AC 29/4/2013

Item no. 4.93

University of Mumbai

Syllabus for **Semesters - I to IV**

Program - M. Sc

Course -Physics

(Credit based Semester and Grading system

With effect from the academic year 2012-13)

Course Structure & Distribution of Credits.

M. Sc. in Physics Program consists of total 16 theory courses, total 6 practical lab courses and 2 projects spread over four semesters. Twelve theory courses and four practical lab course will be common and compulsory to all the students. Four theory courses can be chosen from the elective courses offered by the institute. Two Lab courses can be chosen from the elective lab courses offered by the institute. Each theory course will be of 4 (four) credits, a practical lab course will be of 4 (four) credits and a project will be of 4 (four) credits. A project can be on theoretical physics, experimental physics, applied physics, development physics, computational physics or industrial product development. A student earns 24 (twenty four) credits per semester and total 96 (ninety six) credits in four semesters. The course structure is as follows,

Theory Courses

	Paper-1	Paper-2	Paper-3	Paper-4
Semester-I	Mathematical Methods	Classical Mechanics	Quantum Mechanics-I	Solid State Devices
Semester-II	Advanced Electronics	Electrodynamics	Quantum Mechanics-II	Solid State Physics
Semester-III	Statistical Mechanics	Nuclear Physics	Elective Course	Elective Course
Semester-IV	Experimental Physics	Atomic and Molecular Physics	Elective Course	Elective Course

Practical Lab courses

Semester-I	Lab Course -1	Lab Course -2
Semester-II	Lab Course -3	Lab Course -4
Semester-III	Project-1	Elective Lab Course-1
Semester-IV	Project-2	Elective Lab Course-2

The elective theory courses offered by PG Centers will be from the following list: 1; Nuclear Structure 2; Experimental Techniques in Nuclear Physics 3; Electronic structure of solids 4; Surfaces and Thin Films 5; Microcontrollers and Interfacing 6; Embedded systems and RTOS 7; Signal Modulation and Transmission Techniques 8; Microwave Electronics, Radar and Optical Fiber Communication 9; Semiconductor Physics 10; Thin Film Physics and Techniques 11; Fundamentals of Materials Science 12; Nanoscience & Nanotechnology 13; Astronomy and Space Physics 14; Laser Physics 15; Group Theory 16; Applied Thermodynamics 17; Quantum Field Theory 18; Nuclear Reactions 19; Particle Physics 10; Properties of Solids 21; Crystalline &

Non-crystalline solids 22; Advanced Microprocessor and ARM-7 23; VHDL and communication Interface 24; Digital Communication Systems and Python Programming 25; Computer Networking 26; Physics of Semiconductor Devices 27; Semiconductor Technology 28; Materials and their applications 29; Energy Studies 30; Galactic & Extragalactic Astronomy 31; Plasma Physics 32; Liquid Crystals 33; Numerical Techniques 34; Polymer Physics. Only some electives will be offered by each PG centre. Every year different electives may be offered depending on the availability of experts in PG centers.

Semester I

M.Sc. in Physics Program for Semester-I consists of four theory courses and two practical courses. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one hour duration)

Theory Paper	Subject	Lectures (Hrs.)	Credits
PSPH101	Mathematical Methods	60	04
PSPH102	Classical Mechanics	60	04
PSPH103	Quantum Mechanics I	60	04
PSPH104	Solid State Devices	60	04
	Total	**240**	**16**

Practical lab courses (2): 16 hours per week

Practical Lab Course	Practical Lab Sessions (Hrs)	Credits
PSPHP101	120	04
PSPHP102	120	04
Total	**240**	**08**

Semester II

M.Sc. in Physics Program for Semester-II consists of four theory courses and two practical courses. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one week duration)

Theory Paper	**Subjects**	**Lectures (Hrs.)**	**Credits**
PSPH201	Advanced Electronics	60	04
PSPH202	Electrodynamics	60	04
PSPH203	Quantum Mechanics II	60	04
PSPH204	Solid State Physics	60	04
	Total	**240**	**16**

Practical lab courses (2): 16 hours per week

Practical Lab Course	Practical Lab Sessions (Hrs.)	Credits
PSPHP201	120	04
PSPHP202	120	04
Total	**240**	**08**

Semester III

M.Sc. in Physics Program for Semester-III consists of four theory courses, one practical course and one Project. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one week duration)

Theory Paper	Subjects	Lectures (Hrs)	Credits
PSPH301	Statistical Mechanics	60	04
PSPH302	Nuclear Physics	60	04
*	Elective Course	60	04
*	Elective Course	60	04
	Total	**240**	**16**

*: To be chosen from the list below with odd-even number combination. Odd numbered course will be paper-3 and even numbered course will be paper-4.

Theory Paper	Subjects	Lectures (Hrs)	Credits
PSPHET301	Nuclear Structure	60	04
PSPHET302	Nuclear Reactions	60	04
PSPHET303	Electronic structure of solids	60	04
PSPHET304	Surfaces and Thin Films	60	04
PSPHET305	Microcontrollers and Interfacing	60	04
PSPHET306	Embedded systems and RTOS	60	04
PSPHET307	Signal Modulation and Transmission Techniques	60	04
PSPHET308	Microwave Electronics, Radar and Optical Fiber Communication	60	04
PSPHET309	Semiconductor Physics	60	04
PSPHET310	Thin Film Physics and Techniques	60	04
PSPHET311	Fundamentals of Materials Science	60	04
PSPHET312	Nanoscience & Nanotechnology	60	04
PSPHET313	Galactic & Extragalactic Astronomy	60	04
PSPHET314	Plasma Physics	60	04

PSPHET315	Group Theory	60	04
PSPHET316	Applied Thermodynamics	60	04
PSPHET317	Quantum Field Theory	60	04

Project (1): 8 hours per week

Project	Course	Total Project period (Hrs.)	Credits
PSPHP301	Project-1	120	04

Practical lab courses (1): 8 hours per week

Practical Lab Course	Course	Practical Lab Sessions (Hrs.)	Credits
PSPHPAP302	Advanced Physics Lab-1	120	04

Semester IV

M.Sc. in Physics Program for Semester-IV consists of four theory courses, one practical course and one Project. The details are as follows:

Theory Courses (4): 16 hours per week (One lecture of one week duration)

Theory Paper	Subjects	Lectures (Hrs)	Credits
PSPH401	Experimental Physics	60	04
PSPH402	Atomic and Molecular Physics	60	04
*	Elective Course	60	04
*	Elective Course	60	04
	Total	**240**	**16**

*: To be chosen from the list below with odd-even number combination. Odd numbered course will be paper-3 and even numbered course will be paper-4.

Theory Paper	Subjects	Lectures (Hrs)	Credits
PSPHET401	Experimental Techniques in Nuclear Physics	60	04
PSPHET402	Particle Physics	60	04
PSPHET403	Crystalline & Non-crystalline solids	60	04
PSPHET404	Properties of Solids	60	04
PSPHET405	Advanced Microprocessor and ARM-7	60	04

PSPHET406	VHDL and communication Interface	60	04
PSPHET407	Digital Communication Systems and Python Programming	60	04
PSPHET408	Computer Networking	60	04
PSPHET409	Physics of Semiconductor Devices	60	04
PSPHET410	Semiconductor Technology	60	04
PSPHET411	Materials and their applications	60	04
PSPHET412	Energy Studies	60	04
PSPHET413	Astronomy and Space Physics	60	04
PSPHET414	Laser Physics	60	04
PSPHET415	Liquid Crystals	60	04
PSPHET416	Numerical Techniques	60	04
PSPHET417	Polymer Physics	60	04

Project (1): 8 hours per week

Project	Total Project period (Hrs)	Credits
PSPHP401	120	04

Practical lab courses (1): 8 hours per week

Practical Lab Course	Subject	Practical Lab Sessions (Hrs)	Credits
PSPHPAP402	Advanced Physics Lab-2	120	04

The candidate shall be awarded the degree of Master of Science in Physics **(M. Sc. in Physics)** after completing the course and meeting all the evaluation criteria. The Elective Course Titles will appear in the statement of marks. When the elective courses are chosen from a particular specialization, the statement of marks shall also carry a name of the specializations as stated below. Courses selected at third semester for a particular specialization are pre-requisites for courses in fourth semester for that specialization.

No.	**Group of Elective Courses chosen**	**Name appearing in the Statement of Marks**	**Name appearing in the Degree Certificate**
1	PSPHET301, PSPHET302 PSPHET401, PSPHET402	M. Sc. in Physics (Nuclear Physics)	M. Sc. in Physics
2	PSPHET303, PSPHET304 PSPHET403, PSPHET404	M. Sc. in Physics (Solid State Physics)	M. Sc. in Physics
3	PSPHET305, PSPHET306	M. Sc. in Physics	M. Sc. in Physics

	PSPHET405, PSPHET406	(Electronics-I)	
4	PSPHET307, PSPHET308 PSPHET407, PSPHET408	M. Sc. in Physics (Electronics-II)	M. Sc. in Physics
5	PSPHET309, PSPHET310 PSPHET409, PSPHET410	M. Sc. in Physics (Solid State Electronics)	M. Sc. in Physics
6	PSPHET311, PSPHET312 PSPHET411, PSPHET404	M. Sc. in Physics (Materials Science)	M. Sc. in Physics
7	PSPHET311, PSPHET316 PSPHET411, PSPHET412	M. Sc. in Physics (Materials for Energy Technology)	M. Sc. in Physics
8	Any other combination of courses	M. Sc. in Physics	M. Sc. in Physics

2. Scheme of Examination and Passing:

1. This course will have 40% Term Work (TW) / Internal Assessment (IA) and 60% external (University written examination of 2.5 Hours duration for each course paper and practical examination of 4 Hours duration for each practical). All external examinations will be held at the end of each semester and will be conducted by the University as per the existing norms.
2. Term Work / Internal Assessment - IA (40%) and University examination (60%)- shall have separate heads of passing. For Theory courses, internal assessment shall carry 40 marks and Semester-end examination shall carry 60 marks for each Theory Course.
3. To pass, a student has to obtain minimum grade point E, and above separately in the IA and external examination.
4. The University (external) examination for Theory and Practical shall be conducted at the end of each Semester and the evaluation of Project work i.e. Dissertation if any, at the end of the each Semester.
5. The candidates shall appear for external examination of 4 theory courses each carrying 60 marks of 2.5 hours duration and 2 practical courses each carrying 100 marks at the end of each semester.
6. The candidate shall prepare and submit for practical examination a certified Journal based on the practical course carried out under the guidance of a faculty member with minimum number of experiments as specified in the syllabus for each group.

3. Standard of Passing for University Examinations:

As per ordinances and regulations prescribed by the University for semester based credit and grading system.

4. Standard point scale for grading:

Grade	Marks	Grade Points
O	70 & above	7
A	60 to 69.99	6
B	55 to 59.99	5
C	50 to 54.99	4
D	4 5 to 49.99	3
E	40 to 44 .99	2
F (Fail)	39.99 & below	1

5. Grade Point Average (GPA) calculation:

1. GPA is calculated at the end of each semester after grades have been processed and after any grade have been updated or changed. Individual assignments / quizzes / surprise tests / unit tests / tutorials / practicals / project / seminars etc. as prescribed by University are all based on the same criteria as given above. The teacher should convert his marking into the Quality-Points and Letter-Grade.
2. Performance of a student in a semester is indicated by a number called Semester Grade Point Average (SGPA). It is the weighted average of the grade points obtained in all the subjects registered by the students during the semester

$$\textbf{SGPA} = \frac{\sum_{i=1} C_i p_i}{\sum_{i=1} C_i}$$

C_i = The number of credits earned in the i^{th} course of a semester.

p_i = Grade point earned in the i^{th} course

i = 1,2,….n represents number of courses for which the student is registered.

3 The Final remark will be decided on the basis of Cumulative Grade Point Average (CGPA) which is weighted average of the grade point obtained in all the semesters registered by the learner.

$$CGPA = \frac{\sum_{j=1} C_j p_j}{\sum_{j=1} C_j}$$

C_j = The number of credits earned in the j^{th} course upto the semester.for whic h the CGPA is calculated

p_j = Grade point earned in the j^{th} course*

j = 1,2,….n represents number of courses for which the student is registered upto the semester for which the CGPA is calculated.

* : A letter Grade lower than E in a subject shall not be taken into consideration for the calculation of CGPA

The CGPA is rounded upto the two decimal places.

M.Sc. (Physics) Theory Courses
Semester –I

Semester-I : Paper-I:
Course no.: PSPH101: Mathematical Methods (60 lectures, 4 credits)

Unit-I

Properties of Fourier series, integral transforms, development of Fourier integrals, Fourier transform of derivatives, convolution theorem. Laplace transforms, Laplace transform of derivatives, Inverse Laplace transform and Convolution theorem.

Unit-II

Matrices, Eigenvalues and Eigen vectors, Diagonalization of Matrices, Application to Physics problems, Applications to differential equations. Introduction to Tensor Analysis, Addition and Subtraction of Tensors, summation convention, Contraction, Direct Product, Levi-Civita Symbol

Unit-III

Complex Variables, Limits, Continuity, Derivatives, Cauchy-Riemann Equations, Analytic functions, Harmonic functions, Elementary functions: Exponential and Trigonometric, Taylor and Laurent series, Residues, Residue theorem, Principal part of the functions, Residues at poles, zeroes and poles of order m, Contour Integrals, Evaluation of improper real integrals, improper integral involving Sines and Cosines, Definite integrals involving sine and cosine functions.

Unit-IV

Differential Equations: Frobenius method, series solutions, Legendre, Hermite and Laguerre polynomials, Bessel equations, Partial differential equations, separation of variables, wave equation and heat conduction equation. Green's functions in one dimension.

Main references:

S.D.Joglekar, Mathematical Physics: The Basics, Universities Press 2005

S. D.Joglekar, Mathematical Physics: Advanced Topics, CRC Press 2007

M.L. Boas, Mathematical methods in the Physical Sciences, Wiley India 2006

Additional references.

1. G. Arfken: Mathematical Methods for Physicists, Academic Press
2. A.K. Ghatak, I.C. Goyal and S.J. Chua, Mathematical Physics, McMillan
3. A.C. Bajpai, L.R. Mustoe and D. Walker, Advanced Engineering Mathematics, John Wiley
4. E. Butkov, Mathematical Methods, Addison-Wesley
5. J. Mathews and R.L. Walker, Mathematical Methods of physics
6. P. Dennery and A. Krzywicki , Mathematics for physicists
7. T. Das and S.K. Sharma, Mathematical methods in Classical and Quantum Mechanics
8. R. V. Churchill and J.W. Brown, Complex variables and applications, V Ed. Mc Graw. Hill, 1990
9. A. W.Joshi, Matrices and Tensors in Physics, Wiley India

Semester-I : Paper-II:

Course no.: PSPH102: Classical Mechanics (60 lectures, 4 credits)

Unit-I

Review of Newton's laws, Mechanics of a particle, Mechanics of a system of particles, Frames of references, rotating frames, Centrifugal and Coriolis force, Constraints, D'Alembert's principle and Lagrange's equations, Velocity-dependent potentials and the dissipation function, Simple applications of the Lagrangian formulation. Hamilton's principle, Calculus of variations, Derivation of Lagrange's equations from Hamilton's principle, Lagrange Multipliers and constraint exterimization Problems, Extension of Hamilton's principle to nonholonomic systems, Advantages of a variational principle formulation,

Unit-II

Conservation theorems and symmetry properties, Energy Function and the conservation of energy. The Two-Body Central Force Problem**:** Reduction to the equivalent one body problem, The equations of motion and first integrals, The equivalent one-dimensional problem and classification of orbits, The virial theorem, The differential equation for the orbit and integrable power-law potentials, The Keplerproblem : Inverse square law of force, The motion in time in the Kepler problem, Scattering in a central force field, Transformation of the scattering problem to laboratory coordinates.

Unit-III

Small Oscillations: Formulation of the problem, The eigenvalue equation and the principal axis transformation, Frequencies of free vibration and normal coordinates, Forced and damped oscillations, Resonance and beats.

Legendre transformations and the Hamilton equations of motion, Cyclic coordinates and conservation theorems, Derivation of Hamilton's equations from a variational principle.

Unit-IV

Canonical Transformations, Examples of canonical transformations, The symplectic approach to canonical transformations, Poissson brackets and other canonical invariants, Equations of motion, infinitesimal canonical transformations and conservation theorems in the Poisson bracket formulation, The angular momentum Poisson bracket relations.

Main Text : Classical Mechanics, H. Goldstein, Poole and Safco, 3rd Edition, NarosaPublication (2001)

Additional References :

1. Classical Mechanics, N. C. Rana and P. S. Joag. Tata McGraw Hill Publication.
2. Classical Mechanics , S. N. Biswas, Allied Publishers (Calcutta).
3. Classical Mechanics, V. B. Bhatia, Narosa Publishing (1997).
4. Mechanics, Landau and Lifshitz, Butterworth, Heinemann.
5. The Action Principle in Physics, R. V. Kamat, New Age Intnl. (1995).
6. Classical Mechanics, Vol I and II, E. A. Deslougue, John Wiley (1982).
7. Theory and Problems of Lagrangian Dynamics, Schaum Series, McGraw (1967).
8. Classical Mechanics of Particles and Rigid Bodies, K. C. Gupta, Wiley Eastern (2001)

Semester-I : Paper-III:
Course no.: PSPH103: Quantum Mechanics-I (60 lectures, 4 credits)

Unit-I: Theory:

Review of concepts: Analysis of the double-slit particle diffraction experiment; the de Broglie hypothesis; Heisenberg's uncertainty principle; probability waves. Postulates of QM: Observables and operators; measurements; the state function and expectation values; the time-dependent Schrodinger equation; time development of state functions; solution to the initial value problem. Superposition and Commutation: The superposition principle; commutator relations; their connection to the uncertainty principle; degeneracy; complete sets of commuting observables. Time development of state functions and expectation values; conservation of energy, linear momentum and angular momentum; parity.

Unit-II: Formalism:

Dirac notation; Hilbert space; Hermitian operators and their properties. Matrix mechanics: Basis and representations; matrix properties; unitary and similarity transformations; the energy representation. Schrodinger, Heisenberg and Interaction pictures.

Unit-III: Schrodinger equation solutions: One-dimensional Problems:

General properties of one-dimensional Schrodinger equation. Particle in a box. Harmonic oscillator. Unbound states; one-dimensional barrier problems. Finite potential well.

Unit-IV: Schrodinger equation solutions: Three-dimensional Problems:

Orbital angular momentum operators in cartesian and spherical polar coordinates, commutation and uncertainty relations, spherical harmonics. Two-particle problem - coordinates relative to the centre of mass; radial equation for a spherically symmetric central potential. Hydrogen atom, eigenvalues and radial eigenfunctions, degeneracy, probability distribution.

Texts:

1. Richard Liboff, Introductory Quantum Mechanics, 4th ed., 2003. (RL)
2. DJ Griffiths, Introduction to Quantum Mechanics, 1995. (DG)
3. A Ghatak & S Lokanathan, Quantum Mechanics: Theory &Applications. 5thed., 2004. (GL)

Additional References:

1. W Greiner, Quantum Mechanics: An Introduction, 4th. ed., 2004.
2 R Shankar, Principles of Quantum Mechanics, 2nd ed., 1994.
3 SN Biswas, Quantum Mechanics, 1998.

Semester-I : Paper-IV:

Course no.: PSPH104: Solid State Devices (60 lectures, 4 credits)

Note: Problems form an integral part of the course.

Unit-I: Semiconductor Physics:

Classification of Semiconductors; Crystal structure with examples of Si, Ge & GaAs semiconductors; Energy band structure of Si, Ge & GaAs; Extrinsic and compensated Semiconductors; Temperature dependence of Fermi-energy and carrier concentration. Drift, diffusion and injection of carriers; Carrier generation and recombination processes- Direct recombination, Indirect recombination, Surface recombination, Auger recombination; Applications of continuity equation-Steady state injection from one side, Minority carriers at surface, Haynes Shockley experiment, High field effects. Hall effect; Four – point probe resistivity measurement; Carrier life time measurement by light pulse technique. Introduction to amorphous semiconductors, Growth of semiconductor crystals.

Unit-II: Semiconductor Devices I:

p-n junction : Fabrication of p-n junction by diffusion and ion-implantation; Abrupt and linearly graded junctions; Thermal equilibrium conditions; Depletion regions; Depletion capacitance, Capacitance – voltage (C-V) characteristics, Evaluation of impurity distribution, Varactor; Ideal and Practical Current-voltage (I-V) characteristics; Tunneling and avalanche reverse junction break down mechanisms; Minority carrier storage, diffusion capacitance, transient behavior; Ideality factor and carrier concentration measurements; Carrier life time measurement by reverse recovery of junction diode;; p-i-n diode; Tunnel diode, Introduction to p-n junction solar cell and semiconductor laser diode.

Unit-III: Semiconductor Devices II:

Metal – Semiconductor Contacts: Schottky barrier – Energy band relation, Capacitance-voltage (C-V) characteristics, Current-voltage (I-V) characteristics; Ideality factor, Barrier height and carrier concentration measurements; Ohmic contacts. Bipolar Junction Transistor (BJT): Static Characteristics; Frequency Response and Switching. Semiconductor heterojunctions, Heterojunction bipolar transistors, Quantum well structures.

Unit-IV: Semiconductor Devices III:

Metal-semiconductor field effect transistor (MESFET)- Device structure, Principles of operation, Current voltage (I-V) characteristics, High frequency performance. Modulation doped field effect transistor (MODFET); Introduction to ideal MOS device; MOSFET fundamentals, Measurement of mobility, channel conductance etc. from I_{ds} vs, V_{ds} and I_{ds} vs V_g characteristics. Introduction to Integrated circuits.

Main References:

1. S.M. Sze; Semiconductor Devices: Physics and Technology, 2nd edition, John Wiley, New York, 2002.
2. B.G. Streetman and S. Benerjee; Solid State Electronic Devices, 5th edition, Prentice Hall of India, NJ, 2000.
3. W.R. Runyan; Semiconductor Measurements and Instrumentation, McGraw Hill, Tokyo, 1975.
4. Adir Bar-Lev: Semiconductors and Electronic devices, 2nd edition, Prentice Hall, Englewood Cliffs, N.J., 1984.

Additional References:

1. Jasprit Singh; Semiconductor Devices: Basic Principles, John Wiley, New York, 2001.
2. Donald A. Neamen; Semiconductor Physics and Devices: Basic Principles, 3rd edition, Tata McGraw-Hill, New Delhi, 2002.
3. M. Shur; Physics of Semiconductor Devices, Prentice Hall of India, New Delhi, 1995.
4. Pallab Bhattacharya; Semiconductor Optoelectronic Devices, Prentice Hall of India, New Delhi, 1995.
5. S.M. Sze; Physics of Semiconductor Devices, 2nd edition, Wiley Eastern Ltd., New Delhi, 1985.

M.Sc. (Physics) Practical Lab Course
Semester –I

Semester –I Lab-1
Course number: PSPHP101 (120 hours, 4 credits)
Group A

Experiment	**References**
1. Michelson Interferometer	Advanced Practical Physics -Worsnop and Flint
2. Analysis of sodium spectrum	a).Atomic spectra- H.E. White b).Experiments in modern physics –Mellissinos
3. h/e by vacuum photocell	a). Advance practical physics - Worsnop and Flint b). Experiments in modern physics – Mellissinos
4 Study of He-Ne laser-Measurement of divergence and wavelength	a). A course of experiments with Laser - Sirohi b). Elementary experiments with Laser- G. white
5. Susceptibility measurement by Quincke's method / Guoy's balance method	Advance practical physics -Worsnop and Flint
6. Absorption spectrum of specific liquids	Advance practical physics -Worsnop and Flint
7. Coupled Oscillation	HBCSE Selection camp 2007 Manual

Group B:

Experiment	**References**
1 , Diac - Triac phase control circuit	a) Solid state devices- W.D. Cooper b) Electronic text lab manual - P.B. Zbar
2. Delayed linear sweep using 1C 555	a) Electronic Principles - A. P. Malvino
3. Regulated power supply using 1C LM 317 voltage regulator IC	a) Opeational amplifiers and linear Integrated circuits - Coughlin & Driscoll b) Practical analysis of electronic circuits through experimentation - L.MacDonald
4. Regulated dual power supply using IC LM 317 & 1C LM 337 voltage regulator ICs	a) Opeational amplifiers and linear Integrated circuits - Coughlin & Driscoll b) Practical analysis of electronic circuits through experimentation - L.MacDonald
5. Constant current supply using IC 741 and LM 317	Integrated Circuits - K. R. Botkar
6. Active filter circuits (second order)	a) Op-amps and linear integrated circuit technology- R. Gayakwad b) Operational amplifiers and linear integrated circuits - Coughlin &. Driscoll
7. Study of 4 digit multiplex display system	Digital Electronics - Roger Tokheim

Note: Minimum number of experiments to be performed and reported in the journal = 06 with minimum 3 experiments from each Group. i.e. Group A: 03 and Group B: 03

Semester –I Lab-2

Course number: PSPHP102 (120 hours, 4 credits)

Group A

Experiment	**References**
1. Carrier lifetime by pulsed reverse method	Semiconductor electronics by Gibson
2. Resistivity by four probe method	Semiconductor measurements by Runyan
3. Temperature dependence of avalanche and Zener breakdown diodes	a) Solid state devices - W.D. Cooper b) Electronic text lab manual - PB Zbar c) Electronic devices & circuits - Millman and Halkias
4. DC Hall effect	a) Manual of experimental physics - E.V.Smith b)Semiconductor Measurements - Runyan c) Semiconductors and solid state physics - Mackelvy d) Handbook of semiconductors – Hunter
5. Determination of particle size of lycopodium particles by laser diffraction method	a). A course of experiments with Laser - Sirohi b). Elementary experiments with Laser- G. white
6. Magneto resistance of Bi specimen	Semiconductor measurements by Runyan
7. Microwave oscillator characteristics	a) Physics of Semiconductor Devices by S.M.Sze

Group B:

Experiment	References
1. Temperature on-off controller using IC	a) Op-amps and linear integrated circuit technology by Gayakwad
2. Waveform Generator using ICs	a) Operational amplifiers and linear integrated circuits-— Coughlin & Driscoll b) Op-amps and linear integrated circuit technology — R. Gayakwad c) Opertional amplifiers : experimental manual C.B. Clayton
3. Instrumentation amplifier and its applications	a) Operational amplifiers and linear integrated circuits - Coughlin &. Driscoll b) Integrated Circuits - K. R. Botkar
4. Study of 8 bit DAC	a) Op-amps and linear integrated circuit technology — R. Gayakwad b) Digital principles and applications by Malvino and Leach
5. 16 channel digital multiplexer	a) Digital principles and applications by Malvino and Leach b) Digital circuit practice by RP Jain
6. Study of elementary digital voltmeter	Digital Electronics by Roger Tokheim (5th Edition, page 371)

Note: Minimum number of experiments to be performed and reported in the journal = 06 with minimum 3 experiments from each Group. i.e. Group A: 03 and Goup B: 03

Additional references:

[1] Digital theory and experimentation using integrated circuits - Morris E. Levine (Prentice Hall)

[2] Practical analysis of electronic circuits through experimentation - Lome Macronaid (Technical Education Press)

[3] Logic design projects using standard integrated circuits - John F. Waker (John Wiley & sons)

[4] Practical applications circuits handbook - Anne Fischer Lent & Stan Miastkowski (Academic Press)

[5] Digital logic design, a text lab manual - Anala Pandit (Nandu printers and publishers Pvt. Ltd.)

Note:

1. Journal should be certified by the laboratory in-charge only if the student performs satisfactorily the minimum number of experiments as stipulated above. Such students, who do not have certified journals, will not be allowed to appear for the practical examinations.
2. Total marks for the practical examinations = 200

M.Sc. (Physics) Theory Courses
Semester –II

Semester-II : Paper-I:
Course no.: PSPH201: Advanced Electronics (60 lectures, 4 credits)

Unit-I Microprocessors and Microcontrollers:

(a)Microprocessors: Introduction to Microprocessors, Organization of Microprocessors, Signal Description of Microprocessors, Instruction Sets, Programming Techniques with Additional Instructions, Counters and Time Delays, Stack and Sub-routines, Physical Memory Organization, Bus Operation, I/O Addressing Capability, Application of Microprocessors.

(b) Microcontrollers: Introduction to Microcontrollers, Embedded versus External Memory Devices, 8–bit and 16–bit Microcontrollers, CISC and RISC Processors, Harvard and Von Neumann Architectures, Commercial Microcontroller Devices. MCS–51 Architecture, Registers in MCS, 8051 Pin Description, Connections, I/O Ports and Memory Organization. Addressing Modes, Instructions and Simple programming's, Stack Pointer, Assembly Language Programming, Introduction to Atmel 89C51 & 89C2051 Microcontrollers, Applications of Microcontrollers.

Unit-II Analog and Data Acquisition Systems:

- **(a) Power Supplies**: Linear Power supply, Switch Mode Power supply, Uninterrupted Power Supply, Step up and Step down Switching Voltage Regulators.
- **(b) Inverters:** Principle of voltage driven inversion, Principle of current driven inversion, sine wave inverter, Square wave inverter.
- (c) **Signal Conditioning:** Operational Amplifier, Instrumentation Amplifier using IC, Precision Rectifier, Voltage to Current Converter, Current to Voltage Converter, Op-Amp Based Butterworth Higher Order Active Filters and Multiple Feedback Filters, Voltage Controlled Oscillator , Analog Multiplexer, Sample and Hold circuits, Analog to Digital Converters, Digital to Analog Converters.

Unit-III Data Transmissions, Instrumentations Circuits& Designs:

(a) Data Transmission Systems: Analog and Digital Transmissions, Pulse Amplitude Modulation, Pulse Width Modulation, Time Division Multiplexing, Pulse Modulation, Digital Modulation, Pulse Code Format, Modems.

(b) Optical Fiber: Introduction to optical fibers, wave propagation and total internal reflection in optical fiber, structure of optical fiber, Types of optical fiber, numerical aperture, acceptance angle, single and multimode optical fibers, optical fiber materials and fabrication, attenuation, dispersion, splicing and fiber connectors, fiber optic communication system, fiber sensor, optical sources and optical detectors for optical fiber.

Unit-IV Instrumentation Circuits and Designs :

Microprocessors/ Microcontrollers based D C motor speed controller. Microprocessors /Microcontrollers based temperature controller. Electronic weighing single pan balance using strain gauge/ load cell. Optical analog communication system using fiber link. Electronic intensity meter using optical sensor. IR remote controlled ON/OFF switch.

Reference Books:

1. Microprocessor Architecture, Programming and Applications with the 8085 R. S. Gaonkar, 4th Edition. Penram International.
2. The 8051 Microcontroller and Embedded Systems, Rajiv Kapadia, Jaico Publishing House.
3. Power Electronics and its applications, Alok Jain, 2nd Edition, Penram International India.
4. Op-Amps and Linear Integrated Circuits - R. A. Gayakwad , 3rd Edition Prentice Hall India.
5. Operational Amplifiers and Linear Integrated Circuits, Robert F. Coughlin and Frederic F. Driscoll, 6th Edition, Pearson Education Asia.
6. Optical Fiber Communications, Keiser, G. Mcgraw Hill, Int. Student Ed.
7. Electronic Communication Systems; 4th. Ed. Kennedy and Davis, (Tata-McGraw. Hill, 2004.
8. Electronic Instrumentation, H.S. Kalsi , Tata-McGraw. Hill, 1999

Semester-II : Paper-II:

Course no.: PSPH202: Electrodynamics (60 lectures, 4 credits)

Unit-I:

Maxwell's equations, The Pointing vector, The Maxwellian stress tensor, Lorentz Transformations, Four Vectors and Four Tensors, The field equations and the field tensor, Maxwell equations in covariant notation.

Unit-II:

Electromagnetic waves in vacuum, Polarization of plane waves. Electromagnetic waves in matter, frequency dependence of conductivity, frequency dependence of polarizability, frequency dependence of refractive index. Wave guides, boundary conditions, classification of fields in wave guides, phase velocity and group velocity, resonant cavities.

Unit-III:

Moving charges in vacuum, gauge transformation, The time dependent Green function, The Lienard- Wiechert potentials, Leinard- Wiechert fields, application to fields-radiation from a charged particle, Antennas, Radiation by multipole moments, Electric dipole radiation, Complete fields of a time dependent electric dipole, Magnetic dipole radiation

Unit-IV:

Relativistic covariant Lagrangian formalism: Covariant Lagrangian formalism for relativistic point charges, The energy-momentum tensor, Conservation laws.

Main Texts:

1. W.Greiner, Classical Electrodynamics (Springer- Verlag, 2000) (WG).
2. M.A. Heald and J.B. Marion, Classical Electromagnetic Radiation, 3rd edition (Saunders, 1983) (HM)

Additional references:

1. J.D. Jackson, Classical Electrodynamics, 4Th edition, (John Wiley & sons) 2005 (JDJ)
2. W.K.H. Panofsky and M. Phillips, Classical Electricity and Magnetism,2nd edition, (Addison - Wesley) 1962.
3. D.J. Griffiths, Introduction to Electrodynamics,2nd Ed., Prentice Hall, India,1989.
4. J.R. Reitz ,E.J. Milford and R.W. Christy, Foundation of Electromagnetic Theory, 4th ed., Addison -Wesley, 1993

Semester-II : Paper-III:

Course no.: PSPH203: Quantum Mechanics-II (60 lectures, 4 credits)

Unit-I: Angular Momentum:

1. Ladder operators, eigen values and eigen functions of L^2 and L_z using spherical harmonics, angular momentum and rotations.
2. Total angular momentum J; L.S coupling; eigen values of J^2 and J_z.
3. Addition of angular momentum, Clebsch Gordon coefficients for j_1=j_2=1/2 and j_1= 1, j_2 =1/2, coupled and uncoupled representation of eigen functions.
4. Angular momentum matrices; Pauli spin matrices; spin eigen functions; free particle wave functions including spin, addition of two spins.
5. Identical particles: symmetric / antisymmetric wavefunctions.

Unit-II: Perturbation Theory:

1. Time-independent perturbation theory: First-order and second-order corrections to non-degenerate perturbation theory. Degenerate perturbation theory - First order energies and secular equation.
   Time-dependent perturbation theory and applications.

Unit-III: Approximation methods:

2. Ritz variational method: basic principles, illustration by simple examples.
3. WKB Method.

Unit-IV: Scattering theory:

Scattering cross section and scattering amplitude; partial wave phase shift -- optical theorem, S-wave scattering from a finite spherical attractive and repulsive potential wells; centre of mass frame; Born approximation.

Texts:

1. Richard Liboff, *Introductory Quantum Mechanics,* 4^{th} ed., 2004. (RL)
2. DJ Griffiths, *Introduction to Quantum Mechanics*, 1995. (DG)
3. A Ghatak & S Lokanathan, *Quantum Mechanics: Theory & Applications.* 5^{th}ed., 2004. (GL)

Additional References:

1. W Greiner, *Quantum Mechanics: An Introduction*, 4^{th}. ed., 2004.
2. R Shankar, Principles of Quantum Mechanics, 2^{nd} ed., 1994.
3. SN Biswas, *Quantum Mechanics*, 1998.

<u>Semester-II : Paper-IV:</u>
<u>Course no.: PSPH204: Solid State Physics (60 lectures, 4 credits)</u>

Unit-I: Crystal Diffraction and Reciprocal Lattice:

Crystal Diffraction Methods for X rays- Laue, Rotating Crystal, Powder Method. Reciprocal Lattice and Brillouin Zones. Reciprocal Lattice to sc, bcc, fcc., Scattered wave amplitude, Fourier analysis of the basis ; Structure Factor of lattices (sc, bcc, fcc) ; Atomic Form Factor; Temperature dependence of reflection lines. Elastic scattering from Surfaces; Elastic scattering from amorphous solids.

Unit-II: Lattice Vibrations and thermal properties:

Vibrations of Monoatomic Lattice, normal mode frequencies, dispersion relation. Lattice with two atoms per unit cell, normal mode frequencies, dispersion relation., Quanization of lattice vibrations, phonon momentum, Inelastic scattering of neutrons by phonons, Surface vibrations, Inelastic Neutron scattering. Anharmonic Crystal Interaction. Thermal conductivity – Lattice Thermal Resistivity, Umklapp Process, Imperfections

Unit-III: Diamagnetism and Paramagnetism:

Langevin diamagnetic equation, diamagnetic response, Quantum mechanical formulation, core diamagnetism. Quantum Theory of Paramagnetism, Rare Earth Ions, Hund's Rule, Iron Group ions, Crystal Field Splitting and Quenching of orbital angular momentum; Adiabatic Demagnetisation of a paramagnetic Salt, Paramagnetic susceptibility of conduction electrons;

Unit-IV: Magnetic Ordering:

Ferromagnetic order- Exchange Integral, Saturation magnetisation, Magnons, neutron magnetic scattering; Ferrimagnetic order, spinels, Yttrium Iron Garnets, Anti Ferromagnetic order. Ferromagnetic Domains – Anisotropy energy, origin of domains, transition region between domains, Bloch wall, Coercive force and hysteresis.

References:-

1. Charles Kittel "Introduction to Solid State Physics", 7th edition John Wiley & sons.
2. J.Richard Christman "Fundamentals of Solid State Physics" John Wiley & sons
3. M.A.Wahab "Solid State Physics –Structure and properties of Materials" Narosa Publications 1999.
4. M. Ali Omar "Elementary Solid State Physics" Addison Wesley (LPE)
5. H.Ibach and H.Luth 3rd edition "Solid State Physics – An Introduction to Principles of Materials Science" Springer International Edition (2004)

M.Sc. (Physics) Practical Lab Course
Semester –II

Semester –II Lab-1
Course number: PSPHP201 (120 hours, 4 credits)
Group A

Experiment	**References**
1 . Zeeman Effect using Fabry-Perot etalon / Lummer — Gehrecke plate	a). Advance practical physics - Worsnop and Flint b). Experiments in modern physics - Mellissinos
2. Characteristics of a Geiger Muller counter and measurement of dead time	a). Experiments in modern physics- Mellissions b). Manual of experimental physics --EV-Smith c). Experimental physics for students - Whittle &. Yarwood
3. Ultrasonic Interferometry- Velocity measurements in different Fluids	Medical Electronics- Khandpur
4. Measurement of Refractive Index of Liquids using Laser	Sirohi-A course of experiments with He-Ne Laser; Wiley Eastern Ltd.
5. I-V/ C-V measurement on semiconductor specimen	Semiconductor measurements - Runyan
6. Double slit- Fraunhofer diffraction (missing order etc.)	Advance practical physics - Worsnop and Flint
7. Determination of Young's modulus of metal rod by interference method	Advance practical physics - Worsnop and Flint (page 338)

Group B

Experiment	**References**
1. Adder-subtractor circuits using ICs	a) Digital principles and applications -- Malvino and Leach b) Digital circuits practice - R.P. Jain
2. Study of Presettable counters - 74190 and 74193	a) Digital circuit practice - Jain & Anand b) Digital principles and applications --Malvino and Leach c) Experiments in digital practice -Jain & Anand
3. TTL characteristics of totem pole, open collector and tristate devices	a) Digital circuits practice - Jain & Anand b) Digital principles and applications --Malvino

	and Leach
4. Pulse width modulation for speed control of dc toy motor	Electronic Instrumentation - H. S. Kalsi
5. Study of sample and hold circuit	Integrated Circuits - K. R. Botkar
6. Switching Voltage Regulator	Integrated Circuits - K. R. Botkar

Note: Minimum number of experiments to be performed and reported in the journal = 06 with minimum 3 experiments from each Group. i.e. Group A: 03 and Goup B: 03

Semester –II Lab-2
Course number: PSPHP202 (120 hours, 4 credits)

Group A

Experiment	**References**
1 .Carrier mobility by conductivity	Semiconductor electronics - Gibson
2. Measurement of dielectric constant, Curie temperature and verification of Curie— Weiss law for ferroelectric material	a) Electronic instrumentation & measurement- W. D. Cooper b) Introduction to solid state physics - C. Kittel c) Solid state physics — A. J. Dekkar
3. Barrier capacitance of a junction diode	Electronic engineering - Millman Halkias
4. Linear Voltage Differential Transformer	Electronic Instrumentation - W.D. Cooper
5. Faraday Effect-Magneto Optic Effect a) To Calibrate Electromagnet b) To determine Verdet's constant for KCI & KI solutions.	1. Manual of experimental physics - E.V. Smith 2. Experimental physics for students - Whittle & Yarwood
6. Energy Band gap by four probe method	Semiconductor measurements — Runyan
7. Measurement of dielectric constant (Capacitance)	a) Electronic instrumentation & measurement - W. D. Cooper b) Introduction to solid state physics - C. Kittel

Group B

Experiment	**References**
1. Shift registers	a) Experiments in digital principles-D.P. Leach b) Digital principles and applications - Malvino and Leach
2. Study of 8085 microprocessor Kit and execution of simple Programmes	a) Microprocessor Architecture, Programming and Applications with the 8085 - R. S. Gaonkar b) Microprocessor fundamentals. Schaum Series - Tokheim c) 8085 Kit user manual
3. Waveform generation using 8085	a) Microprocessor Architecture, Programming and Applications with the 8085 - R. S. Gaonkar b) Microprocessor fundamentals, Schaum Series —Tokheim.

	c) 8085 Kit user manual
4. SID& SOD using 8085	a) Microprocessor Architecture, Programming and Applications with the 8085 - R. S. Gaonkar b) Microprocessor fundamentals, Schaum Series —Tokheim. c) 8085 Kit user manual
5. Ambient Light control power switch	a)Electronic Instrumentation H. S. Kalsi b) Helfrick & Cooper, PHI
6. Interfacing TTL with buzzers, relays, motors and solenoids.	Digital Electronics by Roger Tokheim

Note: Minimum number of experiments to be performed and reported in the journal = 06 with minimum 3 experiments from each Group. i.e. Group A: 03 and Goup B: 03

Additional references:

[1] Digital theory and experimentation using integrated circuits - Morris E. Levine (Prentice Hall)

[2] Practical analysis of electronic circuits through experimentation - Lome Macronaid (Technical Education Press)

[3] Logic design projects using standard integrated circuits - John F. Waker (John Wiley & sons)

[4] Practical applications circuits handbook - Anne Fischer Lent & Stan Miastkowski (Academic Press)

[5] Digital logic design, a text lab manual - Anala Pandit (Nandu printers and publishers Pvt. Ltd.)

Note:

1. Journal should be certified by the laboratory in-charge only if the student performs satisfactorily the minimum number of experiments as stipulated above. Such students, who do not have certified journals, will not be allowed to appear for the practical examinations.
2. Total marks for the practical examinations = 200

M.Sc. (Physics) Theory Courses
Semester –III

Semester-III : Paper-I:
Course no.: PSPH301: Statistical Mechanics (60 lectures, 4 credits)

Unit I : Classical Statistical Mechanics

1. Phase space and number of accessible microstates Ω given the macrostate; Statistical definition of entropy; Gibb's paradox and correct counting of microstates Ω.
2. Ensemble Theory: Phase space density and ergodic hypothesis; Liouville theorem; Microcanonical ensemble; Entropy as an ensemble average; Examples of classical ideal gas, ultra-relativistic gas, harmonic oscillators.
3. Canonical ensemble: Equilibrium between a system and an energy reservoir, Canonical partition function and derivation of thermodynamics; Applications to classical ideal gas, system of classical and quantum-mechanical harmonic oscillators, ultra-relativistic ideal gas; Energy fluctuations, Virial and equipartition theorems. Quantum systems in Boltzmann statistics – system of quantum-mechanical harmonic oscillators , paramagnetic system.

G : 5 , 6 , 7 , 8 ; P : Appendix H ; see also H : 5 , 6.

Unit II : Quantum Statistical Mechanics

4. Grand canonical ensemble: Equilibrium between a system and a particle-energy reservoir; Grand partition function and derivation of thermodynamics; Fluctuations.
5. Density operator, density matrix and quantum Liouville equation. Quantum statistical micro-canonical, canonical and grand canonical ensembles and their partition functions. Examples.
6. Ideal gas in q.m. microcanonical ensemble; Statistical weights and occupation number distribution for ideal Bose, Fermi and Maxwell-Boltzmann gases.

G : 9 ; P : 5.1 - 5.3 , 6.1 ; see also H : 8 .

Unit III : Ideal Fermi and Bose Systems

7. Ideal gas in q.m. canonical and grand canonical ensembles; Statistics of occupation numbers.
8. Thermodynamic behavior of an ideal Bose gas, phenomenon of Bose-Einstein condensation. Thermodynamics of blackbody radiation.
9. Thermodynamic behavior of an ideal Fermi gas, concept of Fermi energy, behaviour of specific heat with temperature.

G : 12 , 13 , 14 ; or P : 6.2 – 6.3 , 7.1 , 7.3 , 8.1; see also H : 9.1 -9.4 , 10 , 11.

Unit IV: Non-Equilibrium Statistical Mechanics

10. Brownian motion: as a random walk (Einstein theory), as a diffusion process; Langevin theory of Brownian motion; Fluctuation-dissipation theorem.

11. Master equation and Fokker-Planck equation.
12. Spectral analysis of fluctuations – the Wiener-Khintchine relations.
P : 15.2 - 15.6 ; see also H : 16 , 18.1 - 18.7.

Texts:
Thermodynamics and Statistical Mechanics, Greiner, Neise and Stocker, Springer 1995. (G)
Statistical Mechanics (3rd ed.), RK Pathria and PD Beale (P), Elsevier 2011. (P)
Introduction to Statistical Physics, Kerson Huang (H), Taylor and Francis 2001. (H)

References :
Thermal and Statistical Physics, F Reif.
Statistical Physics, D Amit and Walecka.
Statistical Mechanics, Kerson Huang.
Statistical Mechanics, J.K. Bhattacharjee.
Non-equilibrium Statistical Mechanics, J.K. Bhattacharjee.
Statistical Mechanics, Richard Feynman.
Statistical Mechanics, Landau and Lifshitz.
Thermodynamics, H.B. Callen

Semester-III : Paper-II:
Course no.: PSPH302: Nuclear Physics (60 lectures, 4 credits)

Unit I. (12 Lectures + 3 Tutorials)
Overview of Nuclear Physics (including Introduction to Regulatory framework and nuclear safety in India), Nuclear Properties, Measurement of Nuclear size and estimation of R_0, Deuteron system and its characteristic, Estimate the depth and size of (assume) square well potential, introduction to Tensor force, nucleon-nucleon scattering-qualitative discussion on results, Spin-orbit strong interaction between nucleon, double scattering experiment, The Shell Model (extreme single particle): Introduction, Assumptions, Evidences, Spin-orbit interactions, Predictions, limitation, introduction to Nilsson Model.
***Tutorials should include 3 problem solving session based on above mentioned topics**

Unit II. (11 Lectures + 4 Tutorials)
Review of alpha decay, introduction to Beta decay and its energetic, Fermi theory, Information from Fermi–curie plots, Comparative half lives, selection rules: Fermi and G-T transitions, Gamma decay, Multipole radiation, Selection rule for gamma ray transitions, Gamma ray interaction with matter, and Charge-particle interaction with matter.
***Tutorials should include 4 problem solving session based on above mentioned topics**

Unit III. (11 Lectures + 4 Tutorials)

Conservation laws, Types of nuclear reaction, Q- value equation of nuclear reaction, Center of Mass frame, reaction cross sections (Classical and Quantum), Compound nuclear reaction, Introduction to fission reaction, Characteristics of Fission, Energy in Fission, Controlled fission reaction, Introduction to 3 stage- Nuclear programme of India, Introduction to Fusion Reaction, Characteristics of Fusion, Solar Fusion and CNO cycle, introduction to Controlled fission reaction.

***Tutorials should include 4 problem solving session based on above mentioned topics**

Unit IV. (11 Lectures + 4 Tutorials)

Introduction to the elementary particle Physics, The Eight fold way, the Quark Model, the November revolution and aftermath, The standard Model, Revision of the four forces, cross sections, decays and resonances, Introduction to Quantum Eletrodynamics, Introduction to Quantum Chromodynamics. weak interactions and Unification Schemes (qualitative description), Revision of Lorentz transformations, Four-vectors, Energy and Momentum. Properties of Neutrino, helicity of Neutrino, Parity, Qualitative discussion on Parity violation in beta decay and Wu's Experiment, Charge conjugation, Time reversal, Qualitative introduction to CP violation and TCP theorem.

***Tutorials should include 4 problem solving session based on above mentioned topics**

Main References:

1. *Introduction to Nuclear Physics*, Kenneth Krane, Wiley India Pvt. Ltd.
2. *Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles*, Robert Eisberg and Robert Resnick, Wiley (2006)
3. *Introduction to Elementary Particles*, David Griffith, John Wiley and sons.
4. http://dae.nic.in or http://www.npcil.nic.in for 3 stage- Nuclear programme of India.
5. http://www.aerb.gov.in/ for Regulatory framework and nuclear safety in India.

Other References:

1. *Introduction to Nuclear Physics*, H. A. Enge, Eddison Wesley
2. *Nuclei and Particle*, E. Segre, W. A Benjamin,
3. *Concepts of Nuclear Physics*, B. L. Cohen
4. *Subatomic Particles*, H. Fraunfelder and E. Hanley, Prentice Hall
5. *Nuclear Physics, Experimental and Theoritical*, H. S. Hans, New Age International
6. *Introduction to Nuclear and Particle Physics*, A. Das & T. Ferbel, World Scientific
7. *Introduction to high energy physics*, D. H. Perkins, Addison Wesley
8. *Nuclear and Particle Physics*, W. E. Burcham and M. Jobes, Addison Wesley

9. *Nuclear Physics*, S. N. Ghoshal
10. *Nuclear Physics*- An Introduction, S. B. Patel, New Age International
11. *Nuclear Physics*- D. C. Tayal

Semester-III : Elective Paper-III
Course no.: PSPHET301: Nuclear Structure (60 lectures, 4 credits)

UNIT I: Microscopic Models I (12 lectures + 3 tutorials)
Experimental evidence for shell effects, Concept of average potential, Spin-orbit coupling, Single-particle shell structure, Predictions of the independent particle shell model: spin-parity, magnetic dipole and electric quadrupole moments; Isospin, Two- and Multi- particle configurations, Residual interactions, Pairing interactions: BCS model.

UNIT II: Microscopic Models II (11 lectures + 4 tutorials)
Fermi-Gas Model: symmetry, surface and Coulomb energy; Deformed shell model, Nilsson Hamiltonian, Single-particle energies in a deformed potential, Shell corrections and the Strutinski method, Hartree-Fock approximation: general variational principle, Hartree-Fock equations and applications.

UNIT III: Collective models (11 lectures + 4 tutorials)
Liquid drop model and mass formulas, Fission barriers and types of fission; Parameterization of nuclear surface deformations, Prolate and oblate shapes, Types of multipole deformations, Rotational states in axially symmetric deformed even-even and odd-A nuclei, Rotation of axially asymmetric nuclei, Octupole and higher-order deformations, Rotation-vibration coupling in deformed nuclei: beta and gamma vibrations; Giant resonances;

UNIT IV: Related concepts and selected phenomena
Cranking model and its semi-classical derivation, Cranking formula and applications, High-spin states and nucleon pair breaking at high angular momentum, Cranked Nilsson model, Yrast states in nuclei, Nuclear Isomerism and types of isomers, Superdeformed states in nuclei, Particle-plus-rotor model: weak-coupling limit and strong-coupling approximation

Suggested Reading:
1) *Nuclear Models*, by W. Greiner and J.A. Maruhn (Springer 1996)
2) *Nuclear Structure from a Simple Perspective*, by R. F. Casten (Oxford University Press 1990)
3) *Structure of the Nucleus*, by M.A. Preston and R.K. Bhaduri (Levant Books 2008)
4) *The Nuclear Many-Body Problem*, by P. Ring and P. Schuck (Springer 1980)
5) *Theory of Nuclear Structure*, by M.K. Pal (Affiliated East-West Press 1982)

<u>Semester-III : Elective Paper-IV</u>

<u>Course no.: PSPHET302: Nuclear Reactions (60 lectures, 4 credits)</u>

UNIT I: Basics: (12 lectures + 3 tutorials)

1. Basic elements of nuclear reactions:
   - (i) cross section (σ), mean free path; definition/expression for σ : experimental and theoretical.
   - (ii) Use of σ to calculate: Stopping length, life time modification of unstable states in a medium, mean life of a moving particle in an interacting volume, etc.
   - (iii) Conservation laws: Energy, momentum, angular momentum, parity, isospin.
   - (iv) Frame of reference: Lab. and c.m.
   - (v) Q-values and threshold energies.
2. Partial wave decomposition, phase shifts and partial wave analysis of the cross sections in terms of phase shifts. Behaviour of phase shifts in different situations. Black sphere scattering. Optical theorem and reciprocity theorem. Unitarily.
3. Optical potential: Basic definition. Relation between the imaginary part, W of the OP and σ_{abs} , and between W and mean free path. Folding model and a high energy estimate of the OP.
4. Decaying states. Relation between the mean life time and the width of the states. Energy definition, Lorentzian or Breit-Wigner shape.

UNIT II: Categorization of Nuclear Reaction mechanisms (11 lectures + 4 tutorials)

1. Low energies : Discrete region, Continuum Region

(a) Discrete Region:

- (i) Resonance scattering. Derivation of the resonance cross section from phase shift description of cross section.
- (ii) Transmission through a square well and resonances in continuum.
- (iii) Coulomb barrier penetration for charged particles scattering and centrifugal barrier for l non-zero states.
- (iv) Angular distributions of the particles in resonance scattering.
- (v) Application to hydrogen burning in stars.

(b) Continuum Region:

(i) Bohr’s compound nucleus model, and its experimental verifications.

(ii) Statistical parameters and their estimates for the continuum region.

(iii) Energy distribution of evaporated particles from compound nucleus.

2.. Higher energies: Direct Reaction

(i) Cross section in terms of the T-matrix. Phase space, and its evaluation for simple cases. Lippmann Schwinger equation for the scattering wave function, and its formal solution. On-shell and off- shell scattering.

(ii) Plane wave and distorted wave approximation to the T-matrix (PWBA, DWBA). Application to various direct reactions like, stripping, pick-up, knock-out etc.

(iii) High energy scattering. Eikonal approximation to the scattering wave function. Evaluation of scattering cross section in eikonal approximation.

Suggested Reading :

(i) *Nuclear Reactions*, by Daphne F Jackson (Methen & Co. Ltd.)
(ii) *Theoretical Nuclear Physics*, by John M Blatt and Victor F Weisskopf (John Wiley)
(iii) *Direct Nuclear Reaction Theories*, by Norman Austern (John Wiley)
(iv) *Concepts of Nuclear Physics*, by B. L. Cohen (Tata McGrow-Hill)
(v) *Introduction to Nuclear and Particle Physics*, by A. Das & T. Ferbel (World Scientific)

UNIT III: Physics of ion (stable and unstable) scattering (11 lectures + 4 tutorials)

1. Stable ions
   (i) Basics of heavy ions: short wave length, large angular momentum transfer, kinematics and Coulomb potential.
   (ii) Classical scattering: rainbow, orbiting, glory, etc. Semi-classical scattering.
   (iii) Quantum mechanical description.
2. Radioactive ion beams (RIB)
   (i) From stable to exotic nuclei in nuclear chart. Production and acceleration of radioactive ion beams (RIB). Shell structure of exotic nuclei and magicity. Structural properties of unstable nuclei: radii, skins and halos, spins and electromagnetic moments. Coulomb excitation and knock-out in RIBs.
   (ii) RIBs and nuclear astrophysics. Energy production in stars. Nucleosynthesis.

   Suggested Reading:

   (i) *Semi-classical methods for nucleus-nucleus scattering,* by D. M. Brink(Cambridge University press 1985)
   (ii) *Nuclear heavy ion reactions*, by P. E. Hodgson (Clarendon press 1978)
   (iii) *Introduction to nuclear reactions,* by G. R. Satchler (McMillan 1990)
   (iv) *Nuclear reactions for astrophysics,* by I. J. Thomson and F. Nunes (Cambridge University press, ISBN 9780521856355, 2009)
   (v) *Structure and reactions of light nuclei*, CRC press, ISBN-13: 978-0415308724.
   (vi) *Subatomic Physics*, by E. M. Henley and A. Garcia (2007), World Scientific.

(vii) *Scattering Theory of Waves and Particles*, by Roger G Newton (Spring-Verlag)

UNIT IV: Intermediate Energy Physics and Non-nucleonic Degrees of Freedom(11 lectures + 4 tutorials)

1. Introduction: Classification of elementary particles, Isospin, Conservation rules for strong interaction, Threshold beam energies in pp collisions for the production of various mesons and baryons.
2. Proton-nucleus scattering at high energies: Eikonal approximation, Glauber model, etc.
3. Electron-nucleus scattering and the structure of hadrons. Quark model for hadrons.
4. Pion-nucleon scattering, □$_{33}$ resonance. Pion-nucleon coupling, pseudoscalar and pseudovector. Pion capture in nuclei. One nucleon and two nucleon mechanisms.
5. Pion production and excitation of nucleonic resonances in p-p and p-nucleus collisions, experiments and theory.
6. An introduction to production of other mesons. Possibility of meson-nucleus bound states.

Suggested Reading*:*

1. *Nuclear reactions* , by D. F. Jackson (Methuen & Co. 1970)
2. *Nuclear Interactions*, by Sergo DeBenedetti (John Wlley 1964)
3. *Introduction to Nuclear and Particle Physics*, by A. Das and T. Ferbel (World Scientific 2009).
4. *Subatomic Physics* , by E. M. Henley and A. Garcia (World Scientific 2007),
5. *Physics of nucleons, mesons, quarks & heavy ions, by* Y. K. Gambhir (Ed.) (Quest publications, Mumbai, ISBN 81-87099-25-9 2003)
6. *The pion-nucleon system*, by B. H. Bransden and R. G. Moorhouse (Princeton University press 1973)
7. *SERC school series Nuclear Physics* (1988), B. K. Jain (Ed.) (World Scientific, ISBN 9971506335 1988).

Semester-III : Elective Paper-III

Course no.: PSPHET303: Electronic Structure of Solids (60 lectures, 4 credits)

Unit I. Prototype Electronic Structure

1. Free electron gas in infinite square well potential – Sommerfeld theory of metals.
2. Electron energy levels in a periodic potential.
3. Nearly-free electron approximation.
4. The tight-binding method.

Unit II. Electronic Band Structure Methods

1. Cellular method; Augmented plane-wave (APW) method; Green's function (KKR) method; Orthogonalized plane wave (OPW) method; Pseudopotentials.
2. Band structure / Fermi surface of selected metals – alkali and noble metals, simple multivalent metals, transition metals, rare-earths, semi-metals, semiconductors Si and Ge.
3. Fermi surface probes: Electrons in a magnetic field - the de Haas-van Alfen effect. Magneto-acoustic effect, cyclotron resonance.

Unit III. Motion of Band Electrons

Semi-classical electron dynamics; Motion of band electrons and the effective mass; currents in bands and holes; scattering of band electrons; Boltzmann equation and relaxation time; band electrons in electric field; electrical conductivity of metals; thermoelectric effects; Wiedemann-Franz law; Electrical conductivity of localized electrons; Band electrons in cross E and B fields – magnetoresistance and Hall effect.

Unit IV. Many – Body Effects

1. The Hartree-Fock method; exchange and correlation.
2. Density Functional Theory.
3. Computations on simple atoms.

Texts:

1. H Ibach and H Luth, *Solid State Physics, 3rd ed.;* Springer, 2003. Chpts. 6,7,9.
2. Neil W Ashcroft and N David Mermin, *Solid State Physics*. Holt, Rinehart and Winston, 1976. Chapters 2, 8-17.
3. Michael P Marder, *Condensed Matter Physics, 2nd ed.*; John Wiley and Sons, 2010.

References:

1. Brian Tanner, *Introduction to the Physics of Electrons in Solids, CUP,* 1995.
2. M A Wahab, *Solid State Physics*, Narosa, 2005.

G Grosso and G Paravicini, *Solid State Physics*, Academic Press, 2000.

Semester-III : Elective Paper-IV

Course no.: PSPHET304: Surfaces and Thin Films (60 lectures, 4 credits)

Unit I:- Physics of Surfaces, Interfaces and Thin films

Mechanism of thin film formation: Condensation and nucleation, growth and coalescence of islands, Crystallographic structure of films, factors affecting structure and properties of thin films; Properties of thin films:- Transport and optical properties of metallic, semiconducting and dielectric films; Application of thin films.

Unit II: Thin films : Formation & Measurement

Vacuum Techniques: Review:- Production of low pressures; Measurement of pressure, Leak detections, Materials used

Preparation of Thin Films: Thermal evaporation, Cathode Sputtering, Chemical Deposition, Laser Ablation, Langmur Blochet Films ;

Thickness Measurements: Stylus Method, Electrical Method, Quartz Crystal Method, Optical Methods, mass measurements (microbalance)

Unit III: *Nano Science and Nano Technology*

Band structure and Density of States at Nanoscale, Quantum mechanics for nanoscience- size effects, application of Schrodinger eqution, quantum confinement.Growth techniques for nano materials- Top down, Bottom up technique. Nano technology applications- nano structures of Carbon, BN nanotubes, Nanoelectronics, nanobiometrics

Unit IV:- Surface Analytical Techniques

X-ray Photoelectron spectroscopy (XPS), Auger Electron spectroscopy(AES), Depth profiling by Ar ions, Low Energy Electron Diffraction (LEED), Secondary Ion Mass spectroscopy (SIMS), Rutherford Backscattering spectroscopy (RBS), Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM) with EDAX, Scanning Probe Microscopy – a) Scanning Tunneling Microscopy (STM) , and b) Atomic Force Microscopy (AFM)

References:-

Unit I:

1. K.L. Chopra " Thin Film Phenomenan" McGraw Hill Inc (1969)
2. Ludmila Eckertova " Physics of Thin Films" Plenum Press NY (1986)

Unit II:

1. A. Roth "Vacuum Technology" North Holland Amsterdam
2. Ludmila Eckertova " Physics of Thin Films" Plenum Press NY (1986)
3. Thin Film Phenomena LK Chopra McGraw Hill 1969

Unit III: -

1. "Introduction to NanoScience and Nanotechnology" K.K. Chattopadhyay and A.N. Banerjee PHI learning (2009)
2. "Nanotechnology- Principles and Practices " S.K. Kulkarni, Capital publishing 2007

Unit IV: -

1. "Surface and Thin Film Analysis" ed H. Bubert and H. Jennet, Wiley –VCH (2003)
2 "Fundamentals of Surface and Thin Film Analysis" L.C. Feldman and J.W. Mayer North Holland amsterdam (1986)
3 "Surface Analytical Methods" D.J. O'Conner, B.A. Sexton and R. St. C. Smart (ed) Springer Verlag (1991)

Semester-III : Elective Paper-III

Course no.: PSPHET305: Microcontrollers and Interfacing (60 lectures, 4 credits)

Unit-I:

8051 microcontroller: (Review of 8051), Timer/Counters, Interrupts, Serial communication

Programming 8051 Timers, Counter Programming

Basics of Serial Communication, 8051 Connection to RS232, 8051 Serial Port Programming in assembly.

8051 Interrupts, Programming Timer Interrupts, Programming External hardware Interrupts, Programming the Serial Communication Interrupt, Interrupt Priority in 8051/52.

Ref. MMM: - The 8051 Microcontroller & Embedded Systems by M.A. Mazidi, J.G. Mazidi and R.D. Mckinlay, Second Edition, Pearson

Ref.AVD: - The 8051 Microcontroller

Unit-II

16C61/71 PIC Microcontrollers: Overview and Features, PIC 16C6X/7X, PIC Reset Actions, PIC Oscillator Connections, PIC Memory Organization, PIC 16C6X/7X Instructions, Addressing Modes, I/O Ports, Interrupts in PIC 16C61/71, PIC 16C61/71Timers, PIC 16C71 Analog-to-Digital Converter.

Ref. AVD: - Microcontrollers by Ajay V. Deshmukh, Tata-Mcgraw Hill Publication

Unit-III: PIC 16F8XX Flash Microcontrollers:

Introduction, Pin Diagram, STATUS Register, Power Control Register (PCON), OPTION_REG Register, Program memory, Data memory, I/O Ports

AVD – Ch 10: 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7, 10.10

Capture/Compare/PWM (CCP) Modules in PIC 16F877, Analog-to-Digital Converter
AVD – Ch 11: 11.1, 11.2, 11.5

Ref. AVD: - Microcontrollers by Ajay V. Deshmukh, Tata-Mcgraw Hill Publication

<u>Unit-IV</u>: Interfacing microcontroller/PIC microcontroller and Industrial Applications of microcontrollers:
Light Emitting Diodes (LEDs); Push Buttons, Relays and Latch Connections; Keyboard Interfacing; Interfacing 7-Segment Displays; LCD Interfacing; ADC and DAC Interfacing with 89C51 Microcontrollers.
Introduction and Measurement Applications (For DC motor interfacing and PWM refer Sec 17.3 of MMM)
AVD: Ch.12, Ch.13.
MMM: Sec 17.3

Ref: AVD: - Microcontrollers by Ajay V. Deshmukh, Tata-Mcgraw Hill Publication
Ref. MMM:- The 8051 Microcontroller & Embedded Systems by M.A. Mazidi, J.G. Mazidi and R.D. Mckinlay, Second Edition, Pearson

Additional Reference books:

1. The 8051 Microcontroller & Embedded Systems-Dr. Rajiv Kapadia (Jaico Pub.House)
2. 8051 Micro-controller, K.J.Ayala., Penram International.
3. Design with PIC microcontrollers by John B. Peatman, Pearson Education Asia.
4. Programming & customizing the 8051 microcontroller By Myke Predko, TMH.

<u>Semester-III : Elective Paper-IV</u>
<u>Course no.: PSPHET306: Embedded Systems and RTOS (60 lectures, 4 credits)</u>

<u>Unit-I</u>:
Programming Using C++: Introduction to Computers and programming , Introduction to C++, Expressions and interactivity , Making decisions, Looping , Functions , Arrays , Sorting arrays , Pointers
TG – Ch 1: 1.3 to 1.7 , Ch 2: 2.1 to 2.14, Ch 3: 3.1 to 3.11, Ch 4: 41 to 4.15, Ch 5: 5.1 to 5.13, Ch 6: 6.1 to 6.14, Ch 7: 7.1 to 7.9 , Ch 8: 8.3 , Ch 9: 9.1 to 9.7

Ref. TG: - Starting out with C++ from Control structures through objects, by Tony Gaddis, Sixth edition, Penram International Publications, India

Unit-II:

Introduction to classes: More about classes, Inheritance, polymorphism, virtual functions.

TG – Ch 13: 13.1 to 13.11, Ch 14: 14.1 to 14.5, Ch 15: 15.1 to 15.6

Introduction to VC++

YK – Ch 1, 2, 3

Ref. TG: - Starting out with C++ from Control structures through objects, by Tony Gaddis, Sixth edition Penram International Publications, India

YK: - Introduction to Visual C++ by Yashwant Kanetkar

Unit-III: Embedded systems

Introduction to Embedded Systems: What is an embedded system, Embedded System v/s General Computing System, Classification of Embedded Systems, Major Application Areas of Embedded Systems, Purpose of Embedded Systems, Smart Running Shoes.

SKV – Ch 1: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7

A Typical Embedded system: Core of the embedded system

SKV – Ch 2: 2.1

Characteristics and quality Attributed of Embedded Systems: Characteristics of an Embedded System, Quality Attributes of Embedded Systems

SKV – Ch 3: 3.1, 3.2

Embedded Systems-Application and Domain–Specific: Washing Machine, Automatic-Domain Specific examples of embedded system

SKV – Ch 4: 4.1, 4.2

Design Process and design Examples: Automatic Chocolate Vending machine (ACVM), Smart Card, Digital Camera, Mobile Phone, A Set of Robots

RK - Ch 1: 1.10.2, 1.10.3, 1.10.4, 1.10.5, 1.10.6, 1.10.7

Ref. SKV:- Introduction to embedded systems, by Shibu K. V. ,Sixth Reprint 2012, Tata McGraw Hill

Ref. RK:- “Embedded Systems” Architecture, Programming and Design, by Raj Kamal, Second Edition, The McGraw-Hill Companies

<u>Unit-IV</u>: - **Real –Time Operating System based Embedded System Design:**

Operating system Basics, Types of Operating Systems, Tasks, Process and Threads, Multi-processing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, task Communication, task Synchronizations, Device Drivers, How to choose an RTOS.

SKV: Ch – 10: 10.1, 10.2, 10.3, 10.4, 10.5, 10.6, 10.7, 10.8, 10.9. 10.10

Ref: SKV :- Introduction to embedded systems, by Shibu K. V. ,Sixth Reprint 2012, Tata Mcgraw Hill

Additional references:

1. Object Oriented Programming with C++, By E. Balagurusamy, 2nd ed. TMH.
2. OOPS with C++ from the Foundation, By N. R. Parsa, Dream Tech Press India Ltd.

<u>Semester-III : Elective Paper-III</u>

<u>Course no.: PSPHET307: Signal Modulation and Transmission Techniques, (60 lectures, 4 credits)</u>

<u>Unit I:</u>

Single Sideband Techniques*:* Evolution and description of SSB, Suppression of carrier, Suppression of unwanted sideband, Extensions of SSB, Frequency Modulation: Theory of frequency and phase modulation, Noise and frequency modulation, Generation of frequency modulation. *Radio Receivers:* Receiver types, AM receivers, Communication receivers, FM receivers, Single- sideband receivers, Independent-sideband receivers.

<u>Unit II</u>:

Transmission Line Theory: Fundamental of transmission lines, Different types of transmission lines; Telephone lines and cables, Radio frequency lines, Micro strip transmission lines. Definition of characteristics impedance, Losses in transmission lines, Standing waves, Quarter and Half wavelength lines, Reactance properties of transmission lines, Fundamental of the Smith charts and its applications.

<u>Unit III</u>:

Electromagnetic Radiation and Propagation of Waves: Fundamental of electromagnetic waves, Effects of the environment, Propagation of waves; Ground waves, Sky wave propagation, Space waves, Tropospheric scatter propagation, Extraterrestrial communication

Unit IV:

Antennas: Basic considerations, Wire radiators in space, Terms and definitions, Effects of ground on antennas, Antenna Coupling at medium frequencies, Directional high frequency antennas, UHF and Microwave antennas, Wideband and special purpose antennas

Main References:

[1] Electronic Communication Systems by George Kennedy and Bernard Davis, 4^{th} ed., Tata McGraw-Hill Publishing Company Ltd., New Delhi.

[2] Electronic Communication Systems-*Fundamentals through Advanced* by Wayne Tomasi; 4th Edition, Pearson education Singapore.

Additional References:

[1] Electronic Communications by Dennis Roddy & John Coolen, (4^{th} ed., Pearson Ed.)

[2] Modern Electronic Communication by Gary M. Miller, (6^{th} ed., Prentice Hall International Inc.)

Semester-III : Elective Paper-IV

Course no.: PSPHET308: Microwave Electronics, Radar and Optical Fiber Communication, (60 lectures, 4 credits)

Unit I*:*

Waveguides, Resonators and Components: Rectangular waveguides, Circular and other waveguides, Waveguide coupling, matching and attenuation, Cavity resonators, Auxiliary components.

Unit II:

Microwave Tubes and Circuits*:* Microwave triodes, Multicavity Klystron, Reflex Klystron, Magnetron, Traveling wave tube.

Microwave Semiconductor Devices and Circuits: *Passive* microwave circuits, Transistors and integrated circuits, parametric amplifiers, Tunnel Diodes and Negative Resistance Amplifier, Gunn effect and diodes, Avalanche effects and diodes. PIN Diode, Schottky barrier diode, backward diode.

Microwave Measurements: Slotted line VSWR measurement- Impedance measurement, insertion loss and attenuation measurements

Unit III:

Radar Systems: Basic principles; Fundamentals, Radar performance factors Pulsed systems; Basic pulsed radar system, Antennas and scanning, Display methods, Pulsed radar systems, Moving radar systems. Moving target indication, Radar beacons, CW Doppler radar, Frequency modulated CW radar, Phased array radars, Planar array radars.

Unit IV:

Optical Fiber Communication Systems: Introduction to optical fibers, signal degradation in optical fibers, Fiber optical sources and coupling, Fiber optical receivers, System parameters, Analog optical fiber communication links, Design procedure, Multichannel analog systems, FM/FDM video signal transmission, Digital optical fiber systems.

Main References:

[1] Electronic communication systems by George Kennedy and Bernard Davis, 4^{th} ed., Tata McGraw-Hill Publishing Company Ltd., New Delhi.

[2] Optical Fiber Communication *by Gerd Keiser; McGraw-Hill International, Singapore, 3^{rd} Ed; 2000.*

[3] Electronic Communication Systems Fundamentals through Advanced by Wayne Tomasi; 4th Edition, Pearson education Singapore.

Additional References:

[1] Electronic Communications by Dennis Roddy and John Coolen, (4^{th} ed., Pearson Education).

[2] Modern Electronic Communication by Gary M. Miller, (6^{th} ed., Prentice Hall International, Inc.).

[3] Digital Communications Systems by Harold Kolimbiris, (Pearson Education Asia).

Semester-III : Elective Paper-III

Course no.: PSPHET309: Semiconductors Physics (60 lectures, 4 credits)

(N.B.: Problems form an integral part of the course)

Unit I: Transport Properties of Semiconductors:

The Boltzmann transport equation and its solutions for (i) Electric field alone (ii) Electric and Magnetic fields together. Hall Effect and Magneto resistance (van der Ziel). Scattering mechanism and Relaxation time concept, Transport in high electric fields, hot electrons (Wang), transferred electron effects (Smith). Transport in 2-Dimentional quantum well - (a) High field effects (i) Landau levels, (ii) Shubnikov de Hass effect, (iii) Quantum Hall effect (b) Perpendicular transport - Resonant Tunneling (JS- Art.17.3, 17.6, 17.7, 14.9).

Unit II: Optical Properties of Semiconductors:

Optical properties of Semiconductors: Fundamental absorption, Exciton absorption, Impurity absorption, Free carrier absorption. Radiative recombination. Photoconductivity. Surface recombination (Smith). Optical processes in quantum wells: Interband transitions in quantum wells, Intraband transitions (JS- Art.15.7.2, 15.10)

Unit III: Amorphous & Organic Semiconductors:

Electronic density of states, localization, Transport properties, Optical properties, Hydrogenization of amorphous silicon, Si:H fields effect transistors-design, fabrication and characteristics. Organic semiconductors, Polymers.

Unit IV: Advanced Electronic Materials:

Photovoltaics Fundamentals & Materials, Spintronics materials, Dilute magnetic semiconductors, Magnetites, Giant-magneto resistance. Composites, Glasses, Ceramics, Liquid crystals, Quasicrystals.

Main References:

1. Aldert van der Ziel, Solid State Physical Electronics, 2nd edition, Prentice-Hall, New Delhi, 1971.
2. S.Y. Wang, Introduction to Solid State Electronics, North Holland, 1980,
3. R.A. Smith, Semiconductors, 2nd edition; Cambridge University Press, London, 1978.
4. Jasprit Singh, Physics of Semiconductors and their Heterostructures, McGraw-Hill, New York, 1993.
5. M.H. Brodsky (ed), Topics in Applied Physics Vol.36, Amorphous Semiconductors,
6. S.R. Elliott, Physics of Amorphous Materials, Longman, London, 1983.
7. C.S. Solanki, Solar Photovoltaics-Fundamentals, Technologies and Applications, PHI LPL, New Delhi, 2009.

Additional References:

1. J.I. Pankove, Optical processes in semiconductors,
2. J. Singh, Semiconductors, Optoelectronics, Mc-Graw Hill,

Semester-III : Elective Paper-IV

Course no.: PSPHET310: Thin Film Physics & Technology (60 lectures, 4 credits)

(N.B.: Problems form an integral part of the course)

Unit I: Thin films preparation &Thickness measurement

Methods of Preparation/synthesis of Thin films: Vacuum evaporation, Cathode sputtering, Anodic oxidation, Plasma anodization, Chemical vapour deposition(CVD), Ion-assisted deposition(IAD), Laser ablation, Longmuir Blochet film, Sol-gel film deposition. Thickness measurements: Resistance, capacitance, microbalance, Quartz crystal thickness monitor,Optical absorption, Multiple beam interference, Interference colour, Ellipsometry methods.

Unit II: Thin film Physics

Mechanism of thin film formation: Formation stages of thin films, Condensation and nucleation, Thermodynamic theory of nucleation, Growth and coalescence of islands, Influence of various factors on final structure of thin films, Crystallographic structure of thin films. Properties of thin films: Conductivity of metal films, Electrical properties of semiconductor thin films, Transport in dielectric thin films, Dielectric properties of thin films, Optical properties of thin films. Thin films of high temperature superconductors, Diamond like carbon thin films.

Unit III: Thin films for Devices & other Applications:

Dielectric deposition- silicon dioxide, silicon nitride, silicon oxynitride, polysilicon deposition, metallization, electromigration, silicides. Thin film transistors, thin film multilayers, optical filters, mirrors, sensors and detectors.

Unit IV: Characterization/Analysis of materials and devices:

X-ray diffraction(XRD), Electron diffraction, Transmission electron microscopy (TEM), Scanning electron microscopy(SEM), Energy dispersive analysis of X-rays (EDAX), Low energy electron diffraction (LEED), UV-VIS spectroscopy, Fourier transform infrared (FTIR) spectroscopy, Raman spectroscopy, Electron spin resonance (ESR), X-ray fluorescence (XRF), Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), Scanning tunneling microscopy (STM), Atomic force microscopy (AFM). Ion beam analysis techniques: Rutherford backscattering (RBS), Channeling, Elastic recoil detection analysis (ERDA), Secondary ion mass spectroscopy (SIMS).

Main References:

1. Ludmila Eckertova, Physics of thin films, 2nd Revised edition, Plenum Press, New York, 1986 (Reprinted 1990),
2. K.L. Chopra, Thin film phenomena, Mc-Graw Hill, New York, 1969.
3. L. C. Feldman and J.W. Mayer, Fundamentals of surface and Thin Films Analysis, North Holland, Amsterdam, 1986.
4. S.M. Sze, Semiconductor Devices-Physics and Technology, John Wiley,1985.

Additional References:

1. R.W. Berry, P.M.Hall and M.T. Harris, Thin film technology, Van Nostrand, New Jersey, 1970, K.L.Chopra and LK.Malhotra (ed),
2. Thin Film Technology and Applications, T.M.H. Publishing Co., New Delhi (1984).

Semester-III : Elective Paper-III

Course no.: PSPHET311: Fundamentals of Materials Science, (60 lectures, 4 credits)

Unit I:

Introduction to Materials Science and Engineering, Types of Materials, Competition among Materials, Future trends In Materials Usage, Atomic Structure and Bonding, Types of Atomic and Molecular Bonds, Ionic Bonding, Covalent Bonding, Metallic Bonding, Secondary Bonding, Mixed Bonding, Crystal Structures and Crystal Geometry, The Space Lattice and Unit Cells, Crystal Systems and Bravais Lattices, Principal Metallic Crystal Structures, Atom Positions in Cubic Unit Cells, Directions in Cubic Unit Cells, Miller Indices For Crystallographic Planes In Cubic Unit Cells, Crystallographic Planes and Directions In Hexagonal Unit Cells, Comparison of FCC, HCP, and BCC Crystal Structures, Volume, Planar, and Linear Density Unit Cell Calculations, Polymorphism or Allotropy, Crystal Structure Analysis

Unit II :

Solidification, Crystalline Imperfections, and Diffusion In Solids, Solidification of Metals, Solidification of Single Crystals, Metallic Solid Solutions, Crystalline Imperfections, Rate Processes In Solids, Atomic Diffusion In Solids, Industrial Applications of Diffusion Processes, Effect of Temperature on Diffusion In Solids.

Unit III:

Mechanical Properties of Metals, The Processing of Metals and Alloys, Stress and Strain In Metals, The Tensile Test and The Engineering Stress-Strain Diagram, Hardness and Hardness Testing, Plastic Deformation of Metal Single Crystals, Plastic Deformation of Polycrystalline Metals, Solid-Solution Strengthening of Metals, Recovery and Recrystallization of Plastically Deformed. Metals, Fracture of Metals, Fatigue of Metals, Creep and Stress Rupture of Metals.

Unit IV:

Phase Diagrams, Phase Diagrams of Pure Substances, Gibbs Phase Rule, Binary Isomorphous Alloy Systems, The Lever Rule, Nonequilibrium Solidification of Alloys, Binary Eutectic Alloy Systems, Binary Peritectic Alloy Systems, Binary Monotectic Systems, Invariant Reactions, Phase Diagrams With Intermediate Phases and Compounds, Ternary Phase Diagrams.

Reference:

1. William F Smith, Javad Hashemi, Ravi Prakash, Materials Science and Engineering, Tata-McGraw Hill, 4th Edition.

<u>Semester-III : Elective Paper-IV</u>

<u>Course no.: PSPHET312: Nanoscience and Nanotechnology (60 lectures, 4 credits)</u>

Unit I:

Metal nanoclusters: Magic numbers, Theoretical Modeling of nanoparticles, Geometric Structure, Electronic Structure, Reactivity, Fluctuations, Magnetic clusters, Bulk-to-Nano transition; Semiconducting nanoparticles: Optical properties, Photofragmentation, Coulomb Explosion; Rare-gas and molecular clusters: Inert gas clusters, Superfluid clusters, Molecular clusters, Nanosized Organic crystals; Methods of synthesis: RF plasma, Chemical methods, Thermolysis, Pulsed-Laser method, Synthesis of nanosized organic crystals;

Cohesive Energy: Ionic solids, Defects in Ionic solids, Covalently bonded solids, Organic crystals, Inert-gas solids, Metals, Conclusion;

Quantum wells, wires and dots: Fabricating Quantum Nanostructures: Solution fabrication, Lithography; Size and dimensionality effects: Size effects, Size effects on conduction electrons, Conduction electrons and dimensionality, Fermi gas and density of states, Potential wells, Partial confinement, Properties dependent on density of states; Excitons, Single electron Tunneling; Applications: Infrared detectors, Quantum dot lasers.

(Owens and Poole: Chapter 3, 6 and 9)

Unit II:

Vibrational Properties: The finite One-dimensional monoatomic lattice, Ionic solids, Experimental Observations: Optical and acoustical modes; Vibrational spectroscopy of surface layers of nanoparticles – Raman spectroscopy of surface layers, Infrared Spectroscopy of surface layers; Photon confinement, Effect of dimension on lattice vibrations, Effect of dimension on vibrational density of states, effect of size on Debye frequency, Melting temperature, Specific heat, Plasmons, Surface-enhanced Raman Spectroscopy, Phase transitions.

Electronic Properties: Ionic solids, Covalently bonded solids; Metals: Effect of lattice parameter on electronic structure, Free electron model, The Tight-Binding model; Measurements of electronic structure of nanoparticles: Semiconducting nanoparticles, Organic solids, Metals.

Carbon nanostructures: Introduction; Carbon molecules: Nature of the carbon bond, New Carbon structures; Carbon clusters: Small Carbon clusters, Buckyball, The structure of molecular C_{60}, Crystalline C_{60}, Larger and smaller Buckyballs, Buckyballs of other atoms; Carbon nanotubes: Fabrication, Structure, Electronic properties, Vibrational properties, Functionalization, Doped Carbon Nanotubes, Mechanical properties; Nanotube Composites: Polymer-carbon nanotube composites, Metal-Carbon nanotube composites; Graphene nanostructures.

(Owens and Poole: Chapter 7, 8 and 10)

Unit III:

Mechanical Properties of Nanostructured Materials : Stress-Strain Behavior of materials; Failure Mechanism of Conventional Grain-Sized Materials; Mechanical Properties of Consolidated Nano-Grained Materials; Nanostructured Multilayers; Mechanical and Dynamical Properties of Nanosized Devices : General considerations, Nanopendulum, Vibrations of a Nanometer String, The Nanospring, The Clamped Beam, The challenges and Possibilities of Nanomechanical sensors, Methods of Fabrication of Nanosized Devices.

Magnetism in Nanostructures : Basics of Ferromagnetism; Behavior of Powders of Ferromagnetic Nanoparticles : Properties of a single Ferromagnetic Nanoparticles, Dynamic of Individual Magnetic Nanoparticles, Measurements of Superparamagnetism and the Blocking Temperature, Nanopore Containment of Magnetic Particles; Ferrofluids; Bulk nanostructured Magnetic Materials: Effect of nanosized grain structure on magnetic properties, Magnetoresisitive materials, Carbon nanostructured ferromagnets; Antiferromagnetic nanoparticles.

Nanoelectronics: N and P doping and PN junctions, MOSFET, Scaling of MOSFETs; **Spintronics:** Definition and examples of spintronic devices, Magnetic storage and spin valves, Dilute magnetic semiconductors; Molecular switches and electronics: Molecular switches, Molecular electronics, Mechanism of conduction through a molecule; Photonic crystals.
(Owens and Poole: Chapter 12, 13 and 14)

Unit IV:

An introduction to nanochemistry concepts: Nanochemistry introduction, Surface, Size, Shape, Self-assembly, Defects, The bio-nano interface, Safety.

Gold: Introduction, Surface, Size, Shape, Self-assembly, Defects, Bio-nano, Gold-Nanofood for thought.

Cadmium Selenide: Introduction, Surface, Size, Shape, Self-assembly, Defects, Bio-nano, CdSe-Nanofood for thought.

Iron Oxide: Introduction, Surface, Size, Shape, Self-assembly, Bio-nano, Iron Oxide-Nanofood for thought.

Carbon: Introduction, Surface, Size, Shape, Self-assembly, Bio-nano, Conclusion, Carbon-Nanofood for thought.
(Cademartiri and Ozin: Chapter 1, 3, 5, 6, and 7)

References:

1. The Physics and Chemistry of Nanosolids, *Frank J. Owens and Charles P. Poole,* Wiley-Interscience, 2008.

2. Concepts of Nanochemistry, *Ludovico Cademartiri and Geoffrey A. Ozin,* Wiley-VCH, 2009.

Semester-III : Elective Paper-III
Course no.: PSPHET313: Galactic and Extra-Galactic Astronomy (60 lectures, 4 credits)

Unit I:

Galactic Astronomy: Galactic structure: Nucleus, Bulge, Disk and Corona Morphology of Galaxies: Dwarfs, Ellipticals, Spirals and Irregulars Rotation Curves: Dark Matter Interstellar Medium and Molecular Complexes: Star formation. Metal Content, Initial Mass Function. Distribution and dynamics of Stars Stellar groups: Galactic and Globular clusters and their ages. Spiral arms and magnetic fields Dynamical and chemical evolution of galaxies: Interactions and mergers.

Unit II:

Extragalactic Astronomy: Classification of Galaxies: Hubble sequence. Groups and Clusters of Galaxies: Missing mass (M/L) Intergalactic Medium: Diffuse Radiation and Magnetic Fields. Optical and X-ray observations: Cooling flows, Sunyaev-Zeldovich effect. Superclusters, Filaments, Voids, Walls Radio Sources. Faraday Rotation. Active Galactic Nuclei. Seyferts, BL Lacs and Quasars: Unified Models Gravitational Lenses.

Unit III:

Introduction to General Theory of Relativity

Einstein's field eqns. (qualitative) FRW metric.

Unit IV:

Cosmology

Hubble law for Expanding Universe Age & distance scale in cosmology. Cosmological Parameters. Early Universe: Thermal history & Nucleosynthesis of light elements. Structure formation, Cosmic Microwave Background Radiation: Observations & Inferences.

Main Texts / References:

1. A. Unsold and B Beschek., The New Cosmos, 4th ed.; Springer Verlag 1991.
2. P.V. Ramanmurthy and A.W. Wolfendale, Gamma Ray Astronomy; CUP, 1986.
3. J.V. Narlikar, Introduction to Cosmology; CUP, 1993.
4. G.B. Rybicki & A.P. Lightman, Radiative Processes in Astrophysics; Wiley Intl. 1979.
5. P.J.E. Peebles, Principles of Physical Cosmology; Princeton University Press, 1993.

Semester-III : Elective Paper-IV

Course no.: PSPHET314: Plasma Physics, (60 lectures, 4 credits)

Unit I:

Definition of Plasma, occurrence of plasma, Debye shielding, plasma parameters, criterion for plasma, (FC, JB, KT)

Single particle motion in uniform E and B fields, time varying E field, time varying B field, magnetic mirrors, Adiabatic invariants (FC, JB)

Transport phenomenon, Binary Coulomb collision, multiple Coulomb collisions, Lorentz model of weakly ionized plasma, Diffusion and mobility in weakly ionized gases, collision and diffusion parameters, ambipolar diffusion, diffusion in slab, steady state solutions, recombination, plasma resistivity. Bohm diffusion. (FC, KT)

Unit II:

Plasma Kinetic Theory and Vlasov equation: Introduction to plasma kinetic theory, zeroth order equations Vlasov equation. Equilibrium solutions electrostatic waves, Landau contour, landau damping. Wave energy. Physics of Landau damping, Nyquist method and Penrose criteria, plasma heating in laboratory devices. Stability theory, two stream instability, fire hose instability, flute instability, mirror instability. Rayleigh Taylor instability. Ionospheric irregularities. (DN, KT, JB)

Unit III:

Langmuir waves, dielectric function, electromagnetic waves. Upper hybrid waves, electrostatic ion waves. Electromagnetic waves in magnetized plasmas, electromagnetic waves along Bo Alfven waves, fast magneto sonic waves. Drift waves magnetosphere of the Earth. (DN, CF)

Derivation of fluid equations from the Vlasov equation, Single fluid equation, Introduction to MHD equilibrium. MHD stability, Resistive diffusion. Alfven waves, magneto acoustic waves, electromagnetic waves. (DN, JB, KT)

Unit IV:

Plasma production and diagnostics: Various plasma production techniques, Electrical breakdown in gases using dc. rf, microwave and high frequency fields Glow and arc discharge. (IH, JR)

Plasma diagnostics, electrostatic probe, Magnetic probes, spectroscopic diagnostics, active and passive techniques, interferometry techniques. (IH)

Low temperature plasma applications: plasma processing of materials: Physics of high and low pressure plasma sours and applications to materials processing. Brief review of plasma etching, PECVD, display, radiation sources, plasma source ion implantation. Plasma cutting, melting, spraying and waste processing. Applications to nuclear, space and semiconductor industries. (IH)

High temperature plasma applications, controlled thermonuclear fusion, Introduction to thermonuclear fusion, fusion reactions, cross sections, radiative processes in plasmas, energy loss, Lawson criterion, break even and ignition, magnetic and inertial confinement scheme and devices, emission of X rays and neutrons, fusion plasma diagnostics. (DM, ST)

Main References:

1. Francis F. Chen, Introduction to Plasma Physics and Controlled Fusion Volume 1 Springer (FC)
2. J. A. Bittencourt, Fundamentals of Plasma Physics, Springer, 3rd edition (JB)
3. N. A. Krall and A.W. Trivelpiece, Principles of plasma physics, Mc GrawHill (KT)
4. I R. Hutchinson, Principles of plasma Diagnostics, Cambridge university Press, 2nd edition (IH)
5. D. Nicholson, Introduction to plasma theory, Wiley, (DN)
6. J Reece Roth, Industrial Plasma Engineering, IOP Publications. 2000 (JR)
7. Inertial Confinement fusion, J.J. Dudesrstadt and G.A. Mosses, Wiley (1982) (DM)

8. Fusion An introduction to the Physics and Technology of Magnetic Confinement Fusion, W. M. Stacy, Wiley (1984) (ST)

Additional References:

1. An introduction to plasma Physics. R. R. Goldston & P. H Rutherford
2. Plasma Physics - An introduction. R. Dendy,
3. The physics of lasers plasma & interactions. W. L. Kruer, Addison-Wesley, 1988

Semester-III : Elective Paper-III
Course no.: PSPHET315: Group Theory (60 lectures, 4 credits)

UNIT I: FINITE GROUPS AND THEIR REPRESENTATIONS (12 LECTURES + 3 TUTORIALS)

1. Finite Groups

Group axioms, Finite groups of low order, Cyclic Groups, Permutation Groups ,
Basic Concepts- Conjugation, Normal Subgroups, Quotient Group, Simple Groups, Semi-direct product, Young Tableaux

2. Group Representations

Introduction, Reducible and Irreducible Representations, Schur's Lemmas, Great Orthogonality Theorem, Character Tables, Examples.

UNIT II: LIE GROUPS (11 LECTURES + 4 TUTORIALS)

1. Lie Groups and Lie Algebras
   Introduction to Lie groups and Lie algebras- Roots and Weights, Lie Algebras of matrix Lie groups
2. Representation Theory for Lie Groups/Algebras
   Representations of Lie groups and Lie Algebras, Adjoint representation, Representations of disconnected Lie groups, Direct product of representations of a Lie Group, The groups O(3) and SO(3) as examples.

UNIT III: GROUP THEORY APPLICATIONS IN NON-RELATIVISTIC QUANTUM MECHANICS (11 LECTURES + 4 TUTORIALS)

1. Rotation Group and Angular Momentum
   Angular Momentum algebra, , Addition of angular momenta uncoupled and coupled representation. Clebsch – Gordon coefficients and their simple properties(For revision

purpose only). Spin ½, Matrix Representations ,The rotation operators and rotation matrices, spin angular momentum and its wavefunction, Representations of the rotation group, irreducible tensor operators, The Wigner – Eckart theorem,

2. Applications in Solid State Physics
   Point and Space Groups, Stereographic projections of simple crystallographic point groups, Crystal field splittings of atomic energy levels.

UNIT IV: GROUP THEORY APPLICATIONS IN RELATIVISTIC QUANTUM MECHANICS (11 LECTURES + 4 TUTORIALS)

1. Lorentz Group and its Representations
   Space –time symmetries, Lorentz and Poincare group, Conformal group.
2. Unitary Groups and Unitary Symmetries
   SU(2) and Isospin, SU(3), GellMann matrices, Weights and roots of SU(3), Fundamental representations of SU(3).

Suggested reading:

1. *Group theory*, *and its applications to Physical Problems*, by M. Hamermesh(Addison-Wesley, 1962)
2. *Lie Algebras in Particle Physics*, by Howard Georgi (Westview, 1995)
3. *Group theory* :*A Physicist's Survey,* by Pierre Ramond (Cambridge University Press, 2010)
4. *Elements of Group Theory for Physicists*, by A.W.Joshi *(New Age International, 1997)*
5. *Group Theory in Physics*, by W.K.Tung *(World Scientific 1989)*

Semester-III : Elective Paper-IV

Course no.: PSPHET316: Applied Thermodynamics (60 lectures, 4 credits)

Unit I

First Law of Thermodynamics: Energy, enthalpy, specific heats, first law applied to systems and control volumes, steady and unsteady flow analysis.

Second Law of Thermodynamics: Kelvin-Planck and Clausius statements, reversible and irreversible processes, Carnot theorems, thermodynamic temperature scale, Clausius inequality and concept of entropy, principle of increase of entropy; availability and irreversibility.

Zeroth Law of Thermodynamics: concept of temperature, Overview of techniques in low temperature production

Unit II

Properties of Pure Substances: Thermodynamic properties of pure substances in solid, liquid and vapor phases, P-V-T behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, equations of state, compressibility chart. **Thermodynamic Relations:** T-ds relations, Maxwell equations,Liquefaction of gases: Joule-Thomson effect, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron equation.

Unit III

Equilibrium Concept in Thermodynamics Unary, binary and multicomponent systems, phase equilibria, evolution of phase diagrams, metastable phase diagrams, calculation of phase diagrams, thermodynamics of defects. solution models, **Some Thermodynamic cycles:** Carnot vapor power cycle, Ideal Rankine cycle, Rankine Reheat cycle, Otto cycle, Diesel cycle,

Unit IV

Thermodynamics of Phase transformation and Heterogeneous Systems:

Melting and solidification, precipitation, eutectoid, massive, spinodal, martensitic, order disorder transformations and glass transition. First and second order transitions..Equilibrium Constants and Ellingham diagrams

References:

1. M. Modell and R.C. Reid, Thermodynamics and its Applications, Prentice-Hall, Englewood Cliffs, New Jersey, 1983.
2. H.B. Callen, Thermodynamics and an Introduction to Thermostatics, Jonh Wiley & Sons, New York, 1985.
3. R.T. DeHoff, Thermodynamics in Materials Science, McGraw-Hill, Singapore,
4. Physical Chemistry of Metals: L.S. Darken and R.W. Gurry
5. Thermodynamics of Solids: R.A. Swalin
6. Phase Transformations in Metals and Alloys: D.A. Porter and K.E. Easterling
7. Principles of Extractive Metallurgy: H.S. Ray

Semester-III : Elective Paper-IV

Course no.: PSPHET317: Quantum Field Theory, (60 lectures, 4 credits)

UNIT I: Relativistic Wave Equations and Classical Fields (12 lectures + 3 tutorials)

1. Klein Gordon equation

Relativistic energy-momentum relation, Klein-Gordon equation, solutions of the equation, probability conservation problem, relation with negative energy states.

2. Dirac equation

   Dirac equation, algebra of ⍰ matrices, conservation of probability, solutions of Dirac equation, helicity and chirality, Lorentz covariance, bilinear covariants, trace relations and similar identities.

3. Dynamics of a solid

   The linear atomic chain as a system of coupled oscillators, periodic boundary conditions, normal modes, continuum limit, Lagrangian and Hamiltonian density, Euler-Lagrange equations for fields, extension to two and three dimensions, velocity of sound.

4. Free fields

   Lagrangian formulation for the Schrödinger, Dirac and Klein-Gordon fields, Nöther's theorem, global gauge symmetries and associated Nöther currents.

UNIT II: Canonical Quantisation of Free Fields (11 lectures + 4 tutorials)

5. Quantisation of solids

   Quantisation of the linear chain, creation and annihilation operators, phonons, occupation number representation, extension to two and three dimensions, polarisation vectors.

6. Quantisation of the Schrödinger field

   Expansion of the Schrödinger field in terms of eigenstates of the single particle wave equation, creation and annihilation operators, number operator, occupation number representation, Slater determinant.

7. Quantisation of Relativistic fields

   Quantisation of the scalar field, positive and negative energy solutions, expansion in terms of creation and annihilation operators, antiparticles, eigenvalues of energy and charge.

   Quantisation of the Dirac field along same lines as quantisation of the scalar field.

   Quantisation of the electromagnetic field using Hamiltonian method, gauge invariance, modification of the commutation relation.

UNIT III: Interacting Fields and Feynman Diagrams (11 lectures + 4 tutorials)

8. Dyson formulation for scattering: S matrix

   Interaction picture, time evolution operator, Dyson expansion and S matrix, transition matrix, relation to Fermi's golden rule.

9. Wick expansion and contractions

   Normal-ordered product, time-ordered product and contractions, Wick's theorem for the Schrödinger, Dirac and Klein-Gordon fields,

10. Feynman diagrams and Feynman rules
    diagrammatic representation, tree and loop diagrams, Feynman rules from the Wick expansion.

UNIT IV: QUANTUM ELECTRODYNAMICS (11 LECTURES + 4 TUTORIALS)

11. The QED Lagrangian
    Structure of the QED Lagrangian, gauge invariance and conserved current, Feynman rules for QED, scalar electrodynamics.
12. Basic Processes in QED
    Feynman diagram calculation for $e^+e^- \rightarrow \mu^+\mu^-$, phase space integration, Møller and Bhabha scattering, polarisation vectors, Compton scattering and pair creation/annihilation, Klein-Nishina formula.
13. Loops and Renormalisation in QED
    Loop diagrams: bubble, triangle and box, Ward identity for QED, UV and IR divergences, cutoff regularisation, on-shell renormalisation of mass, wavefunction and charge, BPH renormalisation, counterterms, renormalisation group, running coupling constant.

Suggested reading:

1. *Relativistic Quantum Mechanics and Fiekd Theory,* by Franz Gross(Wiley-VCH Verlag GmbH & Co. KgaA, Weinheim, 2004)
2. *A First Book of Quantum Field Theory*, by A. Lahiri and P.B. Pal (CRC Press, 2005)
3. *An Intro. to Quantum Field Theory*, by M.E. Peskin and D.V. Schroeder (Perseus, 1995)
4. *Quantum Field Theory*, by C. Itzykson and J.-B. Zuber (McGraw-Hill, 1980)

M.Sc. (Physics) Practical Lab Course

Semester –III

<u>Semester III Elective Lab Course-1</u>

<u>Course no.: PSPHAP302: Advanced Physics Lab-1 (120 hours, 4 credits)</u>

A) <u>For Students offering electives other than PSPH305, 306, 307, 308 (i.e. Electronics I or Electronics II), have to perform at least 10 experiments from the following</u>

I. X-ray Powder Diffraction – (4-5 experiments/ analysis of given data)
   1. Structure determination of powder polycrystalline sample
   2. Intensity analysis of XRD peaks
   3. Strain analysis and Particle size determination by XRD
   4. XRD Studies of Thin Films: Phase determination by JCPDS

II. Hall Effect
   1. AC & DC effect in given semiconducting specimen
   2. AC & DC effect at different temperatures and determination of carrier mobility

3. Calibration of unknown magnetic field using a Hall probe

III. Thermometry –
1. Measurement of thermo-emf of Iron-Copper (Fe-Cu) or chromel-alumel thermocouple as a function of temperature.
2. Voltage-Temperature characteristics of a Silicon diode sensor

IV. Dielectric Constant using LCR bridge
1. Determination of Transition Temperature of a Ferroelectric Material
2. Determination of Dielectric constant and studying its frequency dependence

V. LASER
1. Measurement of laser parameters.
2. Laser interferometer to find the wavelength.

VI. Plasma
1. Measurement of critical spark voltage at different separation at a constant pressure.
2. Measurement of plasma parameters. - Double probe method at constant pressure.

VII. Nuclear Physics
1. Mass absorption Coefficient of Beta rays and energy range calculation.
2. Understanding of Poisson distribution and Gaussian distribution.
3. Calculation of rest mass of electron using Compton scattering experiment.
4. Understanding of Surface barrier detector
5. Relative efficiency of beta and gamma rays using GM counter and feather comparison method to find range of unknown beta source.

VIII. Semiconductors and devices
1. Resistivity of Ge sample by van der Pauw method at different temp and determination of band gap
2. Optical transmission and absorption studies of elemental/ compound semiconductors
3. Band gap of semiconductors by photoconductivity
4. I-V measurements of Ge, Si, GaAs diodes at room temp, identification of different regions, determination of ideality factor
5. Carrier lifetime by light pulse method

IX. Vacuum techniques and thin films
1. Pump-down characteristics: pumping speed of rotary and diffusion pump at constant volume
2. Pumping speed of rotary and diffusion pump at constant volume
3. Vacuum evaporation method of thin film preparation and estimation of sheet resistance

4. Measurement of thickness of vacuum evaporated thin films by gravimetric method and by interferometry (Tolansky)

X. Computation

1. Least squares fit / curve-fitting
2. Interpolation

XI. Microscopy

1. Texture determination by polarizing microscopy

XII. Astronomy and Space Physics

1. Image processing in Astronomy: Use of one of the standard software packages like IRAF / MIDAS. Aperture photometry using the given observational data. Seeing profile of a star.
2. CCD: Characteristics of a CCD camera. Differential photometry of a star w.r.t. a standard star.

B) **The Students offering electives PSPH305, PSPH306. (i.e. Electronics I) have to perform at least 10 experiments from the following:**

I Interfacing 8031/8051 based experiments:

1. Interfacing 8 bit DAC with 8031/51 to generate waveforms: square, sawtooth, triangular.
2. Interfacing stepper motor with 8031/51: to control direction, speed and number of steps.
3. Interface 8-bit ADC (0804) with 8031/51: to convert an analog signal into its binary equivalent.

II Microcontroller 8031/8051 based experiments:

1. 8031/51 assembly language programming:
   Simple data manipulation programs.(8/16-bit addition, subtraction, multiplication, division, 8/16 bit data transfer, cubes of nos., to rotate a 32- bit number, finding greatest/smallest number from a block of data, decimal / hexadecimal counter)

2. Study of IN and OUT port of 8031/51 by Interfacing switches, LEDs and Relays: to display bit pattern on LED's, to count the number of "ON" switches and display on LED's, to trip a relay depending on the logic condition of switches, event counter(using LDR and light source)
3. Study of external interrupts (INT0/INT1) of 8031/51.
4. Study of internal timer and counter in 8031/51.

III (16F84 or 16FXXX) PIC Micro-controller based experiments (Using assembly language only):

1. Interfacing LED's: flashing LED's, to display bit pattern, 8-bit counter.

2. Interfacing Push Buttons: to increment and decrement the count value at the output by recognizing of push buttons, etc

3. Interfacing Relay: to drive an ac bulb through a relay; the relay should be tripped on recognizing of a push button.

4. Interfacing buzzer: the buzzer should be activated for two different frequencies, depending on recognizing of corresponding push buttons.

IV C++ and Visual C++ experiments:

1. C++ Program (Conversion from decimal system to binary, octal, hexadecimal system).
2. C++ Program (Program on mean, variance, standard deviation for a set of numbers.
3. C++ Program (Sorting of data in ascending or descending order).
4. C++ experiment (Programs on class, traffic lights)
5. C++ experiment (Programs on inheritance, over loading)
6. Visual C++ experiment

V Computation

1. Least squares fit / curve-fitting
2. Interpolation

C) The Students offering electives PSPH307, PSPH308 (i.e. Electronics II), have to perform at least 10 experiments from the following:

I Electronics Communication:

1. Generation of AM signal using OTA IC CA3080/op-amp and demodulation using diode demodulator.
2. Balanced modulator and demodulator - study of suppressed carrier AM generation using IC 1496/1596.
3. Generation of FM signal using IC 566/XR 2206
4. Characteristics of PLL IC 565/4046.
5. Frequency multiplication using PLL IC 565/4046.
6. FM modulator and demodulator using PLL IC 565/4046.

7. Loss measurements and numerical aperture in optical fiber.
8. Linear control system using fiber optical communication method.
9. Telemetry using optical fiber system.
10. Study of reflex Klystron modes using X-band and oscilloscope.
11. Study of propagation characteristics in a waveguide.
12. Simulation of radiation patterns of various antennas.

II Computation

1. Least squares fit / curve-fitting
2. Interpolation

References:

(i) Op-amp and linear ICs by Ramakant Gayakwad (3rd ed. 1993, Prentice Hall of India).

(ii) Modern Electronic Communication by Gary M. Miller (6th ed., 1999, Prentice Hall International, Inc.).

(iii) Op-amp and linear integrated circuits by Coughlin and Driscoll (4th ed. 1992, Prentice Hall of India).

(iv) Integrate Circuits by K. R. Botkar (8th ed., Khanna Publishers, Delhi).

(v) Design with Operational Amplifiers and Analog Integrated Circuits by Sergio Franco (3rd ed., Tata McGraw Hill).

(vi) Analog and Digital Communication Systems by Martin S. Roden (5th ed., Shroff Publishers and Distributors Pvt. Ltd.).

(vii) Microwaves by K. C. Gupta (New Age International Ltd.).

(viii) Electronic Communications by Dennis Roddy and John Coolen (4th ed., Pearson Education).

(ix) Basic microwave techniques and laboratory manual by M. L. Sisodia and G. S. Raghuvanshi (Wiley Eastern Ltd. 1987.).

(x) Electronic communication systems by George Kennedy and Bernard Davis (4th ed., Tata McGraw Hill Publishing Company Ltd., New Delhi).

(xi) Digital communication systems by Harold Kolimbiris (Pearson Education Asia).

(xii) Optical fiber communication by G. Keiser (3rd ed., McGraw Hill).

(xiii) Digital signal processing demystified by James D. Broesch (Penram International Publications, India).

(xiv) The indispensable PC hardware book - Hans-Peter Messmer, Addison Wesley (PEA).

(xv) Parallel port complete by Jan Axelson, (Penram International Publications, India).

(xvi) Serial port complete by Jan Axelson, (Penram International Publications, India).

(xvii) 8031/8051 Manuel Provided by the manufacturers

(xviii) **.** AVD: - Microcontrollers by Ajay V. Deshmukh, Tata-Mcgraw Hill Publication

(xix) The 8051 Microcontroller & Embedded Systems by M.A. Mazidi, J.G. Mazidi and R.D. Mckinlay, Second Edition, Pearson

(xx) Starting out with C++ from Control structures through objects, by Tony Gaddis, Sixth edition, Penram International Publications, India

(xxi) Object Oriented Programming with C++, By E. Balagurusamy, 2nd ed. TMH.

Note:

1. Journal should be certified by the laboratory in-charge only if the student performs satisfactorily the minimum number of experiments as stipulated above. Such students, who do not have certified journals, will not be allowed to appear for the practical examinations.

M.Sc. (Physics) Theory Courses
Semester –IV

Semester-IV : Paper-I:
Course no: PSPH401 Experimental Physics (60 hours 4 Credits)

Unit-I

Data Analysis for Physical Sciences: Population and Sample, Data distributions Probability, Probability Distribution, Distribution of Real Data, The normal distribution, The normal distribution, From area under a normal curve to an interval, Distribution of sample means, The central limit theorem, The t distribution, The log-normal distribution, Assessing the normality of data, Population mean and continuous distributions, Population mean and expectation value, The binomial distribution The Poisson distribution, Experimental Error, Measurement, error and uncertainty, The process of measurement, True value and error, Precision and accuracy, Random and systematic errors, Random errors, Uncertainty in measurement, Combining uncertainties, Expanded uncertainty, Relative standard uncertainty, Coping with outliers, Weighted mean , Least squares, The equation of a straight line, Excel's LINESTQ function, Using the line of best fit, Fitting a straight line to data when random errors are confined to the x quantity, Linear correlation coefficient, Residuals, Data rejection, Transforming data for least squares analysis, Weighted least squares, Tests of significance, Hypothesis testing, Comparing x with ⍰$_0$when sample sizes are small Significance testing for least squares parameters Comparison of the means of two samples Comparing variances using the F test Comparing expected and observed frequencies using the %2 test Analysis of variance

Main Reference: Data Analysis for Physical Sciences (Featuring Excel®) Les Kirkup, 2nd Edition, Cambridge University Press (2012), Chapters 1-6 and 9

Additional Reference: Statistical Methods in Practice for scientists ad Technologists, Richard Boddy and Gordon Smith, John Wiley & Sons (2009)

Internal tests will be of solving problems using Excel.

Unit II

Vacuum Techniques: Fundamental processes at low pressures, Mean Free Path, Time to form monolayer, Number density, Materials used at low pressurs, vapour pressure Impingement rate, Flow of gases, Laminar and turbulent flow, Production of low pressures; High Vacuum

Pumps and systems, Ultra High Vacuum Pumps and System, Measurement of pressure, Leak detections (9 Lectures)

References:

I. Vacuum Technology, A. Roth, North Holland Amsterdam
II. Ultra High Vacuum Techniques, D. K. Avasthi, A. Tripathi, A. C. Gupta, Allied Publishers Pvt. Ltd (2002)
III. Vacuum Science and Technology, V. V. Rao, T. B. Ghosh, K. L. Chopra, Allied Publishers Pvt. Ltd (2001)

Instruments and Techniques: Instrumentation for UV-visible spectrophotometer, Fourier Transform IR technique, (3 Lectures)

Reference: Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler, and Stanley R. Crouch, Brooks/Cole Pub Co, 6th edition

Unit III

Nuclear Detectors: Gas Detector with emphasis on GM counter, NaI Scintillation Detector, Gamma ray spectrometer using NaI scintillation detector

Acclerators: Cockroft Walten Generator, Van de Graaf Generator, Sloan and Lawrence type Linear Accelerator, Proton Linear Accelerator, Cyclotron, Synchrotron

References

I. Nuclear Radiation Detection- William James Price , McGraw Hill
II. Techniques for Nuclear and Particle Physics Experiments, W.R. Leo, Springer- Verlag
III. Radiation Detection and Measurement, Glenn F. Knoll, John Wiley and sons, Inc.
IV. Particle Accelerators, Livingston, M. S.; Blewett, J.
V. Introduction to Nuclear Physics, HA Enge, pp 345-353
VI. Electricity & Magnetism and Atomic Physics Vol. II, J. Yarwood
VII. Principles of Particle Accelerators, E. Persico, E. Ferrari, S.E. Segre

Unit IV

Characterization techniques for materials analysis: UV Visible spectroscopy, FTIR spectroscopy, Raman Spectroscopy, Mossbauer Spectroscopy, RBS, XRD, XRF, SEM, EDAX, TEM, XPS

References:

i. An Introduction to Materials Characterization, Khangaonkar P. R., Penram International Publishing

ii. Mössbauer Effect: Principles and Applications, G. K. Wertheim, Academic Press (1964),
iii. Fundamentals of Molecular Spectroscopy, C. N. Banwell, Tata-McGraw Hill
iv. Rutherford Backscattering Spectrometry, W. K. Chu, J. W. Mayer, M. A. Nicolet, Academic Press
v. A Guide to Materials Characterization and Chemical Analysis, John P. Sibilia, Wiley-VCH; 2 edition
vi. Fundamentals of Surface and Thin Film Analysis, L.C. Feldman and J.W. Mayer North Holland amsterdam
vii. Elements of X-ray diffraction, Cullity, B. D Addison-Wesley Publishing Company, Inc.

Semester-IV : Paper-II:
Course no: PSPH402 Atomic and Molecular Physics (60 hours 4 Credits)

Unit I:

Review* of one-electron eigenfunctions and energy levels of bound states, Probability density, Virial theorem. (1 lecture)

Fine structure of hydrogenic atoms, Lamb shift. Hyperfine structure and isotope shift. (ER 8-6) (2 lecture)

Linear and quadratic Stark effect in spherical polar coordinates. Zeeman effect in strong and weak fields, Paschen-Back effect. (BJ, GW) (5 lectures)

Schrodinger equation for two electron atoms: Identical particles, The Exclusion Principle. Exchange forces and the helium atom (ER), independent particle model, ground and excited states of two electron atoms. (BJ) (4 lectures)

Unit II

The central field, Thomas-Fermi potential, the gross structure of alkalis (GW). The Hartree theory, ground state of multi-electron atoms and the periodic table (ER), The L-S coupling approximation, allowed terms in LS coupling, fine structure in LS coupling, relative intensities in LS coupling, j-j coupling approximation and other types of coupling (GW) (12 lectures)

Unit III:

Interaction of one electron atoms with electromagnetic radiation: Electromagnetic radiation and its interaction with charged particles, absorption and emission transition rates, dipole approximation. Einstein coefficients, selection rules. Line intensities and life times of excited state, line shapes and line widths. X-ray spectra. (BJ) (12 lectures)

Unit IV:

Born-Oppenheimer approximation - rotational, vibrational and electronic energy levels of diatomic molecules, Linear combination of atomic orbitals (LCAO)and Valence bond (VB) approximations, comparison of valence bond and molecular orbital theories (4 lectures) (GA, IL)

A) Rotation of molecules: rotational energy levels of rigid and non-rigid diatomic molecules, classification of molecules, linear, spherical, symmetric and asymmetric tops. **B)** Vibration of molecules: vibrational energy levels of diatomic molecules, simple harmonic and anharmonic oscillators, diatomic vibrating rotator and vibrational-rotational spectra. **c)** Electronic spectra of diatomic molecules: vibrational and rotational structure of electronic spectra.(4 lectures) (GA, IL)

Quantum theory of Raman effect, Pure rotational Raman spectra, Vibrational Raman spectra, Polarization of light and the Raman effect, Applications (2 lectures)

General theory of Nuclear Magnetic Resonance (NMR). NMR spectrometer, Principle of Electron spin resonance ESR. ESR spectrometer(2 lectures). (GA, IL)

(*Mathematical details can be found in BJ. The students are expected to be acquainted with them but not examined in these.)

Reference:

1. Robert Eisberg and Robert Resnick, Quantum physics of Atoms, Molecules, Solids, Nuclei and Particles, John Wiley & Sons, 2nd ed, (ER)
2. B.H. Bransden and G. J. Joachain, Physics of atoms and molecules, Pearson Education 2nd ed, 2004 (BJ)
3. G. K. Woodgate, Elementary Atomic Structure, Oxford university press, 2nd ed, (GW).
4. G. Aruldhas, Molecular structure and spectroscopy, Prentice Hall of India 2nd ed, 2002 (GA)
5. Ira N. Levine, Quantum Chemistry, Pearson Education, 5th edition, 2003 (IL)

Additional reference:

1. Leighton, Principals of Modern Physics, McGraw hill
2. Igor I. Sobelman, Theory of Atomic Spectra, Alpha Science International Ltd. 2006
3. C. N. Banwell, Fundamentals of molecular spectroscopy, Tata McGraw-Hill, 3rd ed
4. Wolfgang Demtröder, Atoms, molecules & photons, Springer-Verlag 2006
5. Sune Svanberg, Atomic and Molecular Spectroscopy Springer, 3rd ed 2004
6. C.J. Foot, Atomic Physics, Oxford University Press, 2005 (CF)

Semester-IV : Elective Paper-III
Course no.: PSPHET401: Experimental Techniques In Nuclear Physics (60 lectures, 4 credits)

UNIT I: (12 lectures + 3 Tutorials)
Radiation sources: electrons, heavy charged particles, neutrons, neutrinos, and electromagnetic radiation. Charge particle interaction: Stopping power, energy loss and range straggling, scaling laws, bremsstrahlung, Cherenkov radiation. Interaction of photons: photoelectric effect, Compton scattering, pair production. Slow and fast neutron cross-sections, neutrino interactions, Radiation exposure and dose, Biological effects, Radiation safety in Nuclear Physics Laboratory.

UNIT II : (11 lectures + 4 tutorials)
Characteristics of Probability Distributions, The binomial Distributions, The Poisson Distribution, The Gaussian Distribution, Measurement of errors: systematic errors, Random errors. Error propagation General Characteristics of Detectors: detector response and sensitivity, energy resolution, timing characteristics, dead time, detection efficiency. Modes of detector operation.

UNIT III: (**11 lectures + 4 tutorials)**
Gas-filled ionization detectors: ionization chamber, proportional counters including Multi-Wire Proportional Counters, Geiger-Muller counter. Scintillation detectors: organic (crystals, liquids and plastics) and inorganic (alkali halide and activated). Light collection, Photomultiplier tubes. Semiconductor detectors: silicon diode detectors (surface barrier, ion-implanted, lithium-drifted), position-sensitive detectors, intrinsic germanium detectors, Introduction to Large Detector Arrays.

UNIT IV: (11 lectures + 4 tutorials)
Electronics for pulse Signal Processing: Pre-amplifiers, Main Amplifiers, Pulse shaping networks in Amplifiers, Biased Amplifiers, Discriminators, Constant fraction Discriminator, Single channel Analyser, Analog to Digital converter, Multi-channel Analyser, Time to Amplitude Converter. Delayed Coincidence Techniques, slow and fast Coincidence Techniques, Electrostatic and Magnetic Spectrometers, Overview of Instrumentation Standards.
Note: tutorials may include demonstration of the various instruments

References:

1. Techniques for Nuclear and Particle Physics Experiments, W.R. Leo, Springer- Verlag
2. Radiation Detection and Measurement, Glenn F. Knoll, John Wiley and sons, Inc.
3. Techniques for Nuclear and Particle Physics Experiments, Stefaan Tavernier, Springer

Semester-IV : Elective Paper-IV
Course no.: PSPHET402: Particle Physics (60 lectures, 4 credits)

UNIT I :GENERAL CONCEPTS (12 LECTURES + 3 TUTORIALS)

1. Survey of Particle Physics
   The four fundamental interactions, classification by interaction strength and decay lifetimes, numerical estimates, use of natural units.

   Classification of elementary particles by masses, interactions and conserved quantum numbers, selection rules for particle decays and scattering.

2. Experimental Techniques:
   Particle detectors and accelerators: cloud and bubble chambers, emulsion techniques, electronic detectors, proportional counters, fixed target and collider machines, basic idea of cyclotron, synchrotron and linac.

3. Klein Gordon equation
   Relativistic energy-momentum relation, Klein-Gordon equation, solutions of the equation, probability conservation problem, relation with negative energy states.

4. Dirac equation
   Dirac equation, algebra of □ matrices, conservation of probability, solutions of Dirac equation, helicity and chirality, Lorentz covariance, bilinear covariants, trace relations and similar identities, C, P and T invariance of the Dirac equation.

UNIT II: QUANTUM ELECTRODYNAMICS (11 LECTURES + 4 TUTORIALS)

5. The QED Lagrangian
   Structure of the QED Lagrangian, gauge invariance and conserved current, scalar electrodynamics, Feynman rules for QED (no derivation).

6. Basic Processes in QED
   Feynman diagram calculation for $e^+e^- \to \mu^+\mu^-$, phase space integration, Møller and Bhabha scattering, polarisation vectors, Compton scattering and pair creation/annihilation, Klein-Nishina formula.

7. Higher Orders in QED
   Concept of multi-loop diagrams (no computation), momentum integral, UV and IR singularities, idea of regularisation, running coupling constant.

UNIT III: QUARK PARTON MODEL (11 LECTURES + 4 TUTORIALS)

8. The Eightfold Way

   Isospin and strangeness, introduction to unitary groups, generators, Casimir invariants, fundamental and adjoint representations, root and weight diagrams, meson and baryon octets, baryon decuplet and the prediction of the Ω^-, Gell-Mann-Nishijima formula.

9. Quark Model

   Product representations and irreps, symmetry group, Young tableaux, quark model, meson and baryon wavefunctions.

10. Deep Inelastic Scattering

    Elastic scattering off a point particle, form factors, Rosenbluth formula, Breit frame, inelastic scattering, structure functions, dimensionless variables.

11. Parton Model

    Bjorken scaling, parton model, structure functions in terms of PDFs, Callan-Gross relation, kinematic regions, valence and sea quarks, gluons.

UNIT IV: WEAK INTERACTIONS (11 LECTURES + 4 TUTORIALS)

12. Fermi theory

    Beta decay, Fermi and Gamow-Teller transitions, current-current form of weak interactions, Fermi constant, universality, unitarity violation at high energies.

13. Intermediate vector bosons

    $W^{\pm}$ bosons, unitarity, requirement of conserved currents, muon decay, pion decay, form factor.

14. Parity violation

    Intrinsic parity, parity conservation in strong and electromagnetic interactions, parity violation in weak interactions, experiments of Wu *et al* and of Goldhaber *et al*, maximal parity violation.

15. Flavour Mixing and CP Violation

    FCNC suppression, Cabibbo hypothesis, kaon decays, theta-tau puzzle, $K^0 - \bar{K}^0$ mixing, regeneration experiment, GIM mechanism, CKM matrix and quark mixing.

Suggested reading:

1. *Introduction to Elementary Particles*, by D. Griffiths (Wiley 1987).
2. *Quarks and Leptons*, by F. Halzen and A.D. Martin (Wiley 1984).
3. *Particle Physics*, by B.R. Martin and G. Shaw (Wiley 2008).

Semester-IV : Elective Paper-III

Course no.: PSPHET403: Properties of Solids (60 lectures, 4 credits)

Unit I Optical and Dielectric properties

Maxwell's equations and the dielectric function, Lorentz oscillator, the Local field and the frequency dependence of the dielectric constant, Polarization catastrophe, Ferroelectrics
Absorption and Dispersion, Kraemers' Kronig relations and sum rules, single electron excitations and plasmons in simple metals, Reflectivity and photoemission in metals and semiconductors
Interband transitions and introduction to excitons, Infrared spectroscopy

Unit II Transport Properties

Motion of electrons and effective mass, The Boltzmann equation and relaxation time, Electrical conductivity of metals and alloys, Mathiessen's rule, Thermo-electric effects, Wiedmann-Franz Law, Lorentz number, ac conductivity, Galvanomagnetic effects

Unit III Magnetism and Magnetic materials

Review: Basic concepts and units, basic types of magnetic order
Origin of atomic moments, Heisenberg exchange interaction, Localized and itinerant electron magnetism, Stoner criterion for ferromagnetism, Indirect exchange mechanism: superexchange and RKKY

Magnetic phase transition: Introduction to Ising Model and results based on Mean field theory
Other types of magnetic order: superparamagnetism, helimagnetism, metamagnetism, spin-glasses

Magnetic phenomena: Hysteresis, Magnetostriction, Magnetoresistance, Magnetocaloric and magneto-optic effect

Magnetic Materials: Soft and hard magnets, permanent magnets, media for magnetic recording

Unit IV: Superconductivity

The phenomenon of superconductivity: Perfect conductivity and Meissner effect, Electrodynamics of superconductivity: London's equations, Thermodynamics of the superconducting phase transition: Free energy, entropy and specific heat jump

Ginzburg-Landau theory of superconductivity: GL equations, GL parameter and classification into Type I and Type II superconductors, The mixed state of superconductors

Microscopic theory: The Cooper problem, The BCS Hamiltonian, BCS ground state
Josephson effect: dc and ac effects, Quantum interference

Superconducting materials and applications: Conventional and High Tc superconductors, superconducting magnets and transmission lines, SQUIDs

References

1. Solid State Physics, H. Ibach and H. Luth, *Springer(Berlin)* 2003 (IL)
2. Solid State Physics, Neil Ashcroft and David Mermin (AM)
3. Introduction to Solid State Physics (7^{th}/ 8^{th} ed) Charles Kittel (K)
4. Principles of Condensed Matter Physics, Chaikin and Lubensky (CL)
5. Intermediate theory of Solids, Alexander Animalu (AA)
6. Optical Properties of Solids, Frederick Wooten, Ac Press (New York) 1972 (FW)
7. Electrons and Phonons, J M Ziman
8. Electron transport in metals, J.L. Olsen
9. Physics of Magnetism and Magnetic Materials, K.H.J. Buschow and F.R. de Boer
10. Introduction to Magnetism and Magnetic Materials, D. Jiles
11. Magnetism and Magnetic Materials, B. D. Cullity
12. Solid State Magnetism, J. Crangle
13. Magnetism in Solids, D. H. Martin
14. Superconductivity Today, T.V. Ramakrishnan and C.N.R.Rao
15. Superconductivity, Ketterson and Song
16. Introduction to Superconductivity, Tinkham

Semester-IV : Elective Paper-IV

Course no.: PSPHET404: Crystalline & Non crystalline solids, (60 lectures, 4 credits)

Unit I: Crystal Growth and Crystal Defects

Crystal growth: Phase equilibria and Crystallization Techniques, phase diagrams and solubility curves, Kinetics of Nucleation, Rate equation, Heterogeneous and secondary nucleation, Crystal surfaces, growth mechanisms, mass transport, crystal morphology,, influence of supersaturation, temperature, solvents, impurities; Polymorphism – phase transition and kinetics.

Crystal Defects: Point Defects, equilibrium concentration of point defects, Activation Energy, Colour Centres, Screw and Edge Dislocations, Burger Vector and Burger circuit, Frank Read source, Stacking Faults, Grain boundaries, partial dislocations. Role of Crystal Defects in Crystal Growth

Unit II: Crystal Growth Technology

Silicon, Compound semiconductors, CdTe, CdZnTe - ,Czochralski technique, Bridgman technique, Float zone Process, Liquid Phase expitaxy, Molecular Beam epitaxy. Growth of Oxide & Halide crystals- Techniques and applications,

Unit III: Non Crystalline Solids:

Amorphous Materials: Amorphous semi conductors:- Processing, Properties:- (1) Structural and Electrical conduction mechanism, band-gap, Hall effect (2)Optical:Absorption of light(U.V.,I.R) Applications of amorphous semiconductors: Solar Cells, Device and Device Materials Amorphous Metals: Metallic Glasses, Quasi Crystals. Rapid Quenching Technique, Properties Applications.

Liquid Crystals: Classification-isotropic-nematic, smectic-cholestic phases, Phase transition of liquid phases, Properties:- optical, electric and magnetic fields, Application of liquid crystals

Polymers: Major Polymer Transitions, Polymer Synthesis and Structures, Chain Polymer and Step Polymer, Cross Linking, fillers, Macromolecule Hypothesis, Phases: amorphous & Crystalline States

Unit IV: Bulk Characterization Techniques

Bulk Characterization Techniques and their applications: Normal and small angle XRD, FTIR, UV Spectroscopy, X-ray Fluorescence, Mossbauer, NMR, ESR, neutron diffraction

References:

Unit 1.

1. "from Molecules to Crystallizers: An introduction to Crystallization" Roger Davy and John Garside Oxford University Press (2000)
2. C. Kittel " Solid state Physics : an Introduction" 5 thed Wiley eastern Chap 17 and 18.
3. N.W. Ashcroft and N.D. Mermin "Solid State Physics" Saunders College Chap 30.

Unit 2

1. Crystal Growth Technology" ed Hans J. Scheel and Tsuguo Fukuda Wiley (2004)

Unit 3:

(a) Liquid crystals

1. Peter J. Collins and Michael Hind (Taylor and Francis) Chap 1 and 9

(b) Amorphous semiconductors

2. R. Zallen “the Physics of Amorphous Solids”John Wiley NY (1983)
3. M.H. Brodsky (ed) “Topics in Applied Physics” **38** Amorphous SemiConductors (1979).
4. S.E. Elliot “Physics of amorphous Materials” Longman Gp. London (1990)

(c) Polymers

5. L.H. Sperling “Introduction to Physical Polymer Science” Wiley interScience (2001) Chap 1 and Chap 5 and 6 (relevant portions only)
6. Fred W. Billmeyer “Textbook of Polymer Science” Wiley interscience (1971)

Unit 4:

1. “Spectroscopy” ed D.R. Browning McGrawHill (1969)
2. “Characterization of Materials” John B. Watchman and Zwi H. Kalman, Manning Publications (1993)
3. D.A. Scoog, F.J. Holler and T.A. Nieman “ Principles of Instrument Analysis” Harcourt Pvt ltd. (1998).

Semester-IV : Elective Paper-III

Course no.: PSPHET405: Microprocessors and ARM 7 (60 lectures, 4 credits)

Unit-I:

8085 Interrupts**: The 8085 Interrupt, 8085 Vectored Interrupts, Restart as Software Instructions, Additional I/O Concepts and Processes.**

RSG - Ch 12: 12.1, 12.2, 12.3, 12.4

Programmable Peripheral and Interface Devices: The 8255A Programmable Peripheral Interface, Interfacing Keyboard and Seven Segment Display**, t**he 8259A Programmable Interrupt Controller, Direct Memory Access (DMA) and 8237 DMA Controller, the 8279 Programmable Keyboard/Display Interface

RSG - Ch 15: 15.1, 15.2, 15.5, 15.6 & Ch 14: only 14.3

Serial I/O and Data Communication: Basic Concepts in Serial I/O, Software Controlled Asynchronous Serial I/O, The 8085 Serial I/O lines: SOD and SID

RSG - Ch 16: 16.1, 16.2, 16.3,

Ref. RSG: - Microprocessor Architecture, Programming and Applications with the 8085 by Ramesh S. Gaonkar, Fifth Edition Penram International Publication (India) Pvt Ltd

<u>Unit-II</u>

8086 microprocessor:

Register organization of 8086, Architecture, Signal Descriptions of 8086, Physical Memory Organization, General Bus operation, I/O Addressing Capability, Special Processor Activities, Minimum mode 8086 system and timings, Maximum mode of 8086 system and timings.

AB - Ch 1: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9.

8086 Instruction set and assembler directives:

Machine Language Instructions Formats, Addressing modes of 8086, Instruction set of 8086.

AB - Ch 2: 2.1, 2.2, 2.3.

The Art of Assembly Language Programming with 8086:

A few machine level programs, Machine coding the programs, Programming with an assembler (only using Debug), Assembly language example programs.

AB - Ch 3: 3.1, 3.2, 3.3.4 & 3.4

Special architectural features and related programming:

Introduction to Stack, Stack structure of 8086, Interrupts and Interrupt Service Routines, Interrupt cycle of 8086, Non-maskable interrupt, Maskable interrupt (INTR).

AB - Ch 4: 4.1, 4.2, 4.3, 4.4, 4.5, 4.6

Ref. AB: - Advanced Microprocessors and Peripherals by a K Ray and K M Bhurchandi Second Edition Tata McGraw–Hill Publishing Company Ltd.

(Note: Also refer Intel's 8086 Data Sheet)

<u>Unit-III</u>: ARM 7:

The ARM Architecture: The Acorn RISC Machine, Architectural inheritance, The ARM Programmer's model, ARM development tools.

SF - Ch 2: 2.1, 2.2, 2.3, 2.4

ARM Organization and Implementation: 3 – stage Pipeline ARM organization, ARM instruction execution, ARM implementation.

SF - Ch 4: 4.1, 4.3, 4.4

ARM Processor Cores: ARM7TDMI

SF – Ch 9: 9.1 only

Ref. SF: - ARM System-on-Chip Architecture, by Steve Furber, Second Edition, Pearson

Unit-IV: ARM 7

ARM Assembly language Programming: Data processing instructions, Data transfer instructions, Control flow instructions, Writing simple assembly language programs.
SF – Ch 3: 3.1, 3.2, 3.3, 3.4

The ARM Instruction Set: Introduction, Exceptions, Condition execution, Branch and Branch with Link (B, BL), Branch, Branch with Link and eXchange (BX,BLX), Software Interrupt (SWI), Data processing instructions , Multiply instructions, Count leading zeros (CLZ), Single word and unsigned byte data transfer instructions, Half-word and signed byte data transfer instructions, Multiple register transfer instructions, Swap memory and register instructions (SWP), Status register to general register transfer instructions, General register to Status register transfer instructions
SF – Ch 5: 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 5.9, 5.10, 5.11, 5.12, 5.13, 5.14, 5.15

The Thumb Instruction Set: the Thumb bit in the CPSR, The Thumb programmer's model, Thumb branch instructions, Thumb software interrupt instruction, Thumb data processing instructions, Thumb single register data transfer instructions, Thumb multiple register data transfer instructions, Thumb breakpoint instruction, Thumb implementation, Thumb applications, Example and exercises.
SF – Ch 7: 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 7.10, 7.11

Ref. SF: - ARM System-on-Chip Architecture, by Steve Furber, Second Edition, Pearson
Additional Ref:

1. Microprocessors and interfacing, programming and hardware, By Douglas V. Hall (TMH)
2. 8086 Microprocessor: Programming and Interfacing K.J.Ayala, Penram International

Semester-IV : Elective Paper-IV

Course no.: PSPHET406: VHDL and Communication Interface (60 lectures, 4 credits)

Unit – I: VHDL-I:

Introduction to VHDL: VHDL Terms, Describing Hardware in VHDL, Entity, Architectures , Concurrent Signal Assignment , Event Scheduling, Statement concurrency, Structural Designs, Sequential Behavior, Process Statements, Process Declarative Region, Process Statement Part, Process Execution, Sequential Statements, Architecture Selection, Configuration Statements, Power of Configurations.
DLP - Ch 1

Behavioral Modeling: Introduction to Behavioral Modeling, Transport Versus Inertial Delay, Inertial Delay, Transport Delay, Inertial Delay Model, Transport Delay Model, Simulation Deltas, Drivers, Driver Creation, Bad Multiple Driver Model, Generics, Block Statements, Guarded Blocks.
DLP - Ch 2

Sequential Processing: Process Statement, Sensitivity List, Process Example, Signal Assignment Versus Variable Assignment, Incorrect Mux Example, Correct Mux Example, Sequential Statements, IF Statements, CASE Statements, LOOP statements, NEXT Statement, EXIT Statement, ASSERT Statement, Assertion BNF, WAIT Statements, WAIT ON Signal, WAIT UNTIL Expression, WAIT FOR time_expression, Multiple WAIT Conditions, WAIT Time-Out, Sensitivity List Versus WAIT Statement, Concurrent Assignment Problem, Passive Processes.
DLP - Ch 3

Ref. DLP: - VHDL programming by example by Douglas L. Perry, Fourth edition, Tata McGraw-Hill

<u>Unit-II</u>: VHDL-II:
Data Types: Object Types, Signal, Variables, Constants, Data Types, Scalar Types, Composite Types, Incomplete Types, File Types, File Type Caveats, Subtypes.
DLP - Ch 4

Subprograms and Packages: Subprograms Function, Conversion Functions, Resolution Functions, Procedures, Packages, Package Declaration, Deferred Constants, Subprogram Declaration, Package Body.
DLP - Ch 5

Predefined Attributes: Value Kind Attributes, Value Type Attributes, Value Array Attributes, Value Block Attributes, Function Kind Attributes, Function Type Attributes, Function Array Attributes, Function Signal Attributes, Attributes ‘EVENT and ,LAST-VALUE Attribute ‘LAST-EVENT Attribute, ‘ACTIVE and ‘LAST-ACTIVE Signal Kind Attributes, Attribute ‘DELAYED, Attribute ‘STABLE, Attribute ‘QUIET, Attribute TRANSACTION, Type Kind Attributes, Range Kind Attributes.
DLP - Ch 6

Configurations: Default Configurations, Component Configurations, Lower-Level Configurations, Entity-Architecture Pair Configuration, Port Maps, Mapping Library Entities, Generics in

Configurations, Generic Value Specification in Architecture, Generic Specifications in Configurations, Board-Socket-Chip Analogy, Block Configurations, Architecture configurations.
DLP - Ch 7

Ref. DLP: - VHDL programming by example by Douglas L. Perry, Fourth edition, Tata McGraw-Hill

Unit-III: Understanding USB and USB Protocols
USB Basics: Uses and limits, Evolution of an interface, Bus components, Division of Labor, Developing a Device.
JA – Ch 1

Inside USB Transfers: Transfer Basics, Elements of a Transfer, USB 2.0 Transactions, Ensuring Successful Transfers, SuperSpeed Transactions.
JA – Ch 2

A Transfer Type for Every Purpose: Control transfers, Bulk Transfers, Interrupt Transfers, Isochronous Transfers, More about time-critical transfers.
JA – Ch 3
Enumeration: How the Host learns about devices: The Process, Descriptors.
JA – Ch 4

Control Transfers: Structured Requests for Critical Data: Elements of a Control Transfer, Standard Requests, Other Requests.
JA – Ch 5

Chip Choices: Components of USB device.
JA – Ch 6: Pages 137 - 141

How the Host Communicates: Device Drivers, Inside the Layers, Writing Drivers, Using GUIDs.
JA – Ch 8

Ref. JA: - The Developers Guide “USB Complete”, by Jan Axelson, Fourth Edition, Penram International Publishing (India) Pvt Ltd

Unit-IV: Communication Interface
On board Communication Interface: Inter Integrated Circuit (I2C), Serial Peripheral Interface (SPI), Universal Asynchronous Receiver Transmitter (UART), Wire Interface, Parallel Interface

External Communication Interfaces: RS-232 & RS-485, USB, IEEE 1394 (Firewire), Infrared (IrDA), Bluetooth, Wi-Fi, ZigBee, GPRS.
SKV: Ch – 2: 2.4

Detailed studies of I2C Bus refer:
I2C Bus Specification Version 2.1 by Philips (Pages 4-18 and 27-30)
(Download from www.nxp.com)

- The I2C-Bus Benefits designers and manufacturers (Art 2: 2.1, 2.2)
- Introduction to the I2C-Bus Specification (Art 3)
- The I2C-Bus Concept (Art 4)
- General Characteristics (Art 5)
- Bit Transfer (Art 6)

Data validity (6.1), START and STOP conditions (6.2)

- Transferring Data (Art 7)

Byte format 7.1, Acknowledge 7.2

- Arbitration and Clock Generation (Art 8)
  Synchronization (8.1), Arbitration (8.2), Use of the clock synchronizing mechanism as a handshake (8.3)
- Formats with 7-Bit Addresses (Art 9)
- 7-Bit Addressing (Art 10)

Definition of bits in the first byte (10.1)

- 10-Bit Addressing (Art 14)

Definition of bits in the first two bytes (14.1), Formats with 10-bit addresses (14.2)

Detailed study of Bluetooth: Overview, Radio Specifications, FHSS
WS: Ch- 15: 15.1, 15.2 upto Page 512

Ref: SKV :- Introduction to embedded systems, by Shibu K. V. ,Sixth Reprint 2012, Tata Mcgraw Hill
WS:-Wireless Communications and Networks, by William Stallings, 2nd edition Pearson

Semester-IV : Elective Paper-III
Course no.: PSPHET407: Digital Communication Systems and Python Programming language (60 lectures, 4 credits)

Unit I:

Digital Modulation: Introduction , information capacity , bits , bit rate , Baud and M-Ary encoding , ASK , FSK , PSK , QAM , Bandwidth efficiency , carrier recovery , clock recovery.
Digital Transmission: Introduction, Pulse modulation, PCM sampling, Signal to quantization noise ratio, Commanding, PCM line speed, Delta modulation PCM, Adaptive delta modulation.

Unit II:
Telephone Instruments and Signals: Introduction, The subscriber Loop, Standard telephone set, Basic telephone call procedures, Call progress tones and signals, Cordless telephones, Caller ID, Electronic telephones, paging system.
Telephone Circuits: Introduction, Local subscriber loop, Transmission parameters and private line circuits (concepts only), Voice frequency circuit arrangement.

Unit III:
Study of PC Serial Port: Options and choices, Formats and protocols, The PCs serial port from the connector in, PC programming.
Cellular Phone Concepts : Introduction , Mobile phone service , evolution of cellular phone , frequency reuse , interference , cell Splitting , sectoring , segmentation and dualization , cellular system topology , roaming and handoffs
Cellular Phone Systems: Digital cellular phone, Interim standard 95, CDMA, GSM communication.

Unit IV:
Python Programming language: Introduction, Installing Python, First steps, The basics, operators and expressions, control flow, Functions.

Main References:
[1] Advanced Electronic Communications Systems (Sixth edition) by Wayne Tomasi (PHI EE Ed)
[2] Serial Port Complete by Jan Axelson; Penram International Publications.
[3] A Byte of Python by C. H. Swaroop.

Additional References:
[1] Electronic Communication Systems Fundamentals Through Advanced by Wayne Tomasi; 4th Edition, Pearson education Singapore.
[2] Electronic Communications by Dennis Roddy and John Coolen, (4^{th} ed., Pearson Education).
[3] Modern Electronic Communication by Gary M. Miller, (6^{th} ed., Prentice Hall International, Inc.).
[4] Wireless Communication Technology by Roy Blake, (Delmar – Thomson Learning).

[5] Digital Communications Systems by Harold Kolimbiris, (Pearson Education Asia).

Semester-IV : Elective Paper-IV
Course no.: PSPHET408: Computer Networking (60 lectures, 4 credits)

Unit I:
Overview of Data Communication and Networking: Introduction, Data communications, Networks, The internet, Protocols and standards; Network models, Layered tasks, Internet model, OSI model.
Data Link layer: Error detection and correction, Types of errors, Detection, Error correction, Data link control and protocols, Flow and error control, Stop and wait ARQ, Go-back-N ARQ, Selective repeat ARQ, HDLC, Point to point access, Pont to point protocol, PPP stack, Multiple access, Random access, Controlled access, Channelization.

Unit II:
Local Area Networks: Ethernet: Traditional ethernet, Fast ethernet, Gigabit Ethernet, Wireless LANs, IEEE 802.11, Bluetooth. Connecting LANs, Connecting devices (Repeaters, Hubs, Bridges, Two layer switch, Router and three layer switches), Backbone networks, Virtual LANs, Virtual circuit switching, Frame relay, ATM, ATM LANs.

Unit III:
Network Layer: Internetworks, Addressing, Routing, Network layer protocols, ARP, IP, ICMP, IPV6, Unicast and multicast routing protocols, Unicast routing, Unicast routing Protocols, Multicast routing, Multicast routing Protocols.
Transport Layer: Process to process delivery, User datagram protocol (UDP), Transmission control protocol (TCP).
Application Layer: Domain name system, Name space, Domain name space, Distribution of name space, DNS in the internet, Resolution, DNS messages, DDNS, Encapsulation, Electronic mail, File transfer (FTP), HTTP, World wide web (WWW).

Unit IV:
Network Security: Cryptography, Introduction, Symmetric cryptography, Public-key cryptography, Message security, Digital signature, User authentication, Key management, Kerberos, Security protocols in the internet, IP level security (IPSEC), Transport level security, Application layer security, Firewalls, Virtual private network.
References:

1. Data Communications and Networking by B. A. Forouzan (3^{rd} ed., Tata McGraw Hill Publishing Company Ltd., New Delhi). Chapters
2. Advanced Electronic communications systems (Sixth edition) by Wayne Tomasi (PHI – EE Ed)
3. Data Communications and Computer Networks by Prakash Gupta

Semester-IV : Elective Paper-III

Course no.: PSPHET409: Physics of Semiconductor Devices (60 lectures, 4 credits)

(N.B.: Problems form an integral part of the course)

Unit I: Metal-Insulator-Semiconductor (MIS) Devices:

Review of ideal MIS device, Si-SiO_2 Practical MOS diode, Oxide charges, defects, Surface and interface states, C-V and G-V measurement techniques and characterization of MOS devices. Review of MOSFET Basic device characteristics, Types of MOSFETs, Non-uniform doping and buried-channel devices, Short-channel effects, MOS transistor scaling. MOSFET structures- HMOS, DMOS, SOI, VMOS, and HEXFET. Charge coupled devices (CCDs), Non-volatile memory devices, Simulation.

Unit II: Microwave, Power & Hot electron devices:

Microwave devices-Different types of Tunnel diodes, Tunnel transitor, IMPATT diode, BARITT diode, DOVETT diode, Transferred electron device, Gunn diode, Microwave transistor, Thyristors, Bipolar power transistor, Hot electron transistor; MOS Power transistor, HEMT.

Unit III: Optoelectronic Devices:

Light-Emitting Diodes, Liquid crystal displays, Photo detectors, Photodiode materials, Phototransistor, Solar cells, Materials and design considerations, Thin film solar cells, amorphous silicon solar cells, Semiconductor Lasers, Optical processes in semiconductor lasers (JS-Art.15.8), Heterojunction lasers. Exciton (JS-Art16.1), Quantum confined Stark effect (JS.Art16.6), Quantum well IR photodetector, Application of laser in materials processing, Fiber optical waveguides, Losses and dispersion in fibers, Measurement of fiber characteristics, Fiber materials and fabrication, Fiber optics simulation.

Unit IV: Quantum well & Nano structures:

Quantum wells: Band structure modifications by heterostructures; Band structure in quantum wells, quantum wires, quantum dots; Modulation doping; Mobility in a MODFET quantum well (JS-6.2, 6.3, 8.6, 14.2) Nanotechnology: Nanomaterials, nanostructures, Synthesis of nanoparticles, Semiconductor nanocrystals, Metallic nanoclusters, Carbon nanostructures, Bulk nanostructured materials, Microelectromechanical systems (MEMS).

Main References:

1. S.M. Sze, Physics of Semiconductor Devices, John Wiley, N.Y., 1981,
2. Jasprit Singh, Semiconductor Devices-Basic Principles, Wiley Student Edition, New Delhi, 2009.
3. P. Bhattacharya, Semiconductor Optoelectronics devices, Prentice Hall, India, 1995.
4. Gerd Kelser, Optical fiber communication, Mc Graw Hill-1980.
5. Jasprit Singh, Physics of Semiconductors and their Heterostructures, McGraw-Hill, New York, 1993.
6. C. P. Poole and F. J. Owens, Introduction to Nanotechnology, Wiley Interscience, Hoboken, New Jersey, 2003.

Additional References:

1. E.H. Nicollian an J.R. Brews, MOS Physics and Technology, John Wiley, 1982,
2. J. Wilson and J.F.B. Hawkes, Optoelectronics, An Introduction, Prentice Hall, 1983,
3. Jasprit Singh, Semiconductor Optoelectronics, Mc-Graw Hill

Semester-IV : Elective Paper-IV
Course no.: PSPHET410: Semiconductor Technology (60 lectures, 4 credits)

(N.B.: Problems form an integral part of the course)

Unit I: Crystal growth and Epitaxy

(a) Crystal growth: Czochralski technique, Bridgman technique, Float zone process, Zone refining, Zone levelling.

(b) Epitaxy Vapour phase epitaxy (VPE), Liquid phase epitaxy (LPE), Molecular beam epitaxy (MBE), MOCVD, Heteroepitaxy, Growth of III-V compound semiconductors, Growth of silicon on insulator (SOI) structures.

(c) Oxidation and film deposition: Oxide formation, kinetics of oxide growth, thin oxide growth, oxidation systems.

Unit II: Diffusion and Ion-implantation

(a) Diffusion: Nature of diffusion, basic diffusion theory, extrinsic Diffusion, diffusion related physical processes, Boron diffusion system, Phosphorus diffusion system.

(b) Ion-implantation: Range of implanted ions, ion distribution, ion stopping, ion channeling, Radiation damage and annealing, implantation related processes, evaluation techniques for epitaxial layer, diffused layer implanted layer and oxide layer.

Unit III: Lithography and Etching

(a) Lithography: Clean room, Masking, Photoresist, Passivation, Optical, Electron-beam, X-ray & Ion-beam lithography.

(b) Etching :Wet chemical etching, Dry etching, Plasma etching.

Unit IV: Integrated Devices

Device and circuit design and fabrication: Passive components-Integrated circuit resistor, capacitor and inductor. Bipolar technology: Discrete bipolar circuit fabrication, Bipolar technology, MOSFET technology, MESFET Technology, Fundamental limits of integrated devices, ULSI Technology; Simulation.

Main References:

1. S.M. Sze, Semiconductor Devices-Physics and Technology, John Wiley,1985
2. Integrated circuits (Design principles & fabrication) – R.M.Warner, Motorola series in Solid State Electronics,
3. K. Martin, Digital Integrated Circuit Design Oxford University Press,
   YMCA, New Delhi, 2004

Additional References:

1. E.L. Wolf, Nanophysics and Nanotechnology, Wiley-VCH Verlag, Weinheim, 2004
2. S.K. Ghandhi, The theory and practice of Microelectronics, John Wiley and Sons,
3. S.M. Sze, VLSI Technology, Mc Graw Hill Book, N.Y., 2^{nd} Ed
4. S.K. Ghandhi , VLSI fabrication principles, John Wiley, N.Y., 1983

Semester-IV : Elective Paper-III

Course no.: PSPHET411: Materials and their applications (60 lectures, 4 credits)

Unit I:

Engineering Alloys, Production of Iron and Steel, The Iron-Iron Carbide Phase Diagram, Heat Treatment of Plain-Carbon Steels, Low-Alloy Steels, Aluminum Alloys, Copper Alloys, Stainless Steels, Cast Irons, Magnesium, Titanium, and Nickel Alloys,

Unit II:
Corrosion, Electrochemical Corrosion of Metals, Galvanic Cells, Corrosion Rates (Kinetics), Types of Corrosion, Oxidation of Metals, Corrosion Control

Unit III:
Polymeric Materials, Polymerization Reactions, Industrial Polymerization Methods, Crystallinity and Stereoisomerism In Some Thermoplastics, Processing of Plastic Materials, General-Purpose Thermoplastics, Engineering Thermoplastics, Thermosetting Plastics (Thermosets), Elastomers (Rubbers), Deformation and Strengthening of Plastic Materials, Creep and Fracture of Polymeric Materials.

Unit IV:
Ceramic Materials, Simple Ceramic Crystal Structures, Silicate Structures, Processing of Ceramics, Traditional and Technical Ceramics, Electrical Properties of Ceramics, Mechanical Properties of Ceramics, Thermal Properties of Ceramics, Glasses. Composite Materials, Fibers for Reinforced-Plastic Composite Materials, Fiber-Reinforced-Plastic Composite Materials, Open-Mold Processes for Fiber-Reinforced-Plastic Composite Materials, Closed-Mold Processes for Fiber-Reinforced-Plastic Composite Materials, Concrete, Asphalt and .Asphalt Mixes, Wood, Sandwich Structures

Reference:

1. William F Smith, Javad Hashemi, Ravi Prakash, Materials Science and Engineering, Tata-McGraw Hill, 4th Edition.

Semester-IV : Elective Paper-IV
Course no.: PSPHET412: Elective 12 Energy Studies (60 lectures, 4 credits)

Unit I:
A brief history of energy technology, Global energy trends, Global warming and the greenhouse effect, Units and dimensional analysis, Heat and temperature, Heat transfer, First law of thermodynamics and the efficiency of a thermal power plant, Closed cycle for a steam power plant, Useful thermodynamic quantities, Thermal properties of water and steam, Disadvantages of a Carnot cycle for a steam power plant,

Rankine cycle for steam power plants, Gas turbines and the Brayton (or Joule) cycle, Combined cycle gas turbine, Fossil fuels and combustion, Fluidized beds, Carbon sequestration, Geothermal energy, Basic physical properties of fluids, Streamlines and stream-tubes, Mass

continuity, Energy conservation in an ideal fluid: Bernoulli's equation, Dynamics of a viscous fluid, Lift and circulation, Euler's turbine equation.
(Andrews and Jelly: Chapter 1, 2, and 3)

Unit II:

Hydropower, power output from a dam, measurement of volume flow rate using a weir, Water turbines; Impact, economics and prospects of hydropower; Tides, Tidal power, Power from a tidal barrage, Tidal resonance, Kinetic energy of tidal currents, Ecological and environmental impact of tidal barrages, Economics and prospects for tidal power, Wave energy, Wave power devices; Environmental impact, economics and prospects of wavepower; Binding energyand stability of nuclei, Fission, Thermal reactors, Thermal reactor designs, Fast reactors, Present-day nuclear reactors, Safety of nuclear power, Economics of nuclear power, Environmental impact of nuclear power, Public opinion on nuclear power, Outlook for nuclear power, Magnetic confinement, D-T fusion reactor, Performance of tokamaks, Plasmas, Charged particle motion in E and B fields, Tokamaks, Plasma confinement, Divertor tokamaks, Outlook for controlled fusion.
(Andrews and Jelly: Chapter 4, 8, and 9)

Unit III:

Source of wind energy, Global wind patterns, Modern wind turbines, Kinetic energy of wind, Principles of a horizontal-axis wind turbine, Wind turbine blade design, Dependence of the power coefficient C_p on the tip-speed ratio λ, Design of a modern horizontal-axis wind turbine, Turbine control and operation, Wind characteristics, Power output of a wind turbine, Wind farms, Environmental impact and public acceptance, Economics of wind power, Outlook, Conclusion, The solar spectrum, Semiconductors, p-n junction, Solar photocells, Efficiency of solar cells, Commercial solar cells, Developing technologies, Solar panels, Economics of photovoltaics (PV), Environmental impact of photovoltaics, Environmental impact of photovoltaics, Outlook for photovoltaics, Solar thermal power plants, Photosynthesis and crop yields, Biomass potential and use, Biomass energy production, Environmental impact of biomass, Economics and potential of biomass, Outlook.
(Andrews and Jelly: Chapter 5, 6, and 7)

Unit IV:

Generation of electricity, High voltage power transmission, Transformers, High voltage direct current transmission, Electricity grids, Energy storage, Pumped storage, Compressed air energy storage, Flywheels, Superconducting magnetic energy storage, Batteries, Fuel cells, Storage and production of hydrogen, Outlook for fuel cells, Environmental impact of energy production, Economics of energy production, Cost-benefit analysis and risk assessment, Designing safe

systems, carbon abatement policies, Stabilization wedges for limiting CO_2 emissions, Conclusions.
(Andrews and Jelly: Chapter 10 and 11)

Reference:

ENERGY SCIENCE: principles, technologies, and impacts, *John Andrews and Nick Jelley,* Oxford University Press

Semester-IV : Elective Paper-III

Course no.: PSPHET413: Astronomy and Space Physics (60 lectures, 4 credits)

Unit I:

The Sky, Instruments and Observational tools: (a) Inventory of the Universe Wavelength bands of observation: radio, infrared, optical, UV, X-ray and Gamma-ray windows. Ground-based, balloon-borne and satellite-borne telescopes, Celestial co-ordinate system: Right Ascension, Declination Time keeping. Sidereal and Solar

(b) Resolution of Instruments and Limitations Optical telescopes, Photometers, Spectrographs, CCDs, Polarimeters. Radio telescopes – interferometry X-ray and Gamma-ray detectors Neutrino and Cosmic Ray astronomy - origin, composition and spectrum.

Unit II:

Stellar Structure and Evolution: Stellar parameters: Mass, Radius, Luminosity, Chemical Composition Spectral types colour, magnitude: H-R diagram. Stellar physics: Equation of state, Opacity. Nuclear energy generation, Saha Ionization Equilibrium Planck Blackbody Radiation. Radiative and convective transport of energy. Internal structure of stars and Virial Theorem. Stellar atmosphere. Absorption and Emission of lines. Stellar Evolution: Hayashi phase. Main sequence, Horizontal Branch, Red Giant and Asymptotic Giant Branches. Planetary Nebulae and Supernova remnants. Stellar rotation. Stellar magnetism. Mass Loss. Diffusion. Stellar pulsation: Helio - and Astero-seismology.

Unit III:

Condensed Objects And High Energy Astrophysics: Compact objects: White dwarfs and Chandrasekhar Limit. Neutron stars and Black holes: Pulsars, X-ray and Gamma-ray sources. Binary systems: Accretion process and associated phenomena: Bursts and Quasi-periodic oscillations. Radiation Processes: Blackbody, Bremstrahlung, Cyclotron, Synchrotron and Inverse Compton emission. Interaction of high energy particles and photons with matter. Acceleration of particles to high energy. Gamma ray Bursts and Very High Energy Cosmic Rays.

Unit IV:

Solar Physics: Description of solar internal and external layers, Magnetohydrodynamic equations, Hall effect and generalized Ohm's law, Magnetostatic equilibrium and sunspots, Solar activity cycle, Force-free magnetic fields, Magnetic reconnections and solar flares, Waves: sound waves, Alfven waves, Internal gravity waves, inertial waves, magnetosonic waves; Heating of the solar chromosphere and corona, Coronal mass ejections, Solar wind and Parker's solution.

Main References:

Unit 1:

i. F. Shu, The Physical Universe. An Introduction to Astronomy; University Science Books, Sausalito 1982.,
ii. R.C. Smith, Observational Astrophysics; CUP, 1995,
iii. C.R. Kitchin, Astrophysical Techniques; Adam Hilger, 1984.

Unit 2:

i. M. Schwarzchild, Evolution of the Stars; Dover, 1966.
ii. R.J. Tayler, The Stars: Their Structure and Evolution; CUP 1994.
iii. R.J. Tayler, Galaxies: Structure and Evolution; Wykeham 1978.

Unit 3:

i. H. Harwit, Astrophysical Concepts; Springer Verlag 1988,
ii. M.S. Longair, High Energy Astrophysics, Vols. I and II; CUP 1994.

Unit 4:

i. Solar Magneto–Hydrodynamics, E.R. Priest; D Reidel, 1982. chps. 1, 3.1-3.5, 4.1, 4.3-4.5, 6.1-6.3, 12.1-12.2.

Additional Books:

i. Astronomy, Fred Hoyle, 1975. Astronomy, 8th ed., Robert H Baker,
ii. Princeton: D. Van Nostrand, 1964. The Stars: Their Structure & Evolution; R.J. Tayler, CUP, 1994.

<u>Semester-IV : Elective Paper-IV</u>

<u>Course no.: PSPHET414: Laser Physics (60 lectures, 4 credits)</u>

Unit I: Laser characteristics and Resonators : Principles, Properties of laser radiation, Einstein Coefficients, Light amplification, Threshold condition for laser oscillations, Homogeneous and inhomogeneous broadening,
Laser rate equations for 2,3 and 4 level, variation of laser power around threshold, optimum output coupling, Open planar resonator, Quality Factor ,ultimate line width of the laser, Transverse and Longitudinal mode selection.

Unit II: Non linear optics- Techniques for Q-switching, Mode Locking, Hole burning and Lamb dip in Doppler broadened Gas laser, Non linear oscillator model, Non linear polarization and wave equation, perturbative solution of the Nonlinear oscillator equation, Hormonic generation, Second harmonic generation, Phase matching third harmonic generation. Optical wave mixing, parametric generation of light,parametric oscillation, tuning of parametric oscillators. Non-Linear susceptibilities, non-linear susceptibility tensor, non-linear materials

Unit III: Laser Systems*:* Solid State Laser, Gas lasers ,liquid lasers, Eximer lasers. Semiconductor Laser., liquid –Dye and chemical lasres, high power laser systems and industrial applications.

Unit IV: Spectroscopic Instrumentation and applications: Raman scattering, photo-acoustic Raman Spectroscopy. Raman Amplification and Raman laser, special techniques in non linear spectroscopy, polarization spectroscopy, multi-photon spectroscopy, photofluoroscence excitation spectroscopy.

H*olographic Optical Element:* HOE, Design aspects, resolution, vibration and motion analysis by Holographic techniques, holography, Spatial Frequency filtering, optical Communication, optical computers. Laser ablation, Laser in Biomedicine.

Main References:

1. B. Laud, Laser and Non-linear optics, Wiley Eastern Ltd., (1991).
2. A.K. Ghatak and K. Thyagarajan, optical electronics, Cambridge University Press (1991).
3. S.C Gupta Optoelectronic devices and systems , Prentice Hall of India.
4. (WH) Wilson and Hawkes: Optoelectronics, Prentice Hall of India.
5. Yariv, Optical Electronics in Modern Communications, Oxford University Press (1997),
6. Laser Spectroscopy- Basic concepts and instrumentation by Demtroder (ed. 3, Springer)

Additional Reference books:

1. Laser: Svelto.
2. Optical electronics: Wariv.
3. Laser spectroscopy: Demtroder.
4. Non-linear spectroscopy: Etekhov.
5. Introduction to modern optics: G.R.Flowles.

Semester-IV : Elective Paper-III
Course no.: PSPHET415: Liquid Crystals (60 lectures, 4 credits)

Unit-I : Introduction to the Science and technology of Liquid Crystal.
Types and Classification of liquid crystals, Nature's of Anisotropic Liquid Crystals. Calamtic liquid crystal, Discotic Liquid crystal, Polymer liquid crystals, Chiral liquid crystal, ,membranescolloidal system. Display Technologies Overview.
Ref: CP: Ch 1 ; PDG: Ch 1; PJC: Ch 1, 2, 3,4,5,6.

Unit-II : Theoretical Insights
Nature of phase transitions and critical phenomenon in liquid crystals, Maier-Saupe, Landau de gennes theory, Van der Walls theories. Continuum theory: Curvature elasticity in nematic smectic A phases, Distortions due to magnetic and electric fields, Magnetic coherence length, Freedeicksz transitions. Onsager's mean field theory
Ref: PJC: Ch12, 10. PDG: Ch 7

Unit-III: Merits of LCs
Dynamical properties of Nematic, equations of nemato-dynamics, laminar flow, Fluid vs. solid membranes, energy and elasticity, surface tension, viscoelasticity, Molecular motions. LC in electric and magnetic fields, light and liquid crystals, Mechanical, Optical Properties: Cholesteric, Ferroelectric, Antiferroelectric, Polymer dispersed liquid crystals, Elastomer.
Ref: PDG: Ch 5,6; SERS: Ch 9; CP: Ch 5

Unit IV : *Characterization Techniques and Applications*
Techniques used for Identification and characterizations of Liquid crystal phases, Lyotropic liquid crystals and biological membrane,: Survey over flat panel technologies. Liquid crystal displays, plasma displays .Applications of liquid crystals.
Ref: Ref: CP: Ch 2, 9; PJC: Ch 9, 7, 13; DDLR.

Text Book and References

1. Introduction to liquid crystals: Physics and Chemistry.: Peter J Collings and Michael Hird Taylor and Francis,1997.
2. Liquid crystal: The fourth state of matter.Frankin D saeva. Wiely publication.
3. Liquid Crystals: S Chandrsekhar, Cambridge University Press, 2nd edition, 1992.
4. The physics of liquid crystals: P G de Gennes and J Prost, Oxford University
5. Ferroelectric liquid crystals: Principle properties and Applications: Gooby et a.l Gordon & Breach Publishing Group, 1991
6. Thermotropic liquid crystals: Fundamental Vertogen and de jeu.

7. Polymer materials-Macroscopic properties and molecular Interpretations. Jean-Louis Halary,Lucien monnerie.published by Wiley.
8. The Optic of Thermotropic Liquid Crystals.Steve Elston and Roy Sambles.
9. Textures of Liquid Crystals. Detrich Demus, Lothar Richter.Newyork 1978
10. Textures of Liquid Crystals- Ingo Dierking John Wiley & Sons, 08-May-2006 - Technology & Engineering..
11. .Liquid Crystal: Experimental Study of Physical Properties and Phase Transitions Satyen Kumar, Cambridge University Press, 2001
12. Physical Properties of Liquid Crystals: George W. Gray, Volkmar Vill, Hans W. Spiess, Dietrich Demus, John W. Goodby John Wiley & Sons, -2009 Technology & Engineering.
13. Handbook of Liquid Crystals, High Molecular Weight Liquid Crystal Dietrich Demus, John W. Goodby, George W. Gray, Hans W. Spiess, Volkmar Vills –
14. Principles of condensed matter physics – P.M. Chalkin and T.C. Lubensky.
15. Collidal Dispersions-W.B Russel , Cambridge University Press. New York (1989)
16. Properties and Structure of Liquid Crystals

Semester-IV : Elective Paper-IV

Course no.: PSPHET416: Numerical Methods and Programming (60 lectures, 4 credits)

Unit I : Programming using C++

Elementary information about digital computer, hardware, software, machine language program, assembly language program, assembler, disadvantages of machine and assembly language programming, High level language programs, interpreter and compilers, flow charts-symbols and simple flowcharts, Structure of a C program, header files, constant and variables, data types and their declarations, operators – arithmetic operators, relational operators, logical operators, assignment operators, conditional operator. Built in functions in C, Input/output functions for integer, floating points, characters and strings. Control statements-if, if-else, do-while. For loop, nested if and nested for loops, goto statement. Library functions- mathematical and trigonometric. Arrays- one dimensional and two- dimensional. User defined functions-definition and declaration of a function, passing arguments, return values. File handling-operation with files, opening and closing a file. (structures and unions and pointers are not expected)

Unit II : Curve fitting, interpolation, Roots of Equation

Review of Intermediate Value theorem, Rolle's Theorem, Lagrange Mean Value theorem and Taylor's Theorem, Errors in computation and Numerical stability, Least squares method Principle, fitting a straight line, fitting a parabola, fitting an exponential curve, fitting curve of the form $y=ax^b$, fitting through a polynomial, Linear interpolation, difference schemes, Newton’s forward and backward interpolation formula, Lagrange’s interpolation formula.

Polynomial and transcendental equations, limits for the roots of polynomial equation. Bisectional method, false position method, Newton-Raphson method, direct substitution method

Unit III : Numerical integration and solution of differential equation:

Newton cotes formula, Trapezoidal rule, Simpson’s one third rule, Simpson’s three eight rule, Gauss quadratics method, Monte Carlo method.

Solution of Ordinary differential equation using Taylor series method, Euler’s method, Runge-Kutta method, Milne’s and Adams Bashforth predictor-corrector methods

Classification of second order partial differential equation, Solution of partial differential equation-Difference equation method over a rectangular domain for solving elliptic, parabolic and hyperbolic partial differential equation

Unit IV : Solution of simultaneous equation and Random numbers Gaussian elimination method, Gaussian elimination with pivotal condensation method, Gauss-Jordan elimination method, Gauss-Seidal iteration method, Gauss-Jordan matrix inversion method.

Random numbers - Random number generation, Monte Carlo simulation using Random walk on a square lattice.

Text and Reference books:

i. H. M. Antia: Numerical methods for scientists and engineers.
ii. S. S. Sastry: Introductory method of numerical analysis, PHI India 2005
iii. Rajaraman : Computer oriented Numerical methods, PHI 2004
iv. P. B. Patil and U. P. Verma : Numerical Computational methods, Narosa Publ.
v. E. Balgurusamy : Programming in ANSI C, Tata McGraw Hill
vi. Jain M.K., Iyengar SRK, Jain R.K. : Numerical methods for scientific and
vii. Engineering Computation , New Age International, 1992
viii. http://www.nptel.iitm.ac.in/video.php?subjectId=122102009
ix. Numerical recipes in C

Semester-IV : Elective Paper-III
Course no.: PSPHET417: Polymer Physics (60 lectures, 4 credits)

Unit I:

Structure of Polymers: Structure of Crystalline Polymers - Single crystals. Lamellar Single-crystals, Fibriliar crystals. Globular crystals, Spherulites, Structure of Amorphous Polymers - Domain Structure in amorphous polymers. Oriented State of Polymers. Structure & function of Biopolymers - proteins. DNA. RNA, cellulose. Nano-composite polymers.

Unit II:

Viscoelastic Properties: Elastic deformation, Maxwell and Kelvin Models, Relaxation processes and relaxation spectrum. Creep of polymeric materials. **Polymer Blends**: Miscibility, Morphology and glass transition temperature. Effects of additives and fillers on polymers,

Unit III:

Electrical properties of polymers, electrical conduction, Electronic, ionic and polaron processes. conducting polymers. Photoconduction, photovoltaics and superconductivity in polymers. Optical absorption and optical birefringence in polymers. Liquid crystals and electro-optical properties.

Unit IV:

Preparation of thin films of organic materials (solution casting, electro-chemical, CVD, interfacial method, LB technique), their structure, props, & Application. Fundamentals of electrochemistry, electrochemical methods for preparation characterization of thin films-CV & impedance measurement. Sensors, types of sensors, electrochemical & optical sensors-Construction & functioning of these sensors, advantages & disadvantages of these sensors (study of at-least two types of sensors).

Main References:

1. Physics of Plastics, P.O. Ruchie. Illiffe Books Co. Ltd, (Chapters I to 4 and 6 to 8),
2. Phys. Chem. of Polymers. Tager A, Mir Pubs, ()9?8),Chs. I, 2, 5, 7, 8. 10, 11, 17)
3. Conductive Polymers, R.B. Seymour (Ed.), Plenum Press, New York (1981) (Articles 1,3,7,9,11, 17, 19)
4. Elec. Props, of Polymers, D.A. Seanor (Ed.), Academic Press (1982) (Chs. 1 - 4, Ch. 8)
5. Organic Semiconductors, F, Gutmann and I.E.I. Yons, John Wiley and Sons, New York 1967) (Chapters 1, 2, 4, 5, 7)
6. Electrical Properties of Polymers, A.R. Rlythe, Cambridge University Press. London (1979), (Chapters 1, 5, 6)
7. Elec. Props, of Polymers, J.J. Krosehwitz, John Wiley, New York (1988), Pg, 58-101.
10. Handbook of Conducting Polymers, T.A. Skotheim, Vol. 1 and. Marcel Dekker (1986), (Chapters 8. 17, 20, 21.25)
11. Electrochemical Methods, Fundamentals and Application. A.J. Bard and L, R, Faulkner, John Wiley and Sons, New York (1980)
12. The Chemical Physics of Surfaces, S.R. Morrison, Plenum Publishers (1990)
14. Principles. of Chemical Sensors, Jiri Janata, Plenum Press, New York (1990) (Ch. 1, 4, 5)

M.Sc. (Physics) Practical Lab Course
Semester –IV

Semester IV Elective Lab Course-2

Course no.: PSPHAP402: Advanced Physics Lab-2 (120 hours, 4 credits)

A) Students offering electives other than PSPH405, 406, 407, 408, (i.e. Electronics I or Electronics II), have to perform at least 10 experiments out of following:

I. Neutron Diffraction: Data analysis for structure and dynamic Q-factor
II. Mössbauer Spectroscopy

1. Fe^{57} Mossbauer spectra: Calibration and determination of isomer shift and hyperfine field
2. Determination of isomer shift in stainless steel
3. Determination of isomer shift and quadrupole splitting in Sodium Nitroprusside
4. Fe-based specimen: Determination of isomer shift, hyperfine field, estimation of oxidation state in ferrite samples

III. Hartree –Fock Calculations

IV. Magnetization and Hysteresis

1. B-H loop in low magnetic fields (dc and ac methods)
2. Hysteresis of ring-shaped ferrite
3. Determination of Curie/ Neel temperature
4. Susceptibility of paramagnetic salt by Guoy's method

V. Resistivity and Magnetoresistance

1. Resistivity of metallic alloy specimens with varying temperatures
2. Study of percolation limit by resistivity measurement on ceramic specimens
3. Tracking of first and second order transition by resistivity measurement in shape memory (NiTi) alloy
4. MR of Semiconductor, Bismuth and LSMO (Manganate) specimen
5. Calibration of magnetic field using MR probe

VI. LASER

1. Refractive index of the given materials
2. Refractive index of the Air at different pressure.

VII. Plasma

1. Measurement of plasma parameters. - Single probe
2. Measurement of plasma parameters. - Double probe method at constant current.

VIII. Nuclear Physics

1. Energy resolution of NaI detector and understanding of its Pulse processing electronics
2. Peak to total ratio and efficiency of NaI detector.
3. Sum peak analysis and detector size effect on peak to total ratio using NaI detector.
4. Angular correlation ratio using NaI detector.
5. Coincidence Technique
6. Working mechanism of Plastic detector and measurement of lifetime of muon.

IX. Semiconductors and devices

1. Si, Ge and LED:
    a. I-V at different temperatures,
    b. C-V at room temperature and determination of barrier height.
2. Schottky diode and MOS diode Fabrication
3. Determination of carrier concentration and barrier height from C-V measurements

4. I-V characteristics and identification of the current conduction mechanisms
5. Determination oxide charge, carrier concentration and interface states of from C-V measurements.
6. Solar Cells: I-V characteristics and spectral response
7. Semiconductor lasers- Study of output characteristics and determination of threshold current, differential quantum efficiency and divergence.
8. Infrared detector characteristics and spectral response.
9. Optical fibers- Attenuation and dispersion measurements.
10. Gunn diode characteristics.
11. Determination of surface concentration and junction depth of diffused silicon wafers by four point probe method.

X. Experiments using Phoenix kit

XI. Astronomy and Space Physics

1. The temperature of an artificial star by photometry.
2. Study of the solar limb darkening effect.
3. Polar aligning an astronomical telescope.
4. Study of the atmospheric extinction for different colors.
5. Study the effective temperature of stars by B-V photometry.
6. Estimate of the night sky brightness with a photometer.

XII. Computation

1. Computer program for file handling

XIII. Any one classical Experiment (available in department or affiliated institutions) e.g.

1. Millikan's oil-drop method,
2. Raman effect in liquids,
3. e/m by Thomson's method
4. Rydberg's constant using constant deviation prism.

B) Students offering electives PSPH405, 406, (i.e. Electronics I), have to perform at least 10 experiments out of following:

I.: 8085/8086 Microprocessor based experiments:

1. Study of 8085 interrupts (Vector Interrupt 7.5).
2. Study of PPI 8255 as Handshake I/O (mode 1): interfacing switches and LED's.
3. 8086 assembly language programming:
4. Simple data manipulation programs.(8/16-bit addition, subtraction, multiplication, division, 8/16 bit data transfer, finding greatest/smallest number, finding

positive/negative numbers, finding odd/even numbers, ascending/descending of numbers, converting BCD nos. into Binary using INT 20, displaying a string of characters using INT 20)

Please note: Assembly language programming of 8086 may be done by operating PC in real mode by using 'Debug' program. Separate 8086 study kit not needed.

II: ARM7 based experiments:

1. Simple data manipulation programs (addition, subtraction, multiplication, division etc).
2. Study of IN and OUT port of ARM7 by Interfacing switches, LEDs etc.
3. Study of Timer.
4. Interfacing DAC/ADC using I2C Protocols.

III: Basic VHDL experiments:

1. Write VHDL programs to realize: logic gates, half adder and full adder
2. Write VHDL programs to realize the following combinational designs: 2 to 4 decoder, 8 to 3 encoder without priority, 4 to 1 multiplexer, 1 to 4 de-multiplexer
3. Write VHDL programs to realize the following: SR – Flip Flop, JK – Flip Flop, T – Flip Flop
4. Write a VHDL program to realize a 2/3/4 - bit ALU (2- arithmetic,2-logical operations)

IV: VHDL Interfacing based experiments:

1. Interfacing stepper motor: write VHDL code to control direction, speed and number of steps.
2. Interfacing dc motor: write VHDL code to control direction and speed using PWM.
3. Interfacing relays: write VHDL code to control ac bulbs (at least two) using relays.

V: Computation

1. Computer program for file handling.

VI. Any one classical Experiment (available in department or affiliated institutions) e.g.

1. Millikan’s oil-drop method,
2. Raman effect in liquids,
3. e/m by Thomson’s method
4. Rydberg’s constant using constant deviation prism.

References:

1. Advanced Microprocessors and Peripherals by a K Ray and K M Bhurchandi Second Edition Tata McGraw–Hill Publishing Company Ltd.
2. ARM System-on-Chip Architecture, by Steve Furber, Second Edition, Pearson
3. VHDL programming by example by Douglas L. Perry, Fourth edition, Tata McGraw-Hill
4. Manual of VHDL kit.

B) Students offering electives PSPH407, 408, (i.e. Electronics II), have to perform at least 10 experiments out of following:

Experiments in Electronics Communication

1. Sample and hold circuit using FETs or CMOS switch IC CA 4016/4066 or IC LF398.
2. Study of ADC-DAC system using ADC 0804/0808 and DAC 0800/0808.
3. Flat top pulse amp. Modulation (PAM) using CMOS switch IC CA 4016/4066 FET.
4. Pulse width modulation (PWM) & pulse position modulation (PPM) using IC565/ 555.
5. Time division multiplexing (TDM) using IC CA 4016/4066 or FET.
6. FSK modulator using IC 555 or PLL IC 565 and demodulation using PLL IC 4046.
7. Study of PCM – Transmission and reception using CODEC IC.
8. Two channel analog multiplexer using CMOS switch CA4016/CA4066/LF398.
9. PC to PC communication through serial port.
10. PC to PC communication through parallel port.
11. Study of Manchester coding and decoding using CODEC IC.
12. Experiments using Phoenix kit
13. Computation : Computer program for file handling
14. Any one classical Experiment (available in department or affiliated institutions) e.g.
    1. Millikan's oil-drop method,
    2. Raman effect in liquids,
    3. e/m by Thomson's method
    4. Rydberg's constant using constant deviation prism.

References:

1. Op-amp and linear ICs by Ramakant Gayakwad (3rd ed. 1993, Prentice Hall of India).
2. Modern Electronic Communication by Gary M. Miller (6th ed., 1999, Prentice Hall International, Inc.).

3. Op-amp and linear integrated circuits by Coughlin and Driscoll (4th ed. 1992, Prentice Hall of India).
4. Integrate Circuits by K. R. Botkar (8th ed., Khanna Publishers, Delhi).
5. Design with Operational Amplifiers and Analog Integrated Circuits by Sergio Franco (3rd ed., Tata McGraw Hill).
6. Analog and Digital Communication Systems by Martin S. Roden (5th ed., Shroff Publishers and Distributors Pvt. Ltd.).
7. Microwaves by K. C. Gupta (New Age International Ltd.).
8. Electronic Communications by Dennis Roddy and John Coolen (4th ed., Pearson Education).
9. Basic microwave techniques and laboratory manual by M. L. Sisodia and G. S. Raghuvanshi (Wiley Eastern Ltd. 1987.).
10. Electronic communication systems by George Kennedy and Bernard Davis (4th ed., Tata McGraw Hill Publishing Company Ltd., New Delhi).
11. Digital communication systems by Harold Kolimbiris (Pearson Education Asia).
12. Optical fiber communication by G. Keiser (3rd ed., McGraw Hill).
13. Digital signal processing demystified by James D. Broesch (Penram International Publications, India).
14. The indispensable PC hardware book - Hans-Peter Messmer, Addison Wesley (PEA).
15. Parallel port complete by Jan Axelson, (Penram International Publications, India).
16. Serial port complete by Jan Axelson, (Penram International Publications, India).
17. Innovative experiments using Phoenix by Ajit kumarm IUACm New Delhi, India.

Note:

1. Journal should be certified by the laboratory in-charge only if the student performs satisfactorily the minimum number of experiments as stipulated above. Such students, who do not have certified journals, will not be allowed to appear for the practical examinations.

M.Sc. (Physics) Projects

Semesters III and IV

Project evaluation guidelines

Every student will have to complete one project each in Semester III and Semester IV with four credits (100 marks) each. Students can take one long project (especially for SSP/SSE/Material Sc/Nanotechnology/Nuclear etc) or two short project (especially for EI /EII). However for one long project students have to submit two separate project reports / dissertation consisting of the problem definition, literature survey and current status, objectives, methodology and some preliminary experimental work in Semester III and actual experimental work, results and analysis in semester IV with four credits each. Those who have opted for two separate projects will also have to submit two separate project reports at each examination. The project can be a theoretical or experimental project, related to advanced topic, electronic circuits, models, industrial project, training in a research institute, training of handling a sophisticated equipments etc.

Maximum three students can do a joint project. Each one of them will submit a separate project report with details/part only he/she has done. However he/she can in brief (in a page one or two) mention in Introduction section what other group members have done. In case of electronic projects, use of readymade electronic kits available in the market should be avoided. The electronics project / models should be demonstrated during presentation of the project. In case a student takes training in a research institute/training of handling sophisticate equipment, he/she should mention in a report what training he/she has got, which instruments he/she handled and their principle and operation etc.

Each project will be of 100 marks with 50% by internal and 50% by external evaluation.

There project report should be file bound/spiral bound/hard bound and should have following format

Title Page/Cover page
Certificate endorsed by Project Supervisor and Head of Department
Declaration
Abstract of the project
Table of Contents
List of Figures
List of Tables
Chapters of Content –
Introduction and Objectives of the project
Experimental/Theoretical Methodology/Circuit/Model etc. details
Results and Discussion if any
Conclusions
References

Evaluation by External/Internal examiner will be based on following criteria: (each semester)

criteria	**Maximum Marks**
Literature Survey	05
Objectives/Plan of the project	05
Experimental/Theoretical methodology/Working condition of project or model	10
Significance and originality of the study/Society application and Inclusion of recent References }	05
Depth of knowledge in the subject / Results and Discussions	10
Presentation	15
Maximum marks by External examiner	**50**
Maximum marks by internal examiner/guide	**50**
Total marks	**100**