**Open Elective Papers offered for Minor in Engineering Physics of B.Tech. Programme**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Subjects** | **L-T-P-C** |
|  |  | **Theory Papers** |  |
|  |  |  |  |  |
| **Odd** |  | **** | Advanced Mathematical Physics | 3-0-0-3 |
| **Semester** |  | **** Nano Materials and Applications | 3-0-0-3 |
|  |  |  |  |  |
|  |  |  |  |  |
| **Odd** |  | **** | Computational Physics | 3-0-0-3 |
| **Semester** |  | **** | Materials Science and Nanotechnology | 3-0-0-3 |
|  |  | **** | Experimental Technique | 3-0-0-3 |
|  |  |  |  |
|  |  |  |  |
| **Even** |  | **** Nonconventional Sources of Energy | 3-0-0-3 |
| **Semester** |  | **** Introduction to Nuclear and Particle Physics | 4-1-0-5 |
|  |  | **** Nuclear Hazard and Waste Managements | 4-1-0-5 |
|  |  |  |  |  |
|  |  |  |  |  |
| **Even** |  | **** | Atmospheric Physics | 3-0-0-3 |
| **Semester** |  | **** | Advanced Experimental Technique | 3-0-0-3 |
|  |  |  |  |
|  |  | **Lab Papers** |  |
|  |  |  |  |  |
| **Odd** |  | **** | Advanced Mathematical Physics | 0-0-2-2 |
| **Semester** |  | **** Nano Materials and Applications | 0-0-2-2 |
|  |  |  |  |  |
|  |  |  |  |  |
| **Odd** |  | **** | Computational Physics | 0-0-2-2 |
| **Semester** |  | **** | Experimental Technique | 0-0-2-2 |
|  |  |  |  |
| **Even** |  | **** Nonconventional Sources of Energy | 0-0-2-2 |
| **Semester** |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| **Even** |  | **** | Atmospheric Physics | 0-0-2-2 |
| **Semester** |  | **** | Advanced Experimental Technique | 0-0-2-2 |
|  |  |  |  |  |

**COURSE INFORMATION SHEET**

**Course code: PH 303**

**Course title: ADVANCED MATHEMATICAL PHYSICS**

**Pre-requisite(s): Intermediate Physics and Mathematics**

**Co- requisite(s):**

**Credits:** L: 3 T: 0 P: 0 C : 3

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE I**

**Branch: PHYSICS**

**Name of Teacher:**

|  |  |  |
| --- | --- | --- |
| **Code** **PH 303** | **Title: ADVANCED MATHEMATICAL PHYSICS** | **L-T-P-C****[3-0-0-3]** |
| **Course Objectives**  This course enables the students:

|  |  |
| --- | --- |
|  A. | To learn algebra of linear transformations which is the background for problem formulation in quantum mechanics. |
| B. | To introduce matrix operations and classification of different types of matrices. |
| C. | To learn transformation properties of tensors in cartesian coordinates. |
| D. | To learn algebra and classification of tensors. |

 **Course Outcomes**  After the completion of this course, students will be:

|  |  |
| --- | --- |
| 1. | Use the definition and properties of linear transformations and matrices of linear transformations, and understand the concepts of change of basis, homomorphism and isomorphism of vector spaces. |
| 2. | Find the eigenvalues and corresponding eigenvectors of a given matrix, determine whether a given matrix is diagonalizable and classify matrices as hermitian/skew-hermitian, singular/non-singular, etc. |
| 3. | Use tensor calculus to represent various vector operations like scalar and cross product of vectors, calculate gradient, divergence and curl of tensor fields, etc. |
| 4. | Perform tensor operations like sum and product of two tensors and classify tensors as symmetric and anti-symmetric. |

 |
| Module-1 | **Linear Vector Spaces:** Abstract Systems. Binary Operations and Relations.Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. | **12** |
| Module-2 | **Matrices:** Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar andUnit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of Matrix. Inner Product  | **8** |
| Module-3 | Eigen-values and Eigenvectors. Cayley- Hamiliton Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix | **10** |
| Module-4 | **Cartesian Tensors:** Transformation of Co-ordinates. Einstein’s Summation Convention.Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors : Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry : Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature. Elasticity Tensor. Generalized Hooke’s Law | **20** |
| Module-5 | **General Tensors:** Transformation of Co-ordinates. Minkowski Space. Contravariant &Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.  | **10** |
| **Reference Books:**1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
3. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
4. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
5. Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
6. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
7. Mathematical Methods for Physicis & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence,3rd Ed., 2006, Cambridge University Press
 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Assessment Compoents** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Mid Sem Examination Marks |  |  |  |  |  |
| End Sem Examination Marks  |  |  |  |  |  |
|  Quiz I |  |  |  |  |  |
| Quiz II |  |  |  |  |  |

**Mapping between Course Objectives and Course Outcomes**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Course Objectives** | **1** | **2** | **3** | **4** |
| A | L | M | - | L |
| B | M | H | - | M |
| C | - | M | H | H |
| D | - | M | M | H |

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| a | b | c | d | e | f |
| 1 | H | H | H | M | H | M |
| 2 | H | H | H | M | H | M |
| 3 | L | H | H | M | M | M |
| 4 | L | H | H | M | M | M |

**Lecture wise Lesson planning Details.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | Lect.No. | TentativeDate | Ch.No. | Topics to be covered | TextBook /References | Cos mapped | Actual Content covered | Methodology used | Remarks by faculty if any |
| 1 | L1-L4 |  |  | Abstract Systems. Binary Operations and Relations.Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors |  | 1 |  |  |  |
| 2 | L5-L8 |  |  | Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. |  | 1 |  |  |  |
| 3 | L9- L12 |  |  | Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. |  | 1 |  |  |  |
| 4 | L13-L15 |  |  | Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar andUnit Matrices. Upper-Triangular and Lower-Triangular Matrices. |  | 2 |  |  |  |
| 5 | L15-L17 |  |  | Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices.  |  | 2 |  |  |  |
| 6 | L18-L19 |  |  | Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of Matrix. Inner Product  |  | 2 |  |  |  |
| 7 | L20-L24 |  |  | Eigen-values and Eigenvectors. Cayley- Hamiliton Theorem. Diagonalization of Matrices. |  | 3 |  |  |  |
| 8 | L25-L29 |  |  | Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix |  | 3 |  |  |  |
| 9 | L30-L34 |  |  | Transformation of Co-ordinates. Einstein’s Summation Convention.Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. |  | 4 |  |  |  |
| 10 | L35-L39 |  |  | Invariant Tensors : Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. |  | 4 |  |  |  |
| 11 | L40-L44 |  |  | Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry : Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line.  |  | 4 |  |  |  |
| 12 | L45-L49 |  |  | Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature. Elasticity Tensor. Generalized Hooke’s Law |  | 4 |  |  |  |
| 13 | L50-L54 |  |  | Transformation of Co-ordinates. Minkowski Space. Contravariant &Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. |  | 5 |  |  |  |
| 14 | L55-L59 |  |  | Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.  |  | 5 |  |  |  |

**COURSE INFORMATION SHEET**

**Course code: PH 304**

**Course title: Nano Materials and Applications**

**Pre-requisite(s): Intermediate Physics**

**Co- requisite(s):**

**Credits:** L: 3 T: 0 P: 0 C : 3

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE I**

**Branch: PHYSICS**

**Name of Teacher:**

|  |  |  |
| --- | --- | --- |
| **Code****PH 304** | **Title: Nano Materials and Applications****Theory: 40 Lectures** | **L-T-P-C****[3-0-0-3]** |
| **Course Objectives :** This course enables the students:

|  |  |
| --- | --- |
|  | To become familiar with length scales in physics and their relevance for nanoscience. |
|  | To be familiarized with the top down and bottom up processes for synthesis of nanomaterials. |
|  | To become familiar with the various methods of characterization of nanomaterials. |
|  | To become acquainted with optical properties of nanostructures and the role of quasiparticles. |
|  | To develop an understanding of the quantization of charge transport in nanostructures and application of nanomaterials. |

**Course Outcomes :** After the completion of this course, students will be:

|  |  |
| --- | --- |
| 1. | Able to quantify the change in the energy levels as materials are confined in one, two or three dimensions.  |
| 2. | Able to describe the various methods of nanomaterial synthesis. |
| 3. | Able to compare and choose from the different characterization tools available for nanomaterial characterization. |
| 4. | Able to relate the optical properties with the concept of quasiparticles. |
| 5. | Able to correlate the discrete nature of charge and energy states with the quantization of electron transport in nanostructures. |

 |
| Module-1 | **NANOSCALE SYSTEMS:** Length scales in physics, Nanostructures: 1D, 2D and 3Dnanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. | **10** |
| Module-2 | **SYNTHESIS OF NANOSTRUCTURE MATERIALS:** Top down and Bottom upapproach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots  | **10** |
| Module-3 | **CHARACTERIZATION:** X-Ray Diffraction. Optical Microscopy Scanning Electron Microscopy Transmission Electron Microscopy Atomic Force Microscopy Scanning Tunneling Microscopy | **8** |
| Module-4 | **OPTICAL PROPERTIES:** Coulomb interaction in nanostructures. Concept ofdielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures. | **12** |
| Module-5 | **ELECTRON TRANSPORT**: Carrier transport in nanostrcutures. Coulomb blockadeeffect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **APPLICATIONS:** Applications of nanoparticles, quantum dots, nanowires and thinfilms for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). | **10** |
| **Reference books:**1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
7. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).
 |

|  |  |
| --- | --- |
| **Course Delivery methods** |  |
| Lecture by use of boards/LCD projectors/OHP projectors | Yes |
| Tutorials/Assignments | Yes |
| Seminars | No |
| Mini projects/Projects | No |
| Laboratory experiments/teaching aids | No |
| Industrial/guest lectures | No |
| Industrial visits/in-plant training | No |
| Self- learning such as use of NPTEL materials and internets | Yes |
| Simulation | No |

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

|  |  |
| --- | --- |
|  **Assessment Tool** | **% Contribution during CO Assessment** |
| Mid Sem Examination Marks | 25 |
| End SemExamination Marks  | 60 |
| Quiz | 15 |
| Teachers Assessment | 5 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AssessmentCompoents** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Mid Sem Examination Marks | Yes | Yes | Yes | No | No |
| End Sem Examination Marks  | Yes | Yes | Yes | Yes | Yes |
| Assignment | Yes | Yes | Yes | Yes | Yes |

**Indirect Assessment –**

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

 **Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| a | b | c | d | e | f |
| 1 | H | H | H | L | M | L |
| 2 |  H | H | M | L | L | L |
| 3 | H | M | H | L | L | L |
| 4 | H | M | M | M | L | L |
| 5 | H | H | H | L | H | L |

|  |  |
| --- | --- |
| **Course Outcome #** | **Course Objectives** |
| a | b | c | d | e |
| 1 | H | M | M | M | L |
| 2 |  M | H | M | M | L |
| 3 | M | M | H | L | L |
| 4 | M | M | M | H | L |
| 5 | M | M | L | M | H |

|  |
| --- |
| **Mapping Between COs and Course Delivery (CD) methods** |
|  |  |  |  |  |
| **CD**  | **Course Delivery methods** |  | **Course Outcome** | **Course Delivery Method** |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors |  | CO1 | CD1, CD2 and CD8 |
| CD2  | Tutorials/Assignments |  | CO2 | CD1, CD2 and CD8 |
| CD3  | Seminars |  | CO3 | CD1, CD2 and CD8 |
| CD4  | Mini projects/Projects |  | CO4 | CD1, CD2 and CD8 |
| CD5  | Laboratory experiments/teaching aids |  | CO5 | CD1, CD2 and CD8 |
| CD6  | Industrial/guest lectures |  |  |  |
| CD7  | Industrial visits/in-plant training |  |  |  |
| CD8  | Self- learning such as use of NPTEL materials and internets |  |  |  |
| CD9  | Simulation |  |  |  |

