic devices.
- Calculate the energy levels of periodic structures and nanostructures.
- Calculate the I-V characteristics of nanoelectronic devices.
- Summarise the applications of nanotechnology and nanoelectronics.

Unit – 1 **(15)**
Region of nanostructures, scaling of devices in silicon technology, estimation of technology limits, Uncertainty principle, Experiments on duality, Schrodinger's equation and its applications to square well potential, square potential barrier (1D).

Unit – 2 **(15)**
Infinite array of potential wells, Barrier penetration, applications to tunnel diode, Josephson effect, Perturbation theory and its applications, Scattering. Binomial and related distributions, Phase space, Statistical ensembles, applications of classical statistical mechanics, Quantum statistics, Brownian motion, Random walk problem. Concept of Chemical potential, partition function and its applications in computing thermodynamic quantities.

Unit – 3
(15) Quantum electronic devices, electrons in mesoscopic structures, short channel

MOSFET, split-gate transistor, electron wave transistor, electron spin transistor, quantum cellular automata, Bioelectronics, molecular processor, DNA analyzer as biochip, Molecular electronics, Fullerenes, nanotubes, switches based on Fullerenes and nanotubes.

Unit – 4 **(15)**

Nanoelectronics with tunneling devices, resonant tunneling diode (RTD), three terminal RTDS, RTD based memory, basic logic gates and dynamic logic gates, Principle of single electron transistor, Coulomb blockade.

Text/ Reference Books:

1. Nanoelectronics and Nanosystems: K.Goser, P. Glosekotter, J. Dienstuhl, Springer (2005).
2. Quantum Mechanics: Schiff L.I. , “”
3. Fundamentals of Statistical Mechanics and Thermal Physics: Reif

M.Sc-I, SEME. II, PHYSICS (APPLIED ELECTRONICS)
HCT - 2.1: QUANTUM MECHANICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-21)

COURSE CODE: HCT 2. 1 (60 lectures, 4 credits)

Course Objectives:

1. To study the fundamental postulates of quantum mechanics and to apply them for microscopic bodies.
2. To review the relevant concepts in classical physics before corresponding concepts are developed in quantum mechanics.
3. To provide an understanding of the power and elegance of quantum mechanics.

Learning Outcomes:

- Provides a qualitative description of the remarkable concepts of quantum mechanics such as de-Broglie theory, Heisenberg uncertainty principle, Schrodinger equation, operators, etc.
- Students can gain the idea of applying these concepts to simple systems such as 1D box, 1D harmonic oscillator, hydrogen like atoms and many electron systems as helium atom etc.
- The complete Born-Oppenheimer approximation and Hartee-Fock theories gives the students some understanding of the molecular orbital as well as the current methods of performing electronic structure calculation.
- The problems solved during the course will be helpful for SET/NET.

Unit I: Operator Formalism: (15)

Linear Vector Spaces, Scalar Product, Schwartz Inequality, State Vector, difference between span and basis, orthogonal and orthonormal, General formalism of operator mechanics, operator algebra, commutation relations, Hermitian operator definition and properties, Relation between non commutativity of two operators and uncertainty relation, Dirac's bra-ket notations, Matrix representation of operators, state vector and scalar product. Effect of change of basis on the matrix representation, Unitary transformation.

Unit II : Introductory Quantum Mechanics: (15)

Time dependent and time-independent Schrodinger equation, Interpretation of wave function, admissible wave functions, continuity equation, Operators, Expectation Value, Ehrenfest's theorem, Uncertainty Principle, wave packet, admissible wave functions, stationary states, postulates of quantum mechanics, Eigen Values and Eigen Vectors. Momentum Eigen function in the coordinate representation, box normalization and Dirac Delta function. Coordinate and Momentum representations, Schrodinger equation in momentum representation. . Quantum Dynamics: Schrödinger, Heisenberg and Interaction picture.

Unit III: Solution of Schrodinger equation for some solvable systems and Angular Momentum Algebra: **(15)**

Infinite and finite potential wells, Square Well potential and Nanoscience, Harmonic Oscillator by operator method, Schrodinger in spherical polar coordinate and its solution for hydrogen atom, Angular momentum algebra: Definition, Commutation relations, Simultaneous eigenfunction of L2and Lz operator.

Unit IV: Addition of Angular Momenta and approximation methods: **(15)**

Algebra of Spin angular momenta, Pauli Spin matrices, generalized angular momentum, matrices for J2, Jx, Jy and Jz operators, Clebich Gordon Coefficient: Construction Procedure and simple examples.

Introduction to approximation methods like Variational and WKB methods with simple examples.

Text Books:

1. Introductory Quantum Mechanics (3rd Edition), D. J. Griffiths and D F Schroeter (Cambridge Univ. Press).
2. Quantum Mechanics-Theory and Applications by Ajoy Ghatak ,S. Loknathan (Sixth Edition) Publisher TRINITY
3. Introductory Quantum Mechanics by Liboff (4th Edition), Publisher Pearson
4. Quantum Mechanics Concepts and Applications by Nouredine Zettili, John Wiley and Sons (second Edition)
5. Quantum Mechanics - LI. Schiff (McGraw-Hill).
6. A textbook of Quantum Mechanics - P M Mathews, K Venkatesan. (Tata McGraw Hill).
7. Concept of Modern Physics (6th Edi.) A Beiser, S Mahajan and S R Choudhury. (McGraw-Hill).

M.Sc-I, SEME. II, PHYSICS (APPLIED ELECTRONICS)
HCT - 2.2: ELECTRODYNAMICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: HCT 2.2 (60 lectures, 4 credits)

Course Objectives:

This course develops concepts in electric field and scalar potential, magnetic field and vector potential, Maxwell's equations, electromagnetic boundary conditions, electromagnetic wave equation, waveguides, energy in electromagnetism. Electromagnetic wave propagation in vacuum, conducting and dielectric media, and at interfaces.

Learning outcomes:

Students will have achieved the ability to:

1. use Maxwell equations in analysing the electromagnetic field due to time varying charge and current distribution.
2. describe the nature of electromagnetic wave and its propagation through different media and interfaces.
3. explain charged particle dynamics and radiation from localized time varying electromagnetic sources.

Unit-I: Electrostatics and Magnetostatics: (15)

Dirac delta function, Gauss's law and applications, Differential form of Gauss's law, Poisson and Laplace's equations, Electrostatic potential energy, Boundary conditions, Uniqueness theorems, Method of images, Multipole expansion.

Biot-Savart law, Ampere's law, Differential form of Ampere's law, Vector potential, Magnetic field of a localized current distribution, Boundary conditions.

Unit-II: Time varying fields and Energy, force, momentum relations: (15)

Faraday's law, Maxwell's displacement current, Maxwell's equations, Maxwell's equations in matter, Scalar and vector potentials,

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy.

Unit-III: Electromagnetic wave equations: (15)

Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Normal and Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth.

Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator,

Unit IV: Radiation emission: (15)

Electric dipole, electric quadrupole and magnetic dipole radiation, Radiation by a moving charge: Lienard-Wiechert potentials of a point charge, Larmor's formula, Angular distribution

of radiation. Fields and radiation of a localized oscillating source, radiation from a half wave antenna, radiation damping.

Reference Books

1.Introduction to Electrodynamics: David Griffiths (PHI)

2. Electrodyanamics J. D. Jackson

3. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa)

4. Classical theory of fields, Landau &Lifshitz

5. Electrodynamics, W. Panofsky and M. Phillips

6. Electromagnetism and Classified Theory, A. D. Barut, Dover

7. Electromagnetic theory and Electrodynamics, by Satya Prakash, KedarNath and Co.Meerut.

8. Electromagnetics by B.B.Laud, Willey Eastern.

9. Electrodynamics by Kumar Gupta and Singh.

M.Sc-I, SEME. II, PHYSICS (APPLIED ELECTRONICS)
SCT - 2.1: STATISTICAL PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 2.1 (60 lectures, 4 credits)

Course objectives:

Statistical Mechanics is one of the fundamental mechanics .The aim of statistical mechanics is the evaluation of the laws of classical thermodynamics for macroscopic systems using the properties of its atomic particles. In addition to the classical TD the statistical approach provides information on the nature of statistical errors and variations of thermodynamic parameters.

Learning outcomes:

Students get in detail idea about

This course develops concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, Gibbs paradox, and phase space, statistical interpretation of thermodynamics, micro canonical, canonical and grant canonical ensembles; the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases; selected topics from low temperature physics.Energy fluctuation, Entropy fluctuations, Einstein theory of Brownian motion, Langiviens theory of Brownian motion and fluctuation-dissipation theorem. Phase transition theories, critical indices and their evaluation.

Unit I: Statistical Thermodynamics: (20)

Thermodynamic systems and equilibria, Laws of thermodynamics and their consequences, Nernst heat theorem, Microstates and microstates, Postulate of equal priori probability, Probability calculations, Thermodynamic potentials and Maxwell's relations, Chemical potential, phase equilibria, Black Body radiation and planks distribution, Phase equilibria, Free energy and its connection with thermodynamic quantities, entropy of mixing and Gibbs and paradox.

Unit II: Classical statistical mechanics: (15)

Statistical ensembles, Microcanonical ensemble- system in contact with heat revisor, Condition for thermal equilibrium, canonical ensemble – molecular ideal gas and grand canonical ensemble, Liouville's theorem, Ensembles, Maxwell Boltzmann distribution, classical ideal gas,

Unit III: Quantum Statistical Mechanics **(15)**

Phase space (Diagram of an oscillator), Maxwell- Boltzmann statistics, Fermi-Dirac statistics and Bose- Einstein statistics, Liouville's theorem, Ideal Bose gas, Ideal Fermi gas- weekly and strongly degerate , Bose- Einstein condensation.

Unit IV: Phase transitions and critical phenomena **(10)** Phase transition, Triple Point, Condition for phase equilibrium, First order phase transition, Ehrenfests equations, Clausius- Clayperon equation, Second latent heat equation, Examples, Second order phase transition, Critical indices, The law of corresponding states.

Reference Books:

1. Introduction to Statistical Mechanics by B.B.Laud
2. Statistical Mechanics by S.K.Sinha
3. Statistical Mechanics by I.D. Landau &F.M.Lifshitz
4. Text Book of statistical mechanics. Suresh Chandra, CBS Publications
5. Elementary Statistical Mechanics Gupta, Kumar, Pragati Prakashan.

M.Sc-I, SEME. II, PHYSICS (APPLIED ELECTRONICS)
SCT – 2.2: ELECTRONIC INSTRUMENTATION
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 2.2 (60 lectures, 4 credits)

Course Objectives:

- Explain basic concepts and definitions.
- Describe the bridge configurations and their applications.
- Elaborate discussion about the importance of signal generators and analyzers in Measurement.

Learning outcomes:

- Identify the various parameters that are measurable in electronic instrumentation.
- Employ appropriate instruments to measure given sets of parameters.
- Practice the construction of testing and measuring set up for electronic systems.
- To have a deep understanding about instrumentation concepts which can be applied to Control systems.
- Relate the usage of various instrumentation standards.

Unit I: Transducers (15)

Transducers classification Resistance, Capacitance, Inductance, Piezoelectric, Thermoelectric, Hall effect, Tachogenerator, Optical and Digital transducers, Measurements of displacement, Velocity, Acceleration, position, Force, pressure, flow, level, Torque, Strain, Speed and Sound, flow humidity, PH, position, Piezoelectric devices, micromechanical devices and smart sensors.

Unit II: Instrumentation Electronics (15)

Instrumentation Amplifiers, basic characteristics, D.C. Amplifiers, Isolation amplifiers, feedback transducers system, feedback fundamentals, Inverse transducers, temperature balance system,

Phase sensitive detection, Absolute value circuit, peak detector, sample and hold circuits, RMS converter, Logarithm (Amplifier, Frequency to Voltage and Voltage to Frequency Converter,

Unit III: Measuring Instruments (15)

True RMS measurement and DMM, R, L, C, Q measurement technique, active passive component testing, Automatic Test Equipment. Function generator, Sine, square, triangular, ramp wave generator, pulse generator, sine wave synthesis, arbitrary waveform generator. Oscilloscope: Dual Trace Oscilloscope, sweep modes, active, passive probes, delay line, Digital Storage Oscilloscope and its features like roll, refresh, sampling rate, application of the same in instrumentation and measurement, sampling oscilloscope. Wave analyzer, Distortion analyzer, spectrum analyzers.

