FACULTY OF SCIENCES

SYLLABUS

FOR

M. Sc. Applied Physics (Electronics)
(Under Credit Based Continuous Evaluation Grading System)
(Semester: I-IV)

Session: 2013- 14

GURU NANAK DEV UNIVERSITY
AMRITSAR

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M.Sc. Applied Physics (Electronics) (Semester System)  
(Under Credit Based Continuous Evaluation Grading System)

**Course Code: PHB 3**

### Semester I

<table>
<thead>
<tr>
<th>Course No.</th>
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<th>Course Title</th>
<th>Hrs/Week</th>
<th>LTP</th>
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<tr>
<td>APL-401</td>
<td>C</td>
<td>Quantum Mechanics</td>
<td>4</td>
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<tr>
<td>APL-402</td>
<td>C</td>
<td>Physics and Chemistry of Solids</td>
<td>4</td>
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<td>APL-403</td>
<td>C</td>
<td>Elements of Physical Chemistry</td>
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<td>Basic Mathematics</td>
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**Total Credit 22**

### Semester II

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<td>Solid State Physics Lab-II</td>
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<td>Electronics Lab-II</td>
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**Total Credit 22**
M.Sc. Applied Physics (Electronics) (Semester System)
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### Semester III

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<td>APL-502</td>
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<td>Semiconductor Devices</td>
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<td>Microprocessors</td>
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<td>Fabrication of Electronic Devices</td>
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<td>Advanced Electronics Lab</td>
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**Total Credit 25**

### Elective Courses

- NSL-501 Carbon Nanotubes and its Functionalization
- NSL-502 Nano Sensors and Nanodevices
- NSL-503 Nano Semiconductors, Plasmonics Spintronics

### Semester IV

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**Total Credit 21**

### Elective Courses

- PHL-581 Experimental Methods
- PHL-582 Reactor Physics
- PHL-583 Material Science
- PHL-584 Nanotechnology
- PHL-585 Communication Electronics
- PHL-586 Radiation Physics
- PHL-587 Plasma Physics
- APL-581 Physics of Low Dimensional Semiconductors
- APL-582 Digital Signal Processing
- APL-583 Digital Communications
- APL-584 Optical Communications
M.Sc. Applied Physics (Electronics) (Semester – I)
(Under Credit Based Continuous Evaluation Grading System)

QUANTUM MECHANICS

Course No. APL-401

Unit-I

Introduction
Wave-particle duality, Postulates of quantum mechanics, operators, expectation values, Concepts of wavefunction, eigenfunction, eigenvalues, Normalization and orthogonality of eigenfunctions, parity operator, correspondence principle, Ehrenfest’s theorem, Exact statement and proof of uncertainty principle, Dirac-delta function and its properties and importance in quantum mechanics

Wave Mechanics
Time dependent and independent Schrodinger equation, Solutions of Schrodinger equation for a free particle, particle in a potential well of infinite and finite depth, double potential well, linear harmonic oscillator, one dimensional triangular well, linear harmonic oscillator, Reflection and transmission by a potential step and by a rectangular barrier, Resonant tunneling through a double potential barrier, Solution of Schrodinger equation for a Hydrogen atom, Lamb shift in hydrogen spectra.

Unit-II

Ket-Bra Algebra & Angular Momentum Problem
Vector spaces, ket and bra algebra, Relationship between kets and wavefunctions., Stern-Gerlach experiment, spin angular momentum, The angular momentum operators, and their representation in spherical polar co-ordinates, Eigenvalues and eigenfunctions of L², Commutation relations, Angular momentum and rotations, Rotational symmetry and conservation of angular momentum, reflection invariance and parity, ladder operators, Pauli spin matrices, addition of angular momenta-Clebsch-Gordon Coefficients.

Unit-III

Approximate Methods
WKB approximation and its application to one dimensional problems, Time independent perturbation theory for non-degenerate and degenerate energy levels, Dalgarno’s method, Basic principle of the variational method and hydrogen atom as an example, Time dependent perturbations, transition probability, Fermi’s golden rule, adiabatic approximation, sudden approximation.
M.Sc. Applied Physics (Electronics) (Semester – I)
(Under Credit Based Continuous Evaluation Grading System)

UNIT-IV

Effects of Electric & Magnetic Fields
Solution of Schrodinger equation with linear electric field, Bound states in a triangular well, Stark Effect, Hamiltonian in an electromagnetic field, Landau gauge, Solution of Schrodinger equation with uniform magnetic field, Cyclotron frequency, Landau levels, Interaction of spin angular momentum of the electron with magnetic field, spin-orbit interaction, magnetic resonance.

Quantum Computation
Concept of quantum computation, Quantum computation algorithms, requirements for realisation of quantum computers, spin as a physical realisation of a qubit, Quantum Qbits etc.

Recommended Books:

M.Sc. Applied Physics (Electronics) (Semester – I)  
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PHYSICS AND CHEMISTRY OF SOLIDS

Course No. APL-402
LTP 4 0 0

Unit-I
Structure of Matter
Amorphous, crystalline, crystals, polycrystals, symmetry, Unit Cells, Crystal Structures (Bravais Lattices), Crystallographic Directions, Crystallographic Planes, Miller Indices, Reciprocal lattices, Bragg’s Law, Single Crystal and Powder X-ray Diffraction

Unit-II
Chemical Bonding
Atomic Bonding in solids, Types of bond: Metallic, Ionic, Covalent and Vander waals bond; Hybridisation; H- bonding Molecular orbital theory for simple molecules such as diatomic molecule etc.

