UG Board of Studies 2023-24

3-year BSc (Physics) Curriculum

(NEP 2020 Regulations)

For Affiliated Colleges

Under Pondicherry University

From the academic year 2023-24 onwards

ELIGIBILITY FOR ADMISSION

1. Higher Secondary (12^{th} Grade) Certificate of Central / State board or equivalent with Mathematics, Physics, Chemistry combination and should have secured a minimum of 55% of marks in aggregate; and
2. Age below 20 years as on 01-June of the year of admission.

Duration of the Course

The course shall be of three years duration spread over six semesters. The maximum duration to complete the course shall be five years. Exit options are available as per NEP 2020 regulations.

Attendance Requirements

The minimum attendance required shall be 75% with 5% relaxation on production of a medical certificate.

Medium of instruction

The medium of instruction shall be English, except the language courses.

EXIT OPTIONS

with

CREDITS REQUIREMENTS

At the end of the year	*Minimum Credits Required*	*Exit Option*
1st year	42 + 4*	Certificate in Physics
2nd year	87 + 4**	Diploma in Physics
3rd year	130	BSc (Physics) with Mathematics and Chemistry as Minor subjects.

** In addition, 4 credits of vocational course to be done during the summer vacation.*

*** In addition 4 credits of vocational / internship course to be done in summer vacation.*

DEFINITION OF CREDIT / TUTORIAL / WORKLOAD

- Four credit course means 4 hours of classroom lecture per week. In a semester, a 4-credit theory course means 60 hours of classroom lecture.
- In a semester, a 3-credit theory course means 45 hours of classroom lecture.
- 1 Tutorial means one hour of tutorial session per week.
- Tutorial means helping the students solve numerical and analytical problems.
- For example, the course PHYS 1110 (Mechanics) is 4 credits plus 1 tutorial. The course teacher will have 5 hours per week workload.
- 30 hours of Lab means 15 hours of faculty workload.

ABBREVIATIONS

SEC - Skill Enhancement Course (by Physics Department).

MAJ - Major Disciplinary Course (by Physics Department).

MIN - Minor papers (Chemistry / Mathematics).

MDC- Multi-disciplinary Course.

AEC - Ability Enhancement Course.

VAC - Value Added Course.

DISTRIBUTION OF SUBJECTS AND CREDITS

Type of Course	*Credits*	*How many courses in the respective semester?*						*No. of Courses*	*Credits*
		I	**II**	**III**	**IV**	**V**	**VI**		
MAJ	4	1	1	2	3	3	4	14	56
MIN*	4	1	1	1	1	1	1	6	24
MDC	3	1	1	1	0	0	0	3	9
AEC	3	1	0	1	0	0	0	2	6
MIL	3	0	1	0	1	0	0	2	6
SEC	3	1	1	1	1	1	0	5	15
VAC	2	2	2	0	0	0	0	4	8
INT	4	0	0	0	0	0	1	1	4
COM	2	0	0	0	1	0	0	1	2
PRO	12	0	0	0	0	0	0	0	0
	No. of Courses	7	7	6	7	5	6	38	
	Total Credits at the end of 3rd year								**130**

* These are minor papers offered by *Mathematics / Chemistry departments* and taken by Physics majoring students.

PART - I

SKILL ENHANCEMENT COURSES

Offered by Physics Departments of the Affiliated Colleges

For the Physics Majoring Students

Offered in Semester	*Course Code*	*Credits*	*Title of the Course*
1	PHYS - 1100	3	Physics Laboratory – I
2	PHYS - 1200	3	Physics Laboratory – II
3	PHYS - 2100	3	Physics Laboratory – III
4	PHYS - 2200	3	Physics Laboratory – IV
5	PHYS - 3100	3	Physics Laboratory – V

PART - II

MAJOR PAPERS

Offered by Physics Departments of the Affiliated Colleges

For the Physics Majoring Students

S. No	*Offered in Semester*	*Course Code*	*Credits / Tutorial*	*Title of the Course*
1	1	PHYS – 1110	4 + 1	Mechanics and Properties of Matter
2	2	PHYS – 1210	4 + 1	Kinetic Theory and Thermodynamics
3	3	PHYS – 2110	4 + 1	Analog Electronics
4	3	PHYS – 2120	4 + 1	Geometrical Optics
5	4	PHYS – 2210	4 + 1	Acoustics and Oscillations
6	4	PHYS – 2220	4 + 1	Physical Optics
7	5	PHYS – 2230	4 + 1	Elements of Electromagnetics
8	5	PHYS – 3110	4 + 1	Modern Physics and Relativity
9	5	PHYS – 3120	4 + 1	Quantum Physics
10	6	PHYS – 3130	4 + 1	Materials Science
11	6	PHYS – 3210	4 + 1	Computational Physics
12	6	PHYS – 3220	4 + 1	Digital Electronics
13	7	PHYS – 3230	4 + 1	Atomic and Molecular Spectra
14	7	PHYS – 3240	4 + 1	Elements of Nuclear Physics

PART - III

MINOR PAPERS

Offered by Physics Departments of the Affiliated Colleges

For the Mathematics / Chemistry / other Science Students

- These courses are meant for students from mathematics, chemistry, biology, geology, computer science, and other science departments.
- The number of students may be restricted depending on the available classroom or laboratory facilities.
- A minimum of 10 students should register to offer the minor papers.

S. No	*Offered in Semester*	*Course Code*	*Credits / Tutorial*	*Title of the Course*
1	Odd	PHYS 1111	4 + 1	Concepts in Mechanics
2	Even	PHYS 1211	4 + 1	Concepts in Electromagnetism
3	Odd	PHYS 2101	3	Minor Physics Laboratory (Laboratory training)

PART - IV

MULTI-DISCIPLINARY COURSES

Offered by Physics Departments of the Affiliated Colleges

For the Arts / Commerce / Social Science Students

- These courses are meant for students from arts, commerce, management, sociology, history, and other social science departments.
- The number of students may be restricted depending on the available classroom or laboratory facilities.
- A minimum of 10 students should register to offer the minor papers.

S. No	*Offered in Semester*	*Course Code*	*Credits / Tutorial*	*Title of the Course*
1	Odd	PHYS 1115	4 + 1	Electronics in Everyday Life

PART - V

COURSE STRUCTURE

(Semester-wise Overview of all Subjects together)

SEMESTER - I			
Type	***Course Code***	***Course Title***	***Credits***
SEC	PHYS 1100	Physics Laboratory - I	3 Credits
MAJ	PHYS 1110	Mechanics and Properties of Matter	4 Credits + 1 Tutorial
MIN		Minor Chemistry - I	4 Credits
MDC		Other Department Multi-Disciplinary Course	3 Credits
AEC		Language	3 Credits
VAC		Environmental Science	2 Credits
VAC		Understanding India	2 Credits
SEMESTER - II			
SEC	PHYS 1200	Physics Laboratory - II	3 Credits
MAJ	PHYS 1210	Kinetic Theory and Thermodynamics	4 Credits + 1 Tutorial
MIN		Minor Mathematics - I	4 Credits
MDC		Other Department Multi-Disciplinary Course	3 Credits
MIL		Language	3 Credits
VAC		Yoga Education / Health	2 Credits
VAC		Digital Technologies	2 Credits
SEMESTER - III			
SEC	PHYS 2100	Physics Laboratory - III	3 Credits
MAJ	PHYS 2110	Analog Electronics	4 Credits + 1 Tutorial
MAJ	PHYS 2120	Geometrical Optics	4 Credits + 1 Tutorial
MIN		Minor Mathematics - II	4 Credits
MDC		Other Department Multi-Disciplinary Course	3 Credits
AEC		Language	3 Credits

SEMESTER - IV			
Type	***Course Code***	***Course Title***	***Credits***
SEC	PHYS 2200	Physics Laboratory - IV	3 Credits
MAJ	PHYS 2210	Acoustics and Oscillations	4 Credits + 1 Tutorial
MAJ	PHYS 2220	Physical Optics	4 Credits + 1 Tutorial
MAJ	PHYS 2230	Electricity and Magnetism	4 Credits + 1 Tutorial
MIN		Minor Chemistry - II	4 Credits
MIL		Language	3 Credits
COM		Community Engagement	2 Credits
SEMESTER - V			
SEC	PHYS 3100	Physics Laboratory - V	3 Credits
MAJ	PHYS 3110	Modern Physics and Relativity	4 Credits + 1 Tutorial
MAJ	PHYS 3120	Quantum Physics	4 Credits + 1 Tutorial
MAJ	PHYS 3130	Materials Science	4 Credits + 1 Tutorial
MIN		Minor Mathematics - III	4 Credits
SEMESTER - VI			
INT	PHYS 3200	Internship (Lab work / Industry / Research Institute)	4 Credits
MAJ	PHYS 3210	Computational Physics	4 Credits + 1 Tutorial
MAJ	PHYS 3220	Digital Electronics	4 Credits + 1 Tutorial
MAJ	PHYS 3230	Atomic and Molecular Spectra	4 Credits + 1 Tutorial
MAJ	PHYS 3240	Elements of Nuclear Physics	4 Credits + 1 Tutorial
MIN		Minor Chemistry - III	3 Credits

PART - VI

EVALUATION

Internal Assesment:	25 marks
External end-semester examination:	75 marks
Question paper model:	As given below.