Unit IV: Signal Processing Circuits (15)

ADC and DAC techniques, types, and their specifications, V to F converter, Sample and hold, analog multiplexer, data loggers. Digital Instrumentation: Universal counter and its mode – totalizing frequency, period, time. interval, ratio, measurement errors, application of counters for, frequency meter, capacitance, meter and timers, automation digital instruments. Virtual Instrumentation and its applications,

Reference Books:

1. Transducer Theory and Application: John A Alloca, Allen Stuart (Reston Publishing Company Inc.)
2. Transducer and Display Devices: B. S. Sonde.
3. Integrated Electronics: K. R. Botkar.
4. W. D. Cooper & A. D. Helfrick, ‘Electronic Instrumentation And Measurement Techniques’, PH I, 4th e/d, 1987
5. Kalsi H. S., ‘Electronic Instrumentation’, TMH, 2nd e/d, 2004

M.Sc-I, SEME. II, PHYSICS (APPLIED ELECTRONICS)

OET - 2.1: FUNDAMENTALS OF ELECTRONICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: OET 2.1 (60 lectures, 4 credits)

Course Objectives:
Fundamental of Electronics is mainly designed for bridge course for Physics student. The main objective of this courseis to assign the basic design approach to the students, which will nurture the practical knowledge in electronics.

Learning outcomes:

- Studentswill be able to apply the basic laws of electronics like ohm's law Kirchhoff's laws, Thevenin's. Norton's and maximum power theorems.
- Students can design and analyse the various diode and transistor circuits.
- Students will be able to design and analyse the op-amp and IC555 circuits.

UNIT 1 : Electronic Components (15)
Circuit concept Units, Standards and Dimensions. Electric current, Electric charge, potential difference, Electric power and Energy. Circuit elements: Passive elements and active elements. Network Law's, Junction Law's (KCL), Mesh Law's (KVL) Application of Network Law's to simple dc networks theorems – Thevenin's theorem, Norton's theorem Max power transfer theorem.

UNIT 2 : Semiconductor Devices (15)
Junction Diodes, p-n junction, an unbiased p-n junction, a biased p-n junction and V-I characteristics of p-n junction. Some special P-N junction: - Photodiodes, LED and Solar Cell. Junction transistor, Transistor static characteristic Self-bias or emitter bias, Two-port representation of Transistor (hybrid parameter) JFET: Static Characteristic of FET comparison of FET with Bipolar transistor.

UNIT 3: Applications of Active & Passive (15)
Operational Amplifier Characteristics and Applications
Introduction, Ideal Op-Amp, DC and AC Characteristics: Instrumentation Amplifier, V to I and I-V converter Precision rectifier, Differentiator and Integrator. Comparator Schmitt trigger wave generators (Square wave and Triangular wave) and first order Low pass and High pass filters.

UNIT 4: Special IC series (15)
Op-Amp regulator, Design of power supplies using voltage regulator ICs, 555 Timer as Monostable and Astable operation.

Reference books:

1. D Chattopadhyaya, P.C. Rakshit, B Saha and N NPurkait: Foundations of Electronics, New Age International Edition.
2. D. Roy Choudhary and ShailJain : Linear Integrated Circuit, New Age International (P) Ltd.
3. P-Amp and Linear Integrated Circuits : R. A. Gaikwad, PHI of India Ltd.
4. A Texbook of Electronics (Second Edition) : S. L. Kakani and K. C. Bhandari
5. Electronic Principles : A. P. Malvino, TMH Edition.

M.Sc-I, SEME. II, PHYSICS (APPLIED ELECTRONICS)

OET - 2.2: Conventional & Nonconventional Energy
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: OET 2.2 (60 lectures, 4 credits)

Course Objectives:
To provide a survey of the most important renewable energy resources and the technologies for harnessing these resources within the framework of a broad range of simple to state- of -the-art energy systems.

Learning Outcomes:
Students will be able to
- Demonstrate the generation of electricity from various Non-Conventional sources of energy, have a working knowledge on types of fuel cells.
- Estimate the solar energy, Utilization of it, Principles involved in solar energy collection and conversion of it to electricity generation.
- Explore the concepts involved in wind energy conversion system by studying its components, types and performance.
- Illustrate ocean energy and explain the operational methods of their utilization.

Unit I: Energy Science and Energy Technology
A brief history of energy technology, Various sciences and energy science, Energy, man and environment, Thermodynamics and energy analysis, Classification of conventional and non-conventional energy sources, Global energy trends,

Hydro energy-merits and demerits, Primary hydro energy resources, Types of hydroelectric plants, Energy and power equations, Hydraulic turbines,

Fossil Fuels, Conversion and applications, Types of coal, properties of coal, Coal production and processing.

Unit II: Solar Energy
The solar spectrum, Semiconductors, p-n junction, Solar photocells, Efficiency of solar cells, Commercial solar cells, Developing technologies, Solar panels, Economics of photovoltaics (PV), Environmental impact of photovoltaics, Outlook for photovoltaics,
Solar thermal power plants, Solar thermal collectors, Flat plate collectors, Parabolic collectors, paraboloidal dish collector.

Unit III: Wind and Biomass Energy
Source of wind energy, Global wind patterns, Modern wind turbines, Kinetic energy of wind, Principles of a horizontal-axis wind turbine, Wind turbine blade design, Dependence of the power coefficient C_p on the tip-speed ratio λ, Design of a modern horizontal-axis wind turbine, Turbine control and operation, Wind characteristics, Power output of a wind turbine, Wind farms, Environmental impact and public acceptance, Economics of wind power, Outlook, Conclusion,

Photosynthesis and crop yields, Biomass potential and use, Biomass energy production, Environmental impact of biomass, Economics and potential of biomass, Outlook, Biogas plants, Types of Biogas plants

Unit IV: Nuclear Energy

Binding energy and stability of nuclei, Fission, Thermal reactors, Thermal reactor designs, Fast reactors, Present-day nuclear reactors, Safety of nuclear power, Economics of nuclear power, Environmental impact of nuclear power, Public opinion on nuclear power, Outlook for nuclear power, Magnetic confinement, D-T fusion reactor, Performance of tokamaks, Plasmas, Charged particle motion in E and B fields, Tokamaks, Plasma confinement, Divertor tokamaks, Outlook for controlled fusion.

Reference Books:

1. Energy Technology: Nonconventional, Renewable & Conventional by S. Rao and B.B. Parulekar (3rd Edition, Khanna Publishers).
2. ENERGY SCIENCE: principles, technologies, and impacts, John Andrews and Nick Jelley, Oxford University Press.

M. Sc, PHYSICS (APPLIED ELECTRONICS)
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Practical List

HCP 1.1/1.2/1.3

1. Study of Filters.
2. Voltage Regulator.
3. Transistor Biasing.
4. C. E. Amplifier Design.
5. Op.Amp. Inverting and Non- inverting amplifiers
6. D.T. L. Gates.
7. C.E. with CC Amplifier.
8. AstableMultivibrator (IC 555)
9. Determination of Bandgap of Ge diode.
10. Temperature Transducer (Thermister).
11. Wein Bridge oscillator.
12. Negative Feedback Amplifiers.
13. DC Amplifiers.
14. FET Characteristics and Designing of Amplifier.
15. Op. Amp (Adder, Substractor, Integrator and Differentiator).
16. Crystal Structure (FCC- Type)
17. Verification of Demorgan's Theorem.
18. Op. Amp. Phase Shift Oscillator.
19. Temp. Variation of break down voltage of Zener Diode.
20. AstableMultivibrator (using 741 Op amps)
21. Op amp Phase Lead Circuit.
22. Op amp Phase Lag Circuit
23. Microprocessors (µp) - I (Logsun 8085 Kit)
24. Divide by 2, divide by 5 and divide by 10 counters using IC – 7490.

SCP 1.1/1.2

1. Characteristics of UJT .
2. Op. Amp. Parameters.

3. P - N Junction Capacitance.
4. LVDT.
5. Op. Amp. I to V and V to I converters.
6. Multiplication & Division using Microprocessor 8085.
7. Addition, Substractor, Multiplication using 89C51 microcontroller.
8. Logical operation using 89C51 microcontroller.
9. Microcontroller – III
10. Microcontroller – IV

HCP 2.1/2.2

1. Twin T Networks.
2. Butter worth low pass filter using IC- 741
3. Variable Duty cycle MV using Op. amp.(IC- 741)
4. Constant current source (Floating load).Using Opamp.
5. Constant current source (Grounded load). Using Opamp
6. Wein bridge oscillator
7. Op-Amp Op. Amp. Parameter (Slew rate, power band width, CMMR) .
8. Voltage regulator using IC 723.
9. Constant Voltage Source with Fold back Current Limit.
10. Constant Voltage Source (Precision Voltage Regulator) with
11. Constant Current Limit.
12. Study of Wein Bridge oscillator.

SCP 2.1/2.2

1. Microprocessor - VI (Ascending & Descending).
2. Microprocessor - VII (Decimal Addition & Odd & Even Parity).
3. Microcontroller - I Addition and subtraction of 8 bit and 16 bit numbers with and without carry.
4. Microcontroller – II Study of LED interfacing to 8051 microcontroller.
5. Microcontroller – III Study of ADC Interfacing to 8051 microcontroller.
6. Microcontroller – IV Study of DAC Interfacing to 8051 microcontroller.

7. Microcontroller – V -Determination of minimum & maximumnumbers.
8. Microcontroller – VI- LCD interfacing with µc -8051.
9. Microcontroller – VII-Seven segment interfacing with µc -8051.

OEP 2.1/2.2

1) Transister Parameters.
2) Op-Amp inverting and non-inverting amplifiers.
3) Monostablemultivibratorvsing IC555.
4) FET charaterishes.
5) Op-Amp Adder.
6) Op-Amp subtractor.
7) First order High pass filter.
8) First order Low pass filter.
9) Determination of optical gap.
10) Determination of optical absorption by materials & hence determination of type of transition.
11) Study of p.n. junction photo voltaic.
12) Characterization of a PV cell in dark & in light & hence determination of junction ideality factor.

Department of Physics (MATERIALS SCIENCE)

1. Program Objectives: MATERIALS SCIENCE

The recent developments in Physics have been included in the M.Sc., Physics. (Materials Science) Syllabus to meet the present day needs of Academic and Research Institutions and Industries. An important objective of the course is to develop an understanding of ‘core physics’ at deeper levels, each stage revealing new phenonmena and greater insight into phenomenon of materials synthesis, properties and analysis. The various courses in the first two semesters are designed to bridge the gap between undergraduate and post graduate level physics and to bring all students to a common point. These courses also aim to consolidate the undergraduate level knowledge of physics by providing much more logical and analytical framework which will be essential for the specialization courses in the third and fourth semester. In various advanced courses in the third and fourth semester, a number of recent topics broaden the perspective of the student to appreciate the great flexibility and generality of synthesis of materials by various methods and their applications. However the different kinds of experimental works designed to develop practical skills and prepare the student for advanced laboratory work as synthesis of materials and analysis of materials by use of sophisticated microscopic tools as SEM, TEM etc.

The M.Sc in Materials Science program provides instruction about the use of modern materials, processes, and applications, particularly in the science, engineering and technology field. The courses typically cover the development of new materials and processes, as well.

2. Program Specific Outcome: After completion of M.Sc Physics (Materials Science) course student will

- Apply knowledge and skill in the synthesis and characterization of functional materials for device fabrication.
- Become professionally trained in the area of materials synthesis and characterize of device grade,
- Excel in the research related to Physics and Materials synthesis and characterization.

