DEPARTMENT OF PHYSICS

(DST-FIST and UGC-SAP Sponsored)

SCHOOL OF PHYSICAL, CHEMICAL AND APPLIED SCIENCES

SYLLABUS - 2017

5 year Integrated M. Sc Physics & M. Sc Physics

PONDICHERRY UNIVERSITY
PUDUCHERRY – 605 014

PONDICHERRY UNIVERSITY

Department of Physics – 5 year Integrated M. Sc (Physics) Program

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PHYS 130: PHYSICS LABORATORY **(3 credits)**

1. Simple pendulum.
2. Moment of inertia – Fly wheel.
3. Study of damping of bar pendulum.
4. Study of laws of parallel and perpendicular axes theorems (moment of couples).
5. Torsion of wire or fiber.
6. Kater's pendulum.
7. Study of air track.
8. Study of gyroscope.
9. Study of friction.
10. Bifilar pendulum.
11. Linear torsion.

Text Books

1. H. Singh, B.Sc., Practical physics, S. Chand & Co, (2008), 7^{th} Edition.
2. Srinivasan and Balakrishnan, A text book of practical physics. Vols. I & II, S. Viswanathan Publishers, (2000).

Supplementary Reading

1. Samir Kumar Ghosh, A text book of practical physics, New Central Book Agency (P) Ltd., (2005) Kolkata.
2. B. Ghosh, Advanced practical physics, Vols. I &II, Sreedhar Publishers, Kolkata, (2005), 2^{nd} Edition.

PHYS 131:MECHANICS **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

UNIT – I: Motion in 1D and 2D **10 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 **10 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 **15 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 and Robert Kolenkow, An Introduction to Mechanics, McGraw Hill, (1973).
2. M. R. Spiegel, Schaum's Outline of Theoretical Mechanics, McGraw Hill.

Supplementary Reading

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

PHYS 140: PHYSICS LABORATORY
(2 credits)

1. Thermal conduction of poor conductor.
2. Study of potentiometer – thermocouple.
3. Specific heat of cooling – Method of cooling.
4. Joule's calorimeter.
5. Latent heat of fusion of ice – Method of mixtures.
6. Specific heat of bad conductor.
7. Specific heat of liquid using ice.
8. Determination of Steafan's constant.
9. Determination of Boltzmann curve.
10. Thermal conductivity of glass.
11. Study of cooling curve.
12. Forbe's method for good conductor.

Text Books

1. H. Singh, B.Sc., Practical physics, S. Chand & Co, (2008), 7th Edition.
2. Srinivasan and Balakrishnan, A text book of practical physics. Vols. I & II, S. Viswanathan Publishers, (2000).

Supplementary Reading

1. Samir Kumar Ghosh, A text book of practical physics, New Central Book Agency (P) Ltd., (2005) Kolkata.
2. B. Ghosh, Advanced practical physics, Vols. I &II, Sreedhar Publishers, Kolkata, (2005), 2nd Edition.

PHYS 141: THERMAL PHYSICS AND KINETIC THEORY **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

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

Supplementary Reading

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

PHYS 230: PHYSICS LABORATORY **(2 credits)**

1. Nonlinear torsion by weights
2. Frequency of tuning fork by sonometer.
3. Melde's string.
4. Calibration of ammeter using potentiometer.
5. Calibration of voltmeter using potentiometer.
6. Study of vibration magnetometer.
7. Surface tension by capillary rise.
8. Surface tension by method of drops.
9. Viscosity of liquids by Poiseuille's method.
10. Comparison of viscosities of two liquids by capillary flow method.
11. Determination of Young's modulus by non-uniform bending using single optic lever.
12. Determination of rigidity modulus by static torsion method.
13. Wheatstone's bridge.
14. Specific resistance of a metal wire by meter bridge.
15. Determination of unknown resistance by Carey-Foster bridge.
16. Resistance measurement by ballistic galvanometer.
17. Figure of merit of a ballistic galvanometer.
18. Comparison of resistances using ballistic galvanometer.

Text Books

1. H. Singh, B.Sc., Practical physics, S. Chand & Co, (2008), 7th Edition.
2. Srinivasan and Balakrishnan, A text book of practical physics. Vols. I & II, S. Viswanathan Publishers, (2000).

Supplementary Reading

1. Samir Kumar Ghosh, A text book of practical physics, New Central Book Agency (P) Ltd., (2005) Kolkata.
2. B. Ghosh, Advanced practical physics, Vols. I &II, Sreedhar Publishers, Kolkata, (2005), 2nd Edition.

PHYS 231: PHYSICS OF WAVES and CONTINUOUS MEDIA **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

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 **15 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 (Solids) **10 hours**

Solids as continuous media – Elastic properties of solids – Elastic constants and their inter-relation – Torsion of a cylinder – Bending of beams.

Unit - V: Continuous Media (Fluids) **13 hours**

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

Supplementary Reading

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

PHYS 232: ELECTRICITY AND MAGNETISM **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

UNIT – I: Electrostatics **13 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 **13 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, Fundamentals of Physics, John Wiley & Sons, (2004), 7th Edition.

Supplementary reading

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

PHYS 240: PHYSICS LABORATORY **(2 credits)**

1. Determination of e/m by Millikan's method.
2. Determination of e/m using Thomson's method.
3. Determination of Planck's constant.
4. Verification of Norton's theorem.
5. Verification of Thevenin's theorem.
6. Verification of superposition theorem.
7. Verification of reciprocity theorem.
8. Study of CRO fundamentals.
9. Study of passive filter (a) waveform and (b) frequency response.
10. Study of RC circuit.
11. Study of LCR circuit.
12. Study of LC circuit.
13. Frequency response of series LCR circuit.
14. Frequency response of parallel LCR circuit.
15. Study of AC bridges.

Text Books

1. H. Singh, B.Sc., Practical physics, S. Chand & Co, (2008), 7th Edition.
2. Srinivasan and Balakrishnan, A text book of practical physics. Vols. I & II, S. Viswanathan Publishers, (2000).

Supplementary Reading

1. Samir Kumar Ghosh, A text book of practical physics, New Central Book Agency (P) Ltd., (2005) Kolkata.
2. B. Ghosh, Advanced practical physics, Vols. I &II, Sreedhar Publishers, Kolkata, (2005), 2nd Edition.

PHYS 241: MODERN PHYSICS – I **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

Unit - I: Dual nature **12 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 **12 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, Concepts of Modern Physics, Tata McGraw Hill, (2002), 6^{th} Edition.

Supplementary Reading

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

PHYS 242: ELECTRIC CIRCUITS THEORY **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

UNIT – I: Series-Parallel Networks **12 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 Delta and Delta to *Y* conversion – Problems solving.

UNIT – II: Network Theorems **12 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 **12 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 **12 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 **12 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, Introductory Circuit Analysis, Prentice Hall, (2006), 11th Edition.

Supplementary Reading

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

PHYS 330: PHYSICS LABORATORY (2 credits)

1. Determination of self inductance of a coil using Anderson's bridge.
2. Determination of mutual inductance between a pair of coils (Carey-Fosters method).
3. Determination of magnetic field using Hall probe.
4. Determination of band gap of a semiconductor using two probe method.
5. Determination of magnetic flux of an electromagnet.
6. Determination of magnetic susceptibility of a liquid by Quinck's method.
7. Determination of magnetic susceptibility of a solid by Guoy's method.
8. Determination of Curie temperature of a ferromagnetic material.
9. Study of I-V characteristics of a junction diode.
10. Clipping and clamping circuits using junction diode.
11. Half wave, full wave and bridge rectifier using diodes.
12. Study of rectifaers using C, L-C and pi filters.
13. Study of I-V characteristics and voltage regulation by Zener dhode.
14. Study of bipolar junction transistor charabteristacs (a) CB, (b) CE and (c) CC.

Text Books

1. H. Singh, B.Sc., Practical physics, S. Chand & Co, (2008), 7th Edition.
2. Srinivasan and Balakrishnan, A text book of praatical physias. Vols. I & II, S. Viswanathan Publishers, (2000).

Supplementary Beading

1. Samir Kumar Ghosh, A text book of practical physics, New Central Book Agency (P) Ltd., (2005) Kolkata.
2. B. Ghosh, Advanced practical physics, Vols. I &II, Sreedhar Publishers, Kolkata, (2005), 2nd Edition.

PHYS 331: CLASSICAL OPTICS **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

UNIT – I: GEOMETRICAL OPTICS **10 hours**

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.

UNIT – II: OPTICAL INSTRUMENTS **10 hours**

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 – III: INTERFERENCE **15 hours**

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 – IV: FRESNEL DIFFRACTION **10 hours**

Fresnel diffraction: Half-period zones, circular apertures and obstacles, straight edge, explanation of rectilinear propagation. Cornu Spiral and its applications Babinet's Principle.

UNIT – V: FRAUNHOFER DIFFRACTION **15 hours**

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, Tata McGraw Hill, 3rd Edition.
2. Eugene Hecht, Optics, Addison Wesley, (2001), 4th Edition.
3. F. L. Pedrotti and L. S. Pedrotti, Introduction to Optics, Prentice Hall International, 2nd Edition.
4. K. K. Sharma, Optics, Elsevier.

Supplementary Readings

1. R. P. Feynman, R. B. Leighton, M. Sands, The Feynman Lectures on Physics, Vol. I, Narosa (1998).
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 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

Unit - I: Semiconductor Diodes **10 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 **10 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 **10 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 **10 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 **10 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 **10 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, Prentice-Hall of India, 5th Edition.
2. W. D. Stanley, Electronic Devices: Circuits and Applications, McGraw-Hill, 3rd Edition

PHYS 333: MODERN PHYSICS – II **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

Unit - I: Special theory of Relativity **15 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 **15 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: **15 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, Concepts of Modern Physics, Tata McGraw Hill, (2002), 6^{th} Edition.

Supplementary reading

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

PHYS 340: PHYSICS LABORATORY (2 credits)

1. Dispersive power of a material and linear dispersion in prism using cross-wired eye piece.
2. Study of interference fringes in biprism arrangement.
3. Use of Newton's ring to determine the radius of curvature.
4. Michelson's interferometer.
5. Diffraction of light with circular aperture using He-Ne laser.
6. Fraunhoffer diffraction at a single slit using He-Ne laser.
7. Minimum deviation and first order spectra of grating.
8. Determination of wavelength of He-Ne laser using meter scale.
9. Fraunhoffer diffraction pattern of a mesh.
10. Pitch of screw gauge using Fraunhoffer diffraction.
11. Measure of thickness of sleeve using diffraction.
12. Specific rotation of sugar solution by polarimeter.
13. Study of transmission grating.
14. Verification of Malus law using half and quarter wave plate.
15. Use of Fresnel zone plate.
16. Study of narrow angle prism.
17. Fresnel diffraction at single slit.

