**M.Sc.PHYSICS**

**Syllabus**

**(With effect from 2022-2023)**

**Program Code:**



**DEPARTMENT OF PHYSICS**

**Bharathiar University**

**(A State University, Accredited with “A”Grade by NAAC and**

**14th Rank among Indian Universities by MoE-NIRF)**

**Coimbatore 641046, INDIA**

**BHARATHIAR UNIVERSITY: COIMBATORE 641046**

**DEPARTMENT OF PHYSICS**

**MISSION**

To impart quality science education to make our student scientifically superior, ethically strong, to improve the quality of the human race and to create harmony and peace in the world by means of the words of Bharathiar “EDUCATE to ELEVATE”.

Our mission is to educate students from all corners of the society to improve their living standards through their scientific as well as analytical skills and innovations.

**Instruction:PEOs are:**

* Statement of areas or fields where the graduates find employment
* Preparedness of graduates to take up higher studies

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| **Program Educational Objectives (PEOs)** |
| The **M. Sc. Physics** program describe accomplishments that graduates are expected to attain within five to seven years after graduation |
| From the skills imparted / learned / acquired |
| PEO1 | The students will elevate themselves as job providers/entrepreneurs  |
| PEO2 | They will hold positions in school education / higher education sectors  |
| PEO3 | They will decorate the positions as leading scientists at R&D institutions |
| PEO4 | Pursue their higher studies (Doctoral / Post-Doctoral) at leading institutions across the globe |
| PEO5 | They will undertake positions in the Public/ Administrative services |
| PEO6 | They will serve the country in defense sectors technical experts |
| PEO7 | Elevate themselves as consultants to provide solutions for the industrial problems |
| PEO8 | Find positions in the financial sector |
| PEO9 | Potential resource persons in the non-conventional energy resource sectors |
| PEO10 | They will become a talented pool of source for the semiconductor device fabrication industries / energy material laboratories |
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**Instruction:Program Specific Outcomes (PSOs)**

These are what the students should be able to do at the time of graduation. The PSOs are program specific. PSOs are written by the department offering the program. There usually are five to seven PSOs for a department.

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| **Program Specific Outcomes (PSOs)** |
| After the successful completion of M.Sc., (PHYSICS) program, the students are expected to |
| PSO1 | Problem Analysis – Ability to identify and analyze complex Physics problems using the Physics principles /mathematical tools. |
| PSO2 | Acquired skills will put the learners at an advantage in careers as diverse as physics, material physics, bio-physics, quantum physics, bio-medical, applied mathematics, education and computer science. |
| PSO3 | Graduates will be molded to adopt, absorb and develop innovative ideas |
| PSO4 | Ability to work in a team in sharing the knowledge learned exhibiting the effective individual talent |
| PSO5 | Ability to communicate effectively with peers and professionals and society at large by giving seminars / popular lectures / talks |
| PSO6 | Expected to develop professional ethics and demonstrate commitment to professional ethics; Ability to engage themselves in lifelong learning and teaching process |

**Instruction: Programme Outcomes** are narrow statements that describe what the students are expected to know and would be able to do upon the graduation. These relate to the skills, knowledge, and behavior that students acquire through the programme.

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| **Program Outcomes**  |
| On successful completion of the M.Sc. Physics Program |
| PO1 | Understanding the basic knowledge/techniques/skills/modern tools |
| PO2 | Ability to apply knowledge on the latest development of the topic |
| PO3 | Experimental/Programming /Problem solving skills |
| PO4 | Newer experimental/programming code writing skills |
| PO5 | Team work/Analytical skills |
| PO6 | Effective communication capability |
| PO7 | Out spoken/group discussion/facing questions in the topic |
| PO8 | Independent thinking/confidence in the subject studied |
| PO9 | Obey professional, ethical and social responsibilities  |
| PO10 | Commitment towards quality, timeliness, and continuous improvement |

**Eligibility for Admission:**

A candidate who have passed B.Sc. degree examination with Physics as Major and Mathematics as one of the subjects.

**BHARATHIAR UNIVERSITY: COIMBATORE 641 046**

**M. Sc. PHYSICS Curriculum (University Department)**

*(For the students admitted during the academic year 2022 – 2023 onwards)*

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| --- | --- | --- | --- | --- |
| **Course Code** | **Title of the Course** | **Credits** | **Teaching Hours / Week** | **Maximum Marks** |
| **Theory** | **Practical** | **CIA** | **ESE** | **Total** |
| **FIRST SEMESTER** |
| 22PHYC01 | Classical Mechanics | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYC02 | Mathematical Physics - I | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYC03 | Condensed Matter Physics - I | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYE01 | Industrial Electronics(Or)Molecular Physics(Or)Industry 4.0 | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYL01 | Electronics Lab | 4 | - | 6 | 50 | 50 | 100 |
|  | Offered from/to other Departments | 2 | 2 | - | 25 | 25 | 50 |
| **Total** | 22 | 22 | 6 | 275 | 275 | 550 |
| **SECOND SEMESTER** |
| 22PHYC04 | Quantum Mechanics - I | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYC05 | Mathematical Physics - II | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYC06 | Condensed Matter Physics -II | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYE02 | Computational Methods & Programming(Or)Data Analysis Techniques(Or)Introduction to Data Analytics | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYL02 | Computational Programming Lab | 4 | - | 6 | 50 | 50 | 100 |
|  | Offered from/to other Departments | 2 | 2 | - | 25 | 25 | 50 |
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| **Total** | 22 | 22 | 6 | 275 | 275 | 550 |

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| --- | --- | --- | --- | --- |
| **Course Code** | **Title of the Course** | **Credits** | **Teaching Hours / Week** | **Maximum Marks** |
| **Theory** | **Practical** | **CIA** | **ESE** | **Total** |
| **THIRD SEMESTER** |
| 22PHYC07 | Quantum Mechanics - II | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYC08 | Electromagnetic Theory | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYC09 | Nuclear and Particle Physics | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYC10 | Thermodynamics & Statistical Mechanics | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYL03 | Advanced Physics Lab | 4 | - | 6 | 50 | 50 | 100 |
|  | Offered from/to other Departments | 2 | 2 | - | 25 | 25 | 50 |
|  |  |  |  |  |  |  |  |
| **Total** | 22 | 22 | 6 | 275 | 275 | 550 |
| **FOURTH SEMESTER** |
| 22PHYC11 | Semiconductor Devices | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYC12 | Atomic Physics & Molecular Spectroscopy | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYE03 | Modern Optics (Or)Materials Physics & Processing techniques(Or)Artificial Intelligence | 4 | 5 | - | 50 | 50 | 100 |
| 22PHYL04 | Optics and Laser Lab | 4 | - | 6 | 50 | 50 | 100 |
| 22PHYP01 | Project | 8 | 7 |  | 100 | 100 | 200 |
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| **Total** | 24 | 22 | 6 | 300 | 300 | 600 |
| **Grand Total** | 90 | 88 | 24 | 1125 | 1125 | 2250 |

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| **ONLINE COURSES**In addition to the above, the students have to take any online course from Swayam, Coursera, NPTEL, E-PG Pathshala etc., **for two additional credits** which may be availed at any time during the course of study.  |

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| **SUPPORTIVE COURSES****(Offered to other Department Students)** |
| 22PHYS01 | Basic Electronics(Offered during odd semester) | 2 | 2 | - | 25 | 25 | 50 |
| 22PHYS02 | Energy Resources(Offered during even semester) | 2 | 2 | - | 25 | 25 | 50 |

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| **ADD ON COURSES** |
| **Value Added Courses (Any two offered during 1st and 2nd Year – One course per year)** |
| **Course Code** | **Title of the Course** | **Credits** | **Hours** | **Maximum Marks** |
| **Theory** | **Practical** | **CIA****(Theory)** | **CIA****(Lab)** | **Total** |
| 22PHYV01 | Astrophysics and Cosmology | 2 | 2 | - | 100 | - | 100 |
| 22PHYV02 | Programming with Python | 2 | 2 | 2 | 50 | 50 | 100 |
| 22PHYV03 | Nuclear data for Science & Technology | 2 | 2 | - | 50 | 50 | 100 |
| 22PHYV04 | The art and science of growing crystals | 2 | 2 | 2 | 50 | 50 | 100 |
| **Job Oriented Courses (Offered during 1st and 2nd Year – One course per year)** |
| **Course Code** | **Title of the Course** | **Credits** | **Hours** | **Maximum Marks** |
| **Theory** | **Practical** | **CIA****(Theory)** | **CIA****(Lab)** | **Total** |
| 22PHYJ01 | Plasma Physics and Technology | 2 | 3 | - | 50 | 50 | 100 |
| 22PHYJ02 | Installation and Maintenance of Solar Photovoltaic Systems | 2 | 3 | 3 | 50 | 50 | 100 |

1. **Theory Papers** (Core– 12 x 4 = 48 Credits, Elective– 3 x 4 = 12 credits, Supportive– 3 x 2 = 6 Credits)

**Question paper pattern for Core and Elective courses**

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| --- | --- | --- | --- | --- |
| **External Exam** | Maximum Marks | 50 Marks | Duration | 3 Hours |
| **Part – A*** Answer ALL questions
* Each questions carries one mark
* Two questions from each unit
* Objective questions with four choices
 | 10 x 1 = 10 Marks |
| **Part – B** * Answer ALL questions
* Each questions carries three marks
* One question from each unit with internal choice of either-or type
* Outof the total ten questions 2questions must be problem oriented
 | 5 x 3 = 15 Marks |
| **Part – C** * Answer ALL questions
* Each questions carries five marks
* One question from each unit with internal choice of either-or type
* Out of the total ten questions 2 questions must be problem oriented
 | 5 x 5 = 25 Marks |

1st and 2nd Internal Exams

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| **Internal Exam** | Maximum Marks | 30 Marks | Duration | 2 Hours |
| **Part – A*** Answer ALL questions
* Each question carries one mark
* Objective questions with four choices
 | 5 x 1 = 5 Marks |
| **Part – B** * Answer ALL questions
* Each question carries three marks
* To answer five questions out of seven questions
 | 5 x 3 = 15 Marks |
| **Part – C** * Answer ALL questions
* Each question carries five marks
* To answer two questions out of four questions
 | 2 x 5 = 10 Marks |

3rd Internal Exam

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| --- | --- | --- | --- | --- |
| **External Exam** | Maximum Marks | 50 Marks | Duration | 3 Hours |
| **Part – A*** Answer ALL questions
* Each questions carries one mark
* Two questions from each unit
* Objective questions with four choices
 | 10 x 1 = 10 Marks |
| **Part – B** * Answer ALL questions
* Each questions carries three marks
* One question from each unit with internal choice of either-or type
* Out of the total ten questions 2 questions must be problem oriented
 | 5 x 3 = 15 Marks |
| **Part – C** * Answer ALL questions
* Each questions carries five marks
* One question from each unit with internal choice of either-or type
* Out of the total ten questions 2 questions must be problem oriented
 | 5 x 5 = 25 Marks |

1. **Distribution of Continuous Internal Assessment Marks:**

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| Written Exam | 30 Marks (Average of best two out of three exams) |
| Assignment | 10 Marks (Anassignment within the/ related contents of the course) |
| Seminar | 05 Marks (A seminar within the/ related contents of the course) |
| Others | 05 Mark (Class participation, group discussion, quiz, participation and presentation in conferences |

1. **Lab Courses(4 Labs – 4 x 4 = 16 Credits)**

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| **External Exam** | Maximum Marks | 50 Marks | Duration | 6 Hours |
| **Distribution of Marks** |  |  |  |
| Practical Record | 15 Marks |
| Formula with explanation, Algorithm, Flowchart, Diagram, Tables | 10 Marks |
| Readings, Calculations and Programs | 20 Marks |
| Correct Results with proper units | 5 Marks |

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| **CIA** | Maximum Marks | 50 Marks | Duration | 6 Hours |
| **Distribution of Marks** |  |  |  |
| Observation | 15 Marks |
| Internal Exam | 20 Marks |
| Record submission | 10 Marks |
| Attendance | 5 Marks |

1. **Project Course(8 Credits) – Total of 200 Marks**

**Internal Marks: Maximum 100 Marks**

(Marks to be awarded by the supervisor, based on the consistence progress of the research work, skill, basic understanding of the problem, regular attendance in the lab, presentation, discussion etc.)

**External Marks: Maximum 100 Marks**

60 – Marks – For the duly completed project report

(Marks to be awarded by the supervisor in consultation with the external examiner, based on the presentation of the project report in a bind form, with proper contents, introduction and literature related to the problem chosen, results and discussions supported by necessary figures, tables, references)

40 – Marks – For the presentation by the student in the Viva-Voce exam

(Marks to be awarded by the external examiner in consultation with the internal examiner based on testing the basic understanding, lucid presentation, grasp of the problem, confidence, and mode of communication)

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| **Course** **Code** | **22PHYC01** | **CLASSICAL MECHANICS** | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Basics knowledge in Mechanics (Newtonian)Knowledge in Calculus (Vector, Differential, Integral) | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are: 1. This course introduces the mathematical structure of theoretical physics. The students should able to correlate the conservation of fundamental physical concepts with symmetries
2. The Newtonian mechanics needed for understanding the motion of a system of particles and the associated forces will be introduced. The motion of celestial bodies, and the governing differential equations, the dynamics and kinematics of the rigid bodies will be introduced.
3. The concept of generalized coordinates needed for elimination of constraints, notion of configuration and phase space, variational principles, invariance under transformations will be constructed as a framework to understand the Lagrangian, Hamiltonian and Hamilton-Jacobi formalism for describing the dynamics.
4. The importance of normal modes of vibrating systems and the basic concepts of relativity will be introduced.
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Explain the concepts such as degrees of freedom, constraints, needed for Newtonian mechanics and apply them to mechanical systems | K1,K2 |
| 2 | Explain the concept of generalized coordinates, Phase space and understand the physical principle of Lagrange and Hamilton's equations, and the advantages of these formulations.  | K1,K3,K5 |
| 3 | Construct the Lagrangian and Hamiltonian and solve equations of motion for simple one and two body system, rigid bodies, coupled oscillators. | K3 |
| 4 | Relate symmetries to conservation laws in physical systems, and apply these concepts to practical situations,  | K3,K4 |
| 5 | Solve orbit problems using the conservation of angular momentum and total energy and understand the fundamental principles of the special theory of relativity. | K4,K5 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **Mechanics of Single and Systems of Particles** | **14 hours** |
| Newton’s laws of motion, Mechanics of a particle, Equation of motion of a particle - Motion of a particle under constant force, the law of gravitational and electrostatic forces, motion under a force which depends on time only and motion of a particle subjected to resistive force. Mechanics of systems of particles - Angular momentum of the system - Potential and kinetic energies of the system- Degrees of freedom - Constraints - Motion in a central force field - Motion of two particles equivalent to single particle - Equation of motion of center of mass with respect to center of force - Motion in an inverse-square law force field equation of the orbit, - differential equation of trajectory - Kepler’s Law of planetary motion |
| **Unit:2** | **Collisions of Particles and Motion of Rigid Body** | **14 hours** |
| Elastic and inelastic scattering - Laboratory and center of mass systems - Relations between different quantities in the laboratory and center of mass systems –Kinematics of elastic scattering in the laboratory system, Loss of kinetic energy - Inelastic scattering in the laboratory frame - Motion of a rigid body -Euler’s theorem - Angular momentum and kinetic energy - Inertia tensor - Euler’s equation of motion – Torque Free Motion – Euler’s angles. |
| **Unit:3** | **Lagrangian and Hamiltonian Formulations** | **14 hours** |
| Generalized coordinates - Hamilton’s variational principle - Lagrange’s equations of motion –Conservation theorems and symmetry properties – Cyclic coordinates - Application of Lagrange’s equation; Linear harmonic oscillator, particle moving under a central force, Atwood’s machine - Hamilton’s equations of motion - Application of Hamiltonian’s equations of motion; Particle moving in an electromagnetic field - Phase space - Principle of Least action. |
| **Unit:4** | **Canonical Transformations and Poisson Brackets** | **14 hours** |
| Canonical transformations – Generating function – Properties of canonical transformations, condition for a transformation to be canonical, Poisson brackets – Properties of Poisson brackets, Equations of motion in Poisson bracket, Angular momentum and Poisson brackets, Poisson’s Second Theorem, Invariance of Poisson bracket under canonical transformation, Motion as successive canonical transformation (Infinitesimal generators), Liouville’s theorem, The Hamilton Jacobi Equation,- Principal and characteristic function **-** Solution of harmonic oscillation problem by H-J method, Action and angle variables. |
| **Unit:5** | **Small Oscillations and Relativity** | **14 hours** |
| Small oscillations - Stable and unstable equilibrium - Lagrange’s equation of motion for small oscillations - Normal coordinates and normal frequencies - Small oscillations of particles on string - Free vibrations of a linear triatomic molecule – Two carts connected with three springs, Double pendulum. Galilean transformation- Invariance of Newton’s law, Lorentz transformation, Postulates of special theory of relativity, Time dilation – Length contraction- Mass energy equivalence – Invariant mass – Relativistic momentum. |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Phase Dynamics-.Phase Trajectories-Singular Points (Topological Methods), Phase Trajectories of Linear System and Phase Trajectories of Nonlinear Systems.Expert lectures, online seminars – webinarsNever Ending conundrums of Classical Physics* <https://arstechnica.com/science/2014/08/the-never-ending-conundrums-of-classical-physics/>

Three body problem is Classical Mechanics* <https://towardsdatascience.com/modelling-the-three-body-problem-in-classical-mechanics-using-python-9dc270ad7767>

Our Universe’s Story: Cosmos from Chaos* <http://sitn.hms.harvard.edu/seminars/2014/cosmosfromchaos/>
 |
| Tutorial 1. A particle is projected vertically upwards with speed u and moves in a vertical straightline under uniform gravity with no air resistance, find the maximum height achieved by the particle and the time taken for it to return to its starting position.2. A body of mass m is suspended from a fixed point by a light spring and moving underuniform gravity. The spring is found to be extended by a distance b. Find a period ofoscillations of the body about this equilibrium position (assume there is a small strain).3. Find the moment of inertia of a uniform circular disk of mass M and radius a about itsaxis of symmetry.4. Find the kinetic energy of rotation of a rigid body with respect to the principle axes interms of Eulerian angles.5. Simple pendulum with rigid support, and with variable length. 6. Triple pendulum.  |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Introduction to Classical Mechanics, R. G. Takwale and P. S. Puranik, Tata McGraw-Hill, 2006 |
| 2 |  Classical Mechanics , H. Goldstein, C. Poole and J. Safko , Pearson 3rdEdition 2014 |
| 3 | Classical Mechanics G. Aruldass, PHI Learning Private Ltd, 2009 |
| 4 | Classical Mechanics John R. Taylor, University Science Books, 2005 |
| 5 | Classical Mechanics J.C. Upadhyaya , Himalaya Publishing House , 2005 |
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| **Reference Books** |
| 1 | Classical Mechanics Gupta, Kumar and Sharma, PragatiPrakashan, 2001 |
| 2 | Classical Mechanics R. Douglas Gregory ,Cambridge University press, 2008 |
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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Selected topics in Lecture series on Classical Physics by Prof. V. Balakrishnan, IIT Madras (NPTEL) |
| 2 | Selected topics in Lecture series on Classical Physics by Prof. Shiva Prasad, Department of Physics, IIT Bombay (NPTEL) |
| 3 | Lecture series of Classical Physics by Prof. Mukunda, IISC, Banglore |
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| Course Designed by: Dr. M. Balasubramaniam and Dr. R. Shankar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | S | M | L | M | S | S | L | S |
| **CO2** | S | S | S | M | L | M | S | M | L | M |
| **CO3** | M | M | M | M | L | M | S | S | L | M |
| **CO4** | S | M | S | M | L | M | S | S | L | S |
| **CO5** | S | M | S | M | L | M | S | S | L | S |