Unit-III
Imperfections in solids
Imperfections of crystal structure: point defects, Grain boundaries, phase boundaries, Dislocations Screw, Edge and Mixed Dislocations, generation of defects by quenching, by plastic deformation and by radiation, interaction between point defects and dislocations.

Unit-IV
Thermal and electrical properties of crystals
Phonon heat capacity, Planck distribution function, density of states in one and three dimensions, Debye model for density of states, Debye T^3 law, Einstein model of density of states, General result for density of states- \( D(\omega) \), anharmonic crystal interactions : thermal expansion, thermal conductivity, thermal resistivity of phonon gas: normal and umklapp processes, Free electron Fermi gas, Fermi –Dirac distribution function, Free electron gas in three dimensions, heat capacity of the electron gas, experimental heat capacity and electrical resistivity of metals, heavy fermions, umklapp scattering, Ohm’s law and Hall Effect in metals, Matthiessen’s rule, thermal conductivity of metals, Wiedemann –Franz law, electrical properties of nanostructures.
M.Sc. Applied Physics (Electronics) (Semester – I)
(Under Credit Based Continuous Evaluation Grading System)

**Recommended Books:**

M.Sc. Applied Physics (Electronics) (Semester – I)
(Under Credit Based Continuous Evaluation Grading System)

ELEMENTS OF PHYSICAL CHEMISTRY

Course No.             LTP
APL-403               400

Unit-I
Introduction to Thermodynamics: The first and second law of thermodynamics. Thermodynamic functions, heat capacity, enthalpy, entropy. Equilibrium in one component system, real gases, the reactions between gases, reaction kinetics, rate equations, reactions of solid-state phases

Unit-II

Unit-III
Theory of Solutions and Related Topics
The theory of solutions, Free energy as a function of composition, Methods for calculation of thermodynamic equilibrium, Electrochemical processes.

Diffusion
Fick's Law, mechanisms of diffusion; generation of point defects; self-diffusion; the influence of the pressure and pressure gradient; Kirkendall effect; fast diffusion; influence of isotropic state; experimental methods of investigation of diffusion.

Unit-IV
Phase Transformations
Gibbs phase rule and phase diagram, Mechanisms of phase transformation; homogeneous and heterogeneous nucleation; spinodal decomposition; grain growth; precipitation in solid solution; transformation with constant composition; order-disorder transformations; Martensitic transformation.
M.Sc. Applied Physics (Electronics) (Semester – I)
(Under Credit Based Continuous Evaluation Grading System)

Recommended Books:

M.Sc. Applied Physics (Electronics) (Semester – I)
(Under Credit Based Continuous Evaluation Grading System)

BASIC MATHEMATICS

Course No. APL-404
LTP 4 0 0

Unit-I
Function of a complex variable: Analytic functions, Cauchy-Riemann equations, simply and multiply connected regions, Cauchy integral theorem, Cauchy's integral theorem for multiply-connected regions, Cauchy's integral formula, Taylor and Laurent series, singularities and their classification, residue theorem and evaluation of definite integrals, dispersion relations (Hilbert Transforms).

Unit-II

Unit-III
Solution by power series method: Legendre and associated Legendre differential equation, Hermite differential equation, Laguerre equation, Bessel differential equation, Neumann functions, Hankel functions, spherical Bessel functions. Generating function and the recurrence relations: Legendre polynomials, Hermite polynomials, Bessel functions. Dirac delta function: its representation and properties, Green’s function: Green’s function for one-dimensional case, symmetry properties, expansion of Green’s function, Green’s function for Poisson equation, Green’s function for quantum mechanical scattering problem.
M.Sc. Applied Physics (Electronics) (Semester – I)
(Under Credit Based Continuous Evaluation Grading System)

Unit-IV
Integral Transforms: Laplace transform, first and second shifting theorems, LT of derivative and integral of a function, Inverse LT by partial fractions. Fourier series; Fourier theorem, half range series, change of interval, Fourier integral, complex form of Fourier series, half-wave rectifier, full-wave rectifier, sawtooth wave, square wave, solution of heat conduction equation, generalized Fourier series and Dirac delta function, summation of Fourier series, Gibbs phenomena. Fourier Transforms, convolution Theorem, Parseval's theorem, derivative of Fourier transform, Fourier transform of derivatives.

Recommended Books:
### Solid State Physics Lab-I

<table>
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### Electronics Lab-I

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</table>
M.Sc. Applied Physics (Electronics) (Semester – II)
(Under Credit Based Continuous Evaluation Grading System)

SOLID STATE PHYSICS

Course No.          LTP
APL-451            4 0 0

Unit-I

Band theory of crystals, origin of the energy gap, magnitude of the energy gap, Bloch Functions, Kronig-Penney model, Central equation and its solution, Kronig-Penney model in reciprocal space, Empty lattice approximation, approximate solution near a zone boundary, Number of orbitals in a band and distinction between metals, semimetals, semiconductors and insulators according to band theory. Concept of Fermi Surface in metals, Reduced, extended and periodic zone schemes, construction of Fermi Surfaces, nearly free electrons, electron orbits, hole orbits and open orbits, calculation of energy bands, Tight bonding model for energy bands, Wigner Seitz method, Experimental methods in Fermi surface studies, Quantization of orbits in magnetic field, De Haas-van Alphen effect, Fermi surface of copper and gold, Integral and fractional quantum Hall effects.