- Demonstrate highest standards of Actuarial ethical conduct and Professional Actuarial behavior, critical, interpersonal and communication skills as well as a commitment to life- long learning.

3. Programme relevance to the

a. Local development Needs:

The course content of M.Sc Physics (Materials Science) will be useful to provide new insight of fabrication of novel materials useful for textile industry e.g. dye pigments contaminated water purification, growth of novel fabric materials by use of nanotechnology.

b. National development Needs:

Materials Science is a dynamic, interdisciplinary study that combines the fundamental sciences; chemistry, physics and life sciences. Materials make up the things we see and use and Materials Science modify them and make them better. This involves studying and designing, processing and fabricating, and developing these functional materials for technological applications, making them useful and reliable in the service of human kind.

c. Regional Development Needs:

In the Solapur University jurisdictions, there are more than 30 sugar industries. The basic products of the sugar industry are ethanol, bagas and sugar. The course content of M.Sc Physics (Materials Science) is designed such that it will help to solve the problems of sugar industry as minimizing the green houses emission by developing different sensors, waste water treatment, energy utilization of bagas, testing ethanol and recycling of sugar waste.

d. Global Development Needs:

There are plenty of job opportunities for the graduates with an MSc in Materials Science. These include jobs such as Materials Engineer, Research Scientist, Technical Sales Engineer, Biomedical Engineer, Manufacturing Systems Engineer, and more. Materials engineers often work in the extraction, development, processing of, and testing of materials to be used in the creation of many products.These products might include semiconductors, golf clubs, or computer chips.The development of new materials is often one of the primary goals of these professionals.

M.SC-I, SEME. I, PHYSICS (MATERIALS SCIENCE)

HCT - 1.1: MATHEMATICAL PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT 1.1 (60 lectures, 4 credits)

Course Objectives:

The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics.

Mathematical technique is an important tool that every physist would like to utilize.

Upon completion of the course, the student should be able to understand basic theory of:

- Operator and Matrix Analysis
- Functions of complex variables
- Elements of distribution theory
- Fourier Series

Learning Outcomes:

Successful students should be able to:

- Apply methods of functions of complex variables for calculations of integrals
- Expand functions in Fourier Series
- Work with vectors
- Work with Operators
- Work with Integral Transforms

Unit I: Calculus of Residues (15)

COMPLEX VARIABLE AND REPRESENTATIONS: Algebraic Operations, Argand Diagram: Vector Representation, Complex Conjugate, Euler's Formula, De Moiver's Theorem, The n^{th} Root or Power of a complex number.

ANALYTICAL FUNCTIONS OF A COMPLEX VARIABLE : The Derivative of f(Z) and Analyticity, Harmonic Functions, Contour Integrals, Cauchy's Integral Theorem, Cauchy's Integral Formula,

Zeros, Isolated Singular points, Evaluation of Residues, Cauchy's Residue theorem.

Unit II: Operator and Matrix Analysis (15)

Vector Space and its dimensionality, Vector Spaces and Matrices, Linear independence; Bases; Dimensionality, linear dependence, Inner product Hilbert space, linear operators.

Matrix operations, properties of matrices, Inverse, Orthogonal and unitary matrices; Independent elements of a matrix Diaglonization; Complete orthogonal sets of functions, special square matrices, Eigen values and eigenvectors; Eigen value problem.

Unit III: Ordinary Differential Equations (14)

First-Order homogeneous and non homogeneous equations with variable coefficients. The superposition principle, Second-order homogeneous equations with constant coefficient. Second-order non homogeneous equations with constant coefficients.

Unit IV: Fourier Series, Integral Transforms and Laplace transform (16)

Fourier Series: Fourier's theorem; Cosine, Sine and complex Fourier series, Applications to saw tooth and square waves and full wave rectifier. FS of arbitrary period; Half wave expansions; Partial sums Fourier integral and transforms; cosine since complex forms, Parsevals relation, Application to Gaussian distribution, box and exponential functions; FT of delta function.

Laplace transforms: Laplace transforms of common functions, First and second shifting theorems; inverse LT by partial fractions; LT of derivative and integral of a function.

Reference Books:

1. Introduction to Mathematical Physics by C. Harper, Prentice - Hall of India Ltd. N.Delhi 1993,(Chapters 2,4,6,9)
2. Mathematical Physics by A.G. Ghatak, I.C.Goyal and S.J.Chua, McMillan India Ltd. New Delhi 1995 (Chapters 4, 7,9,10)
3. Matrices and Tensors for Physicists,by A W Joshi
4. Advanced Engineering Mathematics, by E Keryszig
5. Mathematical Method for Physicits and Engineers, by K F Reily, M P Hobson and S J Bence
6. Mathematics for Physicists by Mary L B
7. Mathematical Methods for Physics, by G Arfken

M.Sc-I, SEME. I, PHYSICS (MATERIALS SCIENCE)

HCT - 1.2: SOLID STATE PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT 1.2 (60 lectures, 4 credits)

Course objectives: The course offers an introduction to solid state physics, and will allow the student to employ classical and quantum mechanical theories needed to understand the physical properties of solids. Prominence is put on building models able to explain several different phenomena in the solid state.

The course carries an understanding of how solid state physics has contributed to the existence of a number of important technological developments of importance in our lives now and in the future.

Learning outcomes:

The student is able to

- Explain mechanical properties of matter, and connect these to bond type.
- Explain how diffraction of electromagnetic waves on solid matter can be used to obtain lattice structure.
- Explain simple theories for conduction of heat and electrical current in metals.
- Classify solid state matter according to their band gaps.
- Understand how electrons and holes behave in semiconductors, and explain how they conduct current.
- Explain and give simple models for dielectrics.
- Know the basic physics behind superconductors

Unit I: Crystal Structure (15)

Basic Structures, Bravais systems in 2D and 3D, Bonding in solids, Reciprocal Lattice, Diffraction by X-ray and structure factor, Point defects and dislocations, Specific Heat: Lattice vibration, Phonons, Einstein and Debye’s theories.

Unit II: Energy bands and Semiconductors (20)

Energy bands:

Metal, Insulator and Semiconductor, Bloch theorem, Electron in periodic potential -1D, Tight and loose band approach, Brillion’s Zones, Fermi surfaces.

Semiconductors:

Direct and indirect band gap semiconductors, Effective mass, Hall effect and thermoelectric power, Intrinsic and Extrinsic carrier concentration.

Unit III: Dielectrics (10)

Electronic, Ionic, Orientational polarizations, Clausius-Mossotti equation, Dipole theory of ferroelectricity, Internal field in solids, Classification of magnetic materials,

Unit IV: Superconductors (15)

Basic concept, Meissner effect, Types I and II, Thermal properties of superconductor, Thermodynamics of superconductors, London equation, Josephson tunneling and its theory, BCS theory.

Reference Books:

1. Introduction to Solid State Physics 4 th Ed. C.Kittel,
2. Solid State Physics by N.W.Ashoroff &N.D.Mermin
3. Solid State Physics S.O.Pillai (New age international limited Publications)
4. Solid State Physics by Saxena and Gupta(Pragati Editions)
5. Solid State Physics by Rita John (Mc Graw Hill)

M.Sc-I, SEME. I, PHYSICS (MATERIALS SCIENCE)

HCT - 1.3: ANALOG & DIGITAL ELECTRONICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT 1.3 (60 lectures, 4 credits)

Course Objectives:

- To understand the fundamentals analog and digital electronics.
- To understand the differential amplifier and its types.
- To understand the building blocks of operational amplifiers 741, characteristics, parameters.
- To understand applications of operational amplifiers as multivibrators, Instrumentation amplifier, comparators, voltage regulator, power supplies.
- To understand the digital devices like flip flops, MUX and DEMUX ,shift registers, counters
- To understand the architecture, instruction set and different modes of addressing of 8085 microprocessor.

Learning Outcomes:

After completion of this course, the students should be able…

- To design analog circuits using Op amp 741.
- To design digital circuits using combinational sequential logic.

To write the simple assembly language programs using microprocessor

Unit I: Operational Amplifiers (15)

Differential amplifier Circuit Configurations, Dual Input Balanced Output Differential amplifier, DC analysis, AC analysis, Inverting and Non Inverting Inputs, Constant Current Bias Circuit.

Block diagram of a typical Op-Amp, Open loop configuration, Inverting and Non-inverting amplifiers, Op-amp with negative feedback, Voltage Series Feedback, Effect of feedback on closed loop gain, Input resistance, Output resistance, Bandwidth and Output offset voltage, Voltage follower.

Practical Op-amp, Input Offset Voltage, Input bias current- input offset current, total output offset voltage, CMRR frequency response.

Unit II: Applications of Op amps (15)

DC and AC amplifier, Summing, Scaling and Averaging Amplifiers, Instrumentation amplifier, Integrator and Differentiator.

Oscillator: Principles, Oscillator types, Frequency stability, Response, Phase Shift oscillator, Wein Bridge Oscillator, LC Tunable Oscillator, Multivibrators, Monostable and Astable, Comparators,

Unit III: Combinational & Sequential Logic Circuits (15)

Combinational logic:

The transistor as a switch, OR AND NOT gates- NOR And NAND gates Boolean algebra- Demorgans theorems, Multiplexers and Demultiplexers

Sequential Logic:

Flip- Flops: RS Flip- Flop, JK Flip- Flop, JK master slave Flip-Flops Flip-Flop,
D Flip- Flop, Shift registers Synchronous and Asynchronous counters.

Unit IV: Microprocessors (15)

Architecture of 8085, Signals and timing diagram of 8085, Demultiplexing Address and Data bus, Instruction Set, Addressing modes, Assembly Language Programming of 8085 (Sum /Subtraction, Multiplication & Division of 4 & 8 bit numbers) .

Reference Books:

1. OP Amp amplifiers by Ramakant Gaikwad
2. Integrated Circuits by K.R.Botkar
3. Modern Digital Electronics by R.P.Jain
4. Digital Principle and Application by Malvino &Leeach
5. Digital Fundamentals by Floyd
6. 8085 Microprocessor by Ramesh Gaonkar

M.Sc-I, SEME. I, PHYSICS (MATERIALS SCIENCE)
SCT - 1.1: CLASSICAL MECHANICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT1. 1 (60 lectures, 4 credits)

Course Objectives:

- To focus on understanding of the motion and equation of motion of macroscopic bodies.
- To learn to use the functional mathematical notations that's allows precise understanding of fundamental properties of classical mechanics.
- To study the demerits and to overcome them for further development in classical mechanics.

Learning Outcomes:

- Provides the difference between the equation of motion of the one body and many bodies systems as well as the basic formulations such Lagrangian and Hamilton, canonical transformation etc.
- Students can understand how to apply these formulations to the systems to obtain their equation of motions.
- Further, the problems solved during the course will be helpful for SET/NET.

Unit I: Mechanics of Particles and Rigid Bodies (15)

Mechanics of Particle and system of Particles using vector algebra and vector calculus, Conversion laws, work-energy theorem, open systems (with variable mass), Gyroscopic forces; dissipative systems, Jacobi integral, gauge invariance, integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations.

Unit II: Lagrangian Formulation and Motion Under Central Force (15)

Constrainsts, Generalised co-ordinates, D Alemaberts Principle, Lagranges equations of motion, Central Force, definition and characteristics, Reduction of Two-bod problem into equivalent One-body problem, General analysis of orbits, Keplers laws and equations, Artificial satellites, Rutherford Scattering.

Unit III: Variational Principle (15)

Introduction to Calculus of variation, Variational technique for many independent variables, Eulers Lagrange differential equation, Hamilton's principle, Deduction f Lagrange's equation of motion from Hamilton's principle.

Hamilton, Generalized momentum, Constant of motion, Hamilton's canonical equations of motion, Deduction of canonical equations from Variations principle.

Applications of Hamilton's equations of motion, Principle of least action, Proof of principles of least action, Problems.