\*S-Strong; M-Medium; L-Low

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| **Course Code** | **22PHYC02** | **MATHEMATICAL PHYSICS – I** | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** |  Basic knowledge in differential equations  | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. To provide knowledge on various analytical methods used for solving differential equations.
2. To teach students about the special type of differential equations with their properties and their solution.
3. To expose students to learn about Laplace transforms and uses
4. To provide knowledge on Fourier’s series, integral and transform
5. To expose students to solve practical problems associated partial differential equations
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Solve differential equations with various analytical methods | **K1-K5** |
| 2 | Solve differential equations using special functions  | **K1-K5** |
| 3 | Solve both differential equations using Laplace transform | **K1-K5** |
| 4 | Solve differential equations using Fourier’s series and transform | **K1-K5** |
| 5 | Solve partial differential equations associated with Physics  | **K1-K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **Solving of differential equations** | **14 hours** |
| Homogeneous linear equations of second order with constant coefficients and their solutions – ordinary second order differential with variable coefficients and their solution by power series and Frobenius methods – extended power series method for indicial equations.  |
| **Unit:2** | **Special differential equations and their solutions** | **14 hours** |
| Legendre’s differential equation: Legendre polynomials – Generating functions – Recurrence Formulae– Rodrigue’s formula–orthogonality of Legendre’s polynomial; Bessel’s differential equation: Bessel’s polynomial –generating functions–Recurrence Formulae–orthogonal properties of Bessel’s polynomials; Hermite differential equation– Hermite polynomials – generating functions – recurrence relation; Laguerre’s differential equation: Laguerre’s polynomial –generating function–Recurrence Formulae–orthogonal properties of Laguerre’s polynomials |
| **Unit:3** |  **Laplace Transforms** | **14 hours** |
| Laplace transforms: Linearity property, first and second translation property of LT – Derivatives of Laplace transforms – Laplace transform of integrals – Initial and Final value theorems; Methods for finding LT: direct and series expansion method, Method of differential equation; Inverse Laplace transforms: Linearity property, first and second translation property, Convolution property – Application of LT to differential equations and boundary value problems.  |
| **Unit:4** | **Fourier series, integrals and transform** | **14 hours** |
| Fourier series definition and expansion of a function x – Dirichlet’s conditions- Complex representation of Fourier series – problems related to periodic functions – Fourier integrals – convergence of FS – solving simple partial differential equations using Fourier’s series- Fourier transforms: sin, cosine & complex transforms- solving simple partial differential equations using Fourier transform. |
| **Unit:5** | **Partial differential equations (PDEs)** | **14 hours** |
| Second order PDEs and their types – Solutions of PDEs – Methods for solving PDEs – Laplace, diffusion and wave equations in Cartesian and polar coordinates – Solution of two and three dimensional Laplace, diffusion and wave equations using separation of variable method- Solving simple practical problems.  |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Introduction to numerical methods to solve ordinary and partial differential equations.Fundamentals of delay differential equations (DDE).Expert Lectures, online seminars in contemporary topics in Mathematical PhysicsA (thorough) introduction to Mathematics and Physics* <http://www.birs.ca/events/2017/2-day-workshops/17w2694/videos/watch/201710281436-Bouchard.html>

More than 100 years of superconductivity: do we need a paradigm shift?* <http://www.birs.ca/events/2017/2-day-workshops/17w2694/videos/watch/201710281401-Marsiglio.html>

Relationship between mathematics and physics* <https://lifethroughamathematicianseyes.wordpress.com/2018/05/12/relationship-between-mathematics-and-physics/>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Mathematical methods for Physics, G. Arfken Elsevier, 6th edition, 2010 |
| 2 | Mathematical Physics, B.D.Gupta, Vikas Publishing House, 4th edition, 2010 |
|  | Topics in Mathematical Physics, Parthasarathy H Ane Books Pvt. Ltd 2007 |
|  |
| **Reference Books** |
| 1 | Mathematical Physics,, Rajput, PragatiPrakasam, 17th Edition, 2004 |
| 2 | Advanced Engineering mathematics, Erwin Kreyszig, Wiley Eastern Limited, 7th Edition, 1993 |
| 3 | An Introduction to Delay Differential Equations with Applications to the Life Sciences, Hal Smith, Springer New York, 2011. |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Ordinary and partial differential equations and applications by Prof. P.N.Agarwal, D.N. Pandey, IIT Roorkee, Swayam |
| 2 | [Selected topics in mathematical Physics](https://nptel.ac.in/courses/115/106/115106086/),Prof. V. Balakrishnan, IIT Madras (NPTEL) |
| Course Designed by: Dr. K. Ramachandran and Dr. L. Senthilkumar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | S | L | S | L | L | S | L | M |
| **CO2** | S | M | S | L | S | L | L | S | L | M |
| **CO3** | S | M | S | L | S | L | L | S | L | M |
| **CO4** | S | M | S | L | S | L | L | S | L | M |
| **CO5** | S | M | S | L | S | L | L | S | L | M |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC03** | **CONDENSED MATTER PHYSICS-I**  | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | **Basic knowledge in Materials Science** | **Syllabus Version** |  |
| **Course Objectives:** |
| This course gives an introduction to solid state physics with a primary theme to study the basic theory of structure, composition and physical properties of crystalline materials. Concepts like reciprocal space, Brillouin zones, structure determination by diffraction will be explained correlating the structure and band structure of the crystals. Lattice vibrations, the continuum approximation, phonons, heat capacity will be explained to know the correlation between the structure and thermal properties of the materials. |
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Describe different types of crystal structures in terms of the crystal lattice and the basis of constituent atoms | **K1** |
| 2 | Formulate the theory of X-ray diffraction in the reciprocal lattice (k-space) | **K2** |
| 3 | Describe the different physical mechanisms involved in crystal binding identifying the repulsive and attractive interactions and correlate these with the atomic properties | **K3****K4** |
| 4 | Formulate the theory of lattice vibrations (phonons) and use that to determine thermal properties of solids | **K3** |
| 5 | Formulate the problem of electrons in a periodic potential, examine its consequence on the band-structure of the solid and develop a framework that explains the physical properties of solids in terms of its band-structure | **K4****K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **Fundamentals of Crystallography and Bonding in solids** | **14 hours** |
| Crystalline state – Basic definitions – Bravais lattices and crystal systems – Elements of symmetry – Crystal directions – Miller indices - Simple Crystal structures (NaCl, CsCl, Hexagonal close packed structure, Diamond structure, Cubic ZnS structure).Forces between atoms – Ionic bonding – Bond dissociation energy of NaCl molecule – Cohesive energy of ionic crystals – Evaluation of Madelung constant for NaCl structure – The Born-Haber Cycle – Covalent bonding – Metallic bonding – Hydrogen bonding – Van Der Waals bonding. |
| **Unit:2** | **Diffraction of Waves and Particles by Crystals** | **14 hours** |
| X-rays and their generation - Moseley’s law – Absorption of X-rays (Classical theory) – Absorption Edge – X-ray diffraction – The Laue equations – Equivalence of Bragg and Laue equations – Interpretation of Bragg equation – Ewald construction - Reciprocal lattice – Reciprocal lattice to SC, BCC and FCC crystals- Importance properties of the Reciprocal lattice – Diffraction Intensity - The Powder method – Powder Diffractometer - The Laue method -The Rotating Crystal method - Neutron Diffraction - Electron diffraction |
| **Unit:3** | **Crystal Imperfections and Atomic Diffusion** | **14 hours** |
| Point imperfections – Concentrations of Vacancy, Frenkel and Schottky imperfections – Line Imperfections – Burgers Vector – Presence of dislocation – surface imperfections- Polorans – Excitons.Ficks first and second law - solutions to Ficks second law – Applications of diffusion – Diffusion mechanism – Random walk treatment of diffusion – Kirkendall effect - diffusion in alkali halides - ionic conductivity in alkali halides. |
| **Unit:4** | **Lattice vibrations and thermal properties** | **14 hours** |
| *Lattice vibrations:* One dimensional monoatomic lattice-Dispersion relation-cutt off frequency- phase and group velocity- One dimensional diatomic lattice-Dispersion relation-Brillouin zone-acoustic and optical branches-density of states-scattering of phonons by phonons*Thermal properties*: Lattice specific heats-classical theory-Einstein theory-Debye theory of atomic heat-thermal expansion-Gruneisen parameters-thermal conductivity-Normal and Umklapp processes |
| **Unit:5** | **Free electron theory of metals and Energy bands** | **14 hours** |
| *Free electron theory basics:* Density of states-Fermi Dirac statistics-specific heat-relaxation time-mean free path-mobility-thermal conductivity-Drude model electrical conductivity-Wiedemann Franz Lorentz relations-Hall effect*Energy Band Theory:* Periodic Potential-Bloch Theorem-Kronig-Penney Model-Reduced zone scheme-Effective mass of electron-Nearly free electron model-tight binding model-Wigner Seitz Method-Basics of Augmented plane wave method*Fermi surface:* Introduction Fermi surfaces-characteristics of Fermi surfaces-Construction of Fermi surfaces-Fermi surface and Brillouin zones-Fermi surfaces in metals Experimental study of Fermi surfaces: Anomalous Skin Effect-Magneto Resistance-dHvA effect (de Haas van Alphen effect)-cyclotron resonance |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars – webinarsRoad map on quantum materials* <https://sciencesprings.wordpress.com/tag/condensed-matter-physics/>

Condensed Matter Physics: The Goldilocks Science* <https://physics.berkeley.edu/oppenheimer-lecture-condensed-matter-physics-the-goldilocks-science>

Role of symmetries in Condensed Matter Physics* <https://www.youtube.com/watch?v=ed0q8cZ5Fsk>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Solid State Physics: Structure and Properties of Materials, A. M. Wahab, Narosa Publishing House, 2nd Edition, 2007 |
| 2 | Introduction to Solid State Physics, C. Kittel, Wiley India Edition, Edition, 2019 |
| 3 | Elementary Solid State Physics: Principles and Applications, M. A. Omar |
|  |
| **Reference Books** |
| 1 | Elements of Solid State Physics, J. P. Srivastava, Prentice Hall of India, New Delhi, 2nd Edition, 2001 |
| 2 | Solid State Physics, Ashcroft and Mermin, Eastern Press Pvt. Ltd, Bangalore, 1st Edition2003 |
| 3 | Introductory Solid State Physics, H.P.Myers, Taylors and Francis Ltd, 2nd Edition, 1998 |
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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://nptel.ac.in/courses/115/105/115105099/> |
| 2 | <https://nptel.ac.in/courses/115/106/115106061/> |
| 3 | <https://nptel.ac.in/courses/115/104/115104109/> |
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| Course Designed By:Dr. D. Nataraj and Dr. R. Kalaiselvan |

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|  **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | M | S | L | S | S | M | L |
| **CO2** | S | S | S | M | M | L | S | S | M | L |
| **CO3** | S | S | S | S | M | L | S | S | M | L |
| **CO4** | S | S | M | M | M | L | S | S | M | L |
| **CO5** | S | S | S | S | M | L | S | S | M | L |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYE01A** | **INDUSTRIAL ELECTRONICS** | **L** | **T** | **P** | **C** |
| **~~Core~~/Elective/~~Supportive~~** | **ELECTIVE** | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Basics knowledge of Electronics  | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to:1. Give an insight to the students about basic concepts and techniques of Power electronic devices and its industrial applications.2. Provide an understanding on Sensors for Robotic applications.3. Impart knowledge on basics of Medical electronics and imaging techniques. |
|  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Learn the features of power electronic devices. | **K1, K2** |
| 2 | Study the operation of circuits used in power electronic devices | **K2, K3** |
| 3 | Know the industrial applications of power electronic devices. | **K2, K5** |
| 4 | Know the basics of transducers and sensors, and types of sensors used for Robotics. | **K2, K3** |
| 5 | Understand the working principle of ECG, EEG & EMG, and general biomedical imaging techniques. | **K2, K3** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create |
|  |
| **Unit:1** | Power Electronic Devices | **14 hours** |
| *Construction, operation and I-V characteristics*: Silicon controlled rectifiers (SCR) – Unijunction transistors (UJT) – Diode for alternating current (DIAC) – Triode for alternating current (TRIAC); Insulated gate bipolar junction transistor (IGBT). |
| **Unit:2** | Power Electronic Circuits and Controls | **14 hours** |
| *Converters*: One quadrant choppers – Two quadrant choppers – Four quadrant choppers – Cyclo-converters – Matrix converters; *Rectifiers*: Single-phase half-wave rectifiers – Single-phase full-wave rectifiers; *Inverters*: Single-phase inverters – Three-phase inverters – Multilevel inverters – Line-commutated inverters. |
| **Unit:3** | Applications of Power Electronic Devices | **14 hours** |
| DC motor basics – DC drive basics – SCR DC drives – Three phase brushless (BLDC) motor – Machine construction– *Types and operation of Step Motors*: Variable reluctance step motor – Drive circuits for variable reluctance step motors – Permanent magnet step motor – Control of step motor; *Uninterruptible power supplies (UPS)*: UPS functions – Static UPS topologies – Rotary UPS. |
| **Unit:4** | Sensors in Robotics | **14 hours** |
| Transducers and sensors – *Tactile sensors*: Touch sensors – Force sensors (Stress sensors) – Tactile array sensors –Proximity and range sensors – Uses of sensors in robotics – *Machine vision*: Functions of a machine vision – Sensing and digitizing function: Imaging devices – Lighting techniques. |
| **Unit:5** | Concepts of Medical Electronics | **14 hours** |
| *Bioelectric signals and electrodes*: Electrocardiogram (ECG) – Electroencephalogram (EEG) – Electromyogram (EMG); Electrode-tissue interface; Electrodes for ECG – Electrodes for EEG – Electrodes for EMG – Electrical conductivity of electrode jellies and creams; *Biomedical imaging system*: Principle and Working of – X-ray machine, Computed tomography (CT) and Magnetic resonance imaging (MRI). |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars - webinarsPower electronics in automotive applications – Medical imaging systems.Introduction to biomedical imaging and definitions* <https://www.youtube.com/watch?v=LdiJLkYgZ2M>

Power Electronics* <https://www.youtube.com/playlist?list=PLgwJf8NK-2e5Hnu82T1CYLZ8kbZs4Jx8x>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Industrial Electronics – Circuits, Instruments, and Control Techniques by Terry Bartelt, Cengage Learning India Pvt. Ltd, New Delhi, 1st Indian Reprint: 2009. |
| 2 | The Power Electronics Handbook – Industrial Electronics Series Edited by Timothy L. Skvarenina, CRC press LLC, USA: 2002. |
| 3 | Industrial Robotics–Technology, Programming and Applications byMikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Tata McGraw Hill Education Pvt Ltd, New Delhi, Edition 2008, Ninth reprint: 2011. |
| 4 | Handbook of Biomedical Instrumentation, R.S. Khandpur, Tata McGraw-Hill Publishing Company Ltd, New Delhi, Second edition: 2003 |
|  |
| **Reference Books** |
| 1 | Modern Industrial Electronics by Timothy J. Maloney, Prentice Hall, New Jersy, Third Edition: 1996. |
| 2 | Electronic Devices and Circuits by Anil K. Maini, Varsha Agrawal, Wiley India Pvt. Ltd., New Delhi, 1st Edition: 2009. |
| 3 | Biomedical Instrumentation by M. Arumugam, Anuradha Publications, Chennai, 10th Reprint: 2006. |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Power Electronic Devices: <https://nptel.ac.in/courses/108/105/108105066/> |
| 2 | Power Electronics <https://nptel.ac.in/courses/108/102/108102145/> |
| 3 | Sensors and Controls in Robots: <https://nptel.ac.in/courses/112/101/112101098/> |
| 4 | Medical Image Analysis: <https://nptel.ac.in/courses/108/105/108105091/> |
| Course Designed By:Dr. K. Srinivasan and Dr. K. Suresh |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | L | M | S | S | S | M | M |
| **CO2** | S | M | M | M | M | S | S | S | M | M |
| **CO3** | S | S | S | M | S | S | S | S | M | M |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | M | S | S | S | S | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYE01B** | **MOLECULAR PHYSICS** | **L** | **T** | **P** | **C** |
| **~~Core~~/Elective/~~Supportive~~** | ELECTIVE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Basic knowledge on atoms, molecules, undergraduate level quantum mechanics and chemical bonding | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. To provide the fundamental knowledge on the structure and dynamics of the molecules through various theories
2. Understanding the structure-property relationship
3. Knowing the concept of symmetry and its role on molecular properties
4. Studying the relation between molecular interactions and properties
5. Providing phenomenological theories on reaction dynamics and transport properties
 |
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Know about molecular structure and chemical bonding  | K4 |
| 2 | Understand the bulk properties of matter in-terms of molecular architecture | K2 |
| 3 | Relate the molecular properties with interactions and dynamics of the molecules | K3 |
| 4 | Understand the reaction mechanism, kinetics and transport process | K5 |
| 5 | Apply studied theories to study the properties of the matter | K4 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
|  |
| **Unit:1** | **Molecular structure and bonding**  | **14 hours** |
| Chemical bonding - The VSEPR model - Valence bond theory – The hydrogen molecule - Homonuclear diatomic molecules - Polyatomic molecules - Molecular orbital theory –Homonuclear diatomic molecules – Heteronuclear diatomic molecules – Bond properties - Polyatomic molecules - Molecular shape in terms of molecular orbitals - Molecular structure, properties and conformations |
| **Unit:2** | **Molecular symmetry** | **14 hours** |
| Symmetry elements and operations – The symmetry classification of molecules – Some immediate consequences of symmetry – Applications to molecular orbital theory – Character tables and symmetry labels – Vanishing integrals and orbital overlap - Vanishing integrals and selection rule |
| **Unit:3** | **Molecular interactions and mechanics**  | **14 hours** |
| Electric properties of molecules - Electric dipole moments - Polarizabilities - Relative permittivity’s - Interactions between dipoles - Repulsive and total interactions - Molecular interactions in gases - Potential energy (force field) in molecular mechanics – Various energy terms in force field – Newtonian and Hamiltonian dynamics – Phase space trajectories |
| **Unit:4** | **Molecular reaction dynamics** | **14 hours** |
| Collision theory – Diffusion controlled reactions – Reactive collisions – Potential energy surfaces – Transition state theory – The Eyring equation – Thermodynamic aspects - Microscopic–macroscopic connection - Zero-point Vibrational energy - Molecular electronic, rotational, Vibrational and translational partition functions |
| **Unit:5** | **Electron transfer, electronic structure and spectra** | **14 hours** |
| The rates of electron transfer processes – Theory of electron transfer processes – Crystal-field theory - Ligand-field theory - Electronic spectra of atoms - Electronic spectra of complexes - Charge-transfer bands - Selection rules and intensities – Luminescence |
| **Contemporary Issues : Tutorial** (This portion is not for examination)**2 Hours** |
| 1. Determine the bond orders of (a) S2, (b) Cl2, and (c) NO2 from their molecular orbital configurations and compare the values with the bond orders determined from Lewis structures. (NO has orbitals like those of O2.)
2. When a He atom absorbs a photon to form the excited configuration 1s12s1 (here called He\*) a weak bond forms with another He atom to give the diatomic molecule HeHe\*. Construct a molecular orbital description of the bonding in this species.
3. Use symmetry properties to determine whether or not the integral  is necessarily zero in a molecule with symmetry C4v.
4. The polarizability volume of NH3 is 2.22x10-30 m3; calculate the dipole moment of the molecule (in addition to the permanent dipole moment) induced by an applied electric field strength 15 kV m-1.
5. A rate constant is found to fit the expression k2 = (6.45x1013) e-(5375 K)/T dm3 mol-1 s-1 near 25˚C. Calculate ∆‡G for the reaction at 25˚C.
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Physical Chemistry, P. Atkins and J. Depaula, Oxford University Press, 2009 |
| 2 | Essential of Computational Chemistry - Theories and Models, Christopher J. Cramer, John Wiley & Sons, 2nd Edition, 2004 |
| **Reference Books** |
| 1 | Inorganic chemistry, P. Atkins, T. Overton , J. Rourke and M. Weller, Oxford University Press, 2009 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | [https://chem.libretexts.org/Bookshelves/Physical\_and\_Theoretical\_Chemistry\_Textbook\_Maps/Supplemental\_Modules\_(Physical\_and\_Theoretical\_Chemistry)/Chemical\_Bonding/Lewis\_Theory\_of\_Bonding/Geometry\_of\_Molecules](https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_%28Physical_and_Theoretical_Chemistry%29/Chemical_Bonding/Lewis_Theory_of_Bonding/Geometry_of_Molecules) |
| 2 | <https://chem.yonsei.ac.kr/chem/upload/CHE3103-01/125385455098913.pdf> |
| 3 | <http://vergil.chemistry.gatech.edu/courses/chem6485/pdf/molmech-lecture.pdf> |
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| Course Designed By:Dr. K. Senthilkumar and Dr. L. Senthilkumar |
|  **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | M | S | M | M | S | M | M |
| **CO3** | S | S | S | M | S | M | M | S | M | M |
| **CO3** | S | S | S | M | S | M | M | S | M | M |
| **CO4** | S | S | S | M | S | M | M | S | M | M |
| **CO5** | S | S | S | M | S | M | M | S | M | M |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYE01C** | **INDUSTRY 4.0** | **L** | **T** | **P** | **C** |
| **~~Core~~/Elective/~~Supportive~~** | ELECTIVE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | **Exposure in Computer Science** | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. At the end of completing this course, students will have knowledge on Industry 4.0, need for digital transformation and the following Industry 4.0 tools:
2. Artificial Intelligence
3. Big Data and Data Analytics
4. Internet of Things
 |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Know about What is Industry 4.0 | **K1-K2** |
| 2 | Know about What is AI and associated technologies | **K1-K2** |
| 3 | Know about big data and internet of things | **K1-K2** |
| 4 | Know about Tools of Industry 4.0 | **K1-K2** |
| 5 | Know about Jobs 2030 | **K1-K2** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
| **Unit:1** | **Industry 4.0** | **14 hours** |
| Need – Reason for Adopting Industry 4.0 - Definition – Goals and Design Principles - Technologies of Industry 4.0 – Big Data – Artificial Intelligence (AI) – Industrial Internet of Things - Cyber Security – Cloud – Augmented Reality |
| **Unit:2** | **Artificial Intelligence** | **14 hours** |
| Artificial Intelligence: Artificial Intelligence (AI) – What & Why? - History of AI - Foundations of AI -The AI - environment - Societal Influences of AI - Application Domains and Tools - Associated Technologies of AI - Future Prospects of AI - Challenges of AI |
| **Unit:3** | **Big Data and IoT** | **14 hours** |
| Big Data : Evolution - Data Evolution - Data : Terminologies - Big Data Definitions - Essential of Big Data in Industry 4.0 - Big Data Merits and Advantages - Big Data Components : Big Data Characteristics - Big Data Processing Frameworks - Big Data Applications - Big Data Tools - Big Data Domain Stack : Big Data in Data Science - Big Data in IoT - Big Data in Machine Learning - Big Data in Databases - Big Data Usecases : Big Data in Social Causes - Big Data for Industry -Big Data Roles and Skills -Big Data Roles - Learning Platforms; Internet of Things (IoT) : Introduction to IoT - Architecture of IoT - Technologies for IoT - Developing IoT Applications - Applications of IoT - Security in IoT |
| **Unit:4** | **Applications and Tools of Industry 4.0** | **14 hours** |
| Applications of IoT – Manufacturing – Healthcare – Education – Aerospace and Defense – Agriculture – Transportation and Logistics – Impact of Industry 4.0 on Society: Impact on Business, Government, People. Tools for Artificial Intelligence, Big Data and Data Analytics, Virtual Reality, Augmented Reality, IoT, Robotics |
| **Unit:5** | **Jobs 2030** | **14 hours** |
| Industry 4.0 – Education 4.0 – Curriculum 4.0 – Faculty 4.0 – Skills required for Future - Tools for Education – Artificial Intelligence Jobs in 2030 – Jobs 2030 - Framework for aligning Education with Industry 4.0 |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars – webinarsIndustrial Revolution 4.0* <https://www.mobinius.com/blogs/industrial-revolution-4-0-technologies>

