MAHARAJA'S COLLEGE
ERNAKULAM

(A Government Autonomous College affiliated to M G University)

CURRICULUM AND SYLLABUS

(2016 ADMISSION ONWARDS)

for

Master of Science (MSc) Programme in Physics

UNDER

Choice Based Credit System (CBCS)

Acknowledgement

The Board of Studies in Physics (P G), acknowledges the contributions from participants of the workshop held on 17, 18 of September 2015 for proposals on restructuring the Syllabi of MScProgramme in Physics. The support and recommendations from the sub-groups for designing different courses has shaped this curriculum to this present nature.We thank all the esteemed participants of the workshop for their benevolent support and cooperation to make this venture a success.

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in accommodatingsome specialized topics in various courses of the syllabus. We also convey our regards to the following faculty members of the Department of Physics, Maharaja's college, whose team work made this venture a grand success.

Dr. Mathew George, Associate Professor

Dr. P R Sasikumar, Associate Professor

Sri. Robin Francis, Assistant Professor

Smt. Sheeja V, Assistant Professor

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Prof. Sabu Thomas

Head, Department of Physics

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TABLE OF CONTENTS

GENERAL SCHEME OF THE SYLLABI

THEORY COURSES:

There are sixteen theory courses spread equally in allfour semesters in the M.Sc. Programme. Distribution of theory courses is asfollows. There are twelve core courses common to all students called programme core courses. Semester Iand Semester II will have **four** core courses each and Semester III andSemester IV will have **two** core courses each. **Two** elective courses called programme elective courses, each willcome in Semester III and Semester IV. There are two Elective Groups, with each elective Group has four theory courses.

PRACTICAL:

All four semesters will have a course on laboratorypractical. The laboratory practical of Semesters I, II and III are commoncourses. The Semester IV laboratory practical course will change, subject tothe Elective Group opted by the college. A minimum of 12 experimentsshould be done and recorded in each semester. The practical examinations

will be conducted by two externalexaminers appointed by the college at the end of even semesters only. Thefirst and second semester examinations of laboratory practical courses willbe conducted at the end of Semester II while the third and fourth semester

practical examinations will be conducted at the end of Semester IV.

PROJECT:

The project of the PG program should be very relevant andinnovative in nature. The type of project can be decided by the student andthe guide (a faculty of the department or otherdepartment/college/university/institution). The project work should be takenup seriously by the student and the guide. The project should be aimed tomotivate the inquisitive and research aptitude of the students. The studentsmay be encouraged to present the results of the project in seminars/symposia.The conduct of the project may be started at the beginning of Semester III,with its evaluation scheduled at the end of Semester IV along with thepractical examination as being practiced in the present syllabus. The projectis evaluated by the external examiners. The project guide or a facultymember deputed by the head of the department may be present at the time ofproject evaluation. This is to facilitate the proper assessment of the project.

1. Project work shall be completed by working outside the regular teaching hours
2. Project work shall be carried out under the supervision of a teacher in the concerned department.
3. A candidate may, however, in certain cases be permitted to work on the project in an Industrial / Research Organization on the recommendation of the Supervisor.
4. There should be an in-semester assessment and end-semester assessment for the project work.
5. The end-semester evaluation of the Project work is followed by presentation of work including dissertation and Viva-Voce.

SEMINAR LECTURES

Every PG student shall deliver one seminar lecture as an internal component for every course. The seminar lecture is expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.

TEST PAPERS

Every student shall undergo at least two class tests as an internal component for every course. The weighted average shall be taken for awarding the grade for class tests.

ASSIGNMENTS

Every student shall submit one assignment as an internal component for every course.

ATTENDANCE

The attendance of students for each course shall be another component of in-semesterassessment.

1. The minimum requirement of aggregate attendance during a semester for appearingthe end semester examination shall be 75%.
2. Condonation of shortage of attendance to a maximum of 10 days in a semester, onceduring the whole period of postgraduate programme.
3. If a student represents his/her institution, University, State or Nation in Sports, NCC,NSS or Cultural or any other officially sponsored activities such as college union /university union activities, he/she shall be eligible to claim the attendance for theactual number of days participated subject to a maximum of 10 days in a Semesterbased on the specific recommendations of the Head of the Department and Principalof the College.
4. A student who does not satisfy the requirements of attendance shall not be

permitted to take the end-semester examinations.

MAXIMUM CREDIT

No course shall have more than 4 credits.

VIVA VOCE:

A viva voce examination will be conducted by the twoexternal examiners at the time of evaluation of the project. The componentsof viva consist of subject of special interest, fundamental physics, topicscovering all semesters and awareness of current and advanced topics with separate marks.

COURSE CODE:

The 12 core courses in the programmme are codedaccording to the following criteria. The first two letters of the code is **PG**. One digit to indicate thesemester. Letters PHY indicate PG in Physics, followed by C to indicate core, lastlydigits 01, 02 …….12 run for twelve core courses. (E.g.: PG3PHYC11 – PG in Physics, 3rdsemester, core course number eleven of the programme).The elective courses are coded in similar pattern, PG3PHYEA02 with letter Estands for Elective, while the letter A (it can be B, C, or D) stands for the Elective Group, the digit 2 stands for the 2nd course ofthe Elective Group.Laboratory Practical courses are similarly coded. (E.g.: PG2PHYP01 meansPhysics, IISemester, Practical, course number 1) The course code ofproject/dissertation is PG4PHYD01. The course code of viva voce is PG4PHYV01.The letters D and V stand for dissertation of the project and viva vocerespectively. These codes remain the same for all four categories of electives.

SEM	Title of the course with code	Number of hours per week	Total Credits	Total hours per semester
1	**PG1PHYC01:**Mathematical Methods in Physics- I	4	4	72

1	**PG1PHYC02**: Classical Mechanics	4	4	72
1	**PG1PHYC03**: Electrodynamics	4	4	72
1	**PG1PHYC04**: Electronics	4	4	72
1	**PG1PHYP01**: General Physics Practical	9	3	162
2	**PG2PHYC05**:MathematicalMethodsinPhysics-II	4	4	72
2	**PG2PHYC06**: Quantum Mechanics I	4	4	72
2	**PG2PHYC07**: Statistical Mechanics	4	4	72
2	**PG2PHYC08**: Solid State Physics	4	4	72
2	**PG2PHYP02**: Electronics Practical	9	3	162
3	**PG3PHYC09**:Quantum Mechanics II	4	4	72
3	**PG3PHYC10**: Computational Physics	4	4	72
3	**PG3PHYP03**: Computational Physics Practical	9	3	162
4	**PG4PHYC11**: Atomic and Molecular Spectroscopy	4	4	72
4	**PG4PHYC12**: Nuclear and Particle Physics	4	4	72
4	**PG4PHYD01**: Project/Dissertation	0	2	0
4	**PG4PHYV01**: Seminar and Viva Voce	0	2	0

THE ELECTIVE GROUPS:

There are four Electives Groups offered in this PGCSS Programme. Eachelective consists of a group of **four**theory courses and **one** laboratorycourse. The first two theory courses of a group are placed in the SemesterIII, while the last two theory course and the laboratory course go to theSemester IV.

The Electives Groups are named,

(i) Group A: **Theoretical Physics**

(ii) Group B:**Applied Physics**

Elective	**SEM**	**Title of the course with code**	**Number of hours per week**	**Total credits**	**Total hours per semester**
Group A Theoretical Physics	3	PG3PHYEA01- Astrophysics	4	4	72
	3	PG3PHEA02- Nonlinear Dynamics	4	4	72
	4	PG4PHYEA03- Gravitation & Cosmology	4	4	72
	4	PG4PHYEA04- Quantum Field Theory	4	4	72
	4	PG4PHYEAP01- Special Computational Lab	9	3	162
Group B Applied Physics	3	PG3PHYEB01-Semiconductor device Physics and Micro electronics	4	4	72
	3	PG3PHYEB02- Material Science	4	4	72
	4	PG4PHYEB03- Photonics	4	4	72
	4	PG4PHYEB04- Electronic Communication & DSP	4	4	72
	4	PG4PHYEBP01- Applied Physics Lab	9	3	162

DISTRIBUTION OF CREDIT:

The total credit for the programme is fixed at 80.The distribution of credit points in each semester and allocation of thenumber of credit for theory courses, practical, project and viva is as follows.The credit of theory courses is 4 per course, while that of laboratory practicalcourse is 3 per course. The project and viva voce will have a credit of 2 each.

Semester	**Courses**	**Credit**	**Total Credit**
1	4 Theory courses	4×4=16	16
2	4 Theory courses 2 Practical courses	4×4=16 2×3=6	22
3	4 theory courses	4×=16	16
4	4 Theory courses 2 Practical courses 1 Project 1 Viva-voce	4×4=16 2×3=6 1×2=2 1×2=2	26
	Grand Total		**80**

GRADING AND EVALUATION

EXAMINATIONS

1. There shall be end semester examination at the end of each semester.
2. Practical examinations shall be conducted by the college at the end of each semester.

3. Project evaluation and Viva -Voce shall be conducted at the end of the programme only.
4. Practical examination, Project evaluation and Viva-Voce shall be conducted by twoexternal examiners and one internal examiner

The evaluation of each course shall contain two parts such as Internal or In-Semester Evaluation (ISE) and External or End-Semester Evaluation (ESE).The ratio between internal and external examinations shall be 1:4. That is 20 marks for ISE and 80 for ESE. TheInternal and External examinations shall be evaluated using in-direct Gradingsystem based on 10-point scale.