Unit-II


Unit-III

Diamagnetism, Langevin diamagnetism equation, Failure of classical theory to explain diamagnetism, quantum theory of diamagnetism of mononuclear systems, Paramagnetism, Quantum theory of paramagnetism, Crystal field splitting, quenching of orbital angular momentum, cooling by isentropic demagnetization, paramagnetic susceptibility of conduction electrons, Ferromagnetic order, Curie temperature and exchange integral, Saturation magnetization and its temperature dependence, Ferromagnetic domains, anisotropy energy, Bloch walls and their transitions, Single domain particles, magnons, thermal excitation of magnons, neutron magnetic scattering, ferrimagnetic order: Curie temperature and susceptibility of ferrimagnets, antiferromagnetic order, Neel temperature, antiferromagnetic magnons, Magnetic bubble domains, Important properties in relation to nanomagnetism.
Unit-IV

Occurrence of superconductivity, Meissner effect and isotope effect, Destruction of superconductivity by magnetic fields, Type I and Type II superconductors, Heat capacity of superconductors, energy gap, microwave and infrared properties, Order and thermodynamics of superconductivity transition, London equation, concept of coherence length, BCS theory of conventional superconductors, flux quantization, duration of persistent currents, single particle tunneling, DC and AC Josephson effect, Microscopic quantum interference of superconducting currents, Superconducting magnets and SQUIDS, High temperature superconductors : structure and properties, superconductivity in fullerenes and magnesium diboride (MgB₂).

Recommended Books:

M.Sc. Applied Physics (Electronics) (Semester – II)  
(Under Credit Based Continuous Evaluation Grading System)

MICROWAVES

Course No.          LTP
APL-452            4 0 0

Unit - I
Maxwell’s equations and boundary conditions, Electromagnetic wave equation, Poynting Theorem, Reflection of uniform plane waves at normal and oblique incidence, Plane wave propagation in free space, lossless and lossy dielectric, Plane wave propagation in good and poor conductors, Plane wave propagation in metallic film coating on plastic substrate.
Microwave transmission line equations, solutions of transmission line equations, Reflection and Transmission coefficient, standing wave and standing wave ratio, Line impedance and line admittance, Smith chart, Impedance matching.

Unit - II
Rectangular and Circular waveguides, Solutions of wave equations in rectangular and cylindrical co-ordinate systems, TE and TM modes in rectangular and circular wave guides, Power transmission in rectangular wave guides, Power losses in rectangular wave guides.
Rectangular cavity resonator, circular and semicircular cavity resonators, Q of a cavity resonators, s parameters, wave guide Tees, Magic Tee, Directional couplers, Hybrid couplers, Microwave circulators and isolators

Unit –III
Dipole radiation, Retarded potentials, Electric and magnetic dipole radiation, Radiation form arbitrary distribution of charges and currents, Radiation from a point charge, Lienard-Wiechert Potentials, Fields of a moving charge, Power radiated by a point charge, Radiation reaction, Abraham–Lorentz Formula, Physical origin of radiation reaction.
M.Sc. Applied Physics (Electronics) (Semester – II)
(Under Credit Based Continuous Evaluation Grading System)

Unit - IV

Recommended Books:
2. Introduction to Electrodynamics, D. J. Griffiths, Prentice Hall of India, New Delhi, 1997.
CHARACTERIZATION TECHNIQUES

Course No.  LTP
APL-453  4 0 0

Unit-I
Electrical, optical and mechanical methods for determination of the thickness of thin films, AES, XPS/ESCA, RBS and SIMS techniques for the analysis of surfaces, X-ray diffraction, data manipulation of diffracted X-rays for structure determination, X-ray fluorescence spectrometry for element detection with concentration.

Unit-II

Unit-III
Ultrasonic velocities and attenuation in solids, ultrasonic flaw detection, acoustic emission technique, Surface acoustic wave technique, tensile, bending, hardness, impact, fatigue and creep tests DTA, TGA and DSC measurements and analysis of the curves

Unit-IV
Microwave, infrared, ultra-violet, visible, Raman, ESR, NMR and Mossbauer spectroscopy, Frank-Condon principle, Eddy current methods, Guoy and Faraday balances and vibrating reed magnetometer.

Recommended Books:

M.Sc. Applied Physics (Electronics) (Semester – II)
(Under Credit Based Continuous Evaluation Grading System)

BASIC ELECTRONICS

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<td>APL-454</td>
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Unit-I
Differential amplifier; circuit configurations; dual input, balanced output differential amplifier; DC analysis; AC analysis; inverting and non-inverting inputs; CMRR; constant current bias level transistor.
Block diagram of a typical Op-Amp analysis. Open loop configuration inverting and non-inverting amplifiers. Op-amp with negative feedback; voltage series feedback; effect of feedback on closed loop gain, input resistance, output resistance; bandwidth and output offset voltage; voltage follower.
Practical Op-amp; input offset voltage; input bias current; input offset current; total output offset voltage; CMRR frequency response.

