# COURSE HANDOUTS

B.Sc (Honours) Courses in Physics

Semester II, IV and VI, 2022-2023

## Electricity and Magnetism (PHSACOR03T, PHSACOR03P)

2nd semester, 2022-2023

**About the Course**

- Name of the Course : Electricity and Magnetism
- Nature of the Course : Core Course
- Code of the Course : PHSACOR03T and PHSACOR03P
- Credit point : 4 (Theory) + 2 (Laboratory)
- Class Hours : 60 (Theory) + 60 (Laboratory)

**Course description**

This is a foundation course on electricity and magnetism to introduce to the students basic ideas of classical notion of electric and magnetic fields, fundamental equations governing the behavior of electromagnetism, electric circuits and network analysis.

**Course Outcomes**

**CO1 :** Understanding of the  the electricity and magnetism in vacuum. Familiarity with the fundamental equations of electromagnetic theory for static electric configuration and steady current flows.

**CO2 :** Understanding of the  the statistical nature of electricity and magnetism in matter, linear response of material bodies to external fields and conservation laws.

**CO3 :** Learn a host of techniques to solve idealized yet close to real life examples involving electromagnetic phenomena.

**CO4 :** Understanding of the  the electric circuits and their characteristic behavior.

**CO5 :** Acquire hands-on experience about the behavior of electric circuits in the laboratory.

**Relationship to other courses**

- Assumed knowledge : Good understanding of vector calculus and basic understanding of differential equation.
- Prerequisite : PHSACOR01T
- Follow up course : PHSACOR13T

**Faculty :** Purnendu Chakraborty and Priyanka Chowdhury, Mahuya Chakraborty

**Course Schedule**

| Faculty | Timetable | | | Google Classroom Code |
|---|---|---|---|---|
| **PHSACOR03T** | | | | |
| Purnendu Chakraborty | Thursday | 10:00 – 12:00 | Physics Laboratory | 7ovabu5 |
| Priyanka Chowdhury | Monday | 10:00 – 11:00 | Room No.-116 | j4gn3zd |
| | Tuesday | 11:00 – 12:00 | Physics Laboratory | |
| **PHSACOR03P** | | | | |
| Mahuya Chakrabarti | Tuesday | 14:00 – 16:00 | Physics Laboratory | |
| | Thursday | 14:00 – 16:00 | Physics Laboratory | |

**Course Outline**

| Unit 1 - Electric Field and Electric Potential |
|---|
| Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Charge density of a point charge – Definition of Dirac delta function. Properties of Dirac delta function.<br><br>Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.<br><br>Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Energy stored in Electrostatic field. |
| **Unit 2 - Dielectric Properties of Matter** |
| Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics. Boundary conditions at the interface of two media. |
| **Unit 3 - Magnetic Field** |
| Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole).<br><br>Ampere's Circuital Law and its application to (1) infinite straight wire, (2) infinite planar surface current, and (3) solenoid. Properties of B: curl and divergence. . Axial vector property of B and its consequences. Vector Potential. Calculation of vector potential and magnetic induction in simple cases – straight wire, magnetic field due to small current-loop.<br><br>Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform magnetic field. |
| **Unit 4 - Magnetic Properties of Matter** |
| Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis. Boundary conditions at the interface of two media. |
| **Unit 5 - Electromagnetic Induction** |
| Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current |
| **Unit 6 - Electrical Circuits** |

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|---|
| Charge Conservation – equation of continuity. Transients in D.C.:Growth and decay of current, charging and discharging of capacitors in CR, LR & LCR circuits; oscillatory discharge; time constant; time variation of total energy in LCR cicuit.<br>AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Phasor diagram. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit |
| **Unit 7 - Network theorems** |
| Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. |
| **Reference Books** |
| 1. Electricity and Magnetism, Edward M. Purcell, McGraw-Hill Education<br>2. Introduction to Electrodynamics, D.J. Griffiths, Benjamin Cummings.<br>3. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, Pearson Education.<br>4. Elements of Electromagnetics, M.N.O. Sadiku, Oxford University Press.<br>5. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, Oxford Univ. Press.<br>6. Classical Electricity and Magnetism, W.K.H Panofsky and M. Philips, Dover. |

**Course Calendar**

| Purnendu Chakraborty | | | |
|---|---|---|---|
| Module | Topic | Class Hour | Month |
| 1 | **Electric Field and Electric Potential** | **15** | |
| 1A | Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Charge density of a point charge – Definition of Dirac delta function. Properties of Dirac delta function. | 4 | March |
| 1B | Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. | 4 | March |
| 1C | Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Uniqueness theorem (statement). | 3 | April |
| 1D | Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. | 3 | April |
| | Class Test | 1 | April |
| 2 | **Dielectric Properties of Matter** | **8** | |
| 2A | Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. | 3 | April<br>May |
| 2B | Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. | 2 | May |
| 2C | Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics. Boundary conditions at the interface of two media. | 3 | May |
| **6** | **Electrical Circuits** | **10** | |
| 6A | Charge Conservation – equation of continuity. Transients in D.C. : Growth and decay of current, charging and discharging of capacitors in CR, LR & LCR circuits; oscillatory discharge; time constant; time variation of total energy in LCR cicuit. | 4 | May<br>June |
| 6B | AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Phasor diagram. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit | 5 | June |
| | Class Test | 1 | June |

| Priyanka Chowdhury | | | |
|---|---|---|---|
| Module | Topic | Class Hour | Month |
| **3** | **Magnetic Field** | **10** | |
| 3A | Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). | 4 | March |
| 3B | Ampere's Circuital Law and its application to (1) infinite straight wire, (2) infinite planar surface current, and (3) solenoid. Properties of B: curl and divergence. Axial vector property of B and its consequences. Vector Potential. Calculation of vector potential and magnetic induction in simple cases – straight wire, magnetic field due to small current-loop. | 3 | March April |
| 3C | Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform magnetic field. | 2 | April |
| | 1$^{st}$ Class Test | 1 | April |
| **4** | **Magnetic Properties of Matter** | **5** | |
| 4A | Magnetization vector (M). Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. | 3 | April |
| 4B | Ferromagnetism. B-H curve and hysteresis. Boundary conditions at the interface of two media. | 2 | May |
| **5** | **Electromagnetic Induction** | **6** | |
| 5A | Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance, calculation in simple cases (e.g. circular loops, solenoids). | 4 | May |
| 5B | Reciprocity Theorem. Energy stored in a Magnetic Field. | 2 | May |
| **7** | **Network theorems** | **6** | |
| | Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. | 5 | June |
| | 2$^{nd}$ Class Test | 1 | June |

**Mode of Assessment**

Internal assessment will be done through class tests.

# Waves and Optics (PHSACOR04T, PHSACOR04P)

2nd semester, 2022-2023

**About the Course**

- Name of the Course : Waves and Optics
- Nature of the Course : Core Course
- Code of the Course : PHSACOR04T and PHSACOR04P
- Credit point : 4 (Theory) + 2 (Practical)
- Class Hours : 60 (Theory) + 60 (Laboratory)

**Course description**

The aim of this course is to familiarize students with wave motion, superposition of waves, wave optics, Interference and Diffraction of light waves and Holography.

**Course Outcomes**

**CO1 :** Learn about the superposition of collinear oscillation for equal and different frequencies, superposition of two perpendicular harmonic oscillator and Lissajous figure.

**CO2 :** Learn about the longitudinal and transverse waves, phase and group velocities, intensity of waves and energy transport.

**CO3 :** Idea about velocity of transverse vibrations of stretched string, longitudinal waves in a fluid in pipe, Newton's formula and Laplace’s correction for velocity of sound.

**CO4 :** Learn about standing waves in string, energy of vibrating string, modes of stretched string, standing wave in open and closed pipes.