Unit IV: Canonical Transformations and Hamilton's - Jacobi Theory (15)

Canonical Transformations, Condition for Transformation to be Canonical, Illustration of Canonical Transformation, Poisson's Brackets, Properties of Poisson's Brackets, Hamilton's Canonical equations in terms of Poisson's Brackets.

Hamilton's - Jacobi Theory, Solution of harmonic oscillator problems by HJ Method, Problems.

Texts and Reference Books:

1. Classical Mechanics, By Gupta, Kumar and Sharma (Pragati Prakashan2000).
2. Introduction to Classical Mechanics, by R.G. Takwale and P S Puranik(Tata McGraw Hill 1999).
3. Classical Mechanics, by H Goldstein (Addison Wesley 1980).
4. Classical Mechanics, by N C Rana and P S Joag(Tata McGraw Hill 1991).
5. Mechanics, by A Sommerfeld (Academic Press 1952)

M.Sc-I, SEME. I, PHYSICS (MATERIALS SCIENCE)
SCT– 1.2 (MS): ELEMENTS OF MATERIALS SCIENCE
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Unit I: Introduction to materials: Classification, Properties and Requirements (15)
Introduction, Classification of Engineering Materials, Metals, Alloys, ceramics, Polymers and Semiconducting materials, Application of Engineering Materials.
Chemical Bonding: Introduction, Crystalline and Non-crystalline Solids, Classification of Bonds, Ionic Bond or Electrovalent Bond, Covalent Homopolar Bonds, Metallic Bonds, Molecular Bonds, Hydrogen Bond, van der Walls bond (Inter-molecular and Intra-molecular bonds).

Unit II: Optical Properties of Materials (15)
Introduction, Classification of Optical Materials, Interaction of light with matter, Absorption in Metals, Insulators and Semiconductors, Reflection, Refraction, Transmission and Scattering, Traps, Excitons, Colour Centers, Tauc and Lambert-Beer laws, Optical properties of Photonic material.
Luminescence and Photoconductivity Luminescence: Introduction, Principle, Classification of Luminescence, Photoluminescence, Cathodoluminescence, Electroluminescence, Thermoluminescence, Phosphorescence, Chemiluminescense, Applications.
Photoconductivity: Introduction, Photoconductivity, Characteristics of Photoconductivity Materials, Photodiodes, Photoresistor, Photodetectors, Photodetector Bias Circuit, Performance of Photodetector, Applications, Light emitting diodes (LED) and LASER’s.

Unit III : Functional Materials (15)
Nanophase Materials: Introduction, Synthesis and techniques, Nucleation and growth mechanism, Characterization of Nanostructured Materials, Properties of Nanophase Materials, Applications.
Advanced Ceramics: Introduction, Classification of Ceramics, Structure of the Ceramics, Ceramic Processing, Properties of Ceramics, Applications.
Polymer Materials: Introduction, Polymerization Mechanism, Degree of Polymerization, Classification of Polymers, Structures of polymer and preparation methods, important properties and applications of commercial polymers-viz-polyethylene. Polyvinylchloride, Polystyrene, Nylon, Polyesters, Silicones, Composites, Composite material including nano-materials.

Unit IV: Phase diagrams & Diffusion in Solids (15)
Phase diagrams
Phase rule, Single component system, Binary phase diagram, Microstructure changes during cooling, Lever rule, Phase diagram rules, Applications of phase diagram.
Diffusion in solids
Ficks law of diffusion (1^{st}& 2^{nd}), Applications of second law of diffusion, Kirkendall effect, Atomic model of diffusion.

Reference Books:

1. Materials Science : V. Rajendran, A. Marikani, Tata MC Graw Hill
2. Materials Science & Engineering: Raghavan, Tata MC Graw Hill
3. Materials Science: Arumugam
4. Materials Science & Metallurgy : O. P. Khanna
5. Materials Science and Engineering: Callister S.

M.Sc-I, SEME. II, PHYSICS (MATERIALS SCIENCE)
HCT - 2.1: QUANTUM MECHANICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-21)

COURSE CODE: HCT 2. 1 (60 lectures, 4 credits)

Course Objectives:

- To study the fundamental postulates of quantum mechanics and to apply them for microscopic bodies.
- To review the relevant concepts in classical physics before corresponding concepts are developed in quantum mechanics.
- To provide an understanding of the power and elegance of quantum mechanics.

Learning Outcomes:

- Provides a qualitative description of the remarkable concepts of quantum mechanics such as de-Broglie theory, Heisenberg uncertainty principle, Schrodinger equation, operators, etc.
- Students can gain the idea of applying these concepts to simple systems such as 1D box, 1D harmonic oscillator, hydrogen like atoms and many electron systems as helium atom etc.
- The complete Born-Oppenheimer approximation and Hartee-Fock theories gives the students some understanding of the molecular orbital as well as the current methods of performing electronic structure calculation.
- The problems solved during the course will be helpful for SET/NET.

Unit I: Operator Formalism: (15)

Linear Vector Spaces, Scalar Product, Schwartz Inequality, State Vector, difference between span and basis, orthogonal and orthonormal, General formalism of operator mechanics, operator algebra, commutation relations, Hermitian operator definition and properties, Relation between non commutativity of two operators and uncertainty relation, Dirac's bra-ket notations, Matrix representation of operators, state vector and scalar product. Effect of change of basis on the matrix representation, Unitary transformation.

Unit II : Introductory Quantum Mechanics: (15)

Time dependent and time-independent Schrodinger equation, Interpretation of wave function,admissible wave functions, continuity equation, Operators, Expectation Value,Ehrenfest's theorem, Uncertainty Principle, wave packet, admissible wave functions, stationary states, postulates of quantummechanics, Eigen Values and Eigen Vectors. Momentum Eigenfunction in the coordinate representation, box normalization and Dirac Delta function. Coordinate and Momentum representations, Schrodinger equation in momentum representation. . Quantum Dynamics: Schrödinger, Heisenberg and Interaction picture.

Unit III: Solution of Schrodinger equation for some solvable systems and Angular Momentum Algebra: (15)

Infinite and finite potential wells, Square Well potential and Nanoscience, Harmonic Oscillator by operator method, Schrodinger in spherical polar coordinate and its solution for hydrogen atom, Angular momentum algebra: Definition, Commutation relations, Simultaneous eigenfunction of L2and Lz operator.

Unit IV: Addition of Angular Momenta and approximation methods: (15)

Algebra of Spin angular momenta, Pauli Spin matrices, generalized angular momentum, matrices for J2, Jx, Jy and Jz operators, Clebich Gordon Coefficient: Construction Procedure and simple examples.

Introduction to approximation methods like Variational and WKB methods with simple examples.

Text Books:

1. Introductory Quantum Mechanics (3rd Edition), D. J. Griffiths and D F Schroeter (Cambridge Univ. Press).
2. Quantum Mechanics-Theory and Applications by Ajoy Ghatak ,S. Loknathan (Sixth Edition) Publisher TRINITY
3. Introductory Quantum Mechanics by Liboff (4th Edition), Publisher Pearson
4. Quantum Mechanics Concepts and Applications by Nouredine Zettili, John Wiley and Sons (second Edition)
5. Quantum Mechanics - LI. Schiff (McGraw-Hill).
6. A textbook of Quantum Mechanics - P M Mathews, K Venkatesan. (Tata McGraw Hill).
7. Concept of Modern Physics (6th Edi.) A Beiser, S Mahajan and S R Choudhury. (McGraw-Hill).

M.Sc-I, SEME. II, PHYSICS (MATERIALS SCIENCE)
HCT - 2.2: ELECTRODYNAMICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: HCT 2.2 (60 lectures, 4 credits)

Course Objectives:

This course develops concepts in electric field and scalar potential, magnetic field and vector potential, Maxwell's equations, electromagnetic boundary conditions, electromagnetic wave equation, waveguides, energy in electromagnetism. Electromagnetic wave propagation in vacuum, conducting and dielectric media, and at interfaces.

Learning outcomes:

Students will have achieved the ability to:

- use Maxwell equations in analysing the electromagnetic field due to time varying charge and current distribution.
- describe the nature of electromagnetic wave and its propagation through different media and interfaces.
- explain charged particle dynamics and radiation from localized time varying electromagnetic sources.

Unit-I: Electrostatics and Magnetostatics: (15)

Dirac delta function, Gauss's law and applications, Differential form of Gauss's law, Poisson and Laplace's equations, Electrostatic potential energy, Boundary conditions, Uniqueness theorems, Method of images, Multipole expansion.

Biot-Savart law, Ampere's law, Differential form of Ampere's law, Vector potential, Magnetic field of a localized current distribution, Boundary conditions.

Unit-II: Time varying fields and Energy, force, momentum relations: (15)

Faraday's law, Maxwell's displacement current, Maxwell's equations, Maxwell's equations in matter, Scalar and vector potentials,

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy.

Unit-III: Electromagnetic wave equations: (15)

Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Normal and Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth.

Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator,

Unit IV: Radiation emission: (15)

Electric dipole, electric quadrupole and magnetic dipole radiation, Radiation by a moving charge: Lienard-Wiechert potentials of a point charge, Larmor's formula, Angular distribution

of radiation. Fields and radiation of a localized oscillating source, radiation from a half wave antenna, radiation damping.

Reference Books

1.Introduction to Electrodynamics: David Griffiths (PHI)

2. Electrodyanamics J. D. Jackson

3. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa)

4. Classical theory of fields, Landau &Lifshitz

5. Electrodynamics, W. Panofsky and M. Phillips

6. Electromagnetism and Classified Theory, A. D. Barut, Dover

7. Electromagnetic theory and Electrodynamics, by Satya Prakash, KedarNath and Co.Meerut.

8. Electromagnetics by B.B.Laud, Willey Eastern.

9. Electrodynamics by Kumar Gupta and Singh.

M.Sc-I, SEME. II, PHYSICS (MATERIALS SCIENCE)
SCT - 2.1: STATISTICAL PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 2.1 (60 lectures, 4 credits)

Course objectives:

Statistical Mechanics is one of the fundamental mechanics .The aim of statistical mechanics is the evaluation of the laws of classical thermodynamics for macroscopic systems using the properties of its atomic particles. In addition to the classical TD the statistical approach provides information on the nature of statistical errors and variations of thermodynamic parameters.

Learning outcomes:

Students get in detail idea about

This course develops concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, Gibbs paradox, and phase space, statistical interpretation of thermodynamics, micro canonical, canonical and grant canonical ensembles; the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases; selected topics from low temperature physics.Energy fluctuation, Entropy fluctuations, Einstein theory of Brownian motion, Langiviens theory of Brownian motion and fluctuation-dissipation theorem. Phase transition theories, critical indices and their evaluation.

Unit I: Statistical Thermodynamics: (20)

Thermodynamic systems and equilibria, Laws of thermodynamics and their consequences, Nernst heat theorem, Microstates and microstates, Postulate of equal priori probability, Probability calculations, Thermodynamic potentials and Maxwell's relations, Chemical potential, phase equilibria, Black Body radiation and planks distribution, Phase equilibria, Free energy and its connection with thermodynamic quantities, entropy of mixing and Gibbs and paradox.

Unit II: Classical statistical mechanics: (15)

Statistical ensembles, Microcanonical ensemble- system in contact with heat revisor, Condition for thermal equilibrium, canonical ensemble – molecular ideal gas and grand canonical ensemble, Liouville's theorem, Ensembles, Maxwell Boltzmann distribution, classical ideal gas,

Unit III: Quantum Statistical Mechanics **(15)**

Phase space (Diagram of an oscillator), Maxwell- Boltzmann statistics, Fermi-Dirac statistics and Bose- Einstein statistics, Liouville's theorem, Ideal Bose gas, Ideal Fermi gas- weekly and strongly degerate , Bose- Einstein condensation.

Unit IV: Phase transitions and critical phenomena **(10)** Phase transition, Triple Point, Condition for phase equilibrium, First order phase transition, Ehrenfests equations, Clausius- Clayperon equation, Second latent heat equation, Examples, Second order phase transition, Critical indices, The law of corresponding states.