**Lecture wise Lesson planning Details.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | Lect.No. | TentativeDate | ModuleNo. | Topics to be covered | TextBook /References | Cos mapped | Actual Content covered | Methodology used | Remarks by faculty if any |
| 1 | L1 |  | I | Length scales in physics, Nanostructures: 1D, 2D and 3Dnanostructures (nanodots, thin films, nanowires, nanorods)**,**  | R | CO-1 |  | PPT DigiClass/Chalk-Board |  |
| L2-L4 |  | Band structure and density of states of materials at nanoscale, Size Effects in nano systems, | R | CO-1 |  | PPT DigiClass/Chalk-Board |  |
| 2 | L5-L7 |  | Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, | R | CO-1 |  | PPT DigiClass/Chalk-Board |  |
| 2 | L8-L10 |  | quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. | R | CO-1 |  | PPT DigiClass/Chalk-Board |  |
| 3 | L11-L13 |  | II | Top down and Bottom upapproach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD):  | R | CO-2 |  | PPT DigiClass/Chalk-Board |  |
|  |
| 3 | L14-16 |  | Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). | R | CO-2 |  | PPT DigiClass/Chalk-Board |  |
| 4 | L17-L18 |  | Sol-Gel. Electro deposition. Spray pyrolysis. | R | CO-2 |  | PPT DigiClass/Chalk-Board |  |
| 4-5 | L19-L20 |  | Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots  | R | CO-2 |  | PPT DigiClass/Chalk-Board |  |
| 5-6 | L21-24 |  | III | X-Ray Diffraction. Optical Microscopy, Scanning Electron Microscopy  | R | CO-3 |  | PPT DigiClass/Chalk-Board |  |
| 6-7 | L25-28 |  | Transmission Electron Microscopy Atomic Force Microscopy Scanning Tunneling Microscopy | R | CO-3 |  | PPT DigiClass/Chalk-Board |  |
| 7 | L29-31 |  | IV | Coulomb interaction in nanostructures. Concept ofdielectric constant for nanostructures and charging of nanostructure.  | R | CO-4 |  | PPT DigiClass/Chalk-Board |  |
| 8 | L32-34 |  | Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals.  | R | CO-4 |  | PPT DigiClass/Chalk-Board |  |
| 9 | L35-L37 |  |  | Quantitative treatment of quasi-particles and excitons, charging effects.. Radiative processes: General formalization-absorption, emission and luminescence | R | CO-4 |  | PPT DigiClass/Chalk-Board |  |
| 10 | L38-40 |  |  | Optical properties of heterostrctures and nanostructures. | R | CO-4 |  | PPT DigiClass/Chalk-Board |  |
| 11 | L41-44 |  | V | Carrier transport in nanostrcutures. Coulomb blockadeeffect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **APPLICATIONS:** Applications of nanoparticles, quantum dots, nanowires and thinfilms for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors.  | R | CO-5 | T3 | PPT DigiClass/Chalk-Board |  |
| 12 | L45-47 |  | Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage.  | R | CO-5 | T3 | PPT DigiClass/Chalk-Board |  |
| 13 | L48-50 |  |  | Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). | R | CO-5 | T3 | PPT DigiClass/Chalk-Board |  |

**COURSE INFORMATION SHEET**

**Course code: PH 310**

**Course title: ADVANCED MATHEMATICAL PHYSICS LAB**

**Pre-requisite(s): Intermediate Physics and Mathematics**

**Co- requisite(s):**

**Credits:** L: 0 T: 0 P: 4 C : 2

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE I**

**Branch: PHYSICS**

**Name of Teacher:**

|  |
| --- |
| **ADVANCED MATHEMATICAL PHYSICS LAB L-T-P-C**  **[0-0-4-2]****Course Objectives:**1. To perform computer simulations in C/C++ /Scilab for solving problems like matrix multiplication, matrix diagonalization, etc.
2. To use C/C++ /Scilab programming to calculate eigenvalues and corresponding eigenvectors of a matrix.
3. To do simulations for lagrangian formulation in constrained classical systems.
4. To learn to compute geodesics for various spaces and obtain ground state energy level and wave function of a quantum system.

**Course Outcomes:** Students should be able to1. Multiply and diagonalize matrices of rank 3 using computer program.
2. Find eigenvalues and eigenvectors of 3x3 matrices with real or complex elements.
3. Write programs in C/C++ /Scilab for obtaining lagrangian and calculation of Euler-Lagrange equations for conservative systems.
4. Find the shortest distance between two points in curved spaces and solve quantum systems for their lowest energy levels and wave-functions computationally.

**Scilab/ C++ based simulations experiments based on Mathematical Physics problems like**1. Linear algebra:
	* Multiplication of two 3 x 3 matrices.

1. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
2. Determination of the principal axes of moment of inertia through diagonalization.
3. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differential operator.
4. Lagrangian formulation in Classical Mechanics with constraints.
5. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
6. Estimation of ground state energy and wave function of a quantum system.

**Reference Books:*** Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB:
* Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
* Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
* Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274
 |

**COURSE INFORMATION SHEET**

**Course code: PH 311**

**Course title: Nano Materials and Applications Lab**

**Pre-requisite(s): Intermediate Physics**

**Co- requisite(s):**

**Credits:** L: 0 T: 0 P: 4 C : 2

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE-I**

**Branch: PHYSICS**

**Name of Teacher:**

|  |
| --- |
| **Nano Materials and Applications Lab****L-T-P-C**  **[0-0-4-2]**1. Preparation of thin film using Anodic Vacuum Arc technique
2. Preparation of nano particles using ball milling
3. Nano crystalline or ultra-nano crystalline thin film preparation using Microwave Plasma Enhanced Chemical Vapor Deposition
4. Synthesis of Gold nano particle using chemical route
5. Measurement of thickness of deposited thin film, optical/weight. Quartz crystal.
6. Particle size analysis of broad nano peaks of XRD or GXRD.
7. Optical analysis of given nanomaterials sample
8. Measurement of nano hardness of given thin film
9. Raman analysis of given nano sample
10. Determination of the surface area of nano materials by the BET method Brunauer–Emmett–Teller (BET) technique.
11. Measurement of Contact angle of hydrophobic and hydrophilic thin film or powder.
12. Synthesis of ZnO nano particle using chemical route

**Reference Books**1. Coating Technology Hand book, by D. Satas, A. A. Tracton, Marcel Dekker, 2001.
2. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004)
3. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
4. Surface Analysis- The principle Techniques, J. C. Vickerman, John Wiley and Sons, 1997.
5. The Materials Science of Thin Films by M. Ohring, Academic Press 1992.
6. Nanomaterials by A. K. Bandyopadhyay, New Age Publ., 2009.
 |

**COURSE INFORMATION SHEET**

**Course code: PH 305**

**Course title: Computational Physics**

**Pre-requisite(s): Intermediate Physics and Mathematics**

**Co- requisite(s):**

**Credits:** L: 3 T: 0 P:0 C: 3

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE II**

**Branch: PHYSICS**

**Name of Teacher:**

|  |  |  |
| --- | --- | --- |
| Course Code: **PH 305** | **Title: COMPUTATIONAL PHYSICS** | L-T-P-C3-0-0-3 |
| **Course Objectives**  This course enables the students:

|  |  |
| --- | --- |
|  A. | To learn about the basics of Fortran programming |
| B. | Learn about control statements in Fortran |
| C. | To learn about preparing codes  |
| D. | Learn about Latex and Gnuplot  |

 **Course Outcomes**  After the completion of this course, students will be:

|  |  |
| --- | --- |
|  1. | Able to write simple programs in Fortran |
| 2. | Able to use control statements |
| 3. | Preparing complex codes to solve physical problems |
| 4. | Having good grasp on Latex and Gnuplot |

 |
| Module 1 | **Scientific Programming:** Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems. | [8] |
| Module 2 | **Control Statements:** Types of Logic (Sequential, Selection, Repetition), BranchingStatements (Logical IF, Arithmetic IF, Block IF, Nested Block IF), Looping Statements (DO-ENDDO, DO-WHILE), Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN and CALL Statements, Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems. | [10] |
| Module 3 | Exercises on syntax on usage of Fortran, Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write codes in C. | [7] |
|  | To print out all natural even/ odd numbers between given limits.To find maximum, minimum and range of a given set of numbers. Calculating Euler number using exp(x) series evaluated at x=1 |  |
| Module 4 | Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor,preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors. | [10] |
| Module 5 | Visualization: Introduction to graphical analysis and its limitations. Introduction toGnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot | [10] |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Course Objectives** | **1** | **2** | **3** | **4** |
| **A** | **H** | **H** | **H** | **-** |
| **B** | **L** | **H** | **H** | **-** |
| **C** | **L** | **H** | **H** | **-** |
| **D** | **-** | **-** | **-** | **H** |

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| **a** | **b** | **c** | **d** | **e** | **f** |
| **1** | **-** | **L** | **L** | **M** | **L** | **M** |
| **2** | **-** | **L** | **L** | **M** | **L** | **M** |
| **3** | **-** | **H** | **H** | **M** | **M** | **M** |
| **4** | **-** | **H** | **H** | **M** | **L** | **M** |

 **Lecture wise Lesson planning Details.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | Lect.No. | TentativeDate | Ch.No. | Topics to be covered | TextBook /References | COsmapped | Actual Content covered |  | Remarks byfaculty if any |
| 1 | L1-L3 |  |  | Some fundamental Linux Commands (Internal and External commands). Basics of Fortran, Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program.  | T1, T2 | 1 |  |  |  |
| 2 | L4-L6 |  |  | Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements, Executable and Non-Executable Statements, Layout of programs, Format of writing Program, Examples from physics problems. | T1, T2 | 1 |  |  |  |
| 3 | L7-L9 |  |  | Types of Logic (Sequential, Selection, Repetition), Branching Statements, Looping Statements, Jumping Statements | T1, T2 | 2 |  |  |  |
| 4 | L10-L12 |  |  | Subscripted Variables (Arrays), Functions and Subroutines, I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems. | T1, T2 | 2 |  |  |  |
| 5 | L13-L15 |  |  | Exercises on syntax on usage of Fortran, Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write codes in Fortran. | T1, T2 | 3 |  |  |  |
| 6 | L16-L18 |  |  | To print out all natural even/ odd numbers between given limits.To find maximum, minimum and range of a given set of numbers. Calculating Euler number using exp(x) series evaluated at x=1 | T1, T2 | 3 |  |  |  |
| 7 | L19-L21 |  |  | Introduction to LaTeX: TeX/LaTeX word processor,preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. | T4 | 4 |  |  |  |
| 8 | L22-L24 |  |  | Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors. | T4 | 4 |  |  |  |
| 9 | L25-L27 |  |  | Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data | T3 | 5 |  |  |  |
| 10 | L28-L30 |  |  | Basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file | T3 | 5 |  |  |  |
| 11 | L31-33 |  |  | physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot | T3 | 5 |  |  |  |

