

**M. Sc. Physics**

Syllabus

CENTRE FOR DISTANCE AND ONLINE EDUCATION

(SCHOOL OF DISTANCE EDUCATION)

**OPEN AND DISTANCE LEARNING**

**2023– 2024 Onwards**

**Modified & Approved for SDE vide SCAA Dated 18-06-24 (2022-23 Onwards)**



**BHARATHIARUNIVERSITY**

**AStateUniversity,Accreditedwith“A++”Gradeby NAACRanked21stamongIndianUniversitiesby MHRD-NIRF**

**Coimbatore-641 046, TamilNadu,India**



## Program Educational Objectives (PEOs)

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| The **M. Sc. Physics** program describe accomplishments that graduates are expected to attain within five to seven years after graduation | |
| Graduates will become experts in various professional zones like industry, research, academic, business, etc. at par with national and international standards. |
| Acquired knowledge in physical concepts facilitate the graduates to recognize, formulate, examine, explore and implement the ideas for societal developments. |
| Graduates capable enough to meet any challenge as an individual or in a part of team towards achieving prospective scope in innovative projects. |
| Graduates will have cognitive base to achieve academic excellence by learning  diverse phenomena of physical concepts help them to lead and execute inter- and multidisciplinary academic and research works. |
| Graduates will be skilled enough to perceive novel and innovative concepts to develop cutting edge technologies as entrepreneurial pursuit. |
| Graduates will have a proficiency to enhance the application prospects of physics by interfacing the philosophical concepts with suitable perceptions beyond the  subject boundary. |



**Program Specific Outcomes (PSOs)**

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| After the successful completion of **M.Sc., Physics** program, the students are expected to | |
| Be a potential graduate with the stuff of vibrant subject knowledge in every subdivision of Physics especially in Classical Mechanics, Quantum Mechanics, Mathematical Physics, Nuclear Physics, Electronics and Materials Science with  application tendency. |
| Be a science person to extend the application of Physics discipline to different sectors of common or needy people. |
| Have the competence to get clear any comprehensive examination offers superior opportunity in official, academic and research sectors. |
| Have the skill to manage computational tools to explore scientific activity even at subatomic particle level using theoretical concepts without empirical approach. |
| Be a skillful to perceive rare or exceptional scientific phenomena using the concepts of physical science and to find solution to any challengeable task. |
| Be an efficient to employ research work by applying the subject knowledge acquired from diverse objectives of Physics. |
| Have the ability to meet any employment challenge demands intense subject proficiency. |



**Program Outcomes (POs)**

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| On successful completion of the M. Sc. Physics program |
| Understand the concepts of advanced physics and capable to apply them in real time problems to find appropriate solutions. | |
| Develop model and analyse to derive solution using the background of theoretical physics. | |
| Augment the application feasibility of Physics theoretical formulations in combination with relative concepts belongs to other discipline. | |
| Apply learned experimental skill to develop newer materials with unique characteristics employing variety of synthesis techniques. | |
| Develop software tools by applying the learned concepts in combination belongs to Mathematical physics, Quantum mechanics and computational physics. | |
| Perceive novel and contemporary research philosophies globally facilitate to work at par with international standards. | |
| Meet any challenge globally for employment in academic, research and industry by exposing the learned skill in diverse zone under Physics discipline. | |



**SCHOOL OF DISTANCE EDUCATION**

## BHARATHIAR UNIVERSITY, COIMBATORE-641 046

OPEN AND DISTANCE LEARNING PROGRAMME (ODL)

## M.Sc.PhysicsCurriculum

*(Forthe studentsadmitted duringthe academicyear2023–24 onwards)*

**SCHEME OF EXAMINATIONS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Title of the Course | Credits | Maximum Marks | | |
| CIA | ESE | Total |
| **FIRST SEMESTER** |  |  |  |  |
| Paper - I Classical Mechanics | 4 | 25 | 75 | 100 |
| Paper - II Mathematical Physics-I | 4 | 25 | 75 | 100 |
| Paper - III Integrated Electronics | 4 | 25 | 75 | 100 |
| Paper - IV Advanced Computational Physics | 4 | 25 | 75 | 100 |
| Practical - I General Physics | - | - | - | - |
| Practical - II Electronics | - | - | - | - |
| Elective I – Robotics, Artifical Intelligence and Information Theory | 4 | 25 | 75 | 100 |
| **SECOND SEMESTER** |  |  |  |  |
| Paper - V Quantum Mechanics-I | 4 | 25 | 75 | 100 |
| Paper -VI Mathematical Physics- II | 4 | 25 | 75 | 100 |
| Paper -VII Atomic and Molecular  Spectroscopy | 4 | 25 | 75 | 100 |
| Practical- I General Physics | 4 | 40 | 60 | 100 |
| Practical- II Electronics | 4 | 40 | 60 | 100 |
| Elective II – Elements of Nanoscience and Nanotechnology | 4 | 25 | 75 | 100 |
| **THIRD SEMESTER** |  |  |  |  |
| Paper - VIII Quantum Mechanics – II | 4 | 25 | 75 | 100 |
| Paper-IX ClassicalElectrodynamics | 4 | 25 | 75 | 100 |
| Paper-X StatisticalMechanics | 4 | 25 | 75 | 100 |
| Paper-XI Condensed MatterPhysics | 4 | 25 | 75 | 100 |
| Practical- III Advanced Practicals | - | - | - | - |
| Practical- IV Special Electronics | - | - | - | - |
| Elective III | 4 | 25 | 75 | 100 |
| **FOURTH SEMESTER** |  |  |  |  |
| Paper -XII Nuclear and Particle Physics | 4 | 25 | 75 | 100 |
| Paper -XIII Communication Electronics | 4 | 25 | 75 | 100 |
| Paper -XIV Laser Physics and Nonlinear Optics | 4 | 25 | 75 | 100 |
| Practical- III Advanced Practicals | 4 | 40 | 60 | 100 |
| Practical- IV Special Electronics | 4 | 40 | 60 | 100 |
| Project | 6 | - | - | 150\* |
| Grand Total | **90** |  |  | **2250** |



\* Project report - 120 marks (80%); Viva-voce - 30 marks (20%)



First Semester



## FIRST SEMESTER

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| **Course code** | | **CLASSICAL MECHANICS** | **Core Paper I** |
| **Pre-requisite** | | Students should have basic understanding in mathematical physics and Newtonian mechanics |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Understand basics of variational principle, Lagrangian and Hamiltonianformalism 2. know about central force problem, phase space, canonical transformation andHamilton Jacobitechnique 3. apply normal mode analysis to physical systems 4. learn concepts of special relativity and familarise basics of non-lineardynamics | | | |
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| **Expected Course Outcomes:** | | | |
| On successful completion of the course, the students will be able to : | | | |
| familarise basic mathematical tools like variational calculus to mechanical systems and able to compute Lagrangian and Hamiltonian equation of motion | | | | |
| understand central force problem and also system in non-inertial reference frame | | | | |
| analyse mechanics problems through canonical transformation technique and Hamilton Jacobi technique | | | | |
| learn rigid body dynamics and normal mode analysis | | | | |
| study basic concept of special theory of relativity and non-linear dynamics | | | | |
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| **Unit I** | **Variational Principle: Lagrange’s and Hamilton’s Equations** | | |
| Newton’s Three Laws of Motion (Review) – Constraints, Degrees of freedom, Generalized Coordinates and Configuration Space. Variational Principle – Hamilton’s Principle – Derivation of Euler Lagrangian Equation of Motion – Symmetries and Conservation Laws – Cyclic Coordinates. Phase Space – Hamilton’s Canonical Equation of Motion using Variational Principle – Physical Significance of Hamiltonian.  Applications – Lagrangian and Hamilton’s Equation of Motion for Simple Pendulum, Linear Harmonic Oscillator and A Charged Particle in Electromagnetic Fields | | | |
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| **Unit II** | **Central Force and Non-inertial Frame** | | |
| Motion in a Central Force Field in Lagrangian Formalism – Reduction of Two Body Problem to the Equivalent One Body Problem – Classification of Orbits for Inverse Square Forces - Virial Theorem – Differential Equation for the Orbits - Two Body Collisions. Classical Scattering in Laboratory and Centre  of Mass Frames - Non-inertial Frames – Rotating frame of Reference - Pseudo Forces - Coriolis Force and Effects of Coriolis Force on the Moving Bodies | | | |
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| **Unit III** | **Canonical Transformation and Hamilton Jacobi method** | | |
| Principle of Least Action – Statement and Proof – Canonical Transformation – Generating Functions and its different form – Poisson’s Bracket – Properties – Angular momentum Algebra – Liouville’s Theorem (without Proof) - Hamilton Jacobi method – Harmonic Oscillator Problem - Hamilton’s Characteristic Functions – Conservative Systems – Kepler Problem - Action and Angle Variables – Linear Harmonic  Oscillator using Action and Angle Variables | | | |



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| **Unit IV** | | **Rigid Body and Small Oscillations** |
| Motion of a Rigid Body – Euler Angles – Angular Momentum and Interia Tensor – Moment of Inertia and Products of Inertia – Principal Axis – Rotational Kinetic Enegy - Euler’s Equation of Motion – Torque Free Motion – Free motion of a Symmetric Top - Theory of Small Oscillations – Potential Energy – Stable and Unstable Equilibrium – Eigenvalue Problem – Frequencies of Free Vibrations - Normal Modes –  Normal Coordnates – Linear Triatomic Molecule – Double Pendulum | | |
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| **Unit V** | | **Theory of Relativity and Introduction to Non-Linear Dynamics** |
| Lorentz Transformations – Mass and Energy Equivalance – Relativistic Kinematics - Force in Relativistic Kinematics and Lorentz Transformation of Force – Lagrangian and Hamiltonian in Relativistic Kinematics – Minkowski space – world point and world line – space time intervals - Dynamical Systems – Autonomous and Non-Autonomous Systems - Phase Portraits – Simple Harmonic Oscillator in One Dimension – Simple Pendulum – Linear Stability Analysis – Classification of  Fixed Points | | |
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| **Text Book(s)** | | |
| 1 | Classical Mechanics – J. C. Upadhyaya, Himalaya Publishing House, 2012. | |
| 2 | Introduction to Classical Mechanics – R. G. Takwala and P.S. Puranik, Tata – McGraw Hill, New Delhi, 1980. | |
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| **Reference Books** | | |
| 1 | Classical Mechanics – H. Goldstein, C.P. Poole and J. Safko, 3rd Edition, Pearson, 2012 | |
| 2 | Classical Mechanics - N. C. Rana and P.S. Joag, Tata McGraw Hill, 2001 | |
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| **Course code** | | **MATHEMATICAL PHYSICS I** | **Core Paper II** | |
| **Pre-requisite** | | Students should have basic understanding in vectors, trignometry, algebra and calculus |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. understand basics of vector analysis, curvilinear coordinate system, linear vector space andtensors 2. familiarize infinite series and erroranalysis 3. learn complex variables and residue theorem technique to solve real integrals appearing in physicsproblems 4. understand differential equations and self adjointoperators | | | | |
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| **Expected Course Outcomes:** | | | | |
| On successful completion of the course, the students will be able to : | | | | |
| understand vector calculus and also able to write operators in different coordinate system | | | |
| apply linear vector space concepts in quantum mechanics | | | |
| understand convergence of infinite series, error analysis and curve fitting | | | |
| evaluate real integrals appearing in science and engineering problems | | | |
| solve differential equations and understand self adjoint operators used in quantum mechanics | | | |
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| **Unit I** | **Vector Analysis and Partial Differential Equations** | | | |
| Vector Integration – Line Integral – Path Independence – Exact Differential – Surface Integral – Flux – Volume Integral – Divergence Theorem – Stokes Theorem – Green Theorem– Gauss’s law – Laplace’s Equation and Poission’s Equation in Electrostatics - Orthogonal Curvilinear Coordinates – Unit Vectors in Curvilinear Coordinate System – Arc Length and Volume Element – The Gradient, Divergence, Curl and  Laplacian Operator in Cartesian, Cylindrical and Spherical Polar Coordinate System | | | | |
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| **Unit II** | **Linear Vector Space and Tensors** | | | |
| Definition of Linear Vector Space – Linear Independence – Basis and Dimensions of a Vector Space – Scalar Product – Schwartz Inequality – Orthonormal Basis (ONB) - Gram SchmidOrthogonalization Procedure – Linear Transformations – Linear Operators – Matrix Representation of a Linear - Tensors – Covariant and Contravariant Tensors – Mixed Tensors - Rank of Tensors - Symmetric and Anti Symmetric Tensors – Kronecker Delta – Levi Civita Symbol - Contraction – Tensor Product – Exterior  Product – Metric Tensor | | | | |
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| **Unit III** | **Infinite Series and Error Analysis** | | | |
| Introduction to Sequence and Series – Summation of Series – Geometric Series – Arthematic and | | | | |