**CO5 :** Idea about electromagnetic nature of light, wave front, Huygen’s principle, coherence.

**CO6 :** Conceptual idea about interference, Young's double slit experiment, Lloyd's mirror, Fresnel biprism, interference in thin parallel and wedge shaped film, Haidinger and Fizeau Fringes and Newton’s ring.

**CO7 :** Learn about Interferrometers.

**CO8 :** Idea about Fraunhofer and Fresnel Diffraction, single and double slit diffraction, diffraction grating, resolving power of grating, zone plate, principle of holography, point source holograms.

**Relationship to other courses**

- Assumed knowledge : Basic understanding of differential equation.
- Follow up Course : None

**Faculty :** Mahuya Chakrabarti, Paramita Mallick, Purnendu Chakraborty

**Course Schedule**

| Faculty | Timetable | | | Google Classroom Code |
| --- | --- | --- | --- | --- |
| **PHSACOR04T** | | | | |
| Mahuya Chakrabarti | Monday | 11:00 – 12:00 | Physics Laboratory | bam7jep |
| | Wednesday | 10:00 – 11:00 | Physics Laboratory | |
| Paramita Mallick | Friday | 12:00 – 13:00 | Auditorium 6 | qpt3avh |
| | Saturday | 15:00 – 16:00 | 116 | |
| **PHSACOR04P** | | | | |
| Purnendu Chakraborty | Monday | 14:00 – 16:00 | Physics Laboratory | 7ovabu5 |
| | Saturday | 10:00 – 12:00 | Physics Laboratory | |

**Course Outline**

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|---|
| **Unit 1 - Superposition of Collinear Harmonic oscillations** |
| Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. |
| **Unit 2 - Superposition of two perpendicular Harmonic Oscillations** |
| Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. |
| **Unit 3 - Waves Motion** |
| Plane and Spherical Waves. Longitudinal and Transverse Waves. Progressive (Travelling) Wave and its differential equation. phase and group velocities for harmonic waves. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves |
| **Unit 4 - Velocity of Waves** |
| Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. |
| **Unit 5 - Superposition of Two Harmonic Waves** |
| Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Changes of wavefunction with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. |
| **Unit 6 - Wave Optics** |
| Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. Characteristics of Laser light. |
| **Unit 7 - Interference** |
| Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index |
| **Unit 8 - Interferometer** |
| Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. |
| **Unit 9 -**Diffraction and Holography |
| Kirchhoff's Integral Theorem and Fresnel-Kirchhoff's Integral formula (Statement and Qualitative discussion on consequences only). Fraunhofer diffraction: Single slit, rectangular aperture. Resolving Power of an optical instrument – Rayleigh's criteria. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. |

| Reference Books |
|---|
| 1.Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill. |
| 2. Vibrations and Waves. A.P. French, 2003, CBS. |
| 3. Vibrations & Waves. G.C. King, 2009, Wiley. |
| 4. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons. |
| 5. Optics. E. Hecht, 2003, Pearson Education. |
| 6. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill |
| 7. Basic Optics: Principles and Concepts. A. Lahiri, 2016, Elsevier. |
| 8. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill |
| 9. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press. |
| 10. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill. |
| 11. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications. |

## Course Calendar

| Mahuya Chakrabarti | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **7** | **Interference** | **9** | |
| 7A | Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. | 3 | March |
| 7B | Phase change on reflection: Stokes' treatment, Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination (Haidinger Fringes), Fringes of equal thickness(Fizeau Fringes). | 5 | March |
| 7C | Newton's Rings: measurement of wavelength and refractive index. | 1 | March |
| **8** | **Interferometer** | **4** | |
| 8A | Michelson Interferometer-(1) Idea of form of fringes (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes, Fabry-Perot interferometer. | 4 | April |
| **9** | **Diffracion and Holography** | **20** | |
| 9A | Kirchhoff's Integral Theorem and Fresnel-Kirchhoff's Integral formula (Statement and Qualitative discussion on consequences only). Fraunhofer diffraction: Single slit, rectangular aperture. | 6 | April<br>May |
| 9B | Resolving Power of an optical instrument – Rayleigh's criteria. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. | 5 | May |
| 9c | Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. | 5 | May<br>June |
| 9D | Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. | 3 | June |
| | Class Test | 1 | June |

| Paramita Mallick | | | |
|---|---|---|---|
| Module | Topic | Class Hour | Month |
| **6** | **Wave Optics** | **4** | |
| 6A | Electromagnetic nature of light. | 1 | March |

| | | | |
|---|---|---|---|
| 6B | Definition and Properties of wave front, Huygens Principle. Temporal and Spatial Coherence. Characteristics of Laser light. | 3 | March |
| **1** | **Superposition of Collinear Harmonic oscillations** | **4** | |
| 1A | Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). | 2 | March |
| 1B | Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. | 2 | March |
| **2** | **Superposition of two perpendicular Harmonic Oscillations** | **3** | |
| 2A | Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. | 3 | April |
| **3** | **Waves motion** | **4** | |
| 3A | Plane and Spherical Waves. Longitudinal and Transverse Waves. Progressive (Travelling) Wave and its differential equation. | 1 | April |
| 3B | Phase and group velocities for harmonic waves. Pressure of a Longitudinal Wave. | 1 | April |
| 3C | Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves | 2 | April |
| **4** | **Velocity of Waves** | **5** | |
| 4A | Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. | 4 | April<br>May |
| 4B | Newton’s Formula for Velocity of Sound. Laplace’s Correction. | 1 | May |
| **5** | **Superposition of Two Harmonic Waves** | **7** | |
| 5A | Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. | 2 | May |
| 5B | Changes of wavefunction with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. | 2 | May |
| 5C | Normal Modes of Stretched Strings. Longitudinal Standing Waves and Normal Modes. | 2 | June |
| | Class test | 1 | June |

**Mode of Evaluation :**

Internal Evaluation for PHSACOR04T will be through class tests. All class tests are mandatory.

## Mathematical Physics – III (PHSACOR08T, PHSACOR08P)

4th semester, 2022-2023

**About the Course**

- Name of the course : Mathematical Physics-III
- Nature of the course : Core course
- Code of the Course : PHSACOR08T and PHSACOR08P
- Credit point : 4 (Theory) + 2 (Practical)
- Class Hours : 60 Hrs (Theory) + 60 Hrs (Practical)

**Course Description**

The course is intended to introduce to the students notion of complex analysis, integral transforms, solution of boundary value problems, matrices and eigensystems.

**Course Outcomes**

**CO1 :** Comprehend complex analysis and application to problems of physics.

**CO2 :** Understanding of integral transforms and ability to use them to solve some partial differential equation like heat equation and wave equation.

**CO3 :** Learn to solve the boundary value problems and apply the concepts to the problems of electrodynamics.

**CO4 :** Learn to solve system of equations and find normal modes of coupled oscillators.

**CO5 :** Learn to numerically solve the class of problems cited in CO1-C04 using sophisticated techniques in Python.

**C06 :** Learn to use free and open source symbolic computer algebra like Octave, Scilab.

**Relationship to other courses**

- Assumed knowledge : Understanding of differential equation, algebra.
- Prerequisite : PHSACOR01T, PHSACOR01P, PHSACOR05T, PHSACOR05P
- Follow up courses : PHSADSE01T, PHSADSE01P, PHSADSE04T

**Faculty :** Dr. Priyanka Chowdhury, Dr. Purnendu Chakraborty

**Course Schedule**

| Faculty | Timetable | | | Google Classroom Code |
|---|---|---|---|---|
| **PHSACOR08T** | | | | |
| Priyanka Chowdhury | Tuesday | 10:00 – 11:00 | Physics Laboratory | ps3yjmh |
| | Wednesday | 10:00 – 11:00 | Room No : 111 | |
| Purnendu Chakraborty | Monday | 12:00 – 13:00 | Physics Laboratory | lr2wdem |
| | Tuesday | 12:00 – 13:00 | 116 | |
| **PHSACOR08P** | | | | |
| Priyanka Chowdhury | Monday | 14:00 – 16:00 | Computer Laboratory | ps3yjmh |
| | Wednesday | 14:00 – 16:00 | Computer Laboratory | |

**Course Outline (PHSACOR08T)**

**Unit 1 : Complex Analysis**

Euler's formula. De Moiver's theorem, Roots of complex numbers. Functions of complex variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions : poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's

Inequality. Cauchy’s Integral formula. Simply and multiply connected region. Laurent and Taylor’s expansion. Residues and Residue Theorem. Application in solving definite Integrals.