END-SEMESTER EXAM QUESTION PAPER PATTERN

Maximum Time: 3 hours Total Marks: 75

PART - A - Give Short Answers.

Each question carries one mark. [5 x 1 = 5 marks]

Question 1 from Unit - I
Question 2 from Unit - II
Question 3 from Unit - III
Question 4 from Unit - IV
Question 5 from Unit - V

PART - B - Give Very Detailed Answers

(Answer any two subquestions from each unit. [5 x (7 + 7) = 70 marks]

Unit - I

Question 6 (A): Derivation / Bookwork type question. [7 marks]
Question 6 (B): Derivation / Bookwork type question. [7 marks]
Question 6 (C): Problem Solving (numerical or analytical). [7 marks]

Unit - II

Question 7 (A): Derivation / Bookwork type question. [7 marks]
Question 7 (B): Derivation / Bookwork type question. [7 marks]
Question 7 (C): Problem Solving (numerical or analytical). [7 marks]

Unit - III

Question 8 (A): Derivation / Bookwork type question. [7 marks]
Question 8 (B): Derivation / Bookwork type question. [7 marks]
Question 8 (C): Problem Solving (numerical or analytical). [7 marks]

Unit - IV

Question 9 (A): Derivation / Bookwork type question. [7 marks]
Question 9 (B): Derivation / Bookwork type question. [7 marks]
Question 9 (C): Problem Solving (numerical or analytical). [7 marks]

Unit - V*

Question 10 (A): Derivation / Bookwork type question. [7 marks]
Question 10 (B): Derivation / Bookwork type question. [7 marks]
Question 10 (C): Problem Solving (numerical or analytical). [7 marks]

** If 5th unit is not available in the syllabus, then a mixture of questions may be taken from all units. For example, Q 10(A) can be from unit-1, then Q 10(B) from unit-3 and Q 10 (C) may be from unit-4.*

*** * * End of Question Paper * * ***

PART - VII

DETAILED SYLLABUS

OF

SKILL ENHANCEMENT COURSES

Offered by Physics Departments of the Affiliated Colleges

For Physics Majoring Students

PHYS - 1100 - PHYSICS LABORATORY – I (3 credits)

Choose any eight experiments from the list given below list of experiments

LIST OF EXPERIMENTS

1. Compound pendulum - determination of g, the radius of gyration, and moment of inertia
2. Determination of Young's modulus by non-uniform bending
3. Surface tension of a liquid and interfacial surface tension (water & kerosene) - drop weight method
4. Rigidity modulus using torsional oscillations without added masses.
5. Specific heat capacity of a liquid and emissivity - method of cooling.
6. Thermal conductivity of a bad conductor- Lee's disc method.
7. Sonometer - determination of frequency and verification of laws of transverse vibrations.
8. Spectrometer- refractive index of a liquid-hollow prism.
9. P.O. box - Verification of laws of resistance.
10. Potentiometer - calibration of the low-range voltmeter.
11. Terminal velocity for bodies falling through a fluid.
12. Jolly's constant volume air thermometer - Determination of the melting point of the wax.
13. Computer simulation - equation of motion for a system of particles.
14. Computer simulation - damped oscillator.
15. Computer simulation - spherical body falling in a viscous liquid.
16. Computer simulation - motion of molecular rotations.

Textbooks

1. Practical Physics C.C Ouseph, V.J. Rao and V. Vijayendran.
2. Practical Physics M.N.Srinivasan, Sultan Son.
3. D P Khandelwal, Laboratory Manual of Physics for UG classes (Vani Pub.)
4. B Saraf et al., Physics through Experiments, Vol. 1 (Vikas Pub.).
5. Verma, Ahluwalia, Sharma, Computational Physics (New Age P Ltd.)

Supplementary Readings

1. V Y Rajopadhye and V L Purohit, Textbook of Experimental Physics.

PHYS - 1200 - PHYSICS LABORATORY - II (3 Credits)

Choose eight experiments from the list below

1. Young's modulus - cantilever - pin and microscope.
2. Melde's apparatus - determination of frequency.
3. Spectrometer-Determination - minimum deviation method.
4. P.O. box - temperature coefficient of the material of a coil of wire.
5. Potentiometer - calibration of ammeter (0-1.5 amps).
6. Emf of thermocouple using a digital thermometer.
7. Study of characteristics of a thermistor.
8. Stoke's method of viscosity determination.
9. Study of laws of parallel and perpendicular axes for estimating moment of inertia
10. Kater's pendulum - Determination of acceleration due to gravity at a place
11. Variation of the period of oscillations of a spring (or rubber band).
12. Oscillations on a bifilar suspension.
13. Searle's method.
14. Computer simulation of motion of Study of coupled oscillators.
15. Computer simulation of analyzing a square waveform for its harmonic components.
16. Computer simulation of Generation of phase space plots of simple harmonic oscillator.
17. Computer simulation of motion of a single pulse.

Text Books

1. Practical Physics C.C Ouseph, V.J. Rao and V. Vijayendran.
2. Practical Physics M.N.Srinivasan, Sultan son Pubs.
3. D P Khandelwal, Laboratory Manual of Physics for UG classes (Vani Pub).
4. B Saraf et al., Physics through Experiments, Vol. 1. Vikas Pub.
5. Verma, Ahluwalia, Sharma, Computational Physics (New Age).

Supplementary Readings

1. V Y Rajopadhye and V L Purohit, Textbook of Experimental Physics.

PHYS - 2100 - PHYSICS LABORATORY - III (3 Credits)

Choose eight experiments from the list below.

LIST OF EXPERIMENTS.

1. Young's modulus - Uniform bending - scale and telescope.
2. Rigidity modulus - Torsional pendulum with equal masses.
3. Specific latent heat of fusion of ice.
4. Spectrometer- determination of wavelength - Minimum deviation method.
5. Spectrometer - i-d curve.
6. M and B_H using deflection and vibration magnetometer tan A and tan B position.
7. Carry-Foster's bridge - Resistivity of the material of the coil of wire.
8. Potentiometer - Internal resistance of a cell.
9. B. G - Comparison of emf of two cells.
10. Determining the focal length of a high-power microscope objective.
11. Study of interference fringes bi-prism arrangements.
12. Study of polarization of light by simple reflection.
13. Study of the rise and decay of current in an RC circuit.
14. Study of the impedance of an inductor.
15. Computer simulation circuit analysis using Kirchhoff's laws.
16. Computer simulation of double-slit interference.

TEXTBOOKS

1. Practical Physics C.C Ouseph, V.J. Rao and V. Vijayendran.
2. Practical Physics M.N.Srinivasan, Sultan son Pubs.
3. D P Khandelwal, A Laboratory Manual in Physics for UG Students (Vani Publication).
4. B Saraf et al. "Physics through Experiments, Vol. II. (Vikas Publications).
5. V Y Rajopadhye and V L Purohit, Textbook of Experimental Physics.
6. Verma, Ahluwalia, Sharma, Computational Physics, an Introduction (New Age).

Supplementary Readings

1. Olon, Experiments in Modern Physics.
2. Adrian C. & Melissinos, Experiments in Modern Physics (Academic Press).

PHYS - 2200 - PHYSICS LABORATORY - IV (3 CREDITS)

Choose any eight experiments from the list given below

LIST OF EXPERIMENTS.

1. Young's modulus - Koenig's method (Non-uniform bending).
2. Rigidity Modulus - Statistic Torsion.
3. Specific latent heat of fusion of ice.
4. Spectrometer- determination of - normal incidence method.
5. Field along the axis of the circular coil carrying current and determination of B.
6. Carry-Foster's bridge - Temperature co-efficient of the material of a wire.
7. Potentiometer -Calibration of high range voltmeter.
8. Figure of merit of a periodic moving coil galvanometer.
9. B.G. - Comparison of capacities.
10. Melde's string-specific gravity of a solid and liquid.
11. Study of optical rotation by solutions.
12. Study of the rise and decay of current in RL circuits.
13. Junction and Zenor diode characteristics.
14. Study of Half and full wave rectifier.
15. Computer simulation of the effect of magnetic field on charged particles.
16. Computer simulation of propagation of electromagnetic waves.

TEXTBOOKS

1. Practical Physics C.C Ouseph, V.J. Rao and V. Vijayendran
2. Practical Physics M.N.Srinivasan, Sultan son Pubs.
3. D P Khandelwal, A Laboratory Manual in Physics for UG Students (Vani Publication).
4. B Saraf et al. "Physics through Experiments. (Vika Publications, New Delhi).
5. V Y Rajopadhye and V L Purohit, Textbook of Experimental Physics.
6. Verma, Ahluwalia, Sharma, Computational Physics, an Introduction (New Age).

Supplementary Readings

1. Olon, Experiments in Modern Physics.
2. Adrian C. & Melissinos, Experiments in Modern Physics (Academic Press).

PHYS - 3100 - PHYSICS LABORATORY –V (3 CREDITS)

Choose eight experiments from the list below.