INTERNAL OR IN-SEMESTER EVALUATION (ISE)

The internal evaluation shall be based on pre-determined transparent system involving periodic written tests, assignments, seminars and attendance in respect of theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses.

COMPONENTS OF ISE FOR THEORY

Components of ISE	Marks
Assignment	4
Seminar	4
Test papers(Average of two)	8
Attendance	4
Total	20

COMPONENTS OF ISE FOR PRACTICAL

Components	Marks
Attendance	4
Lab Involvement	4
Test	4
Record	4
Viva	4
Total	**20**

MARKS FOR ATTENDANCE

Percentage of Attendance	Marks
>90%	4
Between 85 and 90	3
Between 80and below 85	2
Between 75 and below 80	1
< 75%	0

CREDIT POINT AND CREDIT POINT AVERAGE

Percentage of Marks	Grade	Grade Point(GP)
95 and above	SOutstanding	10
85 to below 95	A^{+}Excellent	9
75 to below 85	A Very Good	8
65 to below 75	A^{-} Good	7
55 to below 65	B^{+} Above average	6
50 to below 55	B Average	5
40 to below 50	C Pass	4
Below 40	F Fail	0
	Ab Absent	0

Credit Point (CP) of a course is calculated using the formula

CP = C × GP, where C = Credit and GP = Grade Point

Semester Grade Point Average (SGPA) of a Semester is calculated using the formula

SGPA= $\frac{T}{T}$, where TCP = Total Credit Point and TC = Total Credit

Cumulative Grade Point Average (CGPA) of a programme is calculated using the formula

CGPA = $\frac{\Sigma(T \quad \times T \ )}{\Sigma(T \ )}$ shall be rounded off to two decimal places

Grades for different semesters and overall programme are given based on the corresponding CPA as follows

GPA	Grade
Equal to 9.5 and above	SOutstanding
Equal to 8.5 and below 9.5	A^+Excellent
Equal to 7.5 and below 8.5	A Very Good
Equal to 6.5 and below 7.5	A^-Good
Equal to 5.5 and below 6.5	B^+ Above average
Equal to 5.0 and below 5.5	B Average
Equal to 4.0 and below 5.0	C Pass
Below 4.0	F Failure

A separate minimum of 40% marks each for in-semester and end semester (for both theory and practical) and aggregate minimum of 40% are required to pass for a course. To pass in a programme, a separate minimum of Grade E is required for all the individual courses. If a candidate secures **F** Grade for any one of the courses offered in a Semester/Programme only **F** grade will be awarded for that Semester/Programme until he/she improves this to **C**grade or above within the permitted period. Candidate who secures **C**grade and above, shall be eligible for higher studies.

PATTERN OF QUESTIONS FOR END SEMESTER EXAMINATION

Type	Number of Questions	Number of questions to be answered	Marks of each question	Total marks
Short answers	12	10	2	20
Problems & short essays	10	6	5	30
Essays	4	2	15	30
Total	26	18		80

CORE COURSES

SEMESTER I

PG1PHYC01- MATHEMATICL METHODS IN PHYSICS – I

MODULE I: VECTOR AND TENSOR ANALYSIS

Vector algebra, Linear Vector Space, Vector differentiation, Scalar and Vector Fields, Orthogonal curvilinear coordinate systems, Vector integration and integral theorems, Helmholtz's theorem, Tensor analysis – Contravariant and covariant vectors, Tensors of higher rang, Basic operations, Quotient law, Metric tensor, Associated tensors, Geodesics in a Riemannian space, Covariant differentiation, Basic idea of Ricci tensor and scalar.

[18 hours][Book 1, Chapter 1]

MODULE II: ALGEBRA AND LINEAR VECTOR SPACES

Matrix Algebra – Basic algebraic operations, commutator, powers of a matrix, functions of matrices, transpose of a matrix, symmetry, vector product, inverse of a matrix, systems of linear equations, complex conjugate, Hermitian conjugate and matrices, Orthogonal matrix, Unitary matrix, Rotation matrices, Trace, Orthogonal and Unitary transformations, Similarity transformation, Eigen value problem, Eigenvalues and vectors of Hermitian matrices, Diagonalization of a matrix, Eigenvectors of a commutating matrices, Cayley-Hamiton theorem, Moment of Inertia matrix, normal modes of vibrations, direct product of matrices.

Linear vector spaces: Euclidean n-space, general linear vector spaces, subspaces, linear independence, bases, dimensionality, unitary spaces, Gram – Schmidt orthogonalization, Cauchy – Schwartz inequality, dual vectors and dual spaces. Linear operators, matrix representation of operators, Eigenvectors and values of an operator, special operators, change of basis, commuting operators, function spaces.

[20 hours][Book 1, Chapter 2 and 5]

MODULEIII: COMPLEX ANALYSIS

Complex numbers; Functions of a complex variable, Mapping, Branch lines and Riemann surfaces, The differential calculus of complex functions; Elementary functions of z, Complex integration, Series representation of analytic functions; Integration by the method of residues, Evaluation of definite integrals.

[18 hours][Book 1, Chapter 6]

MODULE IV: SPECIAL FUNCTIONS AND INTRODUCTION TO PROBABILITY THEORY

The Factorial function, Gamma function and recursion relation, Gamma function of negative numbers, Beta functions, Beta functions in terms of Gamma functions, The error function, The Stirling's formula, Elliptic integrals and functions

Definition, sample space, Methods of counting, fundamental theorems, random variables and probability distributions, special distributions – binomial, Poisson, Gaussian, Continuous distributions – Gaussian and Maxwell – Boltzmann.

[16 hours] [Book 2 Chapter 11, Book 1, Chapter 14]

TEXT BOOKS:

1. Mathematical Methods for Physicists – A Concise Introduction, Tai L. Chow, Cambridge University Press
2. Mathematical methods in the Physical Sciences, Mary L. Boas, John Wiley & Sons
3. Mathematical Methods for Physicists – A Comprehensive Guide, Arfken and Weber, Academic Press

REFERENCE:

1. Physical Mathematics, Kevin Cahill, Cambridge University Press
2. A Student's Guide to Vectors and Tensors – Daniel Fleisch, Cambridge University Press
3. Mathematical Techniques for Engineers and Scientists, Larry C. Andrews and Ronald L. Philips, SPIE Press
4. Mathematical Physics – A Modern Introduction to Its Foundations, Sadri Hassani, Springer
5. Group Theory in Physics – An Introduction, J. F. Cornwell, Academic Press

PG1PHYC02- CLASSICAL MECHANICS

MODULE I: LAGRANGIAN AND HAMILTONIAN FORMULATIONS

Review of Newtonian and Lagrangian formalisms, Constraints, D'Alembert's principle and Lagrange's equations, calculus of variations-examples, Lagrange's equations from Hamilton's principle, conservation theorems and symmetry properties, energy function and the conservation of energy.

Legendre transformation and the Hamilton equations of motion, cyclic co-ordinates and conservation theorems, Hamilton's equations from a variational principle.

[16 hours] [Chapters 1,2 and 8 of Book 1]

MODULE II: MECHANICS OF SMALL OSCILLATIONS

Equilibrium and potential energy, theory of small oscillations, normal modes, two coupled pendulums, longitudinal vibrations of CO_2 molecule - normal frequencies, normal modes, normal co - ordinates.

[6 hours] [Chapter 9of Book 2]

CANONICAL TRANSFORMATION

Equations of canonical transformation, examples of canonical transformation, harmonic oscillator. Poisson brackets – fundamental Poisson brackets, fundamental properties. Equations of motion in Poisson bracket form, Poisson bracket and integrals of motion, canonical invariance of Poisson bracket. Angular momentum Poisson brackets.

[7 hours] [Chapter 9, Book 1; Chapter 6, Book 2; Chapter 7, Book 3]

HAMILTON JACOBI THEORY (7 HOURS)

Hamilton Jacobi equation for Hamilton's principal function, Harmonic oscillator problem, Hamilton Jacobi equation for Hamilton's characteristic function, action angle variables in systems of one degree of freedom, H-J equation as the short wave length limit of Schrodinger equation.

[7 hours] [Chapter 10, Book 1; Chapter 8, Book 3]

MODULE III: CENTRAL FORCE PROBLEM (18 HOURS)

Reduction to equivalent one body problem, equations of motion and first integrals, equivalent one dimensional problem and classification of orbits, differential equation for the orbit and integrable power law potentials, conditions for closed orbits, Kepler problem - inverse square law of force.

Scattering in a central force field – Rutherford scattering formula, transformation of the scattering problem to laboratory co-ordinates.

[18 hours] [Chapter 3, Book 1]

MODULE 4: RIGID BODY DYNAMICS (18 HOURS)

Independent co-ordinates of a rigid body, orthogonal transformations, angular momentum, kinetic energy, inertia tensor, principal axes, Euler's angles, infinitesimal rotations, rate of change of a vector, Coriolis force, Euler's equations of motion, torque free motion of a rigid body, heavy symmetrical top.