**Unit 2 : Integral Transforms**

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

**Unit 3 : Boundary value problems**

Solutions of Laplaces equation in problems with cylindrically and spherically symmetric boundary conditions. Examples from Electrostatics. Solutions of heat diffusion equation with boundary conditions of rectangular symmetry.

**Unit 4 : Matrices**

Hermitian conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices with properties. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product of matrices.

**Unit 5 : Eigenvalues and eigenvectors**

Eigenvalues and eigenvectors – calculation, characteristic equation. Cayley- Hamiliton Theorem. Similarity transformation with properties. Diagonalization of matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a matrix.

**Reference Books**

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, Elsevier.

2. Mathematical methods in the Physical Sciences, M. L. Boas, Wiley.

3. Mathematical Methods of Physics. J. Mathews and R.L. Walker, Pearson.

4. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, Cambridge University Press

4. Mathematics for Physicists, P. Dennery and A.Krzywicki, Dover Publications.

5. Complex Variables, A.S.Fokas & M.J.Ablowitz, Cambridge University Press

6. Complex Variables, A.K. Kapoor, Cambridge Univ. Press

7. Complex Variables and Applications, J.W. Brown & R.V. Churchill, Tata McGraw-Hill.

8. First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, Jones & Bartlett.

**Course Calendar**

| Priyanka Chowdhury | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **1** | **Complex Analysis** | **20** | |
| 1A | Euler's formula. De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. | 4 | January February |
| 1B | Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. | 5 | February |
| 1C | Integration of a function of a complex variable. Cauchy’s Integral formula. Simply and multiply (qualitative) connected region. | 5 | March |
| 1D | Laurent and Taylor’s expansion. Residues and Residue Theorem. Application in solving Definite Integrals. | 5 | March, April |
| | $1^{st}$ class test | 1 | April |
| | | | |
| **3** | **Boundary value problems** | **10** | |
| 3A | Solutions of Laplaces equation in problems with cylindrically and spherically symmetric boundary conditions. | 3 | April, May |
| 3B | Examples from Electrostatics. | 3 | May |
| 3C | Solutions of heat diffusion equation with boundary conditions of rectangular symmetry. | 3 | May |
| | $2^{nd}$ class test | 1 | May |

| Purnendu Chakraborty | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **2** | **Integral Transforms** | **15** | |
| 2A | Fourier Transformsn: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. | 6 | January February |
| 2B | Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. | 3 | February |
| 2C | Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. | 3 | February March |
| 2D | Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. | 2 | March |

| | | | |
|---|---|---|---|
| | 1st class test | 1 | March |
| | | | |
| **4** | **Matrices** | **7** | |
| 4A | Hermitian conjugate of a Matrix. Hermitian and Skew- Hermitian Matrices with properties. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product of matrices. | 7 | March April |
| | | | |
| **5** | **Eigenvalues and eigenvectors** | **8** | |
| 3A | Eigenvalues and eigenvectors – calculation, characteristic equation. Cayley- Hamiliton Theorem. Similarity transformation with properties. Diagonalization of matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a matrix. | 7 | May |
| | 2nd class test | 1 | May |

**Mode of Internal Assessments**

(1) The internal assessment in PHSACOR08T will be based on class tests.

(2) The internal assessment in PHSACOR08P will based on the number of assignments successfully completed by a student. There will be 10 assignments and minimum 6 assignments should be performed by a student to qualify for end semester examination.

# Elements of Modern Physics (PHSACOR09T, PHSACOR09P)

$4^{th}$ Semester, 2022-2023

**About the Course**

- Name of the Course : Elements of Modern Physics
- Nature of the Course : Core Course
- Code of the Course : PHSACOR09T and PHSACOR09P
- Credit point : 4 (Theory) + 2 (Practical)
- Class Hours : 60 (Theory) + 60 (Laboratory)

**Course Description**

This is an introductory course to give students a glimpse of relativistic dynamics, development of quantum mechanics as correct physical theory in subatomic level, atomic and nuclear physics and LASER.

**Course Outcomes**

On successful completion of this core course students will

**CO1 :** Acquire knowledge of Lorentz transformation, idea of space-like, time-like and light-like separation and proper time. Understand the concept of relativistic mass, relationship between mass and energy.

**CO2 :** Acquire knowledge on the classical approach to deal with the large collection of identical entities in an enclosure at thermal equilibrium, Boltzmann weight factor, classical theory of blackbody radiation, Rayleigh-Jeans law.

**CO3 :** Appreciate the failure to classical physics to describe phenomena at subatomic level and how the quantum theory emerged in this backdrop through the study of blackbody radiation, photoelectric effect, Compton effect. Understand meaning of quantization. Understand wave particle duality and Heisenberg uncertainty principle.

**CO4 :** Acquire knowledge about LASER, Einstein's coefficients, three and four level LASER.

**CO5 :** Understand the structure of atomic nucleus, nuclear models, nuclear mass formula, radioactivity, alpha and beta decay, gamma ray emission, nuclear fission and fusion, and nuclear reactor.

**CO6 :** Acquire the skill to demonstrate the photoelectric effect, measurement of Planck's constant, wavelength of a solid state LASER using plane diffraction grating and double slit, I-V characteristics of tunnel diode.

**Relationship to other courses**

- Assumed knowledge : None
- Follow up Course : PHSACOR11T, PHSACOR14T, PHSADSE03T

**Faculty :** Mahuya Chakrabarti, Paramita Mallick,

**Course Schedule**

| Faculty | Timetable | | | Google Classroom Code |
|---|---|---|---|---|
| **PHSACOR09T** | | | | |
| Mahuya Chakrabarti | Monday | 10:00 – 11:00 | Physics Laboratory | b5hbuyc |
| | Tuesday | 11:00 – 12:00 | 116 | |
| Paramita Mallick | Thursday | 11:00 – 12:00 | 111 | 47umqd2 |
| | Friday | 13:00\|-- 14:00 | 111 | |
| **PHSACOR09P** | | | | |
| Paramita Mallick | Thursday | 14:00 – 16:00 | Physics Laboratory | r5ckito |
| | Friday | 10:00 – 12:00 | Physics Laboratory | |

**Course Outline**

| Unit 1 - Relativistic Dynamics |
|---|
| Invariance of space-time interval under Lorentz transformation. Idea of 4-vector – contravariant and covariant components, metric. 4-scalar. Space-like, time-like and light-like separation, causality in relativity. Proper time. 4-velocity and 4-momentum. Conservation law of 4- momentum. Relativistic mass. Relativistic energy. Rest energy. Equivalence of mass & energy. Applications in two body decay of a particle, two body collisions. |
| **Unit 2 - Collection of Identical Entities – Classical Approach** |
| Large collection of identical entities in an enclosure at thermal equilibrium. Idea of averaging over the collection, relation with bulk variables. Boltzmann weight factor. Law of equipartition of energy for single entity. Example: Cavity radiation and black body, classical theory of blackbody radiation, Rayleigh-Jeans law. Ultraviolet catastrophe. |
| **Unit 3 - Emergence of Quantum Theory** |
| Planck's quantum postulate to avoid ultraviolet catastrophe, Planck's constant and Planck's ditribution law for blackbody Radiation. Photo-electric effect and Compton scattering. Light as a collection of photons; Wilson- Sommerfield quantization rule unifying Planck's quantization rule and Bohr's angular momentum quantization rule. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them.<br>Position measurement- gamma ray microscope thought experiment; Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables) as a consequence of wave description. Estimating minimum energy of a confined particle using uncertainty principle. Energy-time uncertainty principle- application to virtual particles and range of an interaction.<br>Two-Slit interference experiment with electrons and photons. Wave-particle duality, Bohr's complementarity principle. Matter waves and wave function, linear superposition principle as a consequence; Born's probabilistic interpretation of wave function bridging between wave description and particle description. |
| **Unit4 4 - Lasers** |
| Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing |
| **Unit 5 - Nuclear Physics** |
| Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.<br>Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). |
| **Reference Books** |
| 1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill. |