LIST OF EXPERIMENTS:

1. Newton's Rings: determination of the refractive index of the material of the lens.
2. Spectrometer: Hartmann's Interpolation Formula - Determination of wavelength.
3. Spectrometer: i - i' curve and determination of refractive index.
4. Spectrometer Dispersive power of the material prism.
5. Spectrometer: Grating - wavelength by normal incidence method.
6. Young's modulus: Elliptical fringes method.
7. Ultrasonic velocity and compressibility of the liquids - Interferometer method.
8. Field along the axis of a circular coil - Determination of the moment of a magnet.
9. Temperature coefficient of a Thermistor.
10. Potentiometer: Verification of laws of resistance and resistivity of the material of a wire.
11. Potentiometer: Resistance of the potentiometer and measurement of emf of a thermocouple.
12. B.G Internal resistance of a cell.
13. B.G: Current and voltage sensitivities.
14. B.G: Quantity or charge sensitivity.
15. Wien's bridge: Measurement of frequency.
16. Diode laser: study of its characteristics.
17. Computer simulation of the current in the RL circuit.
18. Computer simulation of the JFET characteristics.

TEXTBOOKS

1. Practical Physics C.C Ouseph, V.J. Rao and V. Vijayendran.
2. Practical Physics M.N.Srinivasan, (Sultan son Pubs).
3. D P Khandelwal, A Laboratory Manual for Physics for Undergraduate Students (Vani Pub).
4. B Saraf et al., Physics through Experiments, Vol. II., EMF constant and varying (Vikas Pub).
5. Verma, Ahluwalia & Sharma, "Computational Physics, an Introduction" (New Age).

Supplementary Readings

1. Olon, "Experiments in Modern Physics".
2. Adrian C. & Melissinos, Experiments in Modern Physics, (Academic Press).
3. LTspice Software for Simulation.

PART - VIII

DETAILED SYLLABUS

OF

MAJOR PAPERS

Offered by Physics Departments of the Affiliated Colleges

For Physics Majoring Students

PHYS - 1110 - MECHANICS and PROPERTIES OF MATTER (4 Credits - 60 hours)

UNIT–I **12 hours**

Gradient, divergence, and curl of a vector - Velocity and acceleration in cartesian and polar coordinates - Addition of forces - Polygon of forces - Condition for the equilibrium of a particle under several forces – Lami's theorem and problems based on it - Forces along and perpendicular to the inclined plane - Limiting equilibrium (about to slide) of a particle kept on an inclined plane – Friction laws (static and dynamic) – Calculation of acceleration of sliding objects down an inclined plane – Moment of a force – Conditions for the equilibrium of a rigid body – Resultant of forces – Three parallel forces acting at the vertices of a triangle – Three forces acting along the sides of a triangle – Defining couple and moment of a couple – Resultant of several coplanar forces – Problems solving.

UNIT–II **12 hours**

Elastic and inelastic collisions – Direct and oblique impacts - Newton's law of coefficient of restitution - Motion of two smooth bodies perpendicular to the line of impact – Conservation of momentum - Loss of kinetic energy due to direct impact - Oblique impact of two spheres - Loss of kinetic energy by oblique impact - Calculation of coefficient of restitution - Ballistic pendulum – Laboratory frame of reference - Center of mass coordinate system - Relation between laboratory and center-of-mass systems – Problems solving.

UNIT–III **12 hours**

Degrees of freedom of a rigid body - Relation between angular momentum, angular velocity, and moment of inertia - Fixed axis rotations - Parallel and perpendicular axes theorem - Definition of pure rolling - Inclined plane with rolling - Pure rolling of symmetrical bodies - Angular momentum of a rigid body - Uniformly rotating frame - centrifugal and Coriolis forces - Calculation of moments of inertia of (i) a circular ring, (ii) circular lamina, (iii) solid sphere, (iv) spherical shell - Calculation of center of mass of objects like an arc of a circle, a rectangle with a cavity, triangle, and similar objects - Center of mass of a system of particles - Problems solving.

UNIT–IV **12 hours**

Newton's law of Gravitation - Kepler's Laws - Two-body problem and reduced mass concept - Equation of motion in plane polar coordinates for the Kepler problem - Turning points in potential energy curve - Derivation of equation of circular and elliptic orbits - Escape velocity - Calculation of gravitational potential inside and outside of (i) a spherical shell, (ii) a solid sphere - Work energy theorem - Conservative force - Conservation laws for systems of particles – Derivation of potential energy of a multi-particle system - Calculation of gravitational self energy of a sphere - Problems solving.

UNIT–V **12 hours**

Moduli of elasticity and Poisson ratio – Derivation of the relation between elastic constants - Bending of beams and Cantilever problems - Torsion in a string and torsional pendulum – Calculation of couple per unit twist of a cylinder (torsional rigidity) – Bending of beams: Bending moment and couple – Calculation of bending due to uniformly distributed load – Calculation of depression of supported beams due to weight – Newton's law of viscosity - Kinematic and dynamic viscosity Poiseuille's formula for the flow of liquid through a capillary tube - Streamline and turbulent flows – Archimedes principle - Equation of continuity - Bernoulli theorem – Euler's equation – Reynolds number and its applications – Motion of a body in a viscous medium – Problems solving.

Text Books

1. For Units-1-3: P Duraipandian and M Jayapragasam. Mechanics, S. Chand.
2. For Units 4, 5: D.S. Mathur, Elements of Properties of Matter, S. Chand & Co

Supplementary Readings

- David Morin. Introduction to Classical Mechanics. Cambridge University Press.
- Resnick, Halliday, and Walker. Fundamentals of Physics. Wiley.

PHYS - 1210 - KINETIC THEORY AND THERMODYNAMICS (4 credits - 60 hours)

UNIT–I: **12 hours**

Functions of several variables - Partial derivatives – Euler theorem – Chain rule – Exact and inexact differentials - Extensive and intensive variables - Thermodynamic equilibrium - Zeroth law - State functions - Relations between partial derivatives – Exact differentials – Internal energy function - Differential form of first law and applications - Quasi-static processes - Relation between heat capacities CP and CV - Work done during isothermal and adiabatic processes - Compressibility and expansion coefficients - Second law - Reversible and irreversible processes with examples - Heat engines - Carnot cycle, Carnot engine, efficiency, and coefficient of performance - Second law as Kelvin-Planck statement and its equivalence to Clausius statement – Problems solving.

UNIT–II: **12 hours**

Entropy - Clausius theorem - Clausius inequality - Second law in terms of entropy - Entropy of a perfect gas - Principle of increase of entropy - Entropy changes in reversible and irreversible processes with examples - Entropy of the Universe - Temperature-entropy (TS) diagrams for thermodynamic cycles - Third law of thermodynamics - Unattainability of absolute zero – Problems solving.

UNIT–III: **12 hours**

Thermodynamic potentials - Internal Energy, Enthalpy, Helmholtz Free Energy - Properties and applications - Magnetic work and cooling due to adiabatic demagnetization - First and second-order phase transitions with examples - Ehrenfest classification - Maxwell's thermodynamic relations, derivation, and applications - Clausius Clapeyron equation – Difference between heat capacities CP and CV – The TdS Equation - Joule-Kelvin coefficient for ideal and Van der Waal gases - Energy equations - Change in temperature during the adiabatic process - Joule's experiment – Free adiabatic expansion of a perfect gas – Problems solving.

UNIT–IV: **12 hours**

Maxwell-Boltzmann distribution of velocities in an ideal gas and its experimental verification - Doppler broadening of spectral lines - Mean, RMS, and most probable speeds - The law of equipartition of energy without proof - Specific heat of mono-, di- and tri-atomic gases - Kinetic theory - Molecular collisions - Collision probability - Calculation of mean free path – Problems solving.

UNIT-V **12 hours**

Applications of kinetic theory - Derivation of coefficient of viscosity of a gas using kinetic theory - Derivation of thermal conductivity of a gas using kinetic theory - Calculation of coefficient of self-diffusion of gas using kinetic theory – Behavior of real gases - Deviations from the ideal gas equation - The virial equation - Andrew's experiments on carbon dioxide gas - Continuity of liquid and gaseous state – Boyle temperature - Van der Waal's equation of state for real gases - Law of corresponding states - Comparison with experimental curves – Problems solving.

Text Books

1. M.W. Zemansky, R. Dittman. Heat and Thermodynamics, 1981, McGraw-Hill.
2. Sears and Salinger. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Narosa.

Supplementary Readings

1. S.J. Blundell and K.M. Blundell. Concepts in Thermal Physics, 2012, Oxford University Press.
2. H. B. Callen. Thermodynamics and an introduction to thermos-statistics. 1985, Wiley
3. D. S. Mathur, Heat and Thermodynamics. Sultan Chand.
4. A.B. Pippard. Elements of Classical Thermodynamics. Cambridge University Press.

PHYS - 2110 - ANALOG ELECTRONICS (4 Credits - 60 hours)

UNIT–I: **15 hours**

Kirchoff's laws - Bridge networks – Y to Delta and Delta to Y conversion – Superposition theorem – Thevenin's theorem – Norton's theorem – Maximum power transfer theorem – Millman's theorem – Substitution theorem – Reciprocity theorem - Series LCR resonant circuit – Q-factor – Variation of impedance with frequency – Selectivity of a series resonant circuit – Parallel LCR resonant circuit – Q-factor - Capacitor networks – Reluctance and Resistor-inductor (RL) transients – Average and effective values of alternating waveform – Phasor notation – Response of basic R, L, and C elements to a sinusoidal signal – Voltage divider rule for a.c circuits – Problems solving.