[18 hours] [Chapters 4 and 5, Book 1]

TEXT BOOK:

1. Classical Mechanics, 3rd Edition: Herbert Goldstein, Charles P Poole, John Safko, Addison - Wesley Publishers.
2. Classical mechanics: G Aruldhas, PHI Learning, Pvt Ltd.
3. Classical Mechanics: J C Upadhyaya, Himalaya Publishing House.

PG1PHYC03- ELECTRODYNAMICS

MODULE I: ELECTROSTATIC FIELDS AND ELECTRODYNAMICS

Review of electrostatics, Gauss's law, Scalar and vector potentials, Gauge transformations, Laplace equation in one, two and three dimension, Boundary conditions and uniqueness theorem, The method of images, The classic image problem, induced surface charge, Multipole expansion- Approximate potentials at large distances, The monopole and dipole terms, The electric field of a dipole, Review of magnetism and electrodynamics (Including Magnetic flux theorem and divergence of B, Ampere circuital theorem, Faraday's law, Modification of Ampere circuital theorem by Maxwell etc.)

[18 hours] [Chapters 2,3,4,5,and 7 of Book 1]

MODULE II: ELECTROMAGNETIC WAVES

Maxwell's equations, Wave equations and their solutions, Poynting theorem, Maxwell's stress tensor. Plane waves in conducting and non-conducting medium, Energy and Momentum in electromagnetic waves, Reflection and transmission (Normal and Oblique incidence) in linear dielectric media, Electromagnetic waves in conductors, Reflection at a conducting surface, Absorption and Dispersion.

[14 hours] [Chapter 7 and 9 Book 1]

MODULE III: COVARIANT FORMULATION OF ELECTRODYNAMICS

Special Theory of relativity, Einstein's postulates, Lorentz Transformations, Structure of Space –time, Proper Time and Proper velocity, Relativistic Energy and Momentum, Relativistic Dynamics, Magnetism as a relativistic phenomenon, Lorentz transformation of electromagnetic field, electromagnetic field tensor, electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics.

[10 hours] [Chapter 12, Book 1]

WAVE GUIDES AND RESONANT CAVITIES

Fields at the surface and with in a conductor, Cylindrical cavities and wave guides, wave guides, Modes in a rectangular wave guide, Energy flow and attenuation in wave guides. Resonant cavities, Power losses in a cavity: Q of a cavity.

[10 hours] [Chapter 8, Book 2]

MODULE IV: RADIATION BY MOVING CHARGES (20 HOURS)

Retarded potentials, Jefimenko's equations, Point charges, Lienard- Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion, Radiation reaction, Physical basis of radiation reaction, Collision between charged particles-Energy transfer in Coulomb collisions, Cherenkov radiation, Radiation emitted during collisions, Bremsstrahlung in coulomb collisions.

[20 hours] [Chapter 11, Book 1; Chapter 13, 14 and 15, Book 2]

TEXT BOOKS:

1. Introduction to Electrodynamics, 3rd Edition, David J. Griffiths, PHI.
2. Classical Electrodynamics- 2nd Edition, J.D. Jackson, Wiley Eastern.

PG1PHYC04-ELECTRONICS

MODULE I: OPERATIONAL AMPLIFIER

Block diagram representation – Electrical parameters: Input offset voltage, input offset current, input bias current, CMRR, SVRR, output voltage swing, transient response, slew rate, gain bandwidth product – Ideal opamp, equivalent circuit, ideal voltage transfer curve – open loop opamp configurations

[5 hours]

OP-AMP WITH NEGATIVE FEEDBACK

Feedback configurations - Voltage series feedback: Negative feedback, closed loop voltage gain, difference input voltage ideally zero – Input and output resistance with feedback, bandwidth with feedback, total output offset voltage with feedback, voltage follower

Voltage shunt feedback amplifier: Closed loop voltage gain, inverting input terminal and virtual ground, input and output resistance with feedback, bandwidth with feedback, total output offset voltage with feedback, current to voltage converter, Inverter.

Differential amplifier with one and two op-amps.

[8 hours]

THE PRACTICAL OP-AMP

Input offset voltage, input bias current, input offset current, total output offset voltage, thermal drift, effect of variation in power supply voltage on offset voltage, change in input offset voltage and input offset current with time - Noise – Common mode configuration and CMRR.

[5 hours] [Chapters 2 & 3, Book 1]

MODULE II: FREQUENCY RESPONSE OF AN OP-AMP

Frequency response –Compensating networks – Frequency response of internally compensated and non-compensated op-amps – High frequency op- amp equivalent circuit – Open loop gain as a function of frequency – Closed loop frequency response – Circuit stability - slew rate.

[9 hours]

GENERAL LINEAR APPLICATIONS (WITH DESIGN)

DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing, Scaling, averaging amplifiers – Instrumentation amplifier - integrator and differentiator.

[9 hours]

MODULE III: ACTIVE FILTERS AND OSCILLATORS (WITH DESIGN)

Active filters – First order and second order low pass Butterworth filter - First order and second order high pass Butterworth filter- Wide and narrow band pass filter - Wide and narrow band reject filter- All pass filter – Oscillators: Phase shift and Wien-bridge oscillators – Square, triangular and saw-tooth wave generators - Voltage controlled oscillator.

[10 hours]

COMPARATORS AND CONVERTERS (8 HOURS)

Basic comparator - zero crossing detector – Schmitt trigger – Voltage to frequency and frequency to voltage converters

[8 hours] [Book 1]

MODULE IV: THE 8086 MICROPROCESSOR

Microarchitecture of 8086 –Software model – Memory address space and data organization – Segment registers and memory segmentation – Dedicated, reserved and general use memory – Instruction pointer – Data registers – Pointer and Index registers – Status registers – Generating memory address – The Stack – Input/ Output address space

[Book 2]

Addressing modes - Instruction set – Assembler Directives – Basic programming: Addition of two 16 bit numbers, Largest and smallest numbers in an array, sorting in the ascending and descending order

[Books 2 and 3]

Memory and I/O Interfacing – Semiconductor Memory: ROM and PROM, EPROM, Static RAM, DRAM and NVRAM (Basic ideas) – Interfacing Static RAM and EPROM: Typical EPROM and Static RAM, Memory capacity, Choice of Memory ICs and Address location – Memory organization: Example of implementing full memory space in 8086 based systems.

[Book 2]

Minimum and Maximum modes of operation (Basic idea) - 8087 coprocessor

[Book 3]

Interfacing I/O devices (Ideas): Programmed I/O, Interrupt driven I/O and Direct Memory Access

[Book 3]

[18 hours for the module]

TEXT BOOKS:

1. Op-amps and linear integrated circuits, R.A. Gayakwad 4th Edn., PHI.
2. The 8088 and 8086 Microprocessors: Programming, Interfacing, Software, Hardware and Applications, Walter A. Triebel, Avtar Singh, Pearson.
3. Microprocessors and microcomputer-based system design, Second Edition, Mohammed Rafiquzzaman, CRC Press.
4. Microprocessor 8086 programming and Interfacing, A. NagoorKani, RBA Publications.

SEMESTER II

PG2PHYC05- MATHEMATICL METHODS IN PHYSICS - II

MODULE I: SPECIAL FUNCTIONS

Legendre's equation – Rodrigue's formula, generating function, and orthogonality; Associated Legendre functions and their orthogonality; Hermite's equation - Rodrigue's formula, recurrence relations generating function, and orthogonality; Laugerre's equation - Rodrigue's formula, generating function, and orthogonality; Bessel's equation – equations of the second kind, hanging flexible chain, generating function, integral representation, recurrence formulas, approximations and orthogonality; Spherical Bessel functions.

[18 hours] [Book 1, Chapter 7]

MODULE II: INTEGRAL TRANSFORMS

Periodic functions; Orthogonal functions; Fourier integrals and Fourier transforms; Fourier sine and cosine transforms; Heisenberg's uncertainty principle; Wave packets and group velocity; Heat conduction, Fourier transforms for functions of several variables; Fourier integral and the delta function; Perseval's identity for Fourier integrals; Convolution theorem; Green's function method.

Definition of the Laplace transform; Existence; LT of some elementary functions; Shifting theorems – first and second; Unit step function; LT of periodic function, LT of derivatives; LT of functions defined by integrals;

[18 hours] [Book 1, Chapters 4 and 9]

MODULE III: PARTIAL DIFFERENTIAL EQUATIONS AND INTEGRAL EQUATIONS

Linear second-order partial differential equations; Solutions of Laplace's equation: separation of variables; Solution of wave equation: separation of variables; Solution of Poisson's equation: Green's functions; Laplace transform solutions of boundary-value problems.

Classification of linear integral equations; Methods of solution – separable kernel, Neumann series solutions; Transformation of an integral equation into a differential equation; Laplace transform solution; Fourier transform solution; Schmidt – Hilbert method of solution; Relation between differential and integral equations; Use of integral equation – Abel's equation, Classical simple harmonic oscillator, Quantum simple harmonic oscillator.

[18 hours] [Book 1, Chapter 9 &10]

MODULE IV: GROUP THEORY

Definition of a group; Cyclic groups; Group multiplication table; Isomorphic groups; Group permutations and Cayley's theorem; Subgroups and cosets; Conjugate classes and invariant subgroups; Group representations; Some special groups – the symmetry group D2, D3; U(1); SO(2) and SO(3); SU(n) groups; Homogeneous Lorentz group.

