Department of Physics

Department at a glance :

1. Well-equipped Advanced Physics and Electronics Laboratory
2. Research oriented updated course and learned faculties with vast experience
3. Special Emphasis on experiments/hands on training and industry oriented projects
4. Master thesis in collaboration with Research institutes / Universities / Industries
5. Six - Eight weeks internship program in Industry / Institutes.

Semester Curriculum for Postgraduate (M.Sc.) Program in Physics (Major)

Course Distribution

A. Physics – MAJOR (GENERAL THEORY)

Discipline/ Name (Theory)	Paper No	Total Credits	L-T-P
1. Mathematical Methods	1	4	4-0-0
2. Classical Mechanics	1	4	4-0-0
3. Quantum Mechanics I	1	4	4-0-0
4. Quantum Mechanics II	1	4	4-0-0
5. Classical Electrodynamics	1	4	4-0-0
6. Electronics	1	4	4-0-0
7. Statistical Mechanics	1	4	4-0-0
8. Atomic & Molecular Spectroscopy	1	4	4-0-0
9. Solid State Physics	1	4	4-0-0
10. Nuclear Physics	1	4	4-0-0
Total	**10**	**40**	

B. PHYSICS – MAJOR (PRACTICAL)

Discipline/ Name (Practical)	Paper No	Total Credits	L-T-P
1. Physics Lab I	1	3	0-0-6
2. Physics Lab II	1	3	0-0-6
3. Physics Lab III	1	3	0-0-6
4. Physics Lab IV	1	3	0-0-6
5. Physics Lab V	1	3	0-0-6
6. Numerical Methods for Physicists and Engineers	1	3	0-0-6
Total	**6**	**18**	

C. ADVANCED ELECTIVE PAPERS

Discipline/ Name	Paper No	Total Credits	L-T-P
1.Advanced Elective I	1	4	4-0-0
2. Advanced Elective I	1	4	4-0-0
3. Advanced Elective III	1	4	4-0-0
4. Advanced Elective IV	1	4	4-0-0
5.Advanced Elective Lab I	1	2	0-0-4
6.Advanced Elective Lab II	1	3	0-0-6
Total	**6**	**21**	

D. KNOWLEDGE ENHANCEMENT COURSE (KEC)

Discipline/ Name	Paper No	Total Credits	L-T-P
1. Environmental Science& Energy Resources	1	3	4-0-0
Total	**1**	**3**	

E. PROJECT/DISSERTATION/INDUSTRY INTERACTION

Discipline/ Name	Paper No	Total Credits	L-T-P
Dissertation	1	10	
Term Paper Leading to Dissertation	1	2	
Industry Internship Program	2	2 + 2	
Seminar on Contemporary Research in Physics & Applied Physics	1	2	
Total	**5**	**18**	

Distribution of Papers Semester-wise:

SPH51109 : Physics I (B.Sc. LLB)

Semester - I				
Paper Name	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Mathematical Methods	SPH51101	1	4	4-0-0
Classical Mechanics	SPH51103	1	4	4-0-0
Quantum Mechanics I	SPH51105	1	4	4-0-0
Electronics	SPH51107	1	4	4-0-0
Physics Lab I	SPH51201	1	3	0-0-6
Physics Lab II	SPH51203	1	3	0-0-6
Environmental Science and Energy Resources	SGY51111	1	2	2-0-0
English/ Foreign Language (Non-credit course)		1	0	2-0-0
Total		**4 + 2 + 1 = 7**	**24**	

SPH51109 : Physics I (B.Sc. LLB)

Semester II				
Paper Name	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Classical Electrodynamics	SPH51102	1	4	4-0-0
Quantum Mechanics II	SPH51104	1	4	4-0-0
Statistical Mechanics	SPH51106	1	4	4-0-0
Atomic & Molecular Spectroscopy	SPH51108	1	4	4-0-0
Physics Lab III	SPH51202	1	3	0-0-6
Physics Lab IV	SPH51204		3	0-0-6
Numerical Modeling for Physicists and Engineers	SPH51206	1	3	0-0-6
English/ Foreign Language (Non-credit course)		1	0	2-0-0
Total		4 + 2 +1 = **7**	**25**	

Semester III				
Paper Name	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Solid State Physics	SPH52101	1	4	4-0-0
Nuclear Physics	SPH52103	1	4	4-0-0
Advanced Elective I	SPH52105/ SPH52107/ SPH52109/ SPH52111/ SPH52113	1	4	4-0-0
Advanced Elective II	SPH52121/ SPH52123/SPH52125/ SPH52127/ SPH52129	1	4	4-0-0
Physics Lab V	SPH52201	1	3	0-0-6
Advanced Elective Lab I	SPH52203/ SPH52205/ SPH52207/ SPH52209/ SPH52211	1	2	0-0-4
Term Paper Leading to Dissertation	SPH52701	1	3	
Industry Internship	SPH52601	1	2	
English/ Foreign Language (Non-credit course)		1	0	2-0-0
Total		4 + 2 + 1 + 1= **8**	**26**	

Semester IV				
Paper Name	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Advanced Elective III	SPH52102/ SPH52104/ SPH52106/ SPH52108/ SPH52110	1	4	4-0-0
Advanced Elective IV	SPH52120/ SPH52122/ SPH52124/ SPH52126/ SPH52128	1	4	4-0-0
Advanced Elective Lab II	SPH52202/ SPH52204/ SPH52206/ SPH52208/ SPH52210	1	3	0-0-6
Seminar on Contemporary Research in Physics & Applied Physics	SPH52302	1	2	
Dissertation	SPH52702	1	12	
English/ Foreign Language (Non-credit course)		1	0	2-0-0
Total		2 + 1 + 1 + 1 = **5**	**25**	

TOTAL CREDIT: 100

Options for Advanced Elective Papers	
Sl. No	**Name of the Paper**
1.	Applied Electronics
2.	Condensed Matter Physics
3.	Medical Electronics and Instrumentation
4.	Quantum Field Theory and Particle Physics
5.	Plasma Physics

Details of the Advanced Papers

	Advanced Program I : (Applied Electronics)				
Elective (s)	**Paper Name**	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Elective I	Solid State Devices and VLSI	SPH52105	1	4	4-0-0
Elective II	Microwave Devices and Circuits	SPH52121	1	4	4-0-0
Elective III	Microprocessor and Communication Electronics	SPH52102	1	4	4-0-0
Elective IV	Nano-electronics	SPH52120	1	4	4-0-0
Elective Lab I	Solid State Device & Microwave Lab	SPH52203	1	3	0-0-6
Elective Lab II	Microprocessor and Electronics Circuit Design Lab	SPH52202	1	3	0-0-6
	Total		4 + 2 = 6	**22**	

	Advanced Program II : (Condensed Matter Physics)				
Elective (s)	**Paper Name**	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Elective I	Many Body Theory	SPH52107	1	4	4-0-0
Elective II	Material Science	SPH52123	1	4	4-0-0
Elective III	Collective Phenomena of Solids	SPH52104	1	4	4-0-0
Elective IV	Dielectric, Optical and Transport properties of Solids	SPH52122	1	4	4-0-0
Elective Lab I	Material Science Lab	SPH52205	1	3	0-0-6
Elective Lab II	Condensed Matter Physics Lab	SPH52204	1	3	0-0-6
	Total		4 + 2 = 6	**22**	

	Advanced Program II : (Medical Electronics and Instrumentation)				
Elective (s)	**Paper Name**	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Elective I	Anatomy and Physiology	SPH52109	1	4	4-0-0
Elective II	Bio instrumentation and Medical Physics	SPH52125	1	4	4-0-0
Elective III	Biomedical Spectroscopy and Medical Imaging Technique	SPH52106	1	4	4-0-0
Elective IV	Biosensors and LASER in Medical Application	SPH52124	1	4	4-0-0
Elective Lab I	Bio instrumentation Lab	SPH52207	1	3	0-0-6
Elective Lab II	Microprocessor and Image Processing Lab	SPH52206	1	3	0-0-6
	Total		4 + 2 = 6	**22**	

	Advanced Program III : (Quantum Field Theory and Particle Physics)				
Elective (s)	**Paper Name**	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Elective I	Quantum Field Theory I	SPH52111	1	4	4-0-0
Elective II	Quantum Field Theory II	SPH52127	1	4	4-0-0
Elective III	Particle Physics I	SPH52108	1	4	4-0-0
Elective IV	Particle Physics II	SPH52126	1	4	4-0-0
Elective Lab I	Particle Physics Lab I	SPH52209	1	3	0-0-6
Elective Lab II	Particle Physics Lab II	SPH52208	1	3	0-0-6
	Total		4 + 2 = 6	**22**	

	Advanced Program II : (Plasma Physics)				
Elective (s)	**Paper Name**	**Paper Code**	**No of Papers**	**Credit**	**L-T-P**
Elective I	Plasma Physics I	SPH52113	1	4	4-0-0
Elective II	Plasma Physics II	SPH52129	1	4	4-0-0
Elective III	Plasma Physics III	SPH52110	1	4	4-0-0
Elective IV	Plasma Physics IV	SPH52128	1	4	4-0-0
Elective Lab I	Plasma Physics Lab I	SPH52211	1	3	0-0-6
Elective Lab II	Plasma Physics Lab II	SPH52210	1	3	0-0-6
	Total		4 + 2 = 6	**22**	

Detailed Syllabus for M.Sc. Physics (Post Graduate) Course

SEMESTER - I

Paper Name: Mathematical Methods

Paper Code: SPH51101

Linear Vector space, Hilbert space and matrices:
Vectors in function space, Axiomatic definition, linear independence, bases, dimensionality, inner product, Gram-Schmidt orthogonalisation, Operators, self-Adjoint and Unitary Operators, Transformation of Operators, Matrices: Representation of linear transformations and change of base, Eigenvalues and eigenvectors, Functions of a matrix; Cayley-Hamilton theorem, commuting matrices with degenerate eigenvalues, Orthonormality of eigenvectors. Hermitian matrix Diagonalization.

(8L)

Complex variables:
Recapitulation of Complex numbers, triangular inequalities, Schwarz inequality. Function of a complex variable, single and multiple-valued function, limit and continuity, Differentiation, Cauchy-Riemann equations and their applications, Analytic and harmonic function, Complex integrals, Cauchy's theorem (elementary proof only), converse of Cauchy's theorem, Cauchy's Integral Formula and its corollaries, Series: Taylor and Laurent expansion, Classification of singularities, Branch point and branch cut, Cauchy's Residue theorem and evaluation of some typical real integrals using this theorem. (10L)

Theory of Second Order Linear Homogeneous Differential Equations:
Brief introduction to 1st order ODEs and 2nd order Linear ODEs, Singular points, Regular and Irregular singular points, Frobenius method, Fuch's theorem, Linear independence of solutions, Wronskian, second solution. Sturm-Liouville theory, Hermitian Operator, Completeness.

(7L)

Special functions:
Bessel functions of 1st Kind, Orthogonality, Bessel function of 2nd kind, Generating functions, Spherical Bessel Functions, Legendre polynomials, Orthogonality, Physical interpretation of Generating functions, Associated Legendre's Equation, Spherical Harmonics, Hermite functions, Laguerre Functions. Chebyshev Polynomials.

(12L)

Inhomogeneous differential equations : Green's functions and its applications.

(4L)

Integral transforms:
Fourier and Laplace transforms and their inverse transforms, Bromwich integral [use of partial fractions in calculating inverse Laplace transforms], Discrete Fourier Transform, Transform of derivative and integral of a function, Solution of differential equations using integral transforms.

(7L)

Group theory:
Definitions, Multiplication table, Rearrangement theorem; Isomorphism and homomorphism; Illustrations with point symmetry groups, Group representations: faithful and unfaithful representations, reducible and irreducible representations, Lie groups and Lie algebra with SU(2) as an example. (7L)

List of Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, Mc. Graw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical Methods in Physical Sciences, Mary L. Boas, Wiley
6. Mathematical Methods for Physics and Engineering, K. F. Riley, M. P. Hobson, S. J. Bence, Cambridge University Press
7. Mathematical Physics, H K Dass, S Chand Publisher
8. Theory and problems Complex variables, Schaum's outline series M. R. Spiegel.
9. Complex Variables and Applications by, Brown and Churchill.
10. Matrices and Tensor in Physics, by A. W. Joshi
11. Elements of group theory for physicists, by A. W. Joshi
12. Group Theory (Dover Books on Mathematics) by, W. R. Scott

Paper Name: Classical Mechanics
Paper Code: SPH51103

Variational Principle and Lagrange's Equations

Introduction to Hamilton's Principle, Few applications of the technique of Calculus of Variations, Derivation of Lagrange's Equation from Hamilton's principle, Applications of Lagrange's Equations, Advantages of Variational principle formulation, Conservation theorem and symmetry properties.

(8L)

The Hamilton Equations of motion

Legendre Transformations and the Hamilton Equations of motion, Cyclic co-ordinates and Conservation Theorems, Applications of Hamiltonian formulation, Derivation of Hamilton's equations from Variational principle, The Principle of Least Action. (6L)

Canonical Transformations

The equations of canonical transformation, Examples of Canonical transformations, The Harmonic Oscillator, Poisson bracket and other Canonical Invariants, Equations of Motion, Infinitesimal Canonical Transformation and Conservation Theorems, Symmetry Groups. (8L)

Hamilton-Jacobi Theory Action-Angle Variables

Hamilton-Jacobi Equations, Harmonic Oscillator problems, Action-Angle variables in 1D systems.

(6)

Small Oscillations

Formulation of the problem, Eigen Value Equations, Principle Axis and Normal Co-ordinates, Free Vibrations of a linear tri-atomic molecule, Forced vibrations and Dissipative forces.

(4)

Rigid Body Motion:

Degrees of freedom, Orthogonal Transformations and properties of transformation matrices, Euler angles, Euler's Theorems on the motion of a rigid body, Finite and infinitesimal rotations, Rotating co-ordinate system, Coriolis force, Angular Momentum and Kinetic Energy of motion, Moment of Inertia tensor, Principal axis of transformation, solution of rigid body problem using Euler equation of motion, torque free motion of a rigid body, heavy symmetrical top, precession and nutation.

(10L)

Classical mechanics of Special Theory of Relativity:

Basic postulates, Lorentz transformation, velocity addition, four-vectors, metric tensors, Relativistic Kinematics of Collisions and Many Particle Systems, Relativistic Angular Momentum, Lagrangian Formulation of Relativistic Mechanics, Co-variant Lagrangian formulation.

Relativistic Electrodynamics: Equation of motion in an electromagnetic field, Electromagnetic field tensor, covariance of Maxwell's equations, Maxwell's equations as equations of motion, Lorentz transformation law for the electromagnetic fields and the fields due to a point charge in uniform motion; Field invariants, Covariance of Lorentz force equation and the equation of motion of a charged particle in an electromagnetic field.

(10L)

Introduction to Lagrangian and Hamiltonian Formulations for continuous systems and fields:

Transition from a discrete to a continuous system, Lagrangian formulation for continuous systems, Hamiltonian formulation, Relativistic Field theory and examples, Noether's Theorem.

(6L)

List of Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Introduction to Classical Mechanics, David Morin, Cambridge University Press.
3. Classical Mechanics, H. Goldstein, C.P. Poole, J.L. Safko, 3rdEdn. 2002, Pearson Education.
4. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
5. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.
6. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.
7. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
8. K.C. Gupta: Classical Mechanics of Particles and Rigid Bodies
9. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press.

Paper Name: Quantum Mechanics I

Paper Name: SPH51105

Recapitulation of Basic Concepts:

Wave Packets; Different forms of wave packets (e.g., Gaussian, Square wave etc.), Wave packets and Uncertainty relations, Motion of wave packets, Parserval's theorem.

(6L)

Mathematical Formulation of Quantum Mechanics:

Idea of Hilbert space and Wave functions, Operators, introduction to bra-ket formulation, Representation of operators in discrete bases (Matrix representation), unitary transformations, Representation in continuous bases (Position and Momentum representation), Parity operator, Matrix mechanics and Wave mechanics.

(10L)

Postulates of Quantum Mechanics:

Basic postulates, Observables and Operators, Measurements in Quantum Mechanics, Time evolution of a quantum mechanical system, Schrödinger, Heisenberg and interaction picture, Symmetries and conservation laws, Relation between Classical and Quantum Mechanics.

(10L)

One Dimensional Problems:

Review of potential well problems, δ function potential well and barriers, double δ potential, Application to molecular inversion; Multiple well potential, Kronig-Penney model. One dimensional harmonic oscillator by Operator Method.

(8L)

Three Dimensional Problems:
3-D problems in Cartesian co-ordinate; free particle, Box potential, Delta function potential, Harmonic Oscillator, 3-D problems in Spherical polar co-ordinate; free particle, square well potential, isotropic harmonic oscillator, Hydrogen atom.

(6L)

Angular Momentum:

Stern-Gerlach experiment for spin $\frac{1}{2}$ particle, Orbital angular momentum, Spin angular momentum, Spin $\frac{1}{2}$ and spin 1 particles, Pauli matrices, Eigenvalues and Eigen functions of $\hat{L}^2$ and $\hat{L}_z$ operator, Spherical harmonics. Addition of angular momenta, Clebsch-Gordan co-efficient.

(12L)

List of Books:

1. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
2. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed.,
3. 2010, McGraw Hill.
4. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
5. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
6. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
7. J.J. Sakurai : Modern Quantum Mechanics
8. S. Gasiorowicz : Quantum Physics.
9. Quantum Mechanics: Theory and ApplicationsAuthor: A. *Ghatak*, S. *Lokanathan* Published by Springer Netherlands.

Paper Name: Electronics
Paper Name: SPH51107

Passive Networks: Four-terminal two-port network, parameters for symmetrical and non-symmetrical networks, image, iterative and characteristic impedances, propagation function; lattice network. Bisection theorem and its application.

(4L)

Active Circuits: Transistor amplifiers; Basic design consideration; Class A power amplifier, Coupled Class A power amplifier, Coupled Amplifier, Push-pull amplifier, Class B and Class C tuned power amplifier. High frequency effects, resonance amplifier, feedback and distortion in amplifiers.

(4L)

Physical Mechanisms: Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Band consideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Hole concentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation, Carrier mobility in semiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors(Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/ generationin semiconductors, Shockley Read theory of recombination, Switching in Electronic Devices.

(8L)

Semiconductor Devices: Metal/Semiconductor Junction or (Abrupt P-N Junction), Current-voltage characteristics, C-V Measurements, Estimation of Barrier Height and carrier concentration from C-V characteristics, Surface/Interface States, Role of interface States in Junction Diodes. Field Effect devices, C-V characteristic of MIS diodes (Frequency dependence), Estimation of Interface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices), MESFET, MOSFET.

(6L)

Special Device: Tunnel diode: I-V characteristics, negative voltage region. Uni-junction transistor (UJT), Application as a relaxation oscillator. Silicon Controlled rectifier (SCR, Thyristor) characteristics and applications. Photonic Devices: LED and LASER, Photo detectors, Solar-cells. ATT device, Power diodes. Power transistors. GTOs and IGBTs. Display devices, Operation of LCDs, LED, HDTV, Plasma displays.

(6L)

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors (AD590, LM35, LM75) and signal conditioning. Linear Position transducer: Strain gauge, Piezoelectric. Inductance change transducer: Linear variable differential transformer (LVDT), Capacitance change transducers. Radiation Sensors: Principle of Gas filled detector, ionization chamber, scintillation detector.

(6L)

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization). (4L)

Analog circuits: Comparators, Multivibrators, Waveform generators: Square wave, triangle wave and pulse generators.

(2L)

Digital MOS circuits: NMOS and CMOS gates (AND, NAND and NOT), Dynamic MOS circuits, ratio inverter, two phase inverter; dynamic MOS shift register, static MOS shift registers, four phase shift registers. Memory Devices; Static and dynamic random access memories (SRAM and DRAM)

(2L)

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder / Subtractor. Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered), Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. Timers: IC 555: block diagram and applications: Astable multivibrators and Monostable multivibrator.

(4L)

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

(2L)

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

(2L)

Intel 8085 and 8086 Microprocessor Architecture: Main features of 8085 and 8086. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing

& Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. (2L)

Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions. (2L)

List of Books:

1. J.D. Ryder: Network, Lines and Fields
2. J. Millman and C. Halkias: Integrated Electronics
3. J.D. Ryder: Electronic Fundamental and Applications
4. J. Kennedy: Electronic Communication Systems
5. J. Millman and A. Grabel: Microelectronics
6. B.G. Streetman, S. Banerjee: Solid State Electronic Devices
7. Sedra and Smith: Microelectronic Devices
8. Taub and Schilling: Digital Integrated Electronics
9. P. Bhattacharyya: Semiconductor Optoelectronic Devices
10. S.M. Sze: Physics of Semiconductor Devices
11. Boylestad and Nashelski: Electronic Devices and Circuit Theory

Paper Name: Physics Lab I
Paper Name: SPH51201

List of Experiments:

1. Determine Plank's Constant using photo-cell with filters for different light wave length (λ). Also verify the inverse square law.

2. Determine the electron charge by Millikan's Oil drop method and hence determine the terminal velocity of the oil drop.

3. Determination of e/m of electrons by magnetic focusing method.
4. Determine energy band gap of Ge crystal by Four Probe Method.

5. Determination of Hall coefficient of n-type semiconductor material.

6. Determination of Hall coefficient of p-type semiconductor material.

Paper Name: Physics Lab II
Paper Name: SPH51203

List of Experiments:

A. Experiments using LASER

1. Determination of refractive index of a glass plate using Laser source based on Michelson interferometry technique.

2. To observe the diffraction pattern and calculate the slit width using Laser light.

3. Study of response characteristic of a solar-cell using Laser light.

4. Study of V-I characteristic of a LDR. Also study the response characteristic of a LDR.

5. Study of V-I characteristic and response characteristic of a phototransistor.
6. To study the response characteristic of a photodiode.
7. To study response characteristic of an opto-coupler.
8. To study polarization properties of light and verify the Malu's Law using Laser source.

B. Experiments using Optical Fibre

9. Determination of numerical aperture of an Optical fiber
10. Study the bending loss in an optical fiber.

SEMESTER – II

Paper Name: Classical Electrodynamics

Paper Name: SPH51102

Electrostatics and Magnetostatics:
Scalar and vector potentials; Gauge transformations; Multipole expansion of (i) scalar potential and energy due to a static charge distribution (ii) vector potential due to a stationary current distribution. Calculations of dipole and Quadrupole moment tensor due to different charge distributions. Electrostatic and magnetostatic energy. Poynting's theorem. Maxwell's stress tensor (both in presence and absence of di-electrics), electromagnetic momentum, Radiation pressure.

(12L)

Maxwell's Equations in stationary and moving media.
Quantitative discussion.

(6L)

Fields due to time dependent charge and current distributions:
Solution of inhomogeneous wave equations without green's function, Jefimenko's equations. Near field and far-field approximation, Larmor's formula.

(12L)

Radiation from moving point charges:
Lienard-Wiechert potentials, Fields due to a charge moving with uniform velocity, Fields due to an accelerated charge, Radiation at low velocity, Larmor's formula and its relativistic generalisation, Radiation when velocity (relativistic) and acceleration are parallel, Bremsstrahlung, Radiation when velocity and acceleration are perpendicular, Synchrotron radiation, Cherenkov radiation (qualitative treatment only). Thomson and Compton scattering.

(12L)

Radiation Reaction:
Radiation reaction from energy conservation, Problem with Abraham-Lorentz formula, Limitations of Classical Electrodynamics.

(8L)

Relativistic Electrodynamics:
Lorentz transformation of fields, Lorentz invariants, Symmetric and anti-symmetric field tensor, $F_{\mu\nu}$ and $G_{\mu\nu}$.

(6L)

List of Books:

1. J.D. Jackson: Classical Electrodynamics
2. W.K.H. Panofsky and M. Phillips: Classical Electricity and Magnetism
3. J. R. Reitz, F.J. Milford and R.W. Christy: Foundations of Electromagnetic theory
4. D.J. Griffiths: Introduction to Electrodynamics
5. Classical Electromagnetic Radiation, Mark A. Heald and J. B. Marion, Dover Books on Physics
6. Modern Problems in Classical Electrodynamics, C. A. Brau
7. Classical Electrodynamics, Walter Greiner and D. A. Bromley

Paper Name: Quantum Mechanics II

Paper Name: SPH51104

Approximation methods in quantum mechanics:
Time independent perturbation theory (both non-degenerate and degenerate), First and Second order correction in energy Eigenvalues, and first order corrections in energy Eigen functions. Degenerate perturbation theory, application to one-electron system, Relativistic mass correction, Spin-orbit coupling (L-S and J-J coupling), Zeeman effect, Stark effect. The Variational method, WKB approximation: General formalism, Bound states for potential wells with No rigid walls/ with One rigid wall/ with Two rigid walls.

(15L)

Time dependent perturbation theory:
The pictures of Quantum Mechanics, Schrodinger picture, Heisenberg's picture and Interaction picture. Theoretical framework of time-dependent perturbation theory, Transition probability for a Constant perturbation and Harmonic perturbation, Fermi Golden rule, Adiabatic and Sudden approximations.

(8L)

Scattering Theory: Scattering cross-section, lab frame and CM frame, Scattering amplitude and differential cross section, Green's function technique in scattering phenomena, Born approximation, Validity of Born Approximation, Partial Wave analysis for elastic scattering, scattering of identical particles.

(12L)

Symmetries in quantum mechanics:
Conservation laws and degeneracy associated with symmetries; Continuous symmetries, space and time translations, rotations; Rotation group, homomorphism between SO(3) and SU(2); Explicit matrix representation of generators for; Rotation matrices; Irreducible spherical tensor operators, Wigner-Eckart theorem; Discrete symmetries, parity and time reversal.

(8L)

Identical Particles:
Meaning of identity and consequences; Symmetric and anti-symmetric wave functions; Slater determinant; Symmetric and anti-symmetric spin wave functions of two identical particles.

(6L)

Relativistic Quantum Mechanics:
Klein-Gordan Equation, Dirac Equation, Gamma Matrices, Helicity, Failure of relativistic quantum mechanics

List of Books:

1. L.I. Schiff: Quantum Mechanics
2. Quantum Mechanics, Nouredine Zettili, John Wiley and Sons Ltd.
3. Quantum Mechanics, David J. Griffiths
4. J.J. Sakurai: Advanced Quantum Mechanics
5. C. Cohen-Tannoudji, B. Dier, and F. Laloe: Quantum Mechanics vol. 1 and 2
6. E. Merzbacher: Quantum Mechanics
7. Messiah: Quantum Mechanics, Vol. II
8. Quantum Mechanics, Bransden and Joachain, Pearson Education.
9. J.D. Bjorken and S.D. Drell: Relativistic Quantum Mechanics
10. F. Halzen and A.D. Martin: Quarks and Leptons
11. W. Greiner: Relativistic Quantum Mechanics
12. A. Lahiri and P.B. Pal: A First Book of Quantum Field Theory

Paper Name: Statistical Mechanics

Paper Name: SPH51106

Introduction:
Objective of statistical mechanics. Macrostates and microstates, phase space and statistical ensembles. Ergodic hypothesis, postulate of equal a priori probability (PEAP) and equality of ensemble average and time average. Boltzmann's postulate of entropy. Counting the number of microstates in phase space. Liouville's Theorem.

(6L)

Micro-canonical Ensemble:
Description, Probability distribution function, Different properties, Thermal and Mechanical interaction, Equation of state, Entropy of a classical ideal gas, Gibb's paradox, spin-$\frac{1}{2}$ particles in an external magnetic field.

(8L)

Canonical Ensemble: System in contact with a heat reservoir, expression of entropy, canonical partition function, Equation of State, Average energy, Magnetization of spin-$\frac{1}{2}$ particles in an external magnetic field. Helmholtz free energy, fluctuation of internal energy.

(8L)

Grand Canonical Ensemble:
System in contact with a particle reservoir, Chemical potential, Grand canonical partition function, fluctuation of particle number. Chemical potential of ideal gas.

(6L)

Quantum statistical mechanics:
Density Matrix, Quantum Liouville's theorem, Density matrices for micro canonical, canonical and grand canonical systems, Simple examples of density matrices, one electron in a magnetic field, particle in a box, Identical particles, B-E and F-D distributions.

(8L)

Ideal Bose Systems:
Thermodynamic behaviour of an ideal Bose Gas, Equation of state, Bose-Einstein Condensation.

(8L)

Ideal Fermi Systems:
Equation of state of ideal Fermi gas; Fermi gas at finite T.

(4L)

Special topics:
Saha Ionization formula, Ising model: partition function for one dimensional case; Chemical equilibrium and Saha ionisation formula. Phase transitions: first order and continuous, critical exponents and scaling relations. Calculation of exponents from Mean Field Theory and Landau's theory, upper critical dimension.

(8L)

List of Books:

1. F. Reif: Fundamentals of Statistical and Thermal Physics, McGraw-Hill.
2. R.K. Pathria: Statistical Mechanics, Elsevier
3. K. Huang: Statistical Mechanics, Wiley Student edition
4. F. Mandl: Statistical Physics
5. Statistical Mechanics, F. Schwabl, Springer international edition.
6. Statistical Mechanics, R. Feynman

Paper Name: Atomic and Molecular Spectroscopy

Paper Name: SPH51108

Atomic Spectroscopy:

Review of one electron atom, Dirac equation, Dirac equation in non-relativistic limit i.e., Paoli equation, Fine structure of Hydrogen atom (relativistic correction, coupling due to Spin-Orbit coupling, Derwin term), Lamb shift, Hyperfine structure and isotope shifts.

(12L)

Interaction of atoms with electromagnetic radiation, Classical treatment of the incident radiation, Quantization of the electro-magnetic field, transition rates for emission and absorption of radiation, dipole approximation, Einstein coefficients, selection rules, Spontaneous Emission.

(8L)

Interaction with external electric and magnetic field: Stark effect, Zeeman effect (weak field and strong field limits).

(6L)

Two electron atoms: Schrodinger equations, para and ortho states, Pauli's exclusion principle, ground state and excited state

(3L)

Many electron atoms: Central field approximation, Thomas- Fermi model, Hartree-Fock method, Exchange degeneracy, Symmetrization postulate, Constructing symmetric and anti-symmetric functions, Pauli's Exclusion principle, L-S & J-J coupling, Hund's Rule.

(5L)

General Concept:

General nature of molecular structure, Born-Oppenheimer approximation for diatomic molecule, Electronic structure, Approximation methods for construction of wave functions, LCAO approach, symmetries and shapes of electronic orbital.

(6L)

Microwave spectroscopy: rotation of molecules, rotational spectra for diatomic and polyatomic molecules.

(6L)

Infrared spectroscopy: vibration of diatomic molecule, rotational-vibrational spectra, vibration of polyatomic molecules.

(4L)

Raman spectroscopy: rotational and vibrational Raman spectra, polarization of light and Raman effect, structure determination.

(4L)

Spin resonance spectroscopy : NMR spectroscopy for hydrogen and other nuclei, ESR spectroscopy.

(4L)

Mossbauer spectroscopy: principle and applications.

(2L)

List of Books:

1. B.H. Bransden and C.J. Joachain: Physics of Atoms and Molecules
2. R. Shankar: Principles of Quantum Mechanics
3. C.B. Banwell: Fundamentals of Molecular Spectroscopy
4. G.M. Barrow: Molecular Spectroscopy
5. K. Thyagarajan and A.K. Ghatak: Lasers, Theory and Applications

6. B.H. Eyring, J. Walter and G.E. Kimball: Quantum Chemistry
7. H. Herzberg: Spectra of Diatomic Molecules
8. B.B. Laud: Lasers and Non-linear Optics

Paper Name: Physics Lab III

Paper Name: SPH51202

1. Study of photo-conductivity of a semiconductor material.
2. Study of Current Voltage characteristic of a CdS, a photo resistor as a function of Intensity, by using a monochromator.
3. To determine temperature dependence of Hall coefficient of n-type and p-type semiconductor material.
4. To determine the Magneto-resistance of n-type and p-type semiconductor material.
5. Determination of magnetic parameters of a Ferromagnetic substance by using Hysteresis Loop Tracer.

Paper Name: Physics Lab IV

Paper Name: SPH51204

1. Study of Filters: (a) Active Filter (b) Passive Filter (c) T section filter (d) π section filter.
2. Study of Amplitude and Frequency modulation and demodulation.
3. Study of Dynamic characteristics of a JFET and hence determine the FET parameters.
4. Studies on Characteristics of SCR (Silicon controlled Rectifier).
5. Studies on different types of characteristics of DIAC and TRIAC.
6. To design an astable multivibrator of given specifications using 555 Timer.
7. To design a monostable multivibrator of given specifications using 555 Timer.
8. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
9. To build JK Master-slave flip-flop using Flip-Flop ICs
10. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
11. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.

Paper Name: Numerical Modelling for Physicists and Engineers

Paper Name: SPH51206

A brief review on any language C/ Python.

Numerical solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods, Solution of linear and quadratic equation, solving diffraction equation $\alpha = \tan\alpha$, $I = I_0\left(\frac{\sin\alpha}{\alpha}\right)^2$ in optics.

Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation. Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method.

Finding zeros of a real valued function using Newton-Raphson method.

Scilab/Matlab/Mathematica :

Solution of Linear system of equations by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems, Solution of mesh equations of electric circuits (3 meshes), Solution of coupled spring mass systems (3 masses).

Solution of ODE:

First order differential equation, Euler, Modified Euler and Runge-Kutta second order method. Solve equations for radioactive decay, Newton's law of cooling , classical equations of motion etc.

Second order differential equation, Harmonic oscillator (no friction), Fixed difference method, Damped Harmonic oscillator, Over damped, Critical damped, Oscillatory, Forced Harmonic oscillator, Transient and Steady state solution.

To solve some problems on differential equations like :

1. Solve the coupled first order differential equations

for different initial conditions [e.g., x(0) = 0, y(0) = -1, -2, -3, -4]. Plot x vs. y for each of the four initial conditions on the same screen for $0 \leq t \leq 15$.

2. The ordinary differential equation describing the motion of a pendulum is

$\theta'' = -\sin(\theta)$

The pendulum is released from rest at an angular displacement α i.e. $\theta(0) = \alpha$, $\theta'(0) = 0$. Use the RK4 method to solve the equation for $\alpha = 0.1$, 0.5 and 1.0 and plot θ as a function of time in the range $0 \leq t \leq 8\pi$. Also, plot the analytic solution valid in the small θ ($\sin\theta \approx \theta$).

3. Solve the differential equation:

with the boundary conditions: at $x = 1$, $y = (1/2)\,e^2$, $dy/dx = -(3/2)\,e^2 - 0.5$, in the range $1 \leq x \leq 3$. Plot y and dy/dx against x in the given range. Both should appear on the same graph.

List of Books:

1. V. Rajaraman: Computer Programming in Fortran
2. V. Rajaraman: Computer Oriented Numerical Methods

SEMESTER - III

Paper Name: Solid State Physics

Paper Name: SPH52101

Binding of Solids: Van der Waal binding, Ionic Binding, Covalent Bonding, Metallic bonding.

(4L)

Crystalline State: Two-Dimensional lattice systems, Three dimensional lattice systems, Lattice planes and Miller indices, X ray diffraction, Laue method, Rotating Crystal method, Debye Scherrer method, Structure factor and atomic form factor.

Frenkel and Schottky defects, defects in growth of crystals, The role of dislocations in plastic deformation and crystal growth, Colour centres and photoconductivity, Luminescence and phosphors, Alloys- order-disorder phenomena, Bragg-Williams theory, Extra specific heat in alloys.

(12L)

Electronic states in Solids: Drude Model, Drawbacks of Drude model, Sommerfeld's Correction, Periodic lattice potential, Bloch model of an electron, Weak periodic potential, Repeated Zone Scheme, Reduced Zone Scheme, Velocity of Bloch electron, Effective mass, Crystal momentum, Fermi Surface, Tight binding approximation.

(14L)

Transport properties of Metals: Boltzmann Transport Equation, Electrical conductivity, Relaxation time approximation, Impurity Resistivity, Friedel Sum rule, Thermal Conductivity, Thermoelectricity, Seebeck and Peltier Effect. Hall Effect.

(10L)

Basic introduction to Magnetism and Superconductivity: Origin of magnetism; Quantum theory of atomic diamagnetism, Landau diamagnetism (qualitative discussion), Quantum theory of paramagnetism, case of rare-earth and iron-group ions, quenching of orbital angular momentum, Van-Vleck paramagnetism and Pauli paramagnetism, Ferromagnetism: Curie-Weiss law, temperature dependence of saturated magnetisation, Heisenberg's exchange interaction, ferromagnetic domains; Ferrimagnetism and anti-ferromagnetism.

Phenomenological description of superconductivity, perfect diamagnet, Effect of Magnetic field on Superconductivity, Meissner effect; Type-I and type-II superconductors, Specific heat, energy gap and isotope effect, Flux quantisation; a.c. and d.c. Josephson effect.

(16L)

List of Books:

1. C. Kittel: Introduction to Solid State Physics
2. N.W. Ashcroft and N.D. Mermin: Solid State Physics
3. J.R. Christman: Fundamentals of Solid State Physics
4. A. J. Dekker: Solid State Physics
5. H.Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiment
6. J.P.Srivastava: Elements of Solid State Physics

Paper Name: Nuclear Physics

Paper Name: SPH52103

Nuclear Properties: Basic nuclear properties: nuclear size, Rutherford scattering, nuclear radius and charge distribution, nuclear form factor, mass and binding energy, Angular momentum, parity and symmetry, Magnetic dipole moment and electric Quadrupole moment, experimental determination, Rabi's method.

(8L)

Two-body bound state: Properties of deuteron, Schrödinger equation and its solution for ground state of deuteron, r.m.s. radius, spin dependence of nuclear forces, electromagnetic moment and magnetic dipole moment of deuteron and the necessity of tensor forces.

(4L)

Two-body scattering: Experimental n-p scattering data, Partial wave analysis and phase shifts, scattering length, magnitude of scattering length and strength of scattering, Significance of the sign of scattering length; Scattering from molecular hydrogen and determination of singlet and triplet scattering lengths, effective range theory, low energy p-p scattering, Nature of nuclear forces: charge independence, charge symmetry and isospin invariance of nuclear forces.

(8L)

β-decay: emission and electron capture, Fermi's theory of allowed decay, Selection rules for Fermi and Gamow-Teller transitions, Parity non-conservation and Wu's experiment.

(6L)

Nuclear Structure: Liquid drop model, Bethe-Weizsäcker binding energy/mass formula, Fermi model, Shell model and Collective model.

(8L)

Nuclear Reactions and Fission: Different types of reactions, Quantum mechanical theory, Resonance scattering and reactions, Breit-Wigner dispersion relation; Compound nucleus formation and break-up, Statistical theory of nuclear reactions and evaporation probability, Optical model; Principle of detailed balance, Transfer reactions, Nuclear fission: Experimental features, spontaneous fission, liquid drop model, barrier penetration, statistical model, Super-heavy nuclei.

(12L)

List of Books:

1. M.K. Pal: Theory of Nuclear Structure
2. R.R. Roy and B.P. Nigam: Nuclear Physics
3. S.N. Ghoshal: Atomic and Nuclear Physics (Vol. 2)
4. D.H. Perkins: Introduction to High Energy Physics
5. D.J. Griffiths: Introduction to Elementary Particles
6. W.E. Burcham and M. Jobes: Nuclear and particle Physics

Paper Name: Advanced Elective I (Many Body Theory)

Paper Name: SPH52107

Fundamentals of many-electron system

Hartree-Fock theory, The basic Hamiltonian in a solid, electronic and ionic parts, the adiabatic approximation; Single-particle approximation of the many-electron system, single product and determinantal wave functions, matrix elements of one and two-particle operators; The Hartree-Fock (H-F) theory: the H-F equation, exchange interaction and exchange hole, Koopman's theorem; The occupation number representation: the many electron Hamiltonian in occupation number representation; the H-F ground state energy.

(15L)

The interacting free-electron gas

The H-F approximation of the free electron gas: exchange hole, single-particle energy levels, the ground state energy; Perturbation, theoretical calculation of the ground state energy; Correlation energy, difficulty with the second-order perturbation theoretic calculation, Wigner's result at high density,

low-density limit and Wigner interpolation formula; Cohesive energy in metals; Screening and Plasmons; Experimental observation of plasmons.

(15L)

Higher Order Time dependent perturbation Theory:

Polarons, Shift of bands with temperature, Line broadening, Rayleigh-Schrödinger Diagram Rules, Feynman perturbation theory, Diagram rules for Feynman perturbation theory, Self-energy, Physical meaning of the Green's function.

(15L)

List of Books:

1. S. Raimes: Many Electron Theory
2. Many Body Theory in Condensed Matter Physics, Henric Bruus and Karsten Flensberg
3. A Guide to Feynman Diagrams in the Many-body Problem, R. D. Mattuk
4. The Green Function Method in Statistical Mechanics, V. L. Bonch-Bruevich
5. Many Particle Physics, Gerald D. Mahan, Springer US.

Paper Name: Advanced Elective I (Anatomy and Physiology)
Paper Name: SPH52109

Cell: Introduction to cell and its detailed structure.

Blood: Characteristics of blood, physiology of blood clotting. (2L)

Heart (Circulatory System): Anatomy of heart and blood vessels, origin and conduction of heart beat, cardiac cycle, electrocardiogram, blood pressure, control of cardiac cycle. (6L)

Respiratory System: Anatomy of respiratory system, physiology of respiration in the alveolar and tissue capillaries, control of respiration. (6L)

Digestive system: Anatomy of digestive system, nerve and blood supply, physiology of digestion. (3L)

Kidney and Urinary system: Anatomy of urinary system and kidney, physiology of water and electrolyte balance, acid-base regulation. (4L)

Muscle Tissues: Anatomy, types of muscles, physiology of muscle contraction, generation of action potential, rhythmicity of cardiac muscle contraction, properties of skeletal and Cardiac muscles. (6L)

Nervous system: Neuron, anatomy and function of different parts of brain, spinal cord, autonomic nervous system, special sense organs for taste, smell, sight and hearing. Biological control concept and feedback mechanism. (7L)

Skeletal system: Structure and properties of bone, skeletal joints, mechanics of the elbow, mechanics of shoulder, mechanics of spinal column, mechanics of hip, mechanics of knee, mechanics of ankle. (6L)

List of Books:

1. Human Anatomy and Physiology, Ross and Wilson
2. Anatomy and Physiology, Kenneth and Salad

Paper Name: Advanced Elective II (Material Science)
Paper Name: SPH52123

Crystal Symmetry:

Concepts of point group, Point groups and Bravais lattices; Crystal symmetry space groups, Symmetry and degeneracy, crystal field splitting; Kramer's degeneracy, Quasicrystals: general idea,

approximate translational and rotational symmetry of two-dimensional Penrose tiling, Frank-Casper phase in metallic glass.

(15L)

Overview of materials:

Atomic structure & bonding in solids, Crystalline solids: (metals/insulator/semiconductor). Idea of closed packed structure, lattice constant/cell volume, Imperfection in solids, linear defects, slip & plastic deformation, Planar defects, Volume defects, Formation of colour centres by irradiating a single crystalline materials, Strengthening mechanisms, Diffusion, Thermodynamics of point defects. Amorphous materials: Glasses and their application, Oxide and nitride semiconductors, solar energy materials, luminescent and optoelectronic materials, Structure & properties of ceramics & polymers Corrosion & degradation of materials, Classification according to bonding Pauling and Philips theories.

(12L)

Synthesis and preparation of materials:

Single crystal growth, zone refining, doping techniques in elemental and compound semiconductors, Fabrication process of thin films: thermal evaporation, PLD, CVD and MBE techniques, Smart materials: ferroelectric/piezoelectric/multi-ferroic materials, photoconductivity and superconductivity, Polymer: synthesis, properties and applications, Ceramics: processing, by mechanical and chemical methods. Nano-materials: synthesis, properties and applications, Biomaterials, Alloys: Study of Half and Full Heusler alloys, Half metallic magnetism, shape memory alloys etc.

(15L)

Characterization of materials:

Diffraction techniques: X-ray diffraction, structure determination from XRD data; Neutron diffraction technique for determination of magnetic structure of materials, Thermal methods: DTA, TGA, DSC, Study of microstructure (shape/size): TEM, SEM AFM technique, Optical spectroscopy: UV and IR; Nuclear techniques: NMR, ESR, Mossbauer and Characterization of defects by Positron annihilation lifetime spectroscopic technique. Some special experimental techniques for characterization of materials, Quantum size effect and its applications.

(15L)

List of Books:

1. C. Kittel: Introduction to Solid State Physics
2. R. Zallen: The Physics of Amorphous Solids.
3. N.F. Mott and E.A. Davies: Electronic Processes in Non-crystalline Materials
4. C.N.R. Rao and B. Raveau: Colossal Magnetoresistance, Charge Density and Related Properties of Manganese oxides
5. Quantum Theory of Solids, C. Kittel

Paper Name: Advanced Elective II (Bio instrumentation and Medical Physics)

Paper Name: SPH52125

Evoked potential : Stimulations - Recording - Amplifiers - Analysis and storage : Measurement of average auditory evoked potential - application - visual evoked potential measurement and application -Brain mappers - magneto encephalogram - principles and measurements. (5L)

Principles of electromyography detection & application - Myoelectric control Introduction - Voluntary control of myoelectric signals - properties - myoelectric signals - use of myoelectric signal for control - signal processing and recording. (6L)

Impedance Techniques : Bipolar and tetrapolar circuits , detection of physiological activities using impedance techniques - cardiac output , neural activity , respiratory activity, impedance plethysmography- resistance and capacitance type. (6L)

Bioelectric Signals and Electrodes : Sources of biomedical signals, basic medical instrumentation system, PC based medical instruments, General constraints in design of medical instrumentation systems, origin of bioelectric signals, Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Electrooculogram (EOG), Electroretinogram (ERG), Recording Electrodes – Electrode-tissue interface, polarization, skin contact impedance, motion artifacts, Silver-Silver Chloride electrodes, Electrodes for ECG, Electrodes for EEG, Electrodes of EMG, Electrical conductivity of electrode jellies and creams, microelectrodes.

(10L)

Biomedical Recording Systems & Recorders : Electrocardiograph-block diagram, ECG leads, effects of artifacts, multi-channel, ECG machine, Vector cardiograph, Phonocardiograph-origin of heart sounds, microphones and amplifiers for PCG, Electroencephalograph- block diagram, computerized analysis of EEG, Electromyograph, biofeedback instrumentation. (8L)

Oximeters, Blood Flow & Cardiac Output Measurement : Oximetry- In-vitro & in-vivo, ear oximetry, pulse oximetry, skin reflectance oximeters, intravascular oximeter. Electromagnetic blood flowmeter- principle, square wave electromagnetic flowmeter, Doppler shift ultrasonic flowmeter, flow measurement by Doppler imaging, NMR & Laser Doppler flowmeter, Cardiac output measurement- Indicator & dye dilution technique, impedance method, ultrasound method. (8L)

Respiratory Diagnostic & Therapeutic Instruments : Pulmonary function measurement measurements-respiratory volumes & capacities, compliance & related pressures, dynamic respiratory parameters, basic spirometer, ultrasonic spirometer, pneumotacometer- Fleish& turbine type, measurement of volume-flow volume curve, nitrogen washout technique. (7L)

Pacemakers & Defibrillator: Need for cardiac pacemaker, external pacemaker, implantable pacemakers-types, ventricular synchronous demand pacemaker, programmable pacemaker, power sources for implantable pacemakers. Need for defibrillator, DC defibrillator, automatic external defibrillator, implantable defibrillators. (8L)

Advanced Diagnostic & Therapeutic Instruments : Principle of surgical diathermy & surgical diathermy machine, Electrodiagnosis-Electrotherapy-functional block diagram and working, interferential current therapy. Artificial kidney-Principle and haemodialysis machine. Lithotriptors-

principle, modern lithotriptor-block diagram and working. Anesthesia-Need for anesthesia, delivery of anesthesia, anesthesia machine. Infusion pumps-principle and programmable volumetric infusion pump. Principle of endoscopy and laparoscopy. (10L)

List of Books:

1. Hand Book Of Biomedical Instrumentation, Khandpur
2. Fundamentals of Bio-medical engineering, G. S. Sawhney.

Paper Name: Physics Lab V

Paper Name: SPH52201

1. Determination of Lande-g factor by Electron Spin Resonance Spectroscopy.
2. Determination of Lande-g factor by Nuclear Magnetic Resonance Spectroscopy.
3. Study of Vibrational Coarse Structure of I_2 molecule.
4. Determination of wavelength of a monochromatic source by using Michelson's Interferometer.

Paper Name: Advanced Elective Lab I (Material Science Lab)

Paper Name: SPH52205

1. Synthesis of metal thin film on a glass substrate by using thermal evaporation technique And structural characterization of it.
2. I-V characterization of Solar Cell.
3. Measurements of dielectric constant of $BaTiO_3$

Paper Name: Advanced Elective Lab I (Bio-instrumentation Lab)

Paper Name: SPH52205

1. Experiments and calibration with EEG machine
2. Experiments and calibration with ECG machine
3. Experiments with Pulse-oximeter machine
4. Experiments with Audiometer.
5. Sensor and Transducer Lab

SEMESTER - IV

Paper Name: Advanced Elective III (Collective Phenomena of Solids)

Paper Name: SPH52104

Spin and Magnetic Systems:

Origin of the exchange interaction, Direct exchange, Super exchange, Indirect exchange and itinerant exchange, Spin-waves in ferromagnets, magnons, Spontaneous magnetisation, thermodynamics of magnons, Spin-waves in lattices with a basis, ferri- and Antiferromagnetism, Measurement of magnon spectrum, Ordered magnetism of valence and conduction electrons, Stoner's criterion for metallic ferromagnets, The Ising Model, Zero external magnetic field (Spontaneous Symmetry breaking), External Field (Hysteresis), Critical Fluctuations, Renormalization Group method, Domain and Domain walls, Spin-spin Interactions, Localized states and RKKY Exchange Interactions, Spin flip and Spin dephasing.

(25L)

Superconductivity

Superconductors, Constructing Bosons from Fermions, Cooper pairing, BCS wave-functions, Excitation spectrum of a superconductor, Magnetic effects of a superconductor, Bogoliubov transformation notion of quasiparticles, Ginzburg-Landau theory and London equation, Meissner effect, Type-II superconductors characteristic length, Josephson effect, Novel High Temperature" superconductors, Josephson Junctions. (20L)

Density Functional Theory:

Many Electron Hamiltonian, Born-Oppenhimer Approximation, Wave function based approximation methods, Density based methods, Holenberg Kohn Theorem, Kohn-Sham Ansatz, SCF Cycle, Exchange Correlation functionals (LDA, GGA), Basis sets (Plane wave, LCAO), pseudo potential.

(10L)

List of Books:

1. C. Kittel: Introduction to Solid State Physics
2. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiments
3. J.M. Ziman: Principles of the Theory of Solids
4. C. Kittel: Quantum Theory of Solids
5. J.M. Yeomans: Statistical Mechanics of Phase Transitions
6. Magnetism in Condensed Matter, Stephen Blundell, Oxford Master Physics
7. Solid State Physics: Essential Concepts, avid W. Snoke.
8. Introduction to Superconductivity: Michael Tinkham, Dover Publication
9. A Quantum Approach to Condensed Matter Physics: Philip Taylor
10. Condensed Matter in a Nutshell: Gerald D. Mahan
11. Condensed Matter Physics: Michael P. Marder

Paper Name: Advanced Elective III (Biomedical Spectroscopy and Medical Imaging Technique)

Paper Name: SPH52106

Unit 1: Image Fundamentals: Image Perception, MTF of the visual system, image fidelity criteria, image model, image sampling and quantization – 2 dimensional sampling theory, image quantization, optimum mean square quantizer, image transforms- 2 D – DFT and other transforms. (10L)

Unit 2: Image processing: Image enhancement –point operation, histogram modelling, spatial operation, transforms operations. Image restoration- image degradation model, inverse and wiener filtering. (5L)

Unit 3: Image analysis and classification: Image analysis- spatial feature extraction, edge detection, image segmentation classification technique- statistical methods, neural network approaches. (10L)

Unit 4: Reconstruction of CT and MRI Images: Image reconstructions from projections-radon transforms, filter back projection algorithm, algebraic methods ,3D tomography, imaging methods of CT images, imaging methods in magnetic resonance imagers, Fourier reconstructions of Magnetic resonance images. (7L)

Unit 5: Transmission of Medical Images: Medical Image, Data compression & transmission, Transform coding, pixel coding, predictive coding, interframe coding. (8L)

Unit 6:

Optical characteristics of biomolecules from the point of spectroscopy – principles of UV – Visible absorption – IR and FTIR absorption – Raman and Fluorescence spectroscopy – application with regard to characterization of biomolecules – blood oxygen, glucose measurements, monitoring drug concentration, cancer diagnosis. Nuclear spin and nuclear magnetic moment. The hyperfine structure of the spectra.SternGerlach method and NMR methods (Rabi, Bloch and Purcell) to measure the nuclear magnetic moments.NMR spectroscopy. Biological tissues magnetization. NMR medical imaging device components.NMR image acquisition and reconstruction. Spatial characteristics of the NMR image. Functional NMR imaging. NMR image artifacts removing methods. Protection methods during the NMR image acquisition. Advantage and disadvantage of the NMR imaging as against other medical imaging methods. (20L)

List of Books:

1. Fundamentals of Medical Imaging, Paul Suetens.
2. Digital image processing using Matlab, R. C. Gonzalaz, Richard. E. Woods, Steven L Eddins

Paper Name: Advanced Elective IV (Dielectric, Optical and Transport properties of Solids)

Paper Name: SPH52122

Optical properties of solids:

The dielectric function: the dielectric function for a harmonic oscillator, dielectric losses of electrons, Kramer's-Kronig relations; Interaction of phonons and electrons with photons; Interband transition, direct and indirect transition; Absorption in insulators; Polaritons, Phonon-Polaritons, Lyddane-Sachs-Teller relation, Exciton-Polaritons, Non-linear Optics and photon-photon

Interactions, One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect. (25L)

Electronic properties

Electron as quasi particles, effective mass, excitons, Metals and Fermi gas, Fermi Gas at $T=0$, Fermi Gas at finite temperature. Basic behaviour of semi-conductors, Equilibrium populations of electrons and hole, semi-conductor doping, Equilibrium populations in doped semi-conductors, The Mott transition. Band Bending and Hetero-junctions, Metal-to-Metal junctions, Doped Semiconductor Hetero-junctions, Metal-Semiconductor Hetero-junctions, Surface Band bending, Junctions with un-doped semiconductors. Quantum confinement, Density of States in Quantum-Confined systems, Super lattices, Disorder in quantum confined systems, The Two-Dimensional electron gas. (20L)

Quantum Transport:

Introduction to mesoscopic systems, idea of length scales, Conduction quantization, Conduction fluctuation, persistent current, Kondo effect. Theoretical formulation to study electron and spin transport phenomena: Landauer-Buttiker formulation and Kubo Formalism (Qualitative discussions only). Landau band and Quantum Hall effect, Spin Hall Effect (Qualitative discussions only).
(15L)

List of Books:

1. Optical Properties of Solids: Mark Fox, Oxford Master series
2. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiments
3. Solid State Physics: Essential Concepts, avid W. Snoke.
4. J.M. Ziman: Principles of the Theory of Solids
5. Electronic Transport in Mesoscopic systems: Supriyo Datta, Cambridge Universuty Press
6. Quantum Transport: Atom to Transistor, Supriyo Datta, Cambridge Universuty Press
7. Lessons from Nanoelectronics: Supriyo Datta

Paper Name: Advanced Elective IV (Biosensors and LASER in Medical Application)

Paper Name: SPH52124

Unit 1: Displacement, motion and Pressure Measurement: (with applications) Resistive: Potentiometers, Strain Gauges and Bridge Circuits. Inductive: Variable Inductance and LVDT Capacitive type, Piezoelectric Transducers. Types of Diaphragms, Bellows, Bourdon Tubes.

(8L)

Unit 2: Temperature Measurement: Thermistor, Thermocouple, Resistive Temperature Detector, IC based Temperature Measurement Radiation Sensors

(7L)

Unit 3: Chemical Sensors: Blood gas and Acid- Base Physiology, Potentiometric Sensors (pH, pCO2 Electrodes, Amperometric Sensors (pO2), ISFETS, Transcutaneous Arterial O2 and CO2 Tension Monitoring. Fiber Optic Sensors: Principle of Fiber Optics, Fiber Optic Sensors - Temperature, Chemical, Pressure. Biosensor: Classifications and types with examples.

(8L)

Unit 4: MEMS technology: An introduction to Micro sensors and MEMS, Evolution of Micro sensors& MEMS, Micro sensors & MEMS applications, Microelectronic technologies for MEMS, Micromachining Technology, Surface and Bulk Micromachining, Micro machined Micro sensors, Mechanical, Inertial,

Biological, Chemical, Acoustic, Microsystems Technology, Integrated Smart Sensors and MEMS, Interface Electronics for MEMS, MEMS Simulators, MEMS for RF Applications, Bonding & Packaging of MEMS.

(8L)

Unit 5: Optical properties of tissues (normal and tumor) - experimental methods to determine the reflectance, transmittance, absorption and emission properties of tissues. Laser systems in medicine and biology - Nd-YAG, Ar ion, CO2, Excimer - Gold vapor laser - beam delivery system and control.

(8L)

Unit 6: SURGICAL APPLICATIONS OF LASERS : Evaporation and excitation techniques - sterilization - hemostasis - laryngeal surgery - cancer surgery - liver surgery - stomach surgery - gynecological surgery - urological surgery - cardiac surgery- lasers in Opthalmology – Dermatology and Dentistry – cosmetic surgery.

(7L)

Unit 7: LASERS IN DIAGNOSIS AND THERAPY: Trace elements detection - laser induced fluorescence studies - cancer diagnosis - photo radiation therapy of tumors - lasers in endoscopy – lasers in laproscopy – lasers in trapping of cells and genetic engineering - biosimulation.

(7L)

Unit 8: LASER SAFETY REGULATIONS: Basic laser safety – eye hazards – skin hazards – electrical hazards – fire and flood hazards – laser safety classes – technical precautions – nontechnical measures – laser safety regulations – common obstacles – laser medical surveillance.

(7L)

Paper Name: Advanced Elective Lab II (Condensed Matter Physics Lab)
Paper Name: SPH52204

1. Determination of susceptibility of a paramagnetic solution ($FeCl_3$/$MnSO_4$) by Quinck's Method.
2. Determination of Dielectric constant of a specimen (liquid) at high frequency and Curie temperature of monel metal.
3. Determination of Heat Capacities of Solids.
4. Dispersion Relation in periodic electrical circuit- Study of electrical analogue mono-atomic and di-atomic chain.
5. Study of Ferromagnetic-Paramagnetic phase transition in Ferrites.

Paper Name: Advanced Elective Lab II (Microprocessor and Image Processing Lab)
Paper Name: SPH52206

Details will be provided later.