Industrial Revolution 4.0 and its possibilities* <https://interestingengineering.com/the-industrial-revolution-40-and-its-possibilities-revealed>
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|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | P. Kaliraj, T. Devi, Higher Education for Industry 4.0 and Transformation to Education 5.0, 2020 |
| 2 | Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Thigs, Apress, 2017 |
| 3 | A. Bagha, V. Madisetti, Inter of Things: A hands on approach , Universities Press 2015 |
|  |
| **Reference Books** |
| 1 | Industry 4.0: Industrial revolution of the 21st century, Springer 2019 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | https://nptel.ac.in/courses/106/105/106105195/ |
| 2 | https://onlinecourses.nptel.ac.in/noc20\_cs24/preview |
| Course Designed By:Dr. T. Devi for all University Departments.  |
|  **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | M | S | M | M | S | M | M |
| **CO2** | S | S | S | M | S | M | M | S | M | M |
| **CO3** | S | S | S | M | S | M | M | S | M | M |
| **CO4** | S | S | S | M | S | M | M | S | M | M |
| **CO5** | S | S | S | M | S | M | M | S | M | M |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYL01** | **ELECTRONICS LAB** | **L** | **T** | **P** | **C** |
| **Lab** | **LAB** | **0** | **0** | **6** | **4** |
| **Pre-requisite** | Knowledge on operation of breadboard and soldering. Have practical experience in implementation of circuit diagrams | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to:1. Give hands on training in the construction of simple electronics circuits.2. Make out the students understand practically the characteristics of transistors, amplifiers, oscillators and filters.3. Provide an exposure on digital to analog and analog to digital conversion, use of logic gates. |
|  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Construct simple electronics circuits. | **K3, K6** |
| 2 | Understand the theoretical concepts by doing experiments. | **K2, K5** |
| 3 | Make out the characteristics of transistors, amplifiers, oscillators and filters. | **K2, K4** |
| 4 | Know the conceptual difference between analog and digital electronics. | **K3, K6** |
| 5 | Able to construct oscillator and filter circuits | **K3, K6** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **No.** | **Experiment** |
| 1 | Study the forward and reverse characteristics of a Zener diode.  |
| 2 | Construction of adder, subtractor, differentiator and integrator circuits using the given Op – Amp.  |
| 3 | Study the static and drain characteristics of a JFET. |
| 4 | Construction of an Astablemultivibrator circuit using transistors.  |
| 5 | Study the characteristics of UJT.  |
| 6 | Construction of a single FET amplifier with Common Source configuration.  |
| 7 | Construction of a relaxation oscillator circuit using the given UJT and study its performance.  |
| 8 | Construction a single stage RC coupled amplifier using transistor and study its frequency responses.  |
| 9 | Construction of a two stage RC coupled amplifier using transistor and study its frequency responses.  |
| 10 | Construction of A/D converter circuit and study its performance.  |
| 11 | Construction of D/A converter circuit and study its performance.  |
| 12 | Construction of half-adder and full-adder circuits using NAND gates and study their performance.  |
| 13 | Construction of half- subtractor and full- subtractor circuits using NAND gates.  |
| 14 | Construction of a bi-stable multivibrator circuit using transistors and study its performance.  |
| 15 | Construction of a phase shift oscillator circuit using the given transistor and study its performance.  |
| 16 | Construction of a Wien’s bridge oscillator circuit using transistor and study its performance.  |
| 17 | Construction of a low-pass filter circuit and study its output performance.  |
| 18 | Construction of a high-pass filter circuit and study its output performance.  |
| 19 | Construction of a band-pass filter circuit and study its output performance. |
| 20 | Construction of a voltage regulated power supply using Zener diode. |
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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://nptel.ac.in/courses/122/106/122106025/> |
| 2 | Virtual lab: <http://vlab.co.in/ba-nptel-labs-electronics-and-communications> |
| 3 | <https://freevideolectures.com/course/2261/basic-electronics-and-lab> |
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| Course Designed By:Dr. K. Srinivasan and Dr. K. Suresh |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | S | S | S | S | S | S |
| **CO2** | S | S | S | S | S | S | S | S | S | S |
| **CO3** | S | S | S | S | S | S | S | S | S | S |
| **CO4** | S | S | S | S | S | S | S | S | S | S |
| **CO5** | S | S | S | S | S | S | S | S | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC04** | **QUANTUM MECHANICS I** | **L** | **T** | **P** | **C** |
| **Core** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Basics knowledge in in Calculus (Vector, Differential, Integral), and Matrix | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: * To enable the students, learn the basic postulates of Quantum Mechanics
* Relate the knowledge of mathematics to the formalism of Quantum Mechanics
* Introduce applications of Quantum Mechanics to microscopic particle regime
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Apply principles of quantum mechanics to calculate observables on known wave functions | K1,K2,K3 |
| 2 | Solve time-independent Schrödinger equation for simple potentials | K3 |
| 3 | Understanding about spin and angular momenta | K2 |
| 4 | Knowledge on approximate methods for solving the Schrödinger equation ( the variational method, perturbation theory, Born approximations) | K3,K4 |
| 5 | Application of Schrödinger equation to many body system | K3,k4 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **General formalism of Quantum Mechanics** | **14 hours** |
| Linear Vector Space- Linear Operator- Eigen functions and Eigenvalues- Hermitian Operator- Postulates of Quantum Mechanics- Simultaneous Measurability of Observables- General Uncertainty Relation- Dirac’s Notation- Equations of Motion; Schrodinger, Heisenberg and Dirac representation- momentum representation- Density Matrix and its properties. |
|  |
| **Unit:2** | **Energy Eigenvalue problems** | **14 hours** |
| Particle in a box – Linear Harmonic oscillator- Tunnelling through a barrier- particle moving in a spherically symmetric potential- System of two interacting particles-Rigid rotator- Hydrogen atom: Separation of the center of mass motion-solution to radial equation |
|  |
| **Unit:3** | **Angular Momentum** | **14 hours** |
| Orbital Angular Momentum-Spin Angular Momentum-Total Angular Momentum Operators-Commutation Relations of Total Angular Momentum with Components- Ladder operators-Commutation Relation of Jz with J+ and J- - Eigen values of J2, Jz- Matrix representation of J2, Jz, J+ and J- - Addition of angular momenta- Clebsch-Gordon Coefficients: selection rules – recursion relations-computation of Clebsch-Gordon Coefficients |
| **Unit:4** | **Approximate Methods** | **14 hours** |
| Time-Independent Perturbation Theory in Non-Degenerate Case - Anharmonic Oscillator: First order Correction- The ground state of Helium- Degenerate Case - Stark Effect in Hydrogen atom – Spin-orbit interaction - Variation Method – Born-Oppenheimer approximation - WKB Approximation and its validity |
|  |
| **Unit:5** | **Time Dependent Perturbation Theory** | **14 hours** |
| Time Dependent Perturbation Theory-First and Second Order Transitions-Transition to Continuum of States-Fermi Golden Rule-Constant and Harmonic Perturbation- Collision- Adiabatic and Sudden Approximation- A Charged Particle in an Electromagnetic Field. |
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| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Quantum Computing- Online lectures, webinarsSix things everyone should know about quantum physics* <https://www.forbes.com/sites/chadorzel/2015/07/08/six-things-everyone-should-know-about-quantum-physics/#575831867d46>

The New Quantum Reality* <https://www.wired.com/2014/06/the-new-quantum-reality/>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Quantum Mechanics, G. Aruldhas, Prentice Hall of India, 2013 |
| 2 | Quantum Mechanics - Concepts and Applications,N. Zettili, Wiley, 2016 |
|  |
| **Reference Books** |
| 1 | A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, Tata McGraw Hill, 2010 |
| 2 | Quantum Mechanics, L.I Schiff,McGraw Hill.2010 |
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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://nptel.ac.in/courses/122/106/122106034/> |
| 2 | <https://nptel.ac.in/courses/115/103/115103104/> |
| 3 | <https://nptel.ac.in/courses/115/101/115101107/> |
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| Course Designed By:Dr.L.Senthilkumar, Dr.K.Senthilkumar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | M | M | S | L | L | S | S |
| **CO2** | S | M | S | M | M | S | L | L | S | S |
| **CO3** | S | M | S | M | M | S | L | M | S | S |
| **CO4** | S | M | S | M | M | S | M | M | S | S |
| **CO5** | S | M | M | M | M | S | L | L | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC05** | **MATHEMATICAL PHYSICS – II** | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Basic knowledge on vectors and their properties | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. To expose students to describe physical quantities in the vector form
2. To teach about basic properties of complex functions and related theorems
3. To expose students to different types of groups and their properties.
4. To provide knowledge on various analytical methods for solving differential equations.
5. To impart the knowledge on tensors and their properties
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Choose right method to solve problems in physics.  | **K1-K4** |
| 2 | Integrate various functions with singularities | **K1-K5** |
| 3 | Characterize the physical system using group operations and table | **K1-K4** |
| 4 | Classify the differential equations and choose right method to solve problems | **K1-K4** |
| 5 | Transform physical quantities between coordinate systems.  | **K1-K4** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create |
|  |
| **Unit:1** | **Vector Analysis** | **14 hours** |
| The Scalar and vector fields – Gradient, divergence and curl – Orthogonal curvilinear coordinates – Cylindrical and spherical coordinates as a special curvilinear system – Vector integration – Line, surface and volume integrals – Gauss divergence theorem - Stokes theorem in the space - Green’s theorem in the plane. |
| **Unit:2** | **Complex Variables**  | **14 hours** |
| Complex Algebra- Argand diagram- Properties of Moduli and arguments- Cauchy-Riemann Conditions-Cauchy’s integral Theorem- Cauchy’s integral Formula-Taylor’s and Laurent’s expansion- Singularities- Mapping- Conformal mapping- Cauchy’s residue theorem- Computation of residue – Evaluation of integral |
| **Unit:3** | **Group Theory** | **14 hours** |
| Definition of Group - Subgroup, invariant group, abelian group, orthogonal and unitary groups -Homomorphism, isomorphism - Reducible and irreducible representations - Generators of Continuous groups.  |
|  |
| **Unit:4** | **Gamma, Beta, and Error functions** | **14 hours** |
| Definition of Gamma and Beta functions- Fundamental properties of Gamma functions – Evaluation of Γ(1/2) and graph of the Gamma function- Transformation of Gamma function - Different forms of Beta functions – Relation between Beta and Gamma functions- Reduction of definite integrals to Gamma functions- Error function / probability integral. |
| **Unit:5** | **Tensor Analysis** | **14 hours** |
| Definition of Tensors – Contravariant, covariant and mixed tensors – addition and subtraction of Tensors – Summation convention- Symmetry and Anti-symmetry Tensor – Contraction and direct product – Quotient rule- Pseudo tensors, Levi-Civita Symbol - Dual tensors, irreducible tensors-Metric tensors-Christoffel symbols – Geodesics.  |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Richard Feynmann on the difference between mathematics and physics* <https://medium.com/cantors-paradise/richard-feynman-on-the-differences-between-mathematics-and-physics-c0847e8a3d75>