[18 hours] [Book 1, Chapter 12]

TEXT BOOKS:

1. Mathematical Methods for Physicists – A Concise Introduction, Tai L. Chow, Cambridge University Press
2. Mathematical methods in the Physical Sciences, Mary L. Boas, John Wiley & Sons
3. Mathematical Methods for Physicists – A Comprehensive Guide, Arfken and Weber, Academic Press

REFERENCE:

1. Physical Mathematics, Kevin Cahill, Cambridge University Press
2. A Student's Guide to Vectors and Tensors – Daniel Fleisch, Cambridge University Press
3. Mathematical Techniques for Engineers and Scientists, Larry C. Andrews and Ronald L. Philips, SPIE Press
4. Mathematical Physics – A Modern Introduction to Its Foundations, Sadri Hassani, Springer
5. Group Theory in Physics – An Introduction, J. F. Cornwell, Academic Press

PG2PHYC06- QUANTUM MECHANICS-I

MODULE I: FUNDAMENTAL CONCEPTS

Sequential SG experiments, quantum mechanical state of a system, linear vector spaces, the Hilbert space, ket and bra, dual correspondence, inner product, ortho-normality, operators, outer product, Hermitian adjoint operator, eigen values and eigenkets of an operator, representation in discrete bases, completeness relation, projection operator, inverse and unitary operators.

The fundamental postulates, measurements, expectation value, commutator algebra, the uncertainty relation.

Matrix representation of ket, bra and operators, change of basis and unitary transformations, matrix representation of the eigen value problem.

Representation in continuous bases, position eigenkets and position measurements, translation in space, momentum as generator of translation, fundamental commutation relations.

Wave functions in position and momentum space, connecting the position and momentum representations, illustration using Gaussian wave packets, matrix and wave mechanics.

[22 hours] [Book 1, Chapter 1; Book 2, Chapter 3]

MODULE II: PHYSICAL INTERPRETATIONS AND CONDITIONS ON WAVE FUNCTION

Admissibility conditions on wave function, probability interpretation, conservation of probability, box normalization.

[Book 3, Chapter 2]

EVOLUTION WITH TIME

Time evolution operator and its properties, Schrodinger equation for the time evolution operator, energy eigenkets, time dependence of expectation values, Schrodinger picture and Heisenberg picture, behavior of state kets and observables in both pictures, Heisenberg equation of motion, Ehrenfest's theorem, SHO - energy eigenkets and eigen values.

[Book 1, Chapter 2]

IDENTICAL PARTICLES

System of identical particles, symmetric and anti-symmetric wave functions, spins and statistics, Pauli's exclusion principle, Helium atom.

[Book 2, Chapter 9]

[Total 14 hours for the module]

MODULE III: ANGULAR MOMENTUM

Theory of angular momentum – rotations and angular momentum commutation relations, rotation operator for spin 1/2 system, Pauli two component formalism, rotations in the two component formalism, eigen values and eigen states of angular momentum, matrix elements of angular momentum operators, orbital angular momentum, spherical harmonics, addition of two angular momenta – Clebsch-Gordan coefficients, calculation of Clebsch-Gordan coefficients.

[14 hours] [Book 1, Chapter 3]

MODULE IV: EXACTLY SOLVABLE EIGEN VALUE PROBLEM

Motion in a central potential - three dimensional square well potential, solutions in the interior region, solutions in the exterior region and matching. Hydrogen atom – energy levels, stationary state wave functions, bound states.

[Book 3, Chapter 4]

APPROXIMATION METHODS FOR STATIONARY STATES

Perturbation theory for stationary states – non degenerate case - anharmonic oscillator, Degenerate case – applications, Stark effect in ground state of hydrogen atom.

Variational method – upper bound on ground state energy, hydrogen molecule.

WKB approximation – WKB wave function, validity of the approximation.

[Book 3, Chapter 5]

[Total 22 hours for the module]

TEXT BOOKS:

1. **Modern Quantum Mechanics, 2nd Edition, J J Sakkurai, Pearson.**
2. **Quantum Mechanics: V K Thankappan (2003), New age International**.
3. **A Text Book of Quantum Mechanics: P M Mathews and K Venkatesan, Tata McGraw Hill**.

PG2PHYC07- STATISTICAL MECHANICS

MODULE I: THE STATISTICAL BASIS OF THERMODYNAMICS

The macroscopic and microscopic states - Contact between statistics and thermodynamics – Further contact between statistics and thermodynamics – the classical ideal gas – the entropy of mixing and the Gibbs paradox.Phase space of a classical system – Lioville's theorem and its consequences – the microcanonical ensemble –Examples (1) classical ideal gas, (2) linear harmonic oscillator– quantum states and the phase space.

[12 hours]

MODULE II: THE CANONICAL ENSEMBLE

Equilibrium between system and a heat reservoir – a system in the canonical ensemble – physical significance of the various statistical quantities in the canonical ensemble –

Alternative expressions for the partition function- the classical systems– energy fluctuations in the canonical ensemble – equipartition and the virial theorems – a system of harmonic oscillators – the statistics ofparamagnetism.

[10 hours]

THE GRAND CANONICAL ENSEMBLE

Equilibrium between a system and particle-energy reservoir – a system in the grand canonical ensemble- Physical significance of the various statistical quantities- density and energy fluctuations in grand canonical ensemble – thermodynamic phase diagrams – phase equilibrium and the Clausius-Clapeyron equation.

[8 hours]

MODULE III: FORMULATION OF QUANTUM STATISTICS

Quantum mechanical ensemble theory: the density matrix – statistics of various ensembles-examples: an electron in magnetic field, a free particle in a box, a linear harmonic oscillator – systems composed of indistinguishable particles – density matrix and partition function of a system of free particles.

[6 hours]

THE THEORY OF SIMPLE GASES

An ideal gas in quantum mechanical microcanonical ensemble – an ideal gas in other quantum mechanical ensembles – statistics of the occupation numbers –kinetic considerations– gaseous systems composed of molecules with internal motion: monoatomic, diatomic and polyatomic molecules- chemical equilibrium.

[6 hours]

IDEAL BOSE SYSTEMS

Thermodynamic behavior of an ideal Bose gas – Bose-Einstein condensation in ultracold atomic gases –thermodynamics of the black body radiation – the fields of sound waves - inertial density of the sound fields.

[6 hours]

IDEAL FERMI SYSTEMS

Thermodynamic behavior of an ideal Fermi gas – Magnetic behavior of an ideal Fermi gas –the electron gas in metals – ultracold atomic Fermi gases – Statistical equilibrium of white dwarf stars.

[6 hours]

MODULE IV: PHASE TRANSITIONS

General remarks on the problem of condensation – condensation of a Van der Waals gas –a dynamical model of phase transitions - the lattice gas and binary alloy – Ising model in zeroth approximation – Ising model in the first approximation – the critical exponents – thermodynamic inequalities – Landau's phenomenological theory –one dimensional fluid models – Ising model in one dimension and in two dimensions.

[14 hours]

NON-EQUILIBRIUM STATISTICAL MECHANICS

Equilibrium thermodynamic fluctuations – the Einstein-Smoluchowski theory of the Brownian motion – the Langevin theory of the Brownian motion – the Fokker-Plank equation.

[4 hours]

TEXT BOOK:

1. Statistical Mechanics, Third edition, R. K. Pathria& Paul D. Beale., Academic Press, Indian Edition.

REFERENCE BOOKS:

1. Fundamentals of statistical and thermal physics, FrederickReif, McGraw-Hill book company
2. Statistical Mechanics, KersonHuang, Wiley- Indian edition

PG2PHYC08- SOLID STATE PHYSICS

MODULE I: ELEMENTS OF CRYSTAL STRUCTURE AND FREE ELECTRON THEORY

Review of crystal lattice fundamentals, Bragg's law, interpretation of Bragg's law, Ewald construction, reciprocal lattice, properties of reciprocal lattice, reciprocal lattice of BCC and FCC, Diffraction intensity- atomic, geometrical and crystal structure factors- physical significance

[Chapter 2, Book 1]

Review of Classical theory: Features of metallic state, Classical Free electron theory- Drude Model, Lorentz model, The failures of the classical model

[Chapter 3, Book 2]

Free electron Fermi Gas: Energy levels and density of orbitals in one dimension, Effect of temperature on Fermi Dirac distribution function, Free electron gas in three dimensions, Heat capacity of the electron gas, Electrical conductivity and Ohm's law, Thermal conductivity of metals

[Chapter 7, Book 1]

[18 hours]

MODULE II: BAND THEORY OF SOLIDS

The Band theory of Metals: Introduction, Bloch theorem, The Kronig-Penny model,The motion of electron in one dimension according to the band theory,The distinction between metals, insulators and intrinsic semiconductors, The concept of a hole, Brillouin zones, density of states, overlapping of energy bands

[Chapter 10, Book 3]

Extended, Reduced and Periodic Zone schemes

[Chapter 9,Book 1]

The band theory of Semiconductors: Introduction, intrinsic semiconductors, extrinsic semiconductors- effect of temperature on extrinsic semiconductors, effective mass of the electron, variation of m^* with k, Compound semiconductors, Direct and indirect semiconductors, Drift velocity, mobility and conductivity of intrinsic semiconductors- temperature dependence of mobility, Electron concentration of intrinsic semiconductor in the valence band, concentration of holes of intrinsic semiconductor in the valence band, Fermi level, Electrical conductivity of intrinsic semiconductors, band gap, Law of mass action, Carrier concentration in n-type semiconductors, Carrier concentration in p-type semiconductor, Charge neutrality equation, Carrier transport in semiconductors, Theory of generation and recombination of charge carriers, Hall effect

[Chapter 9, Book 4]

[20 hours]

MODULE III: LATTICE DYNAMICS

Phonons and Lattice Vibrations: Quantization of lattice vibrations, Phonon momentum, Inelastic scattering of photons by long wavelength phonons, Inelastic scattering of x-rays by phonons, Inelastic scattering of neutrons by phonons, Vibrations of monoatomic lattices, Lattice with two atoms per primitive cell, Optical properties in the infrared.