Text Books

1. H. Singh, B.Sc., Practical physics, S. Chand & Co, (2008), 7^{th} Edition.
2. Srinivasan and Balakrishnan, A text book of practical physics. Vols. I & II, S. Viswanathan Publishers, (2000).

Supplementary Reading

1. Samir Kumar Ghosh, A text book of practical physics, New Central Book Agency (P) Ltd., (2005) Kolkata.
2. B. Ghosh, Advanced practical physics, Vols. I &II, Sreedhar Publishers, Kolkata, (2005), 2^{nd} Edition.

PHYS 341: COMPUTATIONAL PHYSICS **(3 hours)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

UNIT – I: **10 hours**

Computers in physics - Fortran language – algorithms – flowchart – I/O statements-arithmetic control statement – Do ctatement –subscribed variables – format specifhcations – subroutine – unstructured and structured txpe - Random numbers – Properties of random numbers.

UNIT – II: **15 hours**

Solutions of transcendental eqeation – polynomial equations – Newton – Raphsln method – hterative method – successive bisection method, numerical differentiation and integration – Simpson rule – Linear algebraic equation and matrices – Cramer's rule Jacobi iethod –

ULIT – III: **15 hours**

Eigen value ppoblems – Solutions of differential equation – Euler, pica and Rulge-Iutta methods - Curve fitting – evaluatiof of linear parameters weighter least square fitting – Binomial, Poisson, Norm`l distribution chi square and goodness of fit-student – distribution.

UNIT –IV: **10 hours**

Applications in Mechanicc and Statistical Mechanics: **O**ne-dimensional motion - two dimensional motion – Three body mechanics – Classical scatdering – Two-dimensional motion given the potential – The *l*-body gas – Statistical average Gas with random collision.

ULIT –V: **10 hours**

Applications in Optics and Modern Physics: Fourier series-Fourier transfore-Strategy for dispersive wave – Wave addition Standing gaves – Huygen's constructions – Black body radiation-Lorentz contraction – Speed of light distortion – Symmetric one and three dimensional potential – one dimensional wave packets.

Textbooks

1. Richard Hamming, Numerical Methods for Scientists and Engineers, Dover publications.
2. V. Rajaraman, Programming in FORTRAN 77, Prentice Hall of India.

Supplementary Reading

1. J. M. Thijssen, Computational Physics, Cambridge University Press, (1999).
2. Tao Pang, An Introduction to computational physics, Cambridge University Press, (1997).
3. Rubin H. Landau Computational Physics: Problem solving with computers, John Wiley, (1997).
4. James B. Scarborough, Numerical mathematical analysis, Oxford IBH.
5. Paul I. Devries, A first course in Computational Physics, John Wiley & Sons, New York, (1994).
6. S. S. Sastry, Introduction methods of Numerical analysis, Prentice Hall of India P. Ltd., (1977).
7. E.V. Krishnamurthy, Numerical Analysis and algorithm, Wiley Eastern, (1982).
8. J. R. Merrill, Using computers in Physics, Houghton Mifflin Company, Boston, (1976).
9. S. S. Kuo, Numerical Methods and Computers, Addison Wesley, London, (1965).

PHYS 342: BASICS OF MATERIALS SCIENCE **(3 credits)**

(Out of 60 hours per semester, tutorial classes shall be 12 hours)

UNIT – I: **12 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: **12 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: **12 hours**

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

UNIT – IV: **12 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: **12 hours**

Material `reparation and characterization – Different techniques of growing crystals –Melt growth - Growth of thin films- Characterisation by X-ray and optical methodr.

Textbook

1. V. Paghavan, Material Science and Engineering, Prentice-Hall.

Supplementary Reading

1. W.D.Callistin, Material Science and Engineering, John Viley Sons.
2. Meissel and Glong, Hand book of thin film technology, McGraw Hill.

PHYS 343: MODERN OPTICS **(3 credits)**

(Out of 60 hours per semeste2, tqtorial classes shall be 12 hours)

UNIT – I: **15 hours**

Double refraction and optical rotation: Double refraction in uniaxial crystals(explanation in terms of electromagnetic theory, phase retardation plates. Rotation mf plane of polarization, origin of optical rotation in liquids afd in crystals. Dispersion and scattering: Theory of dispersion of lig`t; absorption bands ald anomalous dispersion. Theory of Rayleigh scattering; scattering of X-rays and determination of Z of an atom.

UNIT – II: **15 hours**

Introduction to Laser as Coherent Source of lig`t: Puridy 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: **15 hours**

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: **15 hours**

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

Textbooks

1. A. K. Ghatak, Optics, Tata McGraw Hill, 3rd Edition.
2. Eugene Hecht, Optics, Addison Wesley, (2001), 4th Edition.
3. F. L. Pedrotti and L S Pedrotti, Introduction to Optics, Prentice Hall International.
4. K. K. Sharma, Optics, Elsevier.

Supplementary Reading

1. R. P. Feynman, R. B. Leighton and M. Sands, The Feynman Lectures on Physics Vol. I, 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).

PHY 344 : GEOMAGNETISM AND PALEOMAGNETISM **(3 credits)**

UNIT- I **12 Hr**

Geomagnetism

Introduction to different geomagnetic signatures of the past – geo, palaeo and archaeomagnetisms – Main features and origin of geomagnetic field - geo magnetic field variation - diurnal variation - annual and secular variation of geomagnetic field- Geocentric axial diploe- magnetic latitude and longitude - Location of present day geomagnetic poles- Paleomagnetic pole.

UNIT- II **8 H**r

Physical Basis of Magnetism

Magnetic susceptibility – permeability- hysteresis loop- role of electron orbits and spin in atoms- dia, para, ferro, ferri and anti ferro magnetisms (introductory level with expressions for magnetic susceptibility) - Magnetic domains.

UNIT – III **7 Hr**

Magnetic Minerology

Magnetic minerals- structure of magnetite and hematite, Magnetite – Ulvospinal solid solution series – Haematite-Ilmenite solid solution series.

UNIT – IV **9 Hr**

Remanent Magnetism and Measurement Techniques

Various types of remanent magnetisms- Measurement of remanent magnetism- magnetic directions – oriented sample- Astatic, spinner, SQUID magnetometers - magnetic susceptibility meter. Primary component of magnetization- demagnetization techniques

9 Hr

UNIT – V

Magnetic Dating of Formation

Magnetic directions- Virtual geomagnetic poles- plotting of remanent magnetic data of using stereonet – introduction to polar wander- -Polar wander path – movement of continents- estimation of age of formation.

Books:

1. Michael W Mc Elhinny and Philip L.Mc Fadden Academic Press USA (2000).
2. Paleomagnetism Robert F Butler, Electronic Version, University of Portland, Portland Oregon (2000).
3. D.H.Tarling, Paleomagnetism, Chapman & Hall, London (1983).
4. S.E. Haggerty Opaque mineral oxides in terrestrial igneous rocks, in Oxide Minerals, ed: D.Rumble, III, Minerological society of America, Washington, D.C,. (1976)
5. S.Chikazumi, Physics of Magnetism, Wiley, New York (1964)
6. T.Nagata, Rock Magnetism, Maruzen Ltd., Tokyo (1961)
7. F.D. Stacey and S.K.Banerjee, The Physicsl Principle of Rock Magnetism, Elsevier, Amsterdam (1974)

PHYS430 Laboratory **[3 credits]**

General Experiments

1. Resistivity measurement by four probe method.
2. Study of Frank Hertz experiment.
3. Study of ferro-electric phase transition.
4. Study of Hall effect.
5. Constant Deviation Spectrometer.
6. Hysteresis loop of ferromagnetic materials.
7. Determination of magnetic susceptibility of a solid by Guoy's method.
8. Photoconductivity
9. Dielectric constant
10. Michelson Interferometer
11. Diffraction grating experiment
12. Zeeman Effect

Electronics Experiments

1. Bipolar junction transistor – Common emitter amplifier.
2. Bipolar junction transistor – Two stage RC-coupled amplifier.
3. Characteristics of FET.
4. Study of unijunction transistor.
5. Study of phase shift oscillator.
6. Study of Hartley oscillator.
7. Study of Colpitt's oscillator.
8. Operational amplifier characteristics.
9. Frequency response of an operational amplifier.
10. Configurations of an operational amplifier.

Text Books

1. V. Y. Rajopadhye and V. L. Purohit. Text book of experimental physics.
2. H. Singh. B.Sc practical physics. S. Chand & Co.
3. T. C. Hayes and P. Horowitz. Students manual for the art of electronics. Cambridge University Press.
4. Sanish Kumar Gosh. A text book of practical physics. New Central Books.
5. J. P. Holman. Experimental methods for engineers. Tata McGraw Hill.
6. L. K. Maheswari. Laboratory manual for introductory electronics experiments. New Age International.
7. Srinivasan and Balakrishnan. A text book of practical physics. Vols. I, II. S. Viswanathan Publishers.
8. D. Chatopadhyay and P. C. Ratshit. An advanced course in practical physics. New Central Books.
9. B. Ghosh. Advanced practical physics. Vols. I, II. Sreedhar Publishers.

PHYS 431: MATHEMATICAL METHODS IN PHYSICS –I **(4 credits)**

Unit I: Differential Equations **(12 hours)**

Basic Ideas -Ordinary Differential Equations - Partial Differential Equations - Heat equation - Wave equation - Laplace equation - Boundary value problems –Method of Separation of Variables - Linear ordinary differential equations with constant coefficients and the Euler equation -Frobenius method of series solution – Strum-Liouvllie problem – Orthogonal eigen function expansions.

UNIT – II: Special Function **(12 hours)**

Beta, Gamma, Delta and Error functions – Bessel, Hermite, Legendre, Associated Legendre and Laguerre functions – Generating functions – Recurrence relations – Applications in physics.

Unit II: Complex Variables **(12hours)**

Introduction – Elements of analytic function theory – Cauchy-Riemann conditions – Singularities, poles and essential singularities – Cauchy's integral theorem – Cauchy integral formula – Taylor, Maclaurin and Laurent series of complex functions – Residue theorem - Applications of Residue theorem.

UNITIII: 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.

UNIT V: 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 – Unitstepfunction – *t*-shifting– Short impulses – Diracdeltafunction – Convolution – Integral equations – Application to solve differential equations.

Textbooks:

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

References:

1. K. F. Riley, M. P. Hobson and S. J. Bence: Mathematical Methods for physics and engineering Cambridge University Press (2006) Third Edition
2. M. L. Boas Mathematical Methods in the Physical Sciences, Wiley (2005) Third Edition
3. Potter M C and Goldberg J Mathematical Methods, Prentice Hall (1987) Second Edition
4. Sokolnikoff I S and Redheffer R M: Mathematics of Physics and Modern Engineering, McGraw Hill (1966) Second Edition
5. Spiegel M R., Schaum's Outline of Theory and Problems of Complex Variable, McGraw Hill (1964)
6. Spiegel M R., Schaum's Outline of Theory and Problems of Fourier analysis, McGraw Hill (1974)
7. Tai. L. Chow: Mathematical Methods for Physicists, A Concise Introduction, Cambridge press
8. Susan M. Lea: Mathematics for Physicists, Thomson publications
9. Bruce Kusse, Erik Westwig: Mathematical Physics, Wiley-Interscience publications

PHYS 432: CLASSICAL MECHANICS
(4 credits)

Unit I: **15 hours**

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: **15 hours**

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

Unit III: **15 hours**

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: **15 hours**

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 Book

1. H. Goldstein, Classical Mechanics, Narosa (1988)

Supplementary Reading

1. T. G. Takwale and P. S. Puranik, Introduction to classical mechanics,Tata McGraw Hill (1980),
2. D. T. Greenwood, Classical dynamics, Prentice Hall. New Jersey, (1965).
3. A. K. Raychaudri, Classical mechanics : A Course of Lectures, Oxford University Press,Calcutta (1983).
4. J L Synge and B A Griffith, Principles of mechanics. McGraw Hill (1949) Second Edition.
5. K. G. Gupta, Classical mechanics of particles and rigid bodies Wiley Eastern, (1988).

PHYS 434: ELECTRONIC DEVICES, CIRCUITS AND MICROPROCESSORS (4credits)

Unit-I **10 hours**

Semiconductor Diodes: Operation, characteristics and applications of Zener and Avalanche, Varactor, Schottky- barrier, Tunnel diodes; Construction, operation and Characteristics of BJT, FET and MOSFET- FET amplifier - UJT relaxation oscillator.

Unit-II **13hours**

Operational amplifiers: Basics of differential amplifiers-Characteristics of ideal and practical opamps-Applications; inverting, non-inverting, Summing, difference, integrating, differentiating amplifiers- Signal processing circuits,; precision rectifiers, clipper, clamper and peak detectors-Signal generators; triangular and square wave generators, phase shift and Wien bridge oscillator using opamps. Active filters; First order low pass and high pass filters, Band pass and band elimination filters-Temperature compensated logarithmic and antilogarithmic amplifiers.

Unit-III **12hours**

Digital Circuits: Logic circuits using standard TTL and CMOS-Combinational circuits: Adders, subtractors, multiplexer/demultiplexer, decoder and encoders-Flip Flops; S-R, J-K, Master slave S-R and Master slave J-K Flip Flop-counters ; synchronous, asynchronous, Modulo-n-counters-shift registers; Serial to parallel and vice-versa, universal shift registors,ring counter.

UNIT – IV: **10 hours**

Opto-electronics: Radiative and nonradiative transition, Light dependent resistor (LDR), Photodiodes, phototransistors, Photovoltaic (Solar) cell Materials, construction and operation of LED, Diode laser; Structure, Working and factors affecting performance.

UNIT – V: **15 hours**

Microprocessors and Microcontrollers: Fundamentals of computer architecture; Processor design; Control unit design; Memory organisation, I/o System Organisation. Microprocessors and Microcontrollers: Architecture and instruction set of 8085 and 8051, Assembly language Programming; addition, subtraction and multiplication.

Text books

1. J.Millman and C.C.Hallkias, Integrated Electronics: Analog and Digital circuits and systems, Tata McGraw Hill.
2. Robert L. Boylsted and Louis Nashelsky, Electronic Devices and Circuits, Pearson, Tenth Edition (2009).
3. Floyd, Electronic Devices, Pearson, Seventh Edition (2009).
4. J.Wilson, J.F.B.Hawkes, Optoelectronics an Introduction, PHI, New Delhi, Second Edition, (2003).
5. Malvino and Leach, Digital Principles of Electronics, Glencoe/McGraw-Hill, Fifth Edition (1994).
6. Charles M Gillmore, Microprocessors: Principles and Applications, Tata Mc-Graw Hill publishing company Limited (2005).

Supplementary Readings

1. B.Somnath Nair, Electronic Devices and Applications, Prentice-Hall of India, New Delhi, (2002).
2. A.Rogers, Essentials of Optoelectronics, Chapman Hall, 0-412-40890-2.
3. Jasprit Singh, Semiconductor Optoelectronics, McGraw Hill, (1995).
4. Ramakant A Gayakwad “Op-Amps and Linear Integrated Circuits”PHI, New Delhi (1998).
5. John Allison, “Electronic Integrated Circuits-Their Technology and Design”, McGraw Hill, (1975).
6. Simon M.Sze, Physics of Semiconductor devices, John Wiley and Sons, Third Edition (2006).
7. Ghatak and Tyagarajan, Optical Electronics, Cambridge U.P.0-521-31408-9.
8. D.Roy Choudhury and Shail Jain, Linear Integrated circuits,Newage International Ltd,New Delhi(1997).
9. U.A.Bakshi and A.P.Godse, Operational amplifiers and linear ICs, TPP, Pune (2004).
10. Robert F Coughlin and Frederick F Driscoll,”Operational Amplifiers and Linear Integrated Circuits”, Prentice Hall of India (1992).

PHYS 435: NUMERICAL METHODS **(3credits)**

UNIT – I

Representing numbers in a computer – Machine precision – Introduction to numerical errors – Errors in mathematical approximations – Error propagation.

UNIT – II

Matrices and linear system of equations – GaussJordan elimination method – Gauss method to compute the Inverse – LU decomposition – Cholesky decomposition – GaussSeidel iterative method – Eigenvalues and eigenvectors of a real symmetric matrix by Jacobi's method – Determination of largest eigenvalue by Power method.

UNIT – III

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 : The laboratory exercise involves writing programs in FORTRAN 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.

PHYS 436: UNIX, FORTRAN-90 and C++ **(3 credits)**

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 **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, Learning the UNIX Operating System, O'Reilly Media, Inc. (2002) Fifth Edition.
2. F. Mittelbach, M. Goossens, J. Braams, D. Carlisle, C. Rowley, LaTeX Companion, Addison-Wesley (2004), Second Edition.
3. Stephen Chapman, Fortran 90 / 95 for Scientists and Engineers, McGraw Hill (2003) Second Edition
4. Harvey M. Deitel and Paul J. Deitel, C++ How to Program, Prentice Hall (2007) Sixth Edition.

Supplementary Reading

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

PHYS 437: DIFFERENTIAL EQUATIONS and TRANSFORM TECHNIQUES (3 credits)

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 Academic Press (2000) Fifth Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics John Wiley (2005) Ninth Edition.
3. R.K. Jain, S.R.K. Iyengar, Advanced Engineering Mathematics Narosa (2007) Third Edition.

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, Mathematical Methods in the Physical Sciences, Wiley(2005) Third Edition.
3. Potter M C and Goldberg, J Mathematical Methods, Prentice Hall (1988).
4. Sokolnikoff I S and Redheffer R M, Mathematics of Physics and Modern Engineering, McGraw Hill (1966) Second Edition.
5. Spiegel M R., Schaum’s Outline of Theory and Problems of Complex Variable, McGraw Hill (1964).
6. Spiegel M R., Schaum’s Outline of Theory and Problems of Fourier analysis, McGraw Hill (1974).

PHYS 440 Laboratory **[3 credits]**

General Experiments

1. Determination of Lande's g factor of electron by ESR.
2. Study of Geiger-Muller counter: Study of Attenuation coefficient
3. Study of Geiger-Muller counter: Absorption of Gamma rays
4. Fourier analysis of a square wave.
5. Study of superconductivity.
6. Microwaves bench: Study of standing waves and measure the wavelength of microwave source
7. Microwaves bench: Study of Fabry-Perot interferometer
8. Study of Chuha’s circuit.
9. X-ray Diffraction: study of simple cube system
10. Cooling curve
11. Transition temperature of YBCO Superconductor
12. Piezoelectric effect

Electronics Experiments

1. Integrator and differentiator using operational amplifier.
2. Wein bridge oscillator using operational amplifier.
3. Study of comparator using operational amplifier.
4. Study of multivibrators using operational amplifier.
5. Logic gates and boolean algebra.
6. Half and full adder using logic circuits.
7. Decoders using logic circuits.
8. Study of flip flops.

Text Books

1. V. Y. Rajopadhye and V. L. Purohit, Text book of experimental physics.
2. H. Singh, B.Sc practical physics. S. Chand & Co.
3. T. C. Hayes and P. Horowitz, Students manual for the art of electronics. Cambridge University Press.
4. Sanish Kumar Gosh, A text book of practical physics. New Central Books.
5. J. P. Holman. Experimental methods for engineers, Tata McGraw Hill.
6. L. K. Maheswari, Laboratory manual for introductory electronics experiments. New Age International.
7. Srinivasan and Balakrishnan, A text book of practical physics, Vols. I, II. S. Viswanathan Publishers.
8. D. Chatopadhyay and P. C. Ratshit, An advanced course in practical physics, New Central Books.
9. B. Ghosh, Advanced practical physics, Vols. I, II. Sreedhar Publishers.

PHYS 441: QUANTUM MECHANICS – I (4 credits)

UNIT – I: Foundations of Quantum Mechanics **8 hours**

Review of Stern-Gerlach experiment and inadequacy of classical theory – Wave-particle duality – Wave packets – -Fourier Transforms – Postulation of Time dependent Schrödinger Equation in three dimension – Time Independent Schrödinger Equation – Physical interpretation of wave function – Continuity Equation – Expectation values – Ehrenfest's Theorem– Dirac's Bra and Ket vectors – Heisenberg's uncertainty relation – Postulates of Quantum Mechanics – Superposition principle – Schrödinger picture – Heisenberg picture (matrix mechanics) – Interaction picture – Relation among different pictures.