UNIT–II: **15 hours**

Classification of Conductors, insulators, and semiconductors based on energy band diagram - Intrinsic and extrinsic semiconductors. P-type and N-type semiconductors. Formation of PN junction diode - Forward and reverse characteristics - Diode resistance-Effect of temperature on extrinsic semiconductors, halfwave, Centre tap, and Bridge rectifiers, Expression for average DC voltages, qualitative ideas of filters, clipping and clamping circuits-their general applications. Zener diode - Current-voltage characteristics - Avalanche and Zener breakdown mechanisms - Zener voltage. Simple voltage regulator circuit using zener diode - LED and photodiode – Problems solving.

UNIT–III: **15 hours**

BJT, biasing and h parameters: Construction of NPN and PNP transistors - their operation modes-operation of NPN and PNP transistors-CB, CE and CC configurations and their biasing, Input, Output and transfer characteristics of BJTs in CB and CE modes - Active, saturation and cut-off regions -Bias stability- Load line analysis- operating point. Transistor biasing for amplifications. Variations of transistor parameters - stability factor and stabilization - Thermal runaway-Methods of transistor biasing -Base bias with emitter feedback- Voltage divider bias, h-parameters of a transistor and their notations-hybrid equivalent circuits for CE, CB and CC mode transistors – Problems solving.

UNIT–IV: **15 hours**

Classification of amplifiers - Single-stage and two-stage RC coupled amplifiers – Frequency response, bandwidth, and rise time - Flat band equivalent circuits – Cascade connections - Barkhausen condition - OPAMP and applications: Inverting and non-inverting amplifiers - Sinusoidal oscillators: Phase shift, Wein bridge, Colpitt, and Hartley oscillators – Problems solving.

Textbooks

1. Robert L. Boylestad, Introductory Circuit Analysis, Prentice-Hall.
2. Alexander and M. N. O. Sadiku, Fundamentals of Electric Circuits, McGraw Hill.
3. Boylsted and Nashelsky, Electronic Devices and Circuits, Pearson, 2009.

Supplementary Readings

1. Thomas L. Floyd, Electric Circuit Fundamentals, Prentice-Hall, (2006), 7th Edition.
2. W. D. Stanley, Electronic Devices: Circuits and Applications, McGraw-Hill.

PHYS - 2120 - GEOMETRICAL OPTICS (4 Credits - 60 hours)

UNIT I: REFLECTION AND REFRACTION **12 hours**

Sign convention of the optical path - Phenomena of reflection and refraction - Fermat's principle and its application to verify the laws of reflection and refraction at a plane surface and curved surface - Image formation due to reflection and refraction of objects at different positions from the curved surface - Lateral magnification and longitudinal magnification - Smith-Helmoltz equation and Lagrange law for refraction at curved surface - Concept of internal reflection and example of natural phenomena - Critical angle for internal reflection in prism – Problems solving.

UNIT II: REFRACTION THROUGH THIN LENS **12 hours**

Lens maker's formula - Newton's lens equation - Principal points and planes for a thin lens - Image formation by lens and application - Equivalent lens for two lenses with and without separation - Equivalent focal length - Magnification of image - Lateral magnification - Longitudinal magnification - Angular magnification - Dispersion in a lens and prism - Condition for minimum deviation of lens - Image formation by eye lens - Cardinal points and their properties for two coaxial thin lenses - Construction image using cardinal points of thin lens – Problems solving.

UNIT III: REFRACTION THROUGH THICK LENS **12 hours**

Principal focal points of a thick lens; Thick lens equation; Cardinal points and their properties for a thick lens; Construction image using cardinal points of a thick lens; Helmholtz's equation in the case of a thick lens or a system of lenses; Formulation of Matrix Method in geometrical optics; Application of Matrix method to explain image formation by refraction in thin lens; Application of Matrix method to explain image formation and thick lens; Variation of focal length with thickness and change of media of a lens; Power of thin lens and Thick lens; Telephoto lens – Problems solving.

UNIT IV: DEFECTS IN LENS AND REMEDY **12 hours**

Spherical aberration - Methods of minimizing spherical aberration - Coma and its remedy - Astigmatism - Curvature of field and distortion - Magnitude of spherical aberration - Dispersion and dispersive power - Chromatic aberration of a lens - Achromatic systems - Condition for achromatism of two lenses in contact - Condition for achromatism of two lenses separated by a distance - Combination of prisms to have deviation but no dispersion, and dispersion but no deviation - Various defects of the image formation by eye lens and their remedy – Problems solving.

UNIT V: OPTICAL INSTRUMENTS **12 hours**

Introduction to telescope and microscope - Eye-pieces; Magnifying glass; Ramsden's eye-piece; Huygens' eye-piece; Gauss's eye-piece; Effects of stops and diaphragms; Astronomical telescope fitted with Ramsden's eye-piece; High power compound microscope; Principle of compound microscope, Magnifying power of a microscope; Magnifying power of a telescope; Constant deviation spectrometer; Resolving power of optical instruments; Resolving power of a telescope, microscope and a prism – Problems solving.

Textbooks

[1] Ghatak, Optics, Tata McGraw Hill.
[2] Hecht, Optics, Addison Wesley.
[3] Pedrotti and Pedrotti, Introduction to Optics, Prentice Hall.
[4] K. K. Sharma, Optics, Elsevier.
[5] Subrahmaniyam, Brijlal, and Avadhanulu. A Textbook of Optics, S. Chand.

Supplementary Readings

[1] Jenkins and White, Fundamental of Optics, McGraw-Hill.
[3] Meller, Optics, Oxford University Press.
[4] Longhurst, Geometrical and Physical Optics, Longmans.

PHYS - 2210 - ACOUSTICS AND OSCILLATIONS (4 Credits - 60 hours)

Unit–I **(12 hours)**

Classification of differential equations as linear, nonlinear, homogeneous, inhomogeneous and coupled equations - Distinction between initial value and boundary value problems - Method of integrating factor – Method of separation of variables – Second order differential equations – Solving Homogeneous and inhomogeneous equations with variable coefficients - Wronskian and principle of superposition - Method of undetermined coefficients - Method of variation of parameters - Applications to electrical and mechanical vibrations and forced oscillations - Problems solving.

UNIT–II **12 hours**

Harmonic oscillations - Calculation of kinetic energy, potential energy, total energy, and their time-average values - Damped and Forced oscillations – Solution to damped and forced oscillators - Transient states and steady states – Resonance and sharpness of resonance - Logarithmic decrement, Relaxation time, Quality factor - Power dissipation - Rate of Work done - Examples of electrical (vibration) systems like LCR resonance – Problems solving.

UNIT–III **12 hours**

Superposition of two collinear harmonic oscillations - Superposition of two perpendicular harmonic oscillations for phase difference - Graphical and analytical methods - Lissajous figures with equal and unequal frequency and their uses - Superposition of a large number of simple harmonic vibrations of equal amplitude and uniform phase difference – Phase and group velocities - Coupled oscillations - Problems solving.

UNIT–IV **12 hours**

The velocity of transverse vibrations of stretched strings - Standing stationary waves in a string - Fixed and free ends - Analytical solution - Plane wave representation in 2D and 3D – Wave equation in 2D – Energy density of vibrating string – Transfer of energy - Normal modes of stretched strings – Plucked and struck strings - Solution by the method of separation of variables – Normal modes in two-dimensional case – Reflection and transmission of a three-dimensional wave at a plane boundary – Example of total internal reflection and evanescent waves.

UNIT–V **12 hours**

Acoustics - Introduction to longitudinal waves – Sound waves in gases – Energy distribution in sound waves – Intensity of sound waves – Speed of longitudinal waves in a fluid - Velocity of sound in the air - Dependence on pressure and temperature - Normal modes vibrations of air columns - Doppler effect in acoustics – Reflection and transmission of sound waves at boundaries – Diffraction of sound waves – Introduction to acoustic transducers – Acoustics of auditoriums and halls – Reverberation time - Musical notes musical scale.

Text Books

1. Boyce and Diprima, Elementary Differential Equations, Wiley.
2. H. J. Pain. The Physics of Vibrations and Waves, John Wiley, (2005), 6th Edition.
3. I. G. Main. Vibrations and Waves in Physics, Cambridge University Press, 1993.

Supplementary Readings

1. D. P. Roychowdhury. Advanced Acoustics, Chayan Publisher.
2. N. K. Bajaj. Waves and Oscillations. Tata McGraw Hill.
3. R.N. Chaudhuri. Waves and Oscillations, New Age International, 2010.
4. M. Ghosh and D. Bhattacharya. A Textbook of Oscillations, Waves, and Acoustics. S. Chand.
5. K.U. Ingard. Fundamentals of waves and oscillations, Cambridge University Press.
6. G.C. King. Vibrations and Waves, Wiley, Hoboken, NJ, 2009.
7. J. Franklin. Mathematical Methods for Oscillations and Waves, Cambridge University Press.

PHYS - 2220 - PHYSICAL OPTICS (4 Credits - 60 hours)

UNIT I: INTERFERENCE **12 hours**

Wave equation for spherical wave - Huygens' principle and theory of interference – Young's experiment – Width and shape of interference fringes – Interference with white light – Conditions like spatial and temporal coherence of light – Fresnel's Biprism – Lloyd's single mirror – Interference in thin films, Interference due to (i) transmitted and (ii) reflected light – Wedge-shaped film – Effects of narrow source and extended source of light – Fringes of equal inclination – Localized fringe pattern – Colours in thin films – Newton's rings under different configurations – Multiple beam interference.

UNIT II: FRESNEL DIFFRACTION **12 hours**

Huygens-Fresnel theory – Fresnel's assumptions – Fresnel's half-period zones of a plane wavefront – Zone plate – Action of a zone plate as convex lens – Similarity and differences between a zone plate and a convex lens – Fresnel's half-period elements of cylindrical wavefront – Fresnel diffraction at a straight edge – Fresnel diffraction in (i) a narrow rectangular aperture, (ii) around a narrow obstacle (iii) in circular aperture, (iv) in opaque circular disc – Graphical solution of diffraction problems – Problems solving.

UNIT III: FRAUNHOFER DIFFRACTION **12 hours**

Fraunhofer diffraction in (i) a single slit, (ii) a double slit – Plane diffraction grating – Absent spectra and ghosts in a diffraction grating – Overlapping of spectral lines – Angular dispersive power of a grating – Comparison of grating and prism spectra – Resolving power and Rayleigh criterion – Fraunhofer diffraction at (iii) a circular aperture, (iv) a rectangular aperture – Concave Reflection grating – Echelon grating – Phase contrast microscope – Problems solving.

UNIT IV: POLARIZATION **12 hours**

Linearly polarized light – Polarization of light by reflection and Brewster's law – Polarisation by refraction – Importance of Calcite crystal for polarization of light – Double refraction – Nicol prism – Malus's law – Polarization by dichroic crystals – Polaroid – Huygens' theory of double refraction – Uniaxial crystal – Huygens' construction of wave fronts in a uniaxial crystal – Refractive indices of uniaxial crystal – Electromagnetic theory of double refraction – Superposition of two plane polarised waves at right angles – Retardation Plates – Production of elliptically and circularly polarized light – Optical activity and Fresnel's explanation for optical rotation – Specific rotation – Problems solving.

UNIT-V: APPLICATIONS **12 hours**

Michelson interferometer to find refractive index of gas - Thickness of thin films - Standardization of meter scale – Construction of Etalon – Fabry-Perot interferometer – Half-wave and quarter-wave plates – Analysis of circularly and elliptically polarised light by quarter-wave plate – Babinet's compensator – Applications of Polarimeters and Lippich Polarimeter – Experimental demonstration of anomalous dispersion – Magneto-optic Kerr cell – Problems solving.

Textbooks

[1] Ghatak, Optics, Tata McGraw Hill.
[2] Hecht, Optics, Addison Wesley.
[3] Pedrotti and Pedrotti, Introduction to Optics, Prentice Hall.
[4] K. K. Sharma, Optics, Elsevier.
[5] B. Ghosh and K.G. Mazumdar, A Text Book on Light, Sreedhar Publishers.
[6] Subrahmaniyam, Brijlal, and Avadhanulu. A Textbook of Optics, S. Chand.

Supplementary Readings

[1] Jenkins and White, Fundamental of Optics, McGraw-Hill.
[2] Meller, Optics, Oxford University Press.
[3] Longhurst, Geometrical and Physical Optics, Longmans.

PHYS - 2230 - ELEMENTS OF ELECTROMAGNETICS (4 Credits - 60 hours)

UNIT–I: **12 hours**

Divergence, curl, gradient operators, and vector identities - Vector integration, line, surface, and volume integrals of vector fields – Gauss divergence theorem and Stoke's theorem of vectors and their significances - Electric field due to an infinitely long line charge, a sheet of charge, a ring of charge, a charged disk, an electric dipole, and other charge distributions – Derivation of Gauss's law from Coulomb's law – Application to symmetric charge distributions like an infinite sheet of charge, uniformly charged sphere (solid and shell), cylinder, and similar objects. – Electric dipole in an electric field - Discontinuity of electric field on the surface of a conductor – Problems solving.

UNIT–II: **12 hours**

Discontinuity of electric field on the surface of a conductor – Convection and conduction current and deriving Ohms law $J = \sigma E$ – Continuity equation and relaxation time - Dielectric polarization – Definition of electric polarization – Dielectric breakdown – Electric susceptibility and permittivity - Gauss's law in the presence of linear dielectrics –Capacitors with dielectrics - Calculating the capacitance (in presence of dielectrics) of a parallel plate capacitor, a cylindrical capacitor, a spherical capacitor, coaxial cylindrical capacitor, concentric spherical capacitor and for an isolated spherical capacitor - Bound charges, Displacement density vector - Problems solving.

UNIT–III: **12 hours**

Poisson equation - Solution of Laplace's equation for simple cases - The electric potential inside and outside of a spherical shell of charge - Electric potential due to a system of discrete charges and continuous charge distributions – Potential gradient – Derivation of energy density in an electrostatic field –Potential energy of an electric dipole in an electric field – Calculation of energy density due to symmetric charge distributions – Problems solving.

UNIT–IV: **12 hours**

Divergence of the magnetic field - Introduction to magnetic vector potential - Non-existence of magnetic monopoles – Magnetic field due to symmetric current distributions like a solenoid and toroid – Equivalence of current-carrying loop and a magnetic dipole – Motional e.m.f – Eddy currents - Self-induction and mutual induction – Energy stored in a magnetic field – Calculation of magnetic energy density - Lorentz Force and motion of charged particles in electric and magnetic fields - Linear homogeneous isotropic magnetic materials – Ampere's law in material media – Problems solving.

UNIT–V: **12 hours**

Classification of partial differential equations into elliptic, parabolic and hyperbolic equations - Establishing four Maxwell's equations – Derivation of the electromagnetic wave equation from Maxwell's equations - Calculation of speed of light from Maxwell's wave equation - Poynting theorem - Reflection and refraction at a dielectric interface, transmission and reflection coefficients (normal incidence only) – Problems solving.

TEXTBOOKS

1. M. N. O. Sadiku, Elements of Electromagnetics, Oxford University Press
2. D. Halliday, R. Resnick, and J. Walker, Fundamentals of Physics, John Wiley

Supplementary Readings

1. E M. Purcell, Electricity and Magnetism, 1986, McGraw-Hill.
2. D.A. Fleisch, A student's guide to Maxwell's equations, Cambridge University Press

PHYS - 3110 - MODERN PHYSICS AND RELATIVITY (4 Credits - 60 hours)

UNIT–I **12 hours**

Failure of classical concepts: Failure of the classical theory of particles - De Broglie's Hypothesis - Experimental evidence for de Broglie waves - Black body radiation (thermal radiation) – Photoelectric effect – Compton effect - Heisenberg uncertainty relationships - Wave packets - The motion of a wave packet - Probability and randomness - Scattering experiments and the Thomson model - The Rutherford nuclear atom - Electron and x-ray diffraction – Davission-Germer experiment - Energy levels and spectra (line spectra) – The Franck-Hertz experiment - Bohr atom model - Sommerfeld model – Vector atom model – Canonical quantization - Calculation of energy levels for hydrogen atoms and their spectra – Problems solving.

UNIT–II **12 hours**

Fundamentals of Statistics: Discrete and continuous random variables – Discrete and continuous probability distributions - Probability distribution function - Probability density function for (i) uniform, (ii) binomial, (iii) Poisson, and (iv) Gaussian distributions - Calculation of (a) expected values, (b) standard deviation, (c) skewness, (d) kurtosis, (e) higher moments of statistical distributions – Central limit theorem – Law of large numbers - Problems solving.

UNIT–III **12 hours**

Statistical Physics: Different statistical distributions – Maxwell- Boltzmann-statistics - Molecular energies in an ideal gas - Quantum statistics: Fermi-Dirac and Bose-Einstein Statistics - Black body radiation – Rayleigh-Jean's formula – Planck's law and Einstein's approach – Specific heat of solids – Free electron in metals – Problems solving.

UNIT–IV **12 hours**

Wave-particle duality: Heisenberg uncertainty principle - impossibility of a particle following a trajectory - Estimating minimum energy - Energy-time uncertainty principle - Two slit interference experiment with photons, atoms, and particles - Linear superposition principle - Matter waves and wave amplitude - Establishing the Schrödinger equation using conservation of energy – Problems solving.

UNIT–V **12 hours**

Special Theory of Relativity: Constancy of the speed of light. Postulates of the special theory of relativity - Postulates – Lorenz transformations – Time dilation – Length contraction – Doppler effect – Twin paradox – velocity addition – relativistic momentum – Mass energy equivalence – Electricity and magnetism in relativity - Relativistic dynamics and calculation of momentum - Introduction to Minkowski space (spacetime physics) – Problems solving.

Text Books

1. K.S. Krane, Modern Physics, Wiley.
2. Soong, Fundamentals of Probability and Statistics for Engineers, Wiley.
3. Concepts of Modern Physics, Arthur Beiser, McGraw-Hill.
4. Robert Resnick. Special Theory of Relativity. John Wiley.

Supplementary Readings

1. Reif, Fundamentals of Statistical Physics, McGraw Hill.
2. R. Gautreau, W. Savin, Schaum's theory and problems of Modern Physics, McGraw-Hill.
3. Robert Eisberg and Robert Resnick, Quantum Mechanics, Edn., Wiley.
4. Modern Physics, John R. Taylor, Chris D Zafiratos, Michael A Dubson, PHI.
5. Modern Physics, R.A.Serway, C.J. Moses and C.A. Moyer, 2005, Cengage Learning.

PHYS - 3120 - QUANTUM PHYSICS (4 Credits - 60 hours)

UNIT–I: **15 hours**

Postulates of quantum physics - Time-dependent Schrodinger equation - Dynamical evolution of a quantum state - Properties of wavefunction - Probability current density - Physically acceptable wavefunctions - Normalization condition - Linear superposition principle - Eigenvalues and eigenfunctions - Position, momentum, and energy operators - Expectation values - Free particle example - Particle in a 1D and 3D box examples - Concept of degenaracy - Problems solving.

UNIT–II: **15 hours**

Time-independent Schrodinger equation - Stationary states and energy eigenvalues - Expansion of an arbitrary wave function as a linear combination of energy eigenfunctions - Application to the spread of Gaussian wave packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wave function - Introduction to commutators and conjugate variables – Problems solving.

UNIT–III: **15 hours**

General discussion of bound states in an arbitrary potential - Continuity of wave function - Applying boundary conditions - Emergence of discrete energy levels - One-dimensional finite square well potential - Infinite square well (barrier or tunnelling) - Quantum harmonic oscillator - Energy levels and energy eigenfunctions – Problems solving.

UNIT–IV: **15 hours**

Quantum theory of hydrogen atom - Time-independent Schrodinger equation in spherical polar coordinates - Separation of variables - Angular momentum operator - and Hydrogen-like atoms - Quantum numbers - Radial wavefunctions - Orbital angular momentum quantum numbers *l, m, s, p, d* shells – Problems solving.

Textbooks

1. Ajoy Ghatak. Basic Quantum Mechanics, Macmillan.
2. Eisberg and Resnick, Quantum Physics, Wiley.
3. Gasiorowicz, Quantum Physics, Wiley.

Supplementary Readings

1. Liboff, Introductory Quantum Mechanics, Pearson Education.
2. Griffiths, Introduction to Quantum Mechanics, Pearson.
3. Zettili, Quantum Mechanics, Wiley.
4. Quantum Mechanics, Bruce Cameron Reed, Jones, and Bartlett Learning.

PHYS - 3130 - MATERIALS SCIENCE (4 Credits - 60 hours)

UNIT–1: **12 hours**

Phase Rule - Classification of crystalline and amorphous materials - Structure-property relationships – Solubility limit and microstructure - Stability and meta stability - Thermodynamic functions and kinetics of phase transformations - Phase diagrams, Gibb's phase rule - Lever rule - One and two-component solid solutions – Examples of binary phase diagrams – Problems solving.

UNIT–2: **12 hours**

Crystal geometry - Crystal lattice, crystal planes, and Miller indices - unit cells - Typical crystal structures: coordination number, packing fraction. Symmetry elements: rotation, inversion and reflection, basics of point groups and crystal classes, space groups, reciprocal lattice. Crystallography: Diffraction of X-rays by a crystal lattice. Laue's formulation of X-ray diffraction, Laue spots - Rotating crystal – Problems solving.

UNIT–3: **12 hours**

Impurities in solids – Vacancies and interstitials - Point and line defects – Edge and screw dislocations – Planar defects and grain boundaries - Elastic deformation – Ductile and brittle fracture – Plastic deformation Slip – Critical shear stress – Effect of lattice defects on mechanical properties – Stress- strain curve – Yield stress - Youngs modulus, Poisson ratio and hardness of materials - Atomic processes in solids – Diffusion and self-diffusion in solids – Vacancy diffusion – Interstitial diffusion - Concentration gradient - Diffusion constant - Fick's laws (first and second law) of diffusion and its applications – Factors affecting diffusion (like temperature) - Problems solving.

UNIT–4: **12 hours**

Origin of band gap in solids – Classification of metals, insulators, and semiconductors – Electron mobility – Derivation of electrical conductivity of metals based on Drude theory – Drift velocity of electrons in metals – Matthiessen's rule of electrical resistivity – Variation of resistivity with temperature and due to impurities - Forbidden gap – Semiconductor materials (Ge, Si, GaAs) - Effect of temperature on semi-conductivity – Calculation of carrie density of semiconductors using Hall effect – Introduction to compound semiconductors and bandgap engineering – n-type and p-type materials – Majority and minority carriers – Problems solving.

UNIT–5: **12 hours**

Definition of Bohr magneton - Origin of magnetic moment – Magnetic moment of electrons and of atoms – Classification as dia, para, ferro, anti-ferro and ferri magnetic materials – Classical theory of paramagnetism – Derivation of Curie-Weiss law – Langevin theory – Basics of quantum theory of paramagnetism – Lande's *g*-factor – Examples like the salts of transition elements, oxides of rare-earth elements – Molecular field theory of ferromagnetism - Temperature dependence of magnetic susceptibility – Ferromagnetism and ferrimagnetism – Examples with their crystal structures (like cubic ferrites) - Crystalline materials exhibiting ferroelectricity and piezoelectricity – Details of barium titanate structure - Problems solving.

TEXTBOOKS

1. Raghavan, Materials Science and Engineering, Prentice Hall.
2. Callister and Rethwisch. Materials Science and Engineering, Wiley.
3. Hummel, Electronic Properties of Materials, Springer.

Supplementary Readings

1. Moffatt, Pearsall, and Wulff, Structure and Properties of Materials, 4-volume set, Wiley.
2. Cullity and Graham, Introduction to Magnetic Materials, Wiley.
3. Blackmore, Solid State Physics, Cambridge University Press.
4. Srivastava, Elements of Solid State Physics, (PHI).

PHYS - 3200 - Internship (Lab work / Industry / Research Institute) (4 CREDITS)

Choose **ten** experiments from the list below

LIST OF EXPERIMENTS

1. Study of CRO.
2. Transistor characteristics - common emitter.
3. Tuned collector oscillator- Frequency measurement by CRO and Frequency counter.
4. Tuned base oscillator - Frequency measurement by CRO and Frequency counter.
5. JFET characteristics.
6. Emitter follower.
7. Zener diode characteristics - Voltage regulator
8. Phase shift oscillator - Frequency measurement by CRO and Frequency counter.
9. Basic Logic and Universal gates using diodes and transistor components.
10. NAND and NOR as universal gates using ICs
11. Transistor Amplitude modulator and measurement of percentage of modulation.
12. Implementation of logic expression and their simplification
13. Half-adder and full-adder
14. Parity generator/checker
15. Flip-flop circuits using gates
16. Asynchronous counters using ICs
17. Diode AM detection
18. Assembly language programming - microprocessor - addition.

Textbooks

1. Practical Physics C.C Ouseph, V.J. Rao and V. Vijayendran
2. Practical Physics M.N.Srinivasan, (Sultan son Pubs)
3. Jain, Anand Digital electronics Practice Using Integrated Circuits" (Tata McGraw).
4. P Zbar and Malvino, Basic Electronics-A text Lab Manual (Tata McGraw-Hil)
5. Verma, Ahluwalia, Sharma, "Computational Physics, an Introduction" (New Age)

Supplementary Readings

1. Malvino, Electronic principles, 6th Ed. (Tata McGraw-Hill, 1999, New Delhi).
2. Takheim, Digital electronics, 3rd Ed (McGraw-Hill International).

PHYS - 3210 - COMPUTATIONAL PHYSICS (4 Credits - 60 hours)

UNIT–I: **15 hours**

Overview of scientific programming languages like Matlab, Fortran, C++ and Python - Representing numbers in a computer – Floating point arithmetic – Overflow and underflow – Absolute and relative errors - Machine precision (epsilon) – Loss of significance - Robustness of numerical method - Errors in mathematical approximations – Error propagation - Straight line fitting - Least square methods - Fitting to a parabola (least square methods) - Successive approximation method - condition for the convergence order of convergence - Regula-Falsi method - Newton-Rapson method - Criterion for the convergence - Order of convergence - Lagrange polynomial interpolation – Spline interpolation and B-spline interpolation – Problems solving.

UNIT–II: **15 hours**

Taylor series and finite differences – Forward and backward difference tables for first and higher order derivatives – Centered difference and three-point difference formulae - Euler's method for the solution of the ordinary differential equation – Convergence, stability, and error propagation in Euler's method - Runge Kutta methods with Runge's coefficients – Solving differential equations using finite difference method – Problems solving.

UNIT - III **15 hours**

Elementary row operations – Tridiagonal matrices - Symmetric positive definite matrices - Linear systems – Gauss elimination and pivoting - Gauss method to compute the Inverse – LU decomposition – Jacobi and Gauss-Seidel iterative methods to solve linear systems – Eigenvalues and eigenvectors by Jacobi's method – Determination of largest eigenvalue by Power method – Convergence of the above numerical methods – Problems solving.

UNIT - IV **30 hours (Ten 3-hour lab session)**

FORTRAN Programming Practice - Input and output devices - Fortran constants, variables, operators - Writing Fortran expressions - Conditional and unconditional statements - Format and GOTO statements - Programming loops using IF, Do statements - Writing subprograms and subfunctions - Writing working fortran code for finding roots of quadratic equation, area, and volume of geometrical structures, the sum of series, product of *n*-numbers (factorial), calculating the slope of given (x,y) straight line data – Program to solve a ODE by Runge-Kutta method - Program for Gauss-Seidel iteration - Program to solve ODE by Euler method, Program for least-square fitting - Program to find eigenvalues of a matrix - Writing programs (codes) and execution on a computer.

Textbooks

[1] K Atkinson, and W Han. Elementary Numerical Analysis. Wiley, 2003.
[2] E Süli, and D F Mayers. An Introduction to Numerical Analysis. Cambridge University Press.
[3] A C Faul. A Concise Introduction to Numerical Analysis. Chapman, 2016.
[4] Iyengar and Jain. Numerical Methods. New Age, 2009.

Supplementary Readings

[1] I H Hutchinson, A Student's Guide to Numerical Methods. CUP, 2016.
[2] T Sauer, Numerical Analysis, Pearson, 2011.
[3] T Heister, L G Rebholz, and F Xue, Numerical Analysis: An Introduction, De Gruyter, 2019.
[4] R L Burden, J D Faires, Numerical Analysis, Brooks Cole, 2010.

PHYS - 3220 - DIGITAL ELECTRONICS (4 Credits - 60 hours)

UNIT–I: **15 hours**

Digital Principles: Number system, binary arithmetic, Basic gates and universal gate operations. Boolean algebraic theorems and properties-Karnaugh map: two and four variable map, POS and SOP simplification, NAND and NOR implementation, Don't care condition, Logic families: characteristics and parameters. TTL gates, TTL open collector gates, CMOS gates, TTL-CMOS interface. Combinational logic design: parity checker, half and full adders, demultiplexer, multiplexer, decoders, encoders, PAL – Problems solving.

UNIT–II: **15 hours**

Flip Flops and Counters: RS flip-flops, clocked RS flip-flop, edge-triggering. JK flip-flop, D-type flip-flop, JK master slave - Flip-flop design procedure; serial -in - serial out. Serial-in parallel-out shift registers asynchronous counters; decade counter (Mod10 counter); NE 555 timer as astable multivibrator – Problems solving.

UNIT–III: **15 hours**

A/D, D/A Converters: Principle of variable network and binary ladder type: four-bit D/A converter, A/D converter, counter method and successive approximation, resolution and accuracy of and A/D converter; frequency counters and digital voltmeters – Problems solving.

UNIT–IV: **15 hours**

Microprocessors: Components of a microprocessor system, Architecture of 8085, Addressing modes, instruction set. Pin configuration, stack operation, memory stack, and cascade stack, assembly language programming of Intel 8085. Software programs involving addition and subtraction. Simple i/o operations using 8255 ports. An elementary introduction to 16-bit processor – Problems solving.

Textbooks

1. Malvino & Leach, Digital Principles and Applications (Tata McGraw Hill)
2. R.P Jain, Modem Digital Electronics (Tata McGraw-Hill)
3. Morris Mano.M Digital logic and computer design, (Prentice Hall of India)
4. Ramesh S.Gaonkar, Microprocessor Architecture of 8085 (Prentice Hall)

Supplementary Readings

1. Milliman & Halkias, Integrated Electronics(Tata McGraw-Hill)
2. Floyd L. Thomas; Digital fundamentals (Universal Book stall.)
3. Jacob Millman, Microelectronics (McGraw Hill)
4. Badri Ram, Microprocessors and microcomputers, (Dhanpat Rai)

PHYS - 3230 - ATOMIC and MOLECULAR SPECTRA (4 Credits - 60 hours)

UNIT–I: **15 hours**

Atomic and X-ray Spectra: Atomic spectra, Coupling schemes, L-S, J-J couplings, Spectral terms, s,p,d,f, notation, selection rules. Spectra of mono-and di-valent atoms: Doublet fine structure of hydrogen lines; screening constants for monovalent atoms, series limits, doublet structure of alkali spectrum. X-ray spectra: The continuum X-ray spectrum; Duane and Hunt limit—characteristic X-rays; Moseley's law, doublet fine structure, X-ray absorption spectra, absorption edges – Problems solving.

UNIT–II: **15 hours**

Effect of magnetic field on energy levels: Angular momentum and magnetic moment of electron due to orbital motion Gyromagnetic ratios for orbital and spin motions; Bohr magneton, vector model, Lande g factor, Normal and anomalous Zeeman effects - Sodium D-lines – Problems solving.

UNIT–III: **15 hours**

Rotation and Vibration of Molecules: Classification of molecules as various tops, Rotational energy levels of diatomic molecules (no derivation), internuclear distance. Pure rotation spectra; selection rules, isotope effects on rotational energies. Vibrational energy levels, force constants, anharmonicity, dissociation energy, Spectra of diatomic molecules: Vibration-rotation spectra; selection rules, P, Q.and branches. Electronic levels, Raman Effect: Sharing of electrons; formation of molecular orbitals, molecular orbitals in ion, theory of molecule, diatomic molecular orbitals, molecular orbital energy level diagram. Electronic band systems, sequences, and progressions, Franck-Condon principle. Raman effect: Stokes and anti-Stokes lines, quantum theory of Raman effect, selection rules in Raman and IR spectra – Problems solving.

UNIT–IV: **15 hours**

Laser System, Types and Applications: Origin of spectral width, Schalow-Townes limit (only statement), Purity of a spectral line; Coherence: spatial and temporal, Einstein's A and B coefficients; Conditions for laser action; the existence of a metastable state, population inversion by pumping and cavity resonance condition. Ruby Laser, He-Ne Laser, Dye laser; Applications of lasers: Laser communication, Medical applications, and Material processing. Elementary idea of second harmonic generation – Problems solving.

Text Books

[1] H. E. White, Atomic Spectra, McGraw-Hill.
[2] Svanberg, Atomic and Molecular Spectroscopy, Springer.
[3] Rita Kakkar, Atomic and Molecular Spectroscopy, Cambridge University Press.
[4] Mani and Mehta, Introduction to Modern Physics, Affiliated East-West.
[5] Beiser, Perspectives of Modern Physics, McGraw-Hill
[6] Richmeyer, Kennard, Cooper, Introduction to Modern Physics, Tata McGraw Hill.
[7] R B Singh. Introduction to Modern Physics. New Age.

Suggested Readings

[1] Taylor and Zafiratos, Modern Physics, PHI Learning.
[2] Serway, Moses, and Moyer, Modern Physics, Cengage Learning.
[3] Kaur and Pickrell, Modern Physics, McGraw Hill.
[4] Banwell and Mccash, Fundamentals for Molecular Spectroscopy, McGraw Hill

PHYS - 3240 - ELEMENTS OF NUCLEAR PHYSICS (4 Credits - 60 hours)

UNIT–I: **15 hours**

General Properties of Nuclei: Constituents of the nucleus and their Intrinsic properties, quantitative facts about size, mass, charge density (matter-energy), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states – Problems solving.

UNIT–II: **15 hours**

Nuclear Models: Liquid drop model approach, semi-empirical mass formula and significance of various terms, condition of nuclear stability. Two nucleon separation energies, the Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers - Basic assumption of the shell model, the concept of mean-field, residual interaction, the concept of nuclear force – Problems solving.

UNIT–III: **15 hours**

Radioactivity decay:(a) Alpha decay: basics of -decay processes, theory of - emission, Gamow factor, Geiger Nuttall law, -decay spectroscopy. (b) -decay: energy kinematics for -decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering) – Problems solving.

UNIT–IV: **15 hours**

Particle physics: Particle interactions; basic features, types of particles, and their families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, the concept of quark model, color quantum number, and gluons – Problems solving.

Textbooks

1. Introductory Nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008)
2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998)
3. Introduction to Elementary Particles, D. Griffith, John Wiley & Sons

Supplementary Readings

1. Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia)
2. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
3. Basic ideas and concepts in Nuclear Physics by K. Heyde
4. Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
5. Theoretical Nuclear Physics, J.M. Blatt &V.F.Weisskopf (Dover Pub.Inc., 1991)

PART - IX

DETAILED SYLLABUS

OF

MINOR PAPERS

Offered by Physics Departments of the Affiliated Colleges

For Mathematics / Chemistry / other Science Students

PHYS - 1111 - CONCEPTS IN MECHANICS (4 Credits - 60 hours)

UNIT–I **(12 hours)**

Classification of differential equations as linear, nonlinear, homogeneous, inhomogeneous and coupled equations - Distinction between initial value and boundary value problems - Method of integrating factor – Method of separation of variables – Second order differential equations – Solving Homogeneous and inhomogeneous equations with variable coefficients - Wronskian and principle of superposition - Method of undetermined coefficients - Method of variation of parameters - Applications to electrical and mechanical vibrations and forced oscillations - Problems solving.

UNIT–II **12 hours**

Harmonic oscillations - Calculation of kinetic energy, potential energy, total energy, and their time-average values - Damped and Forced oscillations – Solution to damped and forced oscillators - Transient states and steady states – Resonance and sharpness of resonance - Logarithmic decrement, Relaxation time, Quality factor - Power dissipation - Rate of Work done - Examples of electrical (vibration) systems like LCR resonance – Problems solving.

UNIT–III **12 hours**

Gradient, divergence, and curl of a vector - Velocity and acceleration in cartesian and polar coordinates - Addition of forces - Polygon of forces - Condition for the equilibrium of a particle under several forces – Lami's theorem and problems based on it - Forces along and perpendicular to the inclined plane - Limiting equilibrium (about to slide) of a particle kept on an inclined plane – Friction laws (static and dynamic) – Calculation of acceleration of sliding objects down an inclined plane – Moment of a force – Conditions for the equilibrium of a rigid body – Resultant of forces – Three parallel forces acting at the vertices of a triangle – Three forces acting along the sides of a triangle – Defining couple and moment of a couple – Resultant of several coplanar forces – Problems solving.

UNIT–IV **12 hours**

Degrees of freedom of a rigid body - Relation between angular momentum, angular velocity, and moment of inertia - Fixed axis rotations - Parallel and perpendicular axes theorem - Definition of pure rolling - Inclined plane with rolling - Pure rolling of symmetrical bodies - Angular momentum of a rigid body - Uniformly rotating frame - centrifugal and Coriolis forces - Calculation of moments of inertia of (i) a circular ring, (ii) circular lamina, (iii) solid sphere, (iv) spherical shell - Calculation of center of mass of objects like an arc of a circle, a rectangle with a cavity, triangle, and similar objects - Center of mass of a system of particles - Problems solving.

UNIT–V **12 hours**

Newton's law of Gravitation - Kepler's Laws - Two-body problem and reduced mass concept - Equation of motion in plane polar coordinates for the Kepler problem - Turning points in potential energy curve - Derivation of equation of circular and elliptic orbits - Escape velocity - Calculation of gravitational potential inside and outside of (i) a spherical shell, (ii) a solid sphere - Work energy theorem - Conservative force - Conservation laws for systems of particles – Derivation of potential energy of a multi-particle system - Calculation of gravitational self energy of a sphere - Problems solving.

Text Books

1. Boyce and Diprima, Elementary Differential Equations, Wiley.
2. H. J. Pain. The Physics of Vibrations and Waves, John Wiley, (2005), 6th Edition.
3. I. G. Main. Vibrations and Waves in Physics, Cambridge University Press, 1993.
4. P Duraipandian and M Jayapragasam. Mechanics, S. Chand.

Supplementary Readings

1. David Morin. Introduction to Classical Mechanics. Cambridge University Press.
2. Resnick, Halliday, and Walker. Fundamentals of Physics. Wiley.
3. N. K. Bajaj. Waves and Oscillations. Tata McGraw Hill.

PHYS - 1211 - CONCEPTS IN ELECTROMAGNETISM (4 Credits - 60 hours)

UNIT–I **12 hours**

Kirchoff's laws - Bridge networks – Y to Delta and Delta to Y conversion – Superposition theorem – Thevenin's theorem – Millman's theorem – Substitution theorem – Reciprocity theorem - Series LCR resonant circuit – Q-factor – Variation of impedance with frequency – Selectivity of a series resonant circuit – Parallel LCR resonant circuit – Q-factor - Capacitor networks – Resistor-inductor (RL) transients – Average and effective values of alternating waveform – Response of basic R, L, and C elements to a sinusoidal signal – Voltage divider rule for a.c circuits – Problems solving.

UNIT–II **12 hours**

Classification of Conductors, insulators, and semiconductors based on energy band diagram - Intrinsic and extrinsic semiconductors. P-type and N-type semiconductors. Formation of PN junction diode - Forward and reverse characteristics - Diode resistance-Effect of temperature on extrinsic semiconductors, halfwave, Centre tap, and Bridge rectifiers, Expression for average DC voltages, qualitative ideas of filters, clipping and clamping circuits-their general applications. Zener diode - Current-voltage characteristics - Problems solving.

UNIT–III **12 hours**

Divergence, curl, gradient operators, and vector identities - Vector integration, line, surface, and volume integrals of vector fields – Gauss divergence theorem and Stoke's theorem of vectors and their significances - Electric field due to an infinitely long line charge, a sheet of charge, a ring of charge, a charged disk, an electric dipole, and other charge distributions – Derivation of Gauss's law from Coulomb's law – Application to symmetric charge distributions like an infinite sheet of charge, uniformly charged sphere (solid and shell), cylinder, and similar objects. – Electric dipole in an electric field - Discontinuity of electric field on the surface of a conductor – Problems solving.

UNIT–IV **12 hours**

Discontinuity of electric field on the surface of a conductor – Convection and conduction current and deriving Ohms law $J = \sigma E$ – Continuity equation and relaxation time - Dielectric polarization – Definition of electric polarization – Dielectric breakdown – Electric susceptibility and permittivity - Gauss's law in the presence of linear dielectrics –Capacitors with dielectrics - Calculating the capacitance (in presence of dielectrics) of a parallel plate capacitor, a cylindrical capacitor, a spherical capacitor, coaxial cylindrical capacitor, concentric spherical capacitor and for an isolated spherical capacitor - Bound charges, Displacement density vector - Problems solving.

UNIT–V **12 hours**

Divergence of the magnetic field - Introduction to magnetic vector potential - Non-existence of magnetic monopoles – Magnetic field due to symmetric current distributions like a solenoid and toroid – Equivalence of current-carrying loop and a magnetic dipole – Motional e.m.f – Eddy currents - Self-induction and mutual induction – Energy stored in a magnetic field – Calculation of magnetic energy density - Lorentz Force and motion of charged particles in electric and magnetic fields - Linear homogeneous isotropic magnetic materials – Ampere's law in material media – Problems solving.

Textbooks

1. Boylsted and Nashelsky, Electronic Devices and Circuits, Pearson, 2009.
2. Robert L. Boylestad, Introductory Circuit Analysis, Prentice-Hall.
3. M. N. O. Sadiku, Elements of Electromagnetics, Oxford University Press

Supplementary Readings

1. Alexander and M. N. O. Sadiku, Fundamentals of Electric Circuits, McGraw Hill.
2. D. Halliday, R. Resnick, and J. Walker, Fundamentals of Physics, John Wiley.

PHYS - 2101 - MINOR PHYSICS LABORATORY (3 CREDITS)

Choose **seven experiments** from the list**.**

LIST OF EXPERIMENTS

1. Young's modulus - Non-Uniform bending - Pin & Microscope
2. Rigidity modulus - Torsional oscillations without masses.
3. Comparison of coefficient of viscosity.
4. Surface tension of a liquid and interfacial surface tension by drop weight method.
5. Spectrometer - Refractive index of a liquid - Hollow prism.
6. Spectrometer - Grating - N determination by normal incidence method.
7. Spectrometer - Grating-wavelength determination by minimum deviation method.
8. Newton's Rings.
9. Thermal conductivity of a bad conductor - Lee's disc method
10. Post office box - Laws of resistance and specific resistance.
11. Melde's apparatus - Determination of frequency.
12. Meter Bridge - Temperature coefficient of the material of a coil of wire
13. Potentiometer - Calibration of low range voltmeter .
14. Potentiometer - Calibration of ammeter (0-1.5 amps).
15. Figure of merit of a periodic moving coil galvanometer.
16. Field along the axis of the circular coil carrying current - Determination of magnetic field
17. Newton's law of cooling and specific heat determination
18. Frequency measurement by forming Lissajous figures
19. Study of half-wave rectifiers.
20. Transistor characteristics - CE mode - only transfer characteristics.

Textbooks

1. Ouseph and V. Srinivasan, Practical Physics- Part-I &II.

Supplementary Readings

1. Mathchan Lazarus and others- Practical Physics.

PART - X

DETAILED SYLLABUS

OF

MULTI-DISCIPLINARY PAPERS

Offered by Physics Departments of the Affiliated Colleges

For Arts / Commerce / other Social Science Students

PHYS - 1115 - Electronics in Everyday Life (3 credits - 45 hours)

This course aims to introduce a non-specialist student to the world of digital and smart devices the nanoscience and nanotechnology behind it, all covering the following topics (45 Lectures Total).

- Binary system of numbers.
- Difference between analog and digital systems of electronics.
- Concepts of memory (bits, bytes, speed).
- Different digital devices: desktops, tablets, laptops, flash drives, printers, scanners (components operation and communication).
- Introduction to sensors.
- Smart devices: Touch and voice-enabled devices (such as phones, tablets, ATMs, etc.).
- Technologies of inter-device communication.
- Innovative applications, societal impact, and barriers to implementation.
- Future electronic devices.
- Introduction to nanoscience and nanotechnology

* * * The End * * *