**COURSE INFORMATION SHEET**

**Course code: 306**

**Course title: Materials Science and Nanotechnology**

**Pre-requisite(s):**

**Co- requisite(s):**

**Credits:** L: 4 T: 1 P: 0 C : 5

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE II**

**Branch :PHYSICS**

**Name of Teacher:**

|  |  |  |
| --- | --- | --- |
| **CODE****PH306** | **Title: Materials Science and Nanotechnology** | **L-T-P-C [4-1-0-5]** |
| **Course Objectives** This course enables the students to:

|  |  |
| --- | --- |
| A. | Outline the basics of crystallography and define various types of imperfections in crystals. |
| B. | Explain elastic and plastic deformation in solids and summarize the strain hardening mechanisms. |
| C. | Define ceramics and explain its types and applications. |
| D. | Define polymers and composites and categorize them on the basis of their applications. |
| E. | Define Nanotechnology and outline the various properties of nano materials and their fabrication techniques. |

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

|  |  |
| --- | --- |
| 1. | explain various types of imperfections in crystals. |
| 2. | analyze the mechanisms behind elastic and plastic deformation is solids and compare different strengthening techniques.  |
| 3. | summarize ceramics and its types and relate their applications with properties. |
| 4. | classify polymers and composites based on their properties and applications. |
| 5. | Classify nanomaterials, their fabrication techniques and co relate the effects of confinement to nanoscale on their properties. |

 |
| **Module 1** | **Imperfections in solids and elastic deformation**Introduction to crystallography, types of imperfections, point defects, edge dislocation, screw dislocation, mixed dislocation, Burger’s vector,dislocation density, surface defects, grains, grain boundary,volume defects | **[8]** |
| **Module 2** | **Elastic and Plastic deformation** Elastic deformation, Hooke’s law, atomic view of elasticity,anelasticity, elastic moduli.plastic deformation, yield point phenomena, slip, slip systems, resolved shear stress, plastic deformation of single crystals and polycrystalline materials, strain hardening, annealing, recovery, recrystallization, grain growth, introduction to fracture, fatigue, creep. | **[10]** |
| **Module 3** | **Ceramics**Ceramic structures, imperfections in ceramics, mechanical properties of ceramics, types and applications of ceramics, advanced ceramics and their applications. | **[7]** |
| **Module 4** | **Polymers and composites**Polymer structure, polymer crystallinity, mechanical behaviour of polymers, types of polymers and their applications, advanced polymers and their application, general properties, types, and applications of composites, fibre reinforced composites, various types of fibres - plastic, glass, carbon, etc, influence of fibre length & orientation. | **[7]** |
| **Module 5** | **Nanotechnology**Basic concepts of nanotechnology, nanomaterials (nanoparticles, nanoclusters, quantum dots) nanoscale, effect of nano scale on material, properties: thermal, mechanical, electrical, magnetic and optical properties. introduction to nanomaterials fabrication techniques: top-down process (ball milling, lithography), bottom-up process (sputtering techniques, chemical routes). | **[8]** |
| **Text books:**1. W. D. Callister, Materials Science and Engineering: An Introduction, John Wiley, 6th Edition, 2003.
2. W. F. Smith, Principles of Materials Science and Engineering, McGraw Hill International, 1986.
3. Introduction to Nanotechnology, Charles P. Poole, Jr., Frank J. Owens, John Wiley & Sons, 2013.

**Reference books:** 1. The Structure and Properties of Materials, Wiley Eastern

Vol. –I, Moffatt, Pearsall and WulffVol. –III, Hayden, Moffatt and Wulff1. Physical Properties of Materials, M. C. Lovell, A. J. Avery, M. W. Vernon, ELBS
 |

|  |  |
| --- | --- |
| **Course Delivery methods** |  |
| Lecture by use of boards/LCD projectors/OHP projectors | Yes |
| Tutorials/Assignments | Yes |
| Seminars | No |
| Mini projects/Projects | No |
| Laboratory experiments/teaching aids | No |
| Industrial/guest lectures | No |
| Industrial visits/in-plant training | No |
| Self- learning such as use of NPTEL materials and internets | Yes |
| Simulation | No |

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

|  |  |
| --- | --- |
|  **Assessment Tool** | **% Contribution during CO Assessment** |
| Mid Sem Examination Marks | 25 |
| End SemExamination Marks  | 60 |
| Quiz | 15 |
| Teachers Assessment | 5 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **AssessmentCompoents** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Mid Sem Examination Marks | Yes | Yes | Yes | No | No |
| End Sem Examination Marks  | Yes | Yes | Yes | Yes | Yes |
| Assignment | Yes | Yes | Yes | Yes | Yes |

**Indirect Assessment –**

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

 **Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| a | b | c | d | e | f |
| 1 | H | H | H | L | M | L |
| 2 | H | H | M | L | L | L |
| 3 | H | M | M | L | L | L |
| 4 | H | M | M | L | L | L |
| 5 | H | H | H | L | H | L |

|  |  |
| --- | --- |
| **Course Outcome #** | **Course Objectives** |
| a | b | c | d | e |
| 1 | H | M | M | M | L |
| 2 | M | H | M | M | L |
| 3 | M | M | H | L | L |
| 4 | M | M | H | L | L |
| 5 | M | M | L | L | H |

|  |
| --- |
| **Mapping Between COs and Course Delivery (CD) methods** |
|  |  |  |  |  |
| **CD**  | **Course Delivery methods** |  | **Course Outcome** | **Course Delivery Method** |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors |  | CO1 | CD1, CD2 and CD8 |
| CD2  | Tutorials/Assignments |  | CO2 | CD1, CD2 and CD8 |
| CD3  | Seminars |  | CO3 | CD1, CD2 and CD8 |
| CD4  | Mini projects/Projects |  | CO4 | CD1, CD2 and CD8 |
| CD5  | Laboratory experiments/teaching aids |  | CO5 | CD1, CD2 and CD8 |
| CD6  | Industrial/guest lectures |  |  |  |
| CD7  | Industrial visits/in-plant training |  |  |  |
| CD8  | Self- learning such as use of NPTEL materials and internets |  |  |  |
| CD9  | Simulation |  |  |  |

**Lecture wise Lesson planning Details.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | Lect.No. | TentativeDate | ModuleNo. | Topics to be covered | TextBook /References | COsmapped | Actual Content covered | Methodologyused | Remarks byfaculty if any |
| 1 | L1 |  | I | Introduction to materials science and relevance of nanotechnology, course objectives and grading schemes. | T1 | CO-1 |  | PPT DigiClass/Chalk-Board |  |
| L2-L4 |  | Introduction to crystallography | T1 | CO-1 |  | PPT DigiClass/Chalk-Board |  |
| 2 | L5-7 |  | Types of imperfections, point defects, edge dislocation, screw dislocation, mixed dislocation, Burger’s vector | T1 | CO-1 |  | PPT DigiClass/Chalk-Board |  |
| 2 | L8 |  | Dislocation density, surface defects, grains, grain boundary | T1 | CO-1 |  | PPT DigiClass/Chalk-Board |  |
| 3 | L9-L10 |  | II | Elastic deformation, Hooke’s law, atomic view of elasticity, anelasticity, elastic moduli | T1 | CO-2 |  | PPT DigiClass/Chalk-Board |  |
|  |
| 3 | L11-12 |  | Plastic deformation, yield point phenomena, slip, slip systems, resolved shear stress | T1 | CO-2 |  | PPT DigiClass/Chalk-Board |  |
| 4 | L12-L14 |  | Plastic deformation of single crystals and polycrystalline materials | T1 | CO-2 |  | PPT DigiClass/Chalk-Board |  |
| 4-5 | L15-18 |  | Strain hardening, annealing, recovery, recrystallization, grain growth, introduction to fracture, fatigue, creep | T1 | CO-2 |  | PPT DigiClass/Chalk-Board |  |
| 5-6 | L19-22 |  | III | Ceramic structures, imperfections in ceramics, mechanical properties of ceramics. | T1 | CO-3 |  | PPT DigiClass/Chalk-Board |  |
| 6-7 | L23-25 |  | Types and applications of ceramics, advanced ceramics and their applications. |  | CO-3 |  | PPT DigiClass/Chalk-Board |  |
| 7 | L25-28 |  | IV | Polymer structure, polymer crystallinity, mechanical behaviour of polymers, types of polymers and their applications, advanced polymers and their application | T1 | CO-4 |  | PPT DigiClass/Chalk-Board |  |
| 8 | L29-31 |  | General properties, types, and applications of composites, fibre reinforced composites, various types of fibres - plastic, glass, carbon, etc, influence of fibre length & orientation. | T1 | CO-4 |  | PPT DigiClass/Chalk-Board |  |
| 9 | L33-34 |  | V | Basic concepts of nanotechnology, nanomaterials (nanoparticles, nanoclusters, quantum dots) nanoscale, effect of nano scale on material, properties: thermal, mechanical, electrical, magnetic and optical properties |  | CO-5 | T3 | PPT DigiClass/Chalk-Board |  |
| 9 | L35-40 |  | Introduction to nanomaterials fabrication techniques: top-down process (ball milling, lithography), bottom-up process (sputtering techniques, chemical routes). |  | CO-5 | T3 | PPT DigiClass/Chalk-Board |  |

**COURSE INFORMATION SHEET**

**Course code: PH 307**

**Course title: EXPERIMENTAL TECHNIQUES**

**Pre-requisite(s): Intermediate Physics and Mathematics**

**Co- requisite(s):**

**Credits:** L: 3 T: 0 P: 0 C : 3

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE II**

**Branch: PHYSICS**

**Name of Teacher: Dr. Dilip K. Singh**

|  |  |  |
| --- | --- | --- |
| **Code****PH 307** | **Title: EXPERIMENTAL TECHNIQUES** | **L-T-P-C****[3-0-0-3]** |
| **Course Objectives** This course enables the students:

|  |  |
| --- | --- |
| 1. A
 | The course on *Experimental techniques* is designed to cater need of understanding of basic instrumentation to leaners.  |
| B. | Module-1 contains information about various measurement parameters like precession, accuracy and curve fitting.  |
| C. | Under 2nd Module knowledge about variety of signals, frequency response of systems and noise measurements would be transferred.  |
| D. | Module-3 contains information about working, efficiency and applications of Transducers and sensors.  |
| E. | The 4th module contains knowledge about working and construction of digital multimeter, impedance bridges and Q-meter. |
| F. | The working, construction and efficiency of variety of vacuum pumps and techniques of vacuum level measurement are topic of 5th module.  |

 **Course Outcomes**  After the completion of this course, students will be:

|  |  |
| --- | --- |
| 1. | The course intends to impart knowledge of basic instrumentation tools and techniques to physics undergraduates, so that they can conceive / design experiments to test physic principles.  |
| 2. | Leaners would gain knowledge of accuracy, precession and types of errors.  |
| 3. | Students would also gain knowledge of type of signals, variety of noise types and methods of grounding / shielding.  |
| 4. | Course intends to impart knowledge of variety of transducers / sensors required for industrial instrumentation.  |
| 5. | Working and design of digital multimeters and bridges is planned to be covered in this course.  |
| 6.  | Knowledge about variety of vacuum pumps and vacuum measurement techniques will enrich the learners about vacuum techniques: one of the basic experimental skill required to understand working / experiments of variety of branches of physics and engineering like low-temperature physics (cryogenics), ion-beam physics, semiconductor growth and devices and nuclear instrumentation.  |

 |
| Module-1 | **Measurements:** Accuracy and precision. Significant figures. Error and uncertainty analysis.Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution | **8** |
| Module-2 | **Signals and Systems:** Periodic and aperiodic signals. Impulse response, transfer functionand frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise**Shielding and Grounding:** Methods of safety grounding. Energy coupling. Grounding.Shielding: Electrostatic shielding. Electromagnetic Interference | **8** |
| Module-3 | **Transducers & industrial instrumentation (working principle, efficiency, applications):** Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector  | **14** |
| Module-4 | **Digital Multimeter:** Comparison of analog and digital instruments. Block diagram ofdigital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.**Impedance Bridges and Q-meter:** Block diagram and working principles of RLC bridge.Q-meter and its working operation. Digital LCR bridge. | **10** |
| Module-5 | **Vacuum Systems:** Characteristics of vacuum: Gas law, Mean free path. Application ofvacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization).  | **10** |
| **Text books:** **T1:** Thomas L. Floyd. ELECTRONIC. DEVICES. 9th Edition. Prentice Hall.**T2:** Louis Nashelsky and Robert Boylestad, Electronic Devices and Circuit Theory **Reference books: R1:**  |

|  |  |
| --- | --- |
| **Course Delivery methods** |  |
| Lecture by use of boards/LCD projectors/OHP projectors | Y |
| Tutorials/Assignments | Y |
| Seminars | N |
| Mini projects/Projects | N |
| Laboratory experiments/teaching aids | N |
| Industrial/guest lectures | N |
| Industrial visits/in-plant training | N |
| Self- learning such as use of NPTEL materials and internets | Y |
| Simulation  | N |

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

|  |  |
| --- | --- |
|  **Assessment Tool** | **% Contribution during CO Assessment** |
| Mid Sem Examination Marks | 25 |
| End Sem Examination Marks  | 50 |
| Quiz  | 10+10 |
| Teacher’s assessment | 5 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  **Assessment Compoents** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Mid Sem Examination Marks | **√** | **√** | **√** |  |  |
| End Sem Examination Marks  | **√** | **√** | **√** | **√** | **√** |
|  Quiz I | **√** | **√** | **√** |  |  |
| Quiz II |  |  | **√** | **√** | **√** |
| Assignment | **√** | **√** | **√** | **√** | **√** |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

**Mapping between Course Objectives and Course Outcomes**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Course Objectives** | **1** | **2** | **3** | **4** | **5** | **6** |
| A | H | H | H | H | H | H |
| B | H | H | L | L | L | L |
| C | H | L | H | L | L | L |
| D | H | L | L | H | L | L |
| E | H | L | L | L | H | L |
| F | H | L | L | L | L | H |

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| a | b | c | d | e | f |
| 1 | H | H | H | H | H | H |
| 2 | H | H | H | M | H | H |
| 3 | H | H | H | M | H | H |
| 4 | H | H | H | M | H | H |
| 5 | H | H | H | M | H | H |
| 6 | H | H | H | M | H | H |

|  |
| --- |
| **Mapping Between COs and Course Delivery (CD) methods** |
| **CD**  | **Course Delivery methods** |  | **Course Outcome** | **Course Delivery Method** |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors |  | CO1 | CD1 and CD2 |
| CD2  | Tutorials/Assignments |  | CO2 | CD1 and CD2 |
| CD3  | Seminars |  | CO3 | CD1 and CD2 |
| CD4  | Mini projects/Projects |  | CO4 | CD1 and CD2 |
| CD5  | Laboratory experiments/teaching aids |  | CO5 | CD1 and CD2 |
| CD6  | Industrial/guest lectures |  | CO6 | CD1 and CD2 |
| CD7  | Industrial visits/in-plant training |  | - | - |
| CD8  | Self- learning such as use of NPTEL materials and internets |  | - | - |
| CD9  | Simulation |  | - | - |

**Lecture wise Lesson planning Details.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | Lect.No. | TentativeDate | Ch.No | Topics to be covered | TextBook /References | Cos mapped | Actual Content covered | Methodology used | Remarks by faculty if any |
| 1 | L1 |  | 1 | **Measurements:** Accuracy and precision. Significant figures.  | T1, T2 |  |  |  |  |
|  | L2 |  | Error and uncertainty analysis. | T1, T2 |  |  |  |  |
|  | L3 |  | Types of errors: Gross error, systematic error, random error. | T1, T2 |  |  |  |  |
|  | L4 |  | Statistical analysis of data (Arithmetic mean, | T1, T2 |  |  |  |  |
|  | L5 |  | deviation from mean, average deviation,  | T1, T2 |  |  |  |  |
|  | L6 |  | standard deviation,  | T1, T2 |  |  |  |  |
|  | L7 |  | chi-square) and curve fitting.  | T1, T2 |  |  |  |  |
|  | L8 |  | Guassian distribution. | T1, T2 |  |  |  |  |
|  | L9 |  | 2 | **Signals and Systems:** Periodic and aperiodic signals.  | T1, T2 |  |  |  |  |
|  | L10 |  | Impulse response, transfer functionand frequency response of first and second order systems.  | T1, T2 |  |  |  |  |
|  | L11 |  | Fluctuations and Noise in measurement system.  | T1, T2 |  |  |  |  |
|  | L12 |  | S/N ratio and Noise figure. Noise in frequency domain.  | T1, T2 |  |  |  |  |
|  | L13 |  | Sources of Noise: Inherent fluctuations, Thermal noise,  | T1, T2 |  |  |  |  |
|  | L14 |  | Shot noise, 1/f noise | T1, T2 |  |  |  |  |
|  | L15 |  | **Shielding and Grounding:** Methods of safety grounding. Energy coupling. Grounding. | T1, T2 |  |  |  |  |
|  | L16 |  | Shielding: Electrostatic shielding. Electromagnetic Interference. | T1, T2 |  |  |  |  |
|  | L17 |  | 3 | **Transducers & industrial instrumentation (working principle, efficiency, applications):** Static and dynamic characteristics of measurement Systems.  | T1, T2 |  |  |  |  |
|  | L18 |  | Generalized performance of systems,  | T1, T2 |  |  |  |  |
|  | L19 |  | Zero order first order systems | T1, T2 |  |  |  |  |
|  | L20 |  | Second order and higher order systems. | T1, T2 |  |  |  |  |
|  | L21 |  | Electrical, Thermal and Mechanical systems. | T1, T2 |  |  |  |  |
|  | L22 |  | Calibration. Transducers and sensors.  | T1, T2 |  |  |  |  |
|  | L23 |  | Characteristics of Transducers. Transducers as electrical element and their signal conditioning. | T1, T2 |  |  |  |  |
|  | L24 |  | Temperature transducers: RTD, Thermistor, Thermocouples | T1, T2 |  |  |  |  |
|  | L25 |  | Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning.  | T1, T2 |  |  |  |  |
|  | L26 |  | Linear Position transducer: Strain gauge | T1, T2 |  |  |  |  |
|  | L27 |  | Piezoelectric. Inductance change transducer | T1, T2 |  |  |  |  |
|  | L28 |  | Linear variable differential transformer (LVDT), Capacitance change transducers.  | T1, T2 |  |  |  |  |
|  | L29 |  | Radiation Sensors:  | T1, T2 |  |  |  |  |
|  | L30 |  | Principle of Gas filled detector, ionization chamber, scintillation detector. | T1, T2 |  |  |  |  |
|  | L31L32 |  | 4 | **Digital Multimeter:** Comparison of analog and digital instruments.  | T1, T2 |  |  |  |  |
|  |  |  |  |  |  |
|  | L33L34 |  | Block diagram ofdigital multimeter | T1, T2 |  |  |  |  |
|  |  |  |  |  |  |
|  | L35 L36 |  | Principle of measurement of I, V, C.  | T1, T2 |  |  |  |  |
|  |  | T1, T2 |  |  |  |  |
|  | L37 |  | Accuracy and resolution of measurement.  | T1, T2 |  |  |  |  |
|  | L38 |  | **Impedance Bridges and Q-meter:** Block diagram and working principles of RLC bridge. | T1, T2 |  |  |  |  |
|  | L39 |  | Q-meter and its working operation.  | T1, T2 |  |  |  |  |
|  | L40 |  | Digital LCR bridge. | T1, T2 |  |  |  |  |
|  | L41 |  | 5 | **Vacuum Systems:** Characteristics of vacuum:  | T1, T2 |  |  |  |  |
|  | L42 |  | Gas law, Mean free path. | T1, T2 |  |  |  |  |
|  | L43 |  | Application ofvacuum. | T1, T2 |  |  |  |  |
|  | L44 |  | Vacuum system-  | T1, T2 |  |  |  |  |
|  | L45 |  | Chamber, Mechanical pumps,  | T1, T2 |  |  |  |  |
|  | L46 |  | Diffusion pump | T1, T2 |  |  |  |  |
|  | L47 |  | Turbo Modular pump, | T1, T2 |  |  |  |  |
|  | L48 |  | Pumping speed | T1, T2 |  |  |  |  |
|  | L49 |  | Pressure gauges (Pirani) | T1, T2 |  |  |  |  |
|  | L50 |  | Penning, ionization gauge. | T1, T2 |  |  |  |  |

**COURSE INFORMATION SHEET**

**Course code: PH 312**

**Course title: Computational Physics Lab**

**Pre-requisite(s): Intermediate Physics and Mathematics**

**Co- requisite(s):**

**Credits:** L: 0 T: 0 P:4 C: 2

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE II**

**Branch: PHYSICS**

**Name of Teacher: Dr. Madhu Priya**

|  |
| --- |
| **Computational Physics Lab****L-T-P-C**  **[0-0-4-2]**1. Working with basic Linux commands.
2. Defining variables and using arithmetic/logical operators in FORTRAN.
3. Using control statements in FORTRAN.
4. Exercises on usage of FORTRAN.
5. Preparing reports/articles with Latex.
6. Writing equations and incorporating figures in Latex.
7. Plotting data files and simple functions using Gnuplot.
8. Writing codes in Gnuplot.
 |

**COURSE INFORMATION SHEET**

**Course code: PH 313**

**Course title: Materials Science and Nanotechnology Lab**

**Pre-requisite(s): Intermediate Physics and Mathematics**

**Co- requisite(s):**

**Credits:** L: 0 T: 0 P:4 C: 2

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE II**

**Branch: PHYSICS**

**Name of Teacher: Dr. Madhu Priya**

|  |
| --- |
| **Materials Science and Nanotechnology Lab****L-T-P-C**  **[0-0-4-2]**1. Nano crystalline or ultra nano crystalline thin film preparation using Microwave Plasma Enhanced Chemical Vapor Deposition2. Particle size analysis of broad nano peaks of XRD or GXRD.3. Optical analysis of given nanocrystalline sample4. Preparation of nano particles using ball milling5. Measurement of nano hardness of given thin film6. Raman analysis of given nano sample7. Preparation of thin film using Anodic Vacuum Arc technique8. Measurement of thickness of deposited thin film9. Determination of the surface area of nano materials by the BET method Brunauer–Emmett–Teller (BET) technique.10.Meaurment of Contact angle of hydrophobic and hydrophilic nano thin film or powder. 11. Synthesis of ZnO nano particle using chemical route |

**COURSE INFORMATION SHEET**

**Course code: PH 313**

**Course title: EXPERIMENTAL TECHNIQUES LAB**

**Pre-requisite(s): Intermediate Physics and Mathematics**

**Co- requisite(s):**

**Credits:** L: 0 T: 0 P: 4 C : 2

**Class schedule per week: 0x**

**Class: I.M.Sc.**

**Semester / Level: PE II**

**Branch: PHYSICS**

**Name of Teacher:**

|  |
| --- |
| **EXPERIMENTAL TECHNIQUES LAB****L-T-P-C**  **[0-0-4-2]*** 1. Determine output characteristics of a LVDT & measure displacement using LVDT
	2. Measurement of Strain using Strain Gauge.
	3. Measurement of level using capacitive transducer.
	4. To study the characteristics of a Thermostat and determine its parameters.
1. Study of distance measurement using ultrasonic transducer.
2. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
3. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
4. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
5. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
6. To design and study the Sample and Hold Circuit.
7. Design and analyze the Clippers and Clampers circuits using junction diode
8. To plot the frequency response of a microphone.
9. To measure Q of a coil and influence of frequency, using a Q-meter.

**Reference Books:**1. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
3. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.
 |

**COURSE INFORMATION SHEET**

**Course code: PH 317**

**Course title: Nonconventional Sources of Energy**

**Pre-requisite(s):** Student should have knowledge of Solid State Physics

**Co- requisite(s):** Knowledge of Basic Mathematics

**Credits:** L: 3 T:0 P: 0 C : 3

**Class schedule per week:** 3

**Class: I.M.Sc.**

**Semester / Level: III**

**Branch:** Physics

**Name of Teacher:**

|  |
| --- |
| **Title: Nonconventional Sources of Energy** |
| **Course Objectives :** This course enables the students:

|  |  |
| --- | --- |
| A. | To show the energy status in India and world, and environmental aspects of the conventional and non-conventional sources of energy. |
| B. | To illustrate the basics of solar thermal and solar cell. |
| C. | To explain the concepts of wind energyand tidal energy. |
| D. | To illustrate thebio mass, geo thermal energy and hydro energy. |
| E. | To explain the facts about thermoelectric generators, thermionic generators, magneto hydro dynamics generators, batteries and fuel cells. |

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

|  |  |
| --- | --- |
| 1. | Define the energy scenario in Indiaand World and the need of non-conventional energy sources. |
| 2. | Explain the various method for converting the solar radiation to heat and electricity. |
| 3. | Illustrate the generation of electricity by wind turbine and also explain the potential of tidal and ocean energies in the generation of power. |
| 4. | Explain the process of generation of bio energy and basic concepts of geo thermal energy and hydro energy. |
| 5. | Define the concepts of thermoelectric generators, thermionic generators, magneto hydro dynamics generators, batteries and fuel cells. |

 |
| CodePH 317 | **Title: Nonconventional Sources of Energy** | **L-T-P-C****[3-0-0-3]** |
| Module-1 | **Energy Sources**:World energy status, current energy scenario in India, environmental aspects of energy utilization, Classification of energy, Energy Resources, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean energy, Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. Energy conservation and storage. | 10 |
| Module-2 | Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater,flat plate collector, solar distillation, solar cooker, solar green houses, solar cell,absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.  | 10 |
| Module-3 | Wind Energy: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies. Ocean Energy, Potential against Wind and Solar, Wave Characteristics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. | 10 |
| Module-4 | Biomass energy, resources, conversion, gasification, liquefaction, production, energy farming, Geothermal Energy: Geothermal Resources, Geothermal Technologies. small hydro resources. Layout, water turbines, classifications, generators, status. | 10 |
| Module-5 | Direct Energy conversion: Thermoelectric effects, generators, Thermionic generators, magneto hydro dynamics generators, Fuel cells, photovoltaic generators, electrostatic mechanical generators, Thin film solar cells, nuclear batteries**.**  | 10 |
| **Text books:**1. Solar cells: Operating principles, technology and system applications by Martin A Green, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.

**Reference books:*** + - 1. Non conventional Energy Resources, B. H. Khan, Tata McGraw Hill, 2010
			2. Non conventional energy Sources and Utilization, R. K. Rajput, S Chand Publ., 2014
 |

|  |  |
| --- | --- |
| **Course Delivery methods** |  |
| Lecture by use of boards/LCD projectors/OHP projectors | Y |
| Tutorials/Assignments | Y |
| Seminars | N |
| Mini projects/Projects | N |
| Laboratory experiments/teaching aids | N |
| Industrial/guest lectures | N |
| Industrial visits/in-plant training | N |
| Self- learning such as use of NPTEL materials and internets | Y |
| Simulation  | N |

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

|  |  |
| --- | --- |
|  **Assessment Tool** | **% Contribution during CO Assessment** |
| Mid Sem Examination Marks | 25 |
| End SemExamination Marks  | 50 |
|  Quiz I and Quiz II | 10+10 |
| Teacher’s assessment | 5 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Assessment Compoents** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Mid Sem Examination Marks | **√** | **√** | **√** |  |  |
| End Sem Examination Marks  | **√** | **√** | **√** | **√** | **√** |
|  Quiz I | **√** | **√** | **√** |  |  |
| Quiz II |  |  |  | **√** | **√** |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome
3. Teacher’s assessment

 **Mapping between Objectives and Outcomes**

**Mapping between Course Objectives and Course Outcomes**

|  |
| --- |
| **Course Outcomes** |
| **Course Objectives** | **1** | **2** | **3** | **4** | **5** |
| A | H | L | L | L | L |
| B | M | H | M | M | L |
| C | M | M | H | L | L |
| D | M | L | L | H | L |
| E | M | L | L | L | H |

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| a | b | c | d | e | f |
| 1 | L | L | M | H | L | H |
| 2 | M | H | M | H | H | H |
| 3 | M | H | M | H | H | H |
| 4 | M | H | M | H | H | H |
| 5 | M | H | M | H | H | H |

|  |
| --- |
| **Mapping Between COs and Course Delivery (CD) methods** |
|  |  |  |  |  |
| **CD**  | **Course Delivery methods** |  | **Course Outcome** | **Course Delivery Method** |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors |  | CO1 | CD1 and CD2 |
| CD2  | Tutorials/Assignments |  | CO2 | CD1 and CD2 |
| CD3  | Seminars |  | CO3 | CD1 and CD2 |
| CD4  | Mini projects/Projects |  | CO4 | CD1 and CD2 |
| CD5  | Laboratory experiments/teaching aids |  | CO5 | CD1 and CD2 |
| CD6  | Industrial/guest lectures |  | - | - |
| CD7  | Industrial visits/in-plant training |  | - | - |
| CD8  | Self- learning such as use of NPTEL materials and internets |  | - | - |
| CD9  | Simulation |  | - | - |

 **Lecture wise Lesson planning Details.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | Lect.No. | TentativeDate | Ch.No. | Topics to be covered | TextBook /References | COsmapped | Actual Content covered | Methodologyused | Remarks byfaculty if any |
|  | L1 |  |  | World energy status, current energy scenario in India, environmental aspects of energy utilization, Classification of energy, Energy Resources, need of renewable energy, non-conventional energy sources. | R1 |  |  |  |  |
|  | L2, L3 |  |  | An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean energy, | R1 |  |  |  |  |
|  | L4, L5 |  |  | Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. Energy conservation and storage. | R1 |  |  |  |  |
|  | L6-L10 |  |  | Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell | R1, R2T1 |  |  |  |  |
|  | L11-L15 |  |  | absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems | R1, R2T1 |  |  |  |  |
|  | L16-L19 |  |  | Wind Energy: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.  | R1, R2 |  |  |  |  |
|  | L20-L22 |  |  | Ocean Energy, Potential against Wind and Solar, Wave Characteristics, Wave Energy Devices.  | R1, R2 |  |  |  |  |
|  | L23-L25 |  |  | Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.  | R1, R2 |  |  |  |  |
|  | L26-L30 |  |  | Biomass energy, resources, conversion, gasification, liquefaction, production, energy farming, | R1, R2 |  |  |  |  |
|  | L31-L33 |  |  | Geothermal Energy: Geothermal Resources, Geothermal Technologies. | R1, R2 |  |  |  |  |
|  | L34,L35 |  |  | small hydro resources. Layout, water turbines, classifications, generators, status.    | R1, R2 |  |  |  |  |
|  | L36-L38 |  |  | Direct Energy conversion: Thermoelectric effects, generators, Thermionic generators, magneto hydro dynamics generators, Fuel cells | R1, R2 |  |  |  |  |
|  | L39,L40 |  |  | photovoltaic generators, electrostatic mechanical generators, Thin film solar cells, nuclear batteries.  | R1, R2 |  |  |  |  |

**COURSE INFORMATION SHEET**

**Course code: PH 318**

**Course title: Introduction to Nuclear and Particle Physics**

**Pre-requisite(s): Intermediate Physics and Mathematics**

**Co- requisite(s):**

**Credits: 5** L:4 T: 1 P: 0

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE III**

**Branch: PHYSICS**

**Name of Teacher:**

|  |
| --- |
| **Title: Introduction to Nuclear and Particle Physics** |
| **Course objectives**Students will try to learn;1. The fundamental principles governing nuclear and particle physics and have a working knowledge of their application to real life problems.
2. About the subatomic physics, including radioactivity, experimental techniques, nuclear structure, particle interactions, and particle collisions and decays.
3. Skills needed to explain how radiation detector function and use for the measurement of radioactivity.
4. About the different types of nuclear reactors in use and how they produce nuclear energy for the useful purposes.
5. Classification of elementary particles and their decay modes.