Unit-II
DC and AC amplifier; summing, scaling and averaging amplifiers; instrumentation amplifier; integrator and differentiator.
Oscillators: principles; oscillator types; frequency stability; response; The phase shift oscillator; Wein bridge oscillator; LC tunable oscillators; Multivibrators; Monostable and Astable; comparators; square wave and triangle wave generators.
Voltage regulators; fixed regulators; adjustable voltage regulators; switching regulators.
Unit-III

Combinational Logic: The transistor as a switch, OR, AND and NOT gates, NOR and NAND gates; Boolean algebra; Demorgan's theorems; Exclusive OR gate; Adder, Decoder/Demultiplexer; Data selector/multiplexer; Encoder.
Sequential Logic: Flip-Flops: A 1-bit memory; The RS Flip-Flop; JK Flip-Flop; JK master slave Flip-Flop; T Flip-Flop; D Flip-Flop; Shift registers; synchronous and asynchronous counters; cascade counters.

Unit-IV

Active filters; First order low pass Butterworth filter, First order high pass Butterworth filter, Bandpass filter, Band reject filters, Basic comparator, Zero crossing Detector, Schmitt trigger, Digital-to-analog converters, ladder and weighted resistor types. Analog to digital converters-counter type, successive approximation and dual slope converters, Applications of DACs and ADCs.

Recommended Books:
M.Sc. Applied Physics (Electronics) (Semester – II)
(Under Credit Based Continuous Evaluation Grading System)

**Solid State Physics Lab.-II**

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**Electronics Lab.-II**

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M.Sc. Applied Physics (Electronics) (Semester – III)  
(Under Credit Based Continuous Evaluation Grading System)

COMPUTER PROGRAMMING & COMPUTATIONAL METHODS

Course No.  
APL-501  

LTP  
4 0 0

Unit – I

Numerical Methods – I

Unit – II

Numerical Methods – II

Unit – III

Matlab – I
M.Sc. Applied Physics (Electronics) (Semester – III)
(Under Credit Based Continuous Evaluation Grading System)

Unit IV

Matlab – II
Linear Algebra; solving a linear system, Gaussian elimination, finding eigen values and eigen vectors, matrix factorization, Curve fitting and Interpolation; polynomial curve fitting, least square curve fitting, interpolation, Data analysis and statistics, Numerical integration; double integration, Ordinary differential equation; first order linear ODE, second order nonlinear ODE, tolerance, ODE suite, event location, Non linear algebraic equations

Recommended Books:

SEMICONDUCTOR DEVICES

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Unit-I

Semiconductor Materials: Energy Bands, Intrinsic carrier concentration. Donors and Acceptors, Direct and Indirect band semiconductors; Determination of bandgap by optical method. Degenerate and compensated semiconductors, Carrier Transport in Semiconductors: Carrier Drift under low and high fields in (Si and GaAs), saturation of drift velocity, High field effects in two valley semiconductors, Carrier Diffusion, Carrier Injection, Generation Recombination Processes - Direct, Indirect bandgap semiconductors, Minority Carrier Life Time, Drift and Diffusion of Minority Carriers (Haynes-Shockley Experiment), Determination of Conductivity by (a) four probe and (b) Van der Paw techniques, Hall Coefficient, Minority Carrier Life Time.

Unit-II

Junction Devices: (I) p-n junction - Energy Band diagrams for homo and hetero junctions. Current flow mechanism in p-n junction, effect of indirect and surface recombination currents on the forward biased diffusion current, p-n junction diodes rectifiers (high frequency limit), (ii) Metal-semiconductor (Schottky Junction): Energy band diagram, current flow mechanisms in forward and reverse bias, effect of interface states. Applications of Schottky diodes, (iii) Metal-Oxide-Semiconductor (MOS) diodes). Energy band diagram, depletion and inversion layer. High and low frequency Capacitance Voltage (C-V) characteristics. Smearing of C-V curve, flat band shift, Applications of MOS diode.
M.Sc. Applied Physics (Electronics) (Semester – III)
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Unit-III

Transistors: JFET, BJT, MOSFET and MESFET: Structure, Working, Derivations of the equations for I-V characteristics under different conditions. High frequency limits, Memory Devices: Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile-NMOS, magnetic, optical and ferroelectric memories, charge coupled devices (CCD).

Unit-IV

Switching Devices: p-n-p-n Shockley diode; UJT; SCR; DIAC and TRIAC, Microwave Devices: Gunn Diodes, IMPATT diodes, BARRITT diodes, Klystron and Magnetron.

Recommended Books:

M.Sc. Applied Physics (Electronics) (Semester – III)
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MICROPROCESSORS

Course No. APL-503

LTP 400

Unit-I

Introduction to Microprocessors: Microprocessors, binary digits, Microprocessor as a programmable device, Input/Output, Microprocessor as a CPU, Organization of a Microprocessor based system, Arithmetic/Logic unit register array, control unit, Machine Language, 8085 Machine language, 8085 Assembly language, ASCII codes.

