PONDICHERRY UNIVERSITY

Department of Physics – Integrated M.Sc (Physics) Program

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PHYS. 130: PHYSICS LABORATORY (2 CREDITS)

1. Young's modulus –Cantilever
2. Young's modulus –Non-uniform bending
3. Young's modulus –Uniform bending
4. Young's modulus- Single Optic lever
5. Study of damping of a bar pendulum under various kinds of damping mechanisms.
6. Study of laws of parallel and perpendicular axes for estimation of moment of inertia.
7. Study of torsion of a wire; dependence on radius, length, torque and material (static method)
8. Study of torsion of a wire or fiber; dynamic method
9. Study of flow of liquids through capillaries; laminar and turbulent flow stages, capillaries.
10. Study of surface tension of a liquid by three different methods.
11. Comparison of Viscosities
12. Simple Pendulum
13. Viscosity of Liquid(η)
14. Moment of Inertia- Fly Wheel

Text Books

1. D.P. Khandelwal, A laboratory Manual of Physics for Undergraduate Classes, (Vani Publishing House, New Delhi)
2. B. Saraf et.al., Physics through experiments, (Vikas publishing house)
3. V Y Rajopadhye and V L Purohit; Text book of experimental Physics

PHYS-131: MECHANICS **3-0-0-3**

UNIT – I: Motion in 1D and 2D **8 hours**

Basic concepts and definitions in Mechanics – Newton's laws – Conservation laws – Relative motion – Condition for equilibrium – Lami's theorem – Resolution of forces – Nature or types of forces – Freely falling body – Linear harmonic oscillator – Damped oscillator – Motion of a projectile – Simple pendulum – Validity for small oscillations – Curvilinear motion in Polar co-ordinates – Analytical problems solving.

UNIT – II: Central forces **8 hours**

Force and acceleration – Kepler problem – Inverse square law – Turning points in potential energy curve – Equation of orbits – Circular orbit – Elliptic orbit – Escape velocity – Application to geostationary satellites – Analytical problems solving.

UNIT – III: Particles under Friction **5 hours**

Basic concepts – Static friction – Kinetic friction – Climbing on ladder – Banking of curves – Application of Newtons laws – Analytical problems solving.

UNIT – IV: Systems of Particles **10 hours**

Basic concepts – Concept of center of mass – Calculation of center of mass of certain geometrical objects like an arc of a circle, rectangle, triangle, solid hemisphere, solid cone and similar simple objects – Conservation laws for a system of particles – Variable mass problems – Analytical problems solving.

UNIT – V: Mechanics of Rigid bodies **10 hours**

Definition of moment of inertia – Calculation of moment of inertia of simple objects like a triangle about different axes, a cone and similar objects – Angular momentum of a rigid body – Observables in terms of moment of inertia – Ballistic pendulum – Definition of pure rolling – Problems involving rolling down of simple objects – Analytical problems solving.

UNIT – VI: Collisions **8 hours**

Meaning of collision – Elastic and inelastic collisions – Conservation laws in elastic and inelastic collisions – Introduction to laboratory and center-of-mass coordinate systems – Relationship between laboratory and center-of-mass systems – Analytical problems solving.

Textbooks

1. Daniel Kleppner, Robert Kolenkow (1973). *An Introduction to Mechanics*. McGraw Hill.
2. M. R. Spiegel. *Schaum's Outline of Theoretical Mechanics*. McGraw Hill.

Supplementary Reading

1. David Halliday, Robert Resnick and Jearl Walker (2004) *Fundamentals of Physics*. 7th edition. John Wiley & Sons.
2. Fowles Cassiday (2004). *Analytical Mechanics.* 7th Edition. Thomson Brooks/Cole.
3. Y. R. Waghmare (1990) *Classical Mechanics*. Prentice Hall of India, New Delhi.
4. John R. Taylor (2005). *Classical Mechanics*. University Science Books.
5. Keith R. Symon (1971). Mechanics (3rd Edition). Addison-Wesley.
6. A. P. French (1971). *Newtonian Mechanics (M.I.T. Introductory Physics Series)*. Norton Publishing.

PHYS-140: PHYSICS LABORATORY (2 CREDITS)

1. Thermal conduction in poor conductor; temperature distribution using thermocouples in cases of linear geometry (sheets or slabs), cylindrical geometry, spherical geometry.
2. Study of different thermocouples for temperature measurements
3. Young's modulus –Koening's method (Non-uniform bending)
4. Studying the fall of solids through liquid.
5. Joules Calorimeter
6. Latent Heat of fusion of Ice method of mixture
7. Specefic heat of bad conductor method of mixture
8. Specefic heat of Liquid method of mixture
9. Young's modulus –Uniform bending using a Single optic lever
10. Rigidity modulus-Static torsion method
11. Study of the impedance of an inductor at varying frequencies to measure R and L
12. Study of the impedance of a capacitor of varying frequencies to measure C
13. Response curve for LCR circuits series resonances
14. Using an AC bridge to measure L or C
15. Potentiometer for precision measurement of thermo-emf or low resistance

Text Books

1. D.P. Khandelwal, A laboratory Manual of Physics for Undergraduate Classes, (Vani Publishing House, New Delhi)
2. B. Saraf et.al., Physics through experiments, (Vikas publishing house)
3. V Y Rajopadhye and V L Purohit; Text book of experimental Physics

PHYS-141: THERMAL PHYSICS AND KINETIC THEORY **3-0-0-3**

UNIT – I: **10 hours**

Thermodynamics as phenomenological science – Thermodynamic systems – Closed, open, isolated systems – Thermodynamic processes – Adiabatic, isothermal, isochoric, isobaric, isentropic, cyclical and free expansion processes – Reversible, irreversible and Quasi-static processes – Equation of state – Intensive and extensive variables – The *P-V* diagram – Path and Point functions – Thermal equilibrium and zeroth law of thermodynamics – Measuring temperature – Triple point of water as reference – Thermal expansion – Linear and volume expansion coefficients – Isothermal compressibility – Relations between partial derivatives – Exact differentials – Internal energy function – Mathematical formulation of first law – Differential form of first law – Heat flow and its path dependence – Problems solving.

UNIT – II: **10 hours**

Conversion of work into heat and vice-versa – Efficiency – Kelvin-Planck statement of the second law of thermodynamics – Clausius statement of the second law – Carnot cycle – Carnot refrigerator – Carnot's theorem and corollary – Thermodynamic temperature scale – Absolute zero and Carnot efficiency – Derivation of Clausius' theorem – *P-V, P-T* and *T-S* diagrams for a pure substance – Problems solving.

UNIT – III: **12 hours**

Equation of state of a gas from Avogadro's law – Ideal gas equation – Specific heat, internal energy and enthalpy of an ideal gas – Entropy change of an ideal gas – Reversible adiabatic process – Reversible isothermal process – van der Waals equation of state – Virial expansions and coefficients – Law of corresponding states – Dalton's law of partial pressures – Internal energy, enthalpy and specific heats of gas mixtures – Entropy of gas mixtures – Maxwell's thermodynamic relations – Derivation of *TDS* equations – Derivation of difference in heat capacities and ratio of heat capacities – Problems solving.

UNIT – IV: **13 hours**

Concept of entropy – Entropy of an ideal gas – The *T-S* diagram – Entropy, reversibility and irreversibility – Conditions for irreversibility – Irreversible part of the second law – Inequalities of Clausius – Entropy in irreversible processes – Entropy and disorder – Application of the entropy principle – Problems solving.

UNIT – V: **13 hours**

Kinetic theory – Basic assumptions – Molecular flux – Derivation of a equation of state, internal energy and pressure for a monoatomic ideal gas from kinetic theory of gases – The principle of equipartition of energy – Distribution of molecular speeds – Maxwell-Boltzmann distribution – Intermolecular forces – Hard sphere model – Collision cross section – Derivation of coefficient of viscosity, thermal conductivity and coefficient of self-diffusion of a gas using kinetic theory – Problems solving.

Textbooks

1. Units – 1 to IV: M. W. Zemansky and R. H. Dittman (1997). *Heat and Thermodynamics*. 7th edition. McGraw Hill.
2. Unit–V: F. W. Sears and G. L. Salinger (1990). *Thermodynamics, Kinetic Theory and Statistical Thermodynamics*. 3rd edition. Narosa.

Supplementary Reading

1. David Halliday, Robert Resnick and Jearl Walker (2004) *Fundamentals of Physics*. 7th edition. John Wiley & Sons.
2. Paul A. Tipler and Gene Mosca (2007). *Physics for Scientists and Engineers* (Extended version). W. H. Freeman and Company.

PHYS-230: PHYSICS LABORATORY **(2 CREDITS)**

1. Study of a harmonic oscillation and its relaxation; rigid pendulum or torsional oscillations
2. Oscillations on a bifilar suspension
3. Study of transverse wave speed on a string; dependence on density and tension (sonometer)
4. Melde's experiment using cotton thread.
5. Melde's experiment using metallic string.
6. Study of magnetic field using a vibration magnetometer
7. Potentiometer-calibration of ammeter / voltmeter.
8. Potentiometer – Normalized calibration of ammeter / voltmeter.
9. Analyzing a given wave-form for its harmonic components; (a computer may be used)
10. Study of characteristics of ballistic galvanometer
11. Study of magnetic field using a vibration magnetometer
12. Study of the rise and decay of current in RC circuit
13. Study of the rise and decay of current RL circuits

Text Books

1. D.P. Khandelwal, A laboratory Manual of Physics for Undergraduate Classes, (Vani Publishing House, New Delhi)
2. B. Saraf et.al., Physics through experiments, (Vikas publishing house)
3. V Y Rajopadhye and V L Purohit; Text book of experimental Physics

PHYS-231: PHYSICS OF WAVES and CONTINUOUS MEDIA **3-0-0-3**

Unit I: Simple Harmonic Motion **10 hours**

Simple harmonic motion – Velocity and acceleration in SHM – Energy of a simple harmonic oscillator – Examples of simple harmonic oscillators in electrical systems – Superposition of two simple harmonic vibrations in one dimension – Superposition of two perpendicular simple harmonic vibrations – Superposition of a large number of simple harmonic vibrations of equal amplitude and uniform phase difference – Damped harmonic oscillation – Forced oscillator – Introduction to coupled oscillations.

Unit II: Transverse and Longitudinal Waves **12 hours**

Introduction to transverse waves – Velocities in wave motion – The transverse wave equation – Solution of the transverse wave equation – Standing waves on a string of fixed length – Energy of a vibrating string – Standing wave ratio – Wave groups and group velocity – Doppler effect – Examples of waves in optical systems – Introduction to longitudinal waves – Sound waves in gases – Energy distribution in sound waves – Intensity of sound waves – Longitudinal waves in a solid - Example of earthquake – Reflection and transmission of sound waves at boundaries – Noise and music – Limits of human audibility – The decibel unit – Diffraction of sound waves – Introduction to acoustic transducers – Acoustics of auditoriums and halls – Reverberation time.

Unit III: Waves in more than one dimension **12 hours**

Plane wave representation in two and three dimensions – Wave equation in two dimensions – Solution by method of separation of variables – Introduction to 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 IV: Continuous Media **20 hours**

Solids as continuous media – Elastic properties of solids – Elastic constants and their inter-relation – Torsion of a cylinder – Bending of beams – Fluids as continuous media – Flow properties of liquids – Flow of ideal liquids – Bernoulli's theorem – Flow of real liquids – Viscosity – Newtonian and non-Newtonian fluids – Reynolds number – Streamline and turbulent flows – Stoke's law – Surface energy and surface tension.

Textbooks

1. (Units – 1, II, III): H. J. Pain (2005). *The Physics of Vibrations and Waves*. 6th Edition. John Wiley.
2. (Units – IV): D. S. Mathur (2005). *Elements of Properties of Matter*. 11th edition. S. Chand & Co.

Supplementary reading

1. David Halliday, Robert Resnick and Jearl Walker (2004) *Fundamentals of Physics*. 7th edition. John Wiley & Sons.
2. Berkeley Physics Course: *Volume-III: Waves*. McGraw Hill (1969).
3. A.P. French (1971). *Vibrations and Waves* (M.I.T Introductory Physics Series). CRC Press.
4. Lawrence E. Kinsler, Austin R. Frey, Alan B. Coppens, James V. Sanders (2000). *Fundamentals of Acoustics*. John Wiley.
5. Richard P. Feynman, Robert B. Leighton, Matthew Sands (2005). *The Feynman Lectures on Physics: The Definitive and Extended Edition*. Addison-Wesley, 2nd edition.
6. F. H. Newman and V. H. L. Searle (1961) *The General Properties of Matter*. Edward Arnold.
7. B. H. Flowers (1970). *Properties of Matter*. John Wiley.

PHYS-232: ELECTRICITY AND MAGNETISM **3-0-0-3**

UNIT – I: Electrostatics **11 hours**

Review of vector calculus – Divergence, Curl and Gradient operators – Vector identities – Coulomb's law – Electric flux and flux density – Discrete and continuous charge distributions – Electric field due to discrete and continuous charge distributions – Calculation of electric field due to the following: an infinitely long line charge, a sheet of charge, a ring of charge, a charged disk – Electric field due to an electric dipole – Gauss's law – Applications of Gauss's law for the following symmetric charge distributions: Point charge, Infinite line charge, Infinite sheet of charge, Uniformly charged sphere (solid and shell) and cylinder – Electric dipole in an electric field – Torque – Motion of point charges in electric fields – Problems solving.

UNIT – II: Work and energy in electrostatics **11 hours**

Work and energy in electrostatic systems – Electric potential – Definition of potential difference and potential – Calculating the potential from the field and vice-versa – Potential inside and outside of a spherical shell of charge – Equipotential lines and surfaces – Energy expended in moving a point charge in an electric field – Calculation of 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 – III: Conductors, Dielectrics and Capacitors **13 hours**

Properties of conductors – Discontinuity of electric field on the surface of a conductor – Electric current density – Derivation of drift velocity, Ohm's law – Microscopic view of Ohm's law – Derivation of resistivity, resistance and power in a current carrying conductor – Nature of dielectric materials – Definition of electric polarization – Dielectric breakdown – Capacitors – Calculating the capacitance of a parallel plate capacitor, a cylindrical capacitor, a spherical capacitor, coaxial cylindrical capacitor, concentric spherical capacitor and for an isolated spherical capacitor – Capacitor with a dielectric – Gauss's law in presence of linear dielectrics – Capacitance of a two-wire line – Problems solving.

UNIT – IV: Magnetic fields **13 hours**

Biot-Savart's law – Motion of charged particles in magnetic fields – Circulating charged particle and helical paths – Magnetic force on a current carrying wire – Torque on a current loop – Magnetic dipole moment of a magnetic dipole – Calculation of magnetic field due the following: a long straight wire, a circular arc of wire – Force between two parallel currents – Non-existence of magnetic monopoles – Ampere's law – Applications of Ampere's law to calculate magnetic field due to following symmetric current distributions: a long straight current carrying wire, a solenoid and toroid – Equivalence of current carrying loop and a magnetic dipole – Faraday's law of induction – Lenz's law – Induction and energy transfers – Motional e.m.f – Eddy currents – Inductance of a solenoid – Self induction of a coil – Mutual induction – Energy stored in a magnetic field – Calculation of magnetic energy density – Problems solving.

UNIT – V: Maxwell's equations **8 hours**

Introduction to Maxwell's equation in vacuum and in material media – Derivation of electromagnetic wave equation from Maxwell's equations.

Textbook

1. David Halliday, Robert Resnick and Jearl Walker (2004) *Fundamentals of Physics*. 7th edition. John Wiley & Sons.

Supplementary reading

1. Paul A. Tipler and Gene Mosca (2007). *Physics for Scientists and Engineers* (Extended version). W. H. Freeman and Company.
   Matthew N. O. Sadiku. *Elements of Electromagnetics*. 3rd edition. Oxford University Press (2002).

PHYS-240: PHYSICS LABORATORY (2 CREDITS)

ELECTRONICS

1. Construction of a stabilized power supply (using diode)
2. P-N characteristics (forward & reverse)
3. Zener as a voltage regulator
4. N-P-N , P-N-P characteristics
5. Single stage amplifier (voltage gain)
6. Op-amp characteristics
7. Logic gates (OR, AND, NAND, NOR, Truth table)

OPTICS

1. Determination of Wavelength for first order spectra (using minimum deviation method)
2. Dispersive power of material and linear dispersion in prism spectrum using a graticule in the eyepiece
3. Study of interference fringes in biprism arrangement
4. Use of Newton's rings to determine the radii of curvature of surface
5. Use of fringes in a wedge film (to compare the thickness of different sheets of paper or tissues or hair or diameter of a wire)
6. Fresnel diffraction at straight edge and a slit
7. Fraunhofer diffraction at a single slit
8. Minimum deviation setting and first order spectrum for two wavelengths

Text Books

1. D.P. Khandelwal, A laboratory Manual of Physics for Undergraduate Classes, (Vani Publishing House, New Delhi)
2. B. Saraf et.al., Physics through experiments, (Vikas publishing house)
3. V Y Rajopadhye and V L Purohit; Text book of experimental Physics

PHYS-241: MODERN PHYSICS – I **3-0-0-3**

Unit-I: Dual nature **10 hours**

EM waves – Black body radiation – Photoelectric effect – X-rays – Diffraction of x-rays– Compton effect – de Broglie waves – Phase and group velocities – Electron diffraction – Uncertainty principle – Problems solving.

Unit-II : Atomic structure **10 hours**

Electron orbits – Atomic spectra – Bohr atom – Energy levels and spectra – Sommerfeld model – Vector atom model – Canonical quantization – Problems solving.

Unit-III : Quantum mechanics **12 hours**

Wave equation – Schrödinger equation – Operators – Postulates of quantum mechanics – Particle in a box – Finite potential well – Introduction to quantum tunneling – Harmonic oscillator – Problems solving.

Unit-IV: Hydrogen atom **12 hours**

Schrödinger equation – Separation of variable – Quantum numbers – Quantization of energy – Angular momentum – Electron Probability density – Radiative transition – Selection rules – Zeeman effect – Spin of the electron.

Unit-V: Atoms and Molecules **12 hours**

Hund's rules – Pauli's exclusion principle – Periodic table – Spin-orbit coupling – Total angular momentum – Molecular bond – Hydrogen molecule – Rotational energy levels – Vibrational energy levels – Electron spectra of molecules.

Textbook

1. Arthur Beiser (2002). *Concepts of Modern Physics*. 6th edition. Tata McGraw Hill.

Supplementary reading

1. H. S. Mani and G. K. Metha (1988). *Introduction to Modern Physics*. Affiliated East-West Press.
2. David Halliday, Robert Resnick and Jearl Walker (2004) *Fundamentals of Physics*. 7th edition. John Wiley & Sons.
3. Paul A. Tipler and Gene Mosca (2007). *Physics for Scientists and Engineers* (Extended version). W. H. Freeman and Company.
4. F. K. Richtmyer, E. H. Kennard and J. N. Cooper. *Introduction to Modern Physics*. 6th edition. Tata McGraw Hill (1976).
5. M. R. Wehr, J. A. Richards Jr and T. W. Adair. *Physics of the atom*. 4th edition. Narosa Publishing House (1985).

PH – 242: ELECTRIC CIRCUITS THEORY **3-0-0-3**

UNIT – I: Series-Parallel Networks **10 hours**

Review of current electricity – Kirchhoff's laws – Ladder networks – Current sources – Conversion of current source to voltage source – Current sources in series and parallel – Mesh analysis – Nodal analysis – Bridge networks – Y to Δ and Δ to Y conversion – Problems solving.

UNIT – II: Network Theorems **8 hours**

Superposition theorem – Thevenin's theorem – Norton's theorem – Maximum power transfer theorem – Millman's theorem – Substitution theorem – Reciprocity theorem – Problems solving.

UNIT – III: Capacitative, Inductive and Magnetic Circuits **10 hours**

Transients in capacitative networks – Time constant – Capacitor networks – Energy relations – Introduction to Magnetic circuit – Reluctance – Series and parallel magnetic circuits – Analogy between electromotive force (e.m.f) and magnetomotive force (m.m.f) – Inductors – resistor-inductor (RL) transients – Time constant – Problems solving.

UNIT – IV: AC circuits **10 hours**

Introduction to a.c waveforms – Definition of terminology – Average and effective values – Introduction to phasor notation – Response of basic R, L and C elements to a sinusoidal signal – Frequency response – Power factor – Series and parallel a.c circuits – Impedance and phase diagram – Voltage divider rule for a.c circuits – Current divider rule for a.c circuits – Power in a.c circuits – The power triangle – Problems solving.

UNIT –V: Resonance **10 hours**

Introduction to resonance – Series *LCR* resonant circuit – *Q*-factor – Variation of impedance with frequency – Selectivity of a series resonant circuit – Parallel *LCR* resonant circuit – *Q*-factor – Selectivity curves – Application to tuned filters – Bode plots – Problems solving.

Textbook

1. Robert L. Boylestad (2006). *Introductory Circuit Analysis.* 11th edition. Prentice Hall.

Supplementary reading

1. Charles Alexander and Matthew Sadiku (2006). Fundamentals of Electric Circuits, 3rd Edition. McGraw Hill.
2. Thomas L. Floyd (2006). Electric Circuit Fundamentals (7th Edition). Prentice Hall.

PHYS-330: PHYSICS LABORATORY **(2 CREDITS)**

1. Measurement of Milliken's method
2. Determination of e/m by Thompson's method
3. Determination of Plank's constant
4. Constant deviation prism
5. Obtaining B-H curve for a ferromagnetic sample (any method)
6. Magnetic susceptibility of (say) ferric chloride solution and deducing magnetic moment of the ion
7. Magnetic susceptibility of Solids (Guoy method)
8. Hall probe in magnetic field measurement
9. Magnetic circuits –Determination of magnetic flux of electromagnet

Text Books

1. D.P. Khandelwal, A laboratory Manual of Physics for Undergraduate Classes, (Vani Publishing House, New Delhi)
2. B. Saraf et.al., Physics through experiments, (Vikas publishing house)
3. V Y Rajopadhye and V L Purohit; Text book of experimental Physics
4. Olon; Experiments in Modern physics

PHYS-331: CLASSICAL OPTICS **3-0-0-3**

UNIT – I: GEOMETRICAL OPTICS

Fermat's principle: Principle of extreme path: the aplanatic points of a sphere and other applications - General theory of image formation: Cardinal points of an optical system; general relationships, thick lens and lens combinations, telephoto lenses. Aberration in images: chromatic aberrations; achromatic combination of lenses in contact and separated lenses. Monochromatic aberrations and their reduction; aspherical mirrors and Schmidt corrector plates, oil immersion objectives, meniscus lenses. Optical instruments: Entrance and exit pupils, need for a multiple lens eyepiece, common type of eyepieces.

UNIT – II: INTERFERENCE

Interference of light: The principle of superposition; two-slit interference, coherence requirements for the sources, localized fringes in thin films, transition from fringes of equal thickness to those of equal inclination - Michelson interferometer; its uses for determination of wavelength, wavelength difference and standardization of the meter. Intensity distribution in multiple beam interference; Tolansky fringes, Fabry-Perot interferometer and etalon.

UNIT – III: DIFFRACTION

Fresnel diffraction: Half-period zones, circular apertures and obstacles, straight edge, explanation of rectilinear propagation. Cornu Spiral and its applications Babinet's Principle - Fraunhofer diffraction: Diffraction at a slit, a circular aperture and a circular disc. Resolution of images; Rayleigh criterion, resolving power of a telescope and a microscope - Diffraction grating: Diffraction at N parallel slits; plane diffraction grating, concave grating, resolving power of gratings and prisms.

Textbooks

1. A K Ghatak "Optics" 3rd Edition Tata McGraw Hill
2. E Hecht "Optics" 3rd Edition Addison Wesley
3. F L Pedrotti and L S Pedrotti "Introduction to Optics" 2nd Edition Prentice Hall International
4. K K Sharma "Optics" Elsevier

Reference Books

1. R P Feynman, R B Leighton, M Sands: "The Feynman Lectures on Physics" Vol 1. Narosa publishing house
2. Born and Wolf; "Optics" (Pergamon Press)
3. K D Meller, "Optics" (Oxford University Press)
4. Jenkins and White; "Fundamental of Optics" (McGraw-Hill)
5. B B Laud "Lasers and Non-linear Optics" (Wiley Eastern, 1985)
6. R S Longhurst "Geometrical and Physical Optics" (Longmans, 1966)

PHYS-332: ELECTRONIC DEVICES and CIRCUITS **3-0-0-3**

Unit I: Semiconductor Diodes **8 hours**

Basis of Semiconductor Physics: Semiconductor diodes: p-n junction diode, I-V characteristics, Schockley model, application in rectifiers, clippers and limiters, Zener diode and its applications, optoelectronic diodes: LED, photodiodes, optocouplers.