UNIT – II: Bound States and Potential Barriers **10 hours**

Definition of bound states and scattering states – One dimensional potentials – Calculation of reflection and transmission coefficients for the following problems – Dirac-delta potential – Potential step – Infinite square well – Finite square well (or potential well) – Potential barrier and quantum tunneling effect.

UNIT –III: Harmonic Oscillator and Hydrogen atom **12 hours**

One dimensional harmonic oscillator – Solution of 1-D harmonic oscillator problem by analytical method (Hermite polynomials) – Eigen functions and energy eigenvalues harmonic oscillator by operator method – Annihilation (lowering) and creation (raising) operators – Solution of linear harmonic oscillator using (*a*) Schrödinger picture and (*b*) matrix mechanics – Matrix representation of harmonic oscillator operators – Schrodinger equation in spherical coordinate system – Angular equation – Legendre polynomials and spherical harmonics – Radial equation – Spherical Bessel function and spherical Neumann function – Solution of hydrogen atom radial equation by power series method – Derivation of Bohr formula.

UNIT – IV: Introduction to Symmetry and Angular Momentum **12 hours**

Basics of discrete Symmetries – Symmetries, conservation Laws and degeneracy – Parity or Space Inversion – Quantum mechanical definition of angular momentum – Angular momentum operator algebras – Ladder operators and the spectrum of eigenvalues – Commutation relations – Eigenvalues and Eigen functions of angular momentum operator – Matrix representation of angular momentum operators (basics concepts) – Spinor matrix and Pauli spin matrices – Spin of two spin-$1/2$ particles – Addition (coupling) of angular momenta – Clebsch-Gordan coefficients – Wigner-Eckart theorem.

UNIT – V: Approximation Methods **18 hours**

Time independent perturbation theory – Non-degenerate and degenerate perturbation theories – Linear Stark effect – Zeeman effect in hydrogen – Variational method – Ground state of helium atom – WKB approximation – Tunneling through potential barriers.

Textbooks

1. D J Griffiths, *Introduction to Quantum Mechanics*, Pearson Education.
2. V Devanathan, *Quantum Mechanics*, 2nd edition, Narosa Publishing House
3. N Zettili, *Quantum Mechanics: Concepts and applications.* John Wiley.
4. F Schwable. *Quantum Mechanics*. Springer.
5. Ashok Das. *Lectures on Quantum Mechanics.* 2nd edition. World Scientific (2012).

Supplementary Reading

1. Richard L Liboff, *Introductory Quantum Mechanics*, 4th edition, Pearson Education.
2. Stephen Gasiorowicz, *Quantum Physics*, John Wiley & Sons.
3. P.M. Mathews, K. Venkatesan, *A Textbook of Quantum Mechanics*, Tata McGraw-Hill.
4. Leonard I. Schiff, *Quantum Mechanics*, 3rd edition, McGraw-Hill.

References

1. J J Sakuri, J Napolitano. *Modern Quantum Mechanics*. 2nd edition (2010). Addison-Wesley.
2. T Pradhan. *Quantum Mechanics.* Universities Press, India.
3. C C Tannoudji, B Diu and F Laloe. *Quantum Mechanics* (volumes I and II). Wiley-VCH (2009).

PHYS 442: CLASSICAL ELECTRODYNAMICS **(4 credits)**

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, Introduction to electrodynamics, Prentice Hall (1999) Third Edition

Supplementary Reading

1. John David Jackson, Classical Electrodynamics, John Wiley & Sons (1999) Third Edition.
2. Matthew N. O. Sadiku, Elements of Electromagnetics, Oxford University Press (2002) Third Edition.

PHYS 443: SOLID STATE PHYSICS **(4 credits)**

Unit I: Crystal structure **12 hours**

Classification of solids – liquids – amorphous glassy states, characteristics and 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 II: Crystal Binding and Lattice dynamics. **12 hours**

Ionic cohesive energy – Covalent – Metallic Vander Waals and hydrogen bonded crystals – Vibrational modes – one, two and three dimensional lattices – Thermal conductivity – Elastic constants – Phonon dispersion relation – Localised modes.

Unit III: Free Electron Theory and Semiconductors **12 hours**

Transport properties – electronic specific heat – electrons in a periodic potential – energy band – Bloch's theorem, Kronig – Penney's theorem – Band Structure – Carrier concentrations – Intinsic semi-conductor – Imputiry states – Semiconductor states – Electrical conductivity, mobility – Magnetic field effects – Cyclotron resonance and Hall effect.

Unit IV: Superconductivity **12 hours**

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 V: Electrical and Magnetic Properties **12 hours**

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.

Textbook

1. N. W. Aschcroft and N. D. Mermin, Solid state physics, Holt, Rineheart and Winston, New York (1976)

Supplementary Reading

1. C. Kittel, Introduction to solid state physics. John Wiley (2003) Seventh Edition.
2. A. J. Dekker, Solid state physics, MacMillan (1981).
3. Ali Omer, Elementary solid state physics, Pearson Education (1999),
4. L. V. Azaroff, Introduction to solids, Tata McGraw Hill (2008),

PHYS 444: NONLINEAR DYNAMICS **(3 credits)**

Unit I: **12 hours**

Nonlinear waves – Nonlinear partial differential equations – physical examples – AKNS method – Applications of solitons - Introduction to synergetics – examples from Physics, Chemistry, Biology, Computer Science, Economics, Ecology and Sociology.

Unit II: **12 hours**

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

Unit III: **12 hours**

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.

Unit IV: **12 hours**

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

Textbooks

1. H Haken, Synergetics, Springer Berlin (1983).
2. H Haken, Advanced Synergetics, Springer Berlin (1983).
3. I. Prigogine, Order out of chaos, Fontana (1984).
4. P. A. Cook, Nonlinear dynamical systems, Prentice Hall New York (1994).
5. R. Serra, Introduction to the physics of complex system, Pergamon Oxford (1986).

PHYS 445: MEASUREMENT SYSTEMS and DATA ACQUISITION (3 credits)

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. T. G. Beckwith, R. D. Marangoni, J. H. Lienhard, Mechanical Measurements, Prentice Hall (2006), Sixth Edition. – [Units-I, II].
2. J. A. Blackburn, Modern Instrumentation for Scientists and Engineers, Springer (2001) [Unit-III].
3. Bruce Mihura, LabVIEW for Data Acquisition, Prentice Hall (2001) [Unit-IV].

Supplementary reading

1. Ernest O Doebelin, Measurement Systems: Application and Design, Tata McGraw Hill, Fifth Edition.
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 **12 hours**

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 **12 hours**

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 **12 hours**

KB, displays optical motor shift encoders – analogue interfacing D/A and A/D converters – process control – digital filters.

Unit IV: Trends in Microprocessor Technology **12 hours**

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.

Textbooks

1. Ramesh S. Goanker, Microprocessor architecture, programming and applications with 8085/8085A, Wiley Eastern (1989)
2. Douglas V. Hall, Microprocessors and interfacing. McGraw Hill (1986).
3. L. A. Leventhal. Assembly language programming. Prentice Hall (1981).
4. Kenneth L. Sherl, Microprocessors and programmed logic, Prentice Hall.
5. G. V. Rao, Microprocessors and microcomputer system, Van Nostrand Reinhold (1978)

PHYS 447 BASICS OF ASTRONOMY AND ASTROPHYSICS (3 Credits)

Unit I: 10Hrs

Astronomy- Coordinate System- Spherical Trigonometry, Precision, Time, Heliocentric Corrections, Methods of observations, Telescopes at different wavelength, Detectors at different wavelength, Atmospheric effects at different wavelengths, Resolution, Background, Aberrations, Luminosity Bias, Confusion Limit

Distance measurements using parallax method, Newton's' Gravitation law and Kepler's Law in Distance and Mass Measurement.

Unit II: 8Hrs

Stars – Stellar Magnitudes and Colors, Brightness and distance, Luminosity, temperature and spectral class, the motion of stars relative to the Sun, the masses of stars, the Hertzsprung–Russell diagram and main-sequence stars

Unit III : 8Hrs

Stellar Structure – Equations of Stellar Structure – Solutions to Equations of Stellar Structure, Toy Stellar Models: Homologous Stellar Models, the Radiative Stellar Envelope, Fully Convective Stars with H~ Opacity, Observational Aspects of Stellar Atmospheres, Continuum Radiation, Lines

Unit IV: 8Hrs

Stellar Evolution – Pre-Main-Sequence Collapse, Evolution of High-Mass Stars, Evolution of Low-Mass Stars, Late-Stage Evolution of Stars, Supernova (Type II), White Dwarfs, Neutron Stars and Black Holes, Pulsars, Binary Stars and Accretion

Unit V: 14Hrs

Large Scale Structure of Universe- Hubble's Law, Galaxies and Cosmology -Evolution of the Universe, Formation of Dark-Matter Halos, Galaxy Formation, Morphological Classification of Galaxies, the Evolution of Galaxies, Active Galactic Nuclei, Features of Active Galactic Nuclei, Taxonomy of Active Galactic Nuclei, Radio Galaxies, Quasars, Luminosity Function of Galaxies and Quasars, Distribution of Matter, Extragalactic Background Radiation

Textbooks:

1. T Padmanabhan, Theoretical Astrophysics: Vol. I-II-III, Cambridge University Press (2005).
2. WM Smart and R M Greene, Textbook on Spherical Astronomy, Cambridge University Press (1986) Sixth Edition.
3. Frank Shu, The Physical Universe, University of California (1982).
4. Roy A E and Clarke D, Astronomy principles and Practice, Institute of Physics (2003) Fourth Edition.
5. Kitchin C R, Astrophysical techniques, Institute of Physics (2003) Fourth Edition.
6. Herwitt M, Astrophysical Concepts, Springer Verlag, (2006) Third Edition.
7. Swapan K Saha, Diffraction-limited imaging with large and moderate telescopes, World Scientific, (2007).

Reference Books:

1. Chandrasekhar S, An Introduction to the Study of Stellar Structure, Dover Publications (1967).
2. Clayton D D, Principles of Stellar Evolution and Nucleosynthesis, University of Chicago Press (1983).
3. Kippenhahn and Weigert, Stellar Structure and Evolution, Springer (1990).
4. Binney, J. and Tremaine S., Galactic, Dynamics, Princeton University Press (1994).
5. Binney J, and Merrifield, Galactic Astronomy, Princeton University Press (1998).
6. K.D. Abhyankar, Astrophysics (Stars and Galaxies), Tata McGraw Hill (1992).
7. Baidyanath Basu, An Introduction to Astrophysics, Prentice Hall of India (2003).
8. Jayant V Narlikar, An Introduction to Cosmology, Cambridge University Press (2004).

PHYS 448: MATHEMATICAL METHODS IN PHYSICS –II **(4 credits)**

UNIT – I: Linear Algebra **(12 hours)**

Linear vector spaces – Basis- Subspace – Dimension - Linear dependence and independence – Basis sets - Norm and Inner product - Cauchy-Schwarz Inequality – Orthogonality and Completeness -Eigenvalues and Eigenvectros - Matrix representation - Change of orthonormal basis.

UNIT –II: Hilbert Spaces and Operators **(12 hours)**

Hilbert space – Linear Functions –Families of orthogonal polynomials as basis sets in function space (Gram-Schmidt orthogonolization) –Operators – Linear operators – Hermitian, Unitary and Projection operators – Inverse and Rank of an operator - Rotation matrices in 2 and 3 dimensions – Pauli matrices.

UNIT – III: Vector Analysis **(12 hours)**

Vectors and Scalars – Direct angles and direction cosines – Vector algebra – Scalar product – Vector product – Scalar triple product – Vector triple product –Vector identities – Differential operators incurvilinear coordinates – Vector and Scalar fields.

UNIT – IV: Tensors **(12 hours)**

Introduction – Fundamentals of tensors– Cartesian Tensors – Algebra of Cartesian tensors –Outer product – Contraction - Quotient theorem – Symmetric and Skew-symmetric tensors – Kronecker& Levi-Civita tensors – Examples and Applications in physics.

UNIT – V: Group Theory **(12 hours)**

Introduction to Groups, fields - Definitions and examples of physically important finite groups - Point groups - Multiplication table – Subgroups - Cyclic groups, center, classes, cosets, Lagrange Theorem - Representations of finite groups - Irreducible representation – Characters - Orthogonality theorem - Schur's character table - SU(2) – SU(3) - Simple applications.

Text Books:

1. Mathematics for Physicists — Dennery&Kryzywicki
2. Linear Vector Spaces — R. R. Halmos
3. Theory of Finite Groups — L. Jansen and M. Boon

References:

Mathematical Methods for Physicists	George B. Arfken	Academic Press [1995]
Theory and Problems on Applied Mathematics for Scientists & Engineers	Schaum Series	Schaum's Outline Series [1983]
Advanced Engineering Mathematics	Kreyszig	John Wiley and Sons [1993]
Special Functions for Scientists & Engineers	G. Bell & George B. Arfken	Van Nostrad, New York
Mathematical Methods in the Physical Sciences	M. L. Boas	John Wiley and Sons [1993]
Matrices and Tensors	A. W. Joshi	Wiley Eastern Ltd
Groups Theory for Physicists	A. W. Joshi	Wiley Eastern Ltd [1982]

PHYS 530: ***CONDENSED MATTER PHYSICS SPECIALIZATION EXPERIMENTS*** **(3 CREDITS)**

1. X-ray diffraction.
2. Impedance spectroscopy.
3. Infrared spectroscopy.
4. Differential scanning calorimetry with thermal analysis.
5. UV-VIS-IR spectroscopy.
6. High field magnetic hysteresis using VSM.
7. Superconductivity.
8. Emission spectroscopy.
9. Transmission Electron Microscope
10. Electron Probe Microscope Analysis
11. Electron Spin Resonance
12. Energy Dispersive Analysis of X-Rays
13. Nuclear Magnetic Resonance

PHYS 550 ELECTRONICS SPECIALIZATION EXPERIMENTS: **(3 CREDITS)**

1. First order active filters using operational amplifier.
2. Second order active filters using operational amplifier.
3. Counters and registers using logic circuits.
4. Decade counting unit.
5. Study of 8-bit microprocessor.
6. Study of 16 bit microprocessor.
7. Study of 8051 microcontroller.
8. Study of lockinamplifier.
9. Amplitude modulation.
10. Detection of AM signals.
11. Study and detection of Frequency modulation.
12. Pulse modulation.
13. Study of multiplexing and demultiplexing.
14. Digital multiplexer.
15. LabVIEW and Virtual instrumentation laboratory.

PHYS 570- LASER SPECIALIZATION EXPERIMENTS: **(3 CREDITS)**

1. Numerical aperture of optical fiber and propagation of light through optical fiber.
2. Intensity profile of laser through optical fiber and determination of refractive index profile.
3. Refractive index by Brewster angle setup.
4. Study of Faraday effect using He-Ne laser with AC modulator.
5. Study of Electro-optic effect (Pockel effect) with AC modulator.
6. Study of Electro-optic effect (Kerr effect).
7. Study of Acousto-Optic effects.
8. Study of Second Harmonic generation
9. Study of Passive Q switching in Nd:YAG laser
10. Study of Active Q Switching in Nd YAG Laser
11. Study of Laser bean characteristics (beam divergence, spot size, intensity profile) using He-Ne laser
12. Estimating Coherence Length of the Given Light Source.
13. Digital holography.
14. Estimation of Stokes Parameter

PHYS 531: QUANTUM MECHANICS – II (4 credits)

Unit – I: Time dependent perturbation theory **12 hours**

Time dependent perturbation theory – Transition probability – Constant perturbation – Harmonic perturbation – Fermi-Golden rule – Radiative transition in atoms – Dipole transition – Selection rules – Sudden and adiabatic approximation.

Unit II: Identical Particles **12 hours**

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

Unit III: Quantum theory of Scattering **12 hours**

Scattering theory – Scattering particles – Potential scattering – Partial wave analysis – Phase shifts – Scattering lengths – Integral equations in terms of Green function – Born approximation and its validity.

Unit IV: Relativistic Quantum Mechanics **12 hours**

Relativistic wave equations – Klein-Gordon equation – Dirac equation – Dirac matrices – Free Dirac particles – Spin magnetic moment – Spin-Orbit interaction – Central potential – Hydrogen atom – Hole theory and positrons.

Unit V: Introduction to Quantum Field Theory **12 hours**

Lagrangian density of a classical field – Elements of field quantization – Quantization of electromagnetic field – Quantization of electromagnetic field – Quantization of non-relativistic (Schrodinger field) and relativistic (Klein-Gordon and Dirac) fields.

Textbooks

1. D J Griffiths, *Introduction to Quantum Mechanics*, Pearson Education.
2. V Devanathan, *Quantum Mechanics*, 2nd edition, Narosa Publishing House
3. N Zettili, *Quantum Mechanics: Concepts and applications.* John Wiley.
4. A Lahiri and P B Pal. *A first book of Quantum Field Theory.* 2nd edition. Alpha Science (2005).

Supplementary Reading

1. F Schwable. *Quantum Mechanics*. Springer.
2. J J Sakuri, J Napolitano. *Modern Quantum Mechanics*. 2nd edition (2010). Addison-Wesley.
3. J J Sakuri. *Advanced Quantum Mechanics*. 1st edition (1967). Addison-Wesley.
4. M E Peskin and D V Schroeder. *An Introduction to Quantum Field Theory.* Westview Press (1995).
5. Richard L Liboff, *Introductory Quantum Mechanics*, 4th edition, Pearson Education.
6. Stephen Gasiorowicz, *Quantum Physics*, John Wiley & Sons.
7. P.M. Mathews, K. Venkatesan, *A Textbook of Quantum Mechanics,* Tata McGraw-Hill.
8. Leonard I. Schiff, *Quantum Mechanics*, 3rd edition, McGraw-Hill.

References

1. T Pradhan. *Quantum Mechanics.* Universities Press, India.
2. C C Tannoudji, B Diu and F Laloe. *Quantum Mechanics* (volumes I and II). Wiley-VCH (2009).
3. Ashok Das. *Lectures of Quantum Field Theory.* World Scientific (2008).

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

Unit I: **12 hours**

Electromagnetic spectrum – Absorption or Emission of radiation – Line width- Natural line broadening- Doppler broadening –Pressure broadening – Removal of line broadening - X-ray Spectra – Emission and absorption spectra of X-rays. Regular and irregular doublet laws – X-ray satellites – Photoelectron spectroscopy

– Ultravoilet photoelectron spectrometers – XPS techniques and Chemical information from photoelectron spectroscopy – Auger electron spectroscopy.

Unit II: **12 hours**

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 – ***Infrared Spectroscopy:*** Vibrational Energy of a Diatomic molecule – The Diatomic Vibrating Rotator – Break down of Born-Oppenheirmer Approximation – The Vibrations of Polyatomic molecules – Rotation-Vibration spectra of Polyatomic molecules – Analysis by Infra-red Techniques- IR spectrophotometer – Fourier Transform- IR spectrophotometer- Applications – Frank-Condon principle and dissociation energy.

Unit III: **12 hours**

Raman Spectroscopy: 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 – ***Laser Spectroscopy:*** Basic principles: Comparison between conventional light sources and lasers-Saturation-Excitation methods-Detection methods-Laser Wavelength Setting-Doppler Limited Techniques.

Unit IV: **12 hours**

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 – ***Electron Spin Resonance Spectroscopy:*** Basic principles – ESR spectrometer – ESR spectra – Hyperfine interaction – g-factor – line widths – applications.

UNIT V: **12 hours**

NQR Spectroscopy: Quadrupole Hamiltonian- Nuclear Quadrupole energy level for axial and non-axial symmetry – Experimental techniques and applications – ***Mossbauer Spectroscopy:*** Principles of Mossbauer spectroscopy – Chemical shifts – Quadrupole splitting and Zeeman splitting – applications of Mossbauer spectroscopy – applications.

Textbooks

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

PHYS 533: CONDENSED MATTER PHYSICS (3 credits)

Unit I: Liquid State: [12 hours]

Classification of liquids (ionic, molecular and simple) and interactions in liquids– idea of attractive and repulsive potentials -stability condition of bond -Hydrogen molecule –neon liquid - Lenard Jones potential in liquid- theory of scattering in neon liquid - radial distribution function - structural determinations.

Unit II: Equilibrium Structure of Dense Fluids: [12 hours]

Molecular distribution – Van der Waals equation – liquid in canonical ensemble- second virial term – general virial approach thermodynamic functions in dense fluids – equation for pair distribution functions Kirkwood superposition approximation – critical phenomena: critical properties of Van der Waals fluid.

Unit III: Liquid Crystals & Optical properties: [12 hours]

Classification of liquid crystals and mesoscopic phase transitions (nematic, semetic, cholestric) – Landau theory phase transition and Marier Saupe theory in lquid – Optical reflectance: Kramers-Kronig relations, Raman effect in liquids & crystals - Plasmons

Unit IV: Dielectrics & Ferroelectrics: [12 hours]

Macroscopic electric field, local electric field at an atom, Dielectric constant and Polarizability, structural phase transitions, ferroelectricity , Displacive transitions, Relation of dielectric constant and polarization – dipolar polarization theory – time dependence of polarization temperature dependence of dipolar polarization, electrical conductivity (D.C & A.C).

Unit V: Surface, Interface Physics & Nanostructured Materials: [12 hours]

Surface & Interface Physics: Surface crystallography, Surface electronic structure, Magnetoresistance in a two-dimensional channel, heterostructures, tunneling magnetoresistance, scanning tunneling microscopy.

Nanostructured Materials: Synthesis of Nanomaterials by different methods, Size and Shape dependent Structural, Chemical, Optical, Electrical and Mechanical Properties, Nanoindentor, Atomic Force Microscopy.

Text books:

1. Introduction to Liquid State Physics C. A. Croxton John Wiley and Sons, 1975
2. Atkin's Physical Chemistry Peter Atkins and Juliode Paula Oxford University
3. N. W. Aschcroft and N. D. Mermin, Solid state physics, Holt, Rineheart and Winston, New York (1976)
4. C. Kittel, Introduction to solid state physics. John Wiley (2003) Seventh Edition.
5. A. J. Dekker, Solid state physics, MacMillan (1981).

References:

1. Principles of Condensed Matter Physics. P.M.Chaikin and T.C.Lubensky, Cambridge University Press 1997.
2. Liquid Crystals S. Chandrasekar Academic Press 1996

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

Unit I: Advanced Electronic Devices **8 hours**

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

Unit II: Other Electronic Devices **8 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 **10 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: Data conversion circuits **10 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.

UNIT – V: Data acquisition and Virtual Instrumentation **10 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.

Text Books

1. *Semiconductor Physics and Devices: Basic Principals, by Donald A Neamen 3^rd^ Edition* (TMH)
2. *Solid State Electronic Devices by Ben G Streetmann and Sanjay K Banerjee, 5^th^ Edition Pearson Prentice-Hall*
3. *Digital Design : Principal and Principal and Practices by Wakerly J. F, 3^rd^ Edition, Prentice Hall's*
4. Ramesh S. Goanker, Microprocessor architecture, programming and applications with 8085/8085A. Wiley Eastern.
5. *Analog Integrated Circuit Design by David A. Johns and Ken Martin, John and Wiley 2008.*
6. Bruce Mihura (2001). LabVIEW for Data Acquisition. Prentice Hall.

PHYS 535: LASER THEORY **(3 credits)**

UNIT : I 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 : II RADIATIVE TRANSISTION, PROPERTIES OF MOLECULES **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 : III 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 : IV LASER PUMPING REQUIREMENTS & TECHNIQUES 8 hours excitation threshold requirement, pumping pathway, Specific excitation parameters associated with optical & particle pumping.

UNIT : V 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.

PHY 536 NONLINEAR OPTICS **(3 credits)**

Unit I: **8 Hours**

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

Unit II: **10 Hours**

Wave equations description of nonlinear optical susceptibilities – Symmetries in Nonlinear Optical systems-Frequency and intensity dependence of polarization and dielectric susceptibility- First order and higher order susceptibilities

Unit III : **10 Hours**

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

Unit IV : **10 Hours**

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

Unit-V **10 Hours**

Applications frequency mixing and up conversion -Difference frequency generator, Optical Phase ConjugationTheory and Applications, Photorefractive effect and applications, SolitonsTheory and applications – Optical bistability.

Text Book and References

1. W Boyd, Nonlinear OpticsRobert.
2. Y Guo, C K Kao, E.H.Li, K. S.Chiang, Nonlinear Photonics.
3. Y R Shen, Principles of Nonlinear Optics.
4. N. Bloembergen, Nonlinear Optics .
5. H S Nalwa and S Miyata, Nonlinear Optics of Organic Molecules and Polymers.
6. RA Fischer, Optical Phase Conjugation.
7. Quantum Electronics–A Yariv
8. R Sutherland, Handbook of Nonlinear Optics.
9. N B Singh, Growth and Characterization of Nonlinear Optical Materials.

PHYS 537: EXPERIMENTAL DESIGN **(3 credits)**

UNIT – I: **10 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 –

UNIT – II: **8 hours**

Emission and Absorption Spectroscopy – Measurement of Magnetic field – Hall effect – Magnetoresistance – X-ray and neutron Diffraction.

UNIT – III: **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 – IV: **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, Experimental Methods for Engineers. 7^{th} Edition. McGraw Hill (2000).
2. J. M. Lafferty (Editor) (1998), Foundations of Vacuum Science and Technology, Wiley Interscience.
3. Anthony Kent, Experimental Low-Temperature Physics ,Macmillan Physical Science (1993).
4. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley(2004).

Supplementary reading

1. T. G. Beckwith, R. D. Marangoni and J. H. Lienhard ,Mechanical Measurements,6^{th} Edition(2006),Prentice Hall.
2. Ernest O Doebelin, *Measurement Systems: Application and Design*. 5^{th} 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, *Instrument Transducers: An introduction to their performance and design*. Oxford University Press(2003).
5. J. A. Blackburn Modern Instrumentation for Scientists and Engineers, Springer (2001),

PHYS 539 PLASMA PHYSICS AND CONTROLLED FUSION **3 credits**

(45 hours per semester+15 Experimental Demonstration)

UNIT – 1 Collision processes in gases discharge mechanism **(10)**

Breakdown mechanism of gases, Gaseous discharge, Characteristic of dc Glow discharge, positive column, cathode sheath, negative glow, negative glow and Faraday dark space, Analysis of positive column, Analysis of cathode region.

UNIT –2 Plasma and Plasma Parameters **(10)**

Definition of plasma, electron and ion temperature, plasma potential, sheath formation and floating substrate, Debye shielding, The Contact Potential, sheath formation and Bohm criterion, cathode sheath, Plasma oscillations, electron oscillations ion oscillation, Ambipolar diffusion.

UNIT – 3 Plasma sources and Applications **(10)**

Limitations of dc glow discharges, RF discharges, Inductive discharges, power transfer efficiency, matching network, electron-cyclotron resonance discharges, helicon-discharges, surface wave discharges, DBD discharges, characteristics and application of respective discharges, hollow cathode discharge, planer magnetron discharge, plasma etching, dc sputtering, rf sputtering, thin film formation, plasma nitriding, PECVD for nano - material fabrication.

UNIT – 4 Plasma For Controlled Fusion **(15)**

Fission, Fusion and energy needs, Lawson criterion, Magnetic confinement fusion devices (magnetic mirrors trap, tokomak), Particle trajectories in non-uniforms magnetic and electric fields. Drift approximation. Adiabatic invariants. Plasma as a fluid, plasma heating, Current drive, low hybrid current drive (LHCD), Ion Cyclotron Resonance Heating (ICRH), Ion Cyclotron Resonance Heating (ECRH), Neutral beam injection (NBI). Laser and heavy ion beams fusion, Tokomaks in India and ITER and challenges

UNIT-5 Experimental Demonstration **(15)**

1. Dependence of breakdown voltage on pressure and electrode gap (Paschen Curve).
2. Measurement of Plasma parameters by electrostatic probe (Langmuir Prob).
3. To measure the plasma parameters by double Langmuir probe
4. To launch an ion-acoustic wave and demonstrate collective behavior of the plasma
5. Measurement of plasma parameters of a pulsed dc discharges
6. Characterization of dc magnetron discharges and estimation of sputtering yield
7. Studying the conditions for atmospheric pressure plasmas (Dielectric Barrier Discharges)

Text Books

1. Chapman, Brian N. “Glow discharge processes” A Wiley-Interscience Publications
2. M. A. Lieberman and A. J. Lichtenberg, Principles of Plasma Discharges and Material Processing, John Wiley & Sons, New Jersey, 2005.
3. Y. P. Raizer, “Gas Discharge Physics”, Springer 1991.

Reference Books

1. P. I. John, Plasma Science and the Creation of Wealth, Tata McGrow-Hills, New Delhi, 2005.
2. F.F. Chen, “Plasma Physics and Controlled Fusion”, Plenum Press, New York, 1984

PHYS 551 – STATISTICAL PHYSICS (4 credits)

UNIT I: FOUNDATIONS OF STATISTICAL PHYSICS **12 hours**

Microstate and Macrostate of macroscopic system, Phase space and Phase space density, Liouville theorem, Erogodic hypothesis, Postulate of Equal a priori probabilities, Microcanonical Ensemble, Number of microstes and relation to thermodynamic entropy, Calculation of number of microstates to (a) Ideal gas: Equation of state, Gibbs paradox, correct counting (b) Crystalline solid: Du-long Petit's law, Einstein's theory of specific heat and (c) Paramagnetism: Curie's law, Negative temperature and Schottky anomaly in specific heat (d) Elasticity of a rubber.

UNIT II: CANONICAL ENSEMBLE AND PARTITION FUNCTION **12 hours**

Canonical ensemble canonical partition function, The Darwin Fowler method, Calculation of thermodynamic properties from partition function, Equipartition theorem and Virial theorem, Application of canonical partition function to (a) Ideal gas (b) Crystalline solid (c) Black body radiation: Planck's theory (d) Theory of paramagnetism: Langevin and Brillouin functions (e) Diatomic molecular gas.

UNIT III: GRAND CANONOICAL ENSEMBLE **10 hours**

The chemical potential, Grand canonical ensemble and grand partition function, Fugacity, Relation of grand partition function to thermodynamics, Application to (a) Adsorption desorption process (b) Chemical reactions

UNIT IV: QUANTUM STATISTICS **14 hours**

Density operator, Spin statistics connection, Grand partition function for ideal Bose and Fermi gases, Bose-Einstein, Fermi-Dirac and Maxwell-Boltzmann distributions, Application to (a) Electrons in metals (b) Pauli paramagnetism (c) Landau diamagnetism (d) Theory of White dwarf stars (e) Black body radiation: Bose theory (f) Debye theory of specific heat (g) Bose-Einstein condensation.

UNIT V: PHASE TRANSITIONS **12 hours**

Phase transitions, Order of transition, Order parameter, Critical phenomena and critical exponents, Scaling theory and Universality class, Correlation function and fluctuation dissipation theorem, Landau theory of phase transition, Ising Model, Brag Williams theory, Random walk and diffusion equation, Brownian motion,

Text Books

1. K. Huang, Statistical Mechanics, John Wiley & Sons (1987) Second Edition.
2. R.K. Pathria, Statistical Mechanics, Butterworth-Heinemann (1996) Second Edition
3. L.E. Reichl, A Modern Course in Statistical Physics, John Wiely & Sons (1998)

Reference Books

1. F. Reif, Statistical Physics (Berkeley series in Physics Vol 5), McGraw Hill (1967).
2. R.P. Feynman, Statistical Mechanics, Benjamin Cummings Inc. (1972)
3. E.S.R. Gopal, Statistical Mechanics and Properties of Matter, MacMillan India (1988).
4. F. Mandl, Statistical Physics, John Wiley & Sons (1988) Second Edition,
5. D. Chandler, Introduction to Statistical Physics, Oxford University Press (1987).
6. R. Kubo, Statistical Mechanics, North-Holland (1965).
7. D. Yoshioka, Statistical Mechanics, Springer-Verlag (2007)
8. L. D. Landau and E. M. Lifshitz, Statistical Physics, Addison-Wesley (1969).
9. I. Prigogine, Order out of chaos, Fontana (1984).
10. C. Kittel, Elementary Statistical Physics, John Wiley & Sons (1958)

PHYS 552 ASTROPHYSICS – I (3 credits, 3 lectures/week)

Unit – I: Basic concepts of Astronomy

Co-ordinate system, Time system-Solar and Sidereal times, Apparent and Absolute magnitudes, Trigonometric Parallax, Atmospheric extinction, Optical telescopes and their characteristics, Modern Optical telescopes, Astronomical Instruments – Photometer, Spectrographs, Charge Coupled Detector.

(15 hours)

Unit – II: Stellar properties

Observational properties of stars – spectral and luminosity classification of stars- H-R Diagram, Saha Equation, Star Formation - Jeans mass, Jeans Length and Free fall timescale, Main Sequence Evolution, Mass-luminosity relation, White Dwarfs – Chandrasekhar's Limit, Neutron Stars, Pulsars, Supernovae, Stellar Black holes.

(15 hours)

Unit-III: The Milky Way Galaxy

Counting of stars in the sky, star clusters-globular-open- association, historical models, Morphology of the galaxy, different populations, Mass distribution, estimate of the total mass of the galaxy, Kinematics of the Milky Way, Differential rotation of the Galaxy, Rotational curves, Oort's constants, Galactic center, Super massive black hole and jets.

(15 hours)

Text Books

1. M. Zeilik and S. A. Gregory: *Introductory Astronomy and Astrophysics,* Saunders College Publication, 1998.
2. R. Bowers and T. Deeming: *Astrophysics I & II*, Bartlett, 1984
3. M. Schwarzschild: Structure and Evolution of Stars, Dover.
4. A. G. Lyne and F. G. Smith: *Pulsar Astronomy*, Cambridge University Press, NY, 2012

References

5. S. Shapiro and S. Teukolsky: *Black Holes, White Dwarfs and Neutron Stars*, John Wiley, 1983
6. J. Binney and M. Merrifield: *Galactic Astronomy*, Princeton University Press, 1998.
7. C. R. Kitchin: Stars, Nebulae and the Interstellar Medium, Taylor and Francis Group, 1987.

PHYS 541 NUCLEAR PHYSICS **(4 credits)**

Unit I: Nuclear Models: **12 hours**

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: **12 hours**

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: **12 hours**

Stability of nuclei – Decay – decay-Gamow's theory Geiger Nutall law - beta-decay – Fermi's theory – neutrino – energies of gamma-spectrum – conservation of parity – weak interactions – selection rule – pair production – internal conversion – Gamma decay – selection rule.

Unit IV: Nuclear Reactions: **12 hours**

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: **12 hours**

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

Supplementary Reading

1. D. Evans, The Atomic Nucleus, McGraw Hill.
2. Irving Kaplan, Nuclear Physics, Narosa.
3. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill.
4. Blatt and Weiskosf, Theoretical Nuclear Physics, John Wiley.
5. H. A. Enge, Introduction to Nuclear Physics. Addison Wesley.
6. I. S. Hughes, Elementary Particles, Cambridge University Press.
7. H. A. Bethe and D. Morrison, Elementary Nuclear Theory, John Wiley.
8. E. Segre and W. A. Bergemin, Nuclei and Particles.

PHY 542 LASER SYSTEMS (3 credits)

Unit I: Special Laser Cavities & Cavity Effects

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

Unit II: Specific Laser System - 1

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

Unit III: Specific Laser System – 2

Dye lasers, Ruby laser, Nd-YAG laser, Alexandrite laser, Ti-Sapphire laser, Color center laser, Semiconductor lasers.

Unit IV: Specific Laser System – 3

Chemical laser, X-ray Laser, Free electron laser, Excimer laser, Fiber laser

Unit V: 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.

Books

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

PHYS 543: PHYSICS OF AMORPHOUS AND CRYSTALLINE SOLIDS **(3 credits)**

UNIT I: Synthesis and Characterization Techniques: [12 hours]

Solid state and wet chemical methods for preparation of polycrystalline and amorphous materials – Thin film techniques; thermal evaporation, RF sputtering, Pulsed laser deposition (PLD) - Structure: Comparison of X-ray and Neutron diffraction, Raman-Thermal analysis; TG, DTA, DSC- IR, SEM, ESCA, AES & TEM with EDAX

UNIT II: Defects and Dislocations: [12 hours]

Crystal growth, Thermodynamics of point defects, Schottky and Frenkel defects, color centers, polarons & excitons, Dislocations, Strength of crystals, crystal growth, stacking faults & Grain boundaries.

UNIT III: Alloys & Diffusion Process in Crystals: [12 hours]

Alloys: Substitutional solid solutions – Hume –Rothery Rules, Order-Disorder Transformation, Phase diagrams, Transition Metal Alloys, Kondo effect

Phenomenological aspects of diffusion- Microscopic aspects of diffusion – Measurement of diffusion coefficients. Electron conduction in solids: Measurement of conductivity – Determination of transference numbers – Interrelation among diffusion coefficient, mobility and ionic conductivity.

Unit IV: Microscopic Structure and Atomic Transport [12 hours]

X-ray absorption spectroscopy – magnetic resonance – structural modeling: Dense random packing – continuous random packing – 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 V: Ionic Solids: [12 hours]

Fast Ionic materials; alkali metal ion conductors- β alumina's-Silver ion conductors, - Cation conductors – Oxygen ion conductors – Halide ion conductors – Proton conductors

Text books:

1. Principles of Electronic Ceramics, L. L. Hench and J. K. West, (JohnWiley& Sons, New York), 1990.
2. T.Kudo and K.Fueki, Solid State Ionics (VCH,Tokyo, Japan)1990.
3. A.R. West, Solid State Chemistry, (John wiley& Sons)1984.
4. S. Chandra, Superionic Solids, North-Holland, Amsterdam, 1981.
5. S.O.Pillai, Solid State Physics Structure and Electron related properties(Wiley Eastern Limited, New Delhi) 1994.
6. Azaroff; Introduction to Solids (TMH, New Delhi)

References:

1.H.P.Myers; Introductory Solid State Physics (Viva. New Delhi) 1998.
2.B. V. R. Chowdari, M. A. Careem, M A K L Dissanayake, R M G Rajapakse, V A Seneviratne, "Solid State Ionics: Advanced Materials for Emerging Technologies, (World Scientific Publishing Company) 2006.
3.T. Minami, M. Tatsumisago, M. Wakihara, C. Iwakura, "Solid State Ionics for Batteries" (Springer) 2005.
4.J. Ross Macdonald, Impedance Spectroscopy: emphasizing solid materials and systems, (John Wiley & Sons) 1987.

PHYS 544: MAGNETISM & MAGNETO-TRANSPORT (3 credits)

Unit I: Thermal Relaxation and Resonance Phenomena in Paramagnetic Materials [12 hours]

Magnetocaloric effect, Paramagnetic relaxation: Spin-lattice relaxation, spin-spin relaxation, Paramagnetic resonance: Line widths, fine and Hyperfine structure, the spectra of the transition Group ions, the spectra of Paramagnetic Molecules and other systems.

Unit II: Theories of Magnetism: [14 hours]

The exchange interaction: direct and indirect interaction, double exchange, anisotropic exchange interaction, the Bethe-Peierls- Weiss method, Band theories of ferromagnetism, Neel's theory of ferri magnetism, Crystalline anisotropy,

Unit III: Advanced Magnetic properties: [10 hours]

De Haas-van Alphen effect, Cyclotron, Critical phenomena in magnetic materials, Spin wave theory

Unit IV: Introduction to New trends in Magnetism: [10 hours]

Magnetoelasticity, Multiferroics, Nano particle magnetism- core-shell model, Super paramagnetism

Unit V: Magneto-transport: [14 hours]

Basic electron transport & Boltzmann transport equation, Phenomenological theory of giant magnetoresistance (GMR), colossal magnetoresistance (CMR), Anisotropic magnetoresistance (AMR), magneto transport in Semiconductors, Quantum Hall effect.

Text books:

1. The Physical Principle of Magnetism by Allan H. Morrish, Robert E. Krieger Publishing Company (1980)
2. A. J. Dekker, Solid state physics, MacMillan (1981)
3. B.D. Cullity, Introduction to Magnetic Materials. Wiley.
4. David. Jiles, Introduction to Magnetism and Magnetic Materials. Chapmann and Hall.

References:

1. Physics of Magnetism and Magnetic materials by K.H.J. Buschow & F.R. deBoer
2. Spin electronics, - Edited by M.J. Thornton, M. Ziese, Springer 1st edition (2000).
3. J. M. D. Coey, Magnetism and Magnetic Materials, Cambridge University Press
4. R.C.O. Handley, Modern Magnetic Materials, John Wiley & SONS, INC.
5. Stephen Blundell, Magnetism in Condensed Matter Physics, Oxford University Press
6. Nicole A. Spaldin, Magnetic materials : fundamentals and device applications

PHYS 545: SIGNAL PROCESSING AND COMMUNICATION **(3 credits)**

Unit I : Signals and Sampling **10 hours**

Signals, classification of signals, basic operation on signals, elementary signals, systems, properties of systems, Sampling continuous time signals, sampling a sinusoid, aliasing, sub-sampling, sampling theorem, ideal reconstruction and practical reconstruction: zero order hold.

Unit II: Fourier Representation **13 hours**

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. Parseval relationship, Time-Bandwidth product, Duality.

Unit III Communications Systems **10 hours**

Basic information theory; Modulation and detection in analogue and digital systems; Sampling and data reconstructions; Quantization & coding; Time division and frequency division multiplexing; Equalization; Optical Communication: in free space & fiber optic; Propagation of signals at HF, VHF, UHF and microwave frequency; Satellite Communication.

Unit IV Microwave communications **12 hours**

Microwave Tubes and solid state devices, Microwave generation and amplifiers, Waveguides and other Microwave Components and Circuits, Microstrip circuits, Microwave Antennas, Microwave Measurements, Masers, lasers; Microwave propagation. Microwave Communication Systems terrestrial and Satellite based.

Textbooks:

1. S.Haykin and B.Van Veen, Signals and Systems (II edition); Wiley Student Edition.
2. B.P.Lathi, Signal processing and linear systems; Oxford University Press Inc.(USA),2003.
3. P.N.Denbigh, System analysis and signal processing; Addison Wesley, 1998.
4. S.P.Eugene, Signals, systems and signal processing; Xavier.
5. Samuel Y. Liao, Microwave Devices and Circuits; Pearson Education, 3rd Edition, 2003.
6. Annapurna Das, Sik. Das, Microwave Engineering; Tata McGrawHill, 2nd Edidtion, 2009.
7. Kennedy Davis, Electronic Communication Systems; Tata Mc Graw- Hill, 4th Edition, 2008.
8. Simon Haykin, Communication Systems, 3rd Edidtion, Wiley India Edition, 2008.

PHYS 546: ELECTRONIC MEASUREMENT TECHNIQUES AND ANALYSIS (3 credits)

UNIT – I: **10 hours**

Measurement Basics: 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

UNIT – II **15 hours**

Transducers: Classification of instrument transducers – Input and output characteristics – Static and dynamic response – Linearity and hysteresis.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: **10 hours**

Network Theory: Network analysis techniques; Network theorems, transient response, steady state sinusoidal response; Network graphs and their applications in network analysis; Tellegen's theorem. Two port networks; Z, Y, h and transmission parameters. Combination of two ports, analysis of common two ports.

UNIT IV: **10 hours**

Network Functions : parts of network functions, obtaining a network function from a given part. Transmission criteria: delay and rise time, Elmore's and other definitions effect of cascading. Elements of network synthesis.

Text Books:

1. Van Valkenburg, Network Analysis; 3rd edition, Prentice-Hall, 1974.
2. A. Sudhakar, Shyammohan S. Palli, Circuits and Networks; 4th Edition, Tata Mc Graw Hill, 2010.
3. T. G. Beckwith, R. D. Marangoni, J. H. Lienhard (2006)Mechanical Measurements, Prentice Hall.
4. A.K.SAWHNEY INSTRUMENTATION AND MEASUREMENTS, Dhanpai Rai and Co.

Reference Books:

1. Ernest O Doebelin. Measurement Systems: Application and Design. 5th edition. Tata Mc Graw 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 547: VISUAL PROGRAGRAMMING (Pre-requisite: PHYS-436) (3 credits)

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

PHYS 548 QUANTUM ENTANGLEMENT **(3 credits)**

Unit I: **12 Hrs**
Postulates of Quantum Mechanics. Dirac formalism, EPR paradox; hidden variable & Bell's theorem; Quantum calculation of the correlation in Bell's theorem; Bell's theorem without inequalities (GHZ equality).

Unit II: **12 Hrs**
Entanglement as physical resource, Quantum circuits; Quantum search algorithm, Quantum Computers-Physical realization, Condition for quantum computation, Different implementation schemes for quantum computation

Unit III: **12 Hrs**
Quantum information theory (Distinguishing Quantum states, Data compression, Classical & Quantum information & noisy Quantum channels), Quantum Cryptography (Bennett- Brossard protocol)

Unit IV: **8 Hrs**
Quantum Non demolition measurement Quantum key distribution and security of quantum key distribution.

Book:

1. M A Nielsen & I L Chuang, Quantum Computation & Quantum Information Cambridge, 2001.
2. Mikio Nakahara and T Ohmi, C Quantum Computing, RC Press (2007).

PHYS 549 LASER SPECTROSCOPY **(3 credits)**
(For Post-graduate students as a soft-course)

Chapter-I : Laser as Spectroscopic Light Sources **6 Hrs.**
Fundamental of Lasers-Laser Resonators-Spectral Characeteristics of Laser Emission- Experimental Realization of Single Mode Lasers- Controlled Wavelength Tuning of Single Mode Lasers- Linewidths of Single Mode Lasers.

Chapter-II : Nonlinear Optical Mixing Techniques & Spectroscopy **10 Hrs.**
Physical Background- Phase matching-Second Harmonic Generation- Quasi Phase Matching- Sum Frequency and Higher- Harmonic Generation- Difference Frequency Spectrometer.

Chapter-III : Absorption and Fluorescence Spectroscopy with Lasers **10 Hrs.**
Advantages of Lasers in Spectroscopy – Direct Determination of Absorbed Photons – Ionization Spectroscopy-Optogalvanic Spectroscopy- Laser Induced Fluorescence- Comparison between the Different Methods .

Chapter-IV : Nonlinear Spectroscopy **10 Hrs.**
Linear and Nonlinear Absorption- Saturation of Inhomogeneous Line Profiles-Saturation Spectroscopy-Polarization Spectroscopy-Multiphoton Spectroscopy-Special Techniques of Nonlinear Spectroscopy

Chapter-V: Time Resolved Spectroscopy **9 Hrs.**
Lifetime Measurements with Ultra fast Laser pulses-Pump-and –Probe Techniques.

Text Book:

W. Demtroder, Laser Spectroscopy –Basic Concepts and Instrumentation Springer, New York, Third Edition (ISBN 81-8128-205-1

PHYS 553 ASTROPHYSICS – II (3 credits, 3 lectures/week)

Unit – I: Solar atmosphere and active regions

Overview of Sun, Location of Sun, Sun's spectrum, Solar interior structure - Energy Generation, Radiative zone, Convection Zone, Observing the Sun, Solar Telescopes, Satellite Missions, Solar Polarimetry, Solar Radio Astronomy. Solar Atmosphere – Photosphere - active Regions, Sunspots – solar cycle, active and quiet Sun, Granulation, Faculae, Chromosphere -Diagnostics, Radiative Transfer, Heating, Supergranulation, Solar Flares - Properties, Classification, Occurrence, Prominences, Corona - Basic Facts, Observational Features, CME, Radio bursts, Solar Wind and Interplanetary Magnetic field.

(15 hours)

Unit –II: Stellar structure

Hydrostatic Equilibrium, Mass conservation, Luminosity gradient equation, Temperature gradient Equations, Lane – Emden equation for polytrophic stars and its physical solution, estimates of central pressure and temperature, Radiation pressure, equation of temperature gradient for radiative and convective equilibrium, Schwarzschild criterion, gas pressure and radiation pressure, Linear Model and its properties, Volt – Russell theorem, Zero age main sequence, Mass – Luminosity relation.

(15 hours)

Unit-III: Extra Galactic Astronomy

Galactic structure: local and large scale distribution of stars and interstellar matter, the spiral structure, the galactic centre. Galactic dynamics, stellar relaxation, dynamical friction, star clusters, density wave theory of galactic spiral structure, chemical evolution in the galaxy, stellar populations, Morphological classification of galaxies, active galaxies, clusters of galaxies, interactions of galaxies, dark matter, evolution of galaxies. AGN, Quasars and theory of Gravitational lensing.

(15 hours)

Text Books:

1. A. Hanslmeier : *The Sun and Space Weather*, Springer, 2007.
2. J. Binney and S. Tremaine: *Galactic Dynamics*, Princeton University Press, 1994.
3. J. Binney and M. Merrifield: *Galactic Astronomy*, Princeton University Press, 1998.

References

4. M. Zeilik and S. A. Gregory: *Introductory Astronomy and Astrophysics*, Saunders College Publication, 1998.

PHYS 554 ASTROPHYSICS – III (3 credits, 3 lectures/week)

Unit –I: Interstellar Medium

Overview of the ISM, Types of interstellar media, Physical description of the ISM (various equilibria), Models of the ISM, Heating & cooling mechanisms, Thermal stability & equilibrium (2-phase models). Neutral atomic gas (HI regions): Interstellar UV & Visible absorption line observations, Radiative transfer in Lines & Line formation, line broadening mechanisms, Equivalent width, Interstellar HI Lyman absorption lines, Gas-phase abundance of metals, 21cm hydrogen line, 21cm line formation in absorption & emission. Stromgren sphere, Ionized gas (HII regions) & the physical processes.

(15 hours)

Unit –II: Radiative Transfer

Radiation field, Radiative transfer equation, Optical depth, thermodynamic equilibrium, radiative transfer through stellar interior, bramestrahlung, Compton scattering, Thomson scattering, cyclotron and synchrotron radiation, opacity, red shift.

(15 hours)

Unit-III: General Relativity and Cosmology

Foundations of general relativity, elements of tensor analysis, Schwarzschild and Kerr spacetimes, black hole physics, gravitational radiation, gravitational lensing, the redshift, Hubble's Law, uniform expansion, distance measures, Pseudo-Newtonian cosmology, Dynamical evolution, cosmological solutions, age of the universe, matter content, dark matter, cosmological constant, CMBR, observational tests. Theories of universe, Big-bang, expansion of universe, CMB radiation, Olber's paradox.

(15 hrs)

Text Books

1. J. Binney and M. Merrifield: *Galactic Astronomy*, Princeton University Press, 1998.
2. G. B. Rybicki & A. P. Lightman: *Radiative Processes in Astrophysics* 2004, John Wiley & Sons 1979.

References

3. L. Spitzer: Physical Processes in the Interstellar Medium, Taylor and Francis Group, 1987
4. C. R. Kitchin: Stars, Nebulae and the Interstellar Medium, Taylor and Francis Group, 1987.
5. C. W. Misner, K. S. Thorne and J. A. Wheeler: *Gravitation*, H. Freeman 1973
6. M. Berry: *Principles of Cosmology and Gravitaion*, CUP, 1976.
7. J. Luminet: *Black Holes*, CUP, 1992.
8. Narlikar J V: *Introduction to Cosmology*, CUP.
9. Peacock: *Cosmological Physics*, CUP, 1998.