[Chapter 5,Book 1]

The specific heat at constant volume and constant pressure, various theories of lattice specific heat, breakdown of classical theory, Einstein's theory of specific heat, the vibrational modes of a continuous medium, Debye approximation

[Chapter 2,Book 3]

Anharmonic crystal interactions- thermal expansion, thermal conductivity – lattice thermal resistivity, Umklapp process, Imperfections

[Chapter 6,Book 1]

[16 hours]

MODULE IV: MAGNETISM AND SUPERCONDUCTIVITY

Review of basic terms and relations, Quantum theory of paramagnetism - cooling by adiabatic demagnetization – Hund's rule – ferromagnetism -spontaneous magnetization in ferromagnetic materials - Quantum theory of ferromagnetism –Weiss molecular field - Curie- Weiss law- spontaneous magnetism - internal field and exchange interaction – magnetization curve – saturation magnetization - domain model. Ferrimagnetism and Antiferromagnetism- Neel's temperature

[Chapter 9, Book 3]

Superconductivity: Review of discovery and various properties of superconductors, Theoretical survey- Thermodynamics of superconducting transition- London Equation-Coherence length-BCS theory of Superconductivity-BCS ground States-Persistent currents-single particle tunneling-Type II Superconductors, Flux quantization in Superconducting ring, Josephson superconductor tunneling effects-DC Josephson effect-AC Josephson effect, Macroscopic quantum interference, SQUIDS

[Chapter 12,Book 1]

[18 hours]

TEXT BOOKS:

1. Introduction to Solid State Physics, 8th Edition, C. Kittel, Wiley.
2. Solid State Physics, 2nd Edition, J. S. Blakemore, Cambridge
3. Solid State Physics, A.J. Dekker, Mcmillan
4. Essentials of Solid State Physics (2013), S. P. Kuila, New central book agency

REFERENCE:

1. Solid State Physics: Structure and properties of materials, 2nd Edition, M.A. Wahab, Narosa
2. Solid state physics,Ashcroft/Mermin, Cengage

SEMESTER III

PG3PHYC09-QUANTUM MECHANICS – II

MODULE I: TIME DEPENDENT PERTURBATION THEORY (18 HOURS)

Time dependent potentials - interaction picture – time evolution operator in interaction picture – time dependent perturbation theory – Dyson series – transition probability – constant perturbation

Fermi-Golden rule – harmonic perturbation – interaction with classical radiation field–absorption

and stimulated emission – electric dipole approximation – photo electric effect – energy shift and

decay width – sudden and adiabatic approximation.

[18 hours] [Books 1, 2, 3 and 4]

MODULE II: SCATTERING (18 HOURS)

Differential cross section - Asymptotic wave function (Green function method)– Scattering amplitude- Born approximation, Validity of Born approximation – Partial wave analysis – Scattering amplitude in terms of phase shifts, Optical theorem -Low energy scattering, Resonances, Ramsaur- Townsend effect

[18 hours] [Books 1, 2, 5 and 6]

MODULE III: RELATIVISTIC QUANTUM MECHANICS (18 HOURS)

Klein-Gordon equation – Probability conservation – Dirac equation for free particle – Dirac matrices – Conserved current – Representation independence- Plane wave solution - large and small components – negative energy states –Approximate Hamiltonian for electrostatic problems- Spin of the Dirac particle – covariant form –gamma matrices, Bilinear covariants.

[18 hours] [Books 1, 2, and 3]

MODULE IV: ELEMENTS OF QUANTUM FIELD THEORY (18 HOURS)

Euler-Lagrange equation for fields – Hamiltonian formulation – functional derivatives – conservation laws for classical field theory – Noether's theorem statement – Non relativisticquantum field theory – quantization rules for Bose particles, Fermi particles – relativistic quantum field theory – quantization of neutral Klein Gordon field – quantization of Dirac field.

[18 hours] [Books 7, 2, and 8]

TEXT BOOKS:

1. Modern Quantum Mechanics, J. J. Sakurai, Pearson Education
2. Quantum mechanics - V. K. Thankappan, New Age Int. Publishers
3. A Text Book of Quantum Mechanics, P. M. Mathews & K. Venkatesan, Tata McGraw Hill Ltd.
4. Basic Quantum Mechanics, Ajoy Ghatak and S Lokanadhan, Macmillan India Ltd.
5. Quantum Mechanics, Concepts and Applications, N. Zettile, John Wiley & Sons.
6. A Modern Approach to Quantum Mechanics, John S. Townsend, Viva Books Pvt Ltd.
7. Quantum Mechanics, G Aruldhas, PHI Learning New Delhi.
8. Quantum Field Theory, Lewis H. Ryder, Academic Publishers, Calcutta.

PG3PHYC10- COMPUTATIONAL PHYSICS

MODULE I: CURVE FITTING & INTERPOLATION (15 HOURS)

Least squares curve fitting procedures- fitting a straight line, correlation coefficient, multiple linear least squares, linearization of non linear laws, curve fitting by polynomials- parabola and cubic, Interpolation, errors in polynomial interpolation, finite difference operators, Newton's forward and backward formulae, Divided differences, Newton's general formula of interpolation, Lagrange's interpolation formula, inverse Lagrange's formula, Hermite's interpolation formula, interpolation by Iteration, double interpolation, splines.

[15 hours]

MODULE II: NUMERICAL DIFFERENTIATION &INTEGRATION

Numerical differentiation- differentiation formulae using forward and backward differences, maximum and minimum of a tabulated function, differentiation using natural cubic spline, Numerical integration- trapezoidal rule, Simpson's 1/3 and 3/8 rules and their errors, Boole's and Weddle's rules, integration using natural cubic splines, Romberg's integration, Gaussian integration, Monte Carlo method of integration, Numerical calculation of Fourier integrals, Numerical double integration.

[21 hours]

MODULE III: NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS

Solution by Taylor's series, Picard's method of successive approximations, Euler's method of solving ODE, error estimates for the Euler method, Modified Euler's method, Runge-Kutta methods- second order and forth order, predictor-corrector methods- Adams Moulton method, Elementary ideas of finite difference method, solution of heat equation- Bender Schmidt method and Crank Nicholson method, concept of stability, Neumann stability check for Bender Schmidt formula.

[18 hours]

MODULE IV: NUMERICAL SOLUTION OF A SYSTEM OF EQUATIONS

System of linear equations, solvability theory of linear systems, Direct methods-Gauss elimination, Gauss Jordan elimination method, Matrix inversion- Gauss method and Gauss Jordan methods to compute the inverse of matrices, Iterative methods- Jacobi method of simultaneous displacements, Gauss Seidel method of successive displacements, power method to find the eigen value of a matrix, Jacobi's method to solve eigen value problem.

[18 hours]

TEXT BOOK:

1. Introductory methods of Numerical analysis, 5th Edition, S. S. Sastry, PHI

REFERENCE:

1. Elementary numerical analysis, 3rd Edition, Atkinson & Han, Wiley
2. Mathematical methods, G. Shanker Rao and K. Keshava Reddy, I.K. International
3. An introduction to Computational Physics, 2nd Edition, Tao Pang, Cambridge

SEMESTER IV

PG4PHYC11- ATOMIC AND MOLECULAR SPECTROSCOPY

MODULE I: ATOMIC SPECTRA (20 HOURS)

Hydrogen atom and the emergence of quantum numbers– spinning electron and the vector model – normal order of fine structure doublets – electron spin orbit interaction – derivation of spin orbit interaction energy - spin orbit interaction for non-penetrating orbits - spectroscopic terms - fine structure in sodium atom, selection rules. Atom model for two valence electrons - L S and j j coupling schemes (vector diagrams) - examples, derivation of interaction energy. Hund's rule, Lande interval rule. Normal and anomalous Zeeman effects – vector model of one electron system in a weak magnetic field – magnetic moment of a bound electron – magnetic interaction energy – selection rules – examples. Paschen–Back effect – term values of strong field levels – examples. Normal Stark effect - examples. Width of spectral lines – natural width, Doppler effect, external effects. Hyperfine structure of spectral lines.

[20 hours] [Chapter 8, 10, 12 of Book 1; Chapter 1 of Book 2]

MODULE II: MICROWAVE AND INFRA RED AND ELECTRONIC SPECTROSCOPY

MICROWAVE SPECTROSCOPY

Rotational spectra of diatomic molecules - intensity of spectral lines - effect of isotopic substitution. Non–rigid rotor - rotational spectra of polyatomic molecules - linear and symmetric top - Interpretation of rotational spectra.