Reference Books:

1. Introduction to Statistical Mechanics by B.B.Laud
2. Statistical Mechanics by S.K.Sinha
3. Statistical Mechanics by I.D. Landau &F.M.Lifshitz
4. Text Book of statistical mechanics. Suresh Chandra, CBS Publications
5. Elementary Statistical Mechanics Gupta, Kumar, Pragati Prakashan.

M.Sc-I, SEME. II, PHYSICS (MATERIALS SCIENCE)
SCT - 2.2: ANALYTICAL TECHNIQUES
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 2.1 (60 lectures, 4 credits)

Course objectives:

This course is designed to give the student an understanding in the operation and care of instruments used in the physics laboratories

- To introduce the student to principles and theory of analytical instruments
- To teach the student the correct operation of analytical instruments.
- To introduce the student to the techniques of troubleshooting instruments in the laboratory.
- To emphasize the safe use of analytical instruments.
- To teach the student to solve problems related to the use of instruments.

Learning outcomes:

At the end of the course, a student will be able to:

- Select the required instruments for spectroscopic analysis.
- Understand the effects of different constituent in a process outcome and analysis the performance of various on-line or off-line instruments.
- Decide the dominate frequency characterize the substance from spectrum analysis.
- Perform experimental analysis for different offline test like humidity, moisture, dissolve oxygen etc.

Unit I: X-ray Diffraction techniques (18)

Review of basic crystal systems, powder diffraction method, instrumentation of X-ray diffractometer, sources of X-rays, detectors of X-rays, acquisition of raw data, data processing and refinement.

Determination of lattice parameters and crystal structure of cubic systems, structure factors, systematic absence of reflections, intensity calculations for cubic system, determination of particle size using X-ray diffractograms, basic concept for determination of lattice parameters for other crystal systems, use of soft-ware packages.

Unit II: Infra-red spectroscopy & Ultraviolet and visible spectrophotometry (18)

Infra-red spectroscopy (IR):

Introduction, Beer Lamberts law, Instrumentation, calculation of absorption maximum of dienes, dienons and polyenes, Qualitative and Quantitative applications.

Ultraviolet and visible Spectrophotometry (UV/Vis.):

Introduction, instrumentation, sampling technique, selection rule, types of bonds, absorption of common functional groups, Factors frequencies, applications.

Unit III: Fourier - Transform Infra Red Spectroscopy (FTIR) and Raman spectroscopy (12)

Basic principle, instrumentation configuration date interpretation and analysis, and special techniques such as Attenuated Total Reflection (ATR).

Unit IV: X-ray photoelectron spectroscopy (XPS) (10)

Basic principle, instrumentation configuration, data interpretation and analysis, chemical shift, quantification, and depth-profiling.

Reference Books:

1. Elements of X –ray diffraction: B.D. Cullity, Addison-Wiely Publisher
2. Encyclopedia of materials characterization: Surfaces, Interfaces, Thin Films C. Richard Brundle, Charles A. Evans, Jr. Shaun Wilson, BUTTERWORTH-HEINEMANN
3. Nanotechnology: Principles and Practices: S.B.Kulkarni, Capital Publishing Company

M.Sc-I, SEME. II, PHYSICS (MATERIALS SCIENCE)
OET - 2.1 : FUNDAMENTALS OF ELECTRONICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: OET 2.1 (60 lectures, 4 credits)

Course Objectives:
Fundamental of Electronics is mainly designed for bridge course for Physics student. The main objective of this course is to assign the basic design approach to the students, which will nurture the practical knowledge in electronics.

Learning outcomes:
- Studentswill be able to apply the basic laws of electronics like ohm's law Kirchhoff's laws, Thevenin's. Norton's and maximum power theorems.
- Students can design and analyse the various diode and transistor circuits.
- Students will be able to design and analyse the op-amp and IC555 circuits.

UNIT 1 : Electronic Components (15)
Circuit concept Units, Standards and Dimensions. Electric current, Electric charge, potential difference, Electric power and Energy. Circuit elements : Passive elements and active elements. Network Law's, Junction Law's (KCL), Mesh Law's (KVL) Application of Network Law's to simple dc networks theorems – Thevenin's theorem, Norton's theorem Max power transfer theorem.

UNIT 2 : Semiconductor Devices (15)
Junction Diodes, p-n junction, an unbiased p-n junction, a biased p-n junction and V-I characteristics of p-n junction. Some special P-N junction: - Photodiodes, LED and Solar Cell. Junction transistor, Transistor static characteristic Self-bias or emitter bias, Two-port representation of Transistor (hybrid parameter) JFET: Static Characteristic of FET comparison of FET with Bipolar transistor.

UNIT 3: Applications of Active & Passive (15)
Operational Amplifier Characteristics and Applications
Introduction, Ideal Op-Amp, DC and AC Characteristics: Instrumentation Amplifier, V to I and I-V converter Precision rectifier, Differentiator and Integrator. Comparator Schmitt trigger wave generators (Square wave and Triangular wave) and first order Low pass and High pass filters.

UNIT 4: Special IC series (15)
Op-Amp regulator, Design of power supplies using voltage regulator ICs, 555 Timer as Monostable and Astable operation.

Reference books:

1. D Chattopadhyaya, P.C. Rakshit, B Saha and N NPurkait: Foundations of Electronics, New Age International Edition.
2. D. Roy Choudhary and ShailJain : Linear Integrated Circuit, New Age International (P) Ltd.
3. P-Amp and Linear Integrated Circuits : R. A. Gaikwad, PHI of India Ltd.
4. A Texbook of Electronics (Second Edition) : S. L. Kakani and K. C. Bhandari
5. Electronic Principles : A. P. Malvino, TMH Edition.

M.Sc-I, SEME. II, PHYSICS (MATERIALS SCIENCE)
OET - 2.2: Conventional & Nonconventional Energy
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: OET 2.2 (60 lectures, 4 credits)

Course Objectives:

To provide a survey of the most important renewable energy resources and the technologies for harnessing these resources within the framework of a broad range of simple to state- of -the-art energy systems.

Learning Outcomes:

Students will be able to

- Demonstrate the generation of electricity from various Non-Conventional sources of energy, have a working knowledge on types of fuel cells.
- Estimate the solar energy, Utilization of it, Principles involved in solar energy collection and conversion of it to electricity generation.
- Explore the concepts involved in wind energy conversion system by studying its components, types and performance.
- Illustrate ocean energy and explain the operational methods of their utilization.

Unit I: Energy Science and Energy Technology

A brief history of energy technology, Various sciences and energy science, Energy, man and environment, Thermodynamics and energy analysis, Classification of conventional and non-conventional energy sources, Global energy trends,

Hydro energy-merits and demerits, Primary hydro energy resources, Types of hydroelectric plants, Energy and power equations, Hydraulic turbines,

Fossil Fuels, Conversion and applications, Types of coal, properties of coal, Coal production and processing.

Unit II: Solar Energy

The solar spectrum, Semiconductors, p-n junction, Solar photocells, Efficiency of solar cells, Commercial solar cells, Developing technologies, Solar panels, Economics of photovoltaics (PV), Environmental impact of photovoltaics, Outlook for photovoltaics,

Solar thermal power plants, Solar thermal collectors, Flat plate collectors, Parabolic collectors, paraboloidal dish collector.

Unit III: Wind and Biomass Energy

Source of wind energy, Global wind patterns, Modern wind turbines, Kinetic energy of wind, Principles of a horizontal-axis wind turbine, Wind turbine blade design, Dependence of the power coefficient C_p on the tip-speed ratio λ, Design of a modern horizontal-axis wind turbine, Turbine control and operation, Wind characteristics, Power output of a wind turbine, Wind farms, Environmental impact and public acceptance, Economics of wind power, Outlook, Conclusion,

Photosynthesis and crop yields, Biomass potential and use, Biomass energy production, Environmental impact of biomass, Economics and potential of biomass, Outlook, Biogas plants, Types of Biogas plants

Unit IV: Nuclear Energy

Binding energy and stability of nuclei, Fission, Thermal reactors, Thermal reactor designs, Fast reactors, Present-day nuclear reactors, Safety of nuclear power, Economics of nuclear power, Environmental impact of nuclear power, Public opinion on nuclear power, Outlook for nuclear power, Magnetic confinement, D-T fusion reactor, Performance of tokamaks, Plasmas, Charged particle motion in E and B fields, Tokamaks, Plasma confinement, Divertor tokamaks, Outlook for controlled fusion.

Reference Books:

1. Energy Technology: Nonconventional, Renewable & Conventional by S. Rao and B.B. Parulekar (3rd Edition, Khanna Publishers).
2. ENERGY SCIENCE: principles, technologies, and impacts, John Andrews and Nick Jelley, Oxford University Press.

M.Sc, PHYSICS (MATERIALS SCIENCE)
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)
Practical List

HCP 1.1/1.2/1.3

1) Determination Band gap of Ge Diode.
2) Crystal Structure FCC type.
3) Temp. Variation of Breakdown voltage of zerer diode.
4) Temperature Transducer (Thermister).
5) P.N. Junction capacitance.
6) LVDT.
7) Photovoltaic cell.
8) Hall Effect.
9) CC with CC Amplifier.
10) DC Amplifier.
11) Voltage Regulator
12) Astablenultivibrator (using IC741Op Amp)
13) Op-Amp Phase Lead Circuit.
14) Op-Amp Phase Lag circuit.
15) Verificaiton of De Morgans theorem.
16) Wein Bridge Oscillator.
17) Op-Amp Phase shift Oscillator.
18) Negative feedback Amplifier.
19) D.T.L. gates.
20) Study of filters.
21) Transistor Biasing.
22) CE amplifier Desing.
23) FET characteristics and Designing of Amplifier.
24) Divide by 2 Divide by 5 & Divide by 10 counter using IC-7490.

SCP 1.1/1.2

1) Op-Amp (Adder, Subtractor, Integratorc, Differentiator).
2) Op-Amp I to V, V to I converter.
3) Voltage source.
4) Constant current source (floating load).
5) Constant current source (Grounded load).
6) Variable duty cycle MV using Op-Amp.

HCP 2.1/2.2

1) Wave form generator (square & triangular)
2) Twin T network.
3) Bear Lamberts law

4) Resistivity by four probe method.
5) Strain gauge I.
6) Lattice prarameter&particlesiretestimation.
7) Op-Amp instrumentation amplifier IC324.
8) Characteristics of UJT.
9) Electrodepositon of Mn.
10) Op-Amp. Parameters.

SCP 2.1/2.2

1) Study of thermocouple &thermister.
2) Intensity calculation.
3) Crystal structure I.
4) Crystal structure II.
5) Study of phase diagram.
6) Hall Effect II.

OEP 2.1/2.2

13) Transister Parameters.
14) Op-Amp inverting and non-inverting amplifiers.
15) Monostablemultivibratorvsing IC555.
16) FET charaterishes.
17) Op-Amp Adder.
18) Op-Amp subtractor.
19) First order High pass filter.
20) First order Low pass filter.
21) Determination of optical gap.
22) Determination of optical absorption by materials & hence determination of type of transition.
23) Study of p.n. junction photo voltaic.
24) Characterization of a PV cell in dark & in light & hence determination of junction ideality factor.

M.Sc-I, SEME. I, PHYSICS (CONDENSED MATTER PHYSICS)

HCT - 1.1: MATHEMATICAL PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT1.1 (60 lectures, 4 credits)

Course Objectives:

The purpose of the course is to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics.

Mathematical technique is an important tool that every physist would like to utilize.

Upon completion of the course, the student should be able to understand basic theory of:

- Operator and Matrix Analysis
- Functions of complex variables
- Elements of distribution theory
- Fourier Series

Learning Outcomes:

Successful students should be able to:

- Apply methods of functions of complex variables for calculations of integrals
- Expand functions in Fourier Series
- Work with vectors
- Work with Operators
- Work with Integral Transforms

Unit I: Calculus of Residues **(15)**

COMPLEX VARIABLE AND REPRESENTATIONS: Algebraic Operations, Argand Diagram: Vector Representation, Complex Conjugate, Euler's Formula, De Moiver's Theorem, The n^{th} Root or Power of a complex number.

ANALYTICAL FUNCTIONS OF A COMPLEX VARIABLE : The Derivative of f(Z) and Analyticity, Harmonic Functions, Contour Integrals, Cauchy's Integral Theorem, Cauchy's Integral Formula,

Zeros, Isolated Singular points, Evaluation of Residues, Cauchy's Residue theorem.

Unit II: Operator and Matrix Analysis **(15)**

Vector Space and its dimensionality, Vector Spaces and Matrices, Linear independence; Bases; Dimensionality, linear dependence, Inner product Hilbert space, linear operators.

Matrix operations, properties of matrices, Inverse, Orthogonal and unitary matrices; Independent elements of a matrix Diaglonization; Complete orthogonal sets of functions, special square matrices, Eigen values and eigenvectors; Eigen value problem.

Unit III: Ordinary Differential Equations (14)

First-Order homogeneous and non homogeneous equations with variable coefficients. The superposition principle, Second-order homogeneous equations with constant coefficient. Second-order non homogeneous equations with constant coefficients.

Unit IV: Fourier Series, Integral Transforms and Laplace transform (16)

Fourier Series: Fourier's theorem; Cosine, Sine and complex Fourier series, Applications to saw tooth and square waves and full wave rectifier. FS of arbitrary period; Half wave expansions; Partial sums Fourier integral and transforms; cosine since complex forms, Parsevals relation, Application to Gaussian distribution, box and exponential functions; FT of delta function.

Laplace transforms: Laplace transforms of common functions, First and second shifting theorems; inverse LT by partial fractions; LT of derivative and integral of a function.

Reference Books:

1. Introduction to Mathematical Physics by C. Harpcr, Prcnticc - Hall of India Ltd. N.Delhi 1993,(Chapters 2,4,6,9)
2. Mathematical Physics by A.G. Ghatak, I.C.Goyal and S.J.Chua,McMillan India Ltd. New Delhi 1995 (Chapters 4, 7,9,10)
3. Matrices and Tensors for Physicists,by A W Joshi
4. Advanced Engineering Mathematics, by E Keryszig
5. Mathematical Method for Physicits and Engineers, by K F Reily, M P Hobson and S J Bence
6. Mathematics for Physicists by Mary L B
7. Mathematical Methods for Physics, by G Arfken

M.Sc-I, SEME. I, PHYSICS (CONDENSED MATTER PHYSICS)

HCT - 1.2: SOLID STATE PHYSICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT 1.2 (60 lectures, 4 credits)

Course objectives: The course offers an introduction to solid state physics, and will allow the student to employ classical and quantum mechanical theories needed to understand the physical properties of solids. Prominence is put on building models able to explain several different phenomena in the solid state.

The course carries an understanding of how solid state physics has contributed to the existence of a number of important technological developments of importance in our lives now and in the future.

Learning outcomes:

The student is able to

- Explain mechanical properties of matter, and connect these to bond type.
- Explain how diffraction of electromagnetic waves on solid matter can be used to obtain lattice structure.
- Explain simple theories for conduction of heat and electrical current in metals.
- Classify solid state matter according to their band gaps.
- Understand how electrons and holes behave in semiconductors, and explain how they conduct current.
- Explain and give simple models for dielectrics.
- Know the basic physics behind superconductors

Unit I: Crystal Structure (15)

Basic Structures, Bravais systems in 2D and 3D, Bonding in solids, Reciprocal Lattice, Diffraction by X-ray and structure factor, Point defects and dislocations, Specific Heat: Lattice vibration, Phonons, Einstein and Debye’s theories.

Unit II: Energy bands and Semiconductors (20)

Energy bands:

Metal, Insulator and Semiconductor, Bloch theorem, Electron in periodic potential -1D, Tight and loose band approach, Brillion’s Zones, Fermi surfaces.

Semiconductors:

Direct and indirect band gap semiconductors, Effective mass, Hall effect and thermoelectric power, Intrinsic and Extrinsic carrier concentration.

Unit III: Dielectrics (10)

Electronic, Ionic, Orientational polarizations, Clausius-Mossotti equation, Dipole theory of ferroelectricity, Internal field in solids, Classification of magnetic materials,

Unit IV: Superconductors (15)

Basic concept, Meissner effect, Types I and II, Thermal properties of superconductor, Thermodynamics of superconductors, London equation, Josephson tunneling and its theory, BCS theory.

Reference Books:

1. Introduction to Solid State Physics 4 th Ed. C.Kittel,
2. Solid State Physics by N.W.Ashoroff &N.D.Mermin
3. Solid State Physics S.O.Pillai (New age international limited Publications)
4. Solid State Physics by Saxena and Gupta(Pragati Editions)
5. Solid State Physics by Rita John (Mc Graw Hill)

M.Sc-I, SEME. I, PHYSICS (CONDENSED MATTER PHYSICS)

HCT - 1.3: ANALOG & DIGITAL ELECTRONICS

Choice Based Credit System (CBCS)

(w. e. f. June 2020-21)

COURSE CODE: HCT 1.3 (60 lectures, 4 credits)

Course Objectives:

- To understand the fundamentals analog and digital electronics.
- To understand the differential amplifier and its types.
- To understand the building blocks of operational amplifiers 741, characteristics, parameters.
- To understand applications of operational amplifiers as multivibrators, Instrumentation amplifier, comparators, voltage regulator, power supplies.
- To understand the digital devices like flip flops, MUX and DEMUX ,shift registers, counters
- To understand the architecture, instruction set and different modes of addressing of 8085 microprocessor.

Learning Outcomes: After completion of this course, the students should be able…

- To design analog circuits using Op amp 741.
- To design digital circuits using combinational sequential logic.

To write the simple assembly language programs using microprocessor

Unit I: Operational Amplifiers (15)

Differential amplifier Circuit Configurations, Dual Input Balanced Output Differential amplifier, DC analysis, AC analysis, Inverting and Non Inverting Inputs, Constant Current Bias Circuit.

Block diagram of a typical Op-Amp, Open loop configuration, Inverting and Non-inverting amplifiers, Op-amp with negative feedback, Voltage Series Feedback, Effect of feedback on closed loop gain, Input resistance, Output resistance, Bandwidth and Output offset voltage, Voltage follower.

Practical Op-amp, Input Offset Voltage, Input bias current- input offset current, total output offset voltage, CMRR frequency response.

Unit II: Applications of Op amps (15)

DC and AC amplifier, Summing, Scaling and Averaging Amplifiers, Instrumentation amplifier, Integrator and Differentiator.

Oscillator: Principles, Oscillator types, Frequency stability, Response, Phase Shift oscillator, Wein Bridge Oscillator, LC Tunable Oscillator, Multivibrators, Monostable and Astable, Comparators,

Unit III: Combinational & Sequential Logic Circuits (15)

Combinational logic:

The transistor as a switch, OR AND NOT gates- NOR And NAND gates Boolean algebra- Demorgans theorems, Multiplexers and Demultiplexers

Sequential Logic:

Flip- Flops: RS Flip- Flop, JK Flip- Flop, JK master slave Flip-Flops Flip-Flop,
D Flip- Flop, Shift registers Synchronous and Asynchronous counters.

Unit IV: Microprocessors (15)

Architecture of 8085, Signals and timing diagram of 8085, Demultiplexing Address and Data bus, Instruction Set, Addressing modes, Assembly Language Programming of 8085 (Sum /Subtraction, Multiplication & Division of 4 & 8 bit numbers) .

Reference Books:

1. OP Amp amplifiers by Ramakant Gaikwad
2. Integrated Circuits by K.R.Botkar
3. Modern Digital Electronics by R.P.Jain
4. Digital Principle and Application by Malvino &Leeach
5. Digital Fundamentals by Floyd
6. 8085 Microprocessor by Ramesh Gaonkar

M.Sc-I, SEME. I, PHYSICS (CONDENSED MATTER PHYSICS)
SCT - 1.1: CLASSICAL MECHANICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 1.1 (60 lectures, 4 credits)

Course Objectives:
- To focus on understanding of the motion and equation of motion of macroscopic bodies.
- To learn to use the functional mathematical notations that's allows precise understanding of fundamental properties of classical mechanics.
- To study the demerits and to overcome them for further development in classical mechanics.

Learning Outcomes:
- Provides the difference between the equation of motion of the one body and many bodies systems as well as the basic formulations such Lagrangian and Hamilton, canonical transformation etc.
- Students can understand how to apply these formulations to the systems to obtain their equation of motions.
- Further, the problems solved during the course will be helpful for SET/NET.

Unit I: Mechanics of Particles and Rigid Bodies (15)

Mechanics of Particle and system of Particles using vector algebra and vector calculus, Conversion laws, work-energy theorem, open systems (with variable mass), Gyroscopic forces; dissipative systems, Jacobi integral, gauge invariance, integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations.

Unit II: Lagrangian Formulation and Motion Under Central Force (15)

Constrainsts, Generalised co-ordinates, D Alemaberts Principle, Lagranges equations of motion, Central Force, definition and characteristics, Reduction of Two-bod problem into equivalent One-body problem, General analysis of orbits, Keplers laws and equations, Artificial satellites, Rutherford Scattering.

Unit III: Variational Principle (15)

Introduction to Calculus of variation, Variational technique for many independent variables, Eulers Lagrange differential equation, Hamilton's principle, Deduction f Lagrange's equation of motion from Hamilton's principle.

Hamilton, Generalized momentum, Constant of motion, Hamilton's canonical equations of motion, Deduction of canonical equations from Variations principle.

Applications of Hamilton's equations of motion, Principle of least action, Proof of principles of least action, Problems.

Unit IV: Canonical Transformations and Hamilton's - Jacobi Theory (15)

Canonical Transformations, Condition for Transformation to be Canonical, Illustration of Canonical Transformation, Poisson's Brackets, Properties of Poisson's Brackets, Hamilton's Canonical equations in terms of Poisson's Brackets.

Hamilton's - Jacobi Theory, Solution of harmonic oscillator problems by HJ Method, Problems.

Texts and Reference Books:

1. Classical Mechanics, By Gupta, Kumar and Sharma (Pragati Prakashan2000).
2. Introduction to Classical Mechanics, by R.G. Takwale and P S Puranik(Tata McGraw Hill 1999).
3. Classical Mechanics, by H Goldstein (Addison Wesley 1980).
4. Classical Mechanics, by N C Rana and P S Joag(Tata McGraw Hill 1991).
5. Mechanics, by A Sommerfeld (Academic Press 1952)

M.Sc-I, SEME. I, PHYSICS (CONDENSED MATTER PHYSICS)
SCT– 1.2 (CMP): ENERGY STUDIES
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 1.2 (60 lectures, 4 credits)

Course Objectives:

- Introduction to Energy scenario in India and globally, along with the energy resources.
- Study all types of energy and its impact on Environment
- Understanding Energy conservation act in depth along with its Amendments
- Awareness of problems faced in Energy conversions & Energy Storage

Learning Outcomes:
On completion of this course, the students will be able to

- Learn about the Indian and World Energy Scenario and world energy use resources, energy cycle on earth etc.
- Understand the types of energy, energy storage and energy conversion systems.
- Learn the energy economy final energy consumption energy needs of growing economy
- Learn about the energy and environment, air pollution climate changes and its impacts on sustainable development

Unit-I: Indian Energy Scenario (15)
Role of energy in economic development and social transformation, Energy and gross Domestic product (GDP), Gross National Product (GNP) and its dynamics.
Various types of energy sources: Energy sources and overall energy demand,
Availability of energy sources, Energy consumption in various sectors and its changing pattern, projected energy demands. Non Renewable Energy sources : Coal, Oil, Natural gas, Nuclear power, Hydroelectricity, Renewable Energy sources: Solar ,Wind, Biomass, Tidal, Ocean wave, Ocean thermal, Geothermal and other , Depletion of energy sources and impact of exponential rise in energy consumption on economics of India and on international relations.
Energy Security: Energy for security and security of energy, Energy consumption and its impact on environmental climatic change.
Future Energy Option: Sustainable development, Energy crisis, Transition from carbon free technologies, Parameters of transition, Carbon credits.

Unit-II: Solar Radiation and Its Measurements (15)
Importance of Solar Energy: Nature of solar radiation, Sun as a fusion rector, special distribution of extra-terrestrial radiation, Estimation of extra-terrestrial solar radiation, Radiation on horizontal and titled surfaces, Beam, diffuse, global radiation and their Measurement.
Available solar radiation, Measurement of beam, diffuse, global radiation, Pyranomater, Pyrhelimeter, Sunshine duration recorder Angstrom relation. Ref. no. 8

Unit-III : Basics of Heat transfer (15)

Heat and Thermodynamics: Basic units, dimensions, Concept of heat, energy and work, Ideal gas flow, 1st and 2nd law of thermodynamics, Types of heat transfer.

Conductive heat transfer: Fourier's law. Stefans-Boltzman relation and IR heat transfer between gray surfaces.

Radiative heat transfer: sky radiation, radiation heat transfer coefficient

Convective heat transfer: Natural and forced convection, natural convection between parallel plates, Non-dimensional numbers, conductive heat transfer coefficient, Heat transfer due to wind. Ref. no. 9

Unit-IV : Energy Storage (15)

Types of energy storage systems : sensible and latent heat storage systems, Electric energy storage systems, Chemical energy storage systems, Heat exchanges, Hydrostorage, solar pond as a energy storage, Green house. Ref.no. 11

Reference Books:

1.TEDDY Year Book, (Tata Energy Research Institute (TERI) Publication, New Delhi).

2. World Energy Resources, Charles E.Brown (Springer Publication), 2002.

3. Energy Policy for India, B.V. Desai (Welley Eastern Publication)

4. Handbooks of Solar Radiation, A.Mani (Allied Publishers), 1980.

5. Solar Energy Fundamentals and Applications, H.P. Garg and Satya Prakash, (Tata McGraw Hill), 1977.

6. Treatise on Solar energy, H.P. Garg, Volume 1,2 and 3.(John Wiley and Sons) 1982

7. Principles of Solar Engineering, F.Kreith and J.F. Kreider, McGraw Hill , 1978

8. Solar Energy Thermal Processes, J.A. Duffie and W.A. Beckman, (John Wiley and Sons) 1980

9. Heat and Thermodynamics, M.W. Zemansky,(McGraw Hill Publication)

10. Principles of Solar Energy Conversion, A.W.Culp (McGraw Hill Publication)

11. Solar Energy Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd edition (Tata McGraw Hill Publication C.Ltd.(, 1976

12. Solar Energy Utilization, G.D.Rai (Khanna Publishers) 1996

13. Solar Thermal Engineering, J.A. Duffie(Academic Press)

14. Renewable Energy Sources and Conversion Technology, N.K. Basal, M. Kleeman and S.N. Srinivas ,(Tata Energy Reserch Institute, New Delhi) 1996

M.Sc-I, SEME. II, PHYSICS (CONDENSED MATTER PHYSICS)
HCT - 2.1: QUANTUM MECHANICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-21)

COURSE CODE: HCT 2. 1 (60 lectures, 4 credits)

Course Objectives:

- To study the fundamental postulates of quantum mechanics and to apply them for microscopic bodies.
- To review the relevant concepts in classical physics before corresponding concepts are developed in quantum mechanics.
- To provide an understanding of the power and elegance of quantum mechanics.

Learning Outcomes:

- Provides a qualitative description of the remarkable concepts of quantum mechanics such as de-Broglie theory, Heisenberg uncertainty principle, Schrodinger equation, operators, etc.
- Students can gain the idea of applying these concepts to simple systems such as 1D box, 1D harmonic oscillator, hydrogen like atoms and many electron systems as helium atom etc.
- The complete Born-Oppenheimer approximation and Hartee-Fock theories gives the students some understanding of the molecular orbital as well as the current methods of performing electronic structure calculation.
- The problems solved during the course will be helpful for SET/NET.

Unit I: Operator Formalism: (15)

Linear Vector Spaces, Scalar Product, Schwartz Inequality, State Vector, difference between span and basis, orthogonal and orthonormal, General formalism of operator mechanics, operator algebra, commutation relations, Hermitian operator definition and properties, Relation between non commutativity of two operators and uncertainty relation, Dirac's bra-ket notations, Matrix representation of operators, state vector and scalar product. Effect of change of basis on the matrix representation, Unitary transformation.

Unit II : Introductory Quantum Mechanics: (15)

Time dependent and time-independent Schrodinger equation, Interpretation of wave function,admissible wave functions, continuity equation, Operators, Expectation Value,Ehrenfest's theorem, Uncertainty Principle, wave packet, admissible wave functions, stationary states, postulates of quantummechanics, Eigen Values and Eigen Vectors. Momentum Eigenfunction in the coordinate representation, box normalization and Dirac Delta function. Coordinate and Momentum representations, Schrodinger equation in momentum representation. . Quantum Dynamics: Schrödinger, Heisenberg and Interaction picture.

Unit III: Solution of Schrodinger equation for some solvable systems and Angular Momentum Algebra: (15)

Infinite and finite potential wells, Square Well potential and Nanoscience, Harmonic Oscillator by operator method, Schrodinger in spherical polar coordinate and its solution for hydrogen atom, Angular momentum algebra: Definition, Commutation relations, Simultaneous eigenfunction of L2and Lz operator.

Unit IV: Addition of Angular Momenta and approximation methods: (15)

Algebra of Spin angular momenta, Pauli Spin matrices, generalized angular momentum, matrices for J2, Jx, Jy and Jz operators, Clebich Gordon Coefficient: Construction Procedure and simple examples.

Introduction to approximation methods like Variational and WKB methods with simple examples.

Text Books:

1. Introductory Quantum Mechanics (3rd Edition), D. J. Griffiths and D F Schroeter (Cambridge Univ. Press).
2. Quantum Mechanics-Theory and Applications by Ajoy Ghatak ,S. Loknathan (Sixth Edition) Publisher TRINITY
3. Introductory Quantum Mechanics by Liboff (4th Edition), Publisher Pearson
4. Quantum Mechanics Concepts and Applications by Nouredine Zettili, John Wiley and Sons (second Edition)
5. Quantum Mechanics - LI. Schiff (McGraw-Hill).
6. A textbook of Quantum Mechanics - P M Mathews, K Venkatesan. (Tata McGraw Hill).
7. Concept of Modern Physics (6th Edi.) A Beiser, S Mahajan and S R Choudhury. (McGraw-Hill).

M.Sc-I, SEME. II, PHYSICS (CONDENSED MATTER PHYSICS)
HCT - 2.2: ELECTRODYNAMICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: HCT 2.2 (60 lectures, 4 credits)

Course Objectives:

This course develops concepts in electric field and scalar potential, magnetic field and vector potential, Maxwell's equations, electromagnetic boundary conditions, electromagnetic wave equation, waveguides, energy in electromagnetism. Electromagnetic wave propagation in vacuum, conducting and dielectric media, and at interfaces.

Learning outcomes:

Students will have achieved the ability to:

1. use Maxwell equations in analysing the electromagnetic field due to time varying charge and current distribution.
2. describe the nature of electromagnetic wave and its propagation through different media and interfaces.
3. explain charged particle dynamics and radiation from localized time varying electromagnetic sources.

Unit-I: Electrostatics and Magnetostatics: (15)

Dirac delta function, Gauss's law and applications, Differential form of Gauss's law, Poisson and Laplace's equations, Electrostatic potential energy, Boundary conditions, Uniqueness theorems, Method of images, Multipole expansion.

Biot-Savart law, Ampere's law, Differential form of Ampere's law, Vector potential, Magnetic field of a localized current distribution, Boundary conditions.

Unit-II: Time varying fields and Energy, force, momentum relations: (15)

Faraday's law, Maxwell's displacement current, Maxwell's equations, Maxwell's equations in matter, Scalar and vector potentials,

Energy relations in quasi-stationary current systems, Magnetic interaction between two current loops, Energy stored in electric and magnetic fields, Poynting's theorem, General expression for electromagnetic energy.

Unit-III: Electromagnetic wave equations: (15)

Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Normal and Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth.

Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator,

Unit IV: Radiation emission: (15)

Electric dipole, electric quadrupole and magnetic dipole radiation, Radiation by a moving charge: Lienard-Wiechert potentials of a point charge, Larmor's formula, Angular distribution

of radiation. Fields and radiation of a localized oscillating source, radiation from a half wave antenna, radiation damping.

Reference Books

1.Introduction to Electrodynamics: David Griffiths (PHI)

2. Electrodyanamics J. D. Jackson

3. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa)

4. Classical theory of fields, Landau &Lifshitz

5. Electrodynamics, W. Panofsky and M. Phillips

6. Electromagnetism and Classified Theory, A. D. Barut, Dover

7. Electromagnetic theory and Electrodynamics, by Satya Prakash, KedarNath and Co.Meerut.

8. Electromagnetics by B.B.Laud, Willey Eastern.

9. Electrodynamics by Kumar Gupta and Singh.

M.Sc-I, SEME. II, PHYSICS (CONDENSED MATTER PHYSICS)
SCT - 2.1: STATISTICAL PHYSICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 2.1 (60 lectures, 4 credits)

Course objectives:

Statistical Mechanics is one of the fundamental mechanics .The aim of statistical mechanics is the evaluation of the laws of classical thermodynamics for macroscopic systems using the properties of its atomic particles. In addition to the classical TD the statistical approach provides information on the nature of statistical errors and variations of thermodynamic parameters.

Learning outcomes:

Students get in detail idea about

This course develops concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, Gibbs paradox, and phase space, statistical interpretation of thermodynamics, micro canonical, canonical and grant canonical ensembles; the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases; selected topics from low temperature physics.Energy fluctuation, Entropy fluctuations, Einstein theory of Brownian motion, Langiviens theory of Brownian motion and fluctuation-dissipation theorem. Phase transition theories, critical indices and their evaluation.

Unit I: Statistical Thermodynamics: (20)

Thermodynamic systems and equilibria, Laws of thermodynamics and their consequences, Nernst heat theorem, Microstates and microstates, Postulate of equal priori probability, Probability calculations, Thermodynamic potentials and Maxwell's relations, Chemical potential, phase equilibria, Black Body radiation and planks distribution, Phase equilibria, Free energy and its connection with thermodynamic quantities, entropy of mixing and Gibbs and paradox.

Unit II: Classical statistical mechanics: (15)

Statistical ensembles, Microcanonical ensemble- system in contact with heat revisor, Condition for thermal equilibrium, canonical ensemble – molecular ideal gas and grand canonical ensemble, Liouville's theorem, Ensembles, Maxwell Boltzmann distribution, classical ideal gas,

Unit III: Quantum Statistical Mechanics **(15)**
Phase space (Diagram of an oscillator), Maxwell- Boltzmann statistics, Fermi-Dirac statistics and Bose- Einstein statistics, Liouville’s theorem, Ideal Bose gas, Ideal Fermi gas- weekly and strongly degerate , Bose- Einstein condensation.

Unit IV: Phase transitions and critical phenomena **(10)** Phase transition, Triple Point, Condition for phase equilibrium, First order phase transition, Ehrenfests equations, Clausius- Clayperon equation, Second latent heat equation, Examples, Second order phase transition, Critical indices, The law of corresponding states.

Reference Books:

1. Introduction to Statistical Mechanics by B.B.Laud
2. Statistical Mechanics by S.K.Sinha
3. Statistical Mechanics by I.D. Landau &F.M.Lifshitz
4. Text Book of statistical mechanics. Suresh Chandra, CBS Publications
5. Elementary Statistical Mechanics Gupta, Kumar, Pragati Prakashan.

M.Sc-I, SEME. II, PHYSICS (CONDENSED MATTER PHYSICS)
SCT – 2.2: ELECTRONIC INSTRUMENTATION
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 2.2 (60 lectures, 4 credits)

Course Objectives:

- Explain basic concepts and definitions.
- Describe the bridge configurations and their applications.
- Elaborate discussion about the importance of signal generators and analyzers in Measurement.

Learning outcomes:

- Identify the various parameters that are measurable in electronic instrumentation.
- Employ appropriate instruments to measure given sets of parameters.
- Practice the construction of testing and measuring set up for electronic systems.
- To have a deep understanding about instrumentation concepts which can be applied to Control systems.
- Relate the usage of various instrumentation standards.

Unit I: Transducers (15)

Transducers classification Resistance, Capacitance, Inductance, Piezoelectric, Thermoelectric, Hall effect, Tachogenerator, Optical and Digital transducers, Measurements of displacement, Velocity, Acceleration, position, Force, pressure, flow, level, Torque, Strain, Speed and Sound, flow humidity, PH, position, Piezoelectric devices, micromechanical devices and smart sensors.

Unit II: Instrumentation Electronics (15)

Instrumentation Amplifiers, basic characteristics, D.C. Amplifiers, Isolation amplifiers, feedback transducers system, feedback fundamentals, Inverse transducers, temperature balance system,

Phase sensitive detection, Absolute value circuit, peak detector, sample and hold circuits, RMS converter, Logarithm (Amplifier, Frequency to Voltage and Voltage to Frequency Converter,

Unit III: Measuring Instruments (15)

True RMS measurement and DMM, R, L, C, Q measurement technique, active passive component testing, Automatic Test Equipment. Function generator, Sine, square, triangular, ramp wave generator, pulse generator, sine wave synthesis, arbitrary waveform generator. Oscilloscope: Dual Trace Oscilloscope, sweep modes, active, passive probes, delay line, Digital Storage Oscilloscope and its features like roll, refresh, sampling rate, application of the same in instrumentation and measurement, sampling oscilloscope. Wave analyzer, Distortion analyzer, spectrum analyzers.

Unit IV: Signal Processing Circuits (15)

ADC and DAC techniques, types, and their specifications, V to F converter, Sample and hold, analog multiplexer, data loggers. Digital Instrumentation: Universal counter and its mode – totalizing frequency, period, time. interval, ratio, measurement errors, application of counters for, frequency meter, capacitance, meter and timers, automation digital instruments. Virtual Instrumentation and its applications,

Reference Books:

1. Transducer Theory and Application: John A Alloca, Allen Stuart (Reston Publishing Company Inc.)
2. Transducer and Display Devices: B. S. Sonde.
3. Integrated Electronics: K. R. Botkar.
4. W. D. Cooper & A. D. Helfrick, 'Electronic Instrumentation AndMeasurement Techniques', PH I, 4th e/d, 1987
5. Kalsi H. S., 'Electronic Instrumentation', TMH, 2nd e/d, 2004

M.Sc-I, SEME. II, PHYSICS (CONDENSED MATTER PHYSICS)
OET - 2.1: FUNDAMENTALS OF ELECTRONICS
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: OET 2.1 (60 lectures, 4 credits)

Course Objectives:
Fundamental of Electronics is mainly designed for bridge course for Physics student. The main objective of this courseis to assign the basic design approach to the students, which will nurture the practical knowledge in electronics.

Learning outcomes:
- Studentswill be able to apply the basic laws of electronics like ohm's law Kirchhoff's laws, Thevenin's. Norton's and maximum power theorems.
- Students can design and analyse the various diode and transistor circuits.
- Students will be able to design and analyse the op-amp and IC555 circuits.

UNIT 1 : Electronic Components (15)
Circuit concept Units, Standards and Dimensions. Electric current, Electric charge, potential difference, Electric power and Energy. Circuit elements : Passive elements and active elements. Network Law's, Junction Law's (KCL), Mesh Law's (KVL) Application of Network Law's to simple dc networks theorems – Thevenin's theorem, Norton's theorem Max power transfer theorem.

UNIT 2 : Semiconductor Devices (15)
Junction Diodes, p-n junction, an unbiased p-n junction, a biased p-n junction and V-I characteristics of p-n junction. Some special P-N junction: - Photodiodes, LED and Solar Cell. Junction transistor, Transistor static characteristic Self-bias or emitter bias, Two-port representation of Transistor (hybrid parameter) JFET: Static Characteristic of FET comparison of FET with Bipolar transistor.

UNIT 3: Applications of Active & Passive (15)
Operational Amplifier Characteristics and Applications
Introduction, Ideal Op-Amp, DC and AC Characteristics: Instrumentation Amplifier, V to I and I-V converter Precision rectifier, Differentiator and Integrator. Comparator Schmitt trigger wave generators (Square wave and Triangular wave) and first order Low pass and High pass filters.

UNIT 4: Special IC series (15)
Op-Amp regulator, Design of power supplies using voltage regulator ICs, 555 Timer as Monostable and Astable operation.

Reference books:

1. D Chattopadhyaya, P.C. Rakshit, B Saha and N NPurkait: Foundations of Electronics, New Age International Edition.
2. D. Roy Choudhary and ShailJain : Linear Integrated Circuit, New Age International (P) Ltd.
3. P-Amp and Linear Integrated Circuits : R. A. Gaikwad, PHI of India Ltd.
4. A Texbook of Electronics (Second Edition) : S. L. Kakani and K. C. Bhandari
5. Electronic Principles : A. P. Malvino, TMH Edition.

M.Sc-I, SEME. II, PHYSICS (CONDENSED MATTER PHYSICS)
OET - 2.2: Nuclear Techniques
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: OET 2.2 (60 lectures, 4 credits)

Course Objectives:

- The course aims to give students a firm grounding in subjects from radioactivity and nuclear fission to nuclear reactors, fuel production and processing through to nuclear materials, nuclear safety, socio-economic factors and future developments in nuclear engineering.
- It is aimed at giving students the basic background knowledge, understanding and vocabulary that differentiates nuclear engineering from other engineering disciplines. In doing so, this course also provides the foundations for later courses on the nuclear stream.
- The course will introduce a wide breadth of topics. These include nuclear fission, reactor physics and engineering, the historical context of nuclear engineering, the impact of radiation on matter, fuel fabrication and the fuel cycle, radioactive wastes and storage methods, reactor accidents, and nuclear safety and licensing.

Learning outcomes:

The high-level aims of the course are to enable you to

- Perform calculations related to nuclear reactions, reactor physics and nuclear safety.
- Evaluate real-world questions relating to nuclear engineering
- Deconstruct the issues that led to past reactor accidents and challenges of current new-build reactors

Unit-I : Interaction of radiation with matter (15)

General description of interaction processes, interactions of directly ionizing radiation (electrons, protons and ions), stopping power, linear energy transfer, range of particles, straggling, interaction of indirectly ionizing radiation (gamma radiations), attenuation coefficient, energy transfer, build up factor.

Unit-II: Nuclear detectors (15)

Ionization and transport phenomena in gases, cylindrical and multiwire proportional counters, Ionization chamber, Proportional counter, GM counter, general characteristics of organic and inorganic scintillators, scintillation detectors NaI-(Tl), detection efficiency for various types of radiations, scintillators, detection efficiency for various types of radiation, photomultiplier gain, semiconductor detectors, surface barrier detector, Si(Li), Gel(Li), HPGe detectors.

Unit-III: Pulse processing and related electronics (15)

Preamplifier, pulse shaping and pulse stretchers networks, delay lines, amplifier, Pulse height analysis and coincidence technique, Discriminators: Single channel analyzer, multichannel analyzer, pulse height spectroscopy, pulse shape discrimination, coincidence and anti- coincidence units.

Unit-IV: Dosimetry and radiation protection (15)

Units Rontgen, RAD, REM, RBE, BED, Gray, Sievert, kerma, Cema, energy deposit and energy imparted, absorbed dose, main aims of radiation protection, dose equivalent and quality factor, organ dose, effective dose equivalent effects and dose limits, assessment of exposure from natural man-made sources, effects of radiation on human body.

Reference Books:

1. Nuclear radiation detectors, S. S. Kappor and V. S. Rmanurthy. (Wiley Eastern Limited, New Delhi,) 1986.

2. Introduction to radiation protection dosimetry, J. Sabol and P. S. Weng, (World Scientific), 1995.

3. Techniques for nuclear and particle physics, W. R. Len (Springer), 1955.

4. Nuclear Measurement Techniques, K. Sriram, (Affiliated East-West Press, New Delhi), 1986.

5. Fundamentals of surface and thin film analysis, Leonard C. Feldman and James W. Mayer, (North Holland, New York), 1988.

6. Introduction to nuclear science and technology, K. Sriram and Y. R. Waghamare, (A. M. Wheeler), 1991.

7. Nuclear radiation detection, W. J. Price, (McGraw-Hill, New York), 1964.

8. Alphas, beta and gamma-ray spectroscopy,. K. Siegbahn, (North Holland, Amsterdam), 1965.

9. Introduction to experimental nuclear physics, R. M. Singru, (John Wiley and Sons), 1974.

10. Radioactive isotopes in biological research, Willaim R. Hendee, (John Wiley and Sons), 1973.

11. Atomic and Nuclear physics, Satendra Sharma, Pearson Education, 2008

M.Sc, PHYSICS (CONDENSED MATTER PHYSICS)

Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

Practical List

HCP 1.1/1.2/1.3

1. Determination Band gap of Ge Diode.
2. Crystal Structure FCC type.
3. Temp. Variation of Breakdown voltage of zerer diode.
4. Temperature Transducer (Thermister).
5. P.N. Junction capacitance.
6. LVDT.
7. Photovoltaic cell.
8. Hall Effect.
9. CC with CC Amplifier.
10. DC Amplifier.
11. Voltage Regulator
12. Astablenultivibrator (using IC741Op Amp)
13. Op-Amp Phase Lead Circuit.
14. Op-Amp Phase Lag circuit.
15. Verificaiton of De Morgans theorem.
16. Wein Bridge Oscillator.
17. Op-Amp Phase shift Oscillator.
18. Negative feedback Amplifier.
19. D.T.L. gates.
20. Study of filters.
21. Transistor Biasing.
22. CE amplifier Desing.
23. FET characteristics and Designing of Amplifier.
24. Divide by 2 Divide by 5 & Divide by 10 counter using IC-7490.

SCP 1.1/1.2

1. Op-Amp (Adder, Subtractor, Integratorc, Differentiator).
2. Op-Amp I to V, V to I converter.
3. Voltage source.
4. Constant current source (floating load).
5. Constant current source (Grounded load).
6. Variable duty cycle MV using Op-Amp.

HCP 2.1/2.2

1. Wave form generator (square & triangular)
2. Twin T network.
3. Bear Lamberts law
4. Resistivity by four probe method.
5. Strain gauge I.
6. Lattice prarameter&particlesiretestimation.
7. Op-Amp instrumentation amplifier IC324.
8. Characteristics of UJT.
9. Electrodepositon of Mn.
10. Op-Amp. Parameters.

SCP 2.1/2.2

1. Study of thermocouple &thermister.
2. Intensity calculation.
3. Crystal structure I.
4. Crystal structure II.
5. Study of phase diagram.
6. Hall Effect II.

OEP 2.1/2.2

1. Transister Parameters.
2. Op-Amp inverting and non-inverting amplifiers.
3. Monostablemultivibratorvsing IC555.
4. FET charaterishes.
5. Op-Amp Adder.
6. Op-Amp subtractor.
7. First order High pass filter.
8. First order Low pass filter.
9. Determination of optical gap.
10. Determination of optical absorption by materials & hence determination of type of transition.
11. Study of p.n. junction photo voltaic.
12. Characterization of a PV cell in dark & in light & hence determination of junction ideality factor.