2. Relativity. W. Rindler, 2006, Oxford.
3. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles. R. Eisberg and R. Resnick, 1985, Wiley.
4. Perspectives of Modern Physics. A. Beiser, 1969, McGraw-Hill.
5. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
6. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
7. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
8. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
9. An Introduction to Nuclear Physics. W. N. Cottingham and D.A. Greenwood, 2004, Chambridge.
10. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan
Additional Books for Reference
11. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
12. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
13. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
14. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
15. Six Ideas that Shaped Physics : Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

**Course Calendar**

| Mahuya Chakrabarti | | | |
|---|---|---|---|
| **Unit** | **Topic** | **Class Hour** | **Month** |
| **2** | **Collection of Identical Entities – Classical Approach** | **6** | |
| 2A | Large collection of identical entities in an enclosure at thermal equilibrium. Idea of averaging over the collection, relation with bulk variables. Boltzmann weight factor. | 3 | January<br>February |
| 2B | Law of equipartition of energy for single entity. Example: Cavity radiation and black body, classical theory of blackbody radiation, Rayleigh-Jeans law. Ultraviolet catastrophe. | 3 | February |
| **3** | **Emergence of Quantum Theory** | **20** | |
| 3A | Planck’s quantum postulate to avoid ultraviolet catastrophe, Planck’s constant and Planck’s ditribution law for blackbody Radiation. | 2 | February |
| 3B | Photo-electric effect and Compton scattering. Light as a collection of photons; Wilson- Sommerfield quantization rule unifying Planck’s quantization rule and Bohr’s angular momentum quantization rule.<br>De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. | 6 | February<br>March |
| | Class Test | 1 | March |
| 3C | Position measurement- gamma ray microscope thought experiment; Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables) as a consequence of wave description. | 3 | March<br>April |
| 3D | Estimating minimum energy of a confined particle using uncertainty principle. Energy-time uncertainty principle- application to virtual particles and range of an interaction. | 2 | April |
| 3E | Two-Slit interference experiment with electrons and photons. Wave-particle duality, Bohr’s complementarity principle. Matter waves and wave function, linear superposition principle as a consequence; Born’s probabilistic interpretation of wave function bridging between wave description and particle description. | 6 | April<br>May |
| **4** | **LASER** | **4** | |
| 4A | Lasers: Einstein’s A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing | 3 | May |
| | Class Test | 1 | May |

| Paramita Mallick | | | |
|---|---|---|---|
| **Unit** | **Topic** | **Class Hour** | **Month** |
| **1** | **Relativistic Dynamics** | **12** | |
| 1A | Invariance of space-time interval under Lorentz transformation. Idea of 4-vector–contravariant and covariant components, metric. 4-scalar. Space-like, time-like and light-like separation, causality in relativity. Proper time. | 6 | February<br>March |
| 1B | 4-velocity and 4-momentum. Conservation law of 4- momentum. Relativistic mass. Relativistic energy. Rest energy. Equivalence of mass & energy. Applications in two body decay of a particle, two body collisions. | 6 | March |
| | Class Test | | |
| **2** | **Nuclear Physics** | **18** | |
| 2A | Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. | 6 | March<br>April |
| 2B | Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. | 6 | April |
| 2C | Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). | 6 | April<br>May |
| | Class Test | | May |

**Evaluation methodology**

(a) Internal assessment in PHSACOR09T will be through class tests only. Class tests are mandatory.

(2) Internal Assessment in PHSACOR09P will be based on the number of experiments completed by a student. Minimum 6 experiments should be completed to qualify for end-semester examination.

## Analog Systems and Applications (PHSACOR10T, PHSACOR10P)
## 4th Semester, 2022-2023

**About the Course**

- Name of the Course : Analog Systems and Applications
- Nature of the Course : Core Course
- Code of the Course : PHSACOR10T (Theory), PHSACOR10P (Practical)
- Credit point : 4 (Theory) + 2 (Practical)
- Class Hours : 60 (Theory) + 60 (Theory)

**Course Description :** The objective of this course is to provide the students with the basic ideas of Analog Electronics. After successful completion of this course a student is expected to learn the following.

**Course Outcomes**

**CO1 :** Acquire basic knowledge about the development of electronics and advantage of solid state devices in electronics and develop basic ideas of semiconductor.

**CO2 :** Will learn about devices like junction diodes, filters and their applications.

**CO3 :** Learn about bipolar junction transistors, JFFTs and their characteristics.

**CO4 :** Learn about transistor amplifiers and Hybrid Model.

**CO5 :** Students will develop concept of feedback (positive and negative) in amplifier and oscillators

**CO6 :** Will get basic knowledge of Operational Amplifiers (OPAMP).

**CO7:** Acquire skills to design, fabricate different circuits using different electronic components through hands on training.

**.Relationship to other courses**

- Assumed knowledge: Basic ideas of current electricity
- Prerequisite: None

**Course Coordinator :** Dr. Raghu Nath Bera

**Course Schedule**

| Faculty | Timetable | | | Google Classroom Code |
|---|---|---|---|---|
| **PHSACOR08T** | | | | |
| Raghu Nath Bera | Wednesday | 11:00 – 12:00 | Physics Laboratory | To be announced |
| | Thursday | 10:00 – 11:00 | 111 | |
| | Friday | 11:00 – 12:00 | 111 | |
| | Saturday | 13:00 – 14:00 | 116 | |
| **PHSACOR08P** | | | | |
| Raghu Nath Bera | Thursday | 12:00 – 14:00 | Physics Laboratory | To be announced |
| | Saturday | 14:00 – 16:00 | Physics Laboratory | |

**Course Outline (PHSACOR10T)**

| **Unit 1 : History of the development of electronics** |
|---|
| Valve circuits and advantages of using semiconductor devices in modern electronic systems. |
| **Unit 2 : Semiconductor Diodes** |
| P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. |
| **Unit 3 : Two-terminal Devices and their Applications** |
| Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter & π- filter(qualitative, expression only), Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. |
| **Unit 4 : Bipolar Junction transistors** |
| n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Physical Mechanism of Current Flow (unbiased).Current gains $\alpha$ and $\beta$ Relations between $\alpha$ and $\beta$. Load Line analysis of Transistors. DC Load line and Q-point. Active, Cutoff and Saturation Regions. |
| **Unit 5 : Field Effect transistors** |
| Basic principle of operation of JFET, JFET parameters and CS characteristics. |
| **Unit 6 : Amplifiers** |
| Amplifiers: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. |
| **Unit 7 : Coupled Amplifier** |
| Two stage RC-coupled amplifier and its frequency response. |
| **Unit 8 : Feedback in Amplifier** |
| Concept of feedback, Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. |
| **Unit 9 : Sinusoidal Oscillators** |
| Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. |
| **Unit 10: Operational Amplifiers (Black Box approach)** |
| Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. |
| **Unit 11: Applications of Op-Amps** |
| Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers. |
| **Unit 12: Conversions** |

| |
|---|
| Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation) . |
| **Reference Books** |
| 1. Electronic Devices and Circuit Theory. R.L. Boylested and L. Nashelsky, Pearson.<br>2. Integrated Electronics, J. Millman and C.C. Halkias, Tata Mc-Graw Hill.<br>3. Electronics: Fundamentals and Applications, J.D. Ryder, Prentice Hall.<br>4. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, PHI Learning.<br>5. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, Tata Mc-Graw Hill.<br>6. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, Prentice Hall.<br>7. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, Oxford University Press.<br>8. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk, Springer.<br>9. Semiconductor Devices: Physics and Technology, S.M. Sze, Wiley India.<br>10. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning.<br>11. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India |

