Punyashlok Ahilyadevi Holkar Solapur University, Solapur

पुण्यश्लोक अहिल्यादेवी होळकर
सोलापूर विद्यापीठ
॥ विद्यया संपन्नता ॥

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

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Physics: (Energy Studies)

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

(Syllabus to be implemented from w.e.f. June 2021)

PUNYASHLOK AHILYADEVI HOLKAR SOLAPUR UNIVERSITY

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

1) **Title of the course:** M.Sc. in Physics (Energy Studies)
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 (Energy Studies) consists of 100 credits. Credits of a course are specified against the title of the course.

A Four Semester M.Sc. Physics (Energy Studies) 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
• SEC	---	--	4*
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 (Energy Studies) w.e.f. 2021-22

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	Introduction to Energy 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**

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.

M.SC-I, SEME. I, PHYSICS (ENERGY STUDIES)

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 (ENERGY STUDIES)

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 (ENERGY STUDIES)

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 (ENERGY STUDIES)
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 (ENERGY STUDIES)

SCT - 1.2: Introduction to Energy Science
Choice Based Credit System (CBCS)
(w. e. f. June 2021-22)

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

Course Objectives:

To provide knowledge of post-graduate level in the field of energy, so that the students after successfully completing the programme may take research work in the development of renewable energy system, which are technological and economical viable.

Learning Outcomes:

- To understand the different kinds of Energy sources. To study the basis of solar energy and solar radiation measurement. To learn the fundamental principles and theory of wind energy conversion system. Student will acquire enough knowledge enough knowledge about the renewable energy resources.
- This course helps the student to understand the concepts of energy sources and their technologies. To learn the environmental pollution and climate change. To understand the basic need of carbon free energy. Student will acquire enough knowledge about the renewable energy sources.

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 (ENERGY STUDIES)
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 (ENERGY STUDIES)
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 (ENERGY STUDIES)
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 (ENERGY STUDIES)
SCT - 2.2: ANALYTICAL TECHNIQUES
Choice Based Credit System (CBCS)
(w. e. f. June 2020-2021)

COURSE CODE: SCT 2.2 (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 (ENERGY STUDIES)
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 (ENERGY STUDIES)
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 (ENERGY STUDIES)
Choice Based Credit System (CBCS)
(w. e. f. June 2021-2022)
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.