Unit – II

Microprocessor Architecture: Microprocessor Architecture and its operations, Microprocessor initiated operations and 8085 BUS organization, Internal data operations at the 8085 operations, peripheral or externally initiated operations, memory, memory map and memory addresses, memory classifications, Input/Output devices, tristate devices, buffer, decoder, encoder, de flip-flop,

Unit- III

Memory Interface Devices: 8085 MPU, Microprocessor communications and BUS timing, Demultiplexing the Bus AD7-AD0, ALU, Memory structures and its requirement, basic concepts in memory interfacing, address coding, interfacing circuits, address coding and memory addresses.
M.Sc. Applied Physics (Electronics) (Semester – III)
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Unit- IV

Recommended Books:


M.Sc. Applied Physics (Electronics) (Semester – III)
(Under Credit Based Continuous Evaluation Grading System)

FABRICATION OF ELECTRONIC DEVICES

Course No. APL-504

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Unit-I

Unit – II

Unit - III
Metallization applications: Gates and interconnections, Metallization choices, metals, alloys and silicides, deposition techniques, metallization problems, step coverage, electromigration, Etching: Dry and wet chemical etching, Reactive Plasma Etching, Ion enhanced etching and ion induced etching, Plasma etchers and Barrel reactors.

Unit – IV
Optical lithography: photoresists, Contact and proximity printers, projection printers, Mask alignment, X-ray and electron beam lithography, Fundamental considerations for IC processing: Building individual layers, Junction and Trench isolation of devices, NMOS IC technology, CMOS IC technology, Bipolar IC technology.
M.Sc. Applied Physics (Electronics) (Semester – III)
(Under Credit Based Continuous Evaluation Grading System)

**Recommended Books:**


M.Sc. Applied Physics (Electronics) (Semester – III)
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**COMPUTER LAB**

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**ADVANCED ELECTRONICS LAB**

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M.Sc. Applied Physics (Electronics) (Semester – III) (Elective Courses)
(Under Credit Based Continuous Evaluation Grading System)

CARBON NANOTUBES AND ITS FUNCTIONALIZATION

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<th>Course No.</th>
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<td>NSL-501</td>
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Unit I
Preparation of Carbon Nano-Tubes; CVD and other methods of preparation of CNT, Structure and properties of single walled and multi walled carbon nanotubes; Electrical, Optical, Mechanical, Vibrational properties and ballistic conductance of carbon nanotubes.

Unit II
Applications of Carbon Nanotubes; Field emission, Fuel Cells, Display devices, Energy Storage, nanotube sensors, composites for military and space applications, applications in NanoFET

Unit III

Unit IV
Other Important Carbon based materials; Preparation, properties and Characterization of Fullerene and other associated carbon clusters/molecules, Graphene-preparation, characterization and properties, DLC and nanodiamonds.
Recommended Books:


NANO SENSORS AND NANODEVICES

Course No. NSL-502

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Unit I
Micro and nano-sensors: fundamentals and characterization of sensors, micro fluids, MEMS and NEMS, packaging of sensors, methods of packaging at zero level and first level.

Unit II
Sensors: sensors for aerospace and defense, accelerometer, pressure sensor, chemical sensors, strain gauges, night vision system, optical sensors, nano tweezers, nano-cutting tools, integration of sensor with actuators and electronic circuitry, metal insulator semiconductor devices, Schottky devices, other civil applications: metrology, bridges etc.

Unit III
Biosensors: sensor for bio-medical applications: cardiology, neurology, clinical diagnostics and tools, generation of biosensors, immobilization, characteristics, applications, conducting Polymer based sensor, DNA biosensors, biochips, molecular electronics, information storage, molecular switching.

Unit IV
Quantum Structures and Devices: quantum layers, wells, dots and wires, optical properties of quantum dots, quantum wires and quantum wells, quantum well lasers, mesoscopic devices, ballistic transport, nanoscale transistors, single electron transistors, MOSFET and NanoFET, resonant tunneling devices, carbon nanotube based logic gates.
M.Sc. Applied Physics (Electronics) (Semester – III) (Elective Courses)
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Recommended Books:


7. Quantum Transport: Atom to Transistor - Supriyo Datta- Cambridge University Press - 2005


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NANO SEMICONDUCTORS, PLASMONICS SPINTRONICS

Course No. NSL-503 LTP
3 0 0

Unit I
Confinement and transport in nanostructure- size–dependant physical properties; current, reservoirs, and electron channels, conductance formula for nanostructures, quantized conductance, Landauer formula, Ballistic transport, Diffusive transport, Single particle conductance, Coulomb Blockade, Single electron transistors, Resonant Tunneling devices.

Unit -II
Semiconductor nanoparticles – applications; optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, surface-trap passivation in core-shell nanoparticles, carrier injection, polymer-nanoparticle, LED and solar cells, electroluminescence, doping nanoparticles, light emission from indirect semiconductors, light emission form Si nanodots, semiconductor heterostructures.

Unit III
Optical properties of noble metals, Plasmons, Drude-Sommerfeld theory, Surface plasmon polaritons at plane interfaces, excitation of surface plasmon polaritons: Otto and Kretschmann configurations, Surface plasmon sensors, Surface plasmons in nano-optics, plasmons supported by nanowires and particles. Photonic crystals, theory of photonic bandgap, optical microcavities, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmons, optical modulation by plasmonic excitation of quantum dots, near field photonics, localized surface plasmons, slow guided surface plasmons at telecom frequencies.
M.Sc. Applied Physics (Electronics) (Semester – III) (Elective Courses)
(Under Credit Based Continuous Evaluation Grading System)

Unit IV
Spintronics Introduction, Overview, History & Background, Generation of Spin Polarization; theories of spin injection, spin relaxation and spin dephasing, Spintronic devices and applications, spin filters, spin diodes, spin transistors.

Recommended Books:
M.Sc. Applied Physics (Electronics) (Semester – IV)
(Under Credit Based Continuous Evaluation Grading System)

**PROJECT**

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M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses)
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EXPERIMENTAL METHODS

Course No.            LTP
PHL-581               4 0 0


Vacuum & Low Temperature Techniques: Vacuum techniques, Basic idea of conductance, pumping speed, Pumps: Mechanical pumps, Diffusion pumps, Ionization pumps, turbo molecular pumps, gauges; Penning, Pirani, Hot cathode, Low temperature: Cooling a sample over a range upto 4 K and measurement of temperature.

Transducers and Temperature Measurements: Classification of transducers, Selecting a transducers, qualitative treatment of strain gauge, capacitive transducers, inductive transducers, linear variable differential transformer (LVDT), photoelectric transducers, piezoelectric transducers, temperature measurements (Resistance thermometer, thermocouples, Themisters).

Text and Reference Books:
1. Electronic Devices and Circuits: Jacob Milliman, C. Halkias
3. Techniques for Nuclear and Particle Physics Experiments: W.R. Leo.
5. Electronic Instrumentation and Measurements Techniques: William David Cooper.
REACTOR PHYSICS

Course No. PHL-582
LTP 4 0 0

Interaction of Neutrons with Matter in Bulk
Thermal neutron diffusion, Transport and diffusion equations, transport mean free path, solution of diffusion equation for a point source in an infinite medium and for an infinite plane source in a finite medium, extrapolation length and diffusion length-the albedo concept.

Moderation of Neutron
Mechanics of elastic scattering, energy distribution of thermal neutrons, average logarithmic energy decrement, slowing down power and moderating ratio of a medium, Slowing down density, slowing down time, Fast neutron diffusion and Fermi age theory, solution of age equation for a point source of fast neutrons in an infinite medium, slowing down length and Fermi age.

Theory of Homogeneous Bare Thermal and Heterogeneous Natural Uranium Reactors
Neutron cycle and multiplication factor, four factor formula, neutron leakage, typical calculations of critical size and composition in simple cases, the critical equation, material and geometrical bucklings, effect of reflector. Advantages and disadvantages of heterogeneous assemblies, various types of reactors with special reference to Indian reactors and a brief discussion of their design feature.

Power Reactors Problem of Reactor Control
Breeding ratio, breeding gain, doubling time, Fast breeder reactors, dual purpose reactors, concept of fusion reactors, Role of delayed neutrons and reactor period, Inhour formula, excess reactivity, temperature effects, fission product poisoning, use of coolants and control rods.

Reference Books:
M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses)
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MATERIAL SCIENCE

Course No.          LTP
PHL-583             4 0 0

**Thin Film Technology:** Classification of Thin films configurations; Film deposition method: Physical vapor deposition, Chemical vapor deposition, Spray pyrolysis, Sputtering (RF, DC); Modes of film growth by vapor deposition: from vapor to adatoms, from adatoms to film growth, growth modes based on surface energies; film microstructure: Epitaxial films, polycrystalline films, Origin of films stress: classification, stress in epitaxial films, stress in polycrystalline films, consequence of stress in film; effect of substrate temperature, deposition angle and thickness on thin film formation.

**Polymers & Ceramics:** Characteristics, Application and Processing of polymers; Polymerization, Polymer types: Stress- Strain behaviour, melting and glass transition, thermosets and thermoplasts; Characteristics, Application and Processing of Ceramics, glasses and refractories.

**Characterization Techniques-I:** Electrical, Optical and Mechanical method for determination of thickness of films, Transmission electron microscopy (TEM), Scanning electron microscopy (SEM); Scanning tunneling microscopy (STM); Atomic force microscopy (AFM).

**Characterization Techniques-II:** X-ray diffraction, data manipulation of diffracted X-rays for structure determination; X-ray fluorescence spectrometry for element detection with concentration; Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), Secondary ion mass spectroscopy (SIMS)

**Text and Reference Books:**

1. Thin Film Materials-Stress, Defect, Formation and Surface Evolution: L.B. Freund and S. Suresh- Cambridge,
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NANOTECHNOLOGY

Course No.  
PHL-584  
LTP  
4 0 0

**Introduction and Synthesis of Nanomaterials:** Basic idea of Nanomaterials and Nanotechnology, Physical Methods: inert gas condensation, arc discharge, Laser ablation, molecular beam epitaxy, electron deposition, ball milling; electron beam lithography; Chemical Methods: sol-gel, micelles and micro emulsions.

**Nanoparticles:** Introduction to Nanoparticles; Metal Nanoclusters: magic numbers, theoretical modeling of nanoparticles, geometric structure, electronic structure, reactivity, magnetic clusters, bulk to nanotransition; Semiconducting nanoparticles: optical properties, photofragmentation, cumbic explosion; Rare gas and molecular clusters.

**Quantum Nanostructures:** Introduction to quantum wells wires and dots; preparation using lithography; Size and dimensionality effects: size effects, conduction electrons and dimensionality, potential wells, partial confinement, properties dependent on density of states, single electron tunneling; Application: Infrared detectors, Quantum dot Lasers.

**Carbon Nanostructure:** Carbon molecules: nature of carbon bond; new carbon structures; Carbon clusters: small carbon clusters, structure of C_{60}, alkali doped C_{60}; Carbon nanotubes: fabrication, structure, electrical properties, vibrational properties, mechanical properties, Application of carbon nanotubes: field emission and shielding, computers, fuel cells, chemical sensors, catalysis.

**Text and Reference Books:**

COMMUNICATION ELECTRONICS

Course No.          LTP
PHL-585             4 0 0

Amplitude Modulation: Frequency spectrum of AM wave, representation and power relations in AM wave, evaluation and description of SSB, superstition of unwanted side bands, form of amplitude modulation.


Pulse modulation: Information theory, pulse modulation: PWM, PPM and PCM, Multiplexing: frequency-division multiplexing. Time division multiplexing, shot, medium and long-hand system.

Microwave Devices: Klystrons, Magnetrons, Velocity modulation, Basic principles of two cavity Klystrons and Reflex Klystrons, principles of operation of magnetrons., Transferred electron devices, Gunn Effect, Principles of operation. Modes of operation, Read diode, IMPATT diode, TRAPATT diode, Tunnel diode and Stimulated emission and associated devices.

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, antennas used in MW communication systems.

Radar Systems

Reference Books:
M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses)
(Under Credit Based Continuous Evaluation Grading System)

RADIATION PHYSICS

Course No.             LTP
PHL-586              4 0 0

Ionizing Radiations and Radiation Quantities:
Types and sources of ionizing radiation, fluence, energy fluence, kerma, exposure rate and its measurement – The free air chamber and air wall chamber. Absorbed dose and its measurement; Bragg Gray Principle, Radiation dose units- rem, rad, Gray and Sievert dose commitment, dose equivalent and quality factor.

Dosimeters:
Pocket dosimeter, films, solid state dosimeters such as TLD, SSNTD, chemical detectors and neutron detectors, simple numerical problems on dose estimation.

Radiation Effects and Protection
Biological effects of radiation at molecular level, acute and delayed effects, stochastic and non-stochastic effects, Relative Biological Effectiveness (RBE), Linear energy transformation (LET), Dose response characteristics. Permissible dose to occupational and non-occupational workers, maximum permissible concentration in air and water, safe handling of radioactive materials. The ALARA, ALI and MIRD concepts, single target, multitarget and multihit theories, Rad waste and its disposal, simple numerical problems.

Radiation Shielding
Thermal and biological shields, shielding requirement for medical, industrial and accelerator facilities, shielding materials, radiation attenuation calculations – The point kernal technique, radiation attenuation from a uniform plane source. The exponential point-Kernal. Radiation attenuation from a line and plane source. Practical applications and some simple numerical problems.

Reference Books:
2. Radiation Theory, Alison. P. Casart.
PLASMA PHYSICS
(Elective Course)

Course No. LTP
PHL-587 4 0 0

Basics of Plasmas: Occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding and plasma parameter. Single particle motions in uniform E and B, nonuniform magnetic field, grad B and curvature drifts, invariance of magnetic moment and magnetic mirror. Simple applications of plasmas.

Plasma Waves: Plasma oscillations, electron plasma waves, ion waves, electrostatic electron and ion oscillations perpendicular to magnetic field, upper hybrid waves, lower hybrid waves, ion cyclotron waves. Light waves in plasma.

Boltzmann and Vlasov equations: The Fokker Planck equation, integral expression for collision term, zeroth and first order moments, the single equation relaxation model for collision term. Applications of kinetic theory to electron plasma waves, the physics of Landau damping, elementary magnetic and inertial fusion concepts.


Reference Books:
1. Introduction to Plasma Physics and Controlled Fusion: F F Chen-Springer, 1984
M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses)  
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PHYSICS OF LOW DIMENSIONAL SEMICONDUCTORS

Course No. APL-581

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Unit 1

General properties of heterostructures, Growth of heterostructures: MBE & MOCVD, Band Engineering, Band Diagrams of different heterostructures, Superlattice devices, Doped Heterostructures: Modulation Doping, band diagram of modulation doped layer, MODFET, electrostatic potential, conduction band and gate bias, threshold voltage, gate-channel capacitance, screening by 2D electron gas, layered structures, band structure modifications by strain, Quantum wires and dots.

Unit –II

Solution of Schrodinger wave equation in one dimensional square wells of finite and infinite depths, parabolic and triangular wells, Low dimensional systems, sub-bands and their occupation, Two and three dimensional quantum wells: cylindrical, two dimensional parabolic and spherical wells, Quantum wells in heterostructures, Tunneling transport in semiconductors, potential step, square barrier, T -matrices, Tunneling current in one, two and three dimensions, Resonant Tunneling through Quantum Wells, Coulomb Blockade and single electron devices, Tunneling in Heterostructures, Intervally transport.

Unit-III

Semiclassical dynamics of electrons in a magnetic field, semiclassical approach to magnetotransport, Quantum mechanical approach to electrons in uniform magnetic fields, Landau levels, Aharonov-Bohm effect, De-Haas effect, Shubnikov-de-Haas Effect, Quantum Hall Effect, Fractional Quantum Hall Effect.
M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses)
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**Unit-IV**

General Theory of optical properties of Quantum Wells; Kramers-Kronig relations, optical -
response functions, sum rules, valence band structure: Kane model, energy bands in a quantum
well, interband Transitions in quantum wells, Absorption spectrum, optical gain and lasers,
Excitons in two and three dimensions, Excitons in a quantum well.

**Reference Books:**

1. Physics of Low Dimensional Semiconductors - John H Davies -- Cambridge
2. Low Dimensional Semiconductor Heterostructures - Keith Barnham & Dimitri
3. Physics of Semiconductors and their Heterostructures - Jasprit Singh – Mc Graw Hill -
   1994.
M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses)
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DIGITAL SIGNAL PROCESSING

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Unit-I
Signals and systems: Introduction, classification of signals, representation of signals, elementary discrete-time signals, manipulation of signals, classification of systems, static and dynamic systems, linear systems, time invariant systems, causal and non-causal system, stable and unstable systems, Fourier analysis; trigonometric, complex and exponent forms of Fourier series, Parseval identity, power spectrum, Fourier transform and its properties, Fourier transform of power and energy signals, Z-Transform: Introduction, definition, properties, evaluation of inverse z-transform.

Unit-II

Unit-III
M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses)  
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Unit-IV

Infinite Impulse Response (IIR) filters: Introduction, IIR filters design by derivatives, impulse invariant and bilinear transformation method, frequency transformations. Adaptive filters: Theory, structure and applications (speech analysis and mobile communication)

Reference Books:

M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses)
(Under Credit Based Continuous Evaluation Grading System)

DIGITAL COMMUNICATIONS

Course No.          LTP
APL-583            4 0 0

Unit-I
Digital Modulation -Techniques and System: Introduction, comparison of analog and digital
signals, advantages and disadvantages of digital communication, elements of digital
communication system, pulse code modulation (PCM), quantization noise, companding, signal
representation: sampling theorem, PCM bandwidth, PCM system, advantages of PCM over
analog modulation, differential PCM, delta modulation (DM), continuously variable slope delta
modulator (CVSDM) or adaptive delta modulation.

Unit-II
Digital carrier - modulation techniques and system: Introduction, Amplitude Shift Keying
(ASK), ASK spectrum, ASK modulator, Coherent ASK detectors, Noncoherent ASK detector,
Frequency Shift Keying (FSK), bandwidth and frequency spectrum of FSK, Non-coherent FSK
detector, Coherent FSK detector, FSK detection using PLL, Binary Phase Shift Keying, Binary
PSK spectrum, Coherent PSK detection, Quadrature Phase Shift Keying (QPSK), QPSK
demodulator, Differential PSK.

Unit-III
Spread-Spectrum Techniques and Communication Systems: Introduction, principles of spread
spectrum, direct sequence pseudo noise (DSPM) spreading, Frequency Hop Coding, Time Hop
Spreading, spread spectrum modulation systems, generation of pseudo random Sequences,
Sequence length, independence of Sequences, number of ones and zeros in maximal Sequence,
clustering in a PN Sequence, correlation properties, spread spectrum modulation, Continuous-
Phase-Shift-Modulation (CPSM), Code Division Multiple Access (CDMA).
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Unit-IV

Cellular and Mobile Communication Systems: Introduction, main methods of radio transmission, GSM standard for cellular phones, GSM architecture, features of GSM, cellular mobile radio systems, inside the cell phone, other services of GSM, future of telecommunication, operation of cellular systems, concept of frequency, reuse channels, frequency reuse schemes, frequency reuse distance, consideration of components of cellular systems, switching equipment data links, security and identification, supervision, power controls, function of the MTSO, cellular analog switching equipments, description of analog switching equipment, modification of analog switching equipment, cell site controllers and hardware, cellular digital switching equipment, general concept, elements of switching, radio.

Reference Books:
OPTICAL COMMUNICATIONS

Course No.          LTP
APL-584            4 0 0

Unit -I

Unit -II
Lasers, Basic concepts, Emission from semiconductors, Injection laser, Multimode injection laser, Single mode injection laser, Single mode structures, Injection laser characteristics, Non semiconductor lasers, LED, Efficiency, Double heterostructure, Planar, Dome, Burrus type, Lens coupling, Edge emitting, LED characteristics, power, spectrum, Modulation bandwidth, Reliability, Modulation.

Unit -III
Detectors, Device type, Absorption, Quantum efficiency, Responsivity, Longwavelength cut-off, p-n, p-i-n, Avalanche, Silicon reachthrough, Germanium avalanche, Drawbacks of avalanche diodes, Receiver Noise, Thermal, Dark Current, Quantum Noise, p-n and pin diode receiver noise, Receiver capacitance, APD Excess Noise, Receiver Structure, Low impedance front end, Transimpedance front end, FET preamplifiers, GaAs MESFETs, PIN-FET hybrid.
M.Sc. Applied Physics (Electronics) (Semester – IV) (Elective Courses) (Under Credit Based Continuous Evaluation Grading System)

Unit –IV


Reference Books: