R. J. COLLEGE

[Arts, Science & Commerce]

NAAC Re-Accreditation "A" Grade

"BEST COLLEGE" University of Mumbai

(AUTONOMOUS)

Affiliated to University of Mumbai

Department of Physics

Syllabus for Semesters - I to IV

Refer to page no: 05 highlighting component of Research Project

Program - M. Sc.

Course - Physics

Program code: RJSPGPHY

(Choice Based Credit with effect from Academic year 2021-22)

Course Structure & Distribution of Credits

M. Sc. in Physics Program consists of total 16 classroom courses, total 6 laboratory courses and 2 projects spread over four semesters. Twelve classroom courses and four laboratory course are common and compulsory for all the students. Remaining four classroom courses can be chosen from the list of elective courses offered by the college. Two Lab courses can be chosen from the elective lab courses offered by the institute. Each classroom course will be of 4 (four) credits, each lab course will be of 4 (four) credits and each 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,

Classroom Courses

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

Laboratory Courses

Semester-I	General Laboratory -1	Computer Laboratory -1
Semester-II	General Laboratory -2	Computer Laboratory -2
Semester-III	Project -1	Elective Lab Course-1
Semester-IV	Project -2	Elective Lab Course-2

The elective theory courses offered by the department 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. Microprocessors and Microcontrollers
6. Core Electronics, 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
20. Properties of Solids
21. Crystalline & Non-crystalline solids
22. Advanced Microcontroller
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 Methods and Programming
34. Polymer Physics
35. Non-linear Dynamics
36. Advanced Statistical Mechanics

Only some electives will be offered. Every year different electives may be offered depending on the availability of experts.

Semester I

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

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

Course Number	Subject	Lectures(Hrs.)	Credits
RJSPGPHY101	Mathematical Methods	60	04
RJSPGPHY102	Classical Mechanics	60	04

RJSPGPHY103	Quantum Mechanics-I	60	04
RJSPGPHY104	Solid State Physics	60	04
TOTAL		**240**	**16**

Laboratory courses (2): 16 hours per week

Lab Course No.	Lab Sessions (Hrs)	Credits
RJSPGPHY1P01	**120**	**04**
RJSPGPHY1P02	**120**	**04**

Semester II

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

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

Course No.	Subject	Lectures(Hrs.)	Credits
RJSPGPHY201	Statistical Mechanics	60	04
RJSPGPHY202	Electrodynamics	60	04
RJSPGPHY203	Quantum Mechanics-II	60	04
RJSPGPHY204	Atomic and Molecular Physics	60	04
TOTAL		**240**	**16**

Laboratory courses (2): 16 hours per week

Lab Course	Lab Sessions (Hrs)	Credits
RJSPGPHY2P01	**120**	**04**
RJSPGPHY2P02	**120**	**04**

Semester III

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

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

Course No.	Subject	Lectures(Hrs.)	Credits

RJSPGPHY301	Computational Physics	60	04
RJSPGPHY302	Nuclear Physics	60	04
*	Elective Course	60	04
*	Elective Course	60	04
	TOTAL	**240**	**16**

*: To be chosen from the list below

Project (1): 8 hours per week

Project	Course	Total Project Period (Hrs)	Credits
RJSPGPHY3P01	Project -1	**120**	**04**

Lab course (1): 8 hours per week

Lab Course	Course	Practical Lab Sessions (Hrs)	Credits
RJSPGPHY3P02	**Elective Lab Course - 1**	**120**	**04**

Semester IV

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

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

Course No.	Subject	Lectures(Hrs.)	Credits
RJSPGPHY401	Experimental Physics	60	04
RJSPGPHY402	Solid State Devices	60	04
*	Elective Course	60	04
*	Elective Course	60	04
	TOTAL	**240**	**16**

*: To be chosen from the list below

Project (1): 8 hours per week

Project	Course	Total Project Period (Hrs)	Credits
RJSPGPHY4P01	Project -2	**120**	**04**

Lab course (1): 8 hours per week

Lab Course	Course	Lab Sessions (Hrs)	Credits
RJSPGPHY4P02	**Elective Lab Course -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.

The list of Elective Courses along with the course numbers:

Course No.	Subjects	Lectures(Hrs.)	Credits
RJSPGPHYE01	Nuclear Structure	**60**	**04**
RJSPGPHYE02	Experimental Techniques in Nuclear Physics	**60**	**04**
RJSPGPHYE03	Electronic structure of solids	**60**	**04**
RJSPGPHYE04	Surfaces and Thin Films	**60**	**04**
RJSPGPHYE05	Microprocessors and Microcontrollers	**60**	**04**
RJSPGPHYE06	Core Electronics, Embedded Systems and RTOS	**60**	**04**
RJSPGPHYE07	Signal Modulation and Transmission Techniques	**60**	**04**
RJSPGPHYE08	Microwave Electronics, Radar and Optical Fiber Communication	**60**	**04**
RJSPGPHYE09	Semiconductor Physics	**60**	**04**
RJSPGPHYE10	Thin Film Physics and Techniques	**60**	**04**
RJSPGPHYE11	Fundamentals of Materials Science	**60**	**04**
RJSPGPHYE12	Nanoscience & Nanotechnology	**60**	**04**

RJSPGPHYE13	Astronomy and Space Physics	**60**	**04**
RJSPGPHYE14	Laser Physics	**60**	**04**
RJSPGPHYE15	Group Theory	**60**	**04**
RJSPGPHYE16	Applied Thermodynamics	**60**	**04**
RJSPGPHYE17	Quantum Field Theory	**60**	**04**
RJSPGPHYE18	Nuclear Reactions	**60**	**04**
RJSPGPHYE19	Particle Physics	**60**	**04**
RJSPGPHYE20	Properties of Solids	**60**	**04**
RJSPGPHYE21	Crystalline & Non-crystalline solids	**60**	**04**
RJSPGPHYE22	Advanced Microcontroller	**60**	**04**
RJSPGPHYE23	VHDL and communication Interface	**60**	**04**
RJSPGPHYE24	Digital Communication Systems and Python Programming	**60**	**04**
RJSPGPHYE25	Computer Networking	**60**	**04**
RJSPGPHYE26	Physics of Semiconductor Devices	**60**	**04**
RJSPGPHYE27	Semiconductor Technology	**60**	**04**
RJSPGPHYE28	Materials and their applications	**60**	**04**
RJSPGPHYE29	Energy Studies	**60**	**04**
RJSPGPHYE30	Galactic & Extragalactic Astronomy	**60**	**04**
RJSPGPHYE31	Plasma Physics	**60**	**04**
RJSPGPHYE32	Liquid Crystals	**60**	**04**
RJSPGPHYE33	Numerical Methods and Programming	**60**	**04**
RJSPGPHYE34	Polymer Physics	**60**	**04**
RJSPGPHYE35	Non-linear Dynamics	**60**	**04**
RJSPGPHYE36	Advanced Statistical Mechanics	**60**	**04**

2. Scheme of Examination and Passing:

1. This course will have 40% Term Work (TW) / Internal Assessment (IA) and 60% External Assessment. All external examinations will be held at the end of each semester. As decided by the BoS the format of the question paper will be decided by the teacher delivering the course. The Internal Assessment will consist of assignments / quizzes / surprise tests / unit tests / tutorials / practicals / project / seminars etc. as prescribed by the BoS.

2. The External examination for all Classroom and Laboratory courses shall be conducted at the end of each Semester and the evaluation of Project course and Project Dissertation will be conducted at the end of each Semester.

3. The candidates shall appear for external examination of 4 classroom courses each carrying 60 marks of 2 hours duration and 2 laboratory courses(1 Laboratory Course and 1 Project Course in M.Sc. Part II) each carrying 60 marks at the end of each semester.
4. The candidate shall prepare and submit for laboratory examination a certified Journal based on the laboratory course carried out under the guidance of a faculty member with minimum number of experiments as specified in the syllabus for each group.

5. The candidate shall submit a Project Report / Dissertation for the Project Course at the end of each semester as per the guidelines given on page 137.

M.Sc. (Physics) Classroom Courses

Semester –I

<u>Semester-I: Paper-I:</u>

Course no.: RJSPGPHY101: Mathematical Methods (45 lectures + 15 tutorials, 4 credits)

Course Outcomes:

1. This course is expected to equip the students with different mathematical methods used in solving problems in Physics.

2. By extensive problem solving, students would be comfortable in selecting and using any mathematical method learnt.

Learning Outcomes:

1. Students will be able to deal with complex functions and carry out integrations of functions of complex variables. They would also be able to use the methods of complex analysis to solve integrals involving functions of real variables.
2. Students will learn different advanced matrix operations, their properties and classifications. They would also learn the concept of tensors and be able to carry out algebra involving them.
3. Students will advance their knowledge about differential equations and learn to solve some second order differential equations with non-constant coefficients and learn different examples and methods to solve them.
4. Students will be introduced to integral transforms. They will learn Fourier and Laplace transforms in detail with their properties and applications.

Unit-I

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 integrals involving Sines and Cosines, Definite integrals involving sine and cosine functions.

Unit-II

Matrices, Eigenvalues and Eigenvectors, orthogonal, unitary and hermitian matrices, Diagonalization of Matrices, Applications to Physics problems. Introduction to Tensor Analysis, Addition and Subtraction of Tensors, summation convention, Contraction, Direct Product, Levi-Civita Symbol

Unit-III

General treatment of second order linear differential equations with non-constant coefficients, Power series solutions, Frobenius method, Legendre, Hermite and Laguerre polynomials, Bessel equations, Nonhomogeneous equation – Green's function, Sturm-Liouville theory.

Unit-IV

Integral transforms: three dimensional fourier transforms and its applications to PDEs (Green function of Poisson's PDE), convolution theorem, Parseval's relation, Laplace transforms, Laplace transform of derivatives, Inverse Laplace transform and Convolution theorem, use of Laplace's transform in solving differential equations.

Main references:

1. S. D. Joglekar, Mathematical Physics: The Basics, Universities Press 2005
2. S. D. Joglekar, Mathematical Physics: Advanced Topics, CRC Press 2007
3. M.L. Boas, Mathematical methods in the Physical Sciences, Wiley India 2006
4. G. Arfken and H. J. Weber: Mathematical Methods for Physicists, Academic Press 2005

Additional references:

1. A.K. Ghatak, I.C. Goyal and S.J. Chua, Mathematical Physics, McMillan

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

Semester-I: Paper-II:

Course no.: RJSPGPHY102: Classical Mechanics (45 lectures + 15 tutorials, 4 credits)

Course Outcomes:

1. The students are expected to obtain the perspective of the field of classical mechanics.
2. They should be able to appreciate different symmetry principles and their consequences. They should be able to use different symmetries to reduce the complexity of the problem.
3. They should understand that the general dynamical principles of classical mechanics parallel those of quantum mechanics.

Learning Outcomes:

1. Students will learn Lagrangian dynamics in more detail and will be able to solve more involved problems of classical mechanics using it.
2. Students will address the classic two body central force problem and, using the symmetries, reduce it to equivalent one dimensional problem. After a very general treatment they'll learn some specific cases like Kepler's laws and scattering.
3. Students will learn general treatment of small oscillatory motion using the Lagrangian dynamics. They will also be introduced to the Hamilton's formulation of classical mechanics.
4. Students will canonical transformations, will be able to decide if the given transformation is canonical. They will be introduced to Poisson brackets.

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 Kepler problem : 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, Poisson 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 Reference: Classical Mechanics, H. Goldstein, Poole and Safko, 3rd Edition, Narosa Publication (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: RJSPGPHY103: Quantum Mechanics-I (45 lectures + 15 tutorials, 4 Credits)

Course Outcomes:

1. After this course, students are expected to gain knowledge of quantum mechanics in considerable depth.
2. They should be able to apply the methods to any problem needing quantum mechanical treatment.
3. They would be well versed in the mathematical aspects of the course.

Learning Outcomes:

1. The aim of this course is to apprise the students with the mathematical formulation of Quantum Mechanics. Students will learn mathematical formalism and mathematical interconnections between different concepts of quantum mechanics.
2. Students will solve different one dimensional problems involving simple potentials by using different mathematical methods.
3. Also, few problems in three dimensional case will be considered and solved using different coordinate systems.
4. Students will also master different concepts and techniques related to rotational motion.

Unit I

1. Review of concepts:

Postulates of quantum mechanics, observables and operators, measurements, state function and expectation values, the time-dependent Schrodinger equation, time development of state functions, solution to the initial value problem. The Superposition principle, commutator relations, their connection to the uncertainty principle, complete set of commuting observables. Time development of expectation values, conservation theorems and parity.

2. Formalism:

Linear Vector Spaces and operators, Dirac notation, Hilbert space, Hermitian operators and their properties, Matrix mechanics: Basis and representations, unitary transformations, the energy representation. Schrodinger, Heisenberg and interaction picture.

Unit II

1. **Wave packet:** Gaussian wave packet, Fourier transform.

2. **Schrodinger equation solutions: one dimensional problems:**

General properties of one dimensional Schrodinger equation, Particle in a box, Harmonic oscillator by raising and lowering operators and Frobenius method, unbound states, one dimensional barrier problems, finite potential well.

Unit III

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 centre of mass, radial equation for a spherically symmetric central potential, hydrogen atom, eigenvalues and radial eigenfunctions, degeneracy, probability distribution.

Unit IV

Angular Momentum:

1. Ladder operators, eigenvalues and eigenfunctions of L^2 and L_z using spherical harmonics, angular momentum and rotations.
2. Total angular momentum J; LS coupling; eigenvalues of J^2 and Jz.
3. Addition of angular momentum, coupled and uncoupled representation of eigenfunctions, Clebsch Gordan coefficient for $j_1 = j_2 = ½$ and $j_1 =1$ and $j_2 = ½$.
4. Angular momentum matrices, Pauli spin matrices, spin eigenfunctions, free particle wave function including spin, addition of two spins.

Main references:

1. Richard Liboff, Introductory Quantum Mechanics, 4th edition, Pearson.

2. D J Griffiths, Introduction to Quantum Mechanics 4th edition
3. A Ghatak and S Lokanathan, Quantum Mechanics: Theory and Applications, 5th edition.

4. N Zettili, Quantum Mechanics: Concepts and Applications, 2nd edition, Wiley.

Additional References

1. W Greiner, Quantum Mechanics: An introduction, Springer, 2004

2. R Shankar, Principles of Quantum Mechanics, Springer, 1994

3. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1977).

4. J. J. Sakurai, Modern Quantum Mechanics, Addison-Wesley (1994).

Semester-I : Paper-IV:

Course no.: RJSPGPHY104: Solid State Physics (45 lectures + 15 tutorials, 4 credits)

Course Outcomes:

1. The course will further the understanding the structure of solids, ways to determine it and its effect on the thermal conductivity properties.
2. The course will advance the knowledge about magnetism and gain theoretical understanding of atomic origins of different types of magnetic materials.

Learning Outcomes:

1. The students will learn advanced concepts like reciprocal lattice and study the phenomenon of scattering from periodic lattice systems. They’ll study experimental methods related to x-ray diffraction techniques.
2. Students will understand different modes of thermal transport in

lattice, will study lattice vibrations, phonons etc.

3. Students will gain theoretical understanding of the atomic origin of diamagnetism, paramagnetism and ferromagnetism.

Unit – I: Diffraction of Waves by Crystals and Reciprocal Lattice

Bragg law, Scattered Wave Amplitude – Fourier analysis, Reciprocal Lattice Vectors, Diffraction Conditions, Brillouin Zones, Reciprocal Lattice to SC, BCC and FCC lattice. Interference of Waves, Atomic Form Factor, Elastic Scattering by crystal, Ewald Construction, Structure Factor, Temperature Dependence of the Reflection Lines, Experimental Techniques (Laue Method, Rotating Crystal Method, Powder Method) Scattering from Surfaces, Elastic Scattering by 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., Quantization 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.

Main References:-

1. Charles Kittel "Introduction to Solid State Physics", 7th edition John Wiley & sons.

2. J.RichardChristman "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) Laboratory Courses

Semester –I

Semester – I General Lab-1

Course number: RJSPGPHY1P01 (120 hours, 4 credits)

1. Michelson Interferometer
2. Analysis of sodium spectrum
3. h/e by vacuum photocell
4. Susceptibility measurement by Quincke's method/ Guoy's balance method
5. Absorption spectrum of specific liquids
6. Diac-Triac phase control circuit
7. Delayed linear sweep using IC 555
8. Constant current supply using IC 741 and LM 317
9. Active filter circuits (second order)
10. Study of 4 digit multiplex display system
11. Carrier lifetime by pulsed reverse method
12. Resistivity by four probe method
13. Temperature dependence of avalanche and Zener breakdown diodes
14. DC Hall effect
15. Determination of particle size of lycopodium particles by laser diffraction method
16. Magneto resistance of Bi specimen

17. Microwave oscillator characteristics
18. Temperature on-off controller using IC
19. Waveform Generator using ICs
20. Study of 8 bit DAC
21. Study of elementary digital voltmeter
22. Diffraction using helical structure
23. Divergence and diffraction of He-Ne/ solid LASER Beam
24. Verification of De-Morgan’s Theorem
25. Code converter (Binary to Gray and Gray to Binary) using IC 7486.

References:

1. Advanced Practical Physics -Worsnop and Flint
2. Atomic spectra- H.E. White
3. Experiments in modern physics – Mellissinos
4. A course of experiments with Laser - Sirohi
5. Elementary experiments with Laser - G. White
6. Solid state devices- W.D. Cooper
7. Electronic text lab manual - P.B. Zbar
8. Electronic Principles - A. P. Malvino
9. Operational amplifiers and linear Integrated circuits - Coughlin & Driscoll
10. Practical analysis of electronic circuits through experimentation - L.MacDonald
11. Integrated Circuits - K. R. Botkar
12. Op-amps and linear integrated circuit technology- R. Gayakwad
13. Digital Electronics - Roger Tokheim
14. Semiconductor electronics by Gibson
15. Semiconductor measurements by Runyan
16. Electronic devices & circuits - Millman and Halkias
17. Manual of experimental physics - E. V. Smith
18. Semiconductors and solid state physics - Mackelvy
19. Handbook of semiconductors – Hunter
20. Physics of Semiconductor Devices by S. M. Sze
21. Operational amplifiers : experimental manual C.B. Clayton
22. Digital principles and applications by Malvino and Leach
23. Digital circuit practice by RP Jain

Note: Minimum number of experiments to be performed and reported in the journal =08. Some new experiments may be added from time to time.

Additional references:

1. Digital theory and experimentation using integrated circuits - Morris E. Levine (Prentice Hall)
2. Practical analysis of electronic circuits through experimentation - LomeMacronaid (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 - AnalaPandit (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

2. Total marks for the practical examinations = 100 of which 40% will be given by continuous evaluation and 60% by term-end evaluation.

Semester – I Computer Lab-1

Course number: RJSPGPHY1P02 (120 hours, 4 credits)

1. Simple programs using if-block and loops, introduction to Linux commands
2. Programs using arrays - bubble sort, matrix multiplication etc.
3. Introduction to pointers and converting programs written using arrays to ones using pointers.
4. Write programs to evaluate functions from their Taylor series. Introduction to gnuplot and header files. Create own math library “mymath.h”
5. Programs for average, standard deviation and linear regression.
6. Programs to find a root of a given function.
7. Programs for numerical differentiation
8. Introduction to OOP, program to carry out algebra of complex numbers.
9. Programs for interpolation.
10. Introduction to shell scripts and makefile, more Linux commands and further aspects of gnuplot

References

1. Object Oriented Programming With C++ (4th ed.), E. Balaguruswamy, Tata

Mcgraw-Hill Education, 2008.
2. The C Programming Language (2nd ed.), B. W. Kernighan, D. M. Ritchie, Prentice Hall, 1988. (The ANSI C version)
3. Numerical Recipes in C++ (2nd ed.), W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P Flannery, Cambridge University Press, Cambridge, 2003.
4. Rajaraman: Computer oriented Numerical methods, PHI 2004
5. Jain M.K., Iyengar SRK, Jain R.K. : Numerical methods for scientific and Engineering Computation, New Age International, 1992
6. H. M. Antia: Numerical methods for scientists and engineers.
7. S. S. Sastry: Introductory method of numerical analysis, PHI India 2005
8. P. B. Patil and U. P. Verma: Numerical Computational methods, Narosa Publ.

M.Sc. (Physics) Theory Courses

Semester –II

Semester-II : Paper-I:

Course no.: RJSPGPHY201: Statistical Mechanics (45 lectures + 15 tutorials, 4 credits)

Course Outcome:

1. In this course the students will learn the microscopic origin of several laws especially in thermodynamics.
2. The students will learn concepts and techniques to derive governing equations for macroscopic variables from the interactions at the microscopic level.

Learning Outcomes:

1. The students will be introduced to new concepts of statistical mechanics. They are expected to understand the connection between thermodynamics and statistical mechanics.
2. The students will learn different ensembles in detail. They are expected to be able to identify and work with systems belonging to different ensembles.

Unit – I

Review of thermodynamics (extensive and intensive variable, concept of equilibrium, internal energy and laws of thermodynamics, specific heat, isothermal and adiabatic processes, thermodynamics potentials, free energy and enthalpy), Thermodynamics of Phase Transitions, Postulates of classical statistical mechanics (ergodicity, Liouville's theorem, equal a priori probability), Microcanonical ensemble, Second law of thermodynamics, examples: ideal gas, Einstein solid, paramagnet.

Unit - 2

Boltzmann statistics, Boltzmann factor, canonical ensemble, Maxwell speed distribution, applications to ideal gas, paramagnet etc, Grand canonical ensemble, Gibbs factor, examples.
Fluctuations.

Unit - 3

Bose-Einstein and Fermi-Dirac statistics, Examples: Degenerate Fermi gases, density of states, Sommerfeld Expansion, Blackbody Radiation, Debye theory of solids, Bose-Einstein Condensation

Unit - 4

Interacting systems, weakly interacting gases, Ising model for Ferromagnets, exact solution in one dimensions, mean field approximations, Monte Carlo simulations.

Textbook/Main Reference:

1. Introduction to Statistical Physics, Kerson Huang , Taylor and Francis 2001.
2. An Introduction to Thermal Physics, Daniel V. Schroeder
3. Thermal and Statistical Physics, F Reif.

Additional References:

1. Thermodynamics and Statistical Mechanics, Greiner, Neise and Stocker, Springer 1995.
2. Statistical Mechanics - R. K. Pathria& Paul D. Beale (Third Edition), Elsevier 2011 – Chap. 1 to 8
3. Principles of Equilibrium Statistical Mechanics, Debashish Chowdhury and Dietrich Stauffer (Wiley-VCH)

Semester-II : Paper-II:

Course no.: RJSPGPHY202: Electrodynamics (45 lectures + 15 tutorials, 4 credits)

Course Outcome:

1. The purpose of the course is to advance students' knowledge of electrodynamics to a higher level and also to study its applications to practical examples.
2. The students are expected to have appreciated the theoretical consistency of the theory of Maxwell's equations and also its consequences to the real life situations.

Learning outcomes:

1. Students will learn advanced concepts involving Maxwell's equations. They will also be introduced to the Poynting theorem and its uses. They will learn about the EM waves from the perspective originating from the Maxwell's equations and their propagation through different media and through waveguides.
2. Students will learn about moving charges and the radiation emanating from them leading to the theory of antenas. They'll also go on to study the covariant formulation of the Maxwell equations and related concepts.

Unit-I:

Maxwell's equations, The Poynting 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 Reference:

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.: RJSPGPHY203: Quantum Mechanics-II (45 lectures + 15 tutorials, 4 credits)

Course Outcome:

1. The purpose of this course is to teach advanced concepts of quantum mechanics which will allow them to tackle more complex problems albeit approximately.
2. This course will also introduce the students further advanced concept used later in theoretical physics.

Learning outcomes:

1. Students will advance their knowledge of quantum mechanics by learning some approximation methods like perturbation theory to calculate the corrections to the energy, variational principle or WKB approximation.

2. Students will learn quantum mechanical aspects of scattering theory. They'll also go on to analyse the quantum mechanical reasons behind different behaviors of particles with different spins. Finally, they'll learn relativistic aspects of quantum mechanics.

Unit I: Perturbation Theory:

Time independent perturbation theory: First order and second order corrections to the energy eigenvalues and eigenfunctions. Degenerate perturbation Theory: first order correction to energy.

Time dependent perturbation theory: Harmonic perturbation, Fermi's Golden Rule, sudden and adiabatic approximations, applications.

Unit II: Approximation Methods

1. Variation Method: Basic principle, applications to simple potential problems, He-atom.
2. WKB Approximation: WKB approximation, turning points, connection formulas, Quantization conditions, applications.

Unit III: scattering Theory

Laboratory and centre of mass frames, differential and total scattering cross-sections, scattering amplitude, Partial wave analysis and phase shifts, optical theorem, S-wave scattering from finite spherical attractive and repulsive potential wells, Born approximation.

Unit IV

1. Identical Particles: Symmetric and antisymmetric wave functions, Bosons and Fermions, Pauli Exclusion Principle, slater determinant.
2. Quantum Computing: Information measure, Turing machine and complexity classes, qubits and quantum logic gates.
3. Relativistic Quantum Mechanics: The Klein Gordon and Dirac equations. Dirac matrices, spinors, positive and negative energy solutions physical interpretation. Nonrelativistic limit of the Dirac equation.

Main references:

1. Richard Liboff, Introductory Quantum Mechanics, 4th edition, Pearson.

2. D J Griffiths, Introduction to Quantum Mechanics 4th edition
3. A Ghatak and S Lokanathan, Quantum Mechanics: Theory and Applications, 5th edition.
4. N Zettili, Quantum Mechanics: Concepts and Applications, 2nd edition, Wiley.
5. J. Bjorken and S. Drell, Relativistic Quantum Mechanics, McGraw-Hill (1965).

Additional References

1. W Greiner, Quantum Mechanics: An introduction, Springer, 2004

2. R Shankar, Principles of Quantum Mechanics, Springer, 1994

3. P.M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1977).
4. J.J. Sakurai Modern Quantum Mechanics, Addison-Wesley (1994).

Semester-II : Paper-IV:

Course no: RJSPGPHY204 Atomic and Molecular Physics (60 hours 4 Credits)

Course outcome:

1. The students will extend their knowledge of quantum mechanics as applied to atoms and molecules.
2. They'll study different aspects of the atomic and molecular spectra and study their origin from quantum mechanics.

Learning outcome:

1. The students will study different effects and derive them from the Schrodinger equation. They'll also analyse the effect of the coupling between different angular momenta.
2. The students will learn the theory of how an electromagnetic radiation is absorbed and emitted by an atom. They'll study various aspects of the spectra of atoms as well as molecules.

Unit I: Review* of one-electron eigenfunctions and energy levels of bound states, Probability density, Virial theorem.

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

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

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)

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)

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)

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 (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. (GA, IL)

Quantum theory of Raman effect, Pure rotational Raman spectra, Vibrational Raman spectra, Polarization of light and the Raman effect, Applications

General theory of Nuclear Magnetic Resonance (NMR). NMR spectrometer, Principle of Electron spin resonance ESR. ESR spectrometer. (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, 2nded, (ER)
2. B.H. Bransden and G. J. Joachain, Physics of atoms and molecules, Pearson Education 2nded, 2004 (BJ)
3. G. K. Woodgate, Elementary Atomic Structure, Oxford university press, 2nded, (GW).
4. G. Aruldhas, Molecular structure and spectroscopy, Prentice Hall of India 2nded, 2002 (GA)
5. Ira N. Levine, Quantum Chemistry, Pearson Education, 5th edition, 2003 (IL)

Additional reference:

1. Leighton, Principles 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, 3rded
4. Wolfgang Demtröder, Atoms, molecules & photons, Springer-Verlag 2006
5. SuneSvanberg, Atomic and Molecular Spectroscopy Springer, 3rded 2004
6. C.J. Foot, Atomic Physics, Oxford University Press, 2005 (CF)

M.Sc. (Physics) Laboratory Courses

Semester –II

Semester –II General Lab-2

Course number: RJSPGPHY2P01 (120 hours, 4 credits)

1. Zeeman Effect using Fabry-Perot etalon /Lummer — Gehrecke plate
2. Characteristics of a Geiger Muller counter and measurement of dead time.
3. Ultrasonic Interferometry-Velocity measurements in different Fluids
4. Coupled Oscillations
5. I-V/ C-V measurement on semiconductor specimen
6. Double slit- Fraunhofer diffraction (missing order etc.)
7. Determination of Young’s modulus of metal rod by interference method
8. Adder-subtractor circuits using ICs
9. Study of Presettable counters - 74190 and 74193
10. TTL characteristics of Totempole, Open collector and tristate devices
11. Pulse width modulation for speed control of dc toy motor
12. Study of sample and hold circuit
13. Switching Voltage Regulator
14. Carrier mobility by conductivity
15. Measurement of dielectric constant, Curie temperature and verification of Curie— Weiss law for ferroelectric material
16. Barrier capacitance of a junction diode
17. Design and study the Linear Voltage Differential Transformer
18. Faraday Effect-Magneto Optic effect: a) To Calibrate Electromagnet b) To determine Verdet's constant for KCI & KI solutions.
19. Energy Band gap by four probe method
20. Measurement of dielectric constant (capacitance)
21. Shift registers
22. Ambient Light control power switch
23. Interfacing TTL with buzzers, relays, motors and solenoids
24. h’ by using different Led’s color.
25. Franck Hertz Experiment

References:

1. Advance practical physics - Worsnop and Flint

2. Experiments in modern physics - Mellissinos

3. Manual of experimental physics --EV-Smith

4. Experimental physics for students - Whittle & Yarwood
5. Medical Electronics- Khandpur
6. HBCSE Selection camp 2007 Manual
7. Semiconductor measurements - Runyan
8. Digital Principles and applications-Malvino and Leach
9. Digital circuit practice-R.P.Jain
10. Digital circuit practice-Jain &Anand
11. Experiments in digital practice-Jain &Anand
12. Electronic Instrumentation - H. S. Kalsi
13. Integrated Circuits - K. R. Botkar
14. Semiconductor electronics - Gibson
15. Electronic instrumentation & measurement: W. D. Cooper
16. Introduction to solid state physics - C. Kittel
17. Solid state physics — A. J. Dekkar
18. Electronic Instrumentation - W.D. Cooper
19. Digital Electronics by Roger Tokheim

Note: Minimum number of experiments to be performed and reported in the journal =08. New experiments may be added from time to time.

Additional references:

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

2. Practical analysis of electronic circuits through experimentation - LomeMacronaid (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 - AnalaPandit (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 = 100 of which 40% will be given by continuous evaluation and 60% by the term-end evaluation.

Semester –II Computer Lab-2

Course number: RJSPGPHY2P02 (120 hours, 4 credits)

1. Introduction to GSL, writing some of the previous semester's programs using GSL.
2. Numerical integration/ solving ODEs using C++ and GSL.
3. Random Number generation using GSL and simple programs using Monte Carlo approach (like, area of a circle).
4. Introduction to Scilab/ Octave. Solving ODEs using it (examples: simple and nonlinear/ double pendulum).
5. Introduction to finite element methods and Python or R. Solving a PDE using Python or R.

References

1. Object Oriented Programming With C++ (4th ed.), E. Balaguruswamy, Tata Mcgraw-Hill Education, 2008.

2. The C Programming Language (2nd ed.), B. W. Kernighan, D. M. Ritchie, Prentice Hall, 1988. (The ANSI C version)

3. Numerical Recipes in C++ (2nd ed.), W. H. Press, S. A. Teukolsky, W. T. Vetterling and B. P Flannery, Cambridge University Press, Cambridge, 2003.

4. Rajaraman: Computer oriented Numerical methods, PHI 2004

5. Jain M.K., Iyengar SRK, Jain R.K. : Numerical methods for scientific and Engineering Computation, New Age International, 1992

6. H. M. Antia: Numerical methods for scientists and engineers.

7. S. S. Sastry: Introductory method of numerical analysis, PHI India 2005

8. P. B. Patil and U. P. Verma: Numerical Computational methods, Narosa Publ.

9. A Byte of Python by C. H. Swaroop

M.Sc. (Physics) Theory Courses

Semester –III

Semester-III : Paper-I:

Course no.: RJSPGPHY301: Computational Physics (45 lectures + 15 tutorials, 4 credits)

Course outcome:

1. Students will get exposure to the vast field of computational physics. They would get introduced to various approaches of simulating physical systems on a computer.
2. Students will be able to choose the correct method to solve a computational problem.

Learning outcome:

1. Students will be introduced to two basic approaches in computational physics, molecular dynamics and Monte Carlo simulations. They'll study these methods in some details and would be able to apply it to various situations.
2. Students will also learn some advanced methods like density functional theory (DFT) and finite element method (FEM). In DFT, they would be introduced to the basic theories and the fundamental equations. In FEM, the methods of solving different types of PDEs will be covered.

Unit I: Molecular Dynamics

Integrating equation of motion of a few variables, three-body problem, role of molecular dynamics (MD), the basic machinery, Lennard-Jones potentials modeling physical system, boundary conditions, time integration algorithm, starting a simulation, simulation of microcanonical (NVE) and canonical ensemble (NVT), controlling the system (temperature, pressure), thermostats and barostats, equilibration, running, measuring and analyzing MD simulation data, measurement of statistical quantities, interatomic potentials, force fields.

Unit II: Stochastic Methods

Random number: Definition, True and Pseudo random number generators (RNG), uniform and non-uniform RNG, Linux RNG, testing a RNG.
Monte Carlo simulation: Buffon's needles, MC Integration, hit and miss, stochastic processes, sample mean integration, important sampling, Markov Chain, Metropolis method, master equation, introduction to 2d-Ising model.
Random walk: two dimensional random walk, calculation of rms displacement.

Unit III: Density Functional Theory

The Hartree-Fock theory, Thomas-Fermi theory, Hohenberg-Kohn theory - basic theorem of Hohenberg and Kohn, the Kohn-Sham equation, link to the Hartree-Fock-Slater determinant, LDA approximation

Unit IV: Finite Element Method for PDEs
Introduction of PDE, Classification of PDE: parabolic, elliptic and hyperbolic. Boundary and initial conditions, Taylor series expansion, analysis of truncation error, Finite difference method: FD, BD & CD, Higher order approximation, Order of Approximation, Polynomial fitting, One-sided approximation, solution to each type of PDE by one chosen methods.

References:

1. A Molecular Dynamics Primer, Furio Ercolessi, http://www.fisica.uniud.it/~ercolessi/md/
2. Understanding Molecular Simulation, Daan Frenkel and B. Smit, Academic Press, 1996.
3. Computational Physics, J. M. Thijssen, Cambridge Univ. Press, 1999.
4. Molecular Dynamics Simulation- Haile (Wiley Professional)
5. A first course in computational Physics, Paul, L. Pavries, Pub. John Wiley and Sons, 1994.
6. Monte Carlo Methods, M. H. Kalos and P. A. Whitelock, John Wiley & Sons, NY 1986.
7. A Guide to Monte Carlo Simulations in Statistical Physics - Landau & Binder (Cambridge University Press).
8. Statistical Mechanics - Algorithms and Computations - Krauth (Oxford University Press).

Semester-III : Paper-II:

<u>Course no.: RJSPGPHY302: Nuclear Physics (45 lectures + 15 tutorials, 4 credits)</u>

<u>Course Outcome:</u>

1. The aim of the course is to impart some advanced knowledge of Nuclear Physics. The concepts learnt during the graduation will be developed further.
2. This course also exposes the students to modern high energy physics.

<u>Learning Outcome:</u>

1. Students will learn the properties of nuclei and also ways to estimate their size. They'll go deeper into their structure and also study different decays and their theory.
2. Students will learn different models in detail and also study different types and reactions and their theories. The students will be introduced to the elements of particle physics.

Unit I. (12 Lectures + 3 Tutorials)
All static properties of nuclei (charge, mass, binding energy, size, shape, angular momentum, magnetic dipole momentum, electric quadrupole momentum, statistics, parity, isospin), Measurement of Nuclear size and estimation of R0 (mirror nuclei and mesonic atom method) Q-value equation, energy release in fusion and fission reaction.

Deuteron Problem and its ground state properties, Estimate the depth and size of (assume) square well potential, Introduction 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: derivation of Fermi's Golden rule, Information from Fermi–curie plots, Comparative half-lives, selection rules for Fermi and G-T transitions.

Gamma decay: Multipole radiation, Selection rules 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)

1.Nuclear Models: Shell Model (extreme single particle): Introduction, Assumptions, Evidences, Spin-orbit interactions, Predictions including Schmidt lines, limitations, Collective model - Introduction to Nilsson Model.
2.Nuclear Reactions: Kinematics, scattering and reaction cross sections, Compound nuclear reaction, direct nuclear 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 Eightfold 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 Electrodynamics, 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. Introductory 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.

Other References:

1. Introduction to Nuclear Physics, H. A. Enge, Eddison Wesley

2. Nuclei and Particles, E. Segre, W. A. Benjamin

3. Concepts of Nuclear Physics, B. L. Cohen

4. Subatomic Particles, H. Fraunfelder and E. Henley, Prentice Hall

5. Nuclear Physics : Experimental and Theoretical, 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. Jones, Addison Wesley

9. Introductory Nuclear Physics, S. M. Wong, Prentice Hall.

10. Nuclear Physics: An Introduction, S. B. Patel, New Age International.

11. Nuclear Physics : S. N. Ghoshal

12. Nuclear Physics: Roy and Nigam

M.Sc. (Physics) Laboratory Course

Semester –III

Semester III Elective Lab Course-1

Course no.: RJSPGPHY3P02: Advanced Physics Lab-1 (120 hours, 4 credits)

A) **For Students offering electives other than Electronics I or Electronics II, have to perform at least 10 experiments from the following**

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

3. Cooling curves and Phase diagram of Pb-Sn alloy system.
4. Ionic conductivity.
5. Creep study in Pb-Sn alloy wire.
6. Stress-Strain curves

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. Band gap measurements of thin films using UV-Vis Spectroscopy
5. I-V measurements of Ge, Si, GaAs diodes at room temp, identification of different regions, determination of ideality factor
6. Carrier lifetime by light pulse method
7. d c electrical conductivity of Semiconducting thin films at room temperature and its temp dependence.
8. Thermo-electric power measurement of semiconducting thin films.

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/thermal evaporation method of thin film preparation and estimation of sheet resistance
4. Measurement of thickness of vacuum/thermal evaporated/chemical bath deposited 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. to a standard star

XIII. Nonlinear Dynamics

1) Write a program to generate trajectories of the logistic map and hence the bifurcation diagram.

Evaluate the Feigenbaum number numerically and verify the universality by considering other unimodal maps.

2) Assemble a simple Chua's circuit on a bread board and observe the waveforms on an oscilloscope. Observe the double scroll attractor in the xy mode and the period doubling bifurcations as a control resistance is varied. Draw a bifurcation diagram by noting down the period of the waveforms for different values of the control resistance.

3) Write a program to solve the equations for Duffing's oscillator and study its bifurcation diagram.

4) Construct a double pendulum and from its videogrammatic recordings study its chaotic property.

B) <u>The Students offering electives of Electronics I, have to perform at least 10 experiments from the following:</u>

I 8085 Microprocessor based experiments:

i. Study of 8085: Microprocessor Kit and execution of simple Programs.
ii. Waveform generation using 8085

iii. Study of 8085 interrupts (Vector Interrupt 7.5).
iv. Study of PPI 8255 as Handshake I/O (mode 1): interfacing switches and LED's.

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. Interfacing 8-bit DAC with 8031/51 to generate waveforms: square, sawtooth, triangular.
4. Interfacing stepper motor with 8031/51: to control direction, speed and number of steps.

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 Circuit designing

i. Linear power supply

ii. Precision Rectifier
iii. Digital to Analog converter (R to 2R ladder network/weighted resistor network)
iv. Instrumentation Amplifier.
v. Pulse Width Modulation using 555 timer.
vi. Pulse Amplitude Modulation using 555 timer.

1.

C) <u>The Students offering electives of Electronics II,have to perform at least 10 experiments from the following:</u>

I <u>Electronics Communication:</u>

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.

<u>II Computation</u>

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

References:

(i) Op-amp and linear ICs by RamakantGayakwad (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

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

<u>Course no: RJSPGPHY401 Experimental Physics (60 hours 4 Credits)</u>

<u>Course Outcome:</u>

1. This course teaches the students different techniques needed for good experimental practice, analysis as well as carrying out experiments.
2. It teaches different techniques as well as devices to carry out good experiments.

Learning Outcome:

1. Students start by learning methods to carry out data analysis and the estimation of errors.
2. They'll also learn about different experimental techniques that they may need.
3. They'll also become familiar with different devices used in the experimental science.

Unit-I

Data Analysis for Physical Sciences: Population and Sample, Data distributionsProbability, 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.

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

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)

Unit III

Nuclear Detectors: Gamma ray spectrometer using NaI scintillation detector, High Purity Germanium detector, Multi-wire Proportional counter

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

References

1. Nuclear Radiation Detection- William James Price , McGraw Hill
2. Techniques for Nuclear and Particle Physics Experiments, W.R. Leo, Springer- Verlag
3. Radiation Detection and Measurement, Glenn F. Knoll, John Wiley and sons, Inc.
4. Particle Accelerators, Livingston, M. S.; Blewett, J.
5. Introduction to Nuclear Physics, HA Enge, pp 345-353
6. Electricity & Magnetism and Atomic Physics Vol. II, J. Yarwood
7. Principles of Particle Accelerators, E. Persico, E. Ferrari, S.E. Segre
8. Fundamentals of Molecular Spectroscopy, C. N. Banwell, Tata-McGraw Hill
9. Radiation detection & Measurement-Glenn F. Knoll
10. Techniques for Nuclear & Particle Physics Experiment- William Leo

Unit IV

Characterization techniques for materials analysis:

1. Spectroscopy: XRD, XRF, XPS, EDAX , Raman, UV Visible spectroscopy, FTIR spectroscopy.

2. Microscopy: SEM, TEM, AFM

References:

i. An Introduction to Materials Characterization, Khangaonkar P. R., Penram International Publishing
ii. Rutherford Backscattering Spectrometry, W. K. Chu, J. W. Mayer, M. A. Nicolet, Academic Press
iii. A Guide to Materials Characterization and Chemical Analysis, John P. Sibilia, Wiley- VCH; 2 edition
iv. Fundamentals of Surface and Thin Film Analysis, L.C. Feldman and J.W. Mayer North Holland amsterdam
v. Elements of X-ray diffraction, Cullity, B. D Addison-Wesley Publishing Company, Inc.
vi. Nano: The Essentials: T.Pradeep, TMH Publications

Semester-IV : Paper-II:

Course no.: RJSPGPHY402: Solid State Devices (45 lectures + 15 tutorials, 4 credits)

Course outcome:

1. The purpose of this course is to introduce the students to different electronic devices. At the end of the course, they'll have a fair understanding of the semiconductors and fabrication of different devices using different semiconductors.
2. Students will have a clear idea of their characteristics and properties and will be well versed with the methods of studying them.

Learning outcomes:

1. The students will learn different aspects of semiconductors, their classification, crystal structures, etc. They'll also study the transport properties and different types of recombinations.

2. They'll also learn about the fabrication of p-n junctions by different methods and also study their characteristics. Furthermore, this study will be extended to different devices such as BJT, MOFET etc.

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.

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 –IV

Semester IV Elective Lab Course-2

Course no.: RJSPGPHY4P02: Advanced Physics Lab-2 (120 hours, 4 credits)

A) Students offering electives other than 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 IV 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)

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.

XIV. Advanced Statistical Mechanics

1. Numerical simulation of random walk
2. Videogramatic measurements of brownian motion and determination of Boltzmann constant
3. Numerical simulation of Ising model (equivalent to three experiments).

B. <u>Students offering electives of Electronics I , have to perform at least 10 experiments out of following:</u>

1. **Interfacing (16F84 or 16FXXXI PIC Micro-controller based Experiments using assembly language only)**

i. Event Counter (Using IR Sensor).
ii. Interfacing Opto-Couplers: using as input and output
iii. Interfacing 7-Segment Display in the multiplexing mode: to display a two-digit number
iv. Use of built-in ADC or Interface 8-bit ADC (0804): converting the analog signal into its binary equivalent by using built-in ADC of the PIC micro-controller. OR Interface an 8-bit ADC 0804 to the PIC micro-controller and convert an analog signal into its binary equivalent.

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:

a. Write VHDL programs to realize: logic gates, half adder and full adder

b. 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

c. Write VHDL programs to realize the following: SR – Flip Flop, JK – Flip Flop, T – Flip Flop

d. 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

a. 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.

C) <u>Students offering electives of Electronics II, have to perform at least 10 experiments out of following:</u>

<u>Experiments in Electronics Communication</u>

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.

Millikan's oil-drop method, Raman effect in liquids, e/m by Thomson's method

Rydberg's constant using constant deviation prism.

References:

1. Op-amp and linear ICs by RamakantGayakwad (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

(5^{th} 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 (4^{th} 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 (4^{th} 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 (3^{rd} 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 kumar IUAC 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.

Syllabi of Elective Courses

Course no.: RJSPGPHYE01: Nuclear Structure (45 lectures + 15 tutorials, 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 UniversityPress 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)

Course no.: RJSPGPHYE02: Experimental Techniques In Nuclear Physics (45 lectures + 15 tutorials, 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
5.

Course no.: RJSPGPHYE03: Electronic Structure of Solids (45 lectures + 15 tutorials, 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.

Main References:

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.

Additional References:

1. Brian Tanner, *Introduction to the Physics of Electrons in Solids, CUP,* 1995.
2. M A Wahab, *Solid State Physics*, Narosa, 2005.
3. G Grosso and G Paravicini, *Solid State Physics*, Academic Press, 2000.

<u>Course no.: RJSPGPHYE04: Surfaces and Thin Films (45</u>

<u>lectures + 15 tutorials, 4 credits)</u>

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 detection, Materials used

Preparation of Thin Films: Thermal evaporation, Cathode Sputtering, Chemical Deposition, Laser Ablation, Langmuir 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 equation, quantum confinement.Growth techniques for nanomaterials- 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. LudmilaEckertova “ Physics of Thin Films” Plenum Press NY (1986)

Unit II:

1. A. Roth “Vacuum Technology” North Holland Amsterdam

2. LudmilaEckertova “ 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)

Course no.: RJSPGPHYE05: Microprocessors and Microcontrollers (45 lectures + 15 tutorials, 4 credits) :

Unit-I:

(REVIEW: - Introduction to 8085**,** Pin diagram, Simple basic Programs)

Counters and Time Delays, Stack and Sub-routines

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, the 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

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

Unit-II
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)

Unit III
1. **Introduction to Microcontrollers:** Introduction, Microcontrollers and Microprocessors, Embedded versus External Memory Devices, 8–bit and 16–bit

Microcontrollers, CISC and RISC Processors, Harvard and Von Neumann Architectures, Commercial Microcontroller Devices.
AVD: Ch.1

8051 Microcontrollers: Registers in MCS-51, 8051 Pin Description, 8051 Connections,8051 Parallel I/O Ports and Memory Organization.MCS-51 Addressing Modes , Simple programs.

AVD: Ch. 2, 3, 4

8051 microcontroller: Timer Programming : Timer/Counters, Interrupts, Serial communication Programming 8051 Timers, Counter Programming
AVD- Ch 1 to 4, MMM- Ch 9: 9.1, 9.2

Programming Timer Interrupts, Programming External hardware Interrupts, Interrupt Priority in 8051/52.
MMM- Ch 11: 11.1, 11.2, 11.3, 11.5
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-IV

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.
ADV- Ch 9: 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8, 9.9, 9.10, 9.11
Ref. AVD: - Microcontrollers by Ajay V. Deshmukh, Tata-Mcgraw Hill Publication

Course no.: RJSPGPHYE06: Core Electronics, Embedded Systems and RTOS (45 lectures + 15 tutorials, 4 credits)

Unit-I Analog and Data Acquisition Systems:

1. **Power Supplies**: Linear Power supply, Switch Mode Power supply, Uninterrupted Power Supply, Step up and Step down Switching Voltage Regulators.

2. **Inverters:** Principle of voltage driven inversion, Principle of current driven inversion, sine wave inverter, Square wave inverter.

3. **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-II Data Transmissions, Instrumentations Circuits & Designs:

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

2. **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-III: Embedded systems

Introduction to Embedded Systems: What is an embedded system, Embedded Systemv/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

<u>Course no.: RJSPGPHYE07: Signal Modulation and Transmission Techniques, (45 lectures + 15 tutorials, 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.

Unit III:

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, 4th 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, (4th ed., Pearson Ed.)

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

Course no.: RJSPGPHYE08: Microwave Electronics, Radar and Optical Fiber

Communication, (45 lectures + 15 tutorials, 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, 4th ed., Tata McGraw-Hill Publishing Company Ltd., New Delhi.

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

3. Tomasi; 4th Edition, Pearson education

4. Electronic Communication Systems Fundamentals through Advanced by Wayne n Singapore.

Additional References:

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

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

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

Course no.: RJSPGPHYE09: Semiconductors Physics (45 lectures + 15 tutorials, 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- Dimensional 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,

Course no.: RJSPGPHYE10: Thin Film Physics & Technology (45 lectures + 15 tutorials, 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 L K. Malhotra (ed),

2. Thin Film Technology and Applications, T.M.H. Publishing Co., New Delhi (1984).

Course no.: RJSPGPHYE11: Fundamentals of Material Science (45 lectures + 15 tutorials, 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

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.
2. William D. Callister, Materials Science and Engineering:An Introduction, John Wiley & Sons, Inc**.,** 7th Edition.

Course no.: RJSPGPYHE12: Nanoscience and Nanotechnology (45 lectures + 15 tutorials, 4 credits)

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;

Quantum wells, wires and dots: Fabricating Quantum Nanostructures: Solution fabrication, Lithography; Size and dimensionality effects: Size effects, Size effects on conduction electrons, 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, 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 C60, Crystalline C60, 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, 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, Magnetoresistive materials, Carbon nanostructured ferromagnets; Antiferromagnetic nanoparticles. Nanoelectronics

Spintronics: Definition and examples of spintronic devices, Magnetic storage and spin valves, Dilute magnetic semiconductors; Photonic crystals.

(Owens and Poole: Chapter 12, 13 and 14)

Unit IV:

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, *LudovicoCademartiri and Geoffrey A. Ozin,* Wiley-VCH, 2009.

Course no.: RJSPGPHYE13: Astronomy and Space Physics (45 lectures + 15 tutorials, 4 credits)

Unit I:

The Sky, Instruments and Observational tools: (a) Inventory of the UniverseWavelength 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:

115 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: Whitedwarfs 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.

ii An Introduction to Astronomy; University Science Books, Sausalito 1982.,

iii. R.C. Smith, Observational Astrophysics; CUP, 1995,
iv. 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.

Course no.: RJSPGPHYE14: Laser Physics (45 lectures + 15 tutorials, 4 credits)

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: Nonlinear optics

Techniques for Q-switching, Mode Locking, Hole burning and Lamb dip in Doppler broadened Gas laser, Nonlinear oscillator model, Nonlinear polarization and wave equation, perturbative solution of the Nonlinear oscillator equation, Harmonic 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 lasers, 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 nonlinear spectroscopy, polarization spectroscopy, multi-photon spectroscopy, photofluoroscence excitation spectroscopy.

Holographic 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.

Course no.: RJSPGPHYE15: Group Theory (45 lectures + 15 tutorials, 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 wave function, 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)*

Course no.: RJSPGPHYE16: Applied Thermodynamics (45 lectures + 15

tutorials, 4 credits)

Unit I

First Law of Thermodynamics: Energy, enthalpy, specific heats, and 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 vapour 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

<u>Course no.: RJSPGPHYE17: Quantum Field Theory, (45 lectures + 15 tutorials, 4 credits)</u>

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)

1. Quantisation of solids

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

2. 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.

3. 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)

1. Dyson formulation for scattering:

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

2. Wick expansion and contractions

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

3. **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)

1. **The QED Lagrangian**

Structure of the QED Lagrangian, gauge invariance and conserved current, Feynman rules for QED, scalar electrodynamics.

2. **Basic Processes in QED**

Feynman diagram calculation for $e^+e^- \rightarrow \mu^+ \mu^-$, phase space integration, Moller and Bhabha Scattering, polarization vectors, Compton scattering and pair creation/anhilation, Klein-Nishina formula.

3. **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 Field Theory,* by Franz Gross(Wiley-VCHVerlag 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)

<u>Course no.: RJSPGPHYE18: Nuclear Reactions (45 lectures + 15 tutorials, 4</u>

credits)

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.

(a) 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:

1. *Nuclear Reactions*, by Daphne F Jackson (Methen& Co. Ltd.)
2. *Theoretical Nuclear Physics*, by John M Blatt and Victor F Weisskopf (John Wiley)
3. *Direct Nuclear Reaction Theories*, by Norman Austern (John Wiley)
4. *Concepts of Nuclear Physics*, by B. L. Cohen (Tata McGrow-Hill)
5. *Introduction to Nuclear and Particle Physics*, by A. Das & T. Ferbel (WorldScientific)

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:

1. *Semi-classical methods for nucleus-nucleus scattering,* by D. M. Brink(CambridgeUniversity press 1985)
2. *Nuclear heavy ion reactions*, by P. E. Hodgson (Clarendon press 1978)
3. *Introduction to nuclear reactions,* by G. R. Satchler (McMillan 1990)
4. *Nuclear reactions for astrophysics,* by I. J. Thomson and F. Nunes (CambridgeUniversity press, ISBN 9780521856355, 2009)

5. *Structure and reactions of light nuclei*, CRC press, ISBN-13: 978-0415308724.
6. *Subatomic Physics*, by E. M. Henley and A. Garcia (2007), World Scientific.
7. *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 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 SergoDeBenedetti (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),
6. Physics of nucleons, mesons, quarks & heavy ions, by Y. K. Gambhir (Ed.) (Quest publications, Mumbai, ISBN 81-87099-25-9 2003)
7. The pion-nucleon system, by B. H. Bransden and R. G. Moorhouse (Princeton University press 1973)
8. SERC school series Nuclear Physics (1988), B. K. Jain (Ed.) (World Scientific, ISBN 9971506335 1988).

Course no.: RJSPGPHYE19: Particle Physics (45 lectures + 15 tutorials, 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)

1. The QED Lagrangian

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

2. Basic Processes in QED :

Feynman diagram calculation for $e^+e^- \rightarrow \mu^+ \mu^-$, phase space integration, Moller and Bhabha Scattering, polarisation vectors, Compton scattering and pair creation/annihilation, Klein-Nishina formula.

3. 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)

1. 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.

1. Quark Model

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

3. Deep Inelastic Scattering

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

4. 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)

1. Fermi theory

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

2. Intermediate vector bosons

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

3. 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.

4. Flavour Mixing and CP Violation

FCNC suppression, Cabibbo hypothesis, kaon decays, theta-tau puzzle, 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).

<u>Course no.: RJSPGPHYE20: Properties of Solids (45 lectures + 15 tutorials,</u>

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, 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.

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, Indirect exchange mechanism: super exchange and RKKY.

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

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

Magnetic Materials: Soft and hard magnets, permanent magnets, media feromagnetic 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.
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 (7th/ 8th 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

Course no.: RJSPGPHYE21: Crystalline & Non crystalline solids, (45 lectures + 15 tutorials, 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:

<u>Amorphous Materials</u>: Amorphous semiconductors: 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.

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

<u>Polymers:</u> 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 th ed 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).

Course no.: RJSPGPHYE22: Advanced Microcontroller (45 lectures + 15 tutorials, 4 credits)

Unit-I:

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

Unit-II:

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

Unit-III:

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

Course no.: RJSPGPHYE23: VHDL and Communication Interface (45 lectures + 15 tutorials, 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

Unit-II: 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, 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

<u>Detailed studies of I2C Bus refer</u>:

<u>I2C Bus Specification Version 2.1 by Philips</u>
<u>(Pages 4-18 and 27-30)</u> (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

Course no.: RJSPGPHYE24: Digital Communication Systems and Python Programming language (45 lectures + 15 tutorials, 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.

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.

More emphasis on writing small programmes using Python language

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, (4th

ed., Pearson Education).

3. Modern Electronic Communication by Gary M. Miller, (6th 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).

Course no.: RJSPGPHYE25: Computer Networking (45 lectures + 15 tutorials, 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, Point 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 (3rd 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

Course no.: RJSPGPHYE26: Physics of Semiconductor Devices (45 lectures + 15 tutorials, 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 MOSFET 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, McGraw 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

Course no.: RJSPGPHYE27: Semiconductor Technology (45 lectures + 15 tutorials, 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

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

(a) 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, McGraw Hill Book, N.Y., 2nd Ed
4. S.K. Ghandhi , VLSI fabrication principles, John Wiley, N.Y., 1983

Course no.: RJSPGPHYE28: Materials and their applications (45

lectures + 15 tutorials, 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.

Composite Materials: Fibers for Reinforced-Plastic Composite Materials, Open-Mold Processes for Fiber-Reinforced- Plastic Composite Materials, Closed-Mold Processes for Fiber-Reinforced-Plastic Composite Materials,

Reference:

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

2. William D. Callister, Materials Science and Engineering An Introduction, John Wiley & Sons, Inc**.,** 7th Edition.

<u>Course no.: RJSPGPHYE29: Energy Studies (45 lectures + 15 tutorials, 4 credits)</u>

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 wave power; Binding energy and 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 , 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

Course no.: RJSPGPHYE30: Galactic and Extra-Galactic Astronomy (45 lectures + 15 tutorials, 4 credits)

Unit I:

Galactic Astronomy: Galactic structure: Nucleus, Bulge, Disk and Corona

Morphologyof 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. 5.P.J.E. Peebles, Principles of Physical Cosmology; Princeton

University Press, 1993.

Course no.: RJSPGPHYE31: Plasma Physics, (45 lectures + 15 tutorials, 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

Course no.: RJSPGPHYE32: Liquid Crystals (45 lectures +

15 tutorials, 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, membranes colloidal system. Display Technologies Overview.

Ref: CP: Ch1 ; 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 Chandrasekhar, 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, Lucienmonnerie. published by Wiley.
8. The Optic of Thermotropic Liquid Crystals. SteveElston and Roy Sambles.
9. Textures of Liquid Crystals. Detrich Demus, LotharRichter.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, VolkmarVill, 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, VolkmarVills –

14. Principles of condensed matter physics – P. M. Chaikin and T. C. Lubensky.

15. Colloidal Dispersions-W. B. Russel , Cambridge University Press. New York (1989)

16. Properties and Structure of Liquid Crystals

Course no.: RJSPGPHYE33: Numerical Methods and Programming
(45 lectures + 15 tutorials, 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

Course no.: RJSPGPHYE34: Polymer Physics (45 lectures + 15 tutorials, 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)
13. Principles. of Chemical Sensors, Jiri Janata, Plenum Press, New York (1990) (Ch. 1, 4, 5)

Course no.: RJSPGPHYE35: Nonlinear Dynamics, (45 lectures + 15 tutorials, 4 credits)

Unit I:

Flows on the line and in the plane, possibility and impossibility of oscillatory solutions: Poincare-Bendixson theorem (without proof), types of fixed point, limit cycles and concept of stability, linear stability analysis, bifurcations, Lyapunov stability, self-similarity and Fractals, various definitions of dimensions and their differences, numerical and experimental methods to find dimension, chaos: sensitivity to initial conditions, Lyapunov exponent and the algorithm to determine it, examples of systems: driven Duffing's and van der Pol oscillators, how to identify chaos in experimental signals

Unit II:

Maps as Poincare sections, one dimensional maps: (skewed) tent, logistic and Bernoulli shift, Feigenbaum numbers and universality, Sarkovskii's theorem: period 3 implies chaos, Two dimensional maps: cat map, baker's map and horseshoe map, ergodicity and mixing, stationary densities (invariant measures), Kolmogorov entropy, symbolic dynamics, different routes to chaos, attractor reconstruction: delay coordinates, Taken's embedding theorem, linear stability analysis of periodic orbits, stable and unstable manifolds

Unit III:

Hamiltonian systems, symplectic structure, integrability, action-angle variables, perturbation of integrable systems, KAM theorem, Hamiltonian maps: kicked rotor and standard map, KAM tori, Signatures of chaos in classically chaotic quantum systems: nodal lines, scars, density of states and Weyl's formula, fluctuations in the spectrum

Unit IV:

Many degrees of freedom: Fermi-Pasta-Ulam problem, nonlinear Schrodinger equation, KdV equation, solitons: soliton solution of KdV equation, interaction of solitary waves, Application

to Atmospheric Physics: Rayleigh-Bernard convection and Lorentz equations, Application to Chemistry: BZ reaction, Application to

Astrophysics: Henon-Heiles system

References:

1. S. H. Strogatz: Nonlinear Dynamics and Chaos (1994)

2. Edward Ott : Chaos in dynamical systems, Cambridge university press (1993)

3. Francis C Moon : Chaotic and fractal dynamics, John Wiley(1992)

4. P. G. Drazin, R.S. Johnson : Solitons , an introduction , Cambridge university press(1989)
5. Michael Tabor: Chaos and integrability in nonlinear dynamics, John Wiley(1989)

6. Robert Devaney: An introduction to chaotic dynamical systems

7. Hanz Jurgen Stockmann: Quantum chaos, Cambridge university press (1999)

8. M. C. Gutzwiller: Chaos in Classical and Quantum mechanics (1990)

9. Feder: Fractals

Course no.: RJSPGPHYE36: Advanced Statistical Mechanics (45 lectures + 15 tutorials, 4 credits)

Unit I: Ideal Fermi and Bose Systems

Review of quantum ideal canonical and grand canonical ensembles; Statistics of occupation numbers. Thermodynamic behavior of an ideal Bose gas, phenomenon of Bose-Einstein condensation. Thermodynamics of blackbody radiation.

Thermodynamic behavior of an ideal Fermi gas, concept of Fermi energy, behaviour of specific heat with temperature.

Unit II: Phase transitions and critical phenomena

The Ising model and mappings; mean-field treatment; exact solution in 1 dimension. Classification of phase transitions, critical exponents and scaling hypothesis, correlations and fluctuations, correlation length. Universality; The conceptual basis of scaling; renormalization group; application to Ising models.

Unit III: Non-Equilibrium Statistical Mechanics: Fluctuations

Brownian motion: as a random walk (Einstein theory), as a diffusion process; random walk with bias and boundary conditions: application to phenomenon of sedimentation; Langevin theory of Brownian motion; Fluctuation-dissipation theorem. Spectral analysis of fluctuations – the Wiener-Khintchine relations.

Unit IV: Non-Equilibrium Statistical Mechanics: Stochastic Processes

Chapman-Kolmogorov equation, Kramer-Moyal expansion, Fokker-Planck equation, Master equation, Boltzmann equation. Linear response function, correlation and susceptibility.

Main references:

1. Thermodynamics and Statistical Mechanics, Greiner, Neise and Stocker, Springer 1995.
2. Statistical Mechanics (3 rd ed.), RK Pathria and PD Beale (P), Elsevier 2011.
3. Introduction to Statistical Physics, Kerson Huang (H), Taylor and Francis 2001.
4. The Fokker Planck equation, R. Risken, Springer
5. Stochastic Problems in Physics and Astronomy, S. Chandrasekhar, *Rev. Mod. Phys.* **15** (1943) 1.

Additional references:

1. Stochastic Processes in Physics and Chemistry, N.G. van Kampen, North-Holland.
2. Handbook of Stochastic Methods, C. W. Gardiner, Springer
3. Non-equilibrium Statistical Mechanics, J.K. Bhattacharjee.

4. Elements of Nonequilibrium Statistical Mechanics, V. Balakrishnan, Ane Books, India..
5. Fundamentals of Statistical and Thermal Physics, F. Reif, Levant

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 Physics 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 sophisticated 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.

The project report should be file bound/spiral bound/hard bound and should have the 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	10/100
Objectives/Plan of the project	10/100
Experimental/Theoretical methodology/Working condition of project or model	20/100
Significance and originality of the study/Society application	10/100

and Inclusion of recent References	
Depth of knowledge in the subject / Results and Discussions	20/100
Presentation	30/100
Maximum marks by External examiner	60
Maximum marks by internal examiner/guide	40
Total marks	100