**Course Calendar**

| Raghu Nath Bera | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **1** | **History of the development of electronics** | **3** | |
| | Valve circuits and advantages of using semiconductor devices in modern electronic systems | 3 | January February |
| **2** | **Semiconductor Diodes** | **7** | |
| | P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. | 2 | February |
| | PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. | 2 | February |
| | Current Flow Mechanism in Forward and Reverse Biased Diode. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. | 3 | February |
| **3** | **Two-terminal Devices and their Applications** | **7** | |
| | Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers. | 2 | February |
| | Calculation of Ripple Factor and Rectification Efficiency, C-filter & π-filter(qualitative, expression only). | 3 | February |
| | Zener Diode and Voltage Regulation. | 1 | March |
| | Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell. | 1 | March |
| **4** | **Bipolar Junction Transistors** | **8** | |
| | n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. | 3 | March |
| | Physical Mechanism of Current Flow (unbiased).Current gains $\alpha$ and $\beta$, Relations between $\alpha$ and $\beta$. | 2 | March |
| | Load Line analysis of Transistors. DC Load line and Q-point. Active, Cutoff and Saturation Regions. | 3 | March |
| **5** | **Field Effect Transistors** | **3** | |
| | Basic principle of operation of JFET, JFET parameters and CS characteristics. Problems | 3 | March |
| **6** | **Amplifiers** | **8** | |
| | Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. | 2 | March |
| | Transistor as 2-port Network. h-parameter Equivalent Circuit. | 2 | March |
| | Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. | 3 | April |
| | Classification of Class A, B & C Amplifiers. | 1 | April |
| | 1st Class Test | | |

| | | | |
|---|---|---|---|
| **7** | **Coupled Amplifiers** | **3** | |
| | Two stage RC-coupled amplifier and its frequency response. | 3 | April |
| **8** | **Feedback in Amplifier** | **4** | |
| | Concept of feedback, Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. | 4 | April May |
| **9** | **Sinusoidal Oscillators** | **4** | |
| | Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of frequency. | 3 | May |
| | Hartley & Colpitts oscillators. | 1 | May |
| **10** | **Operational Amplifiers (Black Box approach)** | **4** | |
| | Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. | 4 | May |
| **11** | **Applications of OPAMPs** | **7** | |
| | Linear - (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. | 6 | May |
| | Non-linear – (1) inverting and non-inverting comparators, (2) Schmidt triggers. | 1 | May |
| **12** | **Conversions** | **2** | |
| | Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation) | 2 | June |
| | 2nd Class Test | | |

## Evaluation of students:

Internal evaluation will be done through class tests. The dates of the examination will be declared ahead of time.

## Electromagnetic Theory (PHSACOR013T, PHSACOR013P)

6th Semester, 2022-2023

**About the Course**

- Name of the Course : Electromagnetic Theory
- Nature of the Course : Core Course
- Code of the Course : PHSACOR013T, PHSACOR013P
- Credit point : 4 (Theory) + 2 (Laboratory)
- Class Hours : 60 (Theory) + 60 (Laboratory)

**Course Description**

The objective of the course on Electromagnetic theory is to introduce to the students unified description of electric and magnetic phenomena. Starting with the derivation of Maxwell's equations, electromagnetic waves and their polarization, reflection and refraction, dispersion and scattering are studied. Basic idea of wave guides and optical fibers are introduced.

**Course Outcomes**

**CO1 :** Understanding of the Maxwell's equations, gauge transformations, Poynting theorem, conservation laws.

**CO2 :** Understanding of the emergence of wave equations from Maxwell's equation and propagation of plane waves in unbounded (infinite conducting media, dilute plasma) and bounded media and correlated consequences.

**CO3 :** Understanding of the polarization of electromagnetic waves, optical rotation and Fresnel's theory, working of polarimeter.

**CO4 :** Understanding of the propagation of electromagnetic waves in anisotropic media and correlated consequences.

**CO5 :** Knowledge about the wave guides and basic idea about optical fibres.

**Relationship to other courses**

- Assumed knowledge : Basic understanding of differential equation, Electromagnetism
- Follow up Course : None

**Faculty :** Mahuya Chakrabarti, Paramita Mallick

**Course Schedule**

| Faculty | Timetable | | | Google Classroom Code |
|---|---|---|---|---|
| **PHSACOR13T** | | | | |
| Paramita Mallick | Wednesday | 15:00 – 16:00 | Physics Laboratory | jktxnf2 |
| | Saturday | 10:00 --11:00 | Physics Laboratory | |
| Mahuya Chakrabarti | Monday | 13:00 -- 14:00 | 111 | g6lsgev |
| | Wednesday | 10:00 – 11:00 | 116 | |
| **PHSACOR13P** | | | | |
| Mahuya Chakrabarti | Wednesday | 12:00 – 14:00 | Physics Laboratory | g6lsgev |
| | Thursday | 10:00 --12:00 | Physics Laboratory | |

## Course Outline (PHSACOR13T)

| **Unit 1 – Maxwell's Equations** |
|---|
| Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density. Momentum Density and Angular Momentum Density (statement only). |
| **Unit 2 - EM Wave Propagation in Unbounded Media** |
| Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. |
| **Unit 3 - EM Wave in Bounded Media** |
| Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence). |
| **Unit 4 - Polarization of Electromagnetic Waves** |
| Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light<br>Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter. |
| **Unit 5 - Wave guides** |
| Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. |
| **Unit 6 - Optical Fibres** |
| Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). |
| **Reference Books** |
| 1. Introduction to Electrodynamics, D.J. Griffiths, Benjamin Cummings.<br>2. Optics, E. Hecht, Pearson.<br>3. Elements of Electromagnetics, M.N.O. Sadiku, Oxford University Press.<br>4. Introduction to Electromagnetic Theory, T.L. Chow, Jones & Bartlett Learning.<br>5. Fundamentals of Electromagnetics, M.A.W. Miah, Tata McGraw Hill<br>6. Electromagnetic field Theory, R.S. Kshetrimayun, Cengage Learning. |

7. Engineering Electromagnetic, Willian H. Hayt, McGraw Hill.
8. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, Springer.
9. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, W.H.Freeman & Co.
10. Electromagnetics, J.A. Edminster, Schaum Series, Tata McGraw Hill.
11. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, Cambridge University Press.

**Course Calendar (PHSACOR13T)**

| Mahuya Chakrabarti | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **1** | **Maxwell Equations** | **12** | |
| 1A | Maxwell’s equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. | 3 | February |
| 1B | Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. | 6 | February<br>March |
| 1C | Physical Concept of Electromagnetic Field Energy Density. Momentum Density and Angular Momentum Density (statement only). | 3 | March |
| **2** | **EM Wave Propagation in Unbounded Media** | **10** | |
| 2A | Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. | 6 | March<br>April |
| 2B | Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. | 4 | April |
| **3** | **EM Wave in Bounded Media** | **10** | |
| | Boundary conditions at a plane interface between two media. | 1 | May |
| | Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. | 3 | May |
| | Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence). | 6 | May<br>June |
| | Class Test | | June |

| Paramita Mallick | | | |
|---|---|---|---|
| Unit | Module | Class Hour | Month |
| **4** | **Polarization of Electromagnetic Waves** | **17** | |
| 4A | Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media.<br>Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation<br>in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light.<br>Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis<br>of Polarized Light | 11 | February<br>March |
| 4B | Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light | 2 | March |
| 4C | Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation.<br>Laurent's half-shade polarimeter. | 3 | March<br>April |
| | Class Test (10 Marks) | 1 | April |
| **5** | **Wave guides** | **8** | |
| 5A | Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. | 8 | April<br>May |
| **6** | **Optical Fibres** | **3** | |
| 6A | Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). | 2 | May |
| | Class Test (10 Marks) | 1 | May |

**Evaluation of students:**

Internal evaluation will be done through Class test examination and assignments. The assignments will be given in the classroom after completion of a unit/module. The dates of examinations will be declared ahead of time.