[5 hours]

IR SPECTROSCOPY

Vibrating diatomic molecule as anharmonic oscillator, diatomic vibrating rotor – break down of Born-Oppenheimer approximation - vibrations of polyatomic molecules - overtone and combination frequencies - influence of rotation on the spectra of polyatomic molecules - linear and symmetric top - analysis by IR technique - Fourier transform IR spectroscopy.

[8 hours]

ELECTRONIC SPECTROSCOPY

Electronic spectra of diatomic molecules - progressions and sequences - intensity of spectral lines. Franck – Condon principle - dissociation energy and dissociation products - Rotational fine structure of electronic-vibrational transition - Fortrat parabola - Pre-dissociation

[5 hours]

[Chapter 2,3, 5 of Book 3; Chapter 6,7, 9 of Book 4]

MODULE III: RAMAN SPECTROSCOPY

Pure rotational Raman spectra - linear and symmetric top molecules - vibrational Raman spectra – Raman activity of vibrations - mutual exclusion principle - rotational fine structure - structure determination from Raman and IR spectroscopy.

Non- linear Raman effects - hyper Raman effect - classical treatment - stimulated Raman effect - CARS, PARS - inverse Raman effect

[16 hours] [Chapter 4, Book 3; Chapter 8, Book 4]

MODULE IV: SPIN RESONANCE SPECTROSCOPY (18 HOURS)

NMR: Quantum mechanical and classical descriptions - Bloch equations - relaxation processes - chemical shift - spin–spin coupling - CW spectrometer - applications of NMR.

ESR: Theory of ESR - thermal equilibrium and relaxation - g- factor - hyperfine structure -applications.

Mossbauer spectroscopy: Mossbauer effect - recoilless emission and absorption - hyperfine interactions – chemical isomer shift - magnetic hyperfine and electronic quadrupole interactions - applications.

[18 hours] [Chapter 7 & 9, Book 3; Chapter 10, 11 & 13, Book 4]

TEXT BOOKS

1. Introduction to atomic spectra, H E White, McGraw Hill Kogakusha, Ltd.
2. Spectroscopy, B.P. Straughan& S. Walker, Vol. 1, John Wiley & Sons.
3. Fundamentals of molecular spectroscopy, 4th Edition, C.N. Banwell, Tata McGraw Hill
4. Molecular structure and spectroscopy, 2nd Edition, G. Aruldhas, PHI Learning Pvt. Ltd.

REFERENCE:

1. Spectroscopy (Vol. 2 & 3), B.P. Straughan& S. Walker, Science paperbacks 1976
2. Raman Spectroscopy (1977), D.A. Long, McGraw Hill international
3. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill
4. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G. Herzberg, Van Nostard, London.

5. Elements of Spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan
6. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall. Vol. 1 & 2.
7. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India
8. Spectra of Atoms and Molecules, P. F. Bernath, OUP

PG4PHYC12- NUCLEAR AND PARTICLE PHYSICS

MODULE I: NUCLEAR PROPERTIES AND NUCLEAR MODELS

Nuclear radius, mass and abundance of nuclides, nuclear binding energy, liquid drop model, nuclear angular momentum and parity, nuclear electromagnetic moments, deuteron- binding energy, magnetic and electric moments, nucleon-nucleon scattering, proton proton and neutron neutron interactions, properties of nuclear force, exchange force model, shell model nucleus- shell model potential, spin orbit potential, magnetic dipole moment and electric quadrupole moment, valence nucleons, collective structure, nuclear vibrations and nuclear rotations.

[20 hours] [Chapters 3, 4 & 5, Book 1]

MODULE II: NUCLEAR DECAY

Alpha decay- reason, basic alpha decay processes, alpha decay systematics, theory of alpha emission, angular momentum and parity in alpha decay, Beta decay, neutrino, energy release in beta decay, Fermi's theory of beta decay, classical experimental tests of Fermi's theory- shape of beta spectrum, total decay rate, mass of neutrino, Angular momentum and parity selection rules- allowed decays and forbidden decays, neutrino physics, non conservation of parity in beta decay, gamma decay- energetics of gamma decay, angular momentum and parity selection rules, internal conversion

[18 hours] [Chapters 8, 9 & 10, Book 1]

MODULE III: NUCLEAR REACTIONS

Types of reactions and conservation laws, energetics of nuclear reactions, reaction cross sections, coulomb scattering, nuclear scattering, scattering cross sections, the optical model, compound nucleus reactions, direct reactions, resonance reactions, heavy ion reactions, nuclear fission, reason for fission, characteristics of fission, energy in fission, fission reactors- components and types, radioactive fission products, fission explosives, nuclear fusion, basic fusion processes, characteristics of fusion, solar fusion- pp and CNO chains, fusion reactors, thermonuclear weapons

[18 hours] [Chapters 11, 13 & 14, Book 1]

MODULE IV: PARTICLE PHYSICS

Elementary particles- leptons quarks, particle quantum numbers, symmetries and conservation laws, CPT invariance, Quark model- u, d, s quarks, Gell-mann's eight fold path, deep inelastic scattering, coloured quarks and gluons- colour, hadrons, Gell-mannNishijima formula, reactions and decays in quark model, charm, beauty and truth, quark dynamics, unification of forces- symmetry breaking, Electroweak theory and its predictions, Higgs boson, Grand Unified Theory, predictions of GUT, search for proton decay

[16 hours] [Chapter 18, Book 1]

TEXT BOOKS:

1. Introductory nuclear physics, Kenneth S. Krane, Wiley

REFERENCE:

1. Introduction to nuclear physics, Harald A. Enge, Addison Wesley
2. The atomic nucleus, R.D. Evans, McGraw-Hill
2. Nuclear physics, I. Kaplan, Addison Wesley
3. Introduction to elementary particles, 2nd Edition, David Griffiths, Wiley
4. Elementary particles and symmetries, Lewis H. Ryder, Gordon & Breach Science

ELECTIVES

GROUP – A: THEORETICAL PHYSICS

SEMESTER III

PG3PHYEA01- ASTROPHYSICS

MODULE I: STELLAR EVOLUTION-EARLY STAGES

Birth of stars, Gravitational contraction, Hydrostatic Equilibrium, Equilibrium of a cloud of non relativistic particles, equilibrium of a cloud of ultra relativistic particles, Gravitational collapse, Jeans mass, protostar, contraction of protostar, conditions for stardom, The sun, central pressure of Sun. Stellar nucleosynthesis, The Hertzsprung-Russel diagram.

[18 hours]

MODULE II: MATTER AND RADIATION IN STAR

Stellar material, Electrons in star, degenerate electron gas, density-temperature diagram, electrons in sun, electrons in massive stars, photons in star, photon gas, radiation pressure in star, ionization in star, Saha's equation, stellar interiors, stellar atmosphere.

[18 hours]

MODULE III: FUSION AND HEAT TRANSFER IN STAR

Physics of nuclear fusion, barrier penetration, fusion cross section, thermonuclear reaction rates, Hydrogen burning- proton proton chain and CNO chain, solar neutrinos, Helium burning, Advanced burning, Heat transfer by conduction of ions and electrons, convection and radiation.

[18 hours]

MODULEIV: STELLAR STRUCTURE AND STELLAR EVOLUTION

Simple stellar model, pressure, density and temperature inside star, giant, White dwarf-mass, central density and radius, Chandrasekhar limit, Supernova-type I, Supergiant, Supernova-type II, Neutron star, gravitational binding energy of neutron stars, mass of neutron star -volkoff limit, pulsars, properties of pulsars, Black holes.

[18 hours]

TEXT BOOK:

1. **The physics of stars, 2nd Edition, A C Philips, John Wiley & Sons**

REFERENCE:

1. **An introduction to modern astrophysics, Bradley W Carrol, Dale A Ostlie, 2ndEdition, Pearson**
2. **Introductory Astronomy & Astrophysics, 4th Edition, Zeilik and Gregory, Cengage Learning**
3. **Stars, their structure and evolution, 2nd Edition, R.J.Taylor, Cambridge University Press**

PG3PHYEA02-NONLINEAR DYNAMICS AND CHAOS

MODULE I: DYNAMICS OF ONE AND TWO DIMENSIONAL SYSTEMS

Linear and Nonlinear Systems, Determinism, Unpredictability and Divergence of Trajectories, State Space, Systems Described by First-Order Differential Equations, Dissipative and Conservative systems, Attractors in dissipative Systems, One-Dimensional State Space, Linear Stability Analysis-Taylor Series Linearization near Fixed Points, Trajectories in a One-Dimensional State Space, Two-Dimensional State Space: The General Case, Dynamics and Complex Characteristic Values, Dissipation and the Divergence Theorem, Limit Cycles, Poincare Sections and the Stability of Limit Cycles, Bifurcation Theory, Lyapunov exponent of a one dimensional map.

[18 hours]

LOGISTIC MAP AND UNIVERSALITY OF CHAOS

Discrete dynamical systems- Logistic map, Period doubling bifurcations, Feigenbaum numbers, Convergence ratio for real systems, Feigenbaum Size scaling, Self-Similarity, Other Universal features, Fractals-Cantor Set, Koch Curve.

[9 hours][Chapter 1,2,3, Book 1], [Chapter6, Book 2]

MODULE II: DYNAMICS OF THREE DIMENSIONAL SYSTEMS

Overview, Heuristics, Routes to Chaos, Three-Dimensional Dynamical Systems, Fixed Points in Three Dimensions, Limit Cycles and Poincare Sections, Quasi-Periodic Behavior, The Routes to Chaos – Period-Doubling,Quasi-Periodicity,Intermittency and Crises, Chaotic Transientsand Homoclinic Orbits, Homoclinic Tangles and Horseshoes, Lyapunov Exponents and Chaos, Model of Convecting Fluids- Lorenz Model, Duffing Double well oscillator, van der Pol Oscillator.

[18 hours][Chapter 1,4, Appendices G and I, Book 1]

MODULE III: HAMILTONIAN SYSTEMS

Introduction, Liouville's theorem and phase space distribution, Constants of the Motion and Integrable Hamiltonians, The simple Harmonic oscillator, The Pendulum, Systems with N degrees of freedom, Nonintegrable Systems, KAM Theorem and Period Doubling, Poicare-Birkoff Theorem, Henon-Heilessystem, Chirikov Standard Map, Arnold Cat Map, Dissipative Standard Map.

[18 hours]{ Chapter 8, Book 1]

MODULE IV: MEASURES OFCHAOS

Introduction, Time-Series of Dynamical Variables, Lyapunov Exponents, Universal Scaling of the Lyapunov Exponent, Invariant Measure, Kolmogorov-Sinai Entropy, Correlation Dimension, Fractal Dimension(s).

[9 hours] [Chapter 9, Book 1]

TEXT BOOKS:

1. **Chaos and Nonlinear Dynamics, 2nd Edition, R. C. Hilborn, Oxford.**
2. **Deterministic Chaos, 1996 edition, N. Kumar, Universities Press.**

REFERENCES:

1. Nonlinear Dynamics and Chaos with applications to Physics, Biology, Chemistry and Engineering, 1994 Edition, Steven H. Strogatz, Perseus Book Publishing.
2. Nonlinear dynamics: integrability, chaos, and patterns, 2003 edition, M. Lakshmanan& S. Rajasekar, Springer Verlag,
3. Chaotic Dynamics: An Introduction, 1993, G.L. Baker, and J.P. Gollub, CUP.
4. Deterministic Chaos, 1995, H.G. Schuster, Wiley, N.Y.
5. Chaos in Dynamical System, 2nd Edition, E. Ott, Cambridge University Press.
6. Encounters with Chaos, 1992, D. Gullick, MGH.
7. Nonlinear Dynamics and Chaos, 2nd Edition, J.M.T. Thomson& I. Stewart, John Wiley & Sons.

SEMESTER IV

PG4PHYEA03- GRAVITATION AND COSMOLOGY

MODULE I: TENSOR ANALYSIS

A review of tensors and properties, Product of tensors, direct product, contraction and inner product, quotient rule, tensor densities, metric tensor, parallel transport, Christoffel symbols, covariant derivative, Riemannian geometry, Riemann curvature tensor, , Ricci tensor, Ricci scalar, Equation of geodesic.

[18 hours]

MODULE II: FORMULATION OF GTR

Drawbacks of Newtonian theory of gravity, Mach's principle, principle of equivalence, consequences of principle of equivalence, Gravity as curvature of space-time, Bianchi identity, Einstein's field equation, Reduction to Newtonian gravity.

[18 hours]

MODULE III: SCHWARZCHILD SOLUTION OF EINSTEIN'S EQUATION

Schwarzchild metric, Schwarzchild solution- derivation, Schwarzchild singularity-blackhole, Gravitational redshift, precession of the perihelion- planet mercury, Bending of light, gravitational time dilation, gravitational redshift, gravitational waves, detectors, gravitational lensing(qualitative ideas)

[18 hours]

MODULE IV: COSMOLOGY

Cosmological principle, FRW metric, Friedmann model- closed, flat and open models, matter dominated and radiation dominated universes, cosmological redshift, particle horizon and event horizon, CMBR, primordial nucleosynthesis, flaws of FRW model, acceleration of the universe and dark energy.

[18 hours]

TEXT BOOKS:

1. An introduction to Relativity, J. V. Narlikar, Cambridge University press
2. Introduction to cosmology, 3rd Edition, J. V. Narlikar, Cambridge University press

REFERENCE:

1. Theory of Relativity, 2nd Edition, R. K. Pathria, Dover Publications

2. Classical theory of fields, 4th Edition, L D Landau and E M Lifshitz, Elsevier
3. Principles of cosmology and gravitation, Michael V Berry, IOP Publishing Company
4. Tensor Analysis: Theory and Applications, 2nd Edition, I S Sokolnikoff, Wiley

PG4PHYEA04-QUANTUM FIELD THEORY

MODULE I: THE KLEIN GORDON FIELD

The necessity of the field view point, Elements of classical field theory-Lagrangian field theory, Hamiltonian field theory and Noether's theorem, The Klein Gordon field as Harmonic oscillators, The Klein Gordon field in space time. Causality: The Klein Gordon propagator, particle creation by a classical source.

[10 hours]

THE DIRAC FIELD

Lorentz invariance in wave equations, The Dirac equation: WeylSpinors, Free particle solutions of Dirac equation, Dirac Matrices and Dirac field bilinears, Quantization of Dirac field: The Dirac propagator, Discrete symmetries of Dirac theory-Parity, Time reversal and charge conjugation.

[8 hours][Book 1, Chapters 2 &3]

MODULE II: INTERACTING FIELDS AND FEYNMAN DIAGRAMS

Perturbation Theory, Perturbation expansion of correlation functions, Wick's theorem, Feynman diagrams, Cross sections and the S- matrix, Computing S-matrix elements from Feynman diagrams, Feynman rules for fermions-Yukawa theory, Feynman rules for quantum electrodynamics-The Coulomb potential.

[18 hours][Book 1,Chapter 4]

MODULE III: PATH INTEGRAL FORMALISM

Path Integrals in quantum mechanics, Functional quantization of scalar fields- Functional derivatives and generating functional, Quantization of electromagnetic field, Functional quantization of spinor fields-Anticommuting numbers, The Dirac propagator, Generating functional for Dirac field,QED, Functional determinants, Symmetries in functional formalism: The equations of motion, Conservation laws,The Ward-Takahashi Identity.

[18 hours][Book 1, Chapter 9]

MODULE IV: NON-ABELIAN GAUGE THEORIES

Interactions of Non-Abelian Gauge bosons: Feynman rules for fermions and gauge bosons, The Faddeev-Popov Lagrangian, Ghosts and Unitarity, Spontaneous symmetry breaking: Goldstone theorem, The Higg's mechanism, The Glashow-Weinberg-Salam theory of weak interactions, Higg's boson.

[18 hours][Book 1, Chapters 16, 20]

TEXT BOOK:

1. An Introduction to quantum field theory, 1995, Michael E. Peskin& Daniel V. Schroeder, Westview Press, Chapter16,20.

REFERENCE:

1. Quantum Field Theory, 2nd Edition, Louis H. Ryder,Academic Publishers
2. Relativistic Quantum Mechanics,1964, Bjorken and Drell, Mc Graw Hill.
3. Relativistic Quantum Fields,1965, Bjorken and Drell, Mc Graw Hill.
4. Quantum Field Theory, 2005, Claude Itzykson& Jean Bernard Zuber, Dover Publications.
5. Quantum Field Theory, A Modern Introduction, 1993, Michio Kaku, Oxford University Press.
6. Quantum Mechanics and Path Integrals,Emended Edition 2012, R.P. Feynman & A.Hibbs, Dover Publications.
7. Quantum Field Theory in a nut shell,2nd Edition,2010,A. Zee, Princeton University Press.
8. The Quantum Theory of Fields Vol I-Foundations, 2002 Edition,S. Weinberg, Cambridge University Press.
9. The Quantum Theory of Fields Vol II-Modern Applications, 2001 Edition, S. Weinberg, Cambridge University Press.

ELECTIVES

GROUP B- APPLIED PHYSICS

SEMESTER III

PG3PHYEB01-SEMICONDUCTOR DEVICE PHYSICS AND MICROELECTRONICS

MODULE – I: METAL SEMICONDUCTOR DEVICES

Metal vacuum boundary: Schottky diode – Metal Semiconductor boundary: Ohmic contact (Ideal and non-ideal) – Current transport across a metal semiconductor boundary – Comparison of the Schottky Barrier Diode and the pn junction diode – Ideal non rectifying barriers – Tunneling barrier

[Book 1 and 2]

Heterojunctions – Heterojunction materials – Energy band diagrams – Two dimensional Electron Gas

[Book 4]

MODULE – II: FIELD EFFECT DEVICES

JFET – Qualitative theory of operation – Quantitative I_D- V_D relationships – AC response

[Book 5]

MESFET, HEMT

[Book 6]

MOSFET – Qualitative theory of operation – Quantitative I_D- V_D relationships – Preliminary considerations: Threshold Voltage, Effective mobility – Square law theory – Bulk charge theory - AC Response: Small signal equivalent circuits, Cut off frequency, Small signal Characteristics

[Book 5]

Nanoscale MOSFETs, downscaling rules and their effects – MOS based memory devices: 1C1T DRAM cell, Flash Memory cell

[Book 6]

[18 hours]

MODULE III: THE INSULATED GATE BIPOLAR TRANSISTOR (IGBT)

IGBT – Advantages and Shortcomings of IGBT – IGBT structure and fabrication – Equivalent circuit representation – Principle of operation and charge control phenomena

Device structures: Lateral IGBT, Vertical IGBT, Non Punch though IGBT and Punch through IGBT – Device operational modes: Reverse blocking mode, Forward blocking and conduction modes – Static characteristics: Current – voltage characteristics, Transfer characteristics – Switching behavior of IGBT: Turn on, Turn off (Basic ideas) - Safe operating area

[16 hours][Book 8]

MODULE IV: THE 8051 MICROCONTROLLER

Microprocessor and Microcontroller – Internal architecture – Program and data memory organization – System clock – Reset

I/O ports and Special Function Registers - SFR map, functions – PSW – Accumulator – Register B – Stack pointer – Port registers – PCON

Addressing modes and data move operations – Arithmetic operations – Program branching – Programming examples-I: Copy block, Shift block, Count number of nulls, Sum of natural numbers, Sum of a series Fibonacci series – Subroutines and Stack – Logical operations – Boolean variable manipulation – Programming examples –II: Count 1's in a byte, Largest and smallest integers in an array, Bubble sorting, Factorial – Advanced instructions – Programming examples-III: Sum of a series, HEX to BCD conversion, Generate prime numbers

External interrupts – Timer/ Counter interrupts – Serial communication and Serial interrupts

Introduction to microcontrollers and Embedded systems - comparison of microprocessors and microcontrollers - The 8051 architecture - Register set of 8051 - important operational features - I/O pins, ports and circuits -external memory - counters and timers – interrupts - Instruction set of 8051 - Basic programming concepts - Applications of microcontrollers - (basicideas)

[22 hrs][Book 10 and 11]

BOOK FOR STUDY:

1. Physics of Semiconductor Devices, Second Edition, Dilip K. Roy, University Press, Chapter 4
2. Physics of Semiconductor Devices, Jean-Pierre Colinge, Cynthia A. Colinge, Kluwer Academic Publishers, Chapter 5
3. Device Electronics for Integrated Circuits, 3rd Edition, Richard S. Muller,Theodore I. Kamins, Mansun Chan
4. Semiconductor Physics and Devices, 4e, Donald A Neamen, Dhrubes Biswas
5. Semiconductor Device Fundamentals with Computer Based Exercises and Homework Problems, Robert F. Pierret
6. Principles of Semiconductor Devices (Second Edition), Sima Dimitrijev, Oxford University Press, Chapter 8, 13.
7. Semiconductor device physics and design, Umesh Mishra, Jasprit Singh, Springer, Chapter 9.
8. Insulated Gate Bipolar Transistor IGBT Theory and Design, Vinod Kumar Khanna, Wiley Intersicence.

9. 8051 Microcontroller, Internals, Instructions, Programming and Interfacing, Second Edition, Subrata Ghoshal, Pearson.

10. The 8051 Microcontroller and Embedded Systems using Assembly and C, Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, Pearson.

PG3PHYEB02-MATERIALS SCIENCE

MODULE I: CRYSTAL IMPERFECTIONS, PHASE DIAGRAMS AND DIFFUSION IN SOLIDS

Crystal Imperfections- Point imperfections- geometry of dislocations- Dislocation motion- Dislocation multiplication- Frank-Read mechanism-Work hardening of metals- Surface imperfections

[Chapter 6, Book 1]

Phase Diagrams & Diffusion in Solids - The phase rule- Single component system- Binary phase diagrams- The Lever rule- Some typical phase diagrams and application- Hume Rothery electron compounds-case of limits solid solubility-the Eutectic temperature

Fick's law and solutions- Applications based on the second law solution- The Kirkendall effect- The atomic model of diffusion- Other diffusion processes

[Chapter 7, 8, Book 1]

[18 hours]

MODULE II: THIN FILMS -PREPARATION AND APPLICATIONS

Introduction-Nature of thin film-deposition technology-thermal deposition in vacuum-Kinetic theory of gas and emission condition-distribution of deposit-resistive heating-electron beam method-cathodic sputtering-chemical vapor deposition or vapor plating-chemical deposition

[Chapter 1, Book 2]

Introduction- Thermodynamics of Nucleation-Nucleation Theories: Condensation process - Theories of Nucleation – Capillarity theory – Atomistic theory – Comparison – stages of film growth – Incorporation of defects during growth-Deposition parameter s and grain size - Epitaxy-Thin film structure

[Chapter 1 & 5, Book 2]

Applications of thin films Qualitative ideas of antireflection coatings, reflectometric coating, interference filters - thin film polarizers-beam splitters-optoelectronic applications-microelectronic applications, magnetic thin film devices

[Chapters 2, 3, 4 & 5, Book 3]

[20 hours]

MODULE III: NANOSTRUCTURED MATERIALS - PREPARATION, PROPERTIES AND APPLICATIONS

Review of electron states in crystal

[Chapter 1, Book 4]

Electron states in ideal nanocrystal

From crystal to cluster: effective mass approximation- weak confinement regime-strong confinement limit-surface polarization and finite barrier effects- Hole energy levels and optical transitions in real semiconductors-size dependent oscillator strength

From cluster to crystal: quantum chemical approaches

Semiconductor nanocrystals as large molecules-general characteristics of quantum-chemical methods-semiempirical techniques-quantum –chemical calculations for semiconductor clusters-size regimes in quasi-zero-dimensional structures

[Chapter 2, Book 4]

Preparation of Nanoparticles- Nanoparticles through homogeneous nucleation, nanoparticles through heterogeneous nucleation, kinetically confined synthesis of nanoparticles-epitaxial core-shell nanoparticles

[Chapter 3, Book 5]

Special nanomaterials- carbon fullerenes & nanotubes

[Chapter 6, Book 5]

Physical properties of Nanomaterials

Melting points and lattice constants-Mechanical properties-optical properties-surface Plasmon resonance-quantum size effects

Electrical conductivity

Surface scattering-change of electronic structure-quantum transport-effect of microstructure

[Chapter 8, Book 5]

Applications of nanomaterials: Molecular electronics and Nanoelectronics, Nonobots, Biological applications of nanoparticles, band gap engineered quantum devices, nano-mechanics

[Chapter 9, Book 5]

[23 hours]

MODULE IV: CHARACTERIZATION TECHNIQUES OF THIN FILMS AND NANOSTRUCTURES

Thickness measurement using optical interference method, stylus

XRD - Structural characterization and particle size determination, Mass spectroscopy elimination of strain, size determination

UV-Vis spectroscopy- Absorption, reflectance, and transmission spectrum, Band gap determination

FTIR Spectroscopy-Raman Spectroscopy-Band assignments- Scanning probe microscopy - Atomic force microscope (AFM), magnetic force microscopy(MFM), electron microscopy, SEM, TEM and XPS.

[16 hours][Book 3, Book 3, Book 6]

TEXT BOOKS

1. Materials Science and Engineering – A First Course – 5th Edition- V.Raghavan (Prentice-Hall of India- 2013)
2. Thin Film Fundamentals: A Goswami, New Age Publishers
3. K.L. Chopra and Inderjeet Kaur, Thin Film Device Applications, Plenum press
4. Optical properties of Semiconductor nanocrystals, S.V.Gaponenko, Cambridge University Press
5. Nanostructures and Nanomaterials, Synthesis, properties and applications, G Cao, Imperial College Press
6. Characterization of Semiconductor Heterostructures and Nanostructures, Edited byCarlo Lamberti, Elseveir,2008

REFERENCE:

1. Introduction to Nanoscience & Technology “- K.K.Chathopadhyay, A.N. Banerjee(Prentice-Hall of India -2011.)
2. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J.Owens, Wiley, (2003) 92

SEMESTER IV

PG4PHYEB03 - PHOTONICS

MODULE I: FIBRE OPTICS

Optical waveguides, numerical aperture, Modes in planar waveguides, Goos-Hanschen effect, evanescent field. Cylindrical fibers. Step index and graded index fibres, single mode and multimode fibres, cut of wavelengths, Integrated Optics, channel waveguides, electro optic waveguides, i/p and o/p couplers, e-o and m -o modulators applications of integrated optics - lenses, grating, spectrum analysers. Module 2 Transmission characteristics of optical fibre, attenuation, absorption and scattering losses, nonlinear losses, wavelengths for communication, bend losses, dispersion effects in optical fibres- material and waveguide dispersions, modal birefringence and polarization maintaining fibres.

[18 hours] [Book 1]

MODULE II: QUANTUM ELECTRONICS

Classification of lasers - two level, three level and four level laser systems

Laser systems involving low density media- He-Ne laser, Ar -ion laser, CO 2 laser, Excimer laser, X-ray laser, FEL laser

Laser systems involving high gain media – Dye lasers, Solid state lasers- Ruby laser, NdYAG laser, Nd-glass laser, Pico and Femto second lasers- Alexandrite laser. Ti-Sapphire laser and fiber laser

Laser diode- Threshold current and power output, Semiconductor lasers- hetrojunction lasers, Quantum well lasers, DFB laser, Surface emitting lasers, Rare-earth doped lasers

Photodetectors and Photoconductors, Photodