SRI VENKATESWARA UNIVERSITY::TIRUPATI
DEPARTMENT OF PHYSICS
TWO YEAR M.Sc. COURSE IN PHYSICS (2021-2022)
COURSE STRUCTURE AND EXAMINATION SCHEME

Semester -I

S.No	Components of Study	Title of the Course	Title of the Paper	Credit Hrs/ Week	No. of Credits	IA Marks	Sem End Marks	Total
1.	**Mandatory Core**	PHY 101	1.Classical Mechanics and Theory of Relativity	6	4	20	80	100
2.		PHY102	2.Solid State Physics	6	4	20	80	100
3.	**Compulsory Foundation**	PHY 103(a)	1.Analog and Digital Electronics	6	4	20	80	100
		PHY103(b)	2.Computational Methods & C Language					
		PHY 103(c)	3.Sensors and Transducers					
4.	**Elective Foundation**	PHY104 (a)	1.Atomic and Molecular Physics	6	4	20	80	100
		PHY104 (b)	2.Optical, Microwave and Satellite Communications					
		PHY104 (c)	3.Computer Architecture and Networking					
5.	**Practical -I**	PHY 105	Paper 1& 3 (General Lab)	6	4	--	100	100
6.	**Practical-II**	PHY 106	Paper 3 &4 (Electronics Lab)	6	4	--	100	100
	Total			36	24	80	520	600
7.	Audit Course			0	0	100	0	0

*All core papers are Mandatory

- Compulsory Foundation choose one paper.
- Elective Foundation – Choose one paper.
- Audit course-100 Marks (Internals) Zero Credits under self-study.
- Interested students may register for MOOC with the approval of the concerned DDC but it will be considered for the award of the grade as open elective only giving extra credits.

Semester -II

S.No	Components of Study	Title of the Course	Title of the Paper	Credit Hrs/ Week	No. of Credits	IA Marks	Sem End Marks	Total
1.	**Mandatory Core**	PHY201	1.Statisticical Mechanics	6	4	20	80	100
2.		PHY202	2.EM Theory, Lasers & Modern Optics	6	4	20	80	100
3.	**Compulsory Foundation**	PHY 203(a)	1.Nuclear Physics	6	4	20	80	100
		PHY 203(b)	2.IC fabrication Techniques					
		PHY 203(c)	3.Advanced Microprocessors and its Applications					
4.	**Elective Foundation**	PHY 204(a)	1.Mathematical Physics	6	4	20	80	100
		PHY 204(b)	2.Introduction to VLSI design					
		PHY 204(c)	3.Material Science for Industrial Applications					
5.	**Practical -I**	PHY205	Paper 1& 3 (General Lab)	6	4	--	100	100
6.	**Practical-II**	PHY206	Paper 3 & 4 (Electronics Lab)	6	4	--	100	100
	Total			36	24	80	520	600
7.	Audit Course			0	0	100	0	0

*All core papers are Mandatory

- Compulsory Foundation choose one paper.
- Elective Foundation – Choose one paper.
- Audit course-100 Marks (Internals) Zero Credits under self-study.
- Interested students may register for MOOC with the approval of the concerned DDC but it will be considered for the award of the grade as open elective only giving extra credits.

Semester -III

S.No	Components of Study	Title of the Course	Title of the Paper	Credit Hrs/ Week	No. of Credits	IA Marks	Sem End Marks	Total
1.	**Mandatory Core**	PHY301	1.Introductory Quantum Mechanics	6	4	20	80	100
2.		PHY302	2.Physics of Semiconductor Devices	6	4	20	80	100
3.	**Generic Elective**	PHY 303(a)	1.Applied Spectroscopy	6	4	20	80	100
		PHY 303(b)	2.Condensed Matter Physics					
		PHY 303(c)	3. Embedded Systems					
4.	**Practicals**	PHY 304	Elective Lab	6	4	--	100	100
5.	**Skill Oriented Course**	PHY305	Advances in Physics	6	4	10	90 (T40 +P50)	100
6.	**Open Elective**	PHY 306(a)	1. Basic Spectroscopic Techniques	6	4	20	80	100
		PHY 306(b)	2. Nanomaterials and Devices					
	Total			36	24	90	510	600

*All core papers are Mandatory

- Generic Elective – Choose two
- Core papers and Generic Electives opted paper held Practical-I
- Skill Oriented Course is Mandatory. Relevant society along with practical (10marks internal 40 final theory & 50 for practical's).
- Open Electives are for the students of other Departments. Minimum one paper should be opted. Extra credits may be earned by opting for more number of open electives depending on the interest of the student through self-study.
- Interested students may register for MOOC with the approval of the concerned DDC.

Semester -IV

S.No	Components of study	Title of the Course	Title of the Paper	Credit Hrs/ Week	No. of Credits	IA Marks	Sem End Marks	Total
1.	**Mandatory Core**	PHY401	1.Advanced Quantum Mechanics	6	4	20	80	100
2.		PHY402	2. Physics of Advanced Materials	6	4	20	80	100
3.	**Generic Elective**	PHY 403(a)	1.Photonics	6	4	20	80	100
		PHY403(b)	2.Solar Energy Thermal and Photovoltaic Properties					
		PHY403(c)	3.Vacuum and Thin Film Technology					
4.	**Practicals**	PHY404	Elective Lab	6	4	--	100	100
5.	**Multi Disciplinary Course/ Project Work**	PHY405	Advanced Characterization Techniques	6	4	10	90 (T 40+P 50)	100
6.	**Open Elective**	PHY 406(a)	1.Wireless Communications	6	4	20	80	100
		PHY406(b)	2. Vacuum Technology & Applications					
	Total			36	24	90	510	600

*All core papers are Mandatory

- Generic Elective – Choose two
- Core papers and Generic Electives opted paper held Practical-II.
- Project Work- Collaboration with various firms/companies/societies.
- Multi-Disciplinary Course is Mandatory. Circle formation with other subjects/Dept. of Arts/Commerce.
- Open Electives are for the students of other Departments. Minimum one paper should be opted. Extra credits may be earned by opting for more number of open electives depending on the interest of the student through self-study.
- Interested students may register for MOOC with the approval of the concerned DDC.

(Mandatory Core)

PHY 101: Classical Mechanics and Theory of Relativity

UNIT – I: Lagrangian Mechanics and Hamiltonian Mechanics

Newtonian mechanics of one and many particle systems: Conservation laws: Constraints and their classification: Degrees of freedom: Generalized coordinates: Principle of virtual work, D' Alemberts principle: Lagrange's equations of motion.

Applications: Inclined plane, Linear harmonic oscillator and simple pendulum: Hamiltonian principle: Lagrange's equation from Hamilton's principle: Hamilton's equation of motion: Applications: Simple pendulum, Compound pendulum.

UNIT – II: Canonical Transformations and Hamilton - Jacobi Theory

Canonical Transformations; generating function; properties: Condition for transformation to be canonical; Illustration of canonical transformation: Poisson - Brackets; Canonical equations in terms of Poisson - Bracket notation. Lagrange-Brackets and their properties.

The Hamiltonian - Jacobi equation; one dimensional harmonic oscillator; Action Angle variables: Kepler problem in action angle variables

UNIT –III: Motion in a Central Force Field

Reduction to the equivalent one body problem; Motion in a central force field: Conditions for closed orbits: Inverse square law of forces: Kepler's laws of planetary motion; Rutherford scattering.

Rotations – Space and body fixed axes: Angular momentum and Torque; Eulerian angles – Euler's equations of a rigid body: Motion of symmetrical top; Expression for slow and fast precessions; Larmour precision; Examples of Gyroscope.

UNIT –IV: Special Theory of Relativity

Introduction – Postulates of Special Theory of Relativity – The principle of constancy of light – The Lorentz transformations. Relativistic Kinematics: The velocity transformations – The transformations for the acceleration of a particle. Relativity Optics: The aberration of the of the light from stars – The Doppler effect.

Relativistic Mechanics: The mass of a moving particle – The relativistic dynamics of a single particle – Applications of relativistic dynamics of a single particle: Motion in electric field – Motion in a magnetic field – Experimental verification of the variation of mass with velocity – Bucherer's experiment - Transformation of momentum and force.

Books for Study

1. Classical Mechanics by N.C. Rana and P.S. Joag Tata Mc-graw Hill (1991).
2. Classical Mechanics by H. Goldstein, Addi Wesely, (1980).
3. Classical Mechanics by J.C. Upadyaya, Himalaya Publishing House (2014).
4. Classical Mechanics by Gupta, Kumar and Sharma, Pragati Edition, (2019).
5. Classical dynamics of particles and systems by J.B.Marion, Thomson Books/cole, (2004).
6. Introduction to Classical Mechanics by R.G. Takwale and P.S. Puranik, Tata Mc-graw Hill, (2008).
7. Theory of Relativity by W.Pauli, Dover Publications, (2013).
8. Introduction to the theory of relativity by P.G. Bergmann, Dover Publications (1977).
9. Introductory Relativity by W.G.V.Rosser, London Butterworths, (1967).

(Mandatory Core)

PHY 102: Solid State Physics

UNIT – I: Crystallography, Lattice Energies and Lattice Vibrations

Bravais lattices – Reciprocal lattice – X-ray diffraction – structural factor.

Origin of chemical binding in ionic and van der Waals crystals – Elastic properties – Stress and strain – Elastic moduli - Lattice energy calculations for ionic and van der Waals crystals – Lattice vibrations: Mono and diatomic one dimensional infinitely long lattices – Quantization of lattice vibrations – Phonons – Properties.

UNIT – II: Transport Phenomena and Band Theory

Concept of electrical and thermal resistivity – Expression for thermal and electrical conductivities for metals – Lorenz number - Different scattering mechanisms – Matheissens rule- Distribution function - Formulation of Boltzmann transport equation – Relaxation time approximation.

Sommerfeld model – its consequences – electron-lattice interaction (Quantitative only) – Bloch function - Motion of electron in periodic potential –Kronig - Penny model – Formation of energy bands in solids – Brillouin zones – Concept of effective mass – Distinction between metals, insulators and semiconductors.

UNIT – III: Semiconductor Physics

Intrinsic and extrinsic semiconductors – Expression for position of Fermi levels and carrier concentrations – Variation of Fermi level with temperature – np product – Carrier mobility, conductivity and their variation with temperature – Direct and indirect band gap semiconductors – Differences and examples – Hall effect - Continuity equation – Drift and Diffusion – Einstein relation – Generation, Recombination and life time of non-equilibrium carriers – Heyness-Schockley experiment – Determination of life time, diffusion length of minority charge carriers.

UNIT – IV: Superconductivity

Concept of zero resistance – Magnetic behavior – Distinction between a perfect conductor and superconductor – Meissner effect – Isotope effect – Specific heat behavior – Two-fluid model – Expression for entropy difference between normal and superconducting states – London's equations – Penetration depth – BCS theory –Josephson junctions – SQUIDS and its applications - Applications of superconductors – High T_C superconductors – Preparation – Properties.

Books for Study

1. Solid State Physics, C. Kittel, Edition: 8th 2012, John Wiley & Sons.
2. Solid State Physics, A.J. Dekkar, Edition: 1st, 2000. Macmillan India Ltd.
3. Solid State Electronic Devices, B.G. Streetman. Edition 7th,2018, Pearson Education India
4. Elementary Solid State Physics, M. Ali Omar, 1993, Addison-Wesley.
5. Solid State Physics, M.A. Wahab, Edition:3rd, 2020, Narosa Publishing House.
6. High TC Superconductivity, C.N.R. Rao and S.V. Subramanyam, world scientific publishing company
7. Solid State Physics, S.O. Pillai.Edition:6th,2009, New Academic Science Ltd
8. Solid State Physics, S.L. Kakani and C. Hemarajan, Edition: 4th, 2005, Sultan Chand and Sons
9. Electrons in Solids, Richard H. Bube, Edition 3rd,1992 Elsevier,
10. Solid State Physics by R. K. Puri V.K. Babbar Edition: 1st 2017. S. Chand.

(Compulsory Foundation)

PHY 103 (a): Analog and Digital Electronics

UNIT – I: Introduction to Electronic Devices:

Field Effect Transistor (FET): Structure and working of JFET, Characteristics, and parameters of JFET. Advantages of FET over BJT. FET as switch and Amplifier Application of FET as voltage variable resistor. Structure of MOSFET, depletion type and enhancement type, MOSFET Characteristics, MOSFET as variable resistor, Concept of CMOS. Structure, working and Characteristics of UJT. Application of UJT as a Relaxation oscillator.

UNIT – II: Operational Amplifiers:

Block diagram of a typical Op-Amp, differential Amplifier, Comparator open loop configuration, inverting and non-inverting amplifiers. Op-amp with negative feedback, voltage shunt feedback, effect of feedback on closed loop gain, input resistance, output resistance, CMRR, frequency response slew rate.
Instrumentation- Amplifier, integrator and differentiator. Waveform generators (Square and triangle). Filters (Low pass, high pass and Band pass). Analog to Digital data converters (ADC) and Digital to Analog conversion (DAC).

UNIT – III: Digital Electronics

Combinational Logic: Multiplexers, Decoder, Demultiplexer, Data selector, Multiplexer, Encoder. Sequential Logic: Flip–Flops, A1-bit memory, The RS Flip-Flop, JK Flip – Flop, JK Master Slave Flip–Flops, T Flip-Flop, D Flip-Flop, Shift Registers, Serial-in Serial-out, Serial-in Parallel-out, Parallel-in Serial-out, Parallel-in Parallel-out Registers. Asynchronous and Synchronous Counters.

UNIT – IV: Communication Electronics

Introduction to Modulation (AM & FM), Sampling Theorem, Low pass and Band pass signals, PAM, Channel BW for a PAM signal. Natural sampling, Flat-top sampling. Signal recovery through holding. Quantization of signals, PCM transmission, Quantization of noise, Differential PCM, Delta Modulation, Adaptive Delta modulation CVSD. Signal to noise ratio in PCM and Delta Modulations.

Books for Study

1. Micro Electronics by Milliman and Halkias. TMH Publications
2. OP-Amps & Linear Integrated Circuits, by RamakanthA.Gayakwad, PHI, 2nd
3. Edition, 1991. Digital Systems by Ronald J. Tocci, 6th Edition, PHI, 1999.
4. Digital Principles and Applications by A.P. Malvino and Donald P.Leach, Tata
5. McGraw- Hill, New Delhi, 1993. Principles of Commuunication by Taub and Schilling, Mc-Graw Hill Publication.
6. Electronic Devices and Circuit Theory by Robert Boylested and Louis Nashdsky – Jose Kanedy & Division. PHI, New Delhi, 1991
7. Electronic Principles by Malvino, 6th Ed. TMH
8. Linear Integrated circuits by Roy Choudhry
9. Op-Amps – D.K. Mahesh PH1

(Compulsory Foundation)

PHY 103 (b): Computational Methods & C Language

UNIT – I: (a) Fundamentals of C language

C character set – Identifiers and keywords – Constants – Variables – Data types – Declarations of variables – Declaration of storage class – Defining symbolic constants – Assignment statement. Operators: Arithmetic operators – Relational operators – Logic operators – Assignment operators – Increment and decrement operators – Conditional operators.

(b) Expressions and I/O statements: Arithmetic expressions – Precedence of arithmetic operators – Type converters in expressions – Mathematical (library) functions – Data input and output - Getchar and putchar functions – Scanf – Printf – Simple programs.

(c) Control statements: If-Else statement – Switch statement – The ? operator – GO TO – While , Do-while, FOR statements – BREAK and CONTINUE statements.

UNIT – II: (a) Arrays

One dimensional and two dimensional arrays – Initialization – Type declaration – Inputting and outputting of data for arrays – Programs of matrices addition, subtraction and multiplication.

(b) User Define functions: The form of C functions – Return values and their types – Calling a function – Category of functions. Nesting of functions. Recursion. ANSI C functions – Function declaration. Scope and life time of variables in functions.

(c) Pointers: Accessing the address of variable. Declaration and Initialization of pointer variables. Accessing the value of the variable through its pointer. Pointer Expressions- Pointers and Arrays – Pointers and structures.

UNIT – III: Linear and non-linear equations

(a) Solution of Algebraic and transcendental equations – Bisection, Falsi position and Newton-Rhapson methods – Basic principles – Formulae – Algorithms.

(b) Simultaneous equations: Solutions of simultaneous linear equations – Gauss elimination and Gauss-Seidel iterative methods - Basic principles – Formulae – Algorithms

UNIT – IV: (a) Interpolations

Concept of linear interpolation – Finite differences – Newton's and Lagrange's interpolation formulae –Principles and Algorithms Curve fitting – regression – Least square fitting – Linear and quadratic**.**

(b) Numerical differentiation and integration: Numerical differentiation – algorithm for evaluation of first order derivatives using formulae based on Taylor's series – Numerical integration – Trapezoidal and Simpson's 1/3 rule – Formulae – Algorithms.

(c) Numerical solution of ordinary differential equations: Euler, method, Fourth order Runga-Kutta Method.

Books for Study

1. Programming with 'C' – Byron Gottfried, Tata McGraw Hill
2. Programming in 'C' – Balaguruswamy
3. Numerical Methods, E. Balaguruswamy, Tata Mc Graw Hill
4. Computer oriented numerical methods – Rajaraman
5. Let Us C by Yeswanth Kanetkar

(Compulsory Foundation)

PHY 103 (c): Sensors and Transducers

UNIT – I: General Introduction to sensors/transducers

Definition of a transducer/sensor Role of a transducer in a generalized measurement system. Classification of transducers. Classification of transducers. Significant parameters of transducer. Temperature scales. Mechanical temperature sensors. Platinum resistance thermometer. Thermistors. Thermocouples.

UNIT –II: Displacement and strain transducers

Displacement transducers - Variable resistance, inductance and capacitance. Linear voltage differential Transformer (LVDT) Strain - Definition, Principal of working of strain gauges. Gauge factor. Types of strain gauges. Materials for strain gauges. Temperature compensation. Application

UNIT –III: Opto - electronic transducers

Photoemission tube. Photomultiplier cell. Photoconductive cell. Photovoltaic cell (solar cell). Photodiode, Photo – transistor, Photo FET, Light emitting diode. Liquid crystal display. Optoelectronic couplers. Laser diode.

UNIT –IV: Single conditioners (Filters, Detectors & Amplifiers)

Filters – Integrators, Differentiators and active filters. Detectors Peak Detectors sample and _ hold circuits. Phase sensitive detector and precision rectifiers, Amplifiers – chopper stabilized DC amplifiers. Instrumentation amplifiers. Logarithmic and anti-logarithmic amplifiers Isolation amplifiers, Lock in amplifiers.

Books for Study

1. Instrumentation Measurement Analysis by Nakra and Chaudary
2. Instrumentation - Devices and Systems by Rangan, Mani and Sharma
3. A course in Electrical and Electronic Measurements and Instrumentation by AK Sawhney
4. Instrumental Methods of Analysis by Willard, Meritt, Dean and Seattle
5. Hand Book of Biomedical Instrumentation by RS Khandpur
6. Fundamentals of Electronic Devices by David A. Bell
7. An introduction to Operational amplifiers by SV Subramanyam

(Elective Foundation)

PHY 104 (a): Atomic and Molecular Physics

UNIT- I: Atomic Spectra

Introduction: Hydrogen atom (one electron atom) - quantum numbers- Spectra of hydrogen atom- Spectra of alkali elements- Fine structure- Elements with more than one valence electron- Forbidden transitions and selection rules- Vector atom model – Spin-orbit interaction energy - Stern-Gerlach experiment- Experimental setup to demonstrate S-G - Coupling schemes- Spectral terms and term symbols based on electron configuration - LS coupling - JJ coupling- Interaction energies in LS and JJ couplings - Hund's rule of multiplicity - Pauli's exclusion principle - Equivalent and non-equivalent electronic systems.

UNIT- II: Zeeman and Stark Effects

Introduction: Zeeman effect- Normal and anomalous Zeeman effects - Experimental details - Magnetic moment of atom and Lande's 'g'-factor - Zeeman effect in sodium atom - Lande g-formula for LS and JJ couplings - Paschen-Back effect - Splitting of sodium lines and selection rules - Stark effect - Experimental details - Weak and strong field effects – linear and quadratic Stark effects -Width of spectral lines.

UNIT- III: Diatomic Molecular Spectroscopy – Rotational Energies

Introduction – Rotational, vibrational, electronic spectra of diatomic molecules –types of molecules – Linear, symmetric top, asymmetric top and spherical top molecules – Rotational spectra of a diatomic molecule as rigid rotator – Energy levels and spectra of non-rigid rotor – Intensity of rotational lines - Rotational spectra of polyatomic molecule – Rotational analysis of electronic spectra- Evaluation of rotational constants- Effect of isotopic substitution on rotational levels – Stark splitting of rotational lines – Stark modulated microwave spectrometer – Applications of rotational spectroscopy

UNIT- IV: Diatomic Molecular Spectroscopy – Vibrational Spectra

Introduction–Vibrational spectra of diatomic molecule – Diatomic molecule as simple harmonic oscillator – An harmonic oscillator – Energy levels and spectrum – Molecule as vibrating rotator – PQR branches – progressions and sequences – Vibrational analysis of electronic spectra - Deslander's table – Evaluation of vibrational constants – Morse potential energy curve – Frank-Condon principle – Intensity distribution in absorption and emission spectra - Effect of isotopic substitution on vibrational bands – IR spectrometer – FTIR spectroscopy – Principle – Interferometer arrangement – advantages - Applications of vibrational spectroscopy

Books for Study

1. Introduction to Atomic Spectra, H.E. White, McGraw-Hill Kogakusha. Ltd., New Delhi (1934).
2. Elements of Spectroscopy by Gupta, Kumar, Sarma, Pragati Prakasan, (2012).
3. Fundamentals of Molecular Spectroscopy, C.N. Banwell and E.M. McCash,Tata McGraw-Hill Publishing Company Ltd., New Delhi. (1994).
4. Spectroscopy, Volume I and III, B.P. Straughan and S. Walker, John Wiley & Sons Inc., New York. (1976).
5. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw - Hill Book company, Inc., New York. (1962).
6. Spectra of Diatomic Molecules, G. Herzberg, D. Van Nostrand Company Inc, New York. (1950).
7. Molecular Spectroscopy, J.M. Brown, Oxford Science Publications, Oxford. (1998).
8. Molecular Structure and Spectroscopy, G. Aruldhas, Prentice- Hall of India, Pvt., New Delhi, (2005).

(Elective Foundation)

PHY 104 (b): Optical, Microwave and Satellite Communications

UNIT – I: Microwave Communications

Advantages and Disadvantages of microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading Sources, Detectors, components, antennae used in MW communication systems.

UNIT – II: Radar Systems

Radar block diagram and operation, radar frequencies, pulse considerations. Radar range equation, derivation of the radar range equation, minimum detectable signal, receiver noise, Signal to noise ratio, Integration of radar pulses, Radar cross section, Pulse repetition frequency, Antenna parameters, System Losses and propagation losses, Radar transmitters, receivers, Antennas, Displays.

UNIT - III: Digital Communications

Digital Communications: Principles of digital communications, digital radio, frequency shift keying, phase shift keying, quadrature amplitude modulation.

UNIT – IV: Optical and Satellite Communications

Optical Communications: Optical transmitter and receiver for analog and digital communications, coherent and non-coherent detection, signal to noise ratio, error rate, coding, synchronization and equalization in optical data transmission.

Satellite Communications: Orbital satellites, geostationary satellites, orbital patters, look angles, orbital spacing, satellite systems, Link modules.

Books for Study

1. Microelectronics by Jacob Millman, Mc Graw-Hill International Book Co., NewDelhi, 1990.
2. Optoelectronics: Theory and Practice", edited by Allen Chappel, Mc Graw Hill International Book Co., New York.
3. Microwaves" by K.C. Gupta, Wiley Eastern Limited, New Delhi.
4. Advanced Electronics Communications Systems" by Wayne Tomasi

(Elective Foundation)

PHY 104 (c): Computer Architecture and Networking

UNIT – I: Logic Circuits

Logic functions – synthesis of logic functions – Minimization of logic - Synthesis with NAND and NOR gates – Implementation of Logic gates – Flip-Flops – Registers and shift registers – counters – decoders – multiplexers – PLDs – sequential circuits. Basic structure of computers: Functional units – Basic operational concepts – Bus structures performance – Multiprocessors and multi computers.

UNIT – II: Machine Instructions and programs

Numbers, arithmetic operations and characters – memory locations and address, operations – Instructions and instruction sequencing –addressing modes – assembly language – basic input/output operations – subroutines – encoding of machine instruction. Instructions – assembly languages – O/I operations-registers and addressing – instructions – assembly language – instructions of 68000 and Intel Pentium.

UNIT – III: Input/output organization

Accessing I/O devices – interrupts – direct memory access – buses 240 interface circuits – standard I/O interface.

UNIT – IV: Memory System

Concepts semiconductor RAM memories – Randomly memories - cache memories performance considerations – virtual memories – memory management requirements – secondary storage arithmetic: addition and subtraction of signed numbers – design of fast adders – multiplication of positive numbers – signed operand multiplication – fast multiplication – integer division –floating point numbers and operations.

Books for Study

1. Hamacher C Vranesic Z and Zaky S. Computer Organization, 5th Edition, McGraw Hill 2002.
2. Stallings W. Computer Organization and Architecture 6th Edition, Pearson Education 2003
3. Mano M M, Computer System Architecture 3rd Edition Phi 1993
4. Yarbrough J.M. Digital Logic Applications and Design, Thomas Learning 1997
5. Heuring VP and Jordan HF Computer Systems Design and Architecture, Pearson Education 1977

(Mandatory Core)

PHY 201: Statistical Mechanics

UNIT- I: Ensembles

Phase space – Concept of ensembles – Types of ensembles - Ensemble average - Liouville's Theorem – Microcanonical ensemble : ideal gas – Gibb's paradox and its resolution – Entropy and probability – Canonical ensemble – Ideal gas in canonical ensemble – Grand canonical ensemble – Ideal gas in grand canonical ensemble – Comparison of various ensembles.

UNIT – II: Partition Functions

Canonical partition function – Molecular partition function – Transnational partition function – Rotational partition function – Vibrational partition function – Electronic and Nuclear partition functions – Applications of Rotational partition function – Applications of vibrational partition function to solids

UNIT – III: Maxwell – Boltzmann and Bose – Einstein Statistics

Maxwell - Boltzmann distribution - Distribution of velocities – Experimental verification - Calculation of mean values – Equipartition energy- Bose – Einstein distribution, Bose – Einstein condensation, Black body radiation and the Planck's radiation law - Dulong and Petit's law - Einstein and Debye's theories of heat capacities - Liquid helium – Two fluid model of liquid helium II – Super fluid phase of ^{3}He.

UNIT – IV: Fermi – Dirac Statistics & Fluctuations

Fermi - Dirac distribution – Electrons in metals – Thermionic emission – Magnetic susceptibility of free electrons – White dwarfs – Fluctuations in ensembles, Onsagar's one dimensional and reciprocal rotations and their applications to thermoelectric phenomena, Kelvin's first and second equations: One dimensional random walk – Random walk and Brownian motion.

Books for Study

1. Statistical Mechanics by B.K. Agarwal, Melvin Eisner - Publisher John Wiley & Sons, 1988
2. Statistical Mechanics and properties of Matter by ESR Gopal – Publishers Ellis Horwood, 1974
3. Statistical and Thermal Physics by F. Reif - Publisher Waveland Press, 2009
4. Elementary Statistical Mechanics by C.Kittel- Dover Publications, 2012
5. Statistical Physics by Bhattacharjee, Allied Publishers Limited, 2000
6. Thermal Physics by Kittel and Kremer – W.H. Freeman and company

(Mandatory Core)

PHY 202: Electromagnetic Theory, Lasers and Modern Optics

UNIT – I: Electromagnetic Theory

Electromagnetic radiation; Introduction to electrostatics and magnetostatics –Electrodyanamics: emf – electromagnetic induction – Maxwell's equations in differential and integral forms - Retarded potentials – Radiation from moving point charge and oscillating dipoles – Linear antenna – Radiation resistance – electric quadrupole radiation - Lienard – Wiechert potentials.
General wave equation – Propagation of light in isotropic dielectric medium – Dispersion – Propagation of light in conducting medium - skin depth – Reflection and refraction at the boundary of a dielectric interface – Fresnel's equations – Propagation of light in crystals - Double refraction.

UNIT – II: Lasers and Non-Linear Optics

Introduction to lasers – Spontaneous and stimulated emission – Laser beam properties - Einstein coefficients – Population inversion – Pumping schemes – Losses in laser radiation - Threshold condition for laser oscillation – Laser cavity - Q factor– different experimental methods – Ruby laser - GaAs laser - He-Ne laser – Argon ion laser – CO_2 laser – Laser applications.
Basic Principles – Origin of optical nonlinearity - Harmonic generation – Second harmonic generation – Phase matching condition – Third harmonic generation – Optical mixing – Parametric generation of light – Parametric light oscillator – Frequency up conversion – Self focusing of light - Guided wave optics - Pulse compression - Optical solutions.

UNIT – III: Holography and Fourier Optics

Introduction to Holography – Basic theory of Holography – Recording and reconstruction of Hologram – Diffuse object illumination – Speckle pattern – Frenel and Fourier transform Holography – Applications of Holography.
Introduction to Fourier optics – Two dimensional Fourier transforms – Transforms of Dirac-delta function – The convolution integral – convolution theorem- Spectra and correlation – Parsevel's formula – Apodization – Array theorem – Fourier methods in diffraction - Fraunhouffer diffraction of single slit, double slit and transmission grating using Fourier method.

UNIT – IV: Fiber Optics

Total internal reflection - Optical fiber modes and configuration – Single mode fibers – Graded index fiber structure – Fiber materials and fabrication – Mechanical properties of fibers – Fiber optic cables – Attenuation – Signal distortion on optical wave guides - Erbium doped fiber amplifiers – Solitons in optical fibers - Block diagram of fiber optic communication system - Applications of optical fibers in communication and medicine.

Books for Study

1. Introduction to Electrodynamics, D.J. Griffiths, Prentice-Hall, India
2. Electromagnetics, B.B. Laud, Wiley-Eastern, New Delhi
3. Introduction to Modern Optics, G. R. Fowels
4. Lasers and their Applications, M.J. Beesly, Taylor and Francis, 1976
5. Lasers and Non-Linear Optics, B.B. Laud, Wiley Eastern Ltd., 1983
6. Optics, E. Hecht, Addison Wiley, 1974
7. Optical Fiber Communications, G. Keiser, McGraw Hill Book, 2000

(Compulsory Foundation)

PHY 203 (a): Nuclear Physics

UNIT – I: Nuclear Forces and Models

Nuclear Forces: Characteristics of nuclear forces – Ground state of Deuteron – Proton – Proton scattering – Neutron – Proton scattering – Meson theory of nuclear forces.
Nuclear Models: Introduction – The liquid drop model – Bethe-Weizacker semi-empirical binding energy equation and its applications – Nuclear shell model – Energy levels and calculation of angular momentum – Collective model.

UNIT – II: Nuclear Reactions and Decays

Nuclear Reactions: Types of nuclear reactions – Compound nuclear reactions – Nuclear cross section – Resonance theory – Briet Wigner formula.
Nuclear Decays: Nuclear transformations – Radioactive decay – Alpha decay – Gamow's theory – Beta decay – Fermi theory –Selection rules – Interaction of gamma radiation with matter – Photo electric effect – Compton scattering – Pair production.

UNIT – III: Nuclear Accelerators and Reactors

Nuclear Accelerators: Introduction – Linear accelerators – Drift tube and Wave guide accelerators – Low energy circular accelerators – Cyclotron and Betatron – High energy circular accelerators – Synchrotron and Microtron.
Nuclear Reactors: Nuclear fission and fusion reactions – Nuclear chain reactions – Four factor formula – The critical size of a reactor – General aspects of reactor design – Classification of reactors – Power reactors (elementary aspects only).

UNIT – IV: Elementary particles

Discovery and classification of elementary particles – Types of interactions – Conservation laws – Iso-spin, parity, charge conjugation – Time reversal – CPT theorem – Properties of leptons, mesons and baryons – Elementary particle symmetries (SU_2 and SU_3 symmetries) – Quark model – Search for Higg's particle – elementary ideas.

Book for Study

1. Nuclear Physics, Irving Kaplan, Narosa Pub. (1998).
2. Nuclear Physics, Theory and experiment – P.R. Roy and B.P. Nigam, New Age Int.1997.
3. Atomic and Nuclear Physics (Vol.2), S.N. Ghoshal, S. Chand & Co. (1994).
4. Nuclear Physics, D.C. Tayal, Himalaya Pub. (1997).
5. Atomic and Nuclear Physics, R.C. Sharma, K. Nath & Co., Meerut (2007).
6. Nuclei and Particles, E. Segre, W A Benjamin. Inc., (1965).
7. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley (1975).
8. Introduction to Nuclear Physics, K.S. Krane, John Wiley &Sons (1988).

(Compulsory Foundation)

PHY 203 (b): IC Fabrication Techniques

UNIT – I: IC Fabrication Technology

Wafer preparation: Silicon crystal growth, Wafer orientation, Sawing and polishing, Crystal orientation, Doping of crystals during growth.

Epitaxial deposition: Introduction theory, Growth of an Epitaxial layer, evaluation of Epitaxial layers.

UNIT – II: Oxidation

Introduction, equipment for thermal oxidation, oxidation process, oxide evaluation, recent advances in oxidation technology, oxide thickness determination, oxidation function, redistribution of dopant atoms during thermal oxidation, anodic oxidation.

UNIT - III: Impurity

Introduction and redistribution, the idea of diffusion, diffusion process, diffusion analysis, ion implementation,

UNIT – IV: Photomasking

Introduction – generation of photomask. Metallization: Metallization of requirements, vacuum deposition, deposition techniques, vacuum deposition cycle.

Books for Study

1. Instrumentation Measurement and Analysis by Nakra and Choudary.
2. Instrumentation – Devices and Systems by Rangan, Sarma and Mani.
3. Measurement of Systems Applications and Design by Earnest O.Doeblin
4. A course in Electrical; and Electronic Measurements and Instrumen tation by A.K. Sawhney
5. Electronic Instrumentation and Measurements Techniques, Cooper and Albert D. Helfriek
6. Applied Electronics by G.K. Mithal
7. Principles of Industrial Instrumentation by D. Patranabis

(Compulsory Foundation)

PHY 203 (c): Advanced Microprocessors and Its Applications

UNIT – I: Microprocessors and its Architecture

Internal microprocessor architecture, Real mode and protected modes of memory addressing, Memory paging.

Addressing modes -Data addressing modes, program memory – addressing modes, Stack - memory addressing modes.
Instruction Set - Data movement instruction, Arithmetic and logic Instruction, Program control instructions, Assembler details.

UNIT – II: Programming the Microprocessor

Modular programming, using the keyboard and video display, Data conversions.
Hardware Specifications - Pin - outs and the pin functions, clock - generator (8284A), Bus buffering and latching, Bus timing, Ready and Wait state, Minimum mode versus maximum mode.

UNIT – III: Memory Interface

Memory devices, Address decoding, 8088 and 80188 (8-bit) memory interface, 8086, 80186, 80286 and 80386 (16-bit) memory interface.

Basic I/O Interface - Introducing to I/interface, I/O port address decoding, 8255,8279, 8254, ADC and DAC (excluding multiplexed display & keyboard display using 8255).

UNIT – IV: Interrupts

Basic interrupt processing, Hardware interrupts, expanding the interrupt structure, 8259A PIC.
Direct Memory Access - Basic DMA operation, 8237 DMA controller.
Bus Interface - PCI bus.

Book for Study

1. B.B. Brey, "The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium pro processor architecture, programming and interfacing", 4/e, PHI, 1999.
2. K.J. Ayala, "The 8086 Microprocessor: Programming & Interfacing the PC" Penram International Publishing (India) Pvt. Ltd., 1995.
3. Douglas V. Hall, "Microprocessors and Interfacing, Programming and Hardware", 2/e, McGraw Hill
4. International Edition, 1992.
5. Muhammad Ali Mazidi and Janice Gillispie Mazidi, "The 80x86 IBMPC and Compatible Computers, (Volumes I &II)". 2/e, Printice –Hall, Inc., 1998.
6. Walter A. Triebel and Avatar Singh, "Software, Hardware and Applications" PHI, 1995.
7. Yu Cheng Lin and Glenn A. Gibson, "Microcomputer systems: The 8086/8088 Family Architecture, Programming and Design", PHI,1992.

(Elective Foundation)

PHY 204 (a): Mathematical Physics

UNIT - I: Special Functions

Beta and Gamma Functions – Definitions and properties – Evaluation of integrals, Legendre, Bessel and Hermite differential equations – Solutions – Generating functions – Orthogonal properties of Legendre, Bessel and Hermite Functions (Proof not necessary) – Recurrence relations – (Proof for Legendre polynomials only).

UNIT - II: Integral Transforms

Fourier Transforms: Properties of Fourier transforms – Fourier sine and cosine transforms- Power in Fourier series **–** Modulation theorem, Fourier transform of impulse function, Constants, Unit step function and Periodic functions.
Laplace Transforms: Definition and notation – Properties of Laplace transforms – Laplace transforms of Dirac delta function and periodic functions (Square wave, sawtooth wave and triangular wave) – Inverse Laplace transforms – properties – Solution of linear differential equations with constant coefficients - Applications to LCR circuits and resonance of simple pendulum.

UNIT - III: Numerical Techniques

Solution of an equation – Bisection method, Regular False method, Newton – Rhapson method Solutions of simultaneous – Gauss elimination method and Gauss-Seidel method – Interpolations - Newton's interpolation and Lagrange's interpolation, Curve fitting – Method of Least squares. Numerical differentiation and integration – Trapezoidal rule and Simpson's 1/3 rule – Solutions of differential equations – Euler's method and Runga-kutta Methods.

UNIT – IV: Complex Variables

Functions – Complex differentiation - Analytic function - Cauchy – Riemann equations –Derivatives of elementary functions – Singular points and classification. Complex integration - Cauchy's theorem – Integrals of special functions – Cauchy's integral formula – Taylor's and Lorentz theorem (statements only) – Residues, calculations of residues - Residue theorem – evaluation of definite integrals.

Books for Study

1. Functions for Scientists and Engineers, W.W. Bell, D.Van Nostrand Company, London
2. Special Functions, By Sneden
3. Fourier Analysis, Hsu P Jewi, Unitech Division
4. Laplace Transforms', Murray Spiegle, Schaum's outline series, McGraw Hill, International Book Company, NY
5. Applied Mathematics for Engineers, Pipes and Harval, Third Edition, McGraw Hill Books Co.
6. Murray R. Speigal, 'Theory and Properties of Complex Variables', Schaum's outline series, Mc Graw Hill Book Co., Singapore
7. Complex Variable, Churchle

(Elective Foundation)

PHY 204 (b): Introduction to VLSI Design

UNIT - I: **An Overview of VLSI and Logic Design with MOSFET**

Complexity and Design, Basic concepts, Ideal switches and Boolean operations, MOSFETs as switches, Basic logics gates in CMOS, Complex logic gates in CMOS, Transmission Gate circuits, Clocking and data flow control.

UNIT - II: Physical Structure and Fabrication of CMOS ICs

Integrated Circuit layers, MOSFETs, CMOS layers, Designing FET arrays, Overview of silicon processing, Material growth and deposition, Lithography, The CMOS process flow, Design rules.

UNIT - III: **Elements of Physical Design and Electrical Characteristics of MOSFETs**

Basic concepts, Layout of basic structures, Cell concepts, FET sizing and the unit transistor, Physical design of logic gates, Design hierarchies, MOS physics, nFET current-voltage equations, FET RC model, pFET characteristics, Modeling of small MOSFETs.

UNIT - IV: **Electronic analysis of CMOS logic gates**

DC characteristics of the CMOS inverter, Inverter switching characteristics, Power dissipation, DC characteristics: NAND and NOR gates, NAND and NOR transient response, Analysis of complex logic gates, Gate design for transient performance, Transmission gates and pass transistors.

Designing High-speed CMOS Logic Networks- Gate delays, Driving Large capacitive loads, Logical effort, BiCMOS drivers.

Book for Study

1. John P. Uyemura, “Introduction to VLSI circuits and Systems”, John Wiley & Sons (Asia) Pet Ltd., 2003.
2. S.K. Ghandhi, “VLSI Fabrication principles”, 2/e, John Wiley & Sons (Asia) Pte. Ltd., 2003.
3. S.M. Sze, “VLSI Technology”, 2/e, McGraw-Hill, 1988.
4. N.H.E. Weste and K. Eshraghian, “Principles of CMOS VLSI design”, Pearson Education, Inc., 1999.
5. Yuan Taur and T.H. Ning, “Fundamentals of Modern VLSI devices”, Cambridge University, Press, 1998.
6. R.L. Geiger, P.E. Allen and N.R. Strader, “VLSI design Techniques for Analog and Digital Circuits”, McGraw-Hill, 1990.

(Elective Foundation)

PHY 204 (c): Materials Science for Industrial Applications

UNIT – I: Organic materials and their properties

Introduction - polymerization mechanism. Structure and properties of polymers. Strengthening of polymers. Behaviour of polymers. Deformation of polymers and their industrial use.
Ceramic Materials: Introduction – Classification of ceramic. Structure of ceramics. Polymorphism. Properties of ceramic and their applications.

UNIT – II: Liquid Crystals

Introduction – classification, oriental order, Elasticity, magnetic effects, optical properties – applications.
Ferroelectrics: General properties of ferroelectric materials. Theories of ferroelectricity. Thermodynamic of Ferroelectric transitions.
Magnetic Materials: Classification. The domain structure. Soft and hard magnetic materials, Ferrites, ceramic magnets.

UNIT – III: Phase diagrams and phase transformation

The Phase rules. Unary and binary phase diagrams. Typical phase diagrams - coper-zinc systems. Iron-carbon system. Other applications of phase diagrams. Phase transformation. Nucleation and growth. Nucleation kinetics. Martensic transformation.

UNIT – IV: Thin films

Theories of thin film nucleation and growth. Thin film preparation – Rf sputtering. Chemical vapor deposition. Thickens measurements. Electrical and optical properties of thin films Applications.
Superconductivity: Messier Effect. The critical field. Theories of superconductivity. Tunneling and Josephson effect. High Tc superconductors. Application of superconductors.

Books for Study

1. Introduction to Solid State Physics, Charles Kittel VII edition, John Wiley & Sons.
2. Solid State Physics, A.J. Dekker, McMillan Publications.
3. Solid State Physics, M.A. Wahab, Narosa Publishing House.
4. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena, Pragathi Publications, Meerut.
5. Solid State Physics, R.L. Singhal, Kedar Nath Ram Nath & Co. Pub.
6. Science of Engineering Materials, C.M. Srivastsava and C. Srinivasan, New Age Inter. Pub.
7. Crystal Growth, B.R. Pamplin, Pergmon Press.
8. Crystal Growth from High Temperature Solutions, D. Elwell and H.J. Scheel, Academic Press.

(Mandatory Core)

PHY 301: Introductory Quantum Mechanics

UNIT - I: Formulation and Simple Problems

Wave particle duality – Wave functions in coordinate and momentum representation- Postulates of quantum mechanics -Linear vector space: Hilbert space - Dirac's Bra and Ket notations- Hermitian operators and their properties- Matrix representation of an operator- Unitary operators- Unitary transformation - The Kronicker Delta and Dirac delta functions- Eigen values and Eigen functions for finite potential well and step barrier – Quantum mechanical tunneling.

UNIT - II: Quantum Dynamics and Simple Problems

Equations of motion - Schrodinger Picture- Heisenberg Picture- Interaction Picture- Equivalence of various Pictures- Poisson and Commutation brackets- Their Properties-Eigen values and Eigen functions for Simple harmonic oscillator- Polynomial method and abstract operator method in one dimension- Eigen values and Eigen functions for a free particle and particle in a box in three dimensions.

UNIT - III: Approximate Methods

Time independent perturbation theory for non-degenerate levels: Perturbed harmonic oscillator, Normal Helium atom, Stark effect of the plane rotator. First order perturbation theory for degenerate levels: First order Stark effecting in hydrogen atom; Time dependent perturbation theory: Transition to continuum (Fermi Golden rule).
WKB approximation – Turning points and connecting formulae: Application to potential barrier. Variational methods.

UNIT - IV: Scattering Theory

Introduction: classical theory of scattering - Quantum theory of scattering - Method of partial wave analysis - Scattering by a perfectly rigid sphere - Greens function in scattering theory - Born approximation - Validity of Born approximation - optical theorem.

Books for Study

1. Quantum Mechanics: Concepts and Applications by Nouredine Zettili, Wiley, Ed., 2021
2. Introduction to Quantum Mechanics by David J. Griffiths and Darrell F. Schoeter, Third Ed., Cambridge University Press India Pvt Ltd., 2018.
3. Quantum Mechanics: G. Aruldas PHI learning private limited Second edition, 2018
4. Quantum Mechanics: S.L. Kakani and H.M. Chandalia Sultan Chandand, Sons First Edition
5. Advanced Quantum Mechanics: B.S. Rajput, Pragatiprakasan, 2019
6. Quantum Mechanics: V.K. Thankappan, Wiley Eastern Limited
7. A Textbook of Quantum Mechanics: P.M. Mathews and K. Venkatesan, Tata Mc Graw Hill Publishing Company
8. Quantum Mechanics: S.L. Gupta, V. Kumar, H.V. Sharma and R.C. Sharma, Jai Prakash Nath and Company
9. An Introduction to Quantum Mechanics, P.T. Mathews Mc Graw Hill Publishing Company

(Mandatory Core)

PHY 302: Physics of Semiconductor Devices

UNIT - I: Junctions and Interfaces

p-n Junctions: Description of p-n Junction action – Junction in equilibrium- application of bias – energy band diagrams. Abrupt junction – calculation of the built-in Voltage- electric field and potential distributions – Expression for Depletion layer capacitance, Static I-V characteristics of p-n junction diodes: Ideal diode model- Derivation of ideal diode equation. Real diodes – Carrier generation – recombination in the junction depletion region, I-V characteristics of Real Diodes.
Electrical breakdown in p-n junctions: Zener and Avalanche breakdown in p-n junctions, Distinction between the Zener and Avalanche breakdown.

UNIT- II: Junction Diodes

Majority carrier diodes: Tunnel diode- I-V characteristics, equivalent circuits as an oscillator and amplifier. Backward diode, Schottky barrier diode-operation and applications.
Microwave devices: Varactor diode- basic principle, equivalent circuit, Figure of merit and applications. p-i-n diode operation and its applications. Transferred-electron devices- Gunn effect devices- domain formation- modes of operation. Avalanche Transit devices: IMPATT diode, TRAPATT diode, BARITT diode.

UNIT - III: Junction Transistors

Bipolar junction transistors: Principle of operation- Analysis of the ideal diffusion transistor – Calculation of terminal currents, DC parameters. Ebers-Moll Equations – Four regions of operation of a bipolar transistor. Real transistors -- carrier recombination in the Emitter-Base junction depletion region – Effect of collector bias variation, avalanche multiplication in the collector – base junction and base resistance. Basic Structures and the operating principle of MOSFET, I-V characteristics of an ideal MOSFET, Charge Coupled Devices (CCD)- principle of operation.

UNIT – IV: Power Devices and Semiconductor Technology

Power rectifiers and Thyristors: Power rectifiers, Thyristors, Some special thyristor structures, Bidirectional thyristors, Field-controlled thyristor. Technology of Semiconductor Devices: Crystal growth and Wafer preparation, Methods of p-n junction formation, Growth and deposition of dielectric layers, Planar technology, Masking and lithography, Pattern definition, Metal deposition techniques.

Books for Study

1. Introduction to Semiconductor Materials and Devices by M.S.Tyagi, John Wiley & Sons (Asia) Pte. Ltd., Singapore, 2000.
2. Microwave Devices and circuits by SAMUEL Y. LIAO, Prentice-Hall of India, 1999.
3. Microwave and Radar Engineering by M.Kulkarni, UMESH publications, New Delhi, 1999.
4. Physics of Semiconductor Devices by S.M. Sze, 3rd Edition, Oct.2006, John Wiley
5. Solid State Electronic Devices by B.G. Streetman, PHI, New Delhi,

(Generic Elective)

PHY 303 (a): Applied Spectroscopy

UNIT- I: Molecular Spectroscopy

Introduction – Rotational and vibrational structure of electronic bands of diatomic molecules – Fortrat diagram – General relations – Combination relations for $^1\Sigma$ - $^1\Sigma$ and $^1\Sigma$ – $^1\pi$ bands – Evaluation of rotational constants with reference to above transitions. Isotope effect in electronic spectra of diatomic molecules – Vibrational effect and rotational effect. Potential energy curves - Dissociation energy and pre-dissociation energy - Vibrations of polyatomic molecules: CO_2 and H_2O.

UNIT- II: Raman Spectroscopy

Introduction – Theory of Raman Scattering – Rotational Raman Spectra – Vibrational Raman Spectra – Mutual Exclusion Principle – Laser Raman Spectroscopy – Sample Handling Techniques – Polarization of Raman Scattered Light – Single Crystal Raman Spectra – Raman Investigation of Phase Transitions – Resonance Raman Scattering – Structure Determination using FTIR and Raman Spectroscopy. Fourier Transform (FT) Raman Spectroscopy and its additional advantages over the conventional Raman Spectroscopy - Surface enhanced Raman Scattering-Coherent Anti-Stokes Raman Spectroscopy.

UNIT – III: Spectrophotometry

Introduction – Beer's law – Absorptivity – UV and visible absorption – Instrumentation – Essential parts of spectrophotometer – Gratings and prisms – Radiant energy sources – Filters – Photosensitive detectors – Barrier layer cells – Photo emissive cells – Photomultiplier tubes – Relationship between absorption in the visible and UV region and molecular structure – IR Spectrophotometry – Fourier Transform Infrared (FTIR) Spectrometer – Molecular structure – Qualitative and Quantitative analysis –Importance of photography in the spectrochemical analysis.

UNIT - IV: Fluorescence and Phosphorescence Spectroscopy

Introduction – Normal and Resonance Fluorescence – Intensities of Transitions – Non-radiative decay of fluorescent molecules – Phosphorescence and the nature of the triplet state – Population of the triplet state – Delayed Fluorescence – Excitation spectra – Experimental methods – Emission lifetime measurements – Time resolved emission spectroscopy – Applications of Fluorescence and Phosphorescence.

Books for Study

1. Molecular spectra and Molecular Structure Vol. I, G. Herzberg,2nd Ed, Van. Nostrand (1950).
2. Fundamentals of Molecular Spectroscopy, C.N. Banwell, Tata Mc Graw-Hill, (1983).
3. Spectroscopy Straughan and Walker (Vol. 2 & 3), John Wiley & Sons, (1976).
4. Molecular Structure and Spectroscopy G. Aruldhas, Printice-Hall Pvt. Ltd. (2001).
5. Instrumental Methods of Analysis Willard, Merritt, Dean & Settle, CBS Pub, (2001).
6. Spectrochemical Analysis, L.H. Ahrens and S.R. Taylor, Addison – Wesley, London, Pergamon, 1961.
7. Elements of Spectroscopy, Gupta, Kumar and Sharma Pragati Prakasan, New Delhi (2012).
8. Elements of Diatomic Molecular Spectra, H. Dunford, Addison Wesly Publishing company, 1965.
9. Problems in Spectroscopy, S.V.J. Lakshman, ICSU, Costed, 1988.
10. Basic Principles of Spectroscopy by R. Chang, Mic Graw Hill, 1971.
11. Principles of Fluorescence Spectroscopy, Joseph R. Lakowicz - Plenum Press, (1983).

(Generic Elective)

PHY 303 (b): Condensed Matter Physics

UNIT - I: Elastic Properties of Solids

Lattice as a homogeneous and continuous medium - Analysis of stress and strain tensors – Hooke's law - Elastic compliances and stiffness constants – Elastic energy density – Reduction in the number independent elastic constants in cubic crystals – Cauchy's relations – Bulk modulus and compressibility – Elastic waves in cubic crystals – Formulation and solution of wave equations along [100], [110] and [111] directions – Experimental determination of elastic constants – Pulse-echo technique.

UNIT - II: Thermal Properties of Solids

Quantum theory of lattice vibrations – Properties of phonons – Lattice specific heat at low temperatures – Einstein and Debye models – Born cut-off procedure – Inelastic scattering of neutrons by phonons – Experimental study of dispersion curves – Inadequacy of harmonic model – Anharmonicity – Thermal expansion – Gruneisen parameter- Lattice thermal conductivity – Elementary kinetic theory – Role of U and N processes.

UNIT - III: Energy bands and Fermi Surfaces

Energy band calculations: Plane Wave method and Augmented Plane Wave (APW) method. Importance of Fermi surface – Characteristics of Fermi surface – Construction of Fermi surface - Quantization of electron orbits - Experimental study of Fermi surface: Anomalousskin effect – Cyclotron resonance – de Haas van Alphen effect.

UNIT-IV: Photoconductivity and Luminescence

Excitons: Weakly bound and tightly bound – Photoconductivity – Simple model – Influence of traps – Space charge effects – Determination of photoconductivity. Luminescence – Various types– Thermoluminescence, Electroluminescence, Photoluminescence, Cathodoluminescence and Chemiluminescence - Excitation and emission – Decay mechanisms – Applications

Books for Study

1. Solid State Physics, C. Kittel, Edition: 8 th 2012, John Wiley & Sons.
2. Solid State Physics, A.J. Dekkar, Edition: 1st, 2000. Macmillan India Ltd.
3. Solid State Physics, M.A. Wahab, Edition:3rd, 2020, Narosa Publishing House.
4. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena, Edition: 31st, 2019, Pragathi
5. Solid State Physics, R.L. Singhal,2018, KedarNath, Ram Nath& Co. Publications, Meerut.

(Generic Elective)

PHY 303 (c): Embedded Systems

UNIT - I: Introduction to Embedded Systems

Embedded systems in today's world – examples of Embedded systems – Microprocessors and Microcontrollers – Microchip and PIC microcontroller – Introduction to PIC microcontrollers using the 12 series.
Architecture of 16F84A – Memory organization – in 16F84A – Timing generation – Power-up and Reset functions in 16F84A.

UNIT - II: Hardware Details of 16F84A

Parallel ports: Basic idea – Technical challenge – connecting to the parallel port – Parallel ports of PIC16F84A – Clock oscillator – Power supply – Interrupts – Timers and counters – watch dog timer – Sleep mode.

UNIT - III: Assembler and Assembler Programs

Basic idea – PIC 16 series instruction set and ALU – Assemblers and Assembler format – creating simple programs – Adopting a development environment – Building structured programs – Flow control: Branching and Subroutines – Generating time delays and intervals – Logical instruction – Arithmetic instructions.

UNIT - IV: PIC Microcontroller PIC 16F873A

Block diagram and CPU – Memory and memory maps – Interrupts – Oscillator, Reset and Power supply – Parallel ports.
PIC 16F87XA Timer 0 and Timer 1 – 16F87XA Timer 2, Comparator and PR2 register – capture/Compare/PWM (CCP) Module – Pulse width modulation – ADC module.
Interface: LED displays – Liquid crystal displays –Sensors –Actuators.

Books for Study

1. Designing Embedded Systems with PIC Microcontrollers: Principles and Applications by Tim Wilmshurst, First Edition, 2007, Newnes – Elsevier – Publishers.
2. Microcontrollers: Theory and Applications by Ajay V. Deshmukh, Tata McGraw- Hill, New Delhi, 2005.
3. Designing with PIC Microcontrollers by John B. Peatman, Pearson Education, Inc.,1998.
4. The 8051 Microcontroller and Embedded systems, by Mahammad Ali Mazidi and Janice Gillispie Mazidi, Pearson Education Asia, Pvt. Ltd., 2000.

(Skill Oriented Course)

PHY 305: Advances in Physics

UNIT – I: Nano Technology

Introduction to Nanomaterials – Zero, One and Two Dimensional Nanostructures - Quantum confinement - Density of states and Dependence of dimensionality – Properties of Nanomaterials – Carbon Nanotubes, Fullerenes, Graphene.

Synthesis of Nanomaterials – Physical Techniques: Ball Milling – Plasma Arc Deposition – Inert Gas Condensation – Pulsed Laser Deposition – Molecular Beam Epitaxy.

Chemical Techniques: Hydrothermal synthesis– Sol-Gel Process – Chemical Vapour Deposition.

Applications: Single Electron Transistor – Solar Cells – Light Emitting Diodes.

UNIT – II: Micro and Nano devices

Microelectromechanical systems (MEMS): Introduction to MEMS, Basic MEM structure. Applications of MEMS: Pressure sensors, Accelerometers Mass flow sensors.

Nanodevices: Quantum well and quantum dot devices: Infrared Detectors-Quantum Dot Lasers. Carbon nanotube emitters - Photoelectrical cells - Plasmons propagation in wave guides.

UNIT – III: 8051 Microcontrollers

Introduction of Microprocessors and Microcontrollers, Microcontroller: 8051 Internal Architecture, Register Structure, I/O pins, Memory Organization, 8051 Addressing modes. 8051 Assembly Language Programming Tools. 8051 Instruction set: Data Transfer Instructions, Arithmetic instructions, Logical instructions, Boolean Variable Manipulation Instructions-Bit Addressability, Single-Bit instructions, Program Branching Instructions-Jump, Loop, and Call instructions, Rotate Instructions, Stack Pointer.

UNIT - IV: Remote Sensing

Definition of remote sensing; introduction to concepts and systems; Electromagnetic radiation; electromagnetic spectrum; image characteristics; remote sensing systems; remote sensing platform; Sources of remote sensing information; Advantages of remote sensing. Application of Remote sensing in Environmental Management, Natural resource management – forest resources, water resources, land resources and mineral resources.

Books for Study

1. Nano structures and Nanomaterials: Synthesis, Properties and Application by Guozliong Cao, Imperial College Press (2004).
2. Introduction to Nanotechnology, By Charles P. Poole, Jr and Frank J. Owens, Willey India (2006).
3. An Introduction to Microelectromechanical Systems Engineering by Nadim Maluf
4. Nanomaterials Synthesis Properties and Applications, by Alen. S. Edelstein and Robert C. Cammarata, 1998.
5. The 8051 Microcontroller and Embedded systems, by Mahammad Ali Mazidi and Janice Gillispie Mazidi, Pearson Education Asia, Pvt. Ltd., 2000.
6. Floyd F. Sabins Jr., Remote Sensing Principles and interpretation, by W.H. Freeman and Company, 2nd Ed., New York, 1987.
7. T.M. Lillesand & R.W.Kiefer, Remote Sensing and Image Interpretation', by John Wiley & Sons, New York, 1994.
8. An Introduction to GIS by Ian Heywood et al., Addision Wesley, Longmont Limited, England.

(Open Elective)

PHY 306 (a): Basic Spectroscopic Techniques

UNIT I: Fundamentals of Spectroscopy

Introduction - Interaction of Electromagnetic radiation with matter - Spectra of Hydrogen atom-quantum numbers -Forbidden transitions and selection rules - Spectroscopic transition between two stationary states - Absorption and emission of a photon - Einstein A and B coefficients - Line shape functions - Spectral broadening mechanisms - Spin orbit interaction energy - Stern-Gerlach experiment - LS coupling – JJ coupling – Hund's rule of multiplicity - Pauli's exclusion principle - Rotational and vibrational spectra of different molecules - Energy expressions**.**

UNIT – II: Spectrophotometry

Introduction – Beer's law – Absorptivity – UV and visible absorption – Instrumentation – Essential parts of spectrophotometer – Gratings and prisms – Radiant energy sources – Filters – Photosensitive detectors – Barrier layer cells – Photo emissive cells – Photomultiplier tubes – Relationship between absorption in the visible and UV region and molecular structure – IR Spectrophotometry – Fourier Transform Infrared (FTIR) Spectrometer – Molecular structure – Qualitative and Quantitative analysis –Importance of photography in the spectrochemical analysis.

UNIT – III: Colorimeters, spectrophotometers and microscopes

Colorimeter – Principle - Applications of colorimeters in analytical and biomedical purposes
Spectrophotometer - Principle and working with block diagram – Salient features of individual blocks – Specifications and operation of spectrophotometers – Applications of spectrophotometers to chemical analysis
Electron microscope – Transmission electron microscope - Principle and working with block diagram – Salient features of individual blocks – Scanning electron microscope - Principle and working with block diagram – Description of individual blocks – Applications of electron microscopes.

UNIT – IV: Resonance spectrometers and Mass Spectrometer

Electron spin resonance – theory – ESR spectrometer – Principle and working with block diagram – Experimental techniques – Salient features of individual blocks – Applications of ESR.
Nuclear magnetic resonance – theory – NMR spectrometer - Principle and working with block diagram – Experimental techniques – Description of individual blocks – Applications of NMR.
Mossbauer effect – theory – Mossbauer spectrometer – Principle and working of Mossbauer spectrometer - Experimental methods – Explanation of block diagram – Applications of Mossbauer studies.

Books for Study

1. Introduction to Atomic Spectra, H.E. White, McGraw-Hill Kogakusha. Ltd., New Delhi (1934).
2. Elements of Spectroscopy by Gupta, Kumar, Sarma, Pragati Prakasan, 2012.
3. Spectrochemical Analysis, L. H. Ahrens and S.R. Tayler, Addison- Wesley, London.
4. Instrumental methods of Chemical analysis by Chatwal and Anand, Himalaya Publisher, 2003
5. Spectroscopy by B.K.Sarma, Goelpublishing House, Meerut, 1993.
6. Spectroscopy Vol I by Straughan and Walker, John Wiley and Sons, 1976
7. Basic principles of Spectroscopy by Raymond Chang, MicGraw Hill, 1971
8. Molecular Structure and Spectroscopy by G.Aruldas, Prentice Hall of India, 2001

(Open Elective)

PHY 306 (b): Nanomaterials and Devices

UNIT-1: Introduction to Nanomaterials

Introduction to Nanomaterials -Zero, One and Two Dimensional Nanomaterials Quantum confinement, Density of states, Dependence of dimensionality – Physical and chemical properties.

UNIT –II: Synthesis of Nanomaterials

Introduction to Bottom –up and Top- down approaches

Ball milling –Inert Gas condensation – Physical vapour deposition -, Molecular Beam Epitaxy – Sputtering – Pulsed laser Deposition –Chemical vapour deposition - Sol Gel – Hydrothermal Synthesis

UNIT- III: Nano –Carbon

Carbon molecules: Nature of the carbon bond –New Carbon structure –carbon clusters –Small carbon clusters –Discovery of C_{60} –Structure of C_{60} and its properties –Synthesis of buckyballs and Applications.

Carbon Nanotubes: Fabrication –Structure - Electrical Properties – Mechanical properties – Applications of carbon Nanotubes

Graphene: Fabrication – Structure – Electrical Properties – Mechanical properties – Applications.

UNIT –IV: Nano Devices

Introduction – Nanofabrication –Photo- Lithography – Pattern transfer – Introduction to MEMS –Single Electron Transistor – Solar Cells – Light Emitting diodes –Gas Sensors- Microbatteries – Field emission display devices –Fuel Cells.

Books for Study

1. Nanomaterials: Synthesis, Properties and Applications – Edited by A.S. Edelstein and R.C. Cammarata, Institute of Physics Publishing, 2002.
2. Introudction to Nanotechnology – Charles P. Poole Jr and Frant J. Owens, Wiley Interscience, 2003.
3. Nanopracticles from Theroy to Applications edited by Gunter Schmid, Wiley VCH, 2004.
4. Nanoelectronics and Nanosystems by K. Glosekotter and J. Dienstuthi (Springer).

(Mandatory Core)

PHY 401: Advanced Quantum Mechanics

UNIT- I: Identical Particles and Molecules

Identical particles- Indistinguishability of Identical particles- Construction of Symmetric and Anti-symmetric wave functions for two and three particle systems - Pauli's Exclusion Principle- Hydrogen molecule- Spin-orbit interaction- Ortho and Para hydrogen- Spin statistics connection.

UNIT - II: Angular Momentum

Introduction: Motion in Central Potential, Orbital Angular momentum –L_x , L_y,L_z,L_2,L^+ and L^- Operators -Commutation rules for angular momentum - Eigen values and Eigen functions of L_z and L^2 - Angular momentum in general - Allowed values of angular momentum J - Eigen values of J_+ and J_- angular momentum matrices - Addition of angular momenta and Clebsh- Gorden co-efficients: Clebsh – Gorden co-efficient for $J_1=J_2=1/2$ and $J_1=1$, $J_2=1/2$ - spin angular momentum and Pauli's spin matrices.

UNIT - III: Relativistic Quantum Theory

Klein – Gorden Equation – KG equation in Co-variant form- Probability Density and Probability Current Density – Inadequacies of K.G. Equation – Dirac's Relativistic Equation for a Free Particle - Dirac`s Matrices – Dirac`s Equation in Co-variant form – Plane wave solution – Negative Energy States – Spin Angular Momentum - Existence.

UNIT - IV: Quantization of Wave Fields

Concept of Field - Method of Canonical Quantization: Lagrangian Formulation of Field, Hamilton Formulation of Field - Second Quantization – Field equation - Quantization of Non-relativistic Schrodinger equation – Commutation and Anti-Commutation Relations, The N-representation - System of Fermions and Bosons – Creation and Annihilation.

Books for Study

1. QuantumMechanics: G. Aruldas PHI learning private limited Second edition,2018
2. QuantumMechanics: S.L.Kakani and H.M. Chandalia Sultan Chandand Sons First Edition
3. Advanced Quantum Mechanics: B.S. Rajput, Pragatiprakasan, 2019
4. Quantum Mechanics: V.K. Thankappan, Wiley Eastern Limited
5. A Textbook of Quantum Mechanics: P.M. Mathews and K. Venkatesan, Tata Mc Graw Hill Publishing Company
6. Quantum Mechanics: S.L. Gupta, V. Kumar, H.V. Sharma and R.C. Sharma, Jai Prakash Nath and Company
7. An Introduction to Quantum Mechanics, P.T. Mathews Mc Graw Hill Publishing Company

(Mandatory Core)

PHY 402: Physics of Advanced Materials

UNIT - I: Crystal Growth and Imperfections in Crystals

Crystal growth: Nucleation and growth – Homogeneous and heterogeneous nucleation – Classification of crystal growth techniques – Melt growth: Bridgman,Czochralski techniques.
Imperfections: Classification of imperfections – Point defects – Schottky and Frenkel defects - Expressions for equilibrium defect concentrations – Colourcentres –Production of colourcentres – Line defects – Dislocations – Edge and Screw dislocations – Burger vector – Estimation of dislocation densities – Ordered phases of matter- Translational and orientational order

UNIT- II: Dielectrics and Ferroelectrics

Dielectrics: Introduction – Dipole moment – various types of polarization – Electronic, ionic and orientational polarization **–** Langevin's theory – Lorentz field – Clausius-Mosotti equation – Measurement of dielectric constant – Applications of dielectrics.
Ferroelectrics: Piezo-, Pyro- and ferroelectric crystals– Spontaneous polarization – Classification and properties of ferroelectrics - Ferroelectric domains – Oxygen ion displacement theory – Applications of ferroelectrics.

UNIT- III: Ferromagnetism and Anti-ferromagnetism

Ferromagnetism: Introduction – Weiss molecular field theory – Temperature dependence of spontaneous magnetization – Heisenberg model – Exchange interaction – Ferromagnetic domains – Magnetic bubbles – Bloch wall – Thickness and energy – Ferromagnetic spin waves – Magnons – Dispersion relations.
Anti-ferromagnetism: Introduction – Two sub lattice model of anti-ferromagnetism – Ferri magnetism - Ferrites – Structure – Applications – Multiferroics

UNIT - IV: Functional materials

Amorphous semiconductors: Band structure – Electronic conduction – Optical absorption – Applications.
Liquid crystals: Classification – Orientational order and intermolecular forces – Magnetic effect – Optical properties – Applications.
Polymers: Classification –Structural property correlation – Molecular weight – Crystalline in polymers – Applications.

Books for Study

1. Solid State Physics, C. Kittel, Edition: 8th 2012, John Wiley & Sons.
2. Solid State Physics, A.J. Dekkar, Edition: 1st, 2000. Macmillan India Ltd.
3. Solid State Physics, M.A. Wahab, Edition:3rd, 2020, Narosa Publishing House.
4. Fundamentals of Solid State Physics, Saxena, Gupta, Saxena, Edition: 31st, 2019, Pragathi
5. Solid State Physics, R.L. Singhal,2018, KedarNath, Ram Nath& Co. Publications, Meerut.
6. Science of Engineering Materials and carbon nano tubes, C.M. Srivastsava and C. Srinivasan, Edition:3rd, 2010 New Age Inter. Pub.
7. Crystal Growth, B.R. Pamplin, 1977, Pergmon Press.
8. Crystal Growth from High Temperature Solutions, D. Elwell and H.J. Scheel,1975, Academic Press.

(Generic Elective)

PHY 403 (a): Photonics

UNIT – I: Laser systems, properties and applications

General description, structure, excitation mechanism and working of CO_2, Argon ion, Free-electron, Dye, Nd:YAG, Optical parametric oscillator, semiconductor and erbium doped fiber lasers.
Laser beam linewidth, frequency stabilization, divergence and coherence. Q-Switching and Methods of Q-switching. Modelocking and methods of modelocking. Frequency doubling and phase conjugation.
Laser applications in isotopic separation, velocity measurements, interferometry and speckle metrology.

UNIT - II: Fibre Optic Components and Sensors

Connector principles, Fibre end preparation, Splices, Connectors, Source coupling, Distribution networks, Directional couplers, Star couplers, Switches, Fiber optical isolator, Wavelength division multiplexing, Time division multiplexing, Fiber Bragg gratings. Advantage of fiber optic sensors, Intensity modulated sensors,
Mach-Zehnder interferometer sensors, Current sensors, Chemical sensors –Fiber optic rotation sensors. Optical biosensors: Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Bio-imaging, Biosensing.

UNIT - III: Integrated Optics

Introduction – Planar wave guide – Channel wave guide – Y-junction beam splitters and couplers - FTIR beam splitters – Prism and grating couplers – Lens wave guide – Fabrication of integrated optical devices - Integrated photodiodes – Edge and surface emitting laser – Distributed Bragg reflection and Distributed feedback lasers - Wave guide array laser.

UNIT - IV: Photonic Crystals

Basics concepts, Theoretical modeling of photonic crystals, Features of photonic crystals, Methods of fabrication, Photonic crystal optical circuitry, Nonlinear photonic crystals, Photonic crystal fibers, Photonic crystals and optical communications, Photonic crystal sensors.

Books for Study

1. Lasers: Principles and applications by J. Wilson and J.F.B.Hawkes, Prentice, Hall of India, New Delhi, 1996.
2. Laser fundamentals, W.T.Silfvast, Foundation books, New Delhi, 1999.
3. Fibre Optic Communication, Joseph C. Palais, Pearson Education Asia, India, 2001
4. Introduction To Fibre Optics, A.Ghatak And K.Thyagarajan, Cambridge University Press, New Delhi, 1999
5. Optical Guided Wave Signal Devices, R.Syms And J.Cozens. Mcgraw Hill, 1993.
6. Optical Electronics, A Ghatak and K. Thyagarajan, Cambridge University Press, New Delhi, 1991
7. Fundamentals of Photonics, B.E.A. Saleh and M.C. Teich, John Willy and Sons,1991
8. Nanophotonics, P.N.Prasad, Wiley Interscience, 2003.

(Generic Elective)

PHY 403 (b): Solar Energy – Thermal and Photovoltaic Properties

UNIT - I: Basic Concepts of Solar Energy

Introduction - Distribution of solar radiation – Solar Constant, Zenith Angle, Air Mass, Standard Time, Local Apparent Time, Equation of Time, Declination, Hour Angle, Azimuth Angles (all definitions only). Radiation Measurement using Pyranometer and Pyrheliometer – Principle and working.

Kirchoff's law – Solar transmittance, absorptance, emittance and reflectance – Their relation. Selective coatings - Methods of Preparation of coatings - Measurement of solar absorptance and emittance of a selective surface.

UNIT - II: Solar Thermal Collectors

Introduction, Collector types - Flat plate collector (FPC), Evacuated tube collector – Energy balance equation and efficiency, Definitions of collector overall heat loss coefficient, collector efficiency factor, collector heat-removal factor and collector flow factor, Temperature distribution in FPC - Testing of FPC, solar water heating - natural and forced circulation type; Concentrating collectors, types, single axis and two-axis tracking – Performance of Linear parabolic trough concentrator, Applications - Space heating, Air heater - Configurations - Drier - Principle and working; Energy storage - Sensible heat storage- liquid and pebble-bed storage, Thermochemical storage.

UNIT – III: Solar Cells

Photovoltaic effect – Equivalent circuit of solar cell - Definitions of cell parameters, Type of cells, Crystalline silicon (c-Si), Float zone and Czochrolski methods - Wafer to cell formation steps**,** Poly-Si wafer growth methods – EFG, Web, Heat exchange method, Amorphous Si cells. Thin film cells – Advantages and limitations – CdTe/CdS, CuInGaSe2/CdS and GaAs cells – Configurations and structures – Fabrication of these cells - I-V characteristics and spectral response - Multijunction cells - Quantum dot, Dye sensitized and Perovskite cells.

UNIT – IV: Solar Photovoltaic Systems

Photovoltaic (PV) Module assembly - Description of steps involved in the fabrication of solar module - Performance of module – I-V Characteristics, Modules design for different current and voltages - Module protection - Use of bypass and blocking diodes, Solar PV system - Components – PV Array, battery, invertor and load. Bifacial solar modules – Advantages over mono-facial cells; Applications of solar PV systems – Stand-alone system – Design methodologies, Hybrid system – Types and issues, Grid connected systems.

Books for Study

1. Solar Energy Utilization, G. D. Rai, Khanna Publishers, 1987.
2. Solar Energy - Fundamentals, Design, Modelling and Applications, G.N. Tiwari, Narosa Publications, 2005.
3. Solar Energy-Principles of Thermal Energy Collection & Storage, S.P. Sukhatme, Tata Mc-Graw Hill Publishers, 1999.
4. Science and Technology of Photovoltaics, P. Jayarama Reddy, CRC Press (Taylor & Francis Group, Leiden, Netherlands) & BS Publications, 2009.
5. Solar Photovoltaics- Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI Learning Pvt. Ltd., 2015.

(Generic Elective)

PHY 403 (c): Vacuum and Thin Film Technology

UNIT - I: Basics of Vacuum

Fundamentals of kinetic theory applicable to vacuum technology - Vacuum pumps: Rotary pump - Roots pump – Sorption pump – Diffusion pump - Turbo molecular pump – Cryogenic pump - Vacuum Gauges: Pirani gauge - Penning gauge - Hot cathode ionization gauge – Bayard –Alpert gauge –Quadruple mass spectrometer - Pump combinations – Design of vacuum systems - Leaks and Leak detection- Applications of vacuum.

UNIT - II: Preparation of Thin Films

Physical Methods: Vacuum evaporation - Resistive heating - Electron beam evaporation - Co-evaporation - Epitaxial deposition: Pulsed laser ablation - Molecular beam epitaxy. Sputtering - Glow discharge - DC and RF sputtering - Reactive sputtering - Magnetron sputtering - Chemical methods: Electroplating – Spray pyrolysis – Chemical vapour deposition (CVD) - Sol-gel – Spin coating.
Measurement of film thickness -Multiple beam interferometer (MBI) methods – Quartz crystal thickness monitor - Stylus profiler.

UNIT - III: Properties of thin films

Transport Properties of Thin Films**:** Metallic Films: Sources of resistivity in metallic conductors – sheet resistance and temperature coefficient of resistance of thin films – Influence of thickness on the resistivity of structurally perfect thin films – Fuchs Sondhemier theory – Annealing and agglomeration - Optical Properties -Reflection and transmission by single film and multilayer films - Optical absorption – Determination of optical constants by Ellipsometry.

UNIT - IV: Applications of Thin Films

Photolithography-Pattern Generation-Thin film resistors – Thin film capacitors – Thin film diodes and transistors – Thin film solar cells - Thin film microbatteries – Thin film Gas sensors – Reflection and antireflection coatings - Optical filters - Transparent conducting oxide coatings - Hard coatings - Tribologicalcoatings.

Books for Study

1. Vacuum Technology, A.Roth, North-Holland, 1986.
2. Vacuum Science and Technology, V.VasudevaRao, T.B.Ghosh and K.L.Chopra, Allied Publications, 1998.
3. Handbook of Thin Film Technology, L.I.Maissel and R.L.Glang, McGraw HillBook Co., 1970.
4. Thin Film Phenomena,K.L.Chopra,McGraw Hill Book Co., New York, 1969.
5. Vacuum Deposition onto Webs, Films and Foils, Charles A. Bishop, Elsevier, London, 2011.
6. The Materials Science of Thin Films, M. Ohring, Academic Press, New York, 1992.
7. The User’s Guide to Vacuum Technology, J.F. O’Henlon, John Wiley & Sons, 2003.

(Multidisciplinary Course)

PHY 405: Advanced Characterization Techniques

UNIT – I: Spectrophotometry

Introduction – Beer's law – Absorptivity – UV and visible absorption – Instrumentation – Essential parts of spectrophotometer – IR Spectrophotometry – Fourier Transform Infrared (FTIR) Spectrometer – Molecular structure – Qualitative and Quantitative analysis –Raman Spectroscopy – Qualitative and Quantitative analysis. Fourier Transform (FT) Raman Spectroscopy and its additional advantages over the conventional Raman Spectroscopy,

UNIT – II: Resonance Spectrometers and Mass Spectrometer

Electron Spin Resonance (ESR) – Principle – ESR spectrometer – Working Principle with block diagram – Applications of ESR. Nuclear Magnetic Resonance (NMR) – Principle – NMR spectrometer - Working Principle with block diagram – Experimental techniques –. Basic concepts of NQR spectra: Half integral and integral spins, Instrumentation, Super regenerative oscillator, applications of NQR. Mossbauer effect – theory – Mossbauer spectrometer – Principle and working of Mossbauer spectrometer - Experimental methods with block diagram – Applications of Mossbauer studies.

UNIT – III: Advanced Spectroscopic and Microscopic Techniques

Spectroscopic Techniques: Energy Dispersive Spectroscopy, X-ray Photo Electron Spectroscopy, X ray Fluorescence Spectroscopy and Auger Electron Spectroscopy.
Imaging Techniques: Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy,
Diffraction Techniques: X-Ray diffraction – Laue method – Powder method.

Books for Study

1. Elements of X-ray Diffraction, B.D. Cullity.
2. Methods of Surface Analysis, Techniques and Applications, J.M. Walls Cambridge
3. University Press, 1990.
4. X-ray Structure Determination, H. Stout and LH. Jenson, Macmillan, London, 1968.
5. Instrumental Methods of Analysis, Willard Merritt, Dean Settle, CBS publishers,
6. New Delhi, 1986
7. Spectroscopy, B.P. Straughan and S. Walker, John Wiley & Sons Inc., New York,1976.
8. Spectroscopy, G. Chatwal and S. Anand, Himalaya Pub., 2002.
9. Spectroscopy, B.K. Sharma, Goel Publishers House, Meerut, 1975.
10. Basic principles of Spectroscopy by Raymond Chang, MicGraw Hill, 1971
11. Molecular Structure and Spectroscopy by G.Aruldas, Prentice Hall of India, 2001

(Open Elective)

PHY 406 (a): Wireless Communications

UNIT – I: Base band data transmission

Digital Modulation techniques: BPSK, QPSK, DPSK, QASK, BFSK, MSK, M-ary techniques. Base band binary data transmission system – Inter symbol interference – Nyquist pulse shaping criteria – line coding, pulse shaping, and scrambling techniques, Detection of error probability.

UNIT – II: Codes for error detection and correction

Linear block codes, Convolutional codes. Encoding, Decoding of convolutional codes, State, Tree and Trellis diagrams. Maximum likelihood – Viterby algorithm, Burst error correction - Interleaving techniques – Block and convolutional interleaving, Types of ARQ.

UNIT – III: Introduction to wireless communication systems

Global system for mobile (GSM): cellular concept, system design. Transmission system, receiving system; frequency re-use; Spread spectrum modulation; Multiple access techniques as applied to wireless communications; 1G, 2G, 3G wireless networks.

UNIT – IV: Satellite and Optical communications

Introduction Satellite systems: Orbiting satellites, satellite frequency bands, communication satellite system-modulation and multiple access format-satellite systems in India, Satellite receiving systems, G/T ratio, satellite uplink and down link analysis. Applications to communications and remote sensing. Introduction to Optical communications systems: Optical fibers, sources and detectors, analog and digital systems.

Books for Study

1. Modern Digital and Analog communication system by B.P. Lathi:. Oxford 3rd edition
2. Digital Communications Fundamentals and Applications by Bernard Sklar, Sklar Person Education
3. Principles of Communication Systems: Taub & Schilling, Tata McGraw-Hill
4. Principles of Communication, R.E.Ziemer, WH Tranter Fifth Edition John Wiley (fifth module)
5. Wayne Tomoasi: Morden Electronic Communication Systems. Person Education/PHI
6. John G Proakis : Digital Communication. MGH
7. Digital Communication Techniques Simon, Hindey Lindsey PHI
8. Communication Systems: Simon Haykin, John Wiley & Sons. Pvt. Ltd.
9. Digital and Analog Communication System: K Sam Shanmugam. John Wiley
10. Communication Systems Engineering: Proakis, Pearson Education
11. Digital & Analog Communication System – Leon W Couch, Pearson Education/PHI.
12. Introduction to statistical Signal Processing with Applications M D Srinath, P.K. Rajasekaran, RE. Viswnathan PHI
13. Analog and Digital Communication M S Roden PHI
14. Digital modulation and coding. Wilson, Pearson Education
15. Applied coding and information Theory for engineers, Wells, Pearson education.

(Open Elective)

406 (b) Vacuum Technology and Applications

UNIT-I: **Basics of Vacuum**:

Vacuum – definition – Units of Vacuum – Vacuum ranges - Kinetic theory of gases related to vacuum - Physical parameters at low pressures – Vacuum components - Applications of vacuum – Vacuum metallurgy – Freeze drying – Vacuum in electrical applications – Space simulators – Leaks and detection of leaks – Pressure test – Halogen leak detector – Mass spectrometric leak detection.

UNIT-II: **Production and measurement of Vacuum**:

Classification of vacuum pumps – Rotary pump – Roots pump – Sorption pump – Diffusion pump – Turbo-molecular pump – Ion pump – Cryogenic pump.
Classification of vacuum gauges – McLeod gauge – Pirani gauge – Ionization gauges – Penning gauge – Bayard Alpert gauge – Measurement of partial pressure –Residual gas analyzer - Pump combinations – Construction of high vacuum coating system.

UNIT-III: **Preparation of thin films**:

Physical Methods - Vacuum evaporation - Resistive heating - Electron beam evaporation - Co-evaporation.
Epitaxial deposition -Pulsed laser ablation - Molecular beam epitaxy.
Sputtering - Glow discharge - DC and RF sputtering - Reactive sputtering - Magnetron sputtering
Chemical methods: Electroplating – Spray pyrolysis – Chemical vapour deposition (CVD) - Sol-gel – Spin coating.

UNIT-IV: **Applications of thin films**

Photolithography-Pattern generation- Thin film resistors – Thin film capacitors – Thin film diodes and transistors – Thin film solar cells - Thin film microbatteries – Thin film gas sensors – Reflection and antireflection coatings - Optical filters - Transparent conducting oxide coatings - Hard coatings - Tribological coatings.

Books for Study

1. Vacuum Technology, A.Roth, 3rd Edition, North-Holland Publications, 2012.
2. Vacuum Science and Technology, V. V. Rao, T.B. Ghosh and K.L. Chopra, 3rd Editions, Allied Publications, 2008.
3. Handbook of Thin Film Technology, L.I.Maissel and R.L.Glang, Mc Graw HillBook Co., 1970.
4. Thin Film Phenomena,K.L.Chopra, Mc Graw Hill Book Co., New York, 1969.
5. Vacuum Deposition onto Webs, Films and Foils, Charles A. Bishop, Elsevier, London,
6. The Materials Science of Thin Films, M. Ohring, Academic Press, New York, 1992.
7. The User's Guide to Vacuum Technology, J.F. O'Henlon, John Wiley & Sons, 2003.