Unreasonable relation between mathematics and physics* <https://plus.maths.org/content/unreasonable-relationship-between-mathematics-and-physics>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Mathematical methods for Physics, G. Arfken, Elsevier, 6th edition, 2010 |
| 2 | Mathematical Physics, B.D.Gupta, Vikas Publishing House , 4th edition, 2010 |
| 3 | Topics in Mathematical Physics, Parthasarathy H, Ane Books Pvt. Ltd, 2007 |
|  |
| **Reference Books** |
| 1 | Mathematical Physics, S.D. Joglekar, Universities Press Pvt.Ltd, 1st Edition,2005 |
| 2 | Mathematical Physics, H.K. Dass and R. Verma, S. Chand Company, 2nd Edition, 2001 |
| 3 | Advanced Engineering mathematics, Kreyszig, Wiley Eastern Ltd, 7th Edition, 1993 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | [Selected topics in mathematical Physics](https://nptel.ac.in/courses/115/106/115106086/), Prof. V. Balakrishnan, IIT Madras (NPTEL) |
| Course Designed By:Dr. K. Ramachandran and Dr. L. Senthilkumar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | M | S | L | L | S | L | M |
| **CO2** | S | S | M | M | S | L | L | S | L | M |
| **CO3** | S | S | M | M | S | L | L | S | L | M |
| **CO4** | S | S | M | M | S | L | L | S | L | M |
| **CO5** | S | S | M | M | S | L | L | S | L | M |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC06** | **CONDENSED MATTER PHYSICS – II** | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Basic knowledge on Materials properties | **Syllabus Version** |  |
| **Course Objectives:** |
| This course aims to give an extended knowledge of the principles and techniques of solid state physics.  This course includes the fundamental properties of solid systems based on the classical and quantum physics principles. It also provides a valuable theoretical introduction and an overview of the fundamental applications of the physics of solids. Finally, it introduces the theoretical basis of nanotechnology and its potential applications |
|  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Understanding the physics behind the different properties of the solids. | **K2** |
| 2 | Tailor the properties of solids materials with the adequate knowledge. | **K3** |
| 3 | Develop a new materials based on the fundamental understanding of the properties | **K3** |
| 4 | Studying the materials properties for the cutting-edge applications | **K4** |
| 5 | Critically evaluate the experimental/materials strategies | **K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
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| **Unit:1** | **Theory of Dielectrics:**  | **14 hours** |
| Dipole moment – Polarization – The electric field of a dipole – Local electric field at an atom – Clausius –Mosotti equation - Dielectric constants and its measurements - Polarizability – The Classical theory of electronic polarizability – Ionic polarizabilities - Orientational polarizabilities - Dipole orientation in solids - Dipole relaxation and dielectric losses – Debye Relaxation time - Relaxation in solids - Complex dielectric constants and the loss angle. Frequency and temperature effects on Polarization – Dielectric breakdown and dielectric loss. |
| **Unit:2** | **Theory of Ferroelectrics and Piezo electrics** | **14 hours** |
| Ferroelectric Crystals – Classifications of Ferroelectric crystals – Properties of Rochelle Salt-Properties of BaTiO3 - Dipole theory of ferroelectricity –Theory of the ferroelectric displacive transitions – Thermodynamic theory of ferroelectric transition - Second order Transition – First Order Transition - Ferroelectric domains - Ferroelectric domain wall motion – Difference between ferroelectric and ferromagnetic domain - Antiferroelectricity -– Piezoelectricity – Electrostriction – Applications of piezoelectric crystals. |
| **Unit:3** | **Magnetic Properties of Materials** | **14 hours** |
| Terms and definitions used in magnetism – Classification of magnetic materials – Atomic theory of magnetism – The quantum numbers- The origin of permanent magnetic moments – Langevin’s classical theory of diamagnetism – Sources of paramagnetism – Langevin’s classical theory of paramagnetism – Quantum theory of paramagnetism – Paramagnetism of free electrons - Ferromagnetism – The Weiss molecular field – Temperature dependence of Spontaneous magnetization – The physical origin of Weiss Molecular field - Ferromagnetic domains - Domain theory – Antiferromagnetism – Ferrimagnetism – Structure of Ferrite. |
| **Unit:4** | **Superconductivity** | **14 hours** |
| Sources of superconductivity – The Meissner effect – Thermodynamics of superconducting transitions – Origin of energy gap – Isotope effect - London equations –London Penetration depth – Type I and Type II Superconductors - Coherence length – BCS theory – Flux quantization – Theory of DC and AC Josephson effect – Potential applications of superconductivity. |
| **Unit:5** | **Physics of Nano Solids** | **14 hours** |
| Definition of nanoscience and nanotechnology – Nanoparticles – Metal nanoclusters – Semiconductor nanoparticles - Preparation of nanomaterials – Surface to volume ratio – Quantum confinement – Qualitative and Quantitative description – Density of states of nanostructures – DOS of 3D Bulk solid- DOS of quantum wells - DOS of quantum wires - DOS of quantum dots - Excitons in Nano semiconductors – Properties of Nanomaterials – Carbon in nanotechnology – Graphite – Graphene –Fullerenes- Carbon nanotubes. |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars – webinarsICTP Condensed Matter Physics* <https://www.youtube.com/channel/UCcW7z2pE37Z4I1koTwahBfA>
* <https://www.britannica.com/science/condensed-matter-physics>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Solid State Physics: Structure and Properties of Materials, A. M. Wahab, Narosa Publishing House, 2nd Edition, 2007 |
| 2 | Elements of Solid State Physics, J.P.Srivatava, 4th Edition , 2014 |
| 3 | Solid State Physics, Rita John, McGraw Hill Education, 1st Edition, 2014 |
|  |
| **Reference Books** |
| 1 | Elementary Solid State Physics: Principles and Applications, M. A. Omar, Pearson Education Pvt. Ltd, 4th Edition, 2004 |
| 2 | Ferroelectrics, A.K. Bain, P. Chand, Wiley ,2017 |
| 3 | Dielectric phenomena in solids with emphasis on physical concepts of electronic processes,Kwan Chi Kao, Elsevier Academic Press, 2004 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://nptel.ac.in/courses/113/104/113104090/> |
| 2 | <https://www.youtube.com/watch?v=qXLStQQxHzU> |
| 3 | <https://nptel.ac.in/courses/118/104/118104008/> |
| Course Designed By:Dr. D. Nataraj and Dr. R. Kalaiselvan |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | S | L | L | S | S | L | M |
| **CO2** | S | S | S | S | S | L | S | S | L | M |
| **CO3** | S | S | S | S | M | L | S | S | L | M |
| **CO4** | S | M | S | S | M | L | S | S | L | M |
| **CO5** | S | M | S | S | M | L | S | S | L | M |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYE02A** | **COMPUTATIONAL METHODS AND PROGRAMMING** | **L** | **T** | **P** | **C** |
| **~~Core/~~Elective/~~Supportive~~** | ELECTIVE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Knowledge in Undergraduate level Mathematics (Calculus, programming) | **Syllabus Version** |  |
| **Course Objectives:** |
| To familiarize the students and to impart knowledge about accuracy of numerical calculations, 1. finding zeros of linear, transcendental, simultaneous equations,
2. regression using least square, interpolating methods,
3. finding eigenvalues of matrices, integration of functions, tabulated data, methods of singular and oscillatory integrals,
4. ordinary and partial differential equations,
5. exposure to the scientific programming language Fortran, writing programs using Fortran for the numerical methods learned.
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Find roots of different types of equations  | **K1-K5** |
| 2 | Understand experimental data, its behavior and trend, regression Understand various interpolating techniques and its relevance in various fields | **K1-K5** |
| 3 | Obtain the eigenvalues of matrices and understand its applicability in various physics aspectsUnderstand techniques to evaluate integrals bounded in a range, singular integrals and oscillatory integrals and its usage in various physics concepts. | **K1-K5** |
| 4 | Solve initial value and boundary value problems of ordinary and partial differentials - applicability in physics. Exposure to write scientific programming using Fortran and apply for various techniques studied | **K1-K5** |
| 5 | Understand the programming techniques of FORTRAN and its application | **K1-K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
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| **Unit:1** | **Roots of equation – Simultaneous equations** | **14 hours** |
| ***Roots of equation:*** Bisection method – False position method – Newton Raphson method – Secant method – Order of convergence ***Simultaneous Equations:*** Existence of solutions- Basic Gauss elimination method – Gauss elimination with partial pivoting – Gauss Jacobi iteration method – Gauss Seidal iteration method – Inversion of a matrix using Gauss elimination method – LU decomposition. |
| **Unit:2** | **Curve fitting – Interpolation** | **14 hours** |
| ***Curve fitting:*** Method of least squares – straight line, parabola, y = axn , y = aebx , y = a+bxn type curves – sum of squares of residuals for straight line and parabola fit – Weighted least squares approximation – Method of least squares for continuous functions***Interpolation:***Polynomial Interpolation – Lagrange polynomial – Newton polynomial - Forward and Backward differences – Gregory Newton forward and backward interpolation formula for equal intervals – Divided difference – properties of divided differences – Newton’s divided differences formula – Lagrange’s interpolation formula for unequal interval – Linear spline – Quadratic spline interpolation |
| **Unit:3** | **Eigenvalues – Integration -**  | **14 hours** |
| ***Eigenvalues:*** Power method to find dominant Eigenvalue - Jacobi method ***Integration:***Newton – cotes formula – Trapezoidal rule, Simpson’s rule, Simpson’s 3/8 rule, Boole’s rule – Error estimates in trapezoidal and Simpson’s rule – Gauss quadrature - Adaptive quadrature – Romberg Integration |
| **Unit:4** | **Differential Equations** | **14 hours** |
| ***Ordinary differential equation:*** Solution by Taylor’s series – Picard’s method for successive approximation - Basic Euler method – Improved Euler method – Modified Euler method – RungeKutta fourth order method – RK4 method for simultaneous first order differential equation - RK4 Method for second order differential equation ***Partial differential equation:*** Classification of partial differential equation of the 2nd order - Difference quotients – Graphical representations of partial quotients – standard and diagonal five-point formula for Laplace equations – solution of Laplace’s equation (Liebman’s iteration) – Parabolic equations – Bender Schmidt recurrence relation - Crank Nicolson formula - Hyperbolic equations – three level scheme |
| **Unit:5** | **Fortran programming and applications to numerical methods** | **14 hours** |
| ***Fortran programming:***Algorithms - Flowcharts – Character Set - Constants - Variables – Subscripted variables – Operations - Input and output statements – File processing - Control statements (Do, If, Go to structures) - Function subprogram – Subroutine subprogram ***Applications:*** Ascending, descending order, matrix manipulation, Root of an equation using Newton Raphson method - Matrix inversion using Gauss elimination – Straight line curve fitting – Newton’s polynomial interpolation – Power method– Trapezoidal & Simpson’s rule. |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Numerical simulations for solving scientific problemsExpert lectures, online seminars – webinarsNumerical Relativity* <https://www.youtube.com/watch?v=Q3QLWCFJPiA>

Computational methods in biological physics* <https://www.youtube.com/watch?v=YHSo7_InKdo>

Computational methods for quantum dynamics* <https://www.youtube.com/watch?v=21uJgdiAlg8>
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|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Numerical methods for mathematics, science and engineering, John H. Matthews, Prentice Hall of India, 2nd Edition, 2000 |
| 2 | Introductory methods of numerical analysis, S. S. Shastry, Prentice Hall of India, 2010 |
| 3 | Programming with Fortran 77, Ram Kumar, Tata McGraw Hill, 1994 |
|  |
| **Reference Books** |
| 1 | Numerical Mathematical Analysis, J. B. Scarborough, Oxford Publishing, 6th Edition,1990 |
| 2 | Computer Applications in Physics, S. Chandra, M.K. Sharma, Narosa, 3rd Edition, 2014 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | MIT Openware Course <https://ocw.mit.edu/courses/mathematics/18-335j-introduction-to-numerical-methods-spring-2019/> |
| 2 | Coursera <https://www.coursera.org/learn/intro-to-numerical-analysis> |
| 3 | Swayam<https://swayam.gov.in/nd1_noc19_ma21/preview> |
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| Course Designed By:Dr. M. Balasubramaniam and Dr. K. Senthilkumar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | M | S | L | L | S | L | M |
| **CO3** | S | S | M | M | S | L | L | S | L | M |
| **CO3** | S | S | M | M | S | L | L | S | L | M |
| **CO4** | S | S | M | M | S | L | L | S | L | M |
| **CO5** | S | S | M | M | S | L | L | S | L | M |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYE02B** | **DATA ANALYSIS TECHNIQUES** | **L** | **T** | **P** | **C** |
| **~~Core/~~Elective/~~Supportive~~** | ELECTIVE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Knowledge in Undergraduate level Mathematics, Statistics  | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. To learn the importance of error analysis, and various methods to analyze error
2. To effectively learn statistical tools needed for data analysis.
3. To understand the behavior of distribution of data
 |
|  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | After completing this course, the student will be able to understand the importance of error analysis needed for measurements  | **K1-K5** |
| 2 | Understand the importance of statistical tools required for analysis of experimental / simulation / theoretical data.  | **K1-K5** |
| 3 | Curve fitting procedure needed for advanced research problems | **K1-K5** |
| 4 | Probability and its distribution to understand the spread in the experimental measurements | **K1-K5** |
| 5 | Understand error in measurements  | **K1-K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **Errors and its importance** | **14 hours** |
| Approximate numbers and Significant Figures – Rounding of Numbers – Absolute, Relative and Percentage errors – Relation between Relative error and the significant figures – The general formula for errors – Formulas to the fundamental operations of arithmetic and logarithms – Accuracy in the evaluation of a Formula – Accuracy in the Determination of arguments from a tabulated function – Accuracy of Series approximations – Errors in Determinants  |
| **Unit:2** | **Errors and curve fitting** | **14 hours** |
| Errors of Observations and Measurement – The law of accidental errors – The probability oferrors lying between given limits – The probability equation – The law of error of a linear function of independent quantities – The probability integral and its evaluations – The probability of hitting a target – The principle of least squares – Weighted observations –Residuals – The most probable value of a set of direct measurements – Law of error forresiduals – Agreement between theory and experience |
| **Unit:3** |  **Probability Basics** | **14 hours** |
| Chance Experiments and Events – Definition of Probability – Basic Properties: Addition and multiplication laws of Probability – Conditional Probability, population, variants, collection, tabulation and graphical representation of data– Some General Probability Rules – Estimating Probabilities Empirically using Simulation -frequency distributions, averages or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis  |
| **Unit:4** | **Probability distributions** | **14 hours** |
| Random variables – Probability distribution of discrete random variables – Probability distribution for continuous random variables – Mean and Standard deviation of a random variable - Binomial and geometric distribution – Normal distributions - Poisson distribution - Gaussian distribution, exponential distribution – additive property of normal variants, confidence limits, Bi-varite distribution, Correlation and Regression, Chi-Square distribution  |
| **Unit:5** | **Errors in measurements** | **14 hours** |
| Measurement, Direct and Indirect – Precision and Accuracy – Measures of Precision –Relations between the Precision measures – Geometric significance of µ, r and η –Relation between probable error, and the probable errors of the arithmetic and weightedmeans – Computation of the precision measures from the residuals – The combinations ofsets of measurements when the P.E.’s of Sets are given – The probable error of any functionof independent quantities whose P.E.’s are known – The two fundamental problems of indirect measurements – Rejection of observations and measurement |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars – webinarsPredictive analytics* <https://www.youtube.com/watch?v=4y6fUC56KPw>

Statistical data analysis* <https://www.youtube.com/watch?v=dVEdViOurR0>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Introduction to Statistics and Data Analysis, R. Peck, C. Olsen and J.L. Devore, Cengage Learning, 5th Edition, 2014 |
| 2 | Donald L. Smith: Probability statistics and data uncertainties in nuclear science and technology, American nuclear society, 1991 |
|  |
| **Reference Books** |
| 1 | Numerical Mathematical Analysis, J. B. Scarborough, Oxford Publishing, 6th Edition,1990 |
| 2 | Semyen G. Rabinovich: Measurement errors and Uncertainties –theory and practice,Springer,2005 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | MIT Openware Course |
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| Course Designed By:Dr. M. Balasubramaniam and Dr. K. Senthilkumar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | M | S | L | L | S | L | M |
| **CO3** | S | S | M | M | S | L | L | S | L | M |
| **CO3** | S | S | M | M | S | L | L | S | L | M |
| **CO4** | S | S | M | M | S | L | L | S | L | M |
| **CO5** | S | S | M | M | S | L | L | S | L | M |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYE02C** | **DATA ANALYTICS** | **L** | **T** | **P** | **C** |
| **~~Core/~~Elective/~~Supportive~~** | ELECTIVE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Knowledge in basic Computer Science | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. To learn the different types of data terminologies
2. To effectively learn the various aspects of data science
3. To understand the role of Big data in AI, ML and other fields
 |
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | After completing this course, the student will be able to understand the various data terminologies | **K1-K5** |
| 2 | Understand the importance of data science | **K1-K5** |
| 3 | The concepts of Big data and related aspects | **K1-K5** |
| 4 | The potential of Big data in AI and ML and other fields | **K1-K5** |
| 5 | To know about various applications of Big Data filed | **K1-K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **Data Terminologies** | **14 hours** |
| Introduction – Data – Information – Data Terminologies – Database – Data Mining – DataWarehouse – Data Evolution Roadmap – Big Data – Definition – Type of Data - Numeric– Categorical – Graphical – High Dimensional Data –– Data Classification – Hot Data –Cold Data – Warm Data – Thick Data – Thin Data - Classification of digital Data:Structured, Semi-Structured and Un-Structured- Data Sources - Time Series –Transactional Data – Biological Data – Spatial Data – Social Network Data – |
| **Unit:2** | **Data Science** | **14 hours** |
| Data Science: Data Science-A Discipline – Data Science vs Statistics, Data Science vsMathematics, Data Science vs Programming Language, Data Science vs Database, DataScience vs Machine Learning. Data Analytics - – Relation: Data Science, Analytics, BigData Analytics. Data Science Components: Data Engineering, Data Analytics-Methodsand Algorithm, Data Visualization |
| **Unit:3** | **Big Data Concepts** | **14 hours** |
| Big Data: Digital Data-an Imprint: Evolution of Big Data – What is Big Data – Sources ofBig Data. Characteristics of Big Data 6Vs – Big Data Myths - Data Discovery-TraditionalApproach, Big Data Technology: Big Data Technology Process – Big Data Exploration -Data Augmentation – Operational Analysis – 360 View of Customers – Security andIntelligence |
| **Unit:4** | **Big Data Potentials** | **14 hours** |
| Big Data Technology Potentials – AI – Machine Learning – Cloud Computing – MobileCommunication – IoT – Big Data in Industry 4.0- Big Data Platforms – HADOOP –SPARK – No SQL Databases - Types - Big Data Challenges |
| **Unit:5** | **Applications of Big Data** | **14 hours** |
| Big Data Use Cases –- Big Data Roles Data Scientist , Data Architect, Data Analyst –Skills – Case Study : Big Data – Customer Insights – Behavioural Analysis – Big DataIndustry Applications - Marketing – Retails – Insurance – Risk and Security – Health care |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars – webinarsMassive Big-Data problems* <https://www.forbes.com/sites/bernardmarr/2017/06/15/3-massive-big-data-problems-everyone-should-know-about/#160a339b6186>

Big-data analytics: Challenges and Implementation* <https://www.hiddenbrains.com/blog/big-data-analytics-challenges-implementation.html>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | V. Bhuvaneswari, T. Devi, “Big Data Analytics: Scitech Publisher , 2018 |
| 2 | Han Hu, Yonggang Wen, Tat-Seng, Chua, XuelongLi,“Toward Scalable Systems forBig Data Analytics: A Technology Tutorial”, IEEE, 2014. |
|  |
| **Reference Books** |
| 1 | Big Data Analytics, RadhaShankarmani, M. Vijayalakshmi, Wiley, 2nd Edition (2016) |
| 2 | Big Data Analytics, VenkatAnkam, PacktPublicatins, (2016) |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://ocw.mit.edu/resources/res-ll-005-mathematics-of-big-data-and-machine-learning-january-iap-2020/> |
| 2 | <https://onlinecourses.nptel.ac.in/noc20_cs92/preview> |
| 3 | <https://onlinecourses.swayam2.ac.in/arp19_ap60/preview> |
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| Course Designed By:Dr. T. Devi and Dr. V. Bhuvaneswari for all University Departments |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | M | S | L | L | S | L | M |
| **CO3** | S | S | M | M | S | L | L | S | L | M |
| **CO3** | S | S | M | M | S | L | L | S | L | M |
| **CO4** | S | S | M | M | S | L | L | S | L | M |
| **CO5** | S | S | M | M | S | L | L | S | L | M |

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| **Course code** | **22PHYL02** | **COMPUTATIONAL PROGRAMMING LAB** | **L** | **T** | **P** | **C** |
| **Lab** | **LAB** | **0** | **1** | **6** | **4** |
| **Pre-requisite** | Knowledge of using computers/simple programming. | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to:* To provide hands on training to the students to write basic to advanced level scientific programming.
* To train the students to write programs to find numerical solutions / roots of linear, transcendental, simultaneous equations,
* To expose them to understand the regression analysis using least square procedure, interpolating methods, eigenvalues of matrices, integration of functions, tabulated data, methods of singular and oscillatory integrals, ordinary and partial differential equations,
 |
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Find roots of different types of equations | **K3, K6** |
| 2 | Understand experimental data, its behavior and trend, regression  | **K2, K5** |
| 3 | Understand various interpolating techniques and its relevance in various fields | **K2, K4** |
| 4 | Obtain the eigenvalues of matrices and understand its applicability in various physics aspects | **K3, K6** |
| 5 | Understand techniques to evaluate integrals bounded in a range. Solve initial value and boundary value problems of ordinary and partial differential equations using different numerical techniques and its applicability in physics concepts. | **K3, K6** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
| No. | Program |
| 1. | Ordering of numbers and characters (Ascending, Descending, Largest, Smallest) |
| 2. | A Program to solve the quadratic equation |
| 3. | Programming with matrices (Addition, Subtraction, Multiplication, Transpose)  |
| 4. | Root of equations – Bisection, False position, Newton-Raphson methods |
| 5. | Solving system of linear equations - Gaussian elimination method |
| 6. | Solving system of linear equations - Gauss Seidal method |
| 7. | A Program for finding the inverse of a matrix – Gauss elimination method |
| 8. | A Program for finding Eigenvalues of a symmetric matrix – Jacobi method |
| 9. | Program for straight line curve fitting – Least squares procedure |
| 10. | Program for polynomial curve fitting - Least squares procedure |
| 11. | Program to integrate any function or tabulated data using the trapezoidal rule |
| 12. | Program to integrate any function or tabulated data using Simpson’s rule  |
| 13. | Solving first order differential equation – Euler methods |
| 14. | Solving first order differential equation – RK4 method |
| 15. | Solving first order simultaneous differential equations – RK4 method |
| 16. | Program for interpolation of equal interval – Newton’s method |
| 17. | Program for interpolation of unequal interval – Lagrange’s method |
| 18. | Solving parabolic partial differential equation |
| 19. | Solving of Schroedingerequations-Hydrogen atom |
| 20. | Solving simple harmonic oscillator |
| 21. | Solving elliptic partial differential equation using finite difference method. |

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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | NPTEL - <https://nptel.ac.in/courses/115/106/115106118/> |
| 2 | SWAYAM <https://swayam.gov.in/nd1_noc19_ph16/preview> |
| 3 | SWAYAM <https://swayam.gov.in/nd1_noc20_ma33/preview> |
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| Course Designed By:Dr. M. Balasubramaniam and Dr. K. Senthilkumar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | L | S | S | L | S | S |
| **CO2** | S | S | S | S | L | S | S | L | S | S |
| **CO3** | S | S | S | S | L | S | S | L | S | S |
| **CO4** | S | S | S | S | L | S | S | L | S | S |
| **CO5** | S | S | S | S | L | S | S | L | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC07** | **QUANTUM MECHANICS II** | **L** | **T** | **P** | **C** |
| **Core** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Basics knowledge in Principles of Quantum mechanics, Calculus (Vector, Differential, Integral), and Matrix | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: * To help the students to continue and deepen the theoretical understanding of Quantum Mechanics
* To enable students to interpret and apply quantum mechanical formalism to various fields of physics
 |
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Applications of time dependent perturbation theory | K1,K2,K3 |
| 2 | Knowledge and understanding of scattering and partial wave analysis | K3 |
| 3 | Knowledge and understanding on interaction of radiation with matter | K2 |
| 4 | Knowledge Dirac matrices and negative energy states | K3,K4 |
| 5 | Understanding of field quantization | K3,k4 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
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| **Unit:1** | **Many Electron Atoms** | **14 hours** |
| Indistinguishable particles – Pauli principle - Inclusion of spin – spin functions for two- electrons- The Helium Atom – Central Field Approximation - Thomas-Fermi model - Hartree - Fock method for many electron system |
| **Unit:2** | **Scattering Theory** | **14 hours** |
| Scattering Amplitude - Expression in terms of Green’s Function - Born Approximation and Its validity- Partial wave analysis - Phase Shifts – Asymptotic behavior of Partial Waves- The Scattering Amplitude in Terms of Phase Shift- Scattering by Coulomb Potential and Yukawa Potential. |
| **Unit:3** | **Semi Classical Theory of Radiation** | **14 hours** |
| **Absorption and Induced Emission:** Maxwell’s equations - Plane electromagnetic waves - Use of perturbation theory - Transition probability - Interpretation in terms of absorption and emission - Electric dipole transitions - Forbidden transitions.**Spontaneous Emission:** Classical radiation field – Asymptotic form – Radiated Energy – Dipole radiation – Angular momentum – Dipole case – Conversion from classical to quantum theory – Planck distribution formula – Line breadth. |
| **Unit:4** | **Relativistic Wave Equation** | **14 hours** |
| Klein-Gordon Equation-Plane Wave Equation-Charge and Current Density - Application to the Study of Hydrogen Like Atom - Dirac Relativistic Equation for a Free Particle - Dirac Matrices - Dirac Equation in Electromagnetic Field - Negative Energy States. |
| **Unit:5** | **Quantum Field Theory** | **14 hours** |
| Quantization of Wave Fields - ClassicalLagrangian Equation - Classical Hamiltonian Equation - Field Quantization of the Non-Relativistic Schrodinger Equation-Creation, Destruction and Number Operators – Anti-Commutation Relations - Quantization of Electromagnetic Field Energy and Momentum. |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Quantum Entanglement- Online lectures, webinarsQuantum Computing* <https://dig.watch/trends/quantum-computing>

Quantum Entanglement* <https://www.youtube.com/watch?v=JFozGfxmi8A>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Quantum Mechanics, G. Aruldhas, Prentice Hall of India, 2013 |
| 2 | Quantum Mechanics Theory and Applications, AjoyGhatak and S. Lokanathan, Macmillan, 2004 |
| **Reference Books** |
| 1 | A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, Tata McGraw Hill, 2010 |
| 2 | Quantum Mechanics, L.I Schiff,McGraw Hill.2010 |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://nptel.ac.in/courses/115/103/115103104/> |
| 2 | <https://nptel.ac.in/courses/115/106/115106065/> |
| 3 | <https://nptel.ac.in/courses/115/106/115106065/> |
| Course Designed By:Dr. L. Senthilkumar and Dr. K. Senthilkumar |
|  **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | M | M | S | S | M | S | S |
| **CO2** | S | M | S | M | M | S | S | M | S | S |
| **CO3** | S | M | S | M | M | S | M | M | S | S |
| **CO4** | S | M | S | M | M | S | M | M | S | S |
| **CO5** | S | M | M | M | M | S | S | M | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC08** | **ELECTROMAGNETIC THEORY** | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Knowledge in key concepts related to electrical energy and power, forces on electric and magnetic fields  | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. To understand the nature of electric and magnetic force fields and the intricate connection between them.
2. To develop a strong background in electromagnetic theory, understand and use various mathematical tools to solve Maxwell equations in problems of wave propagation and radiation.
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Apply vector calculus operations and develop knowledge of vector fields and scalar fields | **K3** |
| 2 | Describe the fundamental nature of static fields, including steady current, static electric and magnetic fields | **K4** |
| 3 | Formulate potential problems within electrostatics, magnetostatics and stationary current distributions in linear, isotropic media, solve such problems in simple geometries using separation of variables and the method of images and also Fluid equation of motion of charged particles in E and B field will be analyzed | **K4** |
| 4 | Apply Maxwell’s equations and their application to time-harmonic fields, boundary conditions, wave equations, and Poynting’s power-balance theorem evaluation | **K5** |
| 5 | Describe the properties of plane waves in unbounded space and understand such concepts as wavelength, phase velocity and attenuation | **K2** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
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| **Unit:1** | **Electrostatics**  | **14 hours** |
| Coulomb’s law – surface, line and volume charge distributions - Gauss’ Law and its applications; Electrostatic potential - Laplace and Poisson equations – Potential of a localized charged distributions – Laplace equation in one, two and three dimensions – Boundary conditions and Uniqueness theorems- Work and Energy in electrostatics – Conductors |
| **Unit:2** | Magnetostatics | **14 hours** |
|  Lorentz force law- Biot-Savart law – condition for steady electric current - Ampere's law – Application of Ampere’s law – comparison of Magnetostatics and Electrostatics – Magnetic vector and Scalar potential – Magneto static boundary conditions – Magnetic fields in matter- Magnetization – The field of a magnetized object.  |
| **Unit:3** | Electrodynamics | **14 hours** |
|  Electromotive force – ohms law – Faradays law – Induced electric field – Energy in magnetic fields – Maxwell’s equation in free space – Magnetic charge - Maxwell’s equation in matter – Boundary conditions - Conservation laws – Conservation of energy – Poynting’s theorem - conservation of momentum.  |
| **Unit:4** | Electromagnetic waves & interaction with matter | **14 hours** |
| Electromagnetic waves in vacuum – Energy and momentum of EMW – EMW in matter – Propagation in linear media – Reflection and transmission at Normal incidence – Reflection and Transmission at Oblique incidence – Implications: Laws of incidence and reflectance, Snell’s law, Brewster law – Fresnel’s equations – wave guides- rectangular waveguide.  |
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| **Unit:5** | **Plasma Physics & Applications** | **14 hours** |
| Plasma – Plasma criteria – Debye shielding (DC current) – Plasma frequency (AC shielding) – Motion charge particles in uniform E and B field - non uniform B field – non uniform E field – time varying E field – time varying B field – guiding centre drifts – plasma confinement – Introduction to plasma diagnostics -Applications.  |
| **Unit:6** | **Contemporary Issues** | **2- hours** |
| Expert lectures, online seminars - webinars 1. Understanding the measurement/study on the plasma parameters
2. Study of basic laws in electro/Magnetostatics
3. Understanding Maxwell, his equations and electromagnetic theory

<https://www.youtube.com/watch?v=HL2vLaLsdTY>1. The spectral spectrum

<https://www.youtube.com/watch?v=-eEgybogUTw>5. Grand Challenges in low temperature Plasma Physics <https://www.frontiersin.org/articles/10.3389/fphy.2014.00039/full> |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Introduction to Electrodynamics, David J. Griffiths, Prentice Hall of India Pvt. Ltd, 3rd Edition, 2000 |
| 2 | Classical Electrodynamics, J.D. Jackson, John Wiley-India, 3rd Edition, 2011 |
| 3 | Introduction to Plasma Physics and Controlled Fusion, F. F. Chen, Springer (India) Pvt. Ltd, New Delhi, 2nd Edition, 2006 |
| **Reference Books** |
| 1 | Electromagnetic theory, P. K. Basu and H. Dhasmana, Ane Books Pvt. Ltd., New Delhi 2010 |
| 2 | Feynman Lectures, R. Feynman , Basic Books, Vol. 2, 2011 |
| 3 | Classical Electrodynamics, Hans Ohanian, Firewall media, 2nd Edition, 2009 |
| 4 | Foundations of Electromagnetic theory, J.R. Reity, F.J. Milford and R.W. Christy, Pearson. 4th Edition (2010) |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Introduction to plasma : <https://nptel.ac.in/courses/115/102/115102020/> |
| 2 | Electrostatics &Magnetostatics : <https://nptel.ac.in/courses/115/101/115101005/> |
| 3 | <https://ocw.mit.edu/courses/physics/8-311-electromagnetic-theory-spring-2004/index.htm> |
| Course Designed By:Dr. G. Shanmugavelayutham and Dr. Y.L. Jeyachandran |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | L | M | M | M | M | L | L |
| **CO2** | M | M | L | L | M | M | L | L | L | M |
| **CO3** | S | L | M | M | L | M | M | M | L | L |
| **CO4** | S | M | S | M | S | M | L | S | M | M |
| **CO5** | S | M | S | L | M | S | L | M | M | L |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC09** | **NUCLEAR AND PARTICLE PHYSICS** | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | A basic knowledge of quantum mechanics, mathematical methods | **Syllabus Version** |  |
| **Course Objectives:** |
| To familiarize the students and to impart knowledge 1. about basic nuclear physics properties, nuclear forces,
2. single particle and collective picture of nucleus,
3. nuclear decays and nuclear reactions, nuclear models for understanding of related reaction dynamics,
4. instrumentation and applications,
5. basic fundamental properties of elementary particles, symmetries and standard model
 |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Describe the basic nuclear properties, like size, density, moments, force, interaction | **K1-K5** |
| 2 | Explain the different forms of radioactivity and account for their occurrence | **K1-K5** |
| 3 | Account for the fission process, shell structure, collective behavior | **K1-K5** |
| 4 | Nuclear Instrumentation and related principles for detection and acceleration | **K1-K5** |
| 5 | Classify elementary particles, associated symmetries, conservations, standard model | **K1-K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
| **Unit:1** |  **Properties of Nuclei** | **14 hours** |
| ***Constituents of the nucleus and Nomenclature:*** Proton – Electron model – Proton – Neutron model - Isotopes, Isobars, Isotones and mirror nuclei – Nuclear mass and binding energy – Unit of atomic mass – Mass defect and packing fraction – Binding fraction versus the mass number***Nuclear Size & Properties*:** Nuclear radius - Estimation of nuclear radius – Mirror nuclei method – Scattering of fast electrons – Nuclear density– Nuclear Angular Momentum – Parity – Statistics – Magnetic dipole moment – Electric Quadrupole moment***Nuclear force*:** Properties – The Deuteron bound state problem – Spin states of the two-nucleon system – Magnetic dipole moment and Electric quadrupole moment of deuteron – Low energy *n-p* scattering to understand nuclear force |
| **Unit:2** | **Nuclear Models** | **14 hours** |
|  ***Liquid drop model*:** Semi empirical mass formula – Applications of LDM - Mass parabola – Q-values (Alpha, Beta and Fission) – Energetics of fission – Fissility parameter - Bohr-Wheeler’s theory ***Shell model*:** Evidences in favour of shell model - Shell model potential – Square well, Harmonic Oscillator, Woods-Saxon – Spin – Orbit coupling – Nuclear Ground state configuration and spin parity – Nuclear moment – Nuclear isomerism – Predictions and failures of the shell model***Collective model*:** Vibrational model – Rotational model – Quadrupole moment – Fermi gas model |
| **Unit:3** | **Decay and Reactions** | **14 hours** |
| ***Alpha decay*:** Energy relations - Q values –Spectrum and selection rules - Gamow’s theory ***Beta decay*:** Energy relations - Q values – Spectrum - Pauli’s neutrino hypothesis – Electron capture – Fermi’s theory of beta decay – Selection rules**Gamma decay** – Kinematics of Gamma decay – Spectrum – Internal conversion – Selection rules***Nuclear Reactions*** – Types and conservation laws – Q–equation – Threshold energy – General solution of the Q equations – Cross section of nuclear reactions –Scattering and reaction cross section - Compound nucleus model – Breit Wigner single level formula – Ghosal’s experiment  |
| **Unit:4** | **Instrumentation and Applications** | **14 hours** |
| ***Detectors:*** General Properties ***-*** Energy proportionality – Pulse shape – Energy resolution – Detection efficiency – Time resolution - Ionization Chamber – Geiger-Muller counter – Scintillation detectors – Semiconductor detectors ***Accelerators*** *–* Linear Accelerator – Cyclotron – Large Hadron Collider***Applications*** *–* Neutron activation analysis – Rutherford backscattering spectrometry – Accelerator mass spectroscopy |
| **Unit:5** | **Particle Physics** | **14 hours** |
| ***Interactions***– Strong – Electromagnetic – Weak – Gravitational***Constituent particles of matter***– Leptons and Quarks – Classification of Particles – Baryon number – Isospin – Resonance Particles – Strangeness and Strange particles – Hypercharge – Charge conjugation – Time reversal – Parity - CPT Theorem – Eightfold Way – Baryon Octet – Meson octet – Hypercharge *vs* Isospin – Baryon de-couplet - Conservation laws – Ideas of Standard model and Higgs particle |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| LHC, Neutron Stars, Black Holes, Gravitational WavesExpert lectures, online seminars – webinarsInside the Worlds largest Particle Accelerator* <https://www.youtube.com/watch?v=328pw5Taeg0>

Neutron Stars* <https://www.youtube.com/watch?v=udFxKZRyQt4>

Gravitational Waves* <https://stfc.ukri.org/news-events-and-publications/features/gravitational-waves-everything-you-need-to-know/>
* <https://www.nytimes.com/2016/02/12/science/ligo-gravitational-waves-black-holes-einstein.html>

Black Holes* <https://www.youtube.com/watch?v=dueX8aVzS6w>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Introductory Nuclear Physics, K.S. Krane, Wiley India Ltd. 2008 |
| 2 | Nuclear Physics – Principles and Applications, John Lilley, Wiley India, 2006 |
| 3 | Nuclear Physics, V. Devanathan, Narosa, 2012 |
|  |
| **Reference Books** |
| 1 | Facts and mysteries in elementary particle physics, M. Veltman, World Scientific,2003 |
| 2 | Introduction to elementary particles,D. Griffiths,John Wiley & Sons1987 |
| 3 | Particle Physics, B.R. Martin and G. Shaw, Wiley, 1997 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Swayam<https://swayam.gov.in/nd1_noc20_ph19/preview> |
| 2 | ePGPathshala Paper No. : Nuclear and Particle Physics Module : Introduction to Nuclear Physics, Sanjay Kumar Chamoli |
| 3 | MIT Open Courseware <https://ocw.mit.edu/courses/physics/8-701-introduction-to-nuclear-and-particle-physics-spring-2004/> |
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| Course Designed By:Dr. M. Balasubramaniam and Dr. P. Christopherselvin |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | M | M | S | L | L | S | S |
| **CO3** | S | M | S | M | M | S | L | L | S | S |
| **CO3** | S | M | S | M | M | S | L | M | S | S |
| **CO4** | S | M | S | M | M | S | M | M | S | S |
| **CO5** | S | M | M | M | M | S | L | L | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC10** | **THERMODYNAMICS AND STATISTICAL MECHANICS** | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Undergraduate level thermodynamics laws, relations, basic knowledge on microscopic and macroscopic particles  | **Syllabus Version** |  |
| **Course Objectives:** |
| * To provide a phenomenological introduction to thermodynamics through thermodynamics postulates, quantities and relations
* Studying the micro and macroscopic properties of the mater through the statistical probability laws and distribution of particles
* Understanding the classical and quantum distribution laws and their relations
* Studying transport properties, different phases of maters, equilibrium and non-equilibrium process
 |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Understanding of thermodynamic concepts, which are related to materials properties, various areas of research and development. | **K2** |
| 2 | Fundamental understanding on relation between microscopic and macroscopic particles and their properties. | **K3** |
| 3 | Knowledge on role of distribution of particles and energy within the available states on properties of the matter | **K4** |
| 4 | Knowing the possible states of the mater and energy exchange during the change in state of the matter | **K4** |
| 5 | Applying thermo-dynamical relations and statistical laws to study the properties of the matter | **K3** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
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| **Unit:1** | **Thermodynamics, Microstates and Macrostates** | **14 hours** |
| Basic postulates of thermodynamics – Fundamental relations and definition of intensive variables – Intensive variables in the entropic formulation – Equations of state – Euler relation, densities - Gibbs-Duhem relation for entropy - Thermodynamic potentials– Maxwell relations – Thermodynamic relations – Microstates and macrostates – Ideal gas – Microstate and macrostate in classical systems – Microstate and macrostate in quantum systems – Density of states and volume occupied by a quantum state |
| **Unit:2** | **Microcanonical, Canonical and Grand canonical Ensembles**  | **14 hours** |
| Microcanonical distribution function – Two level system in microcanonical ensemble – Gibbs paradox and correct formula for entropy – The canonical distribution function – Contact with thermodynamics - Partition function and free energy of an ideal gas –The grand partition function – Relation between grand canonical and canonical partition functions – Chemical potential and chemical reactions- One-orbital partition function. |
| **Unit:3** | **Bose-Einstein, Fermi-Dirac and Maxwell-Boltzmann Distributions** | **14 hours** |
| Bose-Einstein and Fermi-Dirac distributions – Thermodynamic quantities – Non-interacting Bose gas and thermodynamic relations – Chemical potential of bosons – Number density of photons and Bose condensation - Thermodynamic relations for non-interacting Fermi gas – Fermi gas at zero and low temperature – Fermi energy and Fermi momentum - Maxwell-Boltzmann distribution law for microstates in a classical gas - Physical interpretation of the classical limit – Fluctuations in different ensembles  |
| **Unit:4** | **Transport, Equilibrium and Non-Equilibrium processes** | **14 hours** |
| Derivation of Boltzmann transport equation for change of states without and with collisions – Boltzmann equation for quantum statistics – Equilibrium distribution in Boltzmann equation – Transport processes; One speed and one dimension - All speeds and all directions - Distribution of molecular velocities – Equipartition and Virial theorems - Brownian motion - Non-equilibrium process; Joule-Thompson process - Free expansion and mixing - Thermal conduction  |
| **Unit:5** | **Heat capacities, Ising model, and Phase Transitions** | **14 hours** |
| Heat capacities of heteronuclear diatomic gas – Heat capacities of homonuclear diatomic gas – Heat capacity of Bose gas –One-dimensional Ising model and its solution by variational method – Exact solution for one-dimensional Ising model - Phase transitions and criterion for phase transitions – Classification of phase transitions by order and by symmetry – Phase diagrams for pure systems – Clausius-Clapeyron equation – Gibbs phase rule |
| **Contemporary Issues : Tutorial** (This portion is not for examination)**2 Hours** |
| 1. Show explicitly that Gibbs paradox disappears when the correction is included.2. Obtain free energy of the linear harmonic oscillator through thermodynamic quantities 3. Derive Helmholtz free energy in terms of T, H and N.4. Find entropy, energy and heat capacity of a two level system when the temperature is zero and infinity.5. Estimate the critical temperature for Bose condensation for 4He atoms. Take g=1 and n=3X1022 cm-3. 6. Calculate energy density and number density of massless Fermi gas at any temperature when chemical potential is equal to zero and chemical potential is equal to some arbitrary value |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | An Introductory Course of Statistical Mechanics, P.B. Pal, Narosa Publishing House, 2008 |
| 2 | An introduction to Thermodynamic and Statistical Mechanics, Keith Stowe, Cambridge University Press, 2nd Edition, 2013 |
| 3 | Elements of Statistical Mechanics, Kamal Singh & S.P. Singh, S. Chand & Company,1999 |
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| **Reference Books** |
| 1 | Statistical Mechanics An Elementary Outline, AvijitLahiri, University Press, Hyderabad2002 |
| 2 | Thermodynamic and Statistical Mechanics (Lecturers on the theoretical physics), Arnold Sommerfeld, Levant Books, Kolkatta,2005 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://www.grc.nasa.gov/www/k-12/airplane/thermo.html> |
| 2 | <https://web.stanford.edu/~peastman/statmech/> |
| 3 | <https://ocw.mit.edu/courses/physics/8-333-statistical-mechanics-i-statistical-mechanics-of-particles-fall-2013/lecture-notes/> |
| 4 | <https://www.youtube.com/channel/UCcW7z2pE37Z4I1koTwahBfA> |
| 5 | <https://scholar.harvard.edu/schwartz/teaching> |
| Course Designed By:Dr. K. Senthilkumar and Dr. R. Shankar |

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| Mapping with Programme Outcomes |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | M | S | M | M | S | M | M |
| **CO3** | S | S | M | M | S | M | M | S | M | M |
| **CO3** | S | S | M | M | S | M | M | S | M | M |
| **CO4** | S | S | M | M | S | M | M | S | M | M |
| **CO5** | S | S | M | M | S | M | M | S | M | M |

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| **Course code** | **22PHYL03** | **ADVANCED PHYSICS LAB** | **L** | **T** | **P** | **C** |
| **LAB** | LAB | **0** | **1** | **6** | **4** |
| **Pre-requisite** | Know the basic law and theory.Have practical experience to apply the theory and measurement tools | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: 1. To give hands on training to do advanced physics experiments
2. To make the students understand the concepts behind various physics experiments such as polarizability of liquids, dispersive power of prism, refractive index of glass, ultrasonic wave velocity of liquids, young’s modulus of materials etc.,
3. To give exposure to measure some of the physical parameters with maximum accuracy.
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Understand the concepts behind various physics experiments | **K2, K3** |
| 2 | Measure different physical parameters with maximum accuracy | **K2, K5** |
| 3 | Determine various physical constants through different physics experiments | **K2, K4** |
| 4 | Determine Young’s Modulus by fringe method | **K2, K4** |
| 5 | Exposure to advance research laboratories  | **K4, K6** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| No. | Experiment |
| 1. | Determination of Young’s modulus of glass by Cornus Method |
| 2. | Determination of Cauchy’s constant and dispersive power of a given prism by measuring refractive index for different wavelengths. |
| 3. | Determination of the polarizability of the given liquid by measuring the refractive index at different wavelengths.  |
| 4 | To prove the energy transferred from electrons to atoms always has discrete values by Frank hertz experiment. |
| 5 | To calculate the Lande’s splitting factor by using Electron Spin Resonance Spectrometer. |
| 6 | Determination of band gap and resistivity of semiconductor at different temperatures by Four Probe Method. |
| 7 | Determination of the velocity and compressibility of the given liquid using ultrasonic interferometer. |
| 8 | Determination of the wavelength of given monochromatic source and the difference in wavelength of the two spectral lines D1 and D2 of Sodium source using Michelson Interferometer. |
| 9 | Determination of wavelength of different lines in a Mercury spectrum by Michelson Interferometer Experiment. |
| 10 | Determination of optical absorption coefficient and determination of refractive index of the liquids using He-Ne – Laser. |
| 11 | Determination of Refractive index of liquids using He-Ne Laser / Diode Laser.  |
| 12 | Determination of Ultrasonic velocity in a given liquid for a fixed frequency. |
| 13 | To study the characteristics of LDR (light dependent resistor) and photo voltaic cell. |
| 14 | Determination of Young’s modulus of glass plate by Elliptical fringe method. |
| 15 | Determination of Young’s modulus of glass plate by Hyperbolic fringe method. |
| 16 | Determination of Hall coefficient, mobility, Hall angle and number of charge carriers by using Hall setup. |
| 17 | Determination of the coercivity, retentivity and saturation magnetization of the given material using hysteresis loop tracer equipment. |
| 18 | To measure the ionizing radiation from the given source using GM counter experiment |
| 19 | Determination of contact angle and surface energy of given thin film. |
| 20 | Determine the dielectric constant of given semiconductor materials. |
| 21 | Incident photon to current conversion efficiency of silicon solar cell. |
| 22 | Development of thin film coating using sputtering technique. |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
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| **1** | Young”s modulus : <https://nptel.ac.in/courses/115/105/115105110/> |
| **2** | ESR:<http://web.mit.edu/5.33/www/ESR_05.pdf> |
| **3** | Properties of materials :<http://www.iitk.ac.in/mme/test/ESO214.pdf> |
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| Course Designed By: Dr. G. Shanmugavelayutham and Dr. Y.L. Jeyachandran |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | M | S | S | M | M | S |
| **CO3** | M | M | M | S | L | S | S | L | S | S |
| **CO3** | S | S | S | M | L | S | M | M | S | S |
| **CO4** | S | S | S | M | L | S | M | M | S | S |
| **CO5** | S | S | S | M | L | S | M | M | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYC11** | **SEMICONDUCTOR DEVICES** | **L** | **T** | **P** | **C** |
| **Core/~~Elective/Supportive~~** | CORE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Types of crystal structures, Basic Quantum Physics, Material classifications and knowledge on Electronic components  | **Syllabus Version** |  |
| **Course Objectives:** |
| Knowledge and understanding of semiconductors and devices are essential for applied physics graduates planning for a technological career. The aim of this course is to provide the students a sound understanding of semiconductor physics and the operational principles of some electronic devices, for learning and using modern technology. In this course, students can also develop the basic analytical skills required for learning or developing novel devices, their fabrication processes and technological applications for their future career, with the following course objectivesCO1. Understanding the theory of semiconductors and energy band structures.CO2 Understanding the theory of PN junction, including its formation and understanding.CO3 Understanding the theory of MOSFET & MESFETs and related devices.CO4 Understanding the functioning of various microwave devices and their application.CO5 Understanding the theory of photonic devices and their applications.  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Knowledge on the theory of semiconductors and energy band structures | **K1** |
| 2 | Knowledge on the theory of material surface and interfaces (Semiconductor/semiconductor interfaces, metal/semiconductor interface and metal/oxide/semiconductor interfaces)  | **K2** |
| 3 | Knowledge on the theory of different types of electronic devices.  | **K3** |
| 4 | Apply fundamental principles and processes for the development of newer types of semiconductor devices and their uses.  | **K4** |
| 5 | Knowledge on the fabrication of electronic and optoelectronic devices and evaluate and analyze device characteristics in terms of the material properties and/or structural parameters. | **K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
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| **Unit:1** | **Semiconductor Theory** | **14 hours** |
| ***Energy bands:***Semiconductor Materials, Basic Crystal Structure, Basic Crystals Growth Technique, Valence Bonds, Energy Bands, Intrinsic Carrier Concentration, Fermi-Dirac distribution function, Donors and Acceptors, Non-degenerate Semiconductor; impurity doping: basic diffusion process, diffusion equation, diffusion profiles; ***Carrier Transport Phenomena:*** Carrier Drift: mobility, resistivity, Hall Effect; Carrier Diffusion: diffusion process, Einstein Relation, current density equation; Generation and Recombination Processes: direct and indirect recombination, surface recombination, Auger recombination; Continuity Equation, The Haynes-Shockley Experiments; Thermionic Emission Process, Tunneling Process: i.e Schrodinger equation; High Field Effects |
| **Unit:2** | **Semiconductor Junction Theory** | **14 hours** |
| ***Basic Fabrication Steps:*** Oxidation, Lithography; Thermal Equilibrium Condition: Band Diagram, Equilibrium Fermi Level; Depletion Region: Abrupt junction, Linearly Graded junction; Depletion Capacitance, Current-Voltage Characteristics: generation-recombination and high-injection effects; Charge Storage and Transient Behaviour, Junction Breakdown: i.e tunneling effect;, Avalanche multiplication, Hetero junction; ***Bipolar Transistor basics:*** Bipolar transistor Action: operation in the active mode; Static Characteristics of Bipolar Transistor; frequency response |
| **Unit:3** | **MOSFET & Related Devices** | **14 hours** |
| ***MOSFET and Related Devices:*** The MOS Diode: i.e the ideal MOS diode, metal & semiconductor work function, the SiO2 -Si MOS diode, CCD; MOSFET fundamental: linear and saturation regions, types of MOSFET, threshold voltage control; MOSFET scaling: i.e short-channel effect, scaling rules; CMOS and BiCMOS: i.e Latch-up; MOSFET on insulator: i.e thin film transistor; MOS Memory structures: DRAM, SRAM, Non volatile memory; the power MOSFET; ***MESFET and Related Devices:*** Metal-Semiconductor Contacts: i.e the Schottky barrier, semiconductor work function, Ohmic contact; MESFET: Devices structure, principles of operation, high-frequency performance; ***MODFET:*** MODFET fundamentals |
| **Unit:4** | **Theory of Microwave Devices** | **14 hours** |
| ***Basic Microwave Technology:***i.e IEEE microwave frequency bands; Tunnel diode: i.e I-V characteristics; Impatt diode: i.e static & dynamic characteristics, field distributions and generated carrier densities; transferred-electron devices: i.e negative differential resistance, device operation; quantum-effect devices: i.e resonant tunneling diode, energy of electrons; hot-electron devices: i.e hot-electron HBT, real-space-transfer transistor |
| **Unit:5** | **Theory of Photonic Devices** | **14 hours** |
| ***Radiative Transitions & Optical Absorption:***radiative transistor, Boltzman distribution, optical absorption, optical absorption coefficients; LED: visible LEDs, bandgap semiconductors, Snell’s law, orangic LED, Infrared LED ; Semiconductor Laser: laser operation, energy bandgap, carrier & optical confinement, optical cavity & feedback, basic laser structure, distributed feedback laser, quantum-well laser, energy of charge particle Photodetector: photoconductor, photodiode, quantum efficiency, response speed, p-i-n photodiode, heterojunction photodiode, avalanche photodiode) 4.5 Solar Cell: solar radiation, p-n junction solar cell, conversion efficiency, silicon & compound-semiconductor solar cells, optical concentration***Problems:*** Carrier concentration and Fermi level distribution related problems can be asked |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Contemporary issues: Limitation of Moor’s Law, understanding quantum transport in nanoscale transistors/Devices-Designing of semiconductor FABLABs & Training to studentsSolution: Invited lectures from experts, workshops on theme based issues, visiting private industries Expert lectures, online seminars – webinarsOver 50 Years of Moore’s law* <https://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html>

How computing will change amid challenges to Moore’s law* <https://techcrunch.com/2017/04/13/how-computing-will-change-amid-challenges-to-moores-law/>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Semiconductor Devices Physics and Technology, S. M. Sze,Wiley Publication,2nd Edition1985 |
| 2 | Physics of semiconductor devices, S.M. Sze and Kwok K. Ng, Wiley, Third Edition, 2007 |
| 3 | Semiconductor Physics and Devices: Basic Principles, D A Neamen, McGraw-Hill, 3rd Edition, 2003 |
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| **Reference Books** |
| 1 | Solid State Electronic Devices, B G Streetman, S Banerjee, Prentice Hall, 6th Edition, 2009 |
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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://nptel.ac.in/courses/108/108/108108112/> |
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| Course Designed By:Dr. D. Nataraj and Dr. Y.L. Jeyachandran |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | S | S | M | M | M | M | S |
| **CO2** | S | S | M | S | M | S | S | M | M | S |
| **CO3** | S | S | M | S | M | M | M | S | M | S |
| **CO4** | S | M | M | S | S | S | S | M | M | S |
| **CO5** | S | M | M | M | S | M | M | M | M | S |

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| **Course code** | **22PHYC12** | **ATOMIC AND MOLECULAR SPECTROSCOPY** | **L** | **T** | **P** | **C** |
| **Core/Elective/Supportive** | **CORE** | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Basic knowledge on physics of atoms and molecules, and light | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: 1. Educate the students the concepts of atomic and molecular spectroscopy.
2. Introduce the students to various molecular and atomic spectroscopy techniques available to study the chemical and structural properties of materials.
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Understand the principles and concepts of atomic and molecular spectroscopy. | K1, K2 |
| 2 | Understand the electronic structure of atoms and molecules, and transition and selection rules of rotational, vibrational, electronic spectroscopies. | K1, K2 |
| 3 | Identify the spectroscopic tools to investigate rotational, vibrational, electronic and structural characteristics of materials. | K3, K4 |
| 4 | Observe the spectra, extract spectral signatures, interpret them and associate to the structural and chemical properties of materials. | K4, K5 |
| 5 | Develop models to extract detailed information from the spectra  | K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
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| **Unit:1** | **Electronic Spectroscopy of Atoms** | **14 hours** |
| Electronic wave function – atomic quantum numbers – hydrogen atom spectrum – Electronic angular momentum – Fine structure of hydrogen atom – Many-electron atoms – Lithium atom spectrum – angular momentum of many electron atoms – Term symbols – LS and JJ coupling – Spectrum of helium and alkaline earths – Equivalent and non-equivalent electrons – Zeeman effect – Paschen-Back effect – Stark effect – X-ray photoelectron spectroscopy. |
| **Unit:2** | **Aspects of Molecular Spectroscopy and Rotational spectroscopy** | **14 hours** |
| Diatomic molecule – Molecular orbital theory (LCAO) – Shape of molecular orbitals (Morse Potential) – Born-Oppenheimer approximation – Regions of the electromagnetic spectrum – Width and intensity of spectral lines – Rotation of molecules – Rigid diatomic molecules – Intensity of line spectra – the effect of isotropic substitution – non-rigid rotator and their spectra – polyatomic molecules (linear and symmetric top molecules) – Technique and instrumentation of microwave spectroscopy. |
| **Unit:3** | **Vibrational Spectroscopy** | **14 hours** |
| Energy of diatomic molecules – Simple Harmonic Oscillator – Anharmonic oscillator – Diatomic vibrating rotator – Vibration-Rotation spectrum of carbon monoxide – Breakdown of Born-Oppenheimer approximation –Vibrations and symmetry of polyatomic molecules – Influence of rotation on the spectra of polyatomic molecules (linear and symmetric top molecules) – Quantum and classical theory of Raman effect – pure rotational Raman spectra (linear and symmetric top molecules) – Raman active vibrations – Vibrational Raman spectra – Rotational fine structure – Vibrations of spherical tip molecules – Techniques and instrumentation of Infrared and Raman spectrometers. |
| **Unit:4** | **Electronic Spectroscopy of Molecules** | **14 hours** |
| Vibrational coarse structure progressions – Franck-Condon principle – Dissociation energy and their products – Rotational fine structure of vibronic transitions – Fortat Diagram – Pre-dissociation – Spectrum of molecular hydrogen – Change of shape on excitation – Chemical analysis by electronic spectroscopy – Re-emission of energy by an excited molecule. |
| **Unit:5** | **Spin Resonance Spectroscopy** | **14 hours** |
| Nature of spinning particles – Spin and magnetic field interaction – Larmor precession – Relaxation time – Spin-spin relaxation – Spin–lattice relaxation - NMR chemical shift – Coupling constants – Coupling between nuclei – Chemical analysis by NMR – Exchange Phenomena - NMR for nuclei other than hydrogen - ESR spectroscopy – g-factor – Electron-Nucleus Coupling – Electron-Electron Coupling. |
| **Unit:6** | **Contemporary Issues** | **2 Hours** |
| Expert lectures and online seminars – webinars on synchrotron based high resolution spectroscopic techniques.Spectroscopy for the real world* <https://newscenter.lbl.gov/2005/01/31/spectroscopy-for-the-real-world/>

Functional Magnetic Resonance Spectroscopy* <https://www.frontiersin.org/articles/10.3389/fpsyt.2018.00076/full>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Fundamentals of Molecular Spectroscopy, Colin N. Banwell and Elaine M. McCash, McGraw-Hill Education (India) Pvt. Ltd, 5/e, 2013. |
| 2 | Spectroscopy (Atomic and molecular), G. R. Chatwal and S. K. Anand, Himalaya Publishing House, 5/e, 2016. |
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| **Reference Books** |
| 1 | Fundamentals of Molecular Spectroscopy, Walter S. Struve, John Wiley and Sons, 1989. |
| 2 | Atomic and Molecular Spectroscopy, SuneSvanberg, Springer-Verlag, 2004. |
| 3 | Molecular Spectroscopy, Jeanne L. McHale, CRC Press, 2017. |
| 4 | Molecular structure and spectroscopy, G. Aruldhas, Prentice-Hall of India, 2004. |
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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Atomic and Molecular Physics, Prof. T. Kundu, https://nptel.ac.in/courses/115/101/115101003/.  |
| 2 | Atomic and Molecular Physics, Prof. Amal Kumar Das, https://nptel.ac.in/courses/115/105/115105100/. |
| 3 | Select / Special Topic in Atomic Physics, Prof. P.C. Deshmukh, https://nptel.ac.in/courses/115/106/115106057/ |
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| Course Designed By: Dr. Y. L. Jeyachandran and Dr. G. Shanmugavelayutham |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | M | M | L | L | L | S | M | M | M |
| **CO3** | S | M | M | L | L | L | M | M | M | M |
| **CO3** | S | S | S | M | S | L | M | S | S | M |
| **CO4** | S | S | S | M | S | M | M | S | S | S |
| **CO5** | S | M | S | S | M | M | M | S | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYE03A** | **MODERN OPTICS** | **L** | **T** | **P** | **C** |
| **~~Core~~/Elective~~/Supportive~~** | ELECTIVE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | Fundamentals of Optics | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to:1. Learn the concepts behind the various optical phenomena such as polarization and double refraction for day-to-day applications.2. Know the principle of lasers, types and applications.3. Impart knowledge on basics of fiber optics and fiber optic sensors.4. Reveal on non-linear optics, magneto-optics and electro-optics. |
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Understand the usage of various optical components in modern devices and instruments. | **K2, K3** |
| 2 | Describe how the polarization is used to decrease glare by display screens.  | **K3, K6** |
| 3 | Start research work on application aspects of lasers. | **K3, K6** |
| 4 | Establish knowledge and an extensive understanding of non-linear optics. | **K2, K3** |
| 5 | Learn the principles of magneto-optic and electro-optic effects and its applications. | **K2, K3** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | Polarization and Double Refraction | **14 hours** |
| Classification of polarization − Transverse character of light waves − Polarizer and analyzer −Malus law; Production of polarized light: Wire grid polarizer and polaroid − Polarization by reflection − Polarization by scattering; Phenomenon of double refraction: Normal incidence − Oblique incidence; Interference of polarized light: Quarter and Half wave plates; Analysis of polarized light − Optical activity.  |
| **Unit:2** | Lasers | **14 hours** |
| Basic principles: Spontaneous and stimulated emissions; Components of the laser – Resonator − Lasing action; Types of Lasers and its Applications: Solid State Lasers: Ruby laser −Nd:YAG laser; Gas lasers: He-Ne laser − CO2 laser; Chemical lasers: HCl laser − DF-CO2 laser; Central features of Semiconductor lasers. |
| **Unit:3** | Fiber Optics | **14 hours** |
| Total internal reflection − Optical fiber − Glass fibers − Coherent bundle − Numerical aperture − Attenuation in optical fibers − Single mode and Multi-mode fibers; Pulse dispersion in multimode optical fibers: Ray dispersion in multimode step index fibers − Parabolic-index fibers; Fiber-optic Sensors: Precision displacement sensor − Precision vibration sensor. |
| **Unit:4** | Non-Linear Optics | **14 hours** |
| Basic principles − Harmonic generation − Second harmonic generation − Phase matching − Third harmonic generation − Optical mixing − Parametric generation of light − Self-focusing of light.  |
| **Unit:5** | Magneto-Optics and Electro-Optics | **14 hours** |
| Magneto-optics: Zeeman effect − Inverse Zeeman effect − Faraday effect − Voigt effect − Cotton-Mouton effect − Kerr Magneto-optic effect; Electro-optics: Stark effect − Inverse Stark effect − Electric double refraction − Kerr electro-optic effect −Pockels electro-optic effect.  |
| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars - webinarsDouble refraction and applications − Advanced Laser technology and applications − Optical fiber communication − NLO applications − Electro-optic and magneto-optic photonic devices.Index Ellipsoid and Permittivity Tensor* <http://www.infocobuild.com/education/audio-video-courses/physics/ModernOptics-IIT-Kharagpur/lecture-11.html>

Ellipsoid Matrix, Euler angle Rotation, Transformation Matrix* <http://www.infocobuild.com/education/audio-video-courses/physics/ModernOptics-IIT-Kharagpur/lecture-12.html>
 |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Optics, AjoyGhatak, McGraw-Hill Education (India) Pvt Ltd, 6th Edition, 2017. |
| 2 | Lasers and Non-Linear Optics, B.B. Laud, New Age International (P) Ltd., 3rd Edition2011. |
| 3 | Fundamentals of Optics, Francis A. Jenkins and Harvey E. White, McGraw-Hill Edition (India) Pvt. Ltd., 4th Edition, 2011. |
|  |
| **Reference Books** |
| 1 | Optical Physics, Ariel Lipson, Stephen G. Lipson, Henry Lipson, Cambridge University Press, New Delhi, 4th Edition, 2011. |
| 2 | Optics, Light and Lasers, Dieter Meschede, Wiley-VCH, Verley GmbH, 2004. |
| 3 | Laser Fundamentals, William T. Silfvast, Cambridge University Press, New York, 1996. |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Polarization and Double refraction: <https://nptel.ac.in/courses/122/107/122107035/> |
| 2 | Lasers : <https://nptel.ac.in/courses/104/104/104104085/> |
| 3 | Fiber optics: <https://nptel.ac.in/courses/115/107/115107095/> |
| 4 | Non-linear optics: <https://nptel.ac.in/courses/115/105/115105105/> |
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| Course Designed By:Dr. K. Srinivasan and Dr. K. Suresh |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | L | L | S | L | S | S | L | S | S |
| **CO2** | S | L | L | S | L | S | M | M | S | S |
| **CO3** | S | L | L | S | L | S | M | L | S | S |
| **CO4** | S | L | L | S | L | S | L | L | S | S |
| **CO5** | S | L | L  | S | L  | S | M | L | S | S |

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| **Course code** | **22PHYE03B** | **MATERIALS PHYSICS AND PROCESSING TECHNIQUES** | **L** | **T** | **P** | **C** |
| **~~Core~~/Elective~~/Supportive~~** | ELECTIVE | **5** | **1** | **0** | **4** |
| **Pre-requisite** |  **Knowledge on materials science** | **Syllabus Version** |  |
| **Course Objectives:** |
| * To impart knowledge on various materials growth, synthesis and processing techniques
* To learn the structural, morphology, and surface characterization techniques.
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | At the end of this course, students can be able to prepare single crystals using various techniques  | **K2** |
| 2 | Learn the waste treatment method for eco-friendly environment | **K3** |
| 3 | Able to understand the basic concepts of vacuum technique | **K2,K3** |
| 4 | Able to prepare various nanoparticles using wet chemical methods and its functionalization | **K3** |
| 5 | Further, the student can able to analyse the properties of materials using various characterization tools. | **K3, K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** |  **Crystal growth** | **14 hours** |
| Significance of crystal growth-Naturally occurring crystal growth processes-Crystal growth processes in laboratory and industrial scale- Classification of crystal growth methods-Growth from solutions -Nucleation: Homogeneous and heterogeneous, Solubility phase diagram-Saturation-Supersaturation- Metastable zone width-Slow evaporation and slow cooling methods, Growth from gel-Growth from flux-Growth from melt- Bridgeman-Stockbarger method- Czochralski pulling method- Growth from vapour-Sublimation method. |
| **Unit:2** | **Plasma processing**  | **14 hours** |
| Basics of plasma: Introduction, Types of plasma; Properties of plasma; V-I characteristics; Advantages of plasma processing. Thermal plasma: Principles of plasma generation-DC plasma torches; AC plasma torches; RF plasma torches, Plasma spraying; Structure of sprayed deposits, Plasma spheroidization; Plasma decomposition; Treatment of hazardous wastes – Synthesis of ultrafine/nano powders. Plasma melting and remelting. Non-thermal plasma: Glow discharge plasma, Plasma reactors for surface treatment: Corona & DBD atmospheric pressure surface treatment reactors |
| **Unit:3** | **Vacuum Techniques**  | **14 hours** |
| Units and range of vacuum – Formulas for important quantities – Qualitative description of pumping process – Surface processes and outgassing – Gas flow mechanism – Classification of pumps : Positive displacement pumps – Kinetic pumps – Entrapment pumps - Classification of pressure gauges : Total pressure gauges –Hydrostatic pressure gauges - Thermal conductivity gauges – Ionization gagues – Vacuum system : simple rotary, diffusion, turbo molecular, ultra-high vacuum and cryo-pumped systems. |
| **Unit:4** | **Growth technique of Thinfilms and nanomaterials** | **14 hours** |
| Plasma arc discharge-sputtering-chemical vapour deposition-pulsed laser deposition-molecular beam epitaxy- Electrochemical deposition - SILAR methodSolid-State Reaction - Sol-Gel Technique - Hydrothermal growth - Ball Milling – Combustion synthesis – Sonochemical method - Microwave synthesis – Coprecipitation |
| **Unit:5** | **Characterization Tools** | **14 hours** |
| Working principles and instrumentation – XRD – XPS – AES - SIMS - RBS – LEED - AFM – SEM – TEM – EDAX -STM  |
| **Unit:6** | **Contemporary Issues** |  |
| Expert lectures, online seminars – webinars**2 hours**Nano Listicles: <https://newscenter.lbl.gov/2016/08/03/nano-listicle/>Plasma Physics: <https://www.youtube.com/watch?v=FUswgDQGxvE> |
|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Handbook of Thin Film Technology, Maissel and Glange, McGraw Hill, 1stEdition, 1970 |
| 2 | Vacuum Technology, A. Roth, North Holland, Third Edition, 1990 |
| 3 | Fundamentals of Vacuum Techniques, Pipko A, Pliskosky V, MIR Publishers, 1stEdition, 1984 |
| 4 | Non-equilibrium Processing of Materials, Edited by C. Suryanarayana, Vol.2, PP. 1-438 (1999) |
|  |
| **Reference Books** |
| 1 | Ultra High Vacuum Technology, D. K. Avasthi, A. Tripathi, A. C. Gupta, Allied Publishers Private Limited, 2002 |
| 2 | Thin Film Solar CellsKasturiLal Chopra, SuhitRanjan Das, Plenum Press, New York, 1983 |
| 3 | Basic Vacuum Technology,A.Chambers, R.K.Fitch and B.S.Halliday,IOP Publishing Ltd,2ND Edition ,1998 |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Introduction to plasma : <https://nptel.ac.in/courses/115/102/115102020/> |
| Course Designed By:Dr. K. Srinivasan, Dr. D. Nataraj, Dr. R. Kalaiselvan and Dr. G. Shanmugavelayutham |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | M | S | M | M | S | M | M |
| **CO3** | S | S | M | M | S | M | M | S | M | M |
| **CO3** | S | S | M | M | S | M | M | S | M | M |
| **CO4** | S | S | M | M | S | M | M | S | M | M |
| **CO5** | S | S | M | M | S | M | M | S | M | M |

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| **Course code** | **22PHYE03C** | **ARTIFICIAL INTELLIGENCE** | **L** | **T** | **P** | **C** |
| **~~Core~~/Elective~~/Supportive~~** | ELECTIVE | **5** | **1** | **0** | **4** |
| **Pre-requisite** | **Basic Knowledge in Computer Science** | **Syllabus Version** |  |
| **Course Objectives:** |
| * to introduce Artificial Intelligence & machine learning for biology students
* to facilitate students to learn & apply AI tools for solving research issues in physics
* to understand the basics of robotic process automation
* to develop automated solutions for research problems in biology
 |
|  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Know what is artificial intelligence | **K1-K2** |
| 2 | Learn the search strategies using AI  | **K1-K2** |
| 3 | Learn basics of Python programming | **K1-K2** |
| 4 | Understand the robotic process automation | **K1-K2** |
| 5 | Understand automation tasks and debugging | **K1-K2** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** |  | **14 hours** |
| Artificial Intelligence (AI): Introduction to AI – Fundamentals – Need for AI –Foundations of AI – AI environment – Application domains of AI – AI tools – Challengesand Future of AI. |
|  |
| **Unit:2** |  | **14 hours** |
| SEARCH STRATEGIES: Breadth-First Search - Uniform Cost Search - Depth-First Search - Depth-Limited Search - Iterative Deepening Search - Bidirectional Search - Heuristic Search Techniques - A\* Search - AO\* Algorithm |
|  |
| **Unit:3** |  | **14 hours** |
| Python programming: Introduction to Python language – Python, Machine learning andAI - Data types, variables and operators – Conditions and loops – Structure of a Pythonprogram – Packages and function – Writing simple python codes. |
|  |
| **Unit:4** |  | **14 hours** |
| Robotic Process Automation (RPA): Fundamentals of RPA – Programming basics fromRPA perspective – Applying RPA – RPA development methodology – Architecture ofRPA – RPA and emerging ecosystem. |
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| **Unit:5** |  | **14 hours** |
| Introduction - Automation debugging – Automation library - ActivitiesPackages – Basic automation tasks - Text and image automation – Data tables in RPA –Extracting data from data tables and pdf – Building simple Automation projects. |
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| **Unit:6** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars – webinarsSocietal issues concerning Artificial Intelligence* <https://www.karger.com/Article/FullText/492428>

Case studies on Artificial Intelligence* <https://www.digitaleurope.org/news/case-studies-on-artificial-intelligence/>
 |
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|  | **Total Lecture hours** | **72 hours** |
| **Text Book(s)** |
| 1 | Stuart J Russell and Peter Norvig, ―Artificial Intelligence - A Modern Approach‖, Third Edition, Prentice Hall of India/ Pearson Education, New Delhi, 2015. |
| 2 | Elaine Rich and Kevin Knight, ―Artificial Intelligence‖, Tata McGraw Hill Publishing Company, New Delhi, 2014. |
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| **Reference Books** |
| 1 | Eugene Charniak and Drew McDermott, ―Introduction to Artificial Intelligence‖, Pearson Education, New Delhi, 2010. |
| 2 | Nils J Nilsson, ―Principles of Artificial Intelligence‖, Narosa Publishing House, New Delhi, 2000. |
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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | https://onlinecourses.swayam2.ac.in/cec20\_cs10/preview |
| 2 | https://nptel.ac.in/courses/106/105/106105077/ |
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| Course Designed by:Dr. T. Devi and Dr. T. Amudha prepared for all the University Departments |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | M | S | M | M | S | M | M |
| **CO3** | S | S | M | M | S | M | M | S | M | M |
| **CO3** | S | S | M | M | S | M | M | S | M | M |
| **CO4** | S | S | M | M | S | M | M | S | M | M |
| **CO5** | S | S | M | M | S | M | M | S | M | M |

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| **Course code** | **22PHYL04** | **OPTICS AND LASER LAB** | **L** | **T** | **P** | **C** |
| **Lab** | **LAB** | **0** | **1** | **6** | **4** |
| **Pre-requisite** | Fundamentals of Optics and Laser | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to:1. Provide hands on training to use the He-Ne laser source. 2. Train students to do experiments in order to understand the characteristics of lasers. 3. Provide an opportunity to understand the phenomena behind the various interferometry methods. 4. Find various physical parameters of particles, thin wires, optical fibers using laser source. |
|  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Handle He-Ne laser sources effectively for performing experiments to measure different physical parameters of thin wires, particles, optical fibers etc.,  | **K3, K6** |
| 2 | Use different interferometers for measuring refractive index of gas, optical components testing and making fringes for constant surface.  | **K2, K5** |
| 3 | Understand the Magneto Optic effects using laser source | **K2, K5** |
| 4 | Understand the e/m with a laser source | **K2, K5** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **No.** | **Experiment** |
| 1 | Determination of numerical aperture and losses of an optical fiber by using He-Ne Laser. |
| 2 | Determination of the width of single and double slit by diffraction of light by using He-Ne Laser. |
| 3 | Determination of particle size of the given powder sample, diameter of pinhole and measurement of wire mesh by using He-Ne Laser. |
| 4 | Determination of least count of the given meter scale, groove space of a Compact discby using He-Ne Laser. |
| 5 | Determination of wavelength of a Laser source by using diffraction grating and Michelson Interferometer method. |
| 6 | Determination of the beam-spot size using He-Ne Laser. |
| 7 | Determination of focal length of a given lens using He-Ne Laser. |
| 8 | Measurement of the divergence of a Laser beam. |
| 9 | Determination of the polarization of light and verification of Malu’s law using He-Ne Laser. |
| 10 | To study the Magneto-optic effect of the given sample using He-Ne Laser source. |
| 11 | Determination of optical absorption coefficient and determination of refractive index of the liquids using He-Ne – Laser / Diode Laser. |
| 12 | Determination of optical absorption coefficient of various filters using He-Ne Laser. |
| 13 | Direct reading of Zeeman effect (e/m of an electron) with a Laser source. |
| 14 | Demonstration of fringes of constant thickness using Fabry-Perot Interferometer. |
| 15 | Testing of given optical components using Twyman-Green Interferometer. |
| 16 | Measurement of refractive index of gas by Rayleigh Interferometer. |
| 17 | Plasma species analysis by optical emission spectroscopy. |
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| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <https://nptel.ac.in/courses/117/101/117101002/> |
| 2 | Virtual lab: <https://lo-au.vlabs.ac.in/> |
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| Course Designed By:Dr. K. Srinivasan and Dr. K. Suresh |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | L | S | S | L | S | S |
| **CO2** | S | S | S | S | L | S | S | L | S | S |
| **CO3** | S | S | S | S | L | S | S | L | S | S |
| **CO4** | S | S | S | S | L | S | S | L | S | S |
| **CO5** | S | S | S | S | L | S | S | L | S | S |

\*S-Strong; M-Medium; L-Low

**Supportive (Offered to other Department Students)**

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| **Course code** | **22PHYS01** | **BASIC ELECTRONICS** | **L** | **T** | **P** | **C** |
| **~~Core/Elective~~/Supportive** | Supportive | **2** | **1** | **0** | **2** |
| **Pre-requisite** |  Basic Knowledge in Active/ Passive Components in a Circuit and Semiconductors | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: 1. Expose the students to circuit theory and types of semiconducting devices
2. Impart knowledge on Transistor characteristics and its application as amplifiers
3. Teach the basics of Boolean algebra and construction of circuits to perform digital arithmetic operations
 |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 |  Remember Kirchoff’s laws, theorems to analyse the electronic circuits, differences between types of diodes, Boolean laws and theoremsIdentify the components in the electronic circuit, the series and parallel circuits | K1  |
| 2 |  Explain the functioning of a diode, transistor, logic gates and an amplifier | K2  |
| 3 | Analyse the circuit parameters using circuit theorems, outputs of a given Boolean circuit | K3 |
| 4 |  Construct a Boolean circuit for a given expression, employ universal gates for any given expressionAnalyse the Boolean expression using de Morgan’s theorem | K3,K4 |
| 5 | Construct circuits using opamp for executing arithmetic operations, design circuits for a desired input/ output  | K5,K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
| **Unit:1** | **Semiconductor Devices** | **14 hours** |
| Intrinsic semiconductors-Generation of electrons and holes-Extrinsic semiconductors- Effect of Temperature on Semiconductors- PN junction diode- Zener diode- Varactordiode- PIN diode- Light Emitting Diode - Photodiode – Dust sensor- Photovoltaic cell- Laser diode |
| **Unit:2** | **Operational Amplifiers And Digital Logic Circuits**  | **14 hours** |
| Operational Amplifiers (Op amp)- Ideal Op amp – Inverting and non-inverting Op amp circuits-Summing and difference amplifier – Comparator – integrator-differentiator. Boolean laws and theorems-Logic Gates: AND, OR, NOT, EX-OR, EX-NOR, NAND & NOR - Logic Gates using Discrete Components- NAND & NOR as Universal Gates- Half Adder and Full Adder-Half and Full subtractor- de Morgan’s theorems |
|  |
| **Unit:3** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars – webinarsElectronics getting small* <https://phys.org/news/2015-12-electronics-small-big-problems.html>

Challenges for electronics industry* <https://www.electronicspecifier.com/news/analysis/challenging-times-ahead-for-the-electronics-industry>
 |
|  | **Total Lecture hours** | **30 hours** |
| **Text Book(s)** |
| 1 | Electronics: Circuits and Systems-SwaminathanMadhu, Howard W. Sams& Co, Inc - First Edition-(1985)  |
| 2 | A Text book of Applied Electronics- R.S.Sedha , S.Chand& Company , 3rd Edition (2008) |
| 3 | Digital Principles and Applications-A.P Malvino and D.P Leach , Sixth Edition, Tata McGraw-Hill, New Delhi (2006) |
|  |
| **Reference Books** |
| 1 | Digital Circuits and Design - S.Salivahanan, Oxford University Press 5th Edition (2018) |
| 2 | Digital Electronics: Circuits and Systems – V.K.Puri, Tata McGraw Hill, 13th Edition (2006) |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | https://www.mooc-list.com/course/introduction-electronics-coursera |
| 2 | https://www.my-mooc.com/en/mooc/circuits-electronics-1-basic-circuit-mitx-6-002-1x-0/ |
| 3 | https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-ee10/ |
| 4 | https://swayam.gov.in/nd1\_noc20\_mm02/preview |
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| Course Designed By: Dr. P. Christopher Selvin and Dr. R. Shankar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | L | L | L | L | L | S | S | L | M | L |
| **CO2** | S | L | L | L | L | S | L | L | S | S |
| **CO3** | S | L | L | L | L | S | L | L | L | S |
| **CO4** | S | S | S | L | L | L | L | L | S | S |
| **CO5** | S | S | S | L | L | L | L | L | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYS02** | **ENERGY RESOURCES** | **L** | **T** | **P** | **C** |
| **~~Core/Elective/~~Supportive** | Supportive | **2** | **1** | **0** | **2** |
| **Pre-requisite** | Basics knowledge in the field of non-renewable and renewable energy resources | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: 1. To bring awareness to the students on various renewable non-renewable energy resources
2. To bring knowledge to the students on energy utilization and conservation
 |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | At the end of the course students gets to know about Various energy resources and their effective utilization. | K1,K2 |
| 2 | The mechanism and production of Wind Energy. | K3,K4 |
| 3 | The mechanism and production of Bio-Energy | K2,K4 |
| 4 | The mechanism and production of Nuclear Energy | K2,K4 |
| 3 | Students will able to develop new ways to effectively produce energy storing devices | K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
| **Unit:1** | **Introduction to Renewable and Non-Renewable Energy** | **14 hours** |
| Renewable and non-renewable Energy Sources, Earth’s Energy Budget, Solar radiation at the Earths surfaces, Instruments for measuring Solar Radiation, Applications of Solar Energy, Solar cell (Photovoltaic conversion) - Types, Principle and Working-Efficiency- Characteristics, Advantages, Disadvantage and Applications of Solar Cells. |
|  |
| **Unit:2** | **Source of Energies** | **14 hours** |
| Solar Energy-Flat Plate Collector, Solar Air Heater, Water Heater, Cooker, Wind Energy-Wind Energy Conversion, Advantages and Disadvantages of Wind Energy Conversion, Energy from Bio-mass and Bio-gas-Sketch diagram-Production and application of Bio- gas, Nuclear Energy-fission & Fusion reaction, Nuclear reactor and its applications, Energy Storage-Electrical Storage, Chemical Storage, Fuel Cell-Principle, Types and Working Applications. |
|  |
| **Unit:3** | **Contemporary Issues** | **2 hours** |
| Expert lectures, online seminars – webinarsCurrent trends in renewable energies* https://www.ren21.net/what-are-the-current-trends-in-renewable-energy/ Challenges for electronics industry

Nuclear energy facts and information* <https://www.nationalgeographic.com/environment/energy/reference/nuclear-energy/>
 |
|  | **Total Lecture hours** | **30 hours** |
| **Text Book(s)** |
| 1 | Nonconventional energy Sources-GD. Rai, Khanna Publication, (2004), New Delhi. |
| 2 | Modern Physics, R. Murugeshan, S. Chand & Co Ltd, (1999), New Delhi. |
| 3 | Allied and Applied Physics, John Suja, (1995), India. |
|  |
| **Reference Books** |
| 1 | Solar energy utilization by G. D. Roy. KHANNA PUBLISHERS, ISBN: 978817409184X |
| 2 | Renewable Energy, by Bent Sørensen, ISBN:9780126561531, 2004 Academic press (Elsevier) |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | https://www.electrical4u.com/solar-cell/ |
|  | Lecture series on Energy resources and Technology by Prof. S. Banarjee, IIT Kharagpur (NPTEL) |
| 2 | Selected topics in Lecture series on Energy resources and Technology by Prof. Prathapharidoss, IIT Chennai. (NPTEL) |
| 3 | https://americanhistory.si.edu/fuelcells/basics.htm |
| 4 | https://www.nrdc.org/stories/renewable-energy-clean-facts |
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| Course Designed By: Dr. R. Shankar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | M | M | M | M | S | L | S |
| **CO2** | S | S | S | M | S | M | S | S | L | S |
| **CO3** | S | S | S | M | S | M | S | S | L | S |
| **CO4** | S | S | S | M | S | M | S | S | L | S |
| **CO5** | S | S | S | M | S | M | S | S | L | S |

\*S-Strong; M-Medium; L-Low

**Value added Course**

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| **Course code** | **22PHYV01** | **Astrophysics and Cosmology** | **L** | **T** | **P** | **C** |
| **~~Core/Elective/Supportive~~** | Value added Course | **2** | **0** | **0** | **2** |
| **Pre-requisite** | Basics knowledge of observation techniques in Astrophysics and Cosmology  | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: 1. This course introduces the basic concepts in the evaluation of universe through big bang model and cosmology.
2. This course covers a survey of modern astronomy basics from an observer’s perspective, how data from distant sources is obtained through modern telescopes and detectors.
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Students will understand the evaluation of universe and cosmological background  | K1,K2 |
| 2 | Students will demonstrate a basic understanding of various aspects of observational astronomy. | K5 |
| 3 | How data is acquired and interpreted to obtain physical properties of a variety of astronomical objects. | K4,K5 |
| 4 | Know about Hubble’s and Newton’s laws | K1,K2 |
| 5 | Know about parallax methods | K2,K3 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **Early Universe and Cosmological models** | **15 hours** |
| Thermal history of the universe – time line of important dates, big bang nucleosynthesis, structural formation, cosmic microwave background, inflation, Friedman-Robertson-Walker metric for a homogeneous, isotropic universe, Friedman equation from Newton’s and Hubble’s laws, Scale-dependence of different energy forms Cosmological models with one energy component, The ΛCDM model |
|  |
| **Unit:2** | **Astronomical distances** | **15 hours** |
| The electromagnetic spectrum, Measuring the telescope characteristics, Panchromatic observations, Spectroscopic observations, a brief overview of emission processes, Trigonometric parallax, other geometric methods and parallaxes, Doppler Effect and redshift, Hubble’s law, the cosmic distance ladder |
|  |
|  | **Total Lecture hours** | **30 hours** |
| **Text Book(s)** |
| 1 | Introduction to Astronomy & Cosmology by I. Morrison (Wiley, 2008) |
| 2 | Telescopes and Techniques by C.R.Kitchin (Springer, 1995) |
| 3 | A Concise Introduction to Astrophysics, Lecture notes by Michael. Kachelriess |
| 4 | Basics of Astrophysics: Veronique Buat |
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| **Reference Books** |
| 1 | An Introduction to Astronomy and Astrophysics, Pankaj Jain, CRC Press,2015. |
| 2 | An Introduction to Cosmology.V.Narlikar, Cambridge university press, 2002. |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Astrophysics & Cosmology by Prof. S. Bharadwaj, Department of Physics, IIT Kharagpur (NPTL) |
| 2 | https://people.lam.fr/buat.veronique/SPACE\_poly1\_M1.pdf |
| 3 | http://web.phys.ntnu.no/~mika/skript\_astro.pdf |
| 4 | Selected topics Astrophysics lecture by Michael Kachelriess , Department of Physics, NTNU Trondheim, Norway |
| 5 | http://web.phys.ntnu.no/~mika/talks.htm |
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| Course Designed By: Dr. R. Shankar |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | M | M | M | S | S | M |
| **CO3** | S | M | S | S | M | M | M | S | S | S |
| **CO3** | S | M | S | S | M | M | M | S | S | S |
| **CO4** | S | M | S | S | M | M | M | S | S | S |
| **CO5** | S | M | S | S | M | M | M | S | S | S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYV02** | **Programming with Python** | **L** | **T** | **P** | **C** |
| **~~Core/Elective/Supportive~~** | Value Added Course | **2** | **1** | **1** | **2** |
| **Pre-requisite** | Basic knowledge in computer operations | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: 1. Introducing Python programming
2. Exposure to the scientific programming in Python language
 |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Acquire the knowledge to analyze the problem | K2, K4 |
| 2 | Get soft skill | K3 |
| 3 | To know about Various Control statements of Python | K6 |
| 4 | To know about Functions and Module structures in Python | K1,K2 |
| 5 | Write the program in Python for scientific problems | K1,K2 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
| **Unit:1** | **Basics of Programming**  | **10 hours** |
| Basis of programming– IDLE - variables and data types – strings – manipulating data – operators - syntax |
| **Unit:2** | **Control Statements, Looping, File Handling** | **10 hours** |
| Control statements: if, if-else, nested if-else – loops (for, while); nested loops – break – continue – pass - text files – file handling and directories – - printing on screen – reading and writing of data in a file - opening and closing a file  |
| **Unit:3** | **Functions and Modules** | **10 hours** |
| Defining a function - Calling a function – Types of functions – Function arguments – python modules - Importing module – commonly used modules – writing and executing python program for few scientific problems. |
| **Total Lecture hours** | **30 hours** |
| **Text Book(s)** |
| 1 | Fundamentals of Python: First Programs Author: Kenneth Lambert Publisher: Course Technology, Cengage Learning, 2012 ISBN-13: 978-1-111-82270-5 |
| **Reference Books** |
| 1 | Making Use of Python, Rashi Gupta, Wiley Publishing, Inc., New York, 2002  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | www.python.org |
| 2 | <https://wiki.python.org/moin/BeginnersGuide> |
| 3 | <https://www.w3schools.com/python/> |
| Course Designed By: Dr. K. Senthilkumar |
| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | S | M | M | S | M | S |
| **CO2** | S | S | S | S | S | M | M | S | M | S |
| **CO3** | S | S | S | S | S | M | M | S | M |  S |
| **CO4** | S | S | S | S | S | M | M | S | M |  S |
| **CO5** | S | S | S | S | S | M | M | S | M |  S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYV03** | **Nuclear data for science & technology** | **L** | **T** | **P** | **C** |
| **~~Core/Elective/Supportive~~** | Value Added Course | **2** | **1** | **1** | **2** |
| **Pre-requisite** | A exposure to nuclear structure and nuclear reaction | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. Student will learn the importance of data measurement needed for design
2. Exposure to Nuclear data Centres and Tools needed to code EXFOR entries
3. Nuclear Structure Data
4. Nuclear Reaction Data
 |
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Exposure to various activities related to nuclear data | K2, K4 |
| 2 | Knowledge about EXFOR, Entry and related tools | K3 |
| 3 | Knowledge about ENDF formats and related tools | K5 |
| 4 | Understand Nuclear Structure data | K5 |
| 5 | Understand Nuclear Reaction data |  |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
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| **Unit:1** | **Nuclear Data Centers and Tools** | **15 hours** |
| Nuclear Data Centers an Overview – Nuclear Data Measurements – Evaluation of Nuclear Data – Nuclear Data Categories – Nuclear Data Libraries – EXFOR – ENSDF – ENDF/B-6 – EXFOR Coding Tools – EXFOR Editor – Digitization software – IAEA – NDS Tools for Nuclear Data - NDPCIEXFOR coding for Practical (Nuclear Structure), Exposure to GEF code |
|  |
| **Unit:2** | **Nuclear Structure and Reaction** | **15 hours** |
| Examples of Nuclear Structure Data: Isotopic masses – Nuclear Levels and Properties – Half-lives of radionuclides and isomers – Energies and Intensities of Gamma raysExamples of Nuclear Reaction Data: Cross-section for nuclear reactions induced by neutrons, photons, protons, and other charged particles including heavy ions, Nuclear fission: yields of fission-neutrons and fission products, related energy release – Neutron time of flightEXFOR coding for Practical (Nuclear Reactions), Exposure to EMPIRE and TALYS for simple reactions for practical. |
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|  | **Total Lecture hours** | **15 hours** |
| **Text Book(s)** |
| 1 | Nuclear Reactor Physics, 2nd, Completely Revised and Enlarged EditionWeston M. Stacey ISBN: 978-3-527-40679-1,735 pages, May 2007 |
| 2 | The Elements of Neutron Interaction Theory, Anthony Foderaro, MIT PressISBN: 9780262561600, March 2003 |
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| **Reference Books** |
| 1 | <https://www-nds.iaea.org/nrdc/> |
| 2 | <https://www-nds.iaea.org/nsdd/> |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | <http://www.nuclear.lu.se/english/about-nuclear-physics/nuclear-data/> |
| 2 | <https://www-nds.iaea.org/RIPL-3/> |
| 3 | <https://www-nds.iaea.org/exfor/> |
|  | <https://www-nds.iaea.org/exfor/endf.htm> |
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| Course Designed By: Dr. M. Balasubramaniam |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | S | M | M | S | M | S |
| **CO2** | S | S | S | S | S | M | M | S | M | S |
| **CO3** | S | S | S | S | S | M | M | S | M |  S |
| **CO4** | S | S | S | S | S | M | M | S | M |  S |
| **CO5** | S | S | S | S | S | M | M | S | M |  S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYV04** | **The art and science of growing single crystals** | **L** | **T** | **P** | **C** |
| **~~Core/Elective/Supportive~~** | Value Added Course | **2** | **1** | **1** | **2** |
| **Pre-requisite** | Basic knowledge on solid state physics and solution chemistry | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: 1. To make student to understand the importance of single crystals used in various scientific applications
2. To bring exposure to various methods of crystal growth
3. To get hands-on training in growing single crystals from solution phase
4. To understand the knowledge of morphology and internal structure of the grown crystals
 |
|  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Understand the uses of single crystals in various fields | K2 |
| 2 | Grow quality single crystals from solutions  | K3, K6 |
| 3 | Understand the basic crystallography behind the grown single crystals  | K4, K5 |
| 4 | Understand about the indexing of peaks | K4, K5 |
| 5 | Understand about the determination of unit cell parameters | K4, K5 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **Why do we grow single crystals?** | **10 hours** |
| Crystals and their applications in various fields of science and technology-Historical review of Crystal Growth methods- Necessity to grow single crystals- Internal structure and external morphology-Anisotropic properties of single crystals-Structure-property relationships. |
|  |
| **Unit:2** | **Crystal Growth from Solution**  | **10 hours** |
| Solutions-Solubility-Construction of simple phase diagram-Saturation-Supersaturaiton-Metastable zone width- Nucleation-Homogeneous and Heterogeneous nucleation-Growth rate anisotropy |
|  |
| **Unit:3** | **Characterization of the Grown Crystals** | **10 hours** |
| Morphological Evaluation-Miller Indices-Crystal system-point group-space Group-X-ray powder diffraction analysis- indexing of peaks and determination of unit cell parameters. |
|  | **Total Lecture hours** | **30 hours** |
| **Text Book(s)** |
| 1 | Crystal growth processes byJ. C. Brice. Blackie & Son Ltd., Glasgow and London 1986 |
| 2 | Crystals and Crystal Growing by Alan Holden, The MIT Press, London, 1982 |
| 3 | Introduction to Crystallography by Donald E. Sands, Dover Books on Chemistry, New York, 1993. |
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| **Reference Books** |
| 1 | Crystallization - J W Mullin, Butterworth-Heinemann, 4th Ed., Oxford, 2001. |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | NPTELhttps://www.youtube.com/watch?v=G76H7A6\_iyo |
| 2 | NPTELhttps://www.youtube.com/watch?v=VSz\_eKdGz88 |
| 3 | NPTELhttps://www.youtube.com/watch?v=db5nZCipJh8 |
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| Course Designed By: Dr. K. Srinivasan |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | L | S | L | L | L | S | S | S | S | S |
| **CO2** | L | S | L | L | L | S | S | S | S | S |
| **CO3** | L | S | L | L | L | S | S | S | S |  S |
| **CO4** | L | S | L | L | L | S | S | S | S |  S |
| **CO5** | S | S | L | L | L | S | S | S | S |  S |

\*S-Strong; M-Medium; L-Low

**Job Oriented Course**

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| **Course code** | **22PHYJ01** | **Plasma Physics and Technology**  | **L** | **T** | **P** | **C** |
| **~~Core/Elective/Supportive~~** | Job Oriented Course | **2** | **1** | **2** | **2** |
| **Pre-requisite** | Knowledge in key concepts related to discharge physics  | **Syllabus Version** |  |
| **Course Objectives:** |
| 1. To understand the basics of plasma and generation of laboratory plasma.
2. To study and develop a device for industrial plasma applications
 |
|  |
| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Apply basics of plasma and plasma properties to develop the device  | **K3** |
| 2 | To apply the device for industrial applications  | **K4,K5** |
| 3 | Understanding the basic theory and implementing it for various required applications  | **K2, K4** |
| 4 | Understand about the low temperature cold plasma | **K3,K4** |
| 5 | Applications of hot and cold plasma | **K3,K4** |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
|  |
| **Unit:1** |  | **15 hours**  |
| Plasma – Fourth state of matter – Natural and laboratory plasmas – Types of plasmas – Thermal plasma – Generation of thermal plasma: High intensity arcs – Thermal RF discharges – Microwave discharges – Properties – Thermal Plasma Technology: Plasma deposition – Thermal plasma synthesis of fine powders – Plasma metallurgy – Plasma welding and cutting  |
|  |
| **Unit:2** |  | **15 hours** |
| Generation of non-thermal plasma – Plasma diagnostics: plasma parameters – Low pressure cold plasma technology – other plasma processing technologies - Surface modifications of fabrics – Textile applications.  |
|  | **Total Lecture hours** |  **30 hours** |
| **Text Book(s)** |
| 1 | Thermal Plasmas Fundamentals and applications, Vol.1, Maher I. Boulos, Pierre FauchaisAnd Emil Pfender, (1994), published by Plenum Press, New York. |
| 2 | Applications in Composites, Nanostructured Materials and Biomedical Fields, edited by Sabu Thomas, MiranMozetic, UrosCvelbar, PetrSpatenka and K.M. Praveen, (2019), 1st Edition, Science Direct Book.  |
|  |
| **Reference Books** |
| 1 | The Fourth State of Matter: An Introduction to Plasma Science, 2nd Edition, S. Eliezer and Y. Eliezer, (2001), published by Institute of Physics (IOP) Publishing, London. |
| 2 | Basic Plasma Physics, Basudev Ghosh (2014), published by Narosa Publishing House, India  |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | Introduction to plasma : <https://nptel.ac.in/courses/115/102/115102020/> |
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| Course Designed by:Dr. G. Shanmugavelayutham |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | L | S | L | L | L | S | S | S | S | S |
| **CO2** | L | S | L | L | L | S | S | S | S | S |
| **CO3** | L | S | L | L | L | S | S | S | S |  S |
| **CO4** | L | S | L | L | L | S | S | S | S |  S |
| **CO5** | S | S | L | L | L | S | S | S | S |  S |

\*S-Strong; M-Medium; L-Low

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| **Course code** | **22PHYJ02** | **Installation and Maintenance of Solar Photovoltaic Systems** | **L** | **T** | **P** | **C** |
| **~~Core/Elective/Supportive~~** | Job Oriented Course | **2** | **1** | **2** | **2** |
| **Pre-requisite** | Basic knowledge on solar energy and photovoltaic materials. | **Syllabus Version** |  |
| **Course Objectives:** |
| The main objectives of this course are to: 1. To make student to understand the importance of solar energy and its effective utilization.
2. To bring exposure to various tools and equipment used for Solar Photovoltaic installation.
3. To get hands-on training on the installation and maintenance of Solar Photovoltaic Systems.
4. To bring knowledge on the possibility of Employability and Entrepreneurship avenues in the area of solar energy extraction and utilization.
 |
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| **Expected Course Outcomes:** |
| On the successful completion of the course, student will be able to: |
| 1 | Understand the ground reality on the installation and operations of solar photovoltaic energy extraction systems. | K2 |
| 2 | Operate various tools and accessories used for Solar photovoltaic installations and maintenance.  | K3, K4, K5  |
| 3 | Understand about the site assessment | K2 |
| 4 | Understand about the installation procedures | K2, K3 |
| 5 | Acquire self-employment and develop entrepreneurship skills in photovoltaic industry. | K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create |
|  |
| **Unit:1** | **Fundamentals of Solar Photovoltaic Systems** | **10 hours** |
| An Introduction: Energy from the Sun-Sun Path Diagram and Solar Radiation-Components of a Solar PV System-Types of Solar Photovoltaic Systems-Technical Parameters and Performance of a Solar PV Panel.Identification and Uses of Tools and Equipment Used for Solar PV Installation. |
|  |
| **Unit:2** | **Installation of Solar Photovoltaic Systems**  | **10 hours** |
| The Importance of Accurate Load and Site Assessment-Steps for Conducting a Load Assessment-Steps for Conducting a Site Assessment-Procurement of the Solar PV System Components-Civil and Mechanical Parts of Solar PV System-Construction of Equipment Foundation-Installation of Mounting System, Photovoltaic Module and Battery Bank and inverter stands. Installation of Electrical Components, Conduits. Cables- Installation of Grounding Systems and Battery Bank. |
|  |
| **Unit:3** | **Test & Measurement and Maintenance of Solar Photovoltaic Systems** | **10 hours** |
| Tools and Accessories Required for PV System Testing-Overall System Inspection-Testing of Solar Array-Wire and Earthing Continuity Tests-Testing of Charge Controller-Testing of Batteries-Start-up the System-Unintentional Islanding Functionality Tests-Sample Test and Commission Record Sheet-Tools Required for Maintenance-Preventive Maintenance of PV System-Troubleshooting and Maintenance. |
|  | **Total Lecture hours** | **30 hours** |
| **Text Book(s)** |
| 1 | Solar energy by Sukhatme, Tata McGraw-Hill Education, 1987. |
| 2 | Solar Energy Utilization Edited by HafitYüncü, E. Paykoc, Y. Yener, Springer Netherlands, 1987. |
| 3 | Solar Energy Utilization: A Textbook for Engineering Students byG. D. RaiKhanna Publishers, 1987. |
|  |
| **Reference Books** |
| 1 | Handbook of Solar Energy: Theory, Analysis and Applications, by Tiwari, G.N., Tiwari, Arvind, Shyam, Springer Singapore, 2016. |
|  |
| **Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]** |
| 1 | NPTEL https://nptel.ac.in/courses/115/107/115107116/ |
| 2 | NPTELhttps://nptel.ac.in/courses/113/104/113104084/ |
|  |
| Course Designed By: Dr. K. Srinivasan in Coordination with Mr. U. Aiyaappan and Mr. C. Sivakumar, MAS Solar Systems Private Limited153, SIDCO Industrial Estate, Coimbatore-641 050. |

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| **Mapping with Programme Outcomes** |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | L | S | S | S | S | S | S |
| **CO2** | S | S | S | M | S | S | S | S | S | S |
| **CO3** | S | S | S | M | S | S | S | S | S |  S |
| **CO4** | S | S | S | S | S | S | S | S | S |  S |
| **CO5** | S | S | S | S | S | S | S | S | S |  S |

\*S-Strong; M-Medium; L-Low