Unit II: Transistor Characteristics **8 hours**

Bipolar junction transistors (BJT): pnp and npn structures; active and saturation regions, characteristics of BJT, common-emitter configuration, input and output characteristics, B-parameter, common-base configuration, output characteristics, Common-collector configuration.

Unit III: Transistor- low frequencies & Biasing and Stabilization **8 hours**

Two-port analysis of a transistor, Transistor hybrid model-definition of h-parameters- Analysis of a Transistor amplifier circuit using h-parameters, Thevenin's and Norton's theorems and corollaries - Emitter follower, Linear analysis of a Transistor circuit, Miller' theorem and its dual, Simplified hybrid models of CE, CE amplifier with an Emitter resistance, Load line concept, biasing methods, stability factor, Bias compensation.

Unit IV: Field Effect Transistor **8 hours**

Field effect transistor (FET): Classification of various types of FETs, constructional details of junction field-effect transistor, drain characteristics of JFET, biasing of JFET, operating regions, pinch-off voltage, idea of metal-oxide-semiconductor transistor (MOS transistor).

Unit V: Amplifiers **8 hours**

Classification of Amplifiers, Distortion in Amplifiers, frequency response of amplifiers: LC and CR response, band with and rise time, amplifier, flat band equivalent circuits with and without input and output loading, cascade connections. Decibel power, gain and loss. Conversion to voltage and current gain.

Unit VI: Feedback amplifiers & Oscillators **8 hours**

Classification of Amplifiers, Feedback concept, General characteristics of Negative feedback amplifiers, Oscillators and wave-form generators: Positive feedback, Barkhausen criterion, RC oscillator, Wein Bridge oscillator, Phase shift oscillator, Colpitt's oscillator, Hartley oscillator.

Text Book

1. J. Millman and C. C.Hallkias. *Integrated Electronics: Analog and digital circuits and systems*, Tata McGraw Hill.

Supplementary Reading

1. J. D Ryder, *Electronic fundamentals and applications: Integrated and discrete systems*, 5th edition (Prentice-Hall of India).
2. W. D. Stanley, *Electronic Devices: Circuits and Applications*, 3rd Edition. McGraw-Hill.

PHYS-333: MODERN PHYSICS – II **3-0-0-3**

Unit I: Special theory of Relativity **11 hours**

Postulates – Lorenz transformations – Time dilation – Length contraction – Doppler effect – Twin paradox – velocity addition – relativistic momentum – Mass energy equivalence – Electricity and Magnetism in relativity – Introduction to general relativity.

Unit II: Statistical Mechanics **11 hours**

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

Unit III: Nuclear physics: **11 hours**

Introduction to nucleus – Nuclear mass – Nuclear size – Constituents of the nucleus – Binding energy – Stable nuclei – Liquid drop model – Radioactive decay – Alpha decay – Beta decay – Gamma decay – Nuclear energy – Nuclear fission – Nuclear reactors – Uncontrolled chain reactions – Nuclear fusion – Fusion in stars .

Unit IV: Introduction to Particle physics: **15 hours**

Introduction – Properties of elementary particles – Classification and names of elementary particles – Introduction to hardons and leptons – Introduction to conservation laws in elementary particles – Introduction to fundamental interactions.

Textbook

1. Arthur Beiser (2002). *Concepts of Modern Physics*. 6th edition. Tata McGraw Hill.

Supplementary reading

1. H. S. Mani and G. K. Metha (1988). *Introduction to Modern Physics*. Affiliated East-West Press.
2. David Halliday, Robert Resnick and Jearl Walker (2004) *Fundamentals of Physics*. 7th edition. John Wiley & Sons.
3. Paul A. Tipler and Gene Mosca (2007). *Physics for Scientists and Engineers* (Extended version). W. H. Freeman and Company.
4. F. K. Richtmyer, E. H. Kennard and J. N. Cooper. *Introduction to Modern Physics*. 6th edition. Tata McGraw Hill (1976).
5. M. R. Wehr, J. A. Richards Jr and T. W. Adair. *Physics of the atom*. 4th edition. Narosa Publishing House (1985).

PHYS – 340: PHYSICS LABORATORY (2 CREDITS)

1. Sensitivity of a cathode ray oscilloscope
2. Study of fall of a magnet through a metallic cylinder
3. Study of plane of polarization using quarter and half wave plates
4. Study of Michelson-Morley experiment using Michelson Interferometer
5. Simulation study of variation of mass with velocity
6. Simulation study of length contraction
7. Study of counting statistics in radioactive emissions
8. Thickness gauging by beta rays
9. Efficiency and dead time of G.M tube
10. Resolution of scintilator counter and its application
11. Computer simulation of Lennard- Jones potential; binding parameters, elastic constants
12. Computer simulation of 1-D and 2-D lattice vibrations
13. Computer simulation of Kronig-Penney model
14. Numerical simulation of wave-functions of simple harmonic oscillator
15. Computation of wave functions and their interpretation for various potentials
16. Computation of transmission coefficients for barriers of different shapes
17. Simulation of wave functions for a particle in critical box

Text Books

1. D.P. Khandelwal, A laboratory Manual of Physics for Undergraduate Classes, (Vani Publishing House, New Delhi)
2. B. Saraf et.al., Physics through experiments, (Vikas publishing house)
3. V Y Rajopadhye and V L Purohit; Text book of experimental Physics
4. Olon; Experiments in Modern physics

PH – 341: COMPUTATIONAL PHYSICS 3-0-0-3

UNIT – I: 9 hours

Representing numbers in a computer – Machine precision – Introduction to numerical errors – Errors in mathematical approximations – Error propagation – Introduction to MATLAB – Workspace – Creating arrays – Matrix operators – Generating vectors – Accessing sub-matrices – Control flow statements – Infinite loops – Introduction to *M*-files – Graphics in MATLAB – Creating 2D graphs – Creating parametric function plots – Introduction to Mesh and Surface plots – Introduction to toolboxes.

UNIT – II: 10 hours

Matrices and linear system of equations – Gauss-Jordan elimination method – Gauss method to compute the Inverse – LU decomposition – Cholesky decomposition – Review of rotation matrices – Householder transformation – QR decomposition – Gauss-Seidel iterative method – Eigenvalues and eigenvectors of a real symmetric matrix by Jacobi's method – Determination of largest eigenvalue by Power method.

UNIT – III: 9 hours

Introduction to Lagrange polynomials – Numerical differentiation and integration – Trapezoidal single segment and multiple segment rules – Simpson's single segment and multiple segment rules – Newton-Cotes formulas – Romberg integration – Gaussian quadrature formula – Estimation of errors in evaluating the integrals – Introduction to random numbers – Random number generation – Monte-Carlo integration.

UNIT – IV: 10 hours

Numerical solution of ordinary differential equations solution by Taylor's series – Euler's method – Runge Kutta methods with Runge's coefficients. Numerical solution of partial differential equations using finite difference method.

UNIT – V: Laboratory Exercise Session (1 hour per week) 10 hours

The laboratory exercise involves writing programs in C / C++ / FORTRAN / MATLAB to solve problems of numerical techniques for the topics listed above.

Textbook

1. Richard Hamming. *Numerical Methods for Scientists and Engineers.* Dover publications.
2. Duane C. Hanselman and Bruce L. Littlefield (2004). *Mastering MATLAB 7*. Prentice Hall.

Supplementary Reading

1. J.M. Thijssen (1999). *Computational Physics*. Cambridge University Press.
2. Tao Pang (1997). *An Introduction to computational physics*. Cambridge University Press.
3. Rubin H. Landau (1997). *Computational Physics: Problem solving with computers*. John Wiley.
4. James B. Scarborough. *Numerical mathematical analysis*. Oxford IBH.

PH-342: BASICS OF MATERIALS SCIENCE **3-0-0-3**

UNIT – I **10 hours**

Introduction to materials science – Classification of engineering materials – Structure-property relationships – Stability and meta-stability – Basic thermodynamic functions and related processes – Introduction to phase diagrams – Phase rule – Lever rule – One and two components – Solid solution – Eutectic binary mixtures – Microstructural changes during cooling – Typical phase diagrams and their applications.

UNIT – II **10 hours**

Introduction to crystals – Classification of crystal systems – Introduction to Bravais lattice – Calculation of distance between crystal planes – Miller indices – ionic crystals-covalent crystals- Vander wall-Metallic bonds.

UNIT – III **8 hours**

Atomic processes in solids – Diffusion in solids- Self diffusion - Concentration gradient-Diffusion constant - Fick's laws of diffusion and its applications.

UNIT – IV **10 hours**

Introduction to band theory of solids – Classification of metals, insulators and semiconductors – Forbidden gap – Mechanical properties of materials – Elastic deformation – Fracture – Plastic deformation Slip – Critical shear stress – Effect of lattice defects on mechanical properties.

UNIT – V **10 hours**

Material preparation and characterization – Different techniques of growing crystals –Melt growth - Growth of thin films- Characterisation by X-ray and optical methods

Textbooks

1. Material Science and Engineering V. Raghavan, Prentice-Hall
2. Material Science and Engineering, W.D.Callistin, John Wiley Sons
3. Hand book of thin film technology, Meissel and Glong, McGraw Hill

PHYS 343 MODERN OPTICS **3-0-0-3**

Unit I:

Double refraction and optical rotation: Double refraction in uniaxial crystals, explanation in terms of electromagnetic theory, phase retardation plates. Rotation of plane of polarization, origin of optical rotation in liquids and in crystals.

Dispersion and scattering: Theory of dispersion of light; absorption bands and anomalous dispersion. Theory of Rayleigh scattering; scattering of X-rays and determination of Z of an atom.

Unit II:

Introduction to Laser as Coherent Source of light: Purity of a spectral line; coherence length and coherence time, spatial coherence and directionality, estimates of beam intensity. Temporal coherence and spectral energy density.

Unit III

Statistical properties of random light, concept of coherence, interference of partially coherent light. Coherence Time and Line width via Fourier Analysis– Spatial Coherence and Temporal Coherence

Michelson Stellar Interferometer Fourier Transform Spectroscopy

Holography- Introduction Theory Requirements and some applications

Unit IV:

Fiber Optics- Introduction -Optical Fiber- Coherent Bundle- Numerical Aperture Single and Multimode Fibers- Pulse Dispersion -Waveguide Dispersion-Dispersion Compensating Fibers

Nonlinear Optics –Introduction Nonlinear Polarization- Various second order and third order Nonlinear Optical process

Text

1. A K Ghatak “Optics” 3rd Edition (Tata McGraw Hill)
2. E Hecht “Optics” 3rd Edition (Addison Wesley)
3. F L Pedrotti and L S Pedrotti “Introduction to Optics” (Prentice Hall International)
4. K K Sharma “Optics” (Elsevier)

Reference Books

1. R P Feynman, R B Leighton, M Sands: “The Feynman Lectures on Physics” Vol 1. (Narosa publishing house)
2. Born and Wolf; “Optics” (Pergamon Press)
3. K D Meller, “Optics” (Oxford University Press)
4. Jenkins and White; “Fundamental of Optics” (McGraw-Hill)
5. B B Laud “Lasers and Non-linear Optics” (Wiley Eastern, 1985)
6. Smith and Thomson “Optics” (John Wiley and Sons, 1980)
7. R S Longhurst “Geometrical and Physical Optics” (Longmans,1966)

PHYS-430 Laboratory [3 credits]

General Experiments

1. Determination of Semiconductor Bandgap
2. Magnetic Susceptibility of Solids
3. Magnetic Susceptibility of Liquids
4. Hall Effect
5. Curie Temperature
6. Geiger Muller Counter
7. Dielectric constant

Opamp Experiments

1. Opamp Characteristics
2. Frequency response of opamp
3. Opamp Configurations
4. Opamp Integrator
5. Opamp Differentator
6. Opamp – Weinbridge Oscillator
7. Opamp – Comparator
8. Opamp – Multivibrator
9. Opamp – First-order Active Filters

PHYS-431: MATHEMATICAL METHODS IN PHYSICS **3-1-0-4**

UNIT – I: Linear Algebra **12 hours**

Linear vector spaces – Dual space – Basis sets – Orthogonality and completeness – Hilbert space – Linear operators – Self-adjoint and unitary operators – Families of orthogonal polynomials as basis sets in function space – Rotation group in 2 and 3 dimensions – Pauli matrices – Generators of rotations.

UNIT – II: Vectors and Tensors **12 hours**

Rotation group in 2 and 3 dimensions – Pauli matrices – Generators of rotations – Scalars, vectors and tensors in index notation – Del and Laplacian operators – Vector calculus in index notation – Dirac delta function – Representation and properties – Algebra of Cartesian tensors – Outer product – Contraction and quotient theorems – Kronecker & Levi-Civita tensors – Example – Applications in Physics.

UNIT – III: Complex Variables **12 hours**

Elements of analytic function theory – Cauchy-Riemann conditions – Singularities, poles and essential singularities – Cauchy's integral theorem – Cauchy integral formula – Residue theorem and contour integration Residue method for real integration – Taylor and Maclaurin expansion – Laurent and Taylor series of complex functions – Introduction to conformal mapping.

UNIT – IV: Special Functions **12 hours**

Beta, Gamma, Delta and Error functions – Bessel, Hermite, Legendre, Associated Legendre and Laguerre functions – Generating functions – Series solutions – Recurrence relations – Properties of special functions and their applications in physics.

Textbooks

1. G. Arfken, *Mathematical Methods for Physicists* (5th Edition) (Academic Press, 2000).
2. Erwin Kreyszig (2005). *Advanced Engineering Mathematics*. 9th Edition. John Wiley.
3. R.K. Jain, S.R.K. Iyengar (2007). *Advanced Engineering Mathematics.* 3rd Edition. Narosa.

Supplementary Reading

1. K. F. Riley, M. P. Hobson and S. J. Bence, *Mathematical Methods for physics and engineering* (Cambridge Univ. Press, 1998)
2. M. P. Boas (2005). *Mathematical Methods in the Physical Sciences* (3rd Edition) Wiley.
3. Potter M C and Goldberg J (1988). *Mathematical Methods*. Prentice Hall.
4. Sokolnikoff I S and Redheffer R M. *Mathematics of Physics and Modern Engineering*. McGraw Hill.
5. Spiegel M R. *Theory and Problems of Complex Variable*. Schaum's Series. McGraw Hill.
6. Spiegel M R. *Theory and Problems of Fourier analysis*. Schaum's Series. McGraw Hill.

PH- 432: CLASSICAL MECHANICS **3-1-0-4**

Unit I:

Mechanics of a system of particles – conservation laws of linear and angular momenta for systems not subjected to external forces and torques – constraints – principle of virtual work – Lagrangian equations of motion and a few applications – motion in a central field – Kepler's problem – scattering – laboratory and CM frame – differential scattering cross section – scattering by a central field.

Unit II:

Variational method – Hamilton's equations of motion – canonical transformations – generating functions – infinitesimal contact transformations – Lagrange and Poisson brackets – Hamilton, Jacobi theory.

Unit III:

Rigid body rotation – rotating frame – Eulerian angles transformation between rotating and stationery frames – Coriolis and centrifugal forces – moment of inertia tensor – Euler's equations – symmetric top precession – theory of small oscillations – normal co-ordinates and vibrations of a discrete system – Forced oscillations.

Unit IV:

Special theory of relativity: Inertial frames – Lorentz transformations – length contraction, time dilation and Doppler effect – Minkowski space – Energy momentum four vectors – Introduction to general relativity.

Text Books

1	Classical Mechanics	H. Goldstein	Narosa
2	Introduction to Classical Mechanics	T. G. Takwale & P. S. Purnaik	Tata McGraw Hill
3	Classical Dynamics	Donald T. Greenwood	Prentice Hall
4	Classical Mechanics	A. K. Rayachaudri	Oxford University Press
5	Principles of Mechanics	Synge and Griffith	McGraw Hill
6	Classical Mechanics of Particles and Rigid Bodies	K. G. Gupta	Wiley Eastern

PHYS- 433 – STATISTICAL PHYSICS **3-1-0-4**

Unit I: Ensemble and equilibrium

Fundamental concepts of phase space, microstate (semiclassical) Liouville's theorem- Classical treatment – introduction to the concept of density of states.

Statistical systems and ensembles – ergodicity microstates and macrostates – equilibrium states – microcanonical ensemble- Derivation for equation of state using microcanonical ensemble.

Unit II: Partition function and its application

Canonical ensemble- partition function of canonical ensemble- Thermodynamical quantities by partition function- Ideal gas, paramagnetic crystal, diatomic molecule in canonical ensemble- Negative temperature - Schottky anomaly- Grand canonical ensemble- partition function- chemical potential- Criteria of classical statistical physics- equipartition theorem - Gibb's paradox.

Unit III: Quantum Statistics

Introduction to quantum statistics- Ideal quantum gases- Bosons- Fermions- Derivation of expressions of Bose-Einstein, Fermi-Dirac and Maxwell-Boltzmann distribution functions using GCE partition functions- Bose-Einstein condensation- Superfluidity of Helium- Fermion gas and Fermi function- Thermodynamical properties of fermion gas- Fermi surface- specific heat of electrons in Fermi surface- Pauli paramagnetism.

Unit IV: Advanced topics

Phase transitions- First and second order phase transitions- critical point- order parameter- Scaling hypothesis-critical exponents - ferromagnetic phase transition- Ising model- Bragg William approximation- fluctuations in ensembles- One dimensional random walk- power spectrum- electrical noise- Non-equilibrium statistical mechanics- Onsager reciprocity relations, thermo-electric phenomena.

Text Books:

01	Introduction to statistical and thermal Physics	F. Reif	McGraw Hill
02	Statistical Physics (Berkeley series in Physics)	F. Reif	McGraw Hill
03	Molecular Physics	A.N. Matveev	Mir Publications
04	Statistical Mechanics & Properties of Matter	E.S.R. Gopal	Macmillan
05	Statistical Mechanics	Agarwal & Grisner	Wiley Eastern
06	Statistical Physics	F. Mandl	ELBS

Reference:

01	Introduction to Statistical Physics (and solution manual)	D. Chandler	Oxford University Press
02	Lectures on statistical physcs	R.P. Feynman	
03	Statistical physics	K. Huang	John Wiley & Sons
04	Statistical physics	Kubo e. al.	Springer Verlag Solid State Science Series
05	Statistical Physics	Landu and Lifshitz	Addison-Wesley
06	Order out of chaos	I. Prigogine	Fontanta paper backs
07	The principles of statistical mechanics	R. C. Tolman	Oxford University Press

PHYS-434: ELECTRONIC DEVICES, CIRCUITS & MICROPROCESSORS 3-1-0-4

Unit I

Non-linear resistive devices – NTC, PTC, VDR – Structure, working and applications – Diodes – (Rectifier and Zener) – Tunnel diode – V-I Characteristics. Transistors – (BJT, FET, UJT, MOSFET) – Structure and working, small signal models and equations for V-I characteristics under different conditions, frequency limits and applications.

Unit II

Microwave devices and components: IMPATT, GUNN – Klystron, Magnetron – Structure and working, Transmitting and receiving antenna, wave guides, traps, connectors and couplers, filters and matching circuits.

Opto-electronics devices: Radiative and nonradiative transistors, absorption. Bulk and thin film devices – LDR, Photodiode, Solar cell, LED, diode Lasers – Structure, working and factors affecting performance.

Unit III

Analog circuits: Linear circuits – operational amplifiers – parameters and their importance applications – Summing, difference, inverting, non-inverting, integrating, differentiating amplifiers – Non-linear circuits – absolute rectifiers, Clipping, Clamping circuits, logarithmic amplifiers, Filters, modulation and demodulation circuits, Timers and Phase-locked loop.

Unit IV

Digital circuits: Combinational logic circuits using standard TTL and CMOS LSI chips- gates, latches, multiplexer/demultiplexer, decoder and encoders, Half and full adder, ALU. Sequential logic circuits – Counters – synchronous, asynchronous, binary and decade, divide by N counters, Shift registers – Serial to parallel and vice-versa.

Unit V

Microprocessor: 8-bit microprocessor – 8085 Architecture, organization, buses, addressing modes, instruction set, instruction types, Timing and sequencing, Instruction and machine cycle, Timing diagrams – Assembly language programming – simple programs for arithmetic and logical operations, Interrupts – handling interrupts, Interfacing microprocessors – peripheral devices PPI(8255), USART(8251), PIC(8279), DMA(8257) – data transfer modes.

Textbooks

1. Unit I & III – Integrated Electronics by Millman & Halkias
2. Unit II (Half Portion) – Physics of Semiconductor devices by Simon M.Sze.
3. Unit II (Another Half on microwave) – Electronic and Radio Engineering by Terman
4. Unit IV – Digital Principles by Malvino & Leach
5. Unit V – Microprocessor Architecture and Programming 8085 by Ramesh S. Gaonker.

PH – 435: NUMERICAL METHODS and MATLAB **2-0-1-3**

UNIT – I: **10 hours**

Representing numbers in a computer – Machine precision – Introduction to numerical errors – Errors in mathematical approximations – Error propagation – Introduction to MATLAB – Workspace – Creating arrays – Matrix operators – Generating vectors – Accessing sub-matrices – Control flow statements – Infinite loops – Introduction to *M*-files – Graphics in MATLAB – Creating 2D graphs – Creating parametric function plots – Introduction to Mesh and Surface plots – Introduction to toolboxes.

UNIT – II: **10 hours**

Matrices and linear system of equations – Gauss-Jordan elimination method – Gauss method to compute the Inverse – LU decomposition – Cholesky decomposition – Review of rotation matrices – Householder transformation – QR decomposition – Gauss-Seidel iterative method – Eigenvalues and eigenvectors of a real symmetric matrix by Jacobi's method – Determination of largest eigenvalue by Power method.

UNIT – II: **10 hours**

Introduction to Lagrange polynomials – Numerical differentiation and integration – Trapezoidal single segment and multiple segment rules – Simpson's single segment and multiple segment rules – Newton-Cotes formulas – Romberg integration – Gaussian quadrature formula – Estimation of errors in evaluating the integrals – Introduction to random numbers – Random number generation – Monte-Carlo integration.

UNIT – III: **10 hours**

Numerical solution of ordinary differential equations solution by Taylor's series – Euler's method – Runge Kutta methods with Runge's coefficients. Numerical solution of partial differential equations using finite difference method.

UNIT – IV: Laboratory Exercise Session (1 hour per week) **10 hours**

The laboratory exercise involves writing programs in C / C++ / FORTRAN / MATLAB to solve problems of numerical techniques for the topics listed above.

Textbook

1. Richard Hamming. *Numerical Methods for Scientists and Engineers.* Dover publications.
2. Duane C. Hanselman and Bruce L. Littlefield (2004). *Mastering MATLAB 7*. Prentice Hall.

Supplementary Reading

1. J.M. Thijssen (1999). *Computational Physics*. Cambridge University Press.
2. Tao Pang (1997). *An Introduction to computational physics*. Cambridge University Press.
3. Rubin H. Landau (1997). *Computational Physics: Problem solving with computers*. John Wiley.
4. James B. Scarborough. *Numerical mathematical analysis*. Oxford IBH.

PH – 436: UNIX, FORTRAN-90 and C++ **2-0-1-3**

UNIT – I: Unix Operating System **12 hours**

Introduction to operating system – General OS architecture – Evolution of Unix operating system – Architecture of the Unix OS – The kernel – Memory management – Virtual memory – Paging – Segmentation – Shells and GUI – Directory structure – File systems in Unix – Mount point – Processes and threads – Multi-threading – Semaphores – Mutex – CPU process scheduling – Concept of deadlock – Services and Daemons – Introduction to Networking – Network file systems – Elements of system administration – Principles of topography – Typesetting in LaTeX – Elements of bibliography and citation – The Harvard system.

UNIT – II: Fortran-90 **12 hours**

Evolution of Fortran language – Different Fortran compilers – Skeleton of a general Fortran 90 program – Free source format and character set – Specifications – Derived types – Control Structure – CASE construct – New features of DO loop: EXIT, CYCLE statements, Control clauses – Concept of internal, and external procedures, modules and INTERFACE blocks – Concept of scope – CONTAINS statement – Procedure Arguments – Optional arguments – Keyword arguments – Recursive procedures – Modules – Array Processing – Terminology and Specifications – Whole array operations – Vector subscripts – Array assignment – Array constructor – Allocatable dynamic array – Pointers and Dynamic Data Structures – Concept of pointers – Example programs.

UNIT – III: C++ **12 hours**

Introduction – Algorithms – Control Structures – if Selection Statement – if-else statement – do-while repetition Statement – Nested Control Statements – Assignment Operators – Increment and decrement operators – break and continue Statements – Logical Operators – C++ math library functions – Function definitions with multiple parameters – Function prototypes – C++ standard library header files – Random Number Generation – Inline functions – Arrays – Declaring arrays – Examples using Arrays – Passing arrays to functions – Pointer variable declarations and initialization – Pointer Operators – Passing arguments to functions by reference with pointers – Using `const` with pointers – Introduction to operator overloading.

UNIT – IV: Laboratory Exercise Session (1 hour per week) **12 hours**

The following exercises have to be done in Fortran 90 or in C++ : Swapping of two numbers – Counting – Factorial Computation – SINE computation – Base Conversion – Factoring Methods – Array Techniques – Display the Pascal Triangle – Generate prime numbers between 1 to *N* – Generate Fibonacci series up to *N* number – Concatenating two strings – Reversing the string – Finding the substring of a given string – Summation of a sin, cos and exponential series – Matrix computations – Random number generation.

Textbooks

1. Jerry Peek, Grace Todino-Gonguet, John Strang (2002). *Learning the UNIX Operating System*, 5th Edition. O'Reilly Media, Inc.
2. F. Mittelbach, M. Goossens, J. Braams, D. Carlisle, C. Rowley (2004). LaTeX Companion (2nd Edition). Addison-Wesley.
3. Stephen Chapman (2003). *Fortran 90 / 95 for Scientists and Engineers* (2nd Edition) McGraw Hill.
4. Harvey M. Deitel and Paul J. Deitel (2007). *C++ How to Program* (6th Edition). Prentice Hall.

Supplementary Reading

1. W. S. Brainerd, C. H. Goldberg and J. C. Adams (1995). *Programmer's Guide to Fortran 90*. Springer.
2. Michael Metcalf and John K. Reid (1999). *Fortran 90/95 Explained*. Oxford University Press.
3. Michael Metcalf, John Reid and Malcolm Cohen (2004). *Fortran 95 / 2003 Explained (Numerical Mathematics and Scientific Computation)*. Oxford University Press.
4. Bjarne Stroustrup (2000). *The C++ Programming Language* (3rd Edition).

PHYS-437: DIFFERENTIAL EQUATIONS and TRANSFORM TECHNIQUES 3-0-0-3

UNIT – I: Ordinary Differential Equations 12 hours

First order ODE's – Separable ODE's – Orthogonal trajectories – Physical modeling – Second order linear ODE's – Differential operators – Physical modeling – Higher order linear ODE's – Homogeneous and inhomogeneous differential equations – Series solution of ODE's – Frobenius method – Strum-Liouvllie problem – Orthogonal eigenfunction expansions.

UNIT – II: Partial Differential Equations 12 hours

Introduction to partial differential equations – Introduction to curvilinear coordinates – Cylindrical polar and spherical polar systems – Review of vector calculus – Divergence, curl and Grad in polar system – Solution by analytical methods – Solution of (i) Laplace, (ii) Poisson, (iii) Helmholtz wave and (iv) diffusion equations in Cartesian and polar coordinate systems.

UNIT – III: Laplace Transforms 12 hours

Laplace transforms – Inverse transforms – Linearity and Shifting theorems – Laplace transform of derivative of a function – Laplace transform of integral of a function – Unit-step function – *t*-shifting – Short impulses – Dirac-delta function – Convolution – Integral equations – Application to solve differential equations.

UNIT – IV: Fourier Transforms 12 hours

Introduction to Fourier analysis – Half range Fourier series – Harmonic analysis and applications – Forced oscillations – Finite and infinite Fourier transforms – Fourier sine and cosine transforms – Complex Fourier transforms – Fourier expansion and inversion formulas – Convolution theorem – Applications to solutions of partial differential equations.

Textbooks

1. G. Arfken, *Mathematical Methods for Physicists* (5^{th} Edition) (Academic Press, 2000).
2. Erwin Kreyszig (2005). *Advanced Engineering Mathematics*. 9^{th} Edition. John Wiley.
3. R.K. Jain, S.R.K. Iyengar (2007). *Advanced Engineering Mathematics*. 3^{rd} Edition. Narosa.

Supplementary Reading

1. K. F. Riley, M. P. Hobson and S. J. Bence, *Mathematical Methods for physics and engineering* (Cambridge Univ. Press, 1998)
2. M. P. Boas (2005). *Mathematical Methods in the Physical Sciences* (3^{rd} Edition) Wiley.
3. Potter M C and Goldberg J (1988). *Mathematical Methods*. Prentice Hall.
4. Sokolnikoff I S and Redheffer R M. *Mathematics of Physics and Modern Engineering*. McGraw Hill.
5. Spiegel M R. *Theory and Problems of Complex Variable*. Schaum's Series. McGraw Hill.
6. Spiegel M R. *Theory and Problems of Fourier analysis*. Schaum's Series. McGraw Hill.

PHYS-440 Laboratory [3 credits]

General Experiments

1. Thickness of Mesh wire using a He-Ne Laser
2. Pitch of the Screw usinga a He-Ne Laser
3. Michelson Interferometer
4. Zeeman setup
5. Frank-Hertz Experiment
6. Electron spin Resonance
7. Microwave Bench setup
8. Microprocessor

Digital Electronics Experiments

1. Combinational Logic Circuits – Logic Gates
2. Combinational Logic Circuits – Boolean algebra
3. Binary Addition – Half Adder & Full Adder
4. Decoders – 2 bit binary, 2 bit Decoder and 7447 decoder
5. Flip-flops
6. Counters & Registers
7. Decade Counting Unit

PH-441: QUANTUM MECHANICS – I **3-1-0-4**

Unit I: Quantum theory of spherically symmetric systems *(12 Lectures)*
Particle in a spherically symmetric potential – Angular wave function – Radial equation for a free particle, spherical trap – Hydrogen atom – Spin of an electron – Addition of angular momenta.

Unit II: Symmetry in Quantum Mechanics *(12 Lectures)*
Symmetries, Conservation laws, and Degeneracies – Discrete symmetries, Parity, or Space Inversion – Lattice translation as a discrete symmetry – Time reversal discrete symmetry.

Unit III: Pictures of Quantum Mechanics *(8 Lectures)*
Schrodinger picture – Heisenberg picture – Interaction picture – Relation among different pictures – Ehrenfest theorem.

Unit IV: Time independent perturbation theory *(12 Lectures)*
Non-degenerate perturbation theory – Degenerate perturbation theory – The fine structure of hydrogen – The Zeeman effect – The Stark effect – Hyperfine splitting

Unit V: Variational Principle and WKB approximation *(12 Lectures)*
Variational principle – The ground state of helium – The hydrogen molecular ion – WKB approximation – Tunneling through potential barriers.

Text Books:

1	Quantum mechanics	Ghatak & Loganathan	McMillan
2	Quantum mechanics	L. I. Schiff	
3	Introduction to quantum mechanics	Dicks and Witke	
4	Quantum mechanics	J. L. Powell and B. Craseman	Addison-Wesley
5	Quantum mechanics	V. K. Thankappan	Wiley-Eastern
6	Quantum mechanics	Gordon Baym	
7	Fenyman lectures on Physics	Vol. III	Narosa

Reference:

1	Advanced quantum mechanics	J. J. Sakurai, Benjamin/Cummings	
2	Intermediate quantum mechanics	H.A. Bethe and R. Jackiw	
3	Quantum mechanics	Benjamin/Cummings	Merc Backe
4	Quantum mechanics	Vol. I & II, Messiah	
5	Quantum mechanics	Davy dov.	
6	The principles of quantum mechanics	P.A.M. Dirac	
7	Advanced quantum theory	P. Roman	

PH – 442: CLASSICAL ELECTRODYNAMICS 3-1-0-4

UNIT – I: Boundary value problems & Special techniques 15 hours

Boundary conditions and uniqueness theorems — Conductors and second uniqueness theorem — Boundary value problems with linear dielectrics — Multipole expansion — Origin of coordinates in multipole expansions.

UNIT – II: Magnetostatics and Electrodynamics 15 hours

Lorentz force law and Biot-Savart law — Scalar and vector potentials — Multipole expansion of vector potential—Calculation of field of a magnetized object—Amperes law in magnetized materials and Auxiliary field **H** — Magnetostatic boundary conditions — Faraday's law and Lenz's law — Calculation of energy density in magnetic fields — Electrodynamics before Maxwell — Maxwell's correction of Ampere's law — Derivation of Maxwell's equations in vacuum and in matter.

UNIT – III: Electromagnetic waves 15 hours

Electromagnetic waves in vacuum — Wave equation for ***E*** and ***B*** — Reflection, refraction of electromagnetic waves — Snell's law and Fresnel's law — Poynting theorem and its derivation — Electromagnetic waves in matter — Propagation of electromagnetic waves in linear media — Reflection and transmission at normal and oblique incidence — Absorption and dispersion of electromagnetic waves — Electromagnetic waves in conductors — Reflection at a conducting surface — Interference, diffraction and polarization.

UNIT – IV: Potentials and Radiation 15 hours

Potential formulation — Gauge transformations — Coulomb and Lorentz gauge — Retarded potentials of continuous charge distribution — Derivation of Jefimenko's Equations — Retarded potentials of point charges — Lienard-Wiechert potential — Fields of a moving point charge — Electric dipole radiation — Energy radiated by an oscillating electric dipole — Radiation from moving charges — radiation fields — Derivation of Larmor formula – Relativistic formulation of Maxwell's equations.

Textbook

1. David J Griffiths (1999). *Introduction to electrodynamics*. 3rd edition. Prentice Hall.

Supplementary Reading

1. John David Jackson (1999). *Classical Electrodynamics*. 3rd edition. John Wiley & Sons.
2. Matthew N. O. Sadiku (2002). *Elements of Electromagnetics*. 3rd edition. Oxford University Press.

PHYS-443: SOLID STATE PHYSICS **3-1-0-4**

Unit I:
Classification of solids – liquids – amorphous glassy states, characteristics and structure.

Unit II: **Crystal structure:**
Bravais lattice – simple – body centered and face centered cubic lattices – Primitive cell, Wigner-Seitz cell and conventional cell. Crystal structures and lattice with basis – Hexagonal close packed and diamond structure – point groups – space groups – Miller indices – Reciprocal lattice – Brillouin zones – crystal diffraction – Laue – Power – Rotating – crystal methods.

Unit III: **Crystal Binding:**
Ionic cohesive energy – Covalent – Metallic Vander Waals and hydrogen bonded crystals.

Unit IV: **Lattice Dynamics:**
Vibrational modes – one, two and three dimensional lattices – Thermal conductivity – Elastic constants – Phonon dispersion relation – Localised modes.

Unit V: **Free Electron Theory:**
Transport properties – electronic specific heat – electrons in a periodic potential – energy band (Bloch's theorem, Kronig – Penney's theorem).

Unit VI: **Semiconductor Theory:**
Band Structure – Carrier concentrations – Intinsic semi-conductor – Imputiry states – Semiconductor states – Electrical conductivity, mobility – Magnetic field effects – Cyclotron resonance and Hall effect.

Unit VII: **Superconductivity:**
Occurrence of Superconductivity – Destruction of superconductivity by magnetic fields – Meissner effect – Heat capacity – Energy gap – Microwave and IR properties – Isotope effect – Thermodynamics of the superconducting transistors – London equation – Coherence length – BCS theory of superconductivity – Qualitative treatment of DC and AC Josephson effect.

Unit VIII: **Electric and Magnetic Properties:**
Ferro electric crystals – Classification of polarization – Catastrophe – Landau theory of phase transition – Second order transition – First order transition soft optical phonons – Anti ferro electricity – Ferro electric domains – Piezoelectricity – Ferro electricity. Dia – paramagnetism – Quantum theory of para magnetism – ferro – Ferri – Anti ferri magnetism. Curie Neil temperature – Magnetism and susceptibility – Ferro-magnetic domains – Magnons.

Text Books:

01	Introduction to solid state physics	C. Kittel
02	Introduction to solid state physics	A. J. Dekker
03	Elementary solid state physics	M. Ali Omar
04	Introduction to solids	L. V. Azoroff
05	Solid state physics	N. W. Aschroft and N. D. Mermin Holt, 1987

PHYS-444: NONLINEAR DYNAMICS **3-0-0-3**

Introduction to synergetics – examples from Physics, Chemistry, Biology, Computer Science, Economics, Ecology and Sociology.

Survey of first and second order differential equations – inhomogeneous – non-linear differential equations – linear and non-linear dynamical systems – solutions – examples from physics.

Stability of solutions from non-liner dynamics systems – phase portrait – trajectories – limit cycles – driven pendulum – Vender Pol and Durfing oscillator – bifurcations – Hopf bifurcation – period doubling route to chaos Poincare Map – Logistic Map – strange attractors – Lorentz attractor.

Oscillating chemical system – Lotka-Volterra equations – Brusselator model – Beluosov Zhabotinsky reaction chemical chaos – self-organization. Applications to Biology, predator – prey problem, morphogenesis.

Text Books

01	Synergetics – An Introduction	H. Haken	Springer-Verlag
02	Advanced Synergetics	H. Haken	Springer-Verlag
03	Order out of chaos	Ilya Prigogine	Fontana
04	Non-Linear Dynamical systems	Peter A. Cook	Prentice-Hall
05	Introduction to the Physics of Complex Systems	Roberto Serra	Pergamon Press

PHYS-445: MEASUREMENT SYSTEMS and DATA ACQUISITION **3-0-0-3**

UNIT – I: Basic concepts **12 hours**

Significance of measurement – Role of instruments in industrial processes – Block representation of measurement systems – Need for calibration and standards – Instrument parameters: sensitivity, accuracy, resolution, span, range – Classification of instruments – Generalized system configuration – Functions and characteristics of instruments and measurement systems – Errors in measurement – Analysis, sources of errors and techniques for error-minimizing – Classification of instrument transducers – Input and output characteristics – Static and dynamic response – Linearity and hysteresis.

UNIT – II: Transducers and Measurement Systems **12 hours**

– Examples of (i) resistive, (ii) inductive, (iii) capacitive, (iv) thermoelectric, (v) photo-electric, (vi) piezo-electric, (vii) ionization and (viii) Hall-effect based transducers – Displacement measurement – Force and torque measurement – Pressure and sound measurement – Relationship between absolute, atmospheric and gauge pressures – Fluid flow measurement – Temperature measurement – Measurement of light – Measurement of magnetic field.

UNIT – III: Signal conditioning and circuits **12 hours**

The need for signal conditioning – Requirements and characteristics of signal conditioners – DC and AC bridge circuits – Operational amplifiers in instrumentation – Unity gain buffer – Instrumentation amplifier – Log and antilog amplifiers – Constant current source – Voltage and current conversion – Passive and active filters.

UNIT – IV: Data acquisition and Virtual Instrumentation **12 hours**

Introduction to RS232, RS485 – Basics of Interfacing – IEEE 488.2 standards and GPIB – Introduction to USB, PCMCIA, VXI, SCXI, PXI – Historical Perspective and advantages of Virtual Instrumentation (VI) – Defining VI – Block Diagram & architecture of VI – Data Flow Techniques – Graphical Programming in Data Flow – Comparison with conventional programming – Introduction to LabVIEW.

Textbooks

1. (Units-I, II): T. G. Beckwith, R. D. Marangoni, J. H. Lienhard (2006). *Mechanical Measurements* (6^{th} Edition). Prentice Hall.
2. (Unit-III): J. A. Blackburn (2001). *Modern Instrumentation for Scientists and Engineers*. Springer.
3. (Unit-IV): Bruce Mihura (2001). *LabVIEW for Data Acquisition*. Prentice Hall.

Supplementary reading

1. Ernest O Doebelin. *Measurement Systems: Application and Design*. 5^{th} edition. Tata McGraw Hill.
2. Albert D Helfrick and William D Cooper. *Modern Electronic Instrumentation and Measurement Techniques*. Prentice Hall of India Private Limited, New Delhi, 1992.
3. Hermann K P Neubert. *Instrument Transducers: An introduction to their performance and design*. Oxford University Press, 2003.

PHYS-446 MICROPROCESSORS AND APPLICATIONS **(3 credits)**

Unit I: **Architecture of 8 bit Microprocessor:**
Addressing modes – instruction and times – classification – machine control operator – FORMAT – Types of memory –R/W, (RAM) – ROM, PROM, EPROM, EEPROM – I/O interfacing and addressing – display and keyboard interfacing and programming – interrupts, stacks, subroutines, 8155, 8355, 8212 clock generator and bus drives

Unit II: **Assembly Language Programming:**
Programming exercise for 8085 – involving addition, subtracting and logical operations only – Monitor programme – assemblers, basic interpreters. Serial and parallel data transmission: Perriperheral chips – intel 8275, 8279, USART, instrumentation buses, RS232C, IEEE488 bus CAMAC buses.

Unit III: **Digital Interfacing:**
KB, displays optical motor shift encoders – analogue interfacing D/A and A/D converters – process control – digital filters.

Unit IV: **Trends in Microprocessor Technology:**
16 bit CPU, 8086, 8088 – 8086 internal architecture. Assembly language programming of 8086 – simple sequence programs Flags Jumps while – Do implementation IF – THEN, IF-THEN-ELSE and multiple – IF-THEN-ELSE programme – 8086 instruction and assembly direction. Computer systems peripherals, Raster scan, CRTs vector scan CRTs – Floppy disk controllers, hard disk interfacing Data communication networks – serial data transmission mode IBM PC architect.

Text Books

1	Microprocessor architecture, programming and applications with 8085/8085A	Ramesh S. Ganokar	Wiley Eastern Ltd.
2	Microprocessors and interfacing	Dauglaus V. Hall	
3	Assembly language programming	Lance A. Leventhal	Prentice Hall of India Pvt. Ltd.
4	Microprocessors and programmed logic	Kenneth L. Sherl	Prentice Hall of India Pvt. Ltd.
5	Microprocessors and microcomputer system	Guthikonda V. Rao	

PHYS- 530: ADVANCED PHYSICS LABORATORY (2 CREDITS)

Condensed Matter

1. Microwave Bench.
2. X-Ray Diffraction.
3. Impedance Spectroscopy.
4. High Filed Magnetic Hysterisis.
5. Superconductivity.
6. Nuclear laboratory.

Electronics

1. Write Subroutines for addition and Multiplication.
2. Use these Subroutines to evaluate given expression.
3. Write Subroutine to generate a given time delay.
4. Use the Subroutine to set up Hexadecimal & Decimal counters.
5. Set up a real time clock.
6. Generate a square wave of given frequency using DAC interface.

Laser-Optics

1. Measurement of wavelength of the He-Ne Laser using meter scale.
2. To study the Fraunhoffer diffraction through circular apertures.
3. To demonstrate the transmission of Light through optical fibre and measure its numerical aperture.

Computer

1. Monte Carlo of 2D Ising model on a square lattice.
2. Fast Fourier Transform of a given signal.
3. Solving Heat equation.
4. Simulating Chaos.

PHYS- 531: QUANTUM MECHANICS – II **3-1-0-4**

Unit I: Time dependent perturbation theory (15 Lectures)

Time dependent perturbation theory – transition probability – constant perturbation – harmonic perturbation – Fermi Golden rule – radiative transitions in atoms – dipole transition – selection rules – sudden and adiabatic approximation.

Unit iI: Semiclassical theory of Radiation (7 Lectures)

Interaction of Light with Matter: Electric dipole Hamiltonian, absorption and stimulated emission, absorption spectroscopy, Raman scattering.

Unit III: Identical Paricles (12 Lectures)

Systems of identical particles – Exchange degeneracy – Fermi and Bose particles – the exclusion principle – ensemble of indentical systems – spin statistics connection – Slater determinant.

Unit IV: Quantum theory of Scattering (12 Lectures)

Scattering theory – scattering particles – potential scattering – partial wave analysis – phase shifts scattering length – integral equations in terms of Green's function – Born approximation and its validity.

Unit V: Relativistic Quantum Mechanics (12 Lectures)

Relativistic wave equations – the Klein-Gordon equation – Dirac equation – Dirac matrices – free Dirac particles – spin magnetic moment – spin-orbit interaction – central potential – hydrogen atom – Hole theory and positrons.

Text Books:

01	Quantum mechanics	Ghatak & Loganathan	McMillan
02	Quantum mechanics	L. I. Schiff	
03	Introduction to quantum mechanics	Dicks and Witke	
04	Quantum mechanics	J. L. Powell and B. Craseman	Addison-Wesley
05	Quantum mechanics	V. K. Thankappan	Wiley-Eastern
06	Quantum mechanics	Gordon Baym	
07	Fenyman lectures on Physics	Vol. III	Narosa

Reference:

01	Advanced quantum mechanics	J. J. Sakurai, Benjamin/Cummings	
02	Intermediate quantum mechanics	H.A. Bethe and R. Jackiw	
03	Quantum mechanics	Benjamin/Cummings	Merc Backe
04	Quantum mechanics	Vol. I & II, Messiah	
05	Quantum mechanics	Davy dov.	
06	The principles of quantum mechanics	P.A.M. Dirac	
07	Advanced quantum theory	P. Roman	

PHYS-532: ATOMIC AND MOLECULAR PHYSICS **(4 credits)**

Unit I: Basics The Breadth of Spectrum Lines: (4 hours)

Electromagnetic spectrum – Absorption or Emission of radiation – Line width- Natural line broadening-Doppler broadening –Pressure broadening – Removal of line broadnening.

Unit II: Spectroscopy of Inner Electrons

a) X-ray Spectra: Emission and absorption spectra of X-rays. Regular and irregular doublet laws – X-ray satellites. (3 hours)

b) Photoelectron spectroscopy Ultravoilet photoelectron spectrometers XPS techniques and Chemical information from photoelectron spectroscopy- Auger electron spectroscopy (3 hours)

Unit III: Molecular Spectroscopy

a) Microwave Spectroscopy: Classification of Molecules -The rotation of Molecule – Rotational spectra of Rigid Diatomic molecule- Isotope Effect in Rotational Spectra- Intensity of Rotational Lines- Non-rigid Rotator- Vibrational Excitation Effect- Linear Polyatomic molecules- Symmetric top molecules- Asymmetric top molecules – Stark effect- Quadrupole Hyperfine interaction – Microwave spectrometer – Information derived from Rotational spectra. (6 hours)

b) Infrared Spectra: Vibrational Energy of a Diatomic molecule – The Diatomic Vibrating Rotator – Break down of Born-Oppenheirmer Aprroximation- The Vibrations of Polyatomic molecules- Rotation-Vibration spectra of Polyatomic molecules – Analysis by Infra-red Techniques- IR spectrophotometer – Fourier Transfor-IR spectrophotometer- Applications. (5 hours)

Unit IV: Raman Spectroscopy: (5 hours)

Theories of Raman scattering – Rotational Raman Spectra – Vibrational Raman Spectra – Mutual Exclusion principle – Raman Spectrometer – Polarisation of Raman Scattered light – Structural determination from Raman and IR spectroscopy - Near IR FT-Raman spectroscopy.

Unit V:Resonance Spectroscopy

a) Nuclear Magnetic Resonance Spectroscopy: Basic principles – magnetic resonance – relaxation processes – pulsed (Fourier Transform) NMR – wide line NMR spectrometers – Spectra and molecular structure – chemical shifts – spin-spin coupling – integration – applications. (8 hours)

b) Electron Spin Resonance Spectroscopy: Basic principles – ESR spectrometer – ESR spectra – Hyperfine interaction – g-factor – line widths – applications. (5 hours)

c) NQR Spectroscopy: Quadrupole Hamiltonian- Nuclear Quadrupole energy level for axial and non-axial symmetry – Experimental techniques and applications. (5 hours)

d) Mossbauer Spectroscopy: Principles of Mossbauer spectroscopy – Chemical shifts – Quadrupole splitting and Zeeman splitting – applications of Mossbauer spectroscopy – applications. (5 hours)

Unit VI: Laser Spectroscopy: Basic principles: Comparison between conventional light sources and lasers-Saturation-Excitation methods-Detection methods-Laser Wavelength Setting-Doppler Limited Techniques. (5 hours)

Books for Study:

1	Introduction to Atomic Spectra	H. E. White	
2	Spectroscopy Vol. 1 to 3	B. P. Straughan and S. Walker	
3	Raman Spectroscopy	D. A. Long	
4	Microwave Spectroscopy of Gases	T. M. Sugdan & C. N. Kennay	
5	Microwave Spectroscopy	Tores and Schawlow	McGraw Hill
6	High Resolution NMR	Schnoider and Berstin	McGraw Hill
7	Introduction to ESR	Assenheim	Plenum Press
8	Nuclear Quadrupole Resonance Spectroscopy	T. P. Das and E.E. Hahn	Academic Press
9	Mossbauer effect and its application to Chemistry	Goldanskil	Von Nestrand

PHYS-533: LIQUID AND POLYMER PHYSICS **3-0-0-3**

Unit I: Liquid State

Classification of liquids (ionic, molecular and simple) – potential functions – structural determinations – molecular motions in liquids.

Unit II: Equilibrium Structure of Dense Fluids

Molecular distribution – thermodynamic functions in dense fluids – equation for pair distribution functions – Kirkwood superposition approximation – critical phenomena: critical properties of Van der Waals fluid – experimental determination of critical exponents – structural behavior at critical point – Ising model and Onsager's solution.

Unit III: Liquid Solutions

Ideal and non-ideal solutions – Henry's law – activity coefficient – binary mixtures – excess thermodynamic properties – two component system with solid and liquid phases – dielectric and acoustic properties of solutions.

Unit IV: Liquid Crystal

Classification of liquids crystals and phase transitions (nematic, semetic, cholestric) – Marier-Saupe theory – detection by microscopic techniques – phases of the lyotropic system and their application in Biological systems – thermotropic liquid crystal and its applications.

Unit V: Polymer Physics

Classification – molecular weight and size – addition polymerization and co-polymerization – determination of molecular weight and size – structure properties: crystal structure of polymers – morphology of crystalline polymers - XRD studies – visco-elasticity of polymers – acoustical technique – glassy state and glass transition – properties of commercial polymers.

References:

1	Introduction to Liquid State Physics	C. A. Croxton	John Wiley & Sons, 1975
2	Theory of Simple Liquids	N. Pierre Hausen and Ion R. McDonald	Academic Press, 1986
3	Text Book of Polymer Science	Fred W. Billmeyer	John Wiley & Sons 1984
4	Polymer Science	V.R. Gowarikar, N. V. Vishwanath & Jayadev and Sreedhar	Wiley Eastern Ltd., 1987
5	Liquid Crystals	S. Chandrasekar	Academic Press
6	Physical Chemistry	R. A. Abberty	John Wiley & Sons

PH-534: ADVANCED ELECTRONIC DEVICES AND CIRCUITS **(3 credits)**

Unit I: Advanced Electronic Devices –(10 lecture hours)

Advanced Electronic Devices: Schottky diodes, MESFET, IGBT, Thyristors, Diac, Triac, Charge-coupled devices – Structure and working, V-I characteristics and applications.

Unit II: **Other Electronic Devices (10 lecture hours)**

Other Electronic Devices: Electro-optic, magneto-optic, Acousto-optic, Piezo-electric, Electro-strictive, magneto-strictive effects, related material properties for these effects – application in sensor and actuator devices.

Unit III: **Programmable devices (16 lecture hours)**

Programmable devices: PAL, PLA, PLD, CPLD and FPGA – Structure and working, comparison with standard logic devices and application – Memories – Classification of memories, Static and dynamic shift register ROM, PROM, EPROM – Principle and operations, Read/write memories – SRAM, DRAM, DDRAM – Principle and operations – recent advancement in solid-state memories.

Unit IV: **Dataconversion circuits (12 lecture hours)**

Data conversion circuits: Digital to Analog conversion – Weighted and R-2R ladder networks, Frequency to Voltage converters, Analog – to – Digital conversion methods – integrating – single and dual slope converters, Successive approximation, Voltage to frequency and flash converters – Principle, operation and applications.

Text Books

1	Microprocessor architecture, programming and applications with 8085/8085A	Ramesh S. Ganokar	Wiley Eastern Ltd.
2	Microprocessors and interfacing	Dauglaus V. Hall	
3	Assembly language programming	Lance A. Leventhal	Prentice Hall of India Pvt. Ltd.
4	Microprocessors and programmed logic	Kenneth L. Sherl	Prentice Hall of India Pvt. Ltd.
5	Microprocessors and microcomputer system	Guthikonda V. Rao	

PH-535: LASER THEORY **3-0-0-3**

UNIT :1 BRIEF REVIEW OF WAVE & PARTICLE NATURE OF LIGHT **10 hours**

Maxwell's equations; Wave equations, Origin of refractive index; Coherence; Quantum theory of Atomic energy levels & selection rules for single electro & multi-electron atoms.

UNIT : 2 RADIATIVE TRANSISTION, PROPERTIES OF MOLECULES, LIQUIDS, SOLIDS **10 hours**

Decay of excited states, Emission broadening & line width due to radiative decay,

Different broadening mechanism of emission spectra, Radiation laws- cavity radiation, absorption and stimulated emission- Einstein's A & B Coefficient.

UNIT : 3 INTRODUCTION TO LASERS **10 hours**

Condition for producing a laser – population inversion, gain & gain saturation; Saturation intensity, Threshold requirement for a laser, laser oscillation above threshold. Requirements for obtaining population inversion- 2, 3 and 4 level systems; Steady state and transient population process that destroy population Inversion.

UNIT : 4 LASER PUMPING REQUIREMENTS & TECHNIQUES **8 hours**

excitation threshold requirement, pumping pathway, Specific excitation parameters associated with optical & particle pumping.

UNIT : 5 LASER RESONATORS **10 hours**

Laser cavity modes- longitudinal & transverse cavity modes . Properties of laser modes –Mode characteristics & effect of modes in gain profile, Stable laser resonators & propagation of Gaussian beams using ABCD matrices.

Textbooks

1. William T .Silfvast. Laser Fundamentals.
2. Peter W . MIlonni & Joseph H .Eberly. Lasers.
3. Amnon Yariv. Quantum Electronics

PHYS 536 Nonlinear Optics and Materials **3-0-0-3**

Maxwell Equations, Wave Equations in various media and its propagation- (Brief Survey) Origin of Complex Refractive Index -Classical theory of Optical Absorption (Electron Oscillator Model) and Dispersion (Lorentz Oscillator Model). Classical theory of anharmonic oscillators.

Wave equations description of nonlinear optical susceptibilities Quantum mechanical treatment of nonlinear optical susceptibilities, Frequency and intensity dependence of polarization and dielectric susceptibility First order and higher order susceptibilities

Second order optical nonlinearities

Second harmonic generation –sum and difference frequency generation, parametric processes- Simple theory and calculation of nonlinear polarization –Various phase matching technique in SHG

Third order optical nonlinearities

Third harmonic generation, Four wave mixing, Kerr Nonlinearity, Intensity dependent effect, Self Phase modulation, Cross phase modulation Stimulated Raman Scattering (SRS) Stimulated Brillioun Scattering, Parametric gain –Parametric amplification and oscillation Applications frequency mixing and upconversion Difference frequency generator, Optical Phase Conjugation-Theory and Applications, Photorefractive effect and applications, Solitons-Theory and applications – Optical bistability.

Nonlinear optical materials (Structure property relations and its applications):

Nonlinear Optics of Organics and Polymers, Liquid Crystal, Photorefractive materials, Organic doped glasses, Rare earth doped glasses and crystals, Semiconductors, Optical Fibers and Photonic Crystals Fibers, Ferroelectric Materials and other Novel optical materials

Text Book and References

Nonlinear Optics– Robert W Boyd
Nonlinear Photonics-Y Guo, C K Kao, E.H.Li, K. S.Chiang
Principles of Nonlinear Optics- Y R Shen
Nonlinear Optics – N. Bloembergen
Nonlinear Optics of Organic Molecules and Polymers- H S Nalwa and S Miyata
Optical Phase Conjugation-R A Fischer
Quantum Electronics–A Yariv
Handbook of Nonlinear Optics-R Sutherland
Growth and Characterization of Nonlinear Optical Materials – N B Singh

PHYS-537: EXPERIMENTAL DESIGN **3-0-0-3**

UNIT – I: **18 hours**

Measurement of fundamental constants: *e, h, c* – Measurement of high and low resistances, inductance and capacitance – Detection of X-rays, Gamma rays, charged particles, neutrons – Ionization chamber – Proportional counter – GM counter – Scintillation detectors – Solid State detectors – Emission and Absorption Spectroscopy – Measurement of Magnetic field – Hall effect – Magnetoresistance – X-ray and neutron Diffraction.

UNIT – II: **15 hours**

Vacuum Techniques – Basic idea of conductance, pumping speed – Pumps: Mechanical Pump – Diffusion pump – Gauges – Thermocouple gauge – Penning gauge – Pirani gauge – Hot Cathode gauge – Low temperature systems – Cooling a sample over a range up to 4 K – Measurement of low temperatures.

UNIT – III: **15 hours**

Measurement of energy and time using electronic signals from the detectors and associated instrumentation – Signal processing – A/D conversion – multichannel analyzers – Time-of-flight technique – Coincidence Measurements – true to chance ratio – Correlation studies. Error Analysis and Hypothesis testing – Propagation of errors – Plotting of Graph – Distributions – Least squares fitting – Criteria for goodness of fits – Chi square test.

Textbooks

1. J.P. Holman (2000). *Experimental Methods for Engineers*. 7th Edition. McGraw Hill.
2. J. M. Lafferty (Editor) (1998). *Foundations of Vacuum Science and Technology.* Wiley Interscience.
3. Anthony Kent (1993). *Experimental Low-Temperature Physics* (Macmillan Physical Science).
4. Douglas C. Montgomery (2004). *Design and Analysis of Experiments*. John Wiley.

Supplementary reading

1. T. G. Beckwith, R. D. Marangoni, J. H. Lienhard (2006). *Mechanical Measurements* (6th Edition). Prentice Hall.
2. Ernest O Doebelin. *Measurement Systems: Application and Design*. 5th edition. Tata McGraw Hill.
3. Albert D Helfrick and William D Cooper (1992). *Modern Electronic Instrumentation and Measurement Techniques*. Prentice Hall.
4. Hermann K P Neubert (2003). *Instrument Transducers: An introduction to their performance and design*. Oxford University Press.
5. J. A. Blackburn (2001). *Modern Instrumentation for Scientists and Engineers*. Springer.

PHYS 538: ION BEAMS IN NANOTECHNOLOGY **(3-0-0-3)**

Unit – I:

Introduction: Effect of size on material properties, Quantum size effect and density of states, low dimensional systems and their applications. Introduction to microscopy: SEM, STM, AFM, TEM and their application in nanotechnology. (12 hours)

Unit – II:

Ion – Solid interactions: Stopping and range of ions in solids, elastic collisions and kinematics, swift heavy ions, Coulomb explosion and thermal spike models, Nanotrack formation and its applications in nano technology. (10 hours)

Unit – III:

Ion beam techniques: RBS, ERDA, NRA and PIXE, Ion channeling, defect analysis, lattice location and lattice strain measurements, Quantum well intermixing and band-gap tuning. (12 hours)

Unit – IV:

Ion beams in nano-technology: Ion irradiation of surfaces, surface roughness, formation of nanopores, hillocks and self assembled nanodots, embided nanoparticles and their applications in optoelectronics, Focused ion beams, nano-scale fabrication, ion beam milling and nanolithography. (14 hours)

Textbooks:

"Fundamentals of nanoscale film analysis" , T. L. Alford, L.C. Feldman and J. W. Mayer, Springer USA, 2007.

Handbook of nano-structured materials and nanotechnology", Ed. H.S. Nalwa, Acad. Press, CA, 2000.

PHYS 541 NUCLEAR PHYSICS **3-1-0-4**

Unit I: **Nuclear Models:**
Gas model – liquid drop model – semi-empirical mass formula – magic numbers – shell model – isomers – isospin – parity – magnetic moment electric quadropole moment - collective model.

Unit II: **Nuclear Forces:**
Introductory ideas about nuclear forces and range. Central force – Deuteron problem – n-p, p-p scattering at low energy – effective range theory – Wigner's hypothesis – electric quadropole moment of Deuteron – Introductory idea about Bartlet, Majorana, Heisenberg exchange forces – concept of Isotopic spin – Yukawa meson theory.

Unit III: **Nuclear Decay:**
Stability of nuclei – Decay – decay-Gamow's theory Geiger Nutall law - s
energies of -spectrum – conservation of parity – weak interactions – selection rule – pair production – internal conversion – Gamma decay – selection rule.

Unit IV: **Nuclear Reactions:**
Conservation laws – Q value – Breit Wigner formula – Nuclear fission reaction – cross section – fission products – energy release – fissioability parameter (theory of fission) – nuclear fusion – thermo nuclear reactions.

Unit V: **Elementary Particles:**
Classification – symmetries and violations of symmetry – properties and decay models of Baryons, Mesons, Hardons. Tau-Theta Puzzle – stangeness and charm, SU(3) classification – strong interaction – idea of Quarks electro weak and GUT(introductory idea).

Text Books:

1	Nuclear Physics	Roy & Nigam	Wiley, 1986
2	Nuclear Physics	D. C. Tayal	Himalaya, 1987
3	The Atomic Nucleus	J. M. Reid	Manchester University Press, 1984
4	Fundamental Particles	B. G. Dutt	Taylor Fransis, London, 1986
5	Idea of Particle Physics	J. E. Dodd	Cambridge University Press, 1984
6	Concept of Modern Physics	Beiser	McGraw Hill, 1988
7	Modern Physics	Mani and Metha	Tata McGraw Hill, 1988

References:

1	The Atomic Nucleus	D. Evans	McGraw Hill, 1955
2	Nuclear Physics	Irving Kaplan	Narosa, 1987
3	Concepts of Nuclear Physics	L. Cohen	Tata McGraw Hill, 1985
4	Theoretical Nuclear Physics	Blatt & Weiskosf	Wiley, New York, 1952
5	Introduction to Nuclear Physics	H. A. Enge	Addison Wesley Pub. 1966
6	Elementary Particles	I. S. Hughes	Cambridge, 1985
7	Elementary Nuclear Theory	H. A. Bethe & D. Morrison	John Wiley & Sons, New York, 1956
8	Nuclei and Particles	E. Segre & W. A. Bergemin	New York, 1964.

PHYS- 542 LASER SYSTEMS **3-0-0-3**

UNIT : 1

SPECIAL LASER CAVITIES & CAVITY EFFECTS

Unstable resonator, Q-switching, Mode locking, Ring laser, Cavities for producing spectral narrowing of laser output, laser cavities requiring small-diameter gain region- astigmatically compensated cavities.

UNIT : 2

SPECIFIC LASER SYSTEM -1

He-Ne laser, Argon ion laser, Helium-Cadmium laser, Copper-vapor laser, Carbon-dioxide laser, Excimer laser, Nitrogen laser, Far-Infrared gas laser.

UNIT : 3

SPECIFIC LASER SYSTEM – 2

Chemical laser, X-ray laser, Free-electron laser, Dye lasers, Ruby laser, Nd-YAG laser, Alexandrite laser, Ti-sapphire laser, Fiber laser, Color center laser, Semi-conductor lasers.

UNIT : 4

ULTRA SHORT PULSE LASER

Concept of measuring brief intervals of time- Pico seconds & femto second Techniques. Method of generating pulses-optical pulse properties & methods of measurement of pico & femto second pulses.

UNIT : 5

FREQUENCY MULTIPLICATION OF LASER BEAMS

Second order nonlinear process. Second Harmonic Generation (SHG), Sum Frequency & Difference frequency Generation. Optical parametric oscillator, Third Harmonic Generation (THG). Phase matching & methods of phase matching Saturable absorption.

Books

1. Laser Fundamentals William T. Silfvast (Cambridge University Press)
2. Lasers Peter W. Milonni & Joseph H. Eberly.
3. Femto second laser pulses Claude Rulliere (Springer Verlag Publications)
4. Ultra short light pulses- Picosecond techniques & applications—S.L. Shapiro

PHYS-543: PHYSICS OF AMORPHOUS MATERIALS **3-0-0-3**

Unit I: Amorphous Materials

Definitions – preparations of amorphous materials (a) thermal evaporation (b) sputtering (c) melt quenching (d) Gel desiccation (e) solid state diffusional amorphization – Glasses: The glasses transition – theories of glass transition – glass forming systems.

Unit II: Microscopic Structure of Amorphous Materials

Diffraction – X-ray absorption spectroscopy – magnetic resonance – structural modeling: Dense random packing – continuous random packing.

Unit III: Atomic Transport

Theory of ionic conductivity – ionic conductivity in crystalline solids and amorphous solids – electrode polarization – solid electrolyte and fast ion conductors – criterion for fast ion conductors – frequency dependence transport.

Unit IV: Dielectric Properties of Amorphous Materials

Relation of dielectric constant and polarization – dipolar polarization theory – time dependence of polarization – Cole-Cole distribution – temperature dependence of dipolar polarization – composition and structural effects of glasses.

Unit V: Electronic Properties of Amorphous Materials

Electron density of states – theoretical calculation – experimental determinations – D.C. electrical conductivity Hlall effect – Frequency dependence conductivity.

Unit VI: Applications of Amorphous Materials

Electrochemical applications – solid state batteries – electrochemical sensors – electronic applications – electro photographic applications – thin film resistors – Solar cells.

Text Books:

1	Glass: Structure by Spectroscopy	J. Wong and C. A. Angell	Dekker, 1976
2	Chemistry of Glasses	A. Paul	Chapman and Hall 1990
3	Electronic Process in Non-Crystalline Materials	N. F. Mott and E. A. Davis	1979
4	Physics of Amorphous Materials	S. R. Elliot	Longman Scientific & Technical, 1990
5	Principles of Electronic Ceramics	I.L. Hench and J. K. West	John Wiley & Sons
6	The Physics of Amorphous Solids	R. Zallen	Wiley 1983

PHYS-544: PHYSICS OF CRYSTALLINE MATERIALS **3-0-0-3**

Unit I: **Materials Preparation and Characterization:**
Different techniques of growing crystals – characterization techniques – X-ray diffraction, transmission electron microscope, Auger electron spectroscopy and ESCA.

Unit II:
Structure of the solid phase – structural disorder – imperfections in crystals – point defects – dislocations and grain boundaries.

Unit III:
Phase diagram for one and two components – solid solutions – interstitials and substitutional solid solutions.

Unit IV:
Atomic process of solids – diffusion in solids – self-diffusion – Fick's law of diffusion – solution of Fick's law of diffusion – solution of Fick's second law and diffusion in compounds.

Unit V:
Deposition of thin films – vacuum techniques – thermal evaporation – sputtering – chemical methods of deposition – growth of thin films – deposition of thin films – capabilities and limitations of thin films and their applications.

Unit VI:
Type I and type II superconductors – high temperature superconductors – ceramic superconductors – synthesis of $YBa_2Cu_3O_{7-x}$ compounds and their applications.

References:

01	Introduction to Crystal Growth	P. Harmon	North Holland, 1973
02	Materials Science for Engineers	Van Vlack	Addison Wiley, 1970
03	Materials Science and Engineering	V. Raghavan	Prentice Hall
04	Solid State Phase Transitions	V. Raghavan	Prentice Hall
05	Hand Book of Thin Film Technology	Meissel & Glong	McGraw Hill
06	Introduction to Solid State Physics	C. Kittel	

PHYS – 545: SIGNAL PROCESSING AND COMMUNICATION 3-0-0-3

Unit I : Signals (5 lectures)

Signals, classification of signals, basic operation on signals, elementary signals, systems, properties of systems, linear time invariant systems and their properties.

Unit II: Fourier Representation (13 lectures)

Fourier representation for four class of signals, discrete – time periodic signals, discrete- time Fourier series , continuous time periodic signals and the Fourier series , discrete time non- periodic signals, and the discrete time Fourier transform, continuous time non periodic signals and the Fourier transform

Unit III: properties of Fourier representation (10 lectures)

Linearity and symmetry property, convolution property, differentiation and integration, time and frequency shift property, Parseval relationship, Time-Bandwidth product, Duality.

Unit IV: sampling (8 lectures)

Sampling continuous time signals, sampling a sinusoid, aliasing, sub-sampling, sampling theorem, ideal reconstruction and practical reconstruction: zero order hold.

Unit V: Communication (6 lectures)

Types of modulation, full amplitude modulation, generation, frequency domain representation of amplitude modulation, spectral overlap and demodulation.

Text Books:

1. Signals and Systems (II edition);S.Haykin and B.Van Veen, Wiley Student Edition.
2. Signal processing and linear systems; B.P.Lathi, Oxford University Press Inc.(USA),2003.
3. System analysis and signal processing; P.N.Denbigh, Addison Wesley, 1998.
4. Signals, systems and signal processing; S.P.Eugene Xavier

PHYS – 546: POWER ELECTRONICS AND MICROCONTROLLERS **3-0-0-3**

UNIT – I: Introduction **12 hours**

Overview of power electronics – Historical development of power electronics – Classification power semiconductor devices – Power diodes – Thyristors – power MOSFETs – IGBTs – Ratings of power semiconductor devices – Symbols and characteristics – Ideal and practical characteristics – Switching specifications – Block diagram of an uninterrupted power supply.

UNIT – II: Power Diodes and Circuits **12 hours**

Review of semiconductor diodes – Reverse recovery characteristics – Types of power diodes – General purpose, fast recovery and Schottky diodes – Silicon carbide diodes – Diodes with *RC, RL, LC* and *RLC* loads – Freewheeling diodes – Performance parameters of a battery charger – Problems solving.

UNIT – III: Power MOSFET and IGBT **12 hours**

Review of semiconductor MOSFET – Switching characteristics – Power MOSFET – Steady state characteristics – Switching characteristics – IGBT – Symbol and equivalent circuit representation and its operation – Thyristors – On and Off operation – Types of thyristors – Phase controlled and fast-switching thyristors – Problem solving.

UNIT – IV: The 8051 Microcontroller **12 hours**

Introduction and features of 8086, 8088, 80186, 80286, 80386 and 80486 – Comparison between a microprocessor and microcontroller – Key features and architecture of 8051 microcontroller – Memory organization – SFR – Counter and timers – Assembly language programming of 8051 – Software time delay – Interfacing of microcontroller – Keyboard and stepper motor control.

Textbooks

1. (Units – I, II, III) : M. H. Rashid (2004) *Power Electronics*. 3rd edition. Prentice Hall of India.
2. (Unit – IV) : Kenneth J Ayala. *The 8051 Microcontroller.* Penram International.

PHYS – 547: VISUAL PROGRAGRAMMING **2-0-1-3**

UNIT – I: **10 hours**

Review of C++ programming – C++ streams – Console streams – Console stream classes-formatted and unformatted console I/O operations, manipulators – File streams – File pointers and manipulations of file I/O – Exception handling – Object-oriented paradigm – Elements of object oriented programming – Merits and demerits of OO (object oriented) methodology – Classes and objects – constructors and destructors – Operator overloading – Data encapsulation – Member functions – Inheritance – Virtual functions – Polymorphism.

UNIT – II: **10 hours**

Review of procedure oriented programming – Introduction to events – Event handling principles – GUI concepts – Overview of Windows programming – Creating the window – Displaying the window – message Loop – windows procedure – painting and repainting – WM_PAINT message – WM_DESTROY message – An Introduction to GDI – Child window control.

UNIT – III: **10 hours**

Visual Basic Programming: IDE – Introduction to Forms – Intrinsic Controls –Working with files – Accessing databases with data control – Classes and Objects – ADO Object Model – Using Windows Common dialogs – Introduction to dynamic link library.

UNIT – IV: **10 hours**

Visual C++ Programming: Windows Programming Model – Visual C++ components – Microsoft foundation classes Library (MFC) – Application Framework – Using AppWizard – Basic Event handling – Graphics Device Interface, Colors and fonts – Modal and Modeless Dialogs – Windows common dialogs – Windows Message Processing and Multithreading.

UNIT – V: Laboratory Exercise Session (1 hour per week) **10 hours**

The laboratory sessions involve exercise on the following: Creation of files and file handling – Classes with primitive data members – Classes with arrays as data members – Classes with pointers as data members – String Class – Classes with constant data members – Classes with static member functions – Operator Overloading – Function Overloading – Writing code for keyboard and mouse events – Creating Dialog Based applications – Creating SDI and MDI applications.

Textbooks

1. (Units-I, II): Charles Petzold (1996). *Windows Programming*, Microsoft press.
2. (Unit-III): Francesco Balena (2001). *Programming Microsoft Visual Basic 6.0.* Microsoft press.
3. (Unit-IV): David Kruglirski (1998). *Programming Microsoft Visual C++ 6.0.* Microsoft press.