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| Geometric Series – Difference Method – Convergence of Series – Absolute and Conditional Convergence – Convergence of a Serie Containing Only Real Positive Terms – Preliminary Test – Comparision Test – Ratio Comparision Test – Quotient Test – Integral Test – Cauchy’s Root Test – Grouping tems – Alternating Series Test – Operations with Series – Taylor and Maclaurin Series – Errors Analysis – Propagation of Errors - Normal Distribution of Error - Standard Error – Principle of Least Squares – Application of Solution to Linear Equation – CurveFitting | | |
| **Unit IV** | | **Complex Variables** |
| Complex VariablesandFunctions – Analytic Functions – Cauchy Riemann Condition with Proof – Complex Integration – Cauchy’s IntegralTheorem – Cauchy’s Integral Formula – Taylor Series Expansion  - Laurent Series Expansion – Singularities – Poles – Cauchy Residue Theorem – Computations of Residue – Evaluation of integrals using Residues – Principal Value Integrals | | |
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| **Unit V** | | **Ordinary Differential Equations** |
| First and Second Order Ordinary Differential Equations with Constant Coefficients – Initial Value Problem – Method of Finding Solutions – Superposition Principle – Wronskian – Second Order Differential Equations with Variable Coefficients – Definition of Ordinary and Singular Points – Power Series Solution – Solutions About Ordinary Point and Singular Point – Frobenius Method - Operators –  Sturm Liouville Condition – Self Adjoint Operators – Discussions on Completeness Property (no proof). | | |
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| **Text Book(s)** | | |
| 1 | Mathematical Methods for Physicists (a comprehensive guide) – George B. Arfken and Hans J. Weber and Frank E. Harris, Elsevier Academic Press, 7th Edition, 2013. | |
| 2 | Mathematical Methods for Physics and Engineering – K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 3rd Edition, 2006. | |
| 3 | Mathematical Physics – P. K. Chattopadhyay, New Age International Publishers, 2nd Edition, 2013. | |
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| **Reference Books** | | |
| 1 | Advanced Engineering Mathematics – Erwin Kreyszig, Herbert Kreyszig and Edward J. Norminton, John Wiley & Sons, 10th Edition, 2011 | |
| 2 | Mathematical Methods in the Physical Sciences – Mary L. Boas, John Wiley & Sons, 3rd Edition, 2006. | |
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| **Course code** | | **INTEGRATED ELECTRONICS** | **Core Paper III** |
| **Pre-requisite** | | Students should have the basic knowledge about  analog and digital electronics |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Acquire knowledge and apply it to various electronicdevices 2. Develop knowledge about analog and digitalelectronics 3. Motivate the students to apply the principles of electronics in their day – to – daylife | | | |
| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Analyze various semiconductor devices and their applications | | | | |
| Study the characteristics of Op-amp and it’s applications | | | | |
| Update the knowledge of signal processing | | | | |
| Develop the fundamental concepts and techniques used in data storage elements | | | | |
| Design different types of registers and counters | | | | |
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| **Unit I** | **Semiconductor Devices and IC fabrication** | | |
| Semiconductor diodes – Characteristics – Ideal diode – Clipper and clamper circuits. Special diodes: Zener,  Schottky and Tunnel diodes- Applications – Junction transistors – JFET, MOSFET, UJT and SCR – applications – Principle of Integrated Circuits – fabrication process – Linear and Digital Integrated Circuits | | | |
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| **Unit II** | **Operational Amplifier and Applications** | | |
| Op Amp characteristics – DC & AC characteristics - Frequency Response of an Op Amp -Parameters of an Op Amp - Sign Changer - Scale Changer – Adder - Subtractor - Phase Shifter -Differential Amplifier  – Integrator – Differentiator - Analog Computer Setup to Solve Linear Simultaneous Equations - Differential Equations in Physics - Logarithmic & Exponential Amplifiers - Active Filters | | | |
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| **Unit III** | **Signal Processing & Data Acquisition** | | |
| Wave Form Generators and Wave Shaping Circuits - Sinusoidal Oscillators - Phase Shift Oscillator -  Wein Bridge Oscillator - Crystal Oscillator - Multivibrators, Comparators - Schmitt Trigger-Square Wave & Triangular Wave Generators - Pulse Generators - IC 555 Timer and its Application – Signal and | | | |

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| Signal Processing - Analog Multiplexer and Demultiplexer - D/A Converters - A/D Converters | | | |
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| **Unit IV** | | **Flip - Flops** | |
| Types of Flip-flops – RS Flip-flop, Clocked RS Flip-flop, Clocked D Flip-flop, Positive-Edge- Triggered RS Flip-flop, Negative-Edge - Triggered RS Flip-flop, Edge-Triggered D Flip-flop, Positive- Edge - Triggered JK Flip-flop, Flip-flop timing, JK Master-Slave Flip-flop, Conversion of SR Flip-flop  to JK Flip-flop | | | |
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| **Unit V** | | **Registers, Counters and Memories** |  |
| Types of Registers – Serial in Serial out - Serial in Parallel out - Parallel in Serial out - Parallel in  Parallel out - Counters – Asynchronous (Ripple) counters - Synchronous counters - Mod 2 to Mod 10 counters and Decade counters - Memories: RAM, ROM, PROM, EPROM and CCD | | | |
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| **Text Book(s)** | | | |
| 1 | Microelectronics, Millman&Grabel, McGraw Hill, Second edition (2017) | | |
| 2 | Digital Principles and Applications, Malvino& Leach, McGrawHill, Seventh edition (2011) | | |
| 3 | Linear Integrated circuits, D. R. Choudhury & S. Jain, New Age International, New Delhi, Second edition (2003) | | |
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| **Reference Books** | | | |
| 1 | Integrated Electronics, Millman&Halkias, Tata McGraw Hill, 17th Reprint (2000) | | |
| 2 | Electronics Principles & Applications, A.B. Bhattacharya New Central Book Agency (P) LTd., Kolkata (2007) | | |
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| **Course code** | **ADVANCED COMPUTATIONAL PHYSICS** | **Core Paper IV** |
| **Pre-requisite** | The Students should have basic knowledge in differential equation and linear algebra. |
| **Course Objectives:** | | |
| Primary objectives:   1. To equip the computational skill using various mathematicaltools. 2. To apply the software tools to explore the concepts of physicalscience. 3. To approach the real time activities using physics and mathematicalformulations. 4. To apply various mathematical entities, facilitate to visualise any complicatetasks. 5. To enhance the problem-solving aptitudes of students using various numericalmethods. 6. To promote computer programming skills with the help of MATLABtools. | | |
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| **Expected Course Outcomes:** | | |
| On the successful completion of the course, student will be able to: | | |
| Understand and apply numerical methods to find out solution of algebraic equation using different methods under different conditions,and numerical solution of system of algebraic equation. | | |
| Apply various interpolation methods and finite difference concepts. | | |
| Work out numerical differentiation and integration whenever and wherever routine are not applicable. | | |
| Identify modern programming methods and describe the extent and limitations of computational methods in physics | | |
| Process, analyze and plot data from a variety of physical phenomena and interpret their meaning | | |
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| **Unit I** | | **Numerical Differentiation** |
| Finding Roots of a Polynomial - Bisection Method - Newton Raphson Method - Solution of Simultaneous Linear Equation by Gauss elimination method - Solution of Ordinary Differential Equation by Euler – RungeKutta Fourth Order Method for solving first order Ordinary Differential  Equations | | |
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| **Unit II** | | **Numerical integration** |
| Newton’s cotes formula – Trapezoidal rule - Simpson’s 1/3 rule - Simpson’s 3/8 rule - Boole’s rule - Gaussian quadrature method (2 point and 3 point formula) - Giraffe’s root square method for solving  algebraic equation | | |
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| **Unit III** | | **Matlab Fundamentals** |
| Introduction – Matlab Features – Desktop Windows: Command, Workspace, Command History, Array editor and Current Directory – Matlab Help and Demos – Matlab Functions, Operators and commands, Basic Arithmetic in Matlab – Basic Operations with Scalars - Vectors and Arrays - MatricesandMatrixOperations-ComplexNumbers-MatlabBuilt-InFunctions-Illustrative  Examples | | |
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| **Unit IV** | | **Matlab Programming** |
| Control Flow Statements: if else, else if, Switch Statements – For, While Loop Structures – Break Statement – Input / Output Commands – Script ‘m’ Files – Function ‘m’ Files – Controlling output | | |
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| **Unit V** | | **Matlab Graphics** |
| 2D Plots - Planar Plots, Log Plots, Scatter Plots, Contour Plots - Multiple Figures, Graph of a Function  – Titles, Labels, Text in Graph - Line Types, Marker types, Colors - 3D Graphics - Curve Plots - Mesh and Surface Plots - IllustrativeExamples | | |
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| **Text Book(s)** | | |
| 1 | Numerical methods in Science and Engineering - M.K. Venkataraman, National Publishing Co. Madras, 1996 | |
| 2 | Getting Started With Matlab – RudraPratap, Oxford University Press-New Delhi | |
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| **Reference Books** | | |
| 1 | Numerical methods using Matlab – John Mathews & Kurtis Fink, Prentice Hall, New Jersey 2006 | |
| 2 | Matlab Programming - David Kuncicky, Prentice Hall | |
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Second Semester



## SECOND SEMESTER

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| **Course code** | | | **QUANTUM MECHANICS I** | **Core Paper V** |
| **Pre-requisite** | | | Students should have basic understanding in mathematical physics and classical mechanics |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. Understand basics of state vector in abstractrepresentation 2. Solve bound stateproblems 3. Learn angular momentum algebra and concept of spin in quantummechanics 4. Apply approximationmethods | | | | |
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| **Expected Course Outcomes:** | | | | |
| On successful completion of the course, the students will be able to : | | | | |
| 1 | familiarize Dirac notation | | | | |
| 2 | apply Schrodinger equations to exactly solvable simple problems | | | | |
| 3 | learn quantum mechanical angular momentum algebera and spin | | | | |
| 4 | compute corrections in energy and wavefunctions using approximation technique | | | | |
| 5 | calculate transition probability and also selection rules for transition | | | | |
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| **Unit I** | | **Basic Formalism** | | |
| Postulates of Quantum Mechanics – Max Born Statistical Interpretation of Wavefunction – Probability Density – Wavefunctionin Position Representation and Momentum Representation – Derivation of Schrodinger Time Independent Wave Equation – Stationary State – Dirac Notation – State Vector - Hilbert Space – Basis – Orthonormal Basis – Change of Basis – Unitary Transformation – Equation of Motion in Schrodinger Representation –Heisenberg Representation  and Dirac Representation. | | | | |
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| **Unit II** | | **Applications of Schrodinger Wave Equations** | | |
| Bound State Problems – One Dimensional Infinite Square Well (0,L) – Three Dimensional Infinite Cubic Well – Concept of Degeneracy – One Dimensional Finite Square Well – Potential Step – Square Potential Barrier – Explanation of Alpha Decay – Solution of Linear Harmonic Oscillator by Schrodinger Approach (Differential Equation Method) and Heisenberg Approach (Creation and  Annihilation Operator Method) – Central Potential – Hydrogen Atom (qualitatively) | | | | |
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| **Unit III** | | **Angular Momentum Algebra** | | |
| Orbital Angular Momentum Algebra – Spin Angular Momentum Alegbra – Pauli Spin Matrices – Eigen Values and Eigen Vector of Pauli Spin Matrices – Properties of Pauli Spin Matrices – Total Angular Momentum Algebra – Complete Set Of Compactable Operators – CommutationRelations of , , and – Eigen Values of of, - matrix representation of of, , and - addition of angular momenta – Clebsch Gordon coefficients and its properties – CG Coefficients for SpinHalf  systems and Spin One systems. | | | | |
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| **Unit IV** | | **Stationary Approximation Method** | | |

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| Time Indepdent Perturbation Theory – Non Degenerate Case – Ground State of Helium Atom – Degenerate Case - Stark Effect in Hydrogen Atom – Variation Method – The Hellmann Feynman Theorem – Estimation of Ground State of Helium Atom – Estimation of Ground State of Deutron –  WKB Approximation – Connection Formula – Validity – Barrier Penetration – Alpha Emission | | |
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| **Unit V** | | **Time Dependent Perturbation Theory** |
| Time Dependent Perturbation Theory – Formalism - Transition Probability – Transition Probability for a Constant Perturbation - Transition into a constinuum of final states – Fermi Golden Rule – Transistion Probability for a Harmonic Perturbation – Stimulated Emission – Principle of Detailed  Balancing - Selection Rules - Rayleigh Scattering - Raman Scattering | | |
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| **Text Book(s)** | | |
| 1 | Quantum Mechanics – NouredineZettili, John Wiley & Sons, Ltd, 2nd Edition, 2009 | |
| 2 | Quantum Mechanics – G. Aruldhas, PHI Learning Private Limited, 2nd Edition, 2009 | |
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| **Reference Books** | | |
| 1 | Quantum Mechanics - V. Devanathan - Narosa Publishing - New Delhi, 2005 | |
| 2 | Quantum Mechanics - L.I. Schiff - McGraw Hill, 3rd Edition, 1968 | |



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| **Course code** | | **MATHEMATICAL PHYSICS II** | **Core Paper VI** |
| **Pre-requisite** | | Students should have basic understanding in mathematical physics I |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Understand basics of Fourier series, Fourier Transform and LaplaceTransform 2. Learn specialfunctions 3. Familiraize Greens function technique and integralequations 4. Know about group theory applied in physicalproblems | | | |
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| **Expected Course Outcomes:** | | | |
| On successful completion of the course, the students will be able to : | | | |
| Apply Fourier series and Fourier transform techniques to physics and engineering problems | | | | |
| Apply Laplace transform techniques to physics and engineering problems | | | | |
| Understand special functions used in quantum mechancs and electrodynamics course | | | | |
| Solve differential equations using Green’s function technique | | | | |
| Familarize basic group theory concepts used in spectroscopy and nuclear physics | | | | |
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| **Unit I** | **Fourier Series and Fourier Transform** | | |
| Introduction to Fourier Series – Dirichlet’s Theorem and Dirichlet’s Conditions – Fourier Coefficients – Even and Odd Functions – Complex Form of Fourier Series - Change of Interval – Perseval’s Relations – Applications of Fourier Series – Fourier Transform – Fourier Transform of Gaussian Function – Fourier Sine and Cosine Transform – Properties of Fourier Transforms – Perseval Theorem – Fourier Transforms of Derivatives – Applications to Differential Equations and Boundary Value Problems – Introduction to  Discrete Fourier Transform. | | | |
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| **Unit II** | **Laplace Transform** | | |
| Introduction to Laplace Transforms - Laplace Transform for Elementary Functions and Dirac Delta Function – Properties of Laplace Transform – Laplace Transform of Derivatives – Convolution Theorem - Inverse Laplace Transform – Properties – Dirac Delta Function - Properties of Laplace Transform–  Solution to Differential Equations | | | |
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| **Unit III** | **Special Functions** | | |
| Solution of Differential Equations of – Legendre, Hermite, Laguerre and Bessel Differential Equations using Power Series method – Generating Function, Rodrigues Formule, Recuression Relations,  Orthogonality Relations. | | | |
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| **Unit IV** | **Green’s Function and Partial Differential Equations** | | |
| Dirac Delta Distribution – Non Homogeneous Boundary Value Problems and Green’s Function – Green’s | | | |

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| Function for One – Dimensional Problems – Green’s Function for Poisson’s Equation and a Formal Solution of Electrostatic Boundary Value Problems – Green’s Function for Quantum Mechanical Scattering Problem  - Partial Differential Equation – Variable Separable Method – Solutions of Laplace Equations,Wave  Equations and Heat Equation in Two and Three Dimensions | | |
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| **Unit V** | | **Group Theory** |
| Introduction to Group Theory – Group Multiplication Table – Cyclic Group - Subgroup – Cosets - Classes  – Invariant Subgroup – Homomorphism and Isomorphism – The Group Symmetry of an Equilateral Triangle and a Square – Group Representation – Reducible and Irreducible Representation – Schur’s LemmaandOrthogonalityTheorem–CharacterTables–IntroductiontoLieGroupsandLieAlgebras–  SU(2) and SO(3) | | |
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| **Text Book(s)** | | |
| 1 | Mathematical Methods for Physicists (a comprehensive guide) – George B. Arfken and Hans J. Weber and Frank E. Harris, Elsevier Academic Press, 7th Edition, 2013. | |
| 2 | Mathematical Methods for Physics and Engineering – K. F. Riley, M. P. Hobson and S. J. Bence, Cambridge University Press, 3rd Edition, 2006. | |
| 3 | Mathematical Physics – P. K. Chattopadhyay, New Age International Publishers, 2nd Edition, 2013. | |
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| **Reference Books** | | |
| 1 | Advanced Engineering Mathematics – Erwin Kreyszig, Herbert Kreyszig and Edward J. Norminton, John Wiley & Sons, 10th Edition, 2011 | |
| 2 | Mathematical Methods in the Physical Sciences – Mary L. Boas, John Wiley & Sons, 3rd Edition, 2006. | |
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| **Course code** | | **ATOMIC AND MOLECULAR SPECTROSCOPY** | **Core Paper VII** | |
| **Pre-requisite** | | Students should have basic understanding of electricity and magnetism,classical and quantum mechanics |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. understand the nature of electromagnetic radiation, molecular structure, nature of bondingand symmetry of moleculargroups. 2. know about atom and its spectrallines 3. to acquaint molecular groups according to their moment of inertia and the spectraarising from eachgroup 4. learn concepts of different spectroscopictechniques. | | | | |
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| **Expected Course Outcomes:** | | | | |
| On successful completion of the course, the students will be able to : | | | | |
| familarise basics on characterization of electromagnetic radiation and quantization of energy | | | |
| understanding different spectral lines arising from atoms and interaction of spectral lines with  the external source | | | |
| able to design spectroscopic experiments, able to accurately record and analyze the results of such experiments | | | |
| learn different spectroscopic techniques to analyse molecular structure | | | |
| analyse linear, vibrational and rotational motion of the molecules and can evaluate  corresponding energy transitions | | | |
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| **Unit I** | **Atomic & Microwave Spectroscopy** | | | |
| **Atomic Spectroscopy** - Spectra of Alkali Metal Vapours - Normal Zeeman Effect - Anomalous Zeeman Effect  -Magnetic Moment of Atom and the G Factor - Lande’s ‘g’ Formula - Paschen Back Effect - Hyperfine Structure of SpectralLines  **Microwave Spectroscopy** - Experimental Methods - Theory of Microwave Spectra of Linear, Symmetric Top Molecules - Hyperfine Structure - Quadrupole Moment - Inversion Spectrum of Ammonia | | | | |
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| **Unit II** | **Infrared & Raman Spectroscopy** | | | |
| **IR Spectroscopy:** Practical Aspects - Theory of IR Rotation Vibration Spectra of Gaseous Diatomic Molecules - | | | | |



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| Applications - Basic Principles of FTIR Spectroscopy  **Raman Spectroscopy:** Classical and Quantum Theory of Raman Effect - Rotation Vibration Raman Spectra of Diatomic and Polyatomic Molecules – Applications - Laser Raman Spectroscopy | | |
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| **Unit III** | | **Electronic Spectra: Fluorescence & Phosphorescence Spectroscopy** |
| Excitation of Diatomic Species - Vibrational Analysis of Band Systems of Diatomic Molecules - Deslandre’s Table - Intensity Distribution - Franck Condon Principle - Rotational Structure of Electronic Bands - Resonance and Normal Fluorescence - Intensities of Transitions - Phosphorescence - Population of Triplet State and Intensity -Experimental Methods - Applications of Fluorescence andPhosphorescence | | |
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| **Unit IV** | | **NMR & NQR Spectroscopy** |
| **NMR Spectroscopy:** Quantum Mechanical and Classical Description - Bloch Equations - Relaxation Processes  - Experimental Technique - Principle and Working of High Resolution NMR Spectrometer - Chemical Shift.  **NQR Spectroscopy:** Fundamental Requirements - General Principle - Experimental Detection of NQR  Frequencies - Interpretation and Chemical Explanation of NQR Spectroscopy | | |
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| **Unit V** | | **ESR & Mossbauer Spectroscopy** |
| **ESR Spectroscopy:** Basic Principles-Experiments - ESR Spectrometer-Reflection Cavity and Microwave Bridge - ESR Spectrum - Hyperfine Structure  **Mossbauer Spectroscopy:** Mossbauer Effect - Recoilless Emission and Absorption - Mossbauer Spectrum  - Experimental Methods - Hyperfine Interaction - Chemical Isomer Shift - Magnetic Hyperfine and Electric QuadrupoleInteraction | | |
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| **Text Book(s)** | | |
| 1 | Molecular Structure and Spectroscopy - G. Aruldhas | |
| 2 | Introduction to Atomic Spectra - H. E. White, McGraw-Hill Inc., US (1934). | |
| **Reference Books** | | |
| 1 | Spectroscopy: Volumes I, II and III - B.P. Straugham&S.Walker | |
| 2 | Fundamental of molecular spectroscopy - C.B.Banwell | |
| 3 | Introduction to molecular spectroscopy - G.M.Barrow | |
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### SEMESTER I & II

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| **Course code** | | **PRACTICAL I - GENERAL PHYSICS**  **(**Examination at the end of Second Semester**)** | **Core Practical** | |
| Students should have the fundamental knowledge of experimental Physics and Programming skills |
| **Pre-requisite** | |
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| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| Understand the basics of experimental physics and compare the results with  theoretical calculations. | | | |
| Gain knowledge of new conception in practical oriented problems and visualize the experiments through MATLAB programming. | | | |
| Equip the students in basic communication skills in the course of performing the laboratory experiments in groups and by interpreting the results | | | |
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| S.  No. | **LIST OF EXPERIMENTS**  (Any twelve experiments) | | | |
| 1 | Young’s Modulus - Elliptical Fringes (Cornu’s Method) | | | |
| 2 | Young’s Modulus - Hyperbolic Fringes (Cornu’s Method) | | | |
| 3 | Viscosity of a Liquid - Mayer’s Oscillating Disc | | | |
| 4 | Determination of Stefan’s Constant | | | |
| 5 | Rydberg’s Constant - Solar Spectrum | | | |



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| 6 | Thickness of Wire by Air Wedge and Diffraction |
| 7 | Determination of Audio Frequencies - Bridge Method |
| 8 | Thermionic Work function |
| 9 | Thermal Conductivity-Forbe’s Method |
| 10 | Electronic Charge e by Millikan’s Oil Drop Method |
| 11 | Electronic Specific Charge e/m by Thomson’s Method |
| 12 | Thermistor - Temperature Coefficient and Band Gap Energy Determination |
| 13 | Specific Heat of a Liquid – Ferguson’s Method |
| 14 | Biprism on Optical Bench - Determination of Wavelength |
| 15 | He Ne Laser - Measurement of Wavelength using reflectance grating |
| 16 | Thickness of the wire by diffraction using spectrometer |
| 17 | He Ne Laser - Measurement of refractive index of liquids |
| 18 | He Ne Laser - Power distribution measurement |
| 19 | He Ne Laser - Thickness of wire |
| 20 | Fabry-Perot Interferometer - Study of Fine Structure |
| 21 | Geiger Muller Counter - Determination of Half Life period of Radioactive element |
| **MATLAB Programming** | |
| 22 | Matlab Programming - Roots of a Quadratic Equation & Solution of a System of Linear Equations |
| 23 | Matlab Programming - Solution of Ordinary Differential Equations – First Order |
| 24 | Matlab Programming – Runge - Kutta Method |
| 25 | Matlab Programming – Newton - Raphson Method |
| 26 | Matlab Programming - Mean, Median & Standard Deviation |
| 27 | Matlab Programming - Curve Fitting & Interpolation |
| 28 | Matlab Programming - Matrix Summation, Subtraction and Multiplication |
| 29 | Matlab Programming - Matrix Inversion and Solution of Simultaneous Equations |
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**SEMESTER I & II**

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| **Course code** | | **PRACTICAL II - ELECTRONICS**  **(**Examination at the end of Second Semester**)** | **Core Practical** | |
| Students should have the fundamental knowledge in IC’s and Programmingskills |
| **Pre-requisite** | |
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| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| Acquire knowledge on semiconductor devices and op amps characteristics | | | |
| Apply circuit systems to construct electronic devices | | | |
| Evaluate functioning of circuits | | | |
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| S.  No. | **LIST OF EXPERIMENTS**  (Any twelve experiments) | | | |
| 1 | Design of Regulated and Dual Power Supply and Construction using fixed voltage regulator  and 723 | | | |
| 2 | Basic Logic Gates - Digital IC’s | | | |
| 3 | Parameters of Op Amp | | | |
| 4 | Design of Wave Form Generators- using Op Amp and Timer 555 | | | |
| 5 | Design of Wein’s Bridge Oscillator – Op Amp | | | |
| 6 | Design of Active Filters - Op Amp | | | |
| 7 | Design of Differential Amplifier – Op Amp | | | |
| 8 | Design of Phase Shift Oscillator – Op Amp | | | |
| 9 | Sign Changer, Scale Changer, Adder and Subtractor – Op Amp | | | |
| 10 | Analog Computer Setup – Solving Simultaneous Equations | | | |
| 11 | Design of UJT Relaxation Oscillator | | | |
| 12 | CRO-Differentiating, Integrating, Clipping and Clamping Circuits, Square Wave Testing | | | |
| 13 | Source Follower | | | |
| 14 | SCR – Characteristics and an application | | | |
| 15 | A.C. Amplifier - Inverting, Non-Inverting, Voltage Follower using Op Amp | | | |
| 16 | Function generator using IC 8038 | | | |
| 17 | Measurement of Hall Coefficient of Semiconductor -Estimation of Charge Carrier Concentration | | | |
| 18 | Digital IC’s - Counters, shift register (7476) | | | |
| 19 | Schmitt Trigger using discrete components and OP AMP/Timer 555 | | | |
| **MATLAB Programming** | | | | |
| 20 | Matlab Programming - Charging of Capacitor in an RC Circuit with three Time Constants | | | |
| 21 | Matlab Programming – Full Wave Rectifier – Determination (a) Peak – to – Peak Value of Ripple Voltage, (b) DC Output Voltage (c) Discharge Time of the Capacitor (d) Period of  Ripple Voltage | | | |
| 22 | Matlab Programming-Plot of Voltage and Current of RLC Circuit Under Steady State Conditions | | | |
| 23 | Matlab Programming- NPN Transistor - Plotting Input & Output Characteristics | | | |
| 24 | Matlab Programming - Frequency Response of a Low Pass Op-Amp Filter Circuit | | | |



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| 25 | Matlab Programming–Diode-Forward Characteristics Plot & Load Line Plot-Estimation of  Operating Point |



Third Semester



**THIRD SEMESTER**

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| **Course code** | | **QUANTUM MECHANICS II** | **Core Paper VIII** |
| **Pre-requisite** | | Students should have basic understanding in  quantum mechanics I |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. understand basics of scatteringtheory 2. learn theory of radiation and densitymatrix 3. apply approximationmethods | | | |
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| **Expected Course Outcomes:** | | | |
| On successful completion of the course, the students will be able to : | | | |
| understand the mathematical foundation of quantum mechanics | | | | |
| apply Schrodinger equations to exactly solvable simple problems using approximation  methods | | | | |
| learn relativistic effects in quantum mechanics and quantum field theory | | | | |
| compute corrections in energy and wavefunctions using approximation technique | | | | |
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| **Unit I** | **Scattering Theory** | | |
| Scattering Amplitude - Expression in terms of Green’s Function - Born Approximation and its Validity -  Partial Wave Analysis - Phase Shifts - Scattering by Coulomb and Yukawa Potential | | | |
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| **Unit II** | **Application to Atomic Structure** | | |
| Identical Particles – constructing symmetric and antisymmetric functions - latter determinant – Pauli’s Exclusion principle - Central Field Approximation - Thomas Fermi Model - Hartree’s Self Consistent  Model - HartreeFock Equation - Alkali Atoms - Doublet Separation - Intensities | | | |
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| **Unit III** | **Relativistic Wave Equation** | | |
| Klein Gordon Equation - Plane Wave Equation - Charge and Current Density - Application to the study of Hydrogen Like Atoms - Dirac Relativistic Equation for a Free Particle - Dirac Matrices - Dirac  Equation in Electromagnetic Field - Negative Energy States | | | |
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| **Unit IV** | **Theory of Radiation (Semi Classical Treatment)** | | |
| Einstein’s Coefficients - Spontaneous and Induced Emission of Radiation from Semi Classical Theory - Radiation Field as an Assembly of Oscillators - Interaction with Atoms - Emission and Absorption  Rates - Density Matrix and its Applications | | | |
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| **Unit V** | **Introduction to Quantum Field Theory** | | |
| Elements of Quantum Field Theory – Review of Classical Field Theory – Lagrangian and Hamiltonian Formalism – Classical Fields – Quantization of the Fields – Schrodinger Fields – Quantization – Quantization into Bosons – Quantization into Fermions – Relativistic Fields - Scalar Fields – One Component Real Field – Fourier Decomposition – Quantization of Scalar Fields – Ground State and  Normal Ordering – Basic Idea of Dirac Fields (no derivation – only qualitative discussion) | | | |

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| **Text Book(s)** | |
| 1 | Quantum Mechanics – NouredineZettili, John Wiley & Sons, Ltd, 2nd Edition, 2009 |
| 2 | Relativistic Quantum Mechanics and Quantum field Theory - V. Devanathan – Alpha Science International Ltd., Oxford, UK |
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| **Reference Books** | |
| 1 | Quantum Mechanics – G. Aruldhas, PHI Learning Private Limited, 2nd Edition, 2009 |
| 2 | Quantum Mechanics - L.I. Schiff - McGraw Hill, 3rd Edition, 1968 |



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| **Course code** | | **CLASSICAL ELECTRODYNAMICS** | **Core Paper IX** |
| **Pre-requisite** | | Students should have basic understanding in  mathematical physics, classical mechanics and tensor notation |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. calculate electric field and electric potential for a given configuration of charges in free space andmatter 2. understand magnetic properties of materials 3. optical properties like reflection, refraction, interference, diffraction and polarizationof electromagnetic waves 4. learn basics of electromagnetic radiations and relativistic kinematics anddynamics | | | |
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| **Expected Course Outcomes:** | | | |
| On successful completion of the course, the students will be able to : | | | |
| familarize mathematical concepts and boundary conditions used in classical electrodynamics | | | | |
| analyze transmission of electromagnetic waves through wave guide | | | | |
| apply maxwell’s equations to material medium and analyse its electrical and  magnetic properties | | | | |
| derive formulas to experimentally measurable quantities (like electric and  magnetic susceptibility) | | | | |
| evaluate electric, magetic fields, electric potential and vector potentials for  point charge and radiation emitted by moving charges | | | | |
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| **Unit I** | **Electromagnetic Thoery** | | |
| Coulomb’s law and Gauss’s law – Laplace and Poisson Equations – Energy in Electrostatics - Boundary Value Problems - Laplace Equations in One and Three Dimensions – Uniqueness Theorem and Boundary Conditions – Method of Images and Multi pole Expansion | | | |
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| **Unit II** | **Electric Fields in Macroscopic Media** | | |
| Dipole – Concept of Induced Dipole – Alignment of Polar Molecules - Polarization – The Fields of a Polarized Object – Bound Charges – Field inside a Dielectric - The Electric Displacement – Gauss’s Law in the Presence of Dielectrics – Linear Dielectrics – Susceptibility, Permittivity and Dielectric Constant – Boundary Value Problems in Linear Dielectrics – Energy in Dielectric Systems – Forces  on Dielectrics | | | |
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| **Unit III** | | **Magnetostics and Magnetic Fields in Matter** |
| The Lorentz Force Law – The BiotSavart Law – Applications - The Divergence and Curl of B – Ampere’s Law – Applications - Magnetic Vector Potential - Magnetostatic Boundary Conditions – Multiplole Expansion of the Vector Potential – Magnetic Fields in Matter – Magnetisation – Concept of Bound Current – Magnetic Field inside a Matter – The Auxiliary Field H – Linear and Non Linear Media - Magnetic Susceptibility and Permeability | | |
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| **Unit IV** | | **Electrodynamics** |
| Equation of Continuity – Displacement Current – Maxwell’s Equations – Poynting Vector withproof  – Momentum in Electro Magnetic Field – Maxwell’s equation in free space, Dielectric and Condutors – Reflection and Refraction, Polarization, Fresnel’s Law, Interference, Coherence and Diffraction – Dispersion Relation in Plasma – Scalar and Vector Potential - Gauge Transformation – Coulomb Gauge and Lorentz Gauge – Transmission Lines and Guided waves – TE waves in a  Rectangular Wave Guide | | |
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| **Unit V** | | **Radiation and Relativitistic Electrodynamics** |
| Continuous Charge Distribution – Retarded Potentials and Advanced Potentials – Jefimenko’s Equations – LienardWiechert Potentials - Radiation – Electric Dipole Raditions – Magnetic Dipole Radiations – Power Radiated by Point Charge – Abraham – Lorentz Formula Lorentz Invariance of Maxwells Equations - Four Vector – Four Velocity – Relativisitc Energy and Momentum – Relativistic Kinematics – Relativistic Dynamics – The Field Tensor – Electrodynamics in Tensor Notation –  Relativistic Potentials (Scalar and Vector Potentials) | | |
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| **Text Book(s)** | | |
| 1 | Introduction to Electrodynamics – David J. Griffiths, Pearson, 4th Edition, 2012 | |
| 2 | Classical Electromagnetism – Jerrold Franklin, Dover Publications, Inc.,2nd Edition, 2017 | |
| 3 | Basics of Electromagnetism – I. E. Irodov, CBS Publishers & Distributors, 2001 | |
| **Reference Books** | | |
| 1 | Classical Electrodynamics – J. D. Jackson, Wiley Eastern, 3rd Edition, 2004 | |
| 2 | Classical Electrodynamics – W. Greiner, Spring Verlag New York, Inc. , 1998 | |
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| **Course code** | | **STATISTICAL MECHANICS** | **Core Paper X** |
| **Pre-requisite** | | Students should have basic understanding in classical and quantum mechanics |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. understand basics of probability, statistics and distributionfunctions 2. know about classical and quantumstatistics 3. compute probability distributions for MB, BE and FDstatistics 4. learn phase transition and familarise basics of non-equilibrium statisticalmechanics | | | |
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| **Expected Course Outcomes:** | | | |
| On successful completion of the course, the students will be able to : | | | |
| familarise basic mathematical tools like probability, statistics and approximation technique | | | | |
| understand ensemble, connection between microstate and macrostates | | | | |
| understand other branches in physics better | | | | |
| calculate partition function and compute thermodynamics relations | | | | |
| apply to multi disciplinary areas | | | | |
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| **Unit I** | **Mathematical Foundations to Statistical Mechanics** | | |
| Random Variables - Probability – Probability and Frequency Probability of an Ensemble – Basic Rules of Probability Theory – Mean Values of Discrete and Continuous Random Variables – Sterling’s Approximation. Variance Dispersion – Probability Distribution – Binomial – Poisson – Mean and  Fluctuations – Gaussian Distribution – Standard Deviation – Central Limit Theorem. | | | |
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| **Unit II** | **Review of Thermodynamics, Classical Statistics** | | |
| Review of Classical Thermodynamics – Zeroth Law, First Law, Second Law and Third Law and Its Consequences - Thermodynamics Potentials – Maxwell’s Relations – Equipartition Theorem (without Proof) – DulongPetit’s Law - Microstates – Macrostates - Phase Space – Density Distribution in Phase  Space - Liouville’s Theorem, Proof and its Consequences – Statistical Equilibrium - Postulates of Statistical | | | |



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| Mechanics - Classical Statistics - Maxwell Boltzmann Distribution – Maxwell Distribution of Speeds –  Root Mean Square Speed – Average Spead – Most Probable Speed. | | |
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| **Unit III** | | **Stationary Ensembles and Density Matrix** |
| Ensemble and Classification - Micro Canonical Ensemble – Density of States – Application - Classical Ideal Gas - Two Level System – Concept of Negative Temperature - Canonical Ensemble – Derivation of Gibbs Canonical Distribution - Partition Function – Mean and Fluctuations - Applications – Classical Ideal Gas - – Discussion of Gibb’s Paradox and SakkurTetrode Equation - Classical Harmonic Oscillator – Rigid Rotator - Statistics of Paramagnetism - Curie Law - Quantum Systems – State – Pure and MixedState  – Density Matrix – Entropy – Boltzmann Gibbs Entropy – Information Theory – Shannon Entropy–  Introduction to Classical and Quantum Information Theory (Qualitatively). | | |
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| **Unit IV** | | **Quantum Statistics** |
| Quantum Statistics – Bose – Einstein Distribution – Fermi Dirac Distribution – Comparision – Wavefunctions Exchange and Symmetry - Applications – Black Body Radiation and Planck Distribution Law – Einstein Theory of Solids – Debye Theory of Solids – Quantum Mechanical Paramagnetic  Susceptibility - Energy and Pressure of Ideal Bose Einstein Gas - Energy and Pressure of Ideal Fermi Dirac Gas – Free Electron Model and Electronic Emission – Bose Einstein Condensation. | | |
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| **Unit V** | | **Phase Transition and Basics of Nonequilibrium Statistical Mechanics** |
| Phase Equilibria – Equilibrium Conditions – Classification of Phase Transition – Phase Diagram – ClausiusClaperon Equation – Van der Waal’s Equation – Second Order Phase Transitions – Ginzburg Landau Theory–PhaseTransitioninFerromagneticMaterials–LiquidHelium-OnsagarRelations–Fluctuations  – Energy, Pressure and Enthalpy – IsingModel – One Dimension – Bragg William Approximation – Effusion - Diffusion – Random walk and Brownian Motion – Qualitative Discussion of Principleof  Detailed Balance, Focker Planck’s Equation and Boltzmann’s H Theorem (without proof). | | |
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| **Text Book(s)** | | |
| 1 | Fundamentals of Statistical Mechanics – B. B. Laud, New Age International Publishers, 2nd Edition, 2018. | |
| 2 | Introduction to Statistical Physics – Kerson Huang, CRC Press, 2nd Edition, 2010. | |
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| **Reference Books** | | |
| 1 | An introductory course of Statistical Mechanics – P. B. Pal, Narosa Publishing House, 2008. | |
| 2 | Statistical Mechanics - R. K. Pathria, Elsevier, 2nd Edition, 2005. | |

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| **Course code** | | **CONDENSED MATTER PHYSICS** | **Core Paper XI** |
| **Pre-requisite** | | Students should have basic knowledge in band theory and electronic configuration |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. gain an understanding of the interplay between classical and quantum mechanicalphenomena 2. understand microscopic/atomic processes acting between many atoms/molecules that producesthe typical properties of different solid-statematter | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| to know the continuance in condensed matter physics in some central areas | | | | |
| provide the basic knowledge and also give an overview of current problems within the field of condensed matter/materials science mainly on functional materials | | | | |
| learn about phenomenon of magnetism | | | | |
| predict magnetic properties of atoms and molecules based on their electronic configurations | | | | |
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| **Unit I** | **Crystal Structure** | | |
| Crystal classes and system - 2D, 3D lattices - Bravais lattices – Point groups – Space groups – Reciprocal  lattice – Ewald’s sphere construction – Braggs law – Atomic scattering factor - Diffraction – Structure factor | | | |



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| – Experimental techniques – Laue, Powder, Rotation methods - Bonding of common crystal structures –  NaCl, CsCI, ZnS and Diamond – Packing density – hcp, ccp,- random stacking and polytypism | | | |
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| **Unit II** | | **Lattice Vibrations and Thermal Properties** |  |
| Vibration of monoatomic lattices – Lattices with two atoms per primitive cell – Quantization of lattice vibrations – Phonon momentum – Inelastic scattering of neutrons by phonons – Lattice heat capacity –  Einstein model – Density of modes in one-dimension and three- dimension – Debye model of the lattice heat capacity – Thermal conductivity – Umklapp process | | | |
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| **Unit III** | | **Free Electron Theory, Energy Bands and Semiconductor Crystals** | |
| Energy levels and density of orbitals – Fermi-Dirac distribution – Free electron gas in three-dimensions – Heat capacity of the electron gas – Electrical conductivity and Ohms law – Motion in magneticfields  – Hall effect – Thermal conductivity of metals – Nearly free electron model – Electron in a periodic  potential – Semiconductors – Band gap – Effective mass – Intrinsic carrier concentration | | | |
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| **Unit IV** | | **Diamagnetism, Paramagnetism, Ferromagnetism and Antiferromagnetism** | |
| Langevin classical theory of Diamagnetism and paramagnetism – Weiss theory – Quantum theory of paramagnetism – Demagnetization of a paramagnetic salt – Paramagnetic susceptibility of conduction electrons – Hund’srules – Ferromagnetic order – Curie point and the exchange integral – Temperature dependence of saturation magnetization – Magnons – Antiferromagnetic order –  Ferromagnetic domains – Origin of domains – Coercive force and hysteresis | | | |
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| **Unit V** | | **Dielectrics, Ferroelectrics and Superconductivity** | |
| Macroscopic electric field – Local electric field at an atom – Dielectric constant andpolarizability  – ClausiusMossotti equation – Polarization catastrophe – Ferroelectric domains– Occurrence of Superconductivity – Meissner effect – London equation – Coherence length –BCS theory – Flux  quantization – Type I and Type II Superconductors – Josephson superconductor tunneling – DC and AC Josephson effect – SQUID – Applications ofsuperconductors | | | |
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| **Text Book(s)** | | | |
| 1 | C. Kittel, Introduction to Solid State Physics, 5th Ed. (Wiley Eastern, New Delhi,1977) | | |
| 2 | N. W. Ashcrof and N. D. Mermin, Solid State Physics (International Edition, Philadelphia, 1976) | | |
| 3 | J. S. Blakemore, Solid State Physics, Second Edition (Cambridge University Press, Cambridge, London, 1974) | | |
| 4 | A. J. Dekker, Solid State Physics (Mac Millan, Madras, 1971) | | |
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| **Reference Books** | | | |
| 1 | M. M.Woolfson, An Introduction to X-ray Crystallography (CambridgeUniversity  Press, Cambridge, 1991) | | |

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| 2 | T. P. Sheahen, Introduction to High-Temperature Superconductors (Plenum press, New York, 1994) |



Fourth Semester



### FOURTH SEMESTER

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| **Course code** | | **NUCLEAR& PARTICLE PHYSICS** | **Core Paper XII** |
| **Pre-requisite** | | The students should have basic knowledge in nuclear structure, nuclear models and different elementary particles. |
| **Course Objectives:** | | | |
| 1. To impart higher level knowledge and understanding of nuclear physics and technology. 2. Enhance student ability to develop mathematical models of defined physicalsystems. 3. Enable students to analyse mathematical models of physical systems for enhancement ofsystem performance and arrive at limitations of physicalsystems. 4. To respond the global energy and environmental needs andobjectives | | | |
| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, students | | | |
| will have a versatile and solid background in fundamental physics and its application. | | | |
| Have the capability of doing back-of the envelope calculations in a diversity of situations | | | |
| Can apply the theory of nuclear physics for newer applications | | | |
| Can promote the exchange of ideas and research within the nuclear/atomic science community | | | |
| Gain skills to pursue physics as a teaching and research career | | | |
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| **UNIT I** | **NUCLEAR STRUCTURE** | | |
| Distribution of Nuclear Charge-Nuclear Mass-Mass Spectroscopy-Mass Spectrometer- Theories of Nuclear Composition (proton-electron, proton-neutron)- Bound States of Two Nucleons-Spin States- Pauli’s Exclusion Principle-Tensor Force-Static Force- Exchange Force. | | | |
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| **UNIT II** | **RADIOACTIVITY** | | |
| **Alpha Decay:** Properties of α Particles-Gamow’s Theory of α Decay-Geiger Nuttal Law- α Ray Energies-Fine Structure of α Rays- α Disintegration Energy-Long Range α Particles. **Beta Decay:** Properties of β Particles-General Features of β Ray Spectrum- Pauli‘s Hypothesis- Fermi’s Theory of β Decay – Forms of Interactions and Selection Rules. **Gamma Decay:** Absorption of γ Rays by Matter-Interaction of γ Rays with Matter- Measurement of γ Ray Energies-InternalConversion | | | |
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| **UNIT III** | **NUCLEAR MODELS** | | |
| **Liquid Drop Model:** Bohr Wheeler Theory of Fission-Condition for Spontaneous Fission-  ActivationEnergy.**ShellModel:**ExplanationofMagicNumbers-PredictionofShellModel- | | | |



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| Prediction of Nuclear Spin and Parity-Nuclear Statistics-Magnetic Moment of Nuclei-Nuclear Isomerism.  **Collective Model:** Explanation of Quadrupole Moments | | |
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| **UNIT IV** | | **NUCLEAR REACTIONS** |
| Kinds of Reactions and Conservation Laws-Energy of Nuclear Reaction-Iso Spin- Continuum Theory of Nuclear Reaction-Resonance-Breit and Wigner Dispersion Formula - Stages of a Nuclear Reaction- Statistical Theory of Nuclear Reaction-Kinematics of Stripping and Pickup Reaction. | | |
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| **UNIT V** | | **PARTICLE PHYSICS** |
| Leptons-Hadrons-Mesons-Hyperons – P ions - Mesons, Resonances- Strange Mesons and Baryons-Gell-Mann Okuba Mass formula for Baryons - CP Violation in Neutral Kaon (K0) Decay- Symmetry and Conversion Laws-Quark Model-Reaction and Decays. | | |
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| **Text Book(s) for Study** | | |
| 1 | Nuclear and Particle Physics-Pandya and Yadav | |
| 2 | Nuclear Physics-J.C. Tayal -UmeshPrakashan- Gujarat | |
|  | | |
| **Text Book(s) for Reference** | | |
| 1 | Nuclear Physics- D.C. Sharma-K. Nath& Co-Meerut1600 | |
| 2 | Concepts of Nuclear Physics-Bernard L. Cohen-Tata McGraw Hill- New Delhi 1600,1978 | |
| 3 | Introductory Nuclear Physics-Kenneth S. Krane-John Wiley & Sons | |
| 4 | Physics of Nucleus and Particles-Volume I& II-B. Nermeir& Sheldon | |



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| **Course code** | | **COMMUNICATION ELECTRONICS** | **Core Paper XIII** | |
| **Pre-requisite** | | Students should have adequate knowledge in electromagnetic radiation |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. Understand basic concepts of communication and optical communicationsystem 2. Identify different types of modulation and multiplexingformats 3. Compute a simple optical powerbudget | | | | |
|  | | | | |
| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| become effective communicators and critical consumers of messages preparing them for life. | | | |
| integrate the strengths of the liberal arts tradition with the theoretical foundation to enter in the research. | | | |
| gain knowledge in microwave analysis and design techniques | | | |
| apply knowledge of mathematics, science and engineering fundamentals to the solution of complex engineering problems in electronic circuits and communication system | | | |
| Familiar with design consideration of fiber optics system. | | | |
|  | | | | |
| **Unit:1** | **Antennas & Wave Propagation** | | | |
| Terms and Definition - Effect of Ground on Antennas - Grounded /4 - Ungrounded antenna Antenna- Antenna Arrays-Broadside and End Side Arrays-Antenna Gain- Directional High Frequency Antennas - Sky Wave Propagation - Ionosphere- Eccles&Larmor Theory-Magneto Ionic Theory-Ground Wave  Propagation | | | | |
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| **Unit:2** | **Microwaves** | | | |
| Microwave Generation - Multi cavity Klystron-Reflex Klystron – Magnetron - Travelling Wave Tubes (TWT) and other Microwave Tubes – MASER - Gunn Diode | | | | |
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| **Unit:3** | **Radar and Television** | | | |
| Elements of a Radar System-Radar Equation-Radar Performance Factors-Radar Transmitting Systems- Radar Antennas-Duplexers-Radar Receivers and Indicators - Pulsed Systems-Other Radar Systems-  Colour TV Transmission and Reception | | | | |
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| **Unit:4** | **Communication Electronics** | | | |



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| Analog and Digital Signals - Modulation - Types of Modulation- Amplitude modulation theory - Frequency spectrum of the AM wave - Representation of AM - Power relations in the AM wave - GenerationofAM-Basicrequirements-Descriptionoffrequencyandphasemodulation-Mathematical  representation of FM – Frequency spectrum of FM wave | | | |
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| **Unit:5** | | **Optical Fibres** | |
| Propagation of Light in an Optical Fibre - Acceptance Angle-Numerical Aperture- Step and graded Index  Fibres-Optical Fibre as a Cylindrical Wave Guide-Fibre Losses and Dispersion-applications. | | | |
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| **Unit:6** | | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars - webinars | | | |
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|  | | **Total Lecture hours** | **60 hours** |
| **Text Book(s)** | | | |
| 1 | Electronic Communication System-George Kennedy & Davis -Tata McGraw Hill 4th  edition1989 | | |
| 2 | Optical fibre and fibre optic communication systems- S K Sarkar - S.Chand Pub-2007  edition | | |
| 3 | Electronics Devices and circuits– Sanjeev Gupta &Santhosh Gupta, DhanpatRai  Publications. | | |
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| **Reference Books** | | | |
| 1 | Principles of Communication Systems-Taub Schilling-TMH 1986 | | |
| 2 | Communication Systems-Simon Haykin-John Wiley & Sons 2005 | | |



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| **Course code** | | **LASER PHYSICS AND NONLINEAR OPTICS** | **Core Paper XIV** |
| **Pre-requisite** | | Students should have fundamentals of mathematical  formulations, wave theory and operation of laser |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. familiar with basics of nonlinear optics and interaction of electromagnetic waves with matterparticle 2. understand the mechanism of laser radiation and its propagation in differentmedia 3. get insight into the crystalline property modifications by electromagneticinteraction 4. aware the role of laser in industrial and researchactivities | | | |
|  | | | |
| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| familiar with the properties of different types of laser and its operation | | | | |
| understand the process of optical amplification and gain saturation | | | | |
| apply the theoretical concepts of laser optics for industrial purposes | | | | |
| differentiate the efficiency of continuous and pulsed laser mechanism | | | | |
| explore the significance of non linear optical phenomena and its applications | | | | |
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| **Unit I** | **Lasers - Fundamentals and Types** | | |
| Basic Construction and Principle of Lasing - Einstein Relations and Gain Coefficient - Creation of a Population Inversion - Three Level System – Four Level System - Threshold Gain Coefficient for  Lasing - Laser types – He Ne Laser - CO2 Laser - Nd:YAG Laser - Semiconductor Laser | | | |
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| **Unit II** | **Laser Operation** | | |
| Optical Resonator - Laser Modes - Axial modes - Transverse modes - Modification in Basic Laser  Structure - Basic Principle of Mode Locking - Active Mode Locking - Passive Mode Locking – Q Switching - Pulse Shaping | | | |
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| **Unit III** | **Laser Beam Characteristics** | | |
| Wavelength - Coherence - Mode and Beam Diameter - Polarizations - Introduction to Gaussian Beam width - Divergence - Radius of Curvature - Rayleigh Range - Guoy Phase Shift - 3DGaussian | | | |



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| Beams – ABCD Law for Gaussian Beam - Complex Radius of Curvature - Tensorial ABCD Law | | |
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| **Unit IV** | | **Focusing of Laser Beam** |
| Diffraction - Limited spot size - M2 Concept of Beam Quality - Spherical Aberration- Thermal Lensing Effects - Depth of Focus - Tight focusing of laser beam - Angular Spectrum Representation of Optical Near Field – Aplanatic lens - Focusing of Higher order laser modes - Radially Polarized Doughnut mode -  Azimuthally Polarized Doughnut mode | | |
|  | | |
| **Unit V** | | **Non-Linear Optics** |
| Introduction - Nonlinear Optical Media - The Nonlinear Wave Equation - Scattering Theory - Born Approximation – Second Order Nonlinear Optics – Second Harmonic Generation (SHG) andRectification  -TheElectroOpticEffect–ThreeWaveMixing-FrequencyandPhaseMatching-ThirdHarmonic  Generation - Optical Kerr Effect – Self Focusing – Four Wave Mixing (FWM) - Optical Phase Conjugation (OPC) - Use of Phase Conjugators in Wave Restoration | | |
|  | | |
| **Text Book(s)** | | |
| 1 | Nonlinear Optics - D.L. Mills - Basic Concepts, Springer, Berlin, 1998 | |
| 2 | Lasers and Nonlinear Optics - B.B. Laud – 2nd Edition New Age International (P) Ltd. | |
|  | | |
| **Reference Books** | | |
| 1 | Laser Material Processing - M. Steen, J. Mazumder – Springer (2010) | |
| 2 | Fundamentals of Photonics - Bahaa E. A. Saleh, Malvin Carl Teich - John Wiley & Sons, Inc. | |
| 3 | Solid State Laser Engineering - Walter Koechner, 6th Edition, Springer | |



### SEMESTER III & IV

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| **Course code** | | **PRACTICAL III - ADVANCED PRACTICALS**  **(**Examination at the end of Fourth Semester**)** | **Core Practical** | |
| Students should have the fundamental knowledge of Optics, Electricity, Magnetism and Programming skills |
| **Pre-requisite** | |
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| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| Explore the concepts involved in optics | | | |
| Gain knowledge of new conception in practical oriented problems and visualize  the experiments through MATLAB programming. | | | |
| acquire strong laboratory skills | | | |
| Enhance the day to day requirements in industries, research fields. | | | |
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| S.  No. | **LIST OF EXPERIMENTS**  (Any twelve experiments) | | | |
| 1 | Arc Spectra-Constant Deviation Spectrograph-Copper, Iron& Brass | | | |
| 2 | Michelson Interferometer- , d and Thickness of Mica Sheet | | | |
| 3 | Susceptibility-Guoy and Quincke’sMethod | | | |
| 4 | Compressibility of a Liquid-Ultrasonic Method | | | |
| 5 | Hall Effect and its application | | | |
| 6 | e/m-Zeeman Effect | | | |
| 7 | e/m-Magnetron Method | | | |
| 8 | B-H Curve-Anchor Ring | | | |
| 9 | B-H Curve-Solenoid | | | |
| 10 | Double Slit-Wavelength Determination | | | |
| 11 | G.M Counter-Characteristics | | | |
| 12 | Kelvin’s Double Bridge-Determination of Very Low Resistance & Temperature Coefficient of Resistance. | | | |
| 13 | He-Ne Laser determination of particle size. | | | |
| 14 | Conductance of photoconductor, photovoltaic cell (solar cell) and photodiode | | | |
| **MATLAB Programming** | | | | |
| 15 | Matlab Programming-Radioactive Decay | | | |
| 16 | Matlab Programming-Numerical Integration | | | |
| 17 | Matlab Programming-Double Integration | | | |
| 18 | Matlab Programming-Solution of Ordinary Differential Equations – 2ndOrder | | | |
| 19 | Matlab Programming-Computer Simulation of Equations of Motion for a System of Particles | | | |
| 20 | Matlab Programming-Computer Simulation of 1-D and 2-D LatticeVibrations | | | |
| 21 | Matlab Programming-Computer Simulation of Kronig-Penney Model | | | |
| 22 | Matlab Programming-Numerical simulation of Wave-Functions of Simple Harmonic | | | |



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|  | Oscillator |
| 23 | Matlab Programming-Simulation of Wave Functions for a Particle in Critical Box |
| 24 | Matlab Programming-Solution of Diffusion Equation |

**SEMESTER I & II**

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| **Course code** | | **PRACTICAL IV – SPECIAL ELECTRONICS**  **(**Examination at the end of Second Semester**)** | **Core Practical** | |
| Students should have the fundamental knowledge in Op-amp and Microprocessor |
| **Pre-requisite** | |
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| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| Acquire knowledge on op amps characteristics and Microprocessor | | | |
| Apply circuit systems to construct electronic devices | | | |
| produce electronic professionals to work as Electronic circuit Designer | | | |
| Enhance the day to day requirements in industries, research fields. | | | |
|  |  | | | |
| S.  No. | **LIST OF EXPERIMENTS**  (Any twelve experiments) | | | |
| 1 | Op-Amp: Simultaneous Addition &Subtraction | | | |
| 2 | Op-Amp: Instrumentation Amplifier-Temperature Measurement | | | |
| 3 | Op-Amp: Instrumentation Amplifier-Light Intensity-Inverse Square Law | | | |
| 4 | Op-Amp: V to I & I to V Converter | | | |
| 5 | Op-Amp: Circuits Using Diodes-Half Wave, Full Wave, Peak Value, Clipper, Clamper | | | |
| 6 | Op-Amp: Log and Antilog Amplifier | | | |
| 7 | Op-Amp: Analog Computation-Second Order Differential Equation | | | |
| 8 | Op-Amp Comparator-Zero Crossing Detector, Window Detector, Time Marker | | | |
| 9 | IC 555 Timer Application-Monostable, Linear Astable 10.A/D Converters-Any One Method | | | |
| 10 | Converters-Binary Weighted & Ladder Methods | | | |
| 11 | IC Counters with Feedback | | | |
| 12 | Microprocessor: LED Interfacing Name Display (rolling) | | | |
| 13 | Microprocessor: Stepper Motor Interfacing | | | |
| 14 | Microprocessor: Traffic Control Simulation | | | |
| 15 | Microprocessor: ADC Interface-Wave Form Generation | | | |
| 16 | Microprocessor: Hex Keyboard Interfacing | | | |
| 17 | Microprocessor: Musical Tone Generator Interface | | | |
| 18 | Microcontroller: Blinking of LEDs either 8051 or 16F84 20 Microcontroller: Controlling LED with switch | | | |
| 19 | Microcontroller: DC motor control | | | |
| 20 | Microcontroller: triangle wave generator | | | |





Elective Course



**ELECTIVE - I**

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| **Course code** | | **ROBOTICS, ARTIFICIAL INTELLIGENCE AND INFORMATION THEORY** |  |
| **Pre-requisite** | |
| Students should have basic understanding in basic physics, mathematical physics and computer knowledge |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. understand basics ofrobotics 2. introduce basics of artificialintelligence 3. learn fundamentals of python programming, cyber security and ethicalhacking 4. facilitate students to learn and apply ArdunioIDE and introduce basics of informationtheory | | | |
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| **Expected Course Outcomes:** | | | |
| On successful completion of the course, the students will be able to : | | | |
| understand basics of robotics and robotic sensors | | | | |
| learn fundamentals of artificial intelligence | | | | |
| develop an idea to write programme using python, basics of cyber security and  hacking | | | | |
| learn and impliment interfacing between experiments and Ardunio IDE | | | | |
| familiarize basics of classical and quantum computers | | | | |
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| **Unit I** | **Basics of Robotics** | | |
| Robot – Definition of Robot – Industrial Robot – Laws of Robotics – Motivating Factors – Advantages and Disadvantages of Robots – Characteristics of an Industrial Robot – Components of an Industrial Robot – Comparison of the Human and Robot Manipulator – Robot Wrist and End of Arm Tools – Robot Terminology – Robotic Joints – Classification of Robots – Robot Classification on the Basis ofCoordinate System, Power Source and Method of Control - Robot Selection – Robot Workcell – Robotics and MachineVision–RoboticAccidents,Safety,MaintenanceandInstallation–RoboticSensors–Typesof  Sensors in Robots – Exteroceptors – Tactile Sensors – Proximity Sensors – Range Sensors – Machine Vision Sensors – Velocity Sensors – Proprioceptors | | | |
|  | | | |
| **Unit II** | **Artificial Intelligence** | | |
| Introduction to Artificial Intelligence (AI) – Need for AI – Applications domains of AI – tools – Challenges and Future of AI – Fundamentals of Machine Learning and Deep Learning – Machine Learning algorithms to find associations across Biological Data, Cellular Image Classification and Identification of Genetic Variations – AI in Bio Physics Research – AI in drug Design – AI in next  generation Sequencing – AI in Protein Structure – AI in Protein Folding Analysis | | | |
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| **Unit III** | **Basics of Python Programming, Cyber Security and Ethical Hacking** | | |
| Introduction – Python – Data Types – Variables and Operators – Conditions and Loops – Structure of a Python Program– Packages and Function – Writing Simple Python Codes – Cyber Security - Security Environment – Threats – Cyber Crime – Vulnerabilities in Software – Open Access Data – Open Source Software – Ethical Hacking – Hacker and Cracker – Computer Fraud – Malware Threats – Viruses and Worms – Trojans – Spyware – Malware Counter Measures – Ethical and Legality | | | |
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| **Unit IV** | | **Programming Basics with C using Ardunio IDE, Sensors and Actuators** |
| Installing and Setting up the Arduino IDE – Basic Syntax – Data Types / Variables / Constant – Operators Conditional Statements and Loops – Using Arduino C Library Functions for Serial, Delay and Other Invoking Functions – Strings and Mathematics Library Functions – Basics of Analogy and DigitalSensors  –InterfacingTemperatureSensors,UltrasoundSensor,InfraredSensor,LEDandBuzzerwithArduino–  Introduction to ESP8266 NODEMCU Wifi Module – basic knowledge of Programming NODEMCU using ArduinoIDE | | |
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| **Unit V** | | **Information Theory** |
| Classical Information Theory – Classical Bits - Classical Computers – Classical Turing Machine – von Neumann Computer – Classical Logic Gates and Logic Circuits – Quantum Information Theory – Quantum Bits (Qbits) – Superposition Principle – Collapse of Wavefunction – EPR Paradox – Bell’s inequality with proof – Quantum Turning Machine – Quantum Gates - Basics of Quantum Teleportation  and Cryptography | | |
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| **Text Book(s)** | | |
| 1 | Industrial Automation and Robotics – A. K. Gupta, S. K. Arora and J. R. Westcott, Mercury Learning  and Information LLC, 2017 | |
| 2 | Arduino Cookbook – Michael Margolis, O’ Reilly Media, Inc., 2011 | |
| 3 | An Introduction to Python – Fred L. Drake and Guido Van Russom, Network Theory Limited | |
| 4 | Artificial Intelligence: A modern approach – Stuart Russell and Peter Norvig, Prentice Hall, 3rd  Edition, 2009 | |
|  |  | |
| **Reference Books** | | |
| 1 | Principles of Information Security – Michael E Whitman and Herbert J Mattord, Vikas Publishing House, 4th Edition, 2011 | |
| 2 | Ethical Hacking: A Beginners Guide to Learning the World of Ethical Hacking – LakshayEshan, Shockwave Publishing, 2018 | |
| 3 | Quantum Computation and Quantum Information – Michael A. Nielsen and Isaac L. Chuang, Cambridge University Press, 2000 | |



### ELECTIVE - I

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| **Course code** | | | **ELEMENTS OF NANOSCIENCE AND NANOTECHNOLOGY** |  | | | |
| **Pre-requisite** | | |
| The students should have basic understanding in materials |
| **Course Objectives:** | | | | | | | |
| The main objectives of this course are able   1. to learn about basic of nanoscience andtechnology 2. to acquire the knowledge about classification of nanomaterials 3. to learn about properties and characterization techniques ofnanomaterials. 4. to understand the various applications of nanomaterialsin differentfields. | | | | | | | |
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| **Expected Course Outcomes:** | | | | | | | |
| On the successful completion of the course, student will be able to: | | | | | | | |
| understand the fundamentals properties and different types of nanomaterials | | | | | | |
| learn quantum dots, wells and wires | | | | | | |
| study the morphological and size of the nanoparticles using various analytical techniques | | | | | | |
| tune the size and shape of the nanomaterials for diverse applications | | | | | | |
| synthesize nanomaterials using various physical, chemical and biological approaches | | | | | | |
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| **Unit I** | | **Overview of Nanoscience** | | | | | |
| Nano revolution of the 20th century - Properties at Nanoscale (optical, electronic and magnetic) Theory - definitions and scaling | | | | | | | |
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| **Unit II** | | **Different Classes of Nanomaterials** | | | | | |
| Metal and Semiconductor Nanomaterials - Quantum dots, Wells and Wires - Molecule to Bulk Transitions Bucky Balls and Carbon Nanotubes | | | | | | | |
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| **Unit III** | | **Synthesis of Nanomaterials** | | | | | |
| Top down (Nanolithography, CVD) – bottom up (sol gel processing, chemical synthesis) - Wet Deposition Techniques – Self assembly (Supramolecular approach) - Molecular Design and Modeling | | | | | | | |
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| **Unit IV** | | **Characterization** | | | | | |
| TEM, SEM and SPM Technique - Fluorescence Microscopy and Imaging | | | | |  | | |
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| **Unit V** | | **Applications** | | | | | |

Solar Energy Conversion and Catalysis - Molecular Electronics and Printed Electronics Nanoelectronics - Polymers with a special architecture - Liquid Crystalline Systems - Linear and Nonlinear Optical and Electro Optical properties - Applications in Displays and other devices - Advanced Organic Materials for Data Storage – Photonics – Plasmonics - Chemical and Biosensors - Nanomedicine and Nano Biotechnology



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| **Book(s) for Study** | |
| 1 | Nanocrystals: Synthesis, Properties and Applications - C.N.R. Rao, P.J. Thomas and G.U. Kulkarni, Springer  (2007) |
| 2 | Nanostructured Materials and Nanotechnology - Hari Singh Nalwa, Academic Press, 2002 |
|  | |
| **Book(s) for Reference** | |
| 1 | Nanocrystals: Synthesis, Properties and Applications, C.N.R. Rao, P.J. Thomas and G.U. Kulkarni, Springer (2007) |
| 2 | Nanoscience: Nanotechnologies and Nanophysics - C. Dupas, P. Houdy, M. Lahmani, Springer Verlag Berlin Heidelberg, 2007 |

### ELECTIVE - I

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| **Course code** | | **INTRODUCTORY ASTRONOMY, ASTROPHYSICS & COSMOLOGY** |  |
| **Pre-requisite** | |
| Students should have basic knowledge in general  relativity |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. Learn how the systematic method and quantitative influence are used inCosmology 2. Explicate large scale universe areevolved 3. Characterize light year, astronomical unit and transmit these to the size of theplanets | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Apply physical principles in a broad range to astronomical situations. | | | | |
| Be able to formulate scientific problems in mathematical terms and apply  analytical and numerical methods towards its solution. | | | | |
| Develop skills to design observing projects with research telescopes and projects  drawing upon data in the literature and in archives. | | | | |
| Establish competence in focused areas of astrophysical theory and experiment | | | | |
| Build up skills in cosmological models to analyze physical properties of universe. | | | | |
|  | | | |
| **Unit I** | **History of Astronomy** | | |
| Introductory History of Astronomy - Ptolemy’s Geocentric Universe – Copernicus Heliocentric Universe - Tycho Brahe and Galileo’s Observations - Kepler’s Laws of Planetary Motion - Newtonian Concept of Gravity - Highlights of Einstein’s Special and General Theory of Relativity - Curved Space Time - Evidence of Curved Space Time - Bending of Light - Time Dilation | | | |
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| **Unit II** | **Stars & Galaxies** | | |
| Stars and Galaxies – Distances - Trigonometric Parallax-Inverse Square Law- Magnitude ofStars–ApparentMagnitude-AbsoluteMagnitudeandLuminosity–ColorandTemperature-  Composition of Stars - Velocity, Mass and Sizes of Stars - Types of Stars - Temperature Dependence - Spectral Types - Hertzsprung-Russell (HR) Diagram - Spectroscopic Parallax | | | |
|  | | | |
| **Unit III** | **Lives and Death of Stars** | | |
| Stellar Evolution - Mass Dependence - Giant Molecular Cloud – Proto star-Main Sequence Star – Sub giant, Red Giant, Supergiant - Core Fusion - Red Giant (Or) Supergiant – Planetary Nebula (Or) Supernova - White Dwarfs - Novae And Supernovae- Neutron Stars – Pulsars - Black Holes - Detecting Black Holes-The Sun- Its Size and Composition- Sun’s InteriorZones  – Sun’s Surface -Photosphere- Chromospheres – Corona - Sun’s Power Source-Fusion Reaction Mechanism | | | |
|  | | | |
| **Unit IV** | **Cosmology - I** | | |
| IntroductiontoCosmology-BasicObservationsandimplications-OlbersParadox-Expanding  Universe - Gravitational Red shift - Doppler Effect - Hubble’s Law and the age of Universe - Cosmological Principle - The Perfect Cosmological Principle-Observation and interpretation | | | |

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| of Cosmic Microwave background Radiation (CMBR) - Evidence Supporting the General Big  Bang Theory - Salient features of steady state theory | | |
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| **Unit V** | | **Cosmology - II** |
| Fate of the Universe - Dependence on Mass (Curvature of Space) - Critical density – Open Universe - Closed Universe – Homogenous and Isotropic Freidman – Robertson - Walker Universes - Deriving the Geometry of the Universe from the Background Radiation – Flatness  Problem – Horizon Problem - Inflation and its effect on the universe - The Cosmological Constant | | |
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| **Text Book(s)** | | |
| 1 | The Life and Death of Stars, Kenneth R. Lang | |
| 2 | Physical Foundations of cosmology, ViatcheslavMukhanov. | |
|  | | |
| **Reference Books** | | |
| 1 | Lectures on Astronomy, Astrophysics, And Cosmology, Luis A.Anchordoqu | |
| 2 | Lecture Notes of Department of Physics, University of Wisconsin-Milwaukee | |
| 3 | Astrophysics of the Solar System, K.D.Abhayankar | |
| 4 | An Introduction to Planetary Physics, Kaula.W.M | |
| 5 | Astrophysics of the Sun,HaroldZirin. | |
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### ELECTIVE - II

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| **Course code** | | **PLASMA PHYSICS** |  |
| **Pre-requisite** | | Students should have basic knowledge in fundamentals of Plasma Physics |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. explore the plasma universe by means of in-situ and ground-basedobservations 2. understand the model plasma phenomena in theuniverse 3. explore the physical processes which occur in thespaceenvironment | | | |
|  | | | |
| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| calculate fundamental properties of a plasma given appropriate information | | | | |
| apply basic electromagnetism to derive the kinetic theory of plasmas | | | | |
| will able to distinguish single particle approach and fluid approach | | | | |
| apply concepts and analyze plasma diagnostics techniques | | | | |
| interpret geomagnetic field measurements in terms of currents flowing in Earth's ionosphere and magnetosphere | | | | |
|  | | | |
| **Unit I** | **Fundamental Concepts about Plasma** | | |
| Kinetic pressure in a partially ionized - mean free path and collision cross section- mobility of charged particles - Effect of magnetic field on the mobility of ions and electrons - Thermal conductivity - Effect of magnetic field - Quasi neutrality of plasma - Debye shielding distance -  Optical properties of plasma | | | |
|  | | | |
| **Unit II** | **Motion of Charged Particles in Electric and Magnetic Field** | | |
| Particle description of plasma – Motion of charged particle in electrostatic field- Motion of charged particle in uniform magnetic field - Motion of charged particle in electric and magnetic fields - Motion of charged particle in inhomogeneous magnetic field- Motion of charged particle in magnetic mirror confinement - motion of an electron in a time varying electric field - Magneto hydrodynamics – Magneto hydrodynamic equations - Condition for  magneto hydrodynamic behavior | | | |
|  | | | |
| **Unit III** | **Plasma Oscillations and Waves** | | |
| Introduction, theory of simple oscillations - electron oscillation in a plasma - Derivations of plasma oscillations by using Maxwell’s equation - Ion oscillation and waves in a magnetic field - thermal effects on plasma oscillations - Landau damping - Hydro magnetic waves - Oscillations in an electron beam | | | |
|  | | | |
| **Unit IV** | **Plasma Diagnostics Techniques** | | |
| Single probe method - Double probe method - Use of probe technique for measurement of plasma parameters in magnetic field - microwave method - spectroscopic method - laser as a tool for  plasma diagnostics – X ray diagnostics of plasma - acoustic method – conclusion | | | |
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| **Unit V** | | **Possible Applications of Plasma Physics** |
| Magneto hydrodynamic Generator - Basic theory - Principle of Working - Fuel in MHD Generator - Generation of Microwaves Utilizing High Density Plasma – Plasma Diode | | |
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| **Text Book(s)** | | |
| 1 | Plasma Physics - Plasma State of Matter - S.N. Sen, PragatiPrakashan, Meerut | |
| 2 | Principles of Plasma Diagnostics - I. H. Hutchinson | |
|  | | |
| **Reference Books** | | |
| 1 | Introduction to Plasma Physics - F.F.Chen, Plenum Press, London | |
| 2 | Introduction to Plasma Physics - M.Uman | |
| 3 | Plasma Diagnostic Techniques - R.H. Huddlestone& S.L. Leonard | |

### ELECTIVE - II

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| **Course code** | | **CRYSTAL GROWTH METHODS AND CHARACTERIZATION** |  |
| **Pre-requisite** | |
| The students should have basic understanding in Solid state physics |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. provide an extended knowledge on advanced condensed matter topic like crystal growthmethods 2. provide the necessary understanding on the theories involve in the nucleation and growthprocess 3. provide fundamental concepts behind the solution, melt and vapour growthtechniques 4. provide necessary knowledge on the functioning of various characterizationtools | | | |
|  | | | |
| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| understand the process of crystal nucleation and growth | | | | |
| know about various crystal growing techniques | | | | |
| understand the methodologies of solution and gel growth techniques | | | | |
| understand the concepts behind the melt and vapour growth techniques | | | | |
| know about different characterization techniques | | | | |
|  | | | |
| **Unit I** | **NUCLEATION THEORY** | | |
| Importance of crystal growth – Classification of crystal growth methods – Nucleation Theory  - Kindsofnucleation–Homogeneousnucleation-Heterogeneousnucleation-secondarynucleation-  Classical theory of nucleation: Gibbs Thomson equations for vapour and solution – Kinetic theory of nucleation – Energy of formation of a spherical nucleus and cylindrical nucleus. | | | |
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| **Unit II** | **SOLUTION GROWTH TECHNIQUES** | | |
| Growth from low temperature solutions - Selection of solvents and solubility – Meir’s solubility diagram – Saturation and Supersaturation – Metastable zone width – Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods - Gel Growth Technique - Principle – Various types – Structure of gel – Importance of gel – Experimental procedure – Chemical reaction method – Single and double diffusion method – Chemical reduction method – Complex and de complexion method – Advantagesofgelmethod-Growthfromhightemperaturesolutions-Fluxgrowth–Hydrothermalgrowth  method | | | |
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| **Unit III** | **MELT GROWTH TECHNIQUES** | | |
| Basics of melt growth - Bridgman method – Growth apparatus - Crucibles, Heater, Measurement and Control of Temperature – growth process – Applications ofBridgman method - Czochralski technique –  Growth apparatus – seed preparation – pulling rate – shape of crystal melt interface – Growth process | | | |
|  | | | |
| **Unit IV** | **VAPOUR GROWTH TECHNIQUES** | | |
| Physical Vapour Transport (PVT) – Processes of sublimation and condensation principle – crystal growth in closedandsemiopenampoules–ChemicalVapourTransport–Criteriaforthechoiceoftransportreaction  – Transported materials and transporting agents – Temperature variation method for crystal growth -  Stationary temperature profile - Linearly time varying temperature profile and Oscillatory temperature profile | | | |



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| **Unit V** | **CHARACTERIZATION TECHNIQUES** | |
| X Ray Diffraction (XRD) – Powder and single crystal – UV Visible - Fourier Transform Infrared (FT- IR) andRamanspectroscopicanalysis–TGDTA/DSCThermalAnalysis-VickersMicrohardness-Chemical  Etching | | |
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| **Text Book(s)** | | |
| 1 | | J. C. Brice, Crystal Growth Processes, John Wiley and Sons, New York, 1986. |
| 2 | | P. SanthanaRagavan and P. Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam, 2001. |
| 3 | | H.L. Bhat, Introduction to Crystal Growth Principles and Practice CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2015. |
|  | | |
| **Reference Books** | | |
| 1 | | GovindhanDhanaraj, KullaiahByrappa, Vishwanath Prasad, Michael Dudley(Eds.),  Hand book of Crystal Growth Springer Heidelberg Dordrecht London New York, 2010. |
| 2 | | B.R. Pamplin, Crystal Growth, Pergamon Press, Oxford, 1975. |
| 3 | | K. Sangwal, Elementary Crystal Growth (Edited), SAAN Publishers, Lublin, 1994. |
| 4 | | Sam Zhang, Lin Ki, Ashok Kumar, Materials Characterization Techniques, CRC Press, Taylor & Francis Group, Boca Raton, Florida, 2009. |

### ELECTIVE - II

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| **Course code** | | **ATMOSPHERIC PHYSICS** |  | |
| **Pre-requisite** | | Students should have basic knowledge in thermodynamics |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. familiarize microphysical principles and determine the structures of the atmosphere andclouds 2. apply principles of cloud microphysics to the solution of atmosphericproblems 3. impart knowledge on clouds, precipitation and airpollution 4. study meteorological systems and global energybalance | | | | |
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| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| know the composition and structure of atmosphere | | | |
| understand and apply radar meteorology | | | |
| able to interpret clouds and precipitation | | | |
| describe the meteorological systems, global energy balance and to calibrate air pollution | | | |
| create a scope to identify new areas of research in the field of atmospheric science | | | |
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| **Unit I** | **Physical & Dynamic Meteorology** | | | |
| Physical Meteorology: Structure of Earth’s Atmosphere and Composition - Law of Thermodynamics of the Atmosphere - Adiabatic Process - Potential Temperature - ClausiusClapyeron Equation - Laws of Black Body Radiation - Solar and Terrestrial Radiation – Albedo - Green House Effect -Heat  Balance of Earth Atmosphere System | | | | |
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| **Unit II** | **Dynamic Meteorology** | | | |
| Fundamental Forces - Structure of Static Atmosphere - Momentum, Continuity and Energy Equations - Thermodynamics of the Dry Atmosphere - Elementary Applications of the Basic Equations - Circulation  Theorem – Vorticity - Potential Vorticity and Potential Vorticity Equations | | | | |
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| **Unit III** | **Climate & Monsoon Dynamics** | | | |
| Climate Classification - Polar, Artic, Antarctic, Temperate & Tropical Climates Wind, Temperature & Pressure Distribution over India in the Lower, Middle and Upper Atmosphere during Pre – Post - andMid  - Monsoon Season - Dynamics of Monsoon Depression and Easterly Waves - Intra Seasonal and Inter annual Variability of Monsoon – Quasi Bi Weekly and 30 - 60 Day Oscillations - Walker Circulation,  Southern Oscillations & El Nino | | | | |
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| **Unit IV** | **Atmospheric Pollution** | | | |
| Role of Meteorology in Atmospheric Pollution - Atmospheric Boundary Layer - Air Stability - Local Wind Structure - Ekman Spiral - Turbulence & Boundary Layer Scaling - Residence Time and Reaction Rates of Pollutants - Sulphur Compounds - Carbon Compounds - Organic compounds –Aerosols - Toxic  Gases and Radio Active Particles - Trace Gases | | | | |

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| **Unit V** | | **Radar Meteorology** |
| Basic Meteorology - Radar Principles and Technology - Radar Signal Processing & Display - Weather Radar - Observation of Precipitating Systems - Estimation of Precipitation - Radar observation of Tropical Storms & Cyclones - Use of Weather Radar in Aviation - Clear Air Radars - Observation of a Clear Air Phenomena | | |
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| **Text Book(s)** | | |
| 1 | The Atmosphere - Frederick K. Lutgens and Edward J. Tarbuk | |
| 2 | Dynamic Meteorology - J.R. Holton, Academic Press NY | |
|  | | |
| **Reference Books** | | |
| 1 | The Physics of Monsoons - R.N. Keshvamurthy& M. Shankar Rao, Allied Publishers | |
| 2 | Principles of Air Pollution Meteorology – Tom Lyons &Prillscott, CBS Publishers & Distributors | |
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### ELECTIVE - III

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| **Course code** | | **EXPERIMENTAL TECHNIQUES & DATA ANALYSIS** |  |
| **Pre-requisite** | |
| Students should know the fundamentals of  Electronic Circuits |
| **Course Objectives:** | | | |
| The main objectives of this course are to:   1. acquainted with the concept oferrors. 2. make awareness about the constructions and working principle of sensors andtransducers. 3. recognize the parameters those are measurable in electronicinstruments. | | | |
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| **Expected Course Outcomes:** | | | |
| On the successful completion of the course, student will be able to: | | | |
| Develop an appropriate experimental research design for an engineering case study | | | | |
| Taking into account practical limitations | | | | |
| Apply knowledge of statistical analysis to assess a hypothesis by selecting appropriate statistical tests and interpreting the test results accurately | | | | |
| Propose an appropriate statistical model for a given dataset and interpret the goodness of fit | | | | |
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| **Unit I** | **Introduction** | | |
| Introduction - Measurement of errors: accuracy, precision, resolution, sensitivity - absolute and relative errors - Types of errors - gross error, systematic error and random error- standards of measurements - classification of standards, time and frequencystandards,  electrical standards | | | |
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| **Unit II** | **Electrical Transducer Classification** | | |
| Active and Passive transducers - resistive, inductive, capacitive, thermocouple and Piezoelectric transducers - Digital transducers | | | |
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| **Unit III** | **Amplifiers and signal Conditioning** | | |
| Instrumentation amplifiers- Isolation amplifiers - Chopper amplifiers - Voltage tofrequency  and voltage to current converters - Frequency multipliers - logarithmic amplifiers - S/H Circuits Active filters - Low pass, High pass, Band pass and Band stop filters | | | |
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| **Unit IV** | **Analysis** | | |
| Wave Analyzers - Audio frequency Wave analyzer - Heterodyne wave analyzer - Harmonic distortion analyzers - Resonant harmonic distortion analyzer - Heterodyne harmonic distortion analyzer - Fundamental suppression harmonic distortion analyzer - Spectrum analyzer - Spectra  of CW, AM, FM and PM waves | | | |
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| **Unit V** | **Electronic Measuring Instruments** | | |
| Q meter - Vector impedance meter - Digital frequency meter - Digital voltmeter - Phase meter-  RF power and voltage measurement - Power factor meter - Vector voltmeter - Display and Recording: X-Y Recorders - Magnetic Tape recorders - StorageOscilloscope | | | |

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| **Text Book(s)** | |
| 1 | Electrical & Electronics Measurement &Instrumentation - A. K. Sawhney |
| 2 | Electronic Instrumentation – H.S. Kalsi TMH |
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| **Reference Books** | |
| 1 | Modern Electronic Instrumentation - W.D.Cooper |
| 2 | Instrumentation Devices and Systems - C.S. Rangan, G.R. Sharma and VSV Mani, Tata McGraw Hill Publications |
| 3 | Introduction to Instrumentation and Control - A.K. Ghosh - Prentice HallIndia Publications |
| 4 | Modern Electronic Instrumentation and Measurement Techniques - A.O. Hefnick and W.D. Cooper., Prentice Hall India Publications. |

### ELECTIVE - III

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| **Course code** | | **THIN FILM PHYSICS** |  | |
| **Pre-requisite** | | Students should have basic knowledge in the state of matter particles |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. understand the basic concepts of thin filmstechnology 2. acquire the knowledge about thin film coating, its characterization and itsapplications 3. explain the electric, electronic, magnetic, and structural behavior of functional materials, the experimentalmethodsusedtoinvestigatetheirfunctionality,mathematicalandcomputational   techniques used to model their properties | | | | |
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| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| gain knowledge on the mechanism, process for the synthesis and evolution of thin films | | | |
| understand principles, advantages and drawbacks of different thin film deposition methods | | | |
| familiarize basics of defects and dislocations, and learn how it can be identified and removed | | | |
| learn characterization techniques to analyze sample | | | |
| apply the knowledge of thin film in research level applications | | | |
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| **Unit I** | **Preparation of Thin Film** | | | |
| Nature of Thin Film - Deposition Technology - Distribution of Deposit - Resistance Heating - Thermal Evaporation - Flash Evaporation | | | | |
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| **Unit II** | **Deposition techniques** | | | |
| Electron Beam Method - Cathodic Sputtering - Glow Discharge Sputtering - Low Pressure Sputtering -  Reactive Sputtering - RF Sputtering - Chemical Vapour Deposition (CVD) - Chemical Deposition | | | | |
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| **Unit III** | **Film Thickness & Its Control** | | | |
| Mass Methods - Optical Method – Photometry – Ellipsometry - Interferometry - Other Methods -  Substrate Cleaning - Microscopic Defect and Dislocation - Edge Dislocation - Screw Dislocation - Boundary Defect - Stress Effect - Removal of Defect - Defect and Energy State | | | | |
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| **Unit IV** | **Thin Film Analysis** | | | |
| Electron Diffraction Technique - High Energy Electron Diffraction - Low Energy ElectronDiffraction  - Electron Microscopy - Scanning Electron Microscopy – X Ray Photoelectron Spectroscopy -Mass  Spectroscopy - Thermodynamics of Nucleation - Nucleation Theories - Film Growth - Incorporation of Defects, Impurities in Film - Deposition Parameters and grain size | | | | |
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| **Unit V** | **Thin Film Growth Process** | | | |
| Epitaxy - Thin Film Structure – Substrate Effect - Epitaxial Deposit – Twinning and Multi twinning - Phase Transition - Dissociations - Film Thickness Effect - Crystal Growth Process | | | | |
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| **Text Book(s)** | |
| 1 | Thin Film Fundamentals - A. Goswami, New Age International-New Delhi |
| 2 | Thin Film Phenomena - K.L.Chopra |
|  | |
| **Reference Books** | |
| 1 | Handbook of Thin Film Technology-L.T. Meissel& R. Glang-McGrawHill |
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### ELECTIVE - III

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| **Course code** | | **MICROPROCESSOR AND MICROCONTROLLER** |  | |
| **Pre-requisite** | | The students should have fundamental knowledge about digital electronics |
| **Course Objectives:** | | | | |
| 1. To study the Architecture of µP8085 &µC8051 2. To study the addressing modes & instruction set of 8085 &8051. 3. To introduce the need & use of Interrupt structure of 8085 &8051. 4. To develop skill in simple applications development with programming 8085 &8051 | | | | |
|  | | | | |
| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| learn instruction set of microprocessor | | | |
| perform experiments using Intel 8051 microcontrollers and interfacing experiments such as seven segment display, stepper motor control, traffic light control | | | |
| identify architecture of microprocessor and microcontroller and use microcontrollers in instrumentation applications | | | |
| know the various peripheral devices of Intel 8051 and interfacing them | | | |
| create interface between laboratory experiments and microcontroller, and write instruction code | | | |
|  | | | | |
| **Unit I** | **Introduction & Instruction Set of 8085** | | | |
| Pin Diagram – Architecture – De multiplexing the Bus – Generation of Control Signals – Fetching, Decoding  and Execution of Instruction – Instruction set – Addressing modes – Instruction format – Memory Read Machine Cycle – Simple Programs | | | | |
|  | | | | |
| **Unit II** | **Interfacing Concepts** | | | |
| Peripheral I/O Instructions – Device Selection and Data Transfer – Input Interfacing – Parallel and Serial  Interface - Introduction to Programmable Peripheral Interface 8255 – Pin Diagram – Architecture – Modes of Operation: I/O and BSR – Architecture and Operation of 8251 (USART) - 8085 Interrupts | | | | |
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| **Unit III** | **Applications Of µP** | | | |
| Time Delay Program – Traffic Light Control System – Water Level Controller – Stepper Motor Control – Interfacing DAC – Interfacing ADC – Temperature Measurement | | | | |
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| **Unit IV** | **Introduction & Assembly Programming of 8051** | | | |
| Microcontrollers and Embedded Processors – Microcontrollers for Embedded Systems – Overview of 8051 Family – 8051 Instruction Set and Registers - Introduction to 8051 Assembly Programming – the Program Counter and ROM – Data Types and Directives – Flag Bits and PSW Register – Register Bank and Stack –  Loop and Jump Instructions – I/O Port Programming Addressing Modes – Simple Programs | | | | |
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| **Unit V** | **Interfacing and Real time Applications of µC** | | | |
| Interfacing LCD to the 8051 – Interfacing ADC – Interfacing Sensors to 8051 – Interfacing Stepper Motor –  8051 Interfacing to the Keyboard – Interfacing DAC to the 8051 - Real time applications | | | | |
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| **Text Book(s)** | |
| 1 | Microprocessor Architecture, Program And Its Application With 8085 - R.S. Gaonkar, New Age  International (P) Ltd |
| 2 | Microprocessor and Its Application - S. Malarvizhi, Anuradha Agencies Publications |
| 3 | The 8051 Microcontroller And Embedded Systems Using Assembly And C - Muhammad Ali  Mazidi, Janice GillispieMazidi and Rolin D. McKinlay, PHI, 2nd Edition, 2006 |
|  | |
| **Reference Books** | |
| 1 | The 8085 Microprocessor, Architecture, Programming and Interfacing – K Uday Kumar, S. Uma Shankar, Pearson |
| 2 | Fundamentals of Microprocessors and Microcontrollers - B. Ram, DhanpatRai Publications |
| 3 | Fundamentals of Microprocessors and Microcontrollers - B. Ram, DhanpatRai Publications |
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### ELECTIVE - III

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| **Course code** | | **PHYSICS OF NON-CONVENTIONAL ENERGY RESOURCES** |  | |
| **Pre-requisite** | | The students should have basic knowledge about conventional energy resources |
| **Course Objectives:** | | | | |
| The main objectives of this course are to:   1. To develop the human recourse in non-conventional Energyresources 2. To create several self-employment opportunities in renewable energy and energy efficiency sectors for modestly-trained and self-trained human resources exist in all geographic locations of thecountry 3. It will help to develop the skills required in renewable energy and energy managementfields | | | | |
|  | | | | |
| **Expected Course Outcomes:** | | | | |
| On the successful completion of the course, student will be able to: | | | | |
| understand various renewable energy technologies | | | |
| understand characteristics of solar radiation and solar energy devices | | | |
| learn and apply geothermal energy and fuel cells | | | |
| get awareness of non conventional sources of energy technologies | | | |
| acquirer the knowledge of storage technologies from the autonomous renewable energy sources and various possible mechanisms about renewable energy projects | | | |
|  | | | | |
| **Unit I** | **Introduction to Non conventional Energy** | | | |
| Introduction – Various non conventional energy resources – Availability – Classification - Relative merits and Demerits Solar Cells - Theory of Solar Cells - Solar Cell Materials - Solar Cell Array- Solar  Cell Power Plant - Limitations | | | | |
|  | | | | |
| **Unit II** | **Solar Thermal Energy** | | | |
| Solar Thermal Energy - Solar radiation - Flat Plate Collectors and their Materials - Applicationsand  Performance - Focusing of Collectors and their Materials - Applications and Performance - Solar Thermal Power Plants - Thermal Energy Storage for Solar Heating and Cooling - Limitations | | | | |
|  | | | | |
| **Unit III** | **Geothermal Energy and Fuel Cells** | | | |
| Geothermal Energy - Resources of Geothermal Energy - Thermodynamics of Geo Thermal Energy Conversion - Electrical Conversion – Non electrical Conversion - Environmental Considerations - Magneto Hydrodynamics (MHD) - Principle of Working of MHD Power Plant - Performance and Limitations – Fuel Cells - Principle of Working of Various Types of Fuel Cells and their Working -  Performance and Limitations | | | | |
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| **Unit IV** | **Wind Energy and Power Generation** | | | |
| Wind Power and its Sources - Site Selection – Criterion - Momentum Theory - Classification of Rotors  - Concentrations and Augments - Wind Characteristics - Performance and Limitations of Energy Conversion Systems | | | | |
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| **Unit V** | | **Bio mass** |
| Bio mass - Availability of Bio mass and its Conversion Theory - Ocean Thermal Energy Conversion (OTEC) – Availability - Theory and Working Principle - Performance and Limitations - Wave and Tidal  Wave - Principle of Working - Performance and Limitations | | |
|  | | |
| **Text Book(s)** | | |
| 1 | Introduction to Non-Conventional Energy Resources -Raja etal, SciTech Publications | |
| 2 | Non-conventional Energy Resources -D.S. Chauhan, New Age International | |
|  | | |
| **Reference Books** | | |
| 1 | Renewal Energy Resources - John Twideu and Tony Weir, BSP Publications, 2006 | |
| 2 | Energy Resources: Conventional & Non-Conventional - M.V.R. Koteswara Rao, BSP  Publications, 2006 | |
| 3 | Renewal Energy Technologies: A Practical Guide for Beginners C.S. Solanki-PHI Learning | |



Annexure

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| **LIST OF ELECTIVE PAPERS**  **(College can choose any one elective paper from the choices under each section)** | | |
| **Course** | **Course code** | **Course Title** |
| Elective – I | **1EA** | Robotics, Artificial Intelligence and Information Theory  **(Industry 4.0)** |
| **1EB** | Elements of Nano science and Nanotechnology |
| **1EC** | Introductory Astronomy, Astrophysics & Cosmology |
| Elective – II | **2EA** | PlasmaPhysics |
| **2EB** | Crystal growth methods and characterization |
| **2EC** | AtmosphericPhysics |
| Elective - III | **3EA** | Experimental Techniques & Data Analysis |
| **3EB** | Thin filmPhysics |
| **3EC** | Microprocessor and Microcontroller |
| **3ED** | Non- Conventional energy resources |

**MARKS DISTRIBUTION (EXTERNAL AND INTERNAL (CIA))**

1. **THEORY**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TOTAL MARKS** | **EXTERNAL** | | **INTERNAL** | **Overall Passing Minimum**  **(Internal + External)** |
| **Max. Marks** | **Passing Minimum** | **Max. Marks** |
| 100 | 75 | 38 | 25 | **50** |

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| --- | --- | --- |
| **S. No** | **Theory – CIA Breakups** | |
| **Maximum Marks** | **25** |
| 1 | Tests (2 hours test - Best one out of two) | **5** |
| 2 | Model Exam - End semester (3 hours) | **10** |
| 3 | Assignment + Seminar | **10** |

1. **PRACTICALS**

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| --- | --- | --- | --- | --- |
| **TOTAL MARKS** | **EXTERNAL** | | **INTERNAL** | **Overall Passing Minimum**  **(Internal + External)** |
| **Max. Marks** | **Passing Minimum** | **Max. Marks** |
| 100 | 60 | 30 | 40 | **50** |

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| S. No | **Practical – CIA Breakups** | |
| **Maximum CIA Marks** | **40** |
| 1. | At least 12 experiments to be completed. | **20** |
| 2. | Tests: Best one out of two | **15** |
| 3. | Record | **5** |