**Course outcomes**After successful completion of the course student will be able to;1. Understand the fundamental principles and concepts governing classical nuclear and particle physics and have a working knowledge of their application to real -life problems.
2. Explain why nuclear radiations are emitted by radionuclides with very heavy atoms, and understand the nature and properties of the radiations.
3. Explain how charged and uncharged ionizing radiations interact with matter and the effects of the interactions on the material through which they traverse.
4. Classify and explain the function of different nuclear reactors.
5. Classify elementary particles and their possible decay modes
 |
| Code**PH 318** | **Title: Introduction to Nuclear and Particle Physics** | L-T-P-C[4-1-0-5] |
| Module-1 | General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.  | 20 |
| Module-2 | Radioactivity decay:(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) α-decay: energy kinematics for α-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). | 15 |
| Module-3 | Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. | 12 |
| Module-4 | Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator(Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. | 5 |
| Module-5 | Particle physics: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.  | 8 |
|  **Text Books:**1. Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
3. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
4. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

**Reference Books** 1.Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi 2. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000). |

|  |  |
| --- | --- |
| **Course Delivery methods** |  |
| Lecture by use of boards/LCD projectors/OHP projectors | Y |
| Tutorials/Assignments | Y |
| Seminars | N |
| Mini projects/Projects | N |
| Laboratory experiments/teaching aids | N |
| Industrial/guest lectures | N |
| Industrial visits/in-plant training | N |
| Self- learning such as use of NPTEL materials and internets | Y |
| Simulation  | N |

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

|  |  |
| --- | --- |
| **Assessment Tool** | **% Contribution during CO Assessment** |
| Mid Sem Examination Marks | 25 |
| End Sem Examination Marks  | 50 |
|  Quiz  | 10+10 |
| Teacher’s assessment | 5 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Assessment Compoents** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Mid Sem Examination Marks | **√** | **√** | **√** |  |  |
| End Sem Examination Marks  | **√** | **√** | **√** | **√** | **√** |
|  Quiz I |  |  | **√** |  |  |
| Quiz II |  |  |  | **√** |  |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

**Mapping between Course Objectives and Course Outcomes**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Objectives** | **1** | **2** | **3** | **4** | **5** |
| A | H | H | M | H | H |
| B | M | H | H | M | M |
| C | M | H | H | M | M |
| D | M | H | H | H | M |
| E | M | M | H | H | H |

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| a | b | c | d | e | f |
| 1 | H | H | H | H | H | H |
| 2 | M | H | H | H | H | H |
| 3 | H | H | M | H | H | H |
| 4 | M | M | H | H | H | H |
| 5 | M | H | H | H | H | H |

|  |
| --- |
| **Mapping Between COs and Course Delivery (CD) methods** |
| **CD**  | **Course Delivery methods** |  | **Course Outcome** | **Course Delivery Method** |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors |  | CO1 | CD1 and CD2 |
| CD2  | Tutorials/Assignments |  | CO2 | CD1 and CD2 |
| CD3  | Seminars |  | CO3 | CD1 and CD2 |
| CD4  | Mini projects/Projects |  | CO4 | CD1 and CD2 |
| CD5  | Laboratory experiments/teaching aids |  | CO5 | CD1 and CD2 |
| CD6  | Industrial/guest lectures |  | - | - |
| CD7  | Industrial visits/in-plant training |  | - | - |
| CD8  | Self- learning such as use of NPTEL materials and internets |  | - | - |
| CD9  | Simulation |  | - | - |

**Lecture wise Lesson planning Details.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | Lect.No. | TentativeDate | Ch No. | Topics to be covered | TextBook /References | COsmapped | Actual Content covered | Methodologyused | Remarks by faculty if any |
|  | 1-5 |  | 1. | quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number  | T1, T2 |  |  | PPT DigiClass/Chock-Board |  |
|  | 6-10 |  |  | main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.  | T1, T2 |  |  | PPT DigiClass/Chock-Board |  |
|  | 11-15 |  |  | Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas) | T1, T2 |  |  | PPT DigiClass/Chock-Board |  |
|  | 16-20 |  |  | evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force. | T1, T2 |  |  | PPT DigiClass/Chock-Board |  |
|  | 21-25 |  | 2. | (a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) α-decay: energy kinematics for α-decay, positron emission | T1, T2 |  |  | PPT DigiClass/Chock-Board |  |
|  | 26-30 |  |  | electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. Nuclear Reactions: Types of Reactions, | T1, T2 |  |  | PPT DigiClass/Chock-Board |  |
|  | 31-35 |  |  | Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). | T1, T2 |  |  | PPT DigiClass/Chock-Board |  |
|  | 36-37 |  | 3. | Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter | T3, R1 |  |  | PPT DigiClass/Chock-Board |  |
|  | 38-42 |  |  | photoelectric effect, Compton scattering, pair production, neutron interaction with matter. Gas detectors: estimation of electric field | T3, R1 |  |  | PPT DigiClass/Chock-Board |  |
|  | 43-47 |  |  | mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector. | T3, R1 |  |  | PPT DigiClass/Chock-Board |  |
|  | 48-52 |  | 4. | Van-de Graaff generator(Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. | T4, R1 |  |  | PPT DigiClass/Chock-Board |  |
|  | 53-55 |  | 5. | Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum | T4, R2 |  |  | PPT DigiClass/Chock-Board |  |
|  | 56-60 |  |  | angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons | T4, R2 |  |  | PPT DigiClass/Chock-Board |  |

**COURSE INFORMATION SHEET**

**Course code: PH 319**

**Course title: Nuclear Hazard and Waste Managements**

**Pre-requisite(s): Intermediate Physics**

**Co- requisite(s): Modern Physics**

**Credits: 5** L: 4 T: 1 P:0

**Class schedule per week: 5**

**Class: I.M.Sc.**

**Semester / Level: PE III**

**Branch: PHYSICS**

**Name of Teacher:**

|  |
| --- |
| **Title: Nuclear Hazard and Waste Managements**  |
| **Course objectives**This course will describe:1. What must be considered and achieved to satisfy the International Atomic Energy Agency (IAEA) Nuclear Energy Basic Principles in the area of radioactive waste management.
2. A framework for the design of programmes relating to radioactive waste management technology
3. A basis for the development of guidelines on radioactive waste management decommissioning and environmental remediation.

**Course outcomes**After successful completion of the course student will be able to;1. Know about the rules of IEAE and basic principles of Nuclear Energy
2. Get some knowledge relating to radioactive waste management technology
3. Understand guidelines on radioactive waste management decommissioning and environmental remediation
 |
| Code**PH 319** | **Title: Nuclear Hazard and Waste Managements**  | L-T-P-C[4-1-0-5] |
| Module-1 | Radiation interaction fundamentals, [Alpha particle](https://en.wikipedia.org/wiki/Alpha_particle), [Beta particle](https://en.wikipedia.org/wiki/Beta_particle), [Gamma ray](https://en.wikipedia.org/wiki/Gamma_ray), [Table of nuclides](https://en.wikipedia.org/wiki/Table_of_nuclides)[Half-life](https://en.wikipedia.org/wiki/Half-life)., [Radioactive decay](https://en.wikipedia.org/wiki/Radioactive_decay).[Radioactive waste](https://en.wikipedia.org/wiki/Radioactive_waste), Classification of Radioactive Wastes, High-level Waste (HLW), Intermediate-level Waste (ILW), Low-level Waste (LLW). Who is Responsible for Radioactive Wastes, Pertinent Legislation in the US Regarding Radioactive Hazards and Wastes: Examples. | 12 |
| Module-2 | Splitting the Atom for Energy, Status of Nuclear Power World-wide, Commercial Nuclear Power Generation, Nature of HLW as a Function of Time, Fast Reactors, The Nuclear Fuel Cycle, Options in the Fuel Cycle that Impact Waste Management, Once-Through Fuel Option, The Reprocessing Fuel Cycle (RFC), Advanced Fuel Cycle (AFC), Important Characteristics of Actinides. | 12 |
| Module-3 | Separations Technologies for the Nuclear Fuel Cycle, PUREX Process, DIAMEX Process, TRUEX Process, TRAMEX Process, TALSPEAK Process, Stereospecific Extractants, Non-aqueous Processes, Volatility Processes, Molten Salt Processes, Electrochemical Separations using Non-Aqueous Processes, Advanced Fuel Cycle Concepts and Partitioning and Transmutation (P&T). | 12 |
| Module-4 | Transmutation of Minor Actinides, Transmutation of the Long-lived Fission Products, Partitioning Schemes for the Minor Actinides and Long-lived Fission Products, Aqueous Chemical Processing, Improved PUREX Process - Removal of Np, I, and Tc, UREX and UREX+ Processes, Non-Aqueous Chemical Processing, Transmutation Devices for the Advanced Fuel Cycle. | 12 |
| Module-5 | Strategies for Implementation of an Advanced Fuel Cycle, Generation IV Nuclear Energy Systems, Advanced Fuel Cycle Development to Support Generation IV Energy Systems, The Advanced Fuel Cycle Initiative (AFCI), Areas of Scientific Concerns in the AFCI, Future of P&T Radioactive Waste Regulations, [Nuclear Waste Policy Act](https://en.wikipedia.org/wiki/Nuclear_Waste_Policy_Act) | 12 |
| **Text Book:**T1: Natural and Human Induced Hazards and Environmental Waste Management Volume 2 e-ISBN: 978-1-84826-300-0 ISBN : 978-1-84826-750-3 No. of Pages: 370  |
| **Ref. book:** **R1:** Management of Radioactive Waste after a Nuclear Power Plant Accident © OECD 2016 NEA No. 7305 NUCLEAR ENERGY AGENCY ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT**.**   |

|  |  |
| --- | --- |
| **Course Delivery methods** |  |
| Lecture by use of boards/LCD projectors/OHP projectors | Yes |
| Tutorials/Assignments | Yes |
| Seminars | Yes |
| Mini projects/Projects | No |
| Laboratory experiments/teaching aids | No |
| Industrial/guest lectures | No |
| Industrial visits/in-plant training | No |
| Self- learning such as use of NPTEL materials and internets | Yes |
| Simulation | No |

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

 **Direct Assessment**

|  |  |
| --- | --- |
| **Assessment Tool** | **% Contribution during CO Assessment** |
| Mid Sem Examination Marks | 25 |
| End Sem Examination Marks  | 50 |
|  Quiz  | 10+10 |
| Teacher’s assessment | 5 |
|  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Assessment Components** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Quizes | Yes | Yes | Yes | Yes | Yes |
| End Sem Examination Marks  | Yes | Yes | Yes | Yes | Yes |
| Assignment |  |  |  |  |  |

**Indirect Assessment –**

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| a | b | c | d | e | f |
| 1 | H | H | H | L | M | L |
| 2 | M | H | H | L | L | L |
| 3 | H | M | M | M | M | M |
| 4 | M | H | M | M | H | M |
| 5 | H | H | H | L | H | L |

|  |  |
| --- | --- |
| **Course Outcome #** | **Course Objectives** |
| A | B | C | D | E |
| 1 | H | M | M | M | M |
| 2 | L | H | L | L | M |
| 3 | L | M | H | M | M |
| 4 | H | L | H | H | L |
| 5 | H | M | M | L | H |

|  |
| --- |
| **Mapping Between COs and Course Delivery (CD) methods** |
|  |  |  |  |  |
| **CD**  | **Course Delivery methods** |  | **Course Outcome** | **Course Delivery Method** |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors |  | CO1 | CD1, CD2 and CD8 |
| CD2  | Tutorials/Assignments |  | CO2 | CD1, CD2 and CD8 |
| CD3  | Seminars |  | CO3 | CD1, CD2 and CD8 |
| CD4  | Mini projects/Projects |  | CO4 | CD1, CD2 and CD8 |
| CD5  | Laboratory experiments/teaching aids |  | CO5 | CD1, CD2 and CD8 |
| CD6  | Industrial/guest lectures |  |  |  |
| CD7  | Industrial visits/in-plant training |  |  |  |
| CD8  | Self- learning such as use of NPTEL materials and internets |  |  |  |
| CD9  | Simulation |  |  |  |

 **Lecture wise Lesson planning Details**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Week****No.** | **Lect.****No.** | **Tentative****Date** | **Module.****No.** | **Topics to be covered** | **Text****Book /****Refere****nces** | **COs****mapped** | **Actual Content covered** | **Methodology****used** | **Remarks by****faculty if any** |
| 1 | L1 |  | I | Radiation interaction fundamentals, [Alpha particle](https://en.wikipedia.org/wiki/Alpha_particle), [Beta particle](https://en.wikipedia.org/wiki/Beta_particle),  | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 1 | L2 |  | [Gamma ray](https://en.wikipedia.org/wiki/Gamma_ray), [Table of nuclides](https://en.wikipedia.org/wiki/Table_of_nuclides)[Half-life](https://en.wikipedia.org/wiki/Half-life)., | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 1 | L3-L4 |  | [Radioactive decay](https://en.wikipedia.org/wiki/Radioactive_decay).[Radioactive waste](https://en.wikipedia.org/wiki/Radioactive_waste), | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 2 | L5 |  | Classification of Radioactive Wastes, High-level Waste (HLW), Intermediate-level Waste (ILW), | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 2 | L6-L8 |  | Low-level Waste (LLW).Who is Responsible for Radioactive Wastes, | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 2 | L9-L10 |  | Pertinent Legislation in the US Regarding Radioactive Hazards and Wastes: Examples. | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 3 | L11-L13 |  | Splitting the Atom for Energy, Status of Nuclear Power World-wide | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 3 | L14-L16 |  | Commercial Nuclear Power Generation, Nature of HLW as a Function of Time | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 3 | L17- L18 |  | Fast Reactors, The Nuclear Fuel Cycle, Options in the Fuel Cycle that Impact Waste Management, Once-Through Fuel Option | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 4 | L19-L20 |  | II | The Reprocessing Fuel Cycle (RFC), Advanced Fuel Cycle (AFC), Important Characteristics of Actinides | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 4 | L21-22 |  | Separations Technologies for the Nuclear Fuel Cycle | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 5 | L23-24 |  | PUREX Process, DIAMEX Process, TRUEX Process | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 5 | L25-L26 |  | Non-aqueous Processes, Volatility Processes, Molten Salt Processes | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 6 | L27-L28 |  | Electrochemical Separations using Non-Aqueous Processes | T1 |  |  | PPT DigiClass/Chalk-Board |  |
| 6-7 | L29-L30 |  | Advanced Fuel Cycle Concepts and Partitioning and Transmutation (P&T). | T1 |  |  | PPT DigiClass/Chalk-Board |  |
|  | L31-L32 |  |  | Transmutation of Minor Actinides, Transmutation of the Long-lived Fission Products  | T1 |  |  | PPT DigiClass/Chalk-Board |  |
|  | L33-L35 |  | Partitioning Schemes for the Minor Actinides and Long-lived Fission Products | T1 |  |  | PPT DigiClass/Chalk-Board |  |
|  | L36-L38 |  | Aqueous Chemical Processing, Improved PUREX Process - Removal of Np, I, and Tc, UREX and UREX+ Processes | T1 |  |  | PPT DigiClass/Chalk-Board |  |
|  | L39-L40 |  | Non-Aqueous Chemical Processing, Transmutation Devices for the Advanced Fuel Cycle. | T1 |  |  | PPT DigiClass/Chalk-Board |  |
|  | L41-L43 |  | Strategies for Implementation of an Advanced Fuel Cycle, Generation IV Nuclear Energy Systems | T1 |  |  | PPT DigiClass/Chalk-Board |  |
|  | L44-L46 |  | Advanced Fuel Cycle Development to Support Generation IV Energy Systems | T1 |  |  | PPT DigiClass/Chalk-Board |  |
|  | L47-L48 |  | Advanced Fuel Cycle Initiative (AFCI), Areas of Scientific Concerns in the AFCI | T1 |  |  | PPT DigiClass/Chalk-Board |  |
|  | L49-L50 |  | Future of P&T Radioactive Waste Regulations, [Nuclear Waste Policy Act](https://en.wikipedia.org/wiki/Nuclear_Waste_Policy_Act). | T1 |  |  | PPT DigiClass/Chalk-Board |  |

**PE-IV**

**COURSE INFORMATION SHEET**

**Course code: PH 320**

**Course title: Atmospheric Physics**

**Pre-requisite(s):**

**Co- requisite(s): Intermediate Physics**

**Credits: 3** L:3 T: 0 P: 0

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE IV**

**Branch: PHYSICS**

**Name of Teacher:**

|  |  |  |
| --- | --- | --- |
| **Code PH 320** | **Title: Atmospheric Physics** | **L-T-P-C****[3-0-0-3]** |
| **Course Objectives:** This course enables the students

|  |  |
| --- | --- |
| A. | To explains the various component of the Earth system specially atmosphere and to understand the physics associated with atmospheric phenomenon.  |
| B. | To understand the dynamics associated with the atmospheric motion |
| C. | To appreciate the basic laws associated with the solar radiation and remote sensing |
| D. | To understand the basic instruments based on the remote sensing |
| E. | To enlighten atmospheric aerosols and related laws to govern its role in atmosphere |

**Course Outcomes:** After the completion of this course, students will

|  |  |
| --- | --- |
| A. | Be able to explain thermal structure of earth, composition of atmosphere and various atmospheric phenomenon |
| B. | Be able to explain the dynamics of atmospheric motion |
| C. | Be able to appreciate the laws of atmospheric radiation balance and basic laws of remote sensing. |
| D. | Get familiar with instruments based on remote sensing |
| E. | Acquire knowledge of atmospheric aerosols and its impact |

 |
| Module-1 |  **General features of Earth’s atmosphere:** Thermal structure of the Earth’s Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations  | **8** |
| Module-2 | **Atmospheric Dynamics:** Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity  | **8** |
| Module-3 | **Atmospheric radiation** **and remote sensing** Fundamental laws of radiation: Planks law, Stefan’s Boltzmann law, Wien’s displacement law, Kirchhoff’s law; Spectral distribution of solar radiation and atmosphere interaction, path radiance, turbulance, cloud effect; Outgoing long-wave radiation, Radiation budget, Atmospheric windows, Emissivity, Absorption spectra of atmospheric gases, optical depth, atmospheric correction techniques for remote sensing data, SST extraction  | **8** |
| Module-4 | **Atmospheric Radar and Lidar:** Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques  | **8** |
| Module-5 | **Atmospheric Aerosols:** Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Lambert’s and Beer’s laws, Radiative and health effects, Air pollution/pollutants, Effect of boundary layer dynamics on air pollutants  | **8** |
| **Text/Reference Books:**T1: Atmospheric Science : An Introductory Survey ,Second Edition -John M.Wallace and Peter V. Hobbs, University of WashingtonR2: Atmospheric chemistry and physics: from air pollution to climate change, Second edition- John H. Seinfeld, Spyros N. Pandis, a wiley-interscience publication, john wiley & sons, inc.R3: An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004R4: Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014R5: Fundamentals of Remote Sensing, George Joseph and Jeganathan, c. (2017). 3rd Edition, Universities Press, ISBN 978 93 86235 46 6 |

|  |  |
| --- | --- |
| **Course Delivery methods** |  |
| Lecture by use of boards/LCD projectors/OHP projectors | Y |
| Tutorials/Assignments | Y |
| Seminars | N |
| Mini projects/Projects | N |
| Laboratory experiments/teaching aids | Y |
| Industrial/guest lectures | N |
| Industrial visits/in-plant training | N |
| Self- learning such as use of NPTEL materials and internets | Y |
| Simulation  | N |

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

|  |  |
| --- | --- |
| **Assessment Tool** | **% Contribution during CO Assessment** |
| Mid Sem Examination Marks | 25 |
| End Sem Examination Marks  | 50 |
|  Quiz  | 10+10 |
| Teacher’s assessment | 5 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Assessment Components** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Mid Sem Examination Marks | **√** | **√** | **√** |  |  |
| End Sem Examination Marks  | **√** | **√** | **√** | **√** | **√** |
|  Quiz I |  |  | **√** | **√** |  |
| Quiz II |  |  |  |  |  |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

**Mapping between Course Objectives and Course Outcomes**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Objectives** | **1** | **2** | **3** | **4** | **5** |
| A | H | H | H | H | M |
| B | H | H | M | L | M |
| C | M | L | H | H | M |
| D | H | M | H | H | H |
| E | M | M | M | M | H |

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | H | H | M | M | H | H |
| 2 | H | H | M | M | H | H |
| 3 | H | H | M | M | H | H |
| 4 | H | H | M | M | H | H |
| 5 | H | H | M | M | H | H |

|  |
| --- |
| **Mapping Between COs and Course Delivery (CD) methods** |
| **CD**  | **Course Delivery methods** | **Course Outcome** | **Course Delivery Method** |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors | CO1 | CD1 and CD2 |
| CD2  | Tutorials/Assignments | CO2 | CD1 and CD2 |
| CD3  | Seminars | CO3 | CD1 and CD2 |
| CD4  | Mini projects/Projects | CO4 | CD1 and CD2 |
| CD5  | Laboratory experiments/teaching aids | CO5 | CD1 and CD2 |
| CD6  | Industrial/guest lectures | - | - |
| CD7  | Industrial visits/in-plant training | - | - |
| CD8  | Self- learning such as use of NPTEL materials and internets | - | - |
| CD9  | Simulation | - | - |

**Lecture wise Lesson planning Details.**

T1: Atmospheric Science : An Introductory Survey ,Second Edition -John M.Wallace and Peter V. Hobbs, University of Washington

R1: Atmospheric chemistry and physics: from air pollution to climate change, Second edition- John H. Seinfeld, Spyros N. Pandis, a wiley-interscience publication, john wiley & sons, inc.

R2: An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

R3: Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014

R4: Fundamentals of Remote Sensing, George Joseph and Jeganathan, c. (2017). 3rd Edition, Universities Press, ISBN 978 93 86235 46 6

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | Lect.No. | TentativeDate | Ch.No. | Topics to be covered | TextBook /References | COsmapped | Actual Content covered | Methodologyused | Remarks byfaculty if any |
| 1 | L1-L2 |  |  | Thermal structure of the Earth’s Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics,  | T1,R2 |  |  |  |  |
|  | L3-L4 |  |  | Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, | T1,R2 |  |  |  |  |
|  | L5-L6 |  |  | Atmospheric boundary layer, Sea breeze and land breeze. | T1 |  |  |  |  |
|  | L7-L8 |  |  | Instruments for meteorological observations | T1,R3, R4 |  |  |  |  |
|  | L9-L12 |  |  | Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system,  | R2 |  |  |  |  |
|  | L13-L16 |  |  | scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity  | R2 |  |  |  |  |
|  | L17-L20 |  |  | Fundamental laws of radiation: Planks law, Stefan’s Boltzmann law, Wien’s displacement law, Kirchhoff’s law; Spectral distribution of solar radiation and atmosphere interaction, path radiance, turbulance, cloud effect; Outgoing long-wave radiation,  | R1,R4 |  |  |  |  |
|  | L21-L24 |  |  | Radiation budget, Atmospheric windows, Emissivity, Absorption spectra of atmospheric gases, optical depth, atmospheric correction techniques for remote sensing data, SST extraction  | R1,R4 |  |  |  |  |
|  | L25-L28 |  |  | Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena,  | R3, R4 |  |  |  |  |
|  | L31-L32 |  |  | Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques  | R3, R4 |  |  |  |  |
|  | L33-L36 |  |  | Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Lambert’s and Beer’s laws,  | T1,R1 |  |  |  |  |
|  | L37-L40 |  |  | Radiative and health effects, Air pollution/pollutants, Effect of boundary layer dynamics on air pollutants  | T1,R1 |  |  |  |  |

**COURSE INFORMATION SHEET**

**Course code: PH 321**

**Course title: Advanced Experimental Techniques**

**Pre-requisite(s):**

**Co- requisite(s): Intermediate Physics**

**Credits:** L: 3 T: 0 P: 0 C : 3

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE IV**

**Branch: PHYSICS**

**Name of Teacher:**

|  |  |  |
| --- | --- | --- |
| **Code** **PH 321** | **Title: Advanced Experimental Techniques** | **L-T-P-C****[3-0-0-3]** |
| **Course Objectives:**1. To provide knowledge of various types of experimental techniques used to analyze all types of materials.
2. Students learn to analyze gaseous, liquid, amorphous and crystalline materials.
3. They learn to analyze elemental composition, thickness of the thin film, elemental depth profiling, etc.
4. They will know how to generate vacuum to prepare different types of materials.
5. To understand the use and applications of vacuum systems

**Course Outcomes:**1. Student will be able to judge that which techniques will be useful to analyze the given materials.
2. They can design novel experiments to take up scientific problems.
3. They will be able to collect, critically analyze and interpreted the data.
4. They can generate good quality of data and will be able to take up the industrial problems of any field.
5. Students learn about basics of vacuum and various pumps and their applications in R&D.
 |
| Module-1 | **X-ray Diffraction Methods:**  Classification of crystal system, Bragg’s law and Laue conditions, Powder methods, crystal size analysis, Rietvold method of structural analysis, X-ray fluorescence spectroscopy, applications of emission spectra for compounds and alloys, Applications of absorption spectra for solid solutions and transitional metal compounds, Neutron spectroscopy. X-Ray Reflectivity | **10** |
| Module-2 | **Microscopy & Spectroscopy**  Optical microscopy, metallurgical microscope, TEM, SEM and AFM, Atomic absorption spectrophotometer and its application to environmental analysis, UV-visible spectroscopy and its application, IR-spectroscopy and its application, AES, XPS, Introduction to RBS, SIMS, and its applications. Basic principles of ESR, Instrumentations and applications, Principle of Mossbauer spectroscopy, Isomer shift, Quadruple splitting and hyperfine interaction, applications-in determination of phases and diffusion studies. | **15** |
| Module-3 | **Thermochemical analysis** Thermo analytical techniques, Instrumentation and applications of TGA, DTA, DSC. [ | **5** |
| Module-4 | **Electrochemical Techniques** Electrochemical Instrumentation, Coulometry, polarography, cyclic voltametry, application to oxidation-reduction reaction, Principle of Corrosion, types and prevention | **10** |
| Module-5 | **Vacuum Technology & Thin film Deposition Technique** Application to Vacuum Technology, Types of vacuum pumps, different technique of thin film deposition CVD, PVD, MBE, MOCVD | **10** |
| **References**:1. Solid State Physics- Structure and Properties of Materials M. A. Wahab, Narosa 2015. 2. Spectroscopy, Vol. I, II and III, ed. By Straughan and Walker, John Wiley.3. Surface Analysis – The Principal Techniques, Edited by J. C. Vickerman, John Willey & Sons4. Instrumental Methods of Chemical Analysis By G. W. Ewing, Mcgraw –Hill Book Company5. Vacuum Science and Technology by [V.V. Rao](https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:%22Dr.+V.V.+Rao%22), [T.B. Gosh](https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:%22Dr.+T.B.+Gosh%22), [K.L. Chopra](https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:%22Dr.+K.L.+Chopra%22), Allied Publishers, 17-Oct-1998 |

|  |  |
| --- | --- |
| **Course Delivery methods** |  |
| Lecture by use of boards/LCD projectors/OHP projectors | Y |
| Tutorials/Assignments | Y |
| Seminars | Y |
| Mini projects/Projects | Y |
| Laboratory experiments/teaching aids | Y |
| Industrial/guest lectures | Y |
| Industrial visits/in-plant training | Y |
| Self- learning such as use of NPTEL materials and internets | Y |
| Simulation  | Y |

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

|  |  |
| --- | --- |
| **Assessment Tool** | **% Contribution during CO Assessment** |
| Mid Sem Examination Marks | 25 |
| End Sem Examination Marks  | 50 |
|  Quiz  | 10+10 |
| Teacher’s assessment | 5 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Assessment Components** | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
| Mid Sem Examination Marks | **√** | **√** | **√** |  |  |
| End Sem Examination Marks  | **√** | **√** | **√** | **√** | **√** |
|  Quiz I | **√** |  |  |  |  |
| Quiz II |  | **√** |  |  |  |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

**Mapping between Course Objectives and Course Outcomes**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Objectives** | **1** | **2** | **3** | **4** | **5** |
| A | H | H | H | H | M |
| B | H | H | M | L | M |
| C | M | L | H | H | M |
| D | H | M | H | H | H |
| E | H | M | M | H | H |

**Mapping of Course Outcomes onto Program Outcomes**

|  |  |
| --- | --- |
| **Course Outcome #** | **Program Outcomes** |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | H | H | M | M | H | H |
| 2 | H | H | M | M | H | H |
| 3 | H | H | M | M | H | H |
| 4 | H | H | M | M | H | H |
| 5 | H | H | M | M | H | H |

|  |
| --- |
| **Mapping Between COs and Course Delivery (CD) methods** |
| **CD**  | **Course Delivery methods** | **Course Outcome** | **Course Delivery Method** |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors | CO1 | CD1 and CD2 |
| CD2  | Tutorials/Assignments | CO2 | CD1 and CD2 |
| CD3  | Seminars | CO3 | CD1 and CD2 |
| CD4  | Mini projects/Projects | CO4 | CD1 and CD2 |
| CD5  | Laboratory experiments/teaching aids | CO5 | CD1 and CD2 |
| CD6  | Industrial/guest lectures | - | - |
| CD7  | Industrial visits/in-plant training | - | - |
| CD8  | Self- learning such as use of NPTEL materials and internets | - | - |
| CD9  | Simulation | - | - |

**Lecture wise Lesson planning Details.**

T1: Atmospheric Science : An Introductory Survey ,Second Edition -John M.Wallace and Peter V. Hobbs, University of Washington

R1: Atmospheric chemistry and physics: from air pollution to climate change, Second edition- John H. Seinfeld, Spyros N. Pandis, a wiley-interscience publication, john wiley & sons, inc.

R2: An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004

R3: Radar for meteorological and atmospheric observations – S. Fukao and K. Hamazu, Springer Japan, 2014

R4: Fundamentals of Remote Sensing, George Joseph and Jeganathan, c. (2017). 3rd Edition, Universities Press, ISBN 978 93 86235 46 6

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| WeekNo. | LectNo. | TentativeDate | Ch.No | Topics to be covered | TextBook /References | COsmapped | Actual Content covered | Methodologyused | Remarks byfaculty if any |
| 3 | L1-L10 |  |  | Module I | R1 |  |  |  |  |
| 3 | L11-L25 |  |  | Module 2 | R2,34,5 |  |  |  |  |
| 1 | L26-L30 |  |  | Module 3 | R2,3,4,5 |
| 2 | L31-L40 |  |  | Module 4 | R1,4 |  |  |  |  |
| 3 | L41-50 |  |  | Module 5 | R5 |  |  |  |  |

**COURSE INFORMATION SHEET**

**Course code: PH 324**

**Course title: Nonconventional Sources of Energy Lab**

**Pre-requisite(s):** Student should have knowledge of Solid State Physics

**Co- requisite(s):** Knowledge of Basic Mathematics

**Credits:** L: 0 T:0 P: 4 C : 2

**Class schedule per week:** 3

**Class: I.M.Sc.**

**Semester / Level: III**

**Branch:** Physics

**Name of Teacher:**

|  |
| --- |
| **Nonconventional Sources of Energy Lab****L-T-P-C**  **[0-0-4-2]****List of Experiments:**1. Measurement of solar cell characteristic of wafer based Si solar cell
2. Fabrication of DSSC and Measurement of solar cell characteristic
3. Conversion of vibration to voltage using piezoelectric materials
4. Conversion of thermal energy into voltage using thermocouple
5. Effect of Load on Wind Turbine Output by using wind experiment kit
6. Solar thermal energy convertor: Solar water heater efficiency, Solar room heater efficiency, solar cooker max temp. determination
7. Solar thermal energy convertor: Solar water heater efficiency, Solar room heater efficiency, solar cooker max temp. determination Parabolic type solar collector
8. Concentrating type solar collector (Reflector or solar Scheffler dish by tracking system).
9. Fuel cells efficiency determination
10. Light efficiency measurement and comparison of sources (like: incandescent bulb, tube, CFL, LED, etc)
11. Wind mill blade design parameters and torque relationship
12. Experiments in Power Electronics for interconnection of various subsystems:dc-dc convertors, ac-dc / dc to ac convertors for PV systems, wind generators, etc.
13. Data acquisition for obtaining parameters of water waves
 |

**COURSE INFORMATION SHEET**

**Course code: PH 325**

**Course title: Atmospheric Physics Lab**

**Pre-requisite(s): Intermediate Physics**

**Co- requisite(s):**

**Credits:** L: 0 T: 0 P: 4 C : 2

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE IV**

**Branch: PHYSICS**

**Name of Teacher:**

|  |
| --- |
| **Atmospheric Physics Lab** **L-T-P-C**  **[0-0-4-2]**1. Monitoring and estimation of Respirable Suspended Particulate Matter in the ambient air by respirable dust sampler.
2. Monitoring and estimation of NOx in the ambient air by NOx analyzer.
3. Monitoring and estimation of SOx in the ambient air by High Volume Sampler.
4. Monitoring and estimation of CO in the ambient air by CO analyzer.
5. Monitoring and analysis of CO2 in the ambient air by CO2 monitor.
6. Statistical analysis for one month data of atmospheric parameters (Temperature, Relative humidity, pressure, wind speed)
7. Computational analysis for few months data of atmospheric parameters i.e. Temperature, Relative humidity, pressure, wind speed (find daily variation, diurnal variation, wind rose)
8. Estimation and analysis of aerosol optical with satellite data
9. Estimation of analysis of aerosol related properties from AERONET data of any site
10. Estimation and analysis of Sea surface temperature with satellite data
11. Estimation and analysis of Outgoing longwave radiation with satellite data
12. Calculation of color temperature by Planck law.
 |

**COURSE INFORMATION SHEET**

**Course code: PH 326**

**Course title: Advanced Experimental Techniques Lab**

**Pre-requisite(s):**

**Co- requisite(s): Intermediate Physics**

**Credits:** L: 0 T: 0 P: 4 C : 2

**Class schedule per week:**

**Class: I.M.Sc.**

**Semester / Level: PE IV**

**Branch: PHYSICS**

**Name of Teacher:**

|  |
| --- |
| **Advanced Experimental Techniques Lab****L-T-P-C**  **[0-0-4-2]**1. To find corrosion rate using tafel plot
2. To do plasma nitriding coating using nitriding system
3. To understand the working of magnetron coating unit and deposit thin film.
4. To deposit nanocrystalline coating
5. To deposit hard coating and determine hardness of thin film
6. To deposit thin film using anodic vacuum arc coating
7. Determination of elemental and structural analysis using EDX and SEM
8. structural and particle size determination using XRD
9. Band gap determination using UV-visible spectrometer
10. To study the polarizattion vs electric field of ferroelectric materials
11. Phase transition study of barium titanate
 |