## Statistical Mechanics (PHSACOR14T, PHSACOR14P)

6th semester, 2022-2023

**About the Course**

- Name of the course : Statistical Mechanics
- Nature of the course : Core course
- Code of the course : PHSACOR014T (Theory) and PHSACOR014P (Laboratory)
- Credit point : 4 (Theory) + 2 (Laboratory)
- Class hours : 60 Hours (Theory) + 60 Hours (Laboratory)

**Course Description :** Statistical Physics core is an introductory course to inculcate among the students an understanding of classical statistical mechanics, blackbody radiation, system of identical particle and three different statistical distributions (MB, BE and FD distributions).

**Course Outcomes**

On successful completion of this core course students will

**CO1 :** Understand the classical statistical mechanics in particular: Macrostates and microstates, entropy, temperature, ensemble, chemical potential, partition functions.

**CO2 :** Have an idea of chemical equilibrium, chemical potential and ionization potential.

**CO3 :** Acquire knowledge of blackbody radiation, different laws relating to radiation and Planck's Law.

**CO4 :** Understand identical particles and indistinguishability, derivation of the Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics and their applications in different physical systems.

**CO5 :** Acquire familiarity with the computational analysis of different velocity distributions, partition functions, plot of Planck's law for black body radiation.

**Relationship to other courses**

- Assumed knowledge : Understanding of thermal physics, quantum mechanics
- Prerequisite : PHSACOR06T, PHSACOR11T

**Faculty :** Purnendu Chakraborty, Priyanka Chowdhury

**Course Schedule**

| Faculty | Day | Time | Venue | Google Classroom Code |
|---|---|---|---|---|
| **PHSACOR14T** | | | | |
| Purnendu Chakraborty | Tuesday | 13:00 – 14:00 | Auditorium 6 | wmf5l62 |
| | Thursday | 14:00 – 15:00 | Physics Laboratory | |
| Priyanka Chowdhury | Thursday | 12:00 – 13:00 | Physics Laboratory | xt6ey62 |
| | Thursday | 13:00 – 14:00 | Physics Laboratory | |
| **PHSACOR014P** | | | | |
| Purnendu Chakraborty | Tuesday | 10:00 – 12:00 | Computer Laboratory | wmf5l62 |
| | Saturday | 14.00 – 16.00 | Computer Laboratory | |

**Course Outline (PHSACOR14T)**

| Unit 1 : Classical Statistical Mechanics |
| --- |
| Macrostate and Microstate, concept of time averaging in a macroscopic measurement. Ergodic hypothesis (statement only). Elementary Concept of Ensemble, Liouville's theorem. Microcanonical ensemble, Phase Space, postulate of equal a priori probability, Entropy and Thermodynamic Probability, Canonical ensemble, Partition Function, Density of states: for ideal gas, for standing waves in a cavity. Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. Grand canonical ensemble and chemical potential. Equivalence of microcanonical, canonical and grand canonical ensemble for large systems (qualitative discussion only). |
| **Unit 2 : Chemical Equilibrium** |
| Chemical potential and chemical reaction. Law of chemical equilibrium. Chemical potential for ideal gas, for photon gas. Ionisation potential. Saha's Ionization Formula. |
| **Unit 3 : Theory of Blackbody Radiation** |
| Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law, Thermodynamic proof. Radiation Pressure.<br>Recapitulation of Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. |
| **Unit 4 : System of identical particles** |
| Collection of non-interacting identical particles. Classical approach and quantum approach: Distinguishability and indistinguishability. Occupation number and MB distribution, emergence of Boltzmann factor. Composite system postulate and symmetry postulate of quantum mechanics (for a pair of particles only). Bosons and Fermions. Spin statistics theorem (statement only). Pauli exclusion principle for Fermions. |
| **Unit 5 : Bose Einstein Statistics** |
| B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. Phonon gas. Debye theory of specific heat of solids.<br>T^3 law. |
| **Unit 6 : Fermi-Dirac Statistics** |
| Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Fermi temperature, Fermi momentum, Sommerfield correction to free electron theory in a Metal. Specific Heat of Metals, Wiedemann-Franz law. |
| **Reference Books** |
| 1. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell.<br>2. Statistical Physics, Berkeley Physics Course, F. Reif.<br>3. Statistical Mechanics, R.K. Pathria.<br>4. Statistical Mechanics – an elementary outline, A. Lahiri.<br>5. Intermediate Statistical Mechanics. J. Bhattacharjee and D. Banerjee. |

6. An Introductory Course of Statistical Mechanics. P.B. Pal.
7. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir.
8. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, F.W. Sears and G. L. Salinger.
9. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
10. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen.

**COURSE CALENDAR FOR PHSACOR14T**

| **Purnendu Chakraborty** | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **1** | **Classical Statistical Mechanics** | **20** | |
| 1A | Macrostate and Microstate, concept of time averaging in a macroscopic measurement. Ergodic hypothesis. | 2 | February |
| 1B | Elementary Concept of Ensemble, Liouville's theorem. Microcanonical ensemble, Phase Space, postulate of equal a priori probability, Entropy and Thermodynamic Probability. | 3 | February |
| 1C | Canonical ensemble, Partition Function, Density of states: for ideal gas, for standing waves in a cavity. Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. | 10 | March April |
| 1D | Grand canonical ensemble and chemical potential. Equivalence of microcanonical, canonical and grand canonical ensemble for large systems. | 4 | April |
| | $1^{st}$ class test | 1 | May |
| | | | |
| **2** | **Chemical Potential** | **5** | |
| 2A | Chemical potential and chemical reaction. Law of chemical equilibrium. | 2 | May |
| 2B | Chemical potential for ideal gas, for photon gas. Ionisation potential. | 2 | May |
| 2C | Saha's Ionization Formula. | 1 | May |
| | | | |
| **3** | **Theory of Blackbody radiation** | **6** | |
| 3A | Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. | 1 | May |
| 3B | Stefan-Boltzmann law, Thermodynamic proof. Radiation Pressure. | 2 | June |
| 3C | Recapitulation of Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. | 2 | June |
| | $2^{nd}$ class test | 1 | June |

| Priyanka Chowdhury | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **4** | **System of identical particles** | **6** | |
| 4A | Collection of non-interacting identical particles. Classical approach and quantum approach: Distinguishability and indistinguishability. | 1 | February |
| 4B | Occupation number and MB distribution, emergence of Boltzmann factor. | 2 | February |
| 4C | Composite system postulate and symmetry postulate of quantum mechanics (for a pair of particles only). Bosons and Fermions. Spin statistics theorem (statement only). Pauli exclusion principle for Fermions. | 3 | February March |
| | | | |
| **5** | **Bose-Einstein Statistics** | **12** | |
| 5A | B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas. | 3 | March |
| 5B | Bose Einstein condensation, properties of liquid He (qualitative description). | 2 | March |
| 5C | Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. | 3 | March April |
| 5D | Phonon gas. Debye theory of specific heat of solids. T3 law. | 3 | April |
| | 1$^{st}$ class test | 1 | April |
| | | | |
| **6** | **Fermi-Dirac Statistics** | **11** | |
| 6A | Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas | 4 | April May |
| 6B | Fermi Energy, Fermi temperature, Fermi momentum. | 3 | May |
| 6C | Sommerfield correction to free electron theory in a Metal. Specific Heat of Metals, Wiedemann-Franz law. | 3 | May |
| | 2$^{nd}$ class test | 1 | June |

**Evaluation methodology**

1. Internal assessment of PHSACOR014T will be through class tests only. All class tests are mandatory.
2. Internal assessment of PHSACOR014P will be based on number of assignments successfully completed by a student. There will be 10 assignments and minimum 6 assignments have to be completed by a student to qualify for end semester examination.

## Advanced Mathematical Physics – II (PHSADSE04T)
## 6th semester, 2022-2023

**About the Course**

- Name of the course : Advanced Mathematical Physics – II
- Nature of the course : Core course
- Code of the course : PHSADSE04T
- Credit point : 6

**Course Description**

The objective of this advanced level course is to provide the students rigorous training on partial differential equation, group theory and probability theory.

**Course Outcomes**

**CO1 :** Understand the classification of PDE and solution of the homogeneous equation of each type. Comprehend Green’s function and solution of inhomogeneous PDE by Green’s function method.

**CO2 :** Comprehend the basics of group theory, e.g, definitions, types of group, group operations. Learn about special groups, matrix representation, reducibility *of the* groups, Schur’s lemma, Lie groups. Understand rotation group, and homomorphism between
SU(2) and SU(3).

**CO3 :** Revise the theory of probability, random variables and probability distributions, expectation values and variance. Understand various examples of probability distributions used in physics. Learn the principle of least squares.

**Relationship to other courses**

- Assumed knowledge : Understanding of probability theory and partial differential equations.
- Prerequisite : PHSACOR01T, PHSACOR05T.

**Faculty :** Purnendu Chakraborty and Priyanka Chowdhury

**Course Schedule**

| Faculty | Timetable | | | Google Classroom Code |
|---|---|---|---|---|
| Purnendu Chakraborty | Friday | 12:00 – 13:00 | Physics Laboratory | wmf5l62 |
| | Saturday | 12:00 – 14:00 | Physics Laboratory | |
| Priyanka Chowdhury | Monday | 11:00 – 13:00 | Physics Laboratory | xt6ey62 |
| | Friday | 11:00 – 12:00 | Physics Laboratory | |

## Course Outline (PHSADSE04T)

| Unit 1 : Partial Differential Equations |
|---|
| Existence and uniqueness theorem for solutions of partial differential equations (PDE). Categorisation of PDE's. Solution method for one homogeneous example of each type.<br>Inhomogeneous PDE. Green's function. General solution in terms of Green's function. Solution of Poisson's equation by Green's function method. |
| **Unit 2 : Group Theory** |
| Review of sets, Mapping and Binary Operations, Relation, Types of Relations.<br>Groups : Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel.<br>Some special groups with operators. Matrix Representations: Reducible and Irreducible representations. Schur's lemma. Orthogonality theorems. Character tables and their uses. Application to small vibrations. Continuous groups : Generator of Lie group. Rotation group and angular momentum as its generator.<br>Homomorphism between SO(3) and SU(2). |
| **Unit 3 : Advanced Probability Theory** |
| Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions: The binomial distribution, The Poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares. |
| **Reference Books** |
| 1. Lectures on Partial Differential Equation, V.I. Arnold.<br>2. Mathematical Methods for Physicists, Weber and Arfken.<br>3. Mathematical Methods. S. Hassani.<br>4. Mathematical Methods for Physicists : A Concise Introduction, Tai L. Chow.<br>5. Elements of Group Theory for Physicists, A. W. Joshi.<br>6. Group Theory, P. Ramond.<br>7. Group Theory and its Applications to Physical Problems, Morton Hamermesh.<br>8. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong.<br>9. Introduction to Mathematical Probability, J. V. Uspensky. |

**COURSE CALENDAR**

| Purnendu Chakraborty | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **1** | **Partial Differential Equations** | **20** | |
| 1A | Existence and uniqueness theorem for solutions of partial differential equations. | 2 | February |
| 1B | Categorisation of PDE's. | 2 | March |
| 1C | Solution method for one homogeneous example of each type. | 6 | March |
| | 1st class test | 1 | March |
| 1D | Inhomogeneous PDE. Green's function. | 2 | March |
| 1E | General solution in terms of Green's function. | 3 | March |
| 1F | Solution of Poisson's equation by Green's function method. | 2 | April |
| | Summary and Discussion | 1 | April |
| | 2nd class test | 1 | April |
| **2** | **Group Theory** | **18** | |
| | Some special groups with operators. | 2 | April |
| | Matrix Representations : Reducible and Irreducible representations. | 2 | May |
| | Schur's lemma. | 2 | May |
| | Orthogonality theorems. | 1 | May |
| | Character tables and their uses. | 2 | May |
| | Application to small vibrations. | 2 | May |
| | 3rd class test | 1 | May |
| | Continuous groups : Generator of Lie group. | 2 | May |
| | Rotation group and angular momentum as its generator. | 2 | June |
| | Homomorphism between SO(3) and SU(2). | 2 | June |
| | 4th class test | 1 | June |

| Priyanka Chowdhury | | | |
|---|---|---|---|
| Unit | Topic | Class Hour | Month |
| **2** | **Group Theory** | **12** | |
| 2A | Review of sets, Mapping and Binary Operations, Relation, Types of Relations. | 2 | February |
| 2B | Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group. | 4 | February |

| | | | |
|---|---|---|---|
| 2C | Permutation/Transformation. Homomorphism and Isomorphism of group. | 3 | February March |
| 2D | Normal and conjugate subgroups, Completeness and Kernel. | 2 | March |
| | 1st class test | 1 | March |
| | | | |
| **3** | **Advanced Probability Theory** | **25** | |
| 3A | Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. | 6 | March |
| 3B | Random Variables and probability distributions, Expectation and Variance. | 5 | March April |
| 3C | Special Probability distributions: The binomial distribution, The Poisson distribution. | 7 | April |
| 3D | Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares. | 6 | May |
| | 2nd class test | 1 | May |

**Evaluation methodology**

Internal assessment in PHSADSE04T will be through class tests only. All class tests are mandatory.

## Communication Electronics (PHSADSE06T, PHSADSE06P)

6$^{th}$ semester, 2022-2023

**About the Course**

• Name of the course : Communication Electronics
• Nature of the course : Core course
• Code of the course : PHSADSE06T (Theory) and PHSADSE06P (Practical)
• Credit point : 4 (Theory) + 2 (Practical)
• Class hours : 60 Hours (Theory) + 60 Hours (Practical)

**Course Description**

The aim of this course is to impart the students the concepts of electronic communication, modulations, communication and navigation systems and mobile telephony system.

**Course Outcomes**

**CO1 :** Understand fundamentals of electronic communication systems.
**CO2 :** Understand different types of modulation (AM, FM, PM) and demodulation, SSB generation .
**CO3 :** Understand sampling, analog pulse modulation and multiplexing.
**CO4 :** Acquire knowledge about digital pulse modulation, ASK, PSK, FSK etc.
**CO5 :** Acquire basic knowledge about satellite communications.
**CO6 :** Understand mobile telephony system, technologies in mobile telephony.
**C0 7:** Acquire skills to design, construct and use of different types modulators, demodulators, multiplexers transmitters and receivers, through hands on training in the laboratory.

**Relationship to other courses**

• Assumed knowledge : Basic knowledge in current electricity and electronics
• Prerequisite : Digital Electronics (SEM 3), Analog Electronics (SEM 4)

**Course Coordinator :** Dr. Raghu Nath Bera

**Course Schedule**

| PHSADSE06T | | | | |
|---|---|---|---|---|
| Faculty | Timetable | | | Google Classroom Code |
| Raghu Nath Bera | Tuesday | 12:00 – 13.00 | Physics Laboratory | lfkidnf |
| | Wednesday | 14:00 – 15:00 | Physics Laboratory | |
| | Friday | 13:00 – 14:00 | Physics Laboratory | |
| | Saturday | 11:00 – 12:00 | Physics Laboratory | |
| **PHSADSE06P** | | | | |
| Raghu Nath Bera | Tuesday | 14:00 – 16:00 | Physics Laboratory | |
| | Friday | 14:00 – 16:00 | Physics Laboratory | |

**Course Outline - PHSADSE06T**

| Unit 1 : Electronic communication (8 Lectures) |
|---|
| Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio |
| **Unit 2 : Analog Modulation ( 12 Lectures )** |
| Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver |
| **Unit 3 : Analog Pulse Modulation** |
| Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing. |
| **Unit 4 : Digital Pulse Modulation** |
| Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). |
| **Unit 5 : Introduction to Communication and Navigation systems** |
| Satellite Communication– Introduction, need, Geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink. |
| **Unit 6 : Mobile Telephony System** |
| Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only) |
| **Reference Books** |
| 1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.<br>2. Advanced Electronics Communication Systems- Tomasi, Prentice Hall.<br>3. Electronic Communication systems, G. Kennedy, Tata McGraw Hill.<br>4. Principles of Electronic communication systems – Frenzel, McGraw Hill<br>5. Communication Systems, S. Haykin, Wiley India<br>6.Electronic Communication system, Blake, Cengage.<br>7. Wireless communications, Andrea Goldsmith, Cambridge University Press. |

**COURSE CALENDAR FOR PHSADSE06T**

| Unit | Topic | Class Hour | Period |
|---|---|---|---|
| **1** | **Electronic communication** | **8** | |
| 1A | Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). | 3 | February |
| 1B | Electromagnetic communication spectrum, band designations and usage.<br>Channels and base-band signals.<br>Concept of Noise, signal-to-noise (S/N) ratio | 5 | February |
| | | | |
| **2** | **Analog Modulation** | **12** | |
| 2A | Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation),<br>Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. | 6 | March |
| 2B | Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), | 5 | March |
| 2C | Qualitative idea of Superheterodyne receiver | 1 | March |
| | | | |
| **3** | **Analog Pulse Modulation** | **10** | |
| 3A | Channel capacity, Sampling theorem | 1 | March |
| 3B | Basic Principles- PAM, PWM, PPM | 6 | March<br>April |
| 3C | Modulation and detection technique for PAM only. | 2 | April |
| 3D | Multiplexing: TDM & FDM | 1 | April |
| **4** | **Digital Pulse Modulation** | **10** | |
| 4A | Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques | 3 | April |
| 4B | Sampling, Quantization and Encoding | 2 | May |
| 4C | Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK). | 5 | May |
| | | | |
| **5** | **Introduction to Communication and Navigation systems** | **10** | |
| 5A | Satellite Communication– Introduction, need, Geosynchronous satellite orbits geostationary satellite advantages of geostationary satellites. | 4 | May |
| 5B | Satellite visibility, transponders (C - Band), path loss, | 3 | May |

| | | | |
|---|---|---|---|
| 5C | Ground station, simplified block diagram of earth station. Uplink and downlink. | 3 | May |
| **6** | **Mobile Telephony System** | **10** | |
| 6A | Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network | 5 | May |
| 6B | Idea of GSM, CDMA, TDMA and FDMA technologies | 3 | May |
| 6C | Simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only) | 2 | June |

**Evaluation methodology**

1. Internal assessment of PHSADSE06T will be through class tests only. All class tests are mandatory.

## Computational Physics Skills (PHSSSEC02M)

4th and 6th semester, 2022-2023

**About the Course**

- Name of the Course : Computational Physics Skills
- Nature of the Course : Skill Enhancement Course
- Code of the Course : PHSSSEC02M
- Credit point : 2
- Class Hours : 30 Hours

**Course Description**

The objective of this course is to give students an exposure to the use of computational resources as scientific problem solving tool.

**Course Outcomes**

**CO1 :** Understand the importance of computer as problem solving tool in science.
**CO2 :** Acquire working knowledge of Linux opertating system.
**CO3 :** Understand programming logic.
**CO4 :** Learn basics of Fortran 90/95 and exercise some simple programs.
**C05 :** Learn basics of LaTeX, the *de facto* scientific document preparation tool.
**CO6 :** Learn basics of Gnuplot and practice some simple examples.
**CO7 :** As Hands on training on the use of computational tools, the students are supposed to learn basics of programming in Fortran/C and visualization of data using gnuplot.

**Course Coordinator** : Dr. Priyanka Chowdhury

**Course Schedule**

| Faculty | Time Table | Google Classroom Code |
|---|---|---|
| Dr. Priyanka Chowdhury | Tuesday, 13:00 – 15:00 (Computer Laboratory) | mavxp6d |

**Course Outline**

| **Unit 1 : Introduction** |
|---|
| Importance of computers in Physics, paradigm for solving physics problems for solution. Usage of linux as an editor. Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) Lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal. |
| **Unit 2 : Scientific Programming** |
| Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN/ C++, Basic elements of FORTRAN 90/95 or C++: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran 90/95 or C++ Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems. |
| **Unit 3 : Control Statements** |
| Types of Logic (Sequential, Selection, Repetition), Branching Statements, Looping Statements, Jumping statements, Subscripted variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems. |
| **Unit 4 : Programming** |
| 1. Exercises on syntax on usage of FORTRAN 90/95 or C++<br>2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN 90/95 or C++.<br>3. To print out all natural even/ odd numbers between given limits.<br>4. To find maximum, minimum and range of a given set of numbers.<br>5. Calculating Euler number using exp(x) series evaluated at x=1 |
| **Unit 5 : Scientific word processing: Introduction to LaTeX** |
| TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors. |
| **Unit 6 : Visualization** |
| Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of |

| |
|---|
| computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot. |
| **Unit 7 : Hands On Exercise** |
| 1. To compile a frequency distribution and evaluate mean, standard deviation etc.<br>2. To evaluate sum of finite series and the area under a curve.<br>3. To find the product of two matrices<br>4. To find a set of prime numbers and Fibonacci series.<br>5. To write program to open a file and generate data for plotting using Gnuplot.<br>6. Plotting trajectory of a projectile projected horizontally.<br>7. Plotting trajectory of a projectile projected making an angle with the horizontal.<br>8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.<br>9. To find the roots of a quadratic equation.<br>10. Motion of a projectile using simulation and plot the output for visualization.<br>11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.<br>12. Motion of particle in a central force field and plot the output for visualization. |
| **Reference Books** |
| 1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.<br>2. Computer Programming in Fortran 90 and 95. V. Rajaraman, 1997 (Publisher: PHI).<br>3. Object Oriented Programming with C++. E. Balaguruswamy, 2017. McGraw Hill, India.<br>4. LaTeX–ADocument Preparation System, Leslie Lamport (Second Edition, Addison-Wesley, 1994).<br>5. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010) |

**Course Calendar**

| **Faculty : Dr. Priyanka Chowdhury** | | | | |
|---|---|---|---|---|
| Module | Module description | Class Hour (30) | | Month |
| | | Theory | Laboratory | |
| 1 | Introduction | 2 | 0 | February |
| 2 | Scientific Programming | 2 | 1 | February |
| 3 | Control Statements | 1 | 1 | February |
| 4 | Programming | 1 | 2 | February<br>March |
| 5 | Scientific word processing : Introduction to LaTeX | 1 | 2 | March |

| | | | | |
|---|---|---|---|---|
| 6 | Visualization | 1 | 1 | March |
| 7 | Hands On Exercise | 5 | 10 | March, April, May |

**Note on Hand On Exercise :** Students have to code at least 6 programs from Unit 7 at their own to take on end semester examination.

**Mode of End Semester Evaluation**

The end semester evaluation in PHSSSEC02M will be based on hands on exercises, viva-voce and class attendance.

| | Class attendance | End Semester Examination | |
|---|---|---|---|
| | | Hands on exercise | Viva-voce |
| Relative weight | 20% | 60% | 20% |
| Marks Equivalent | 5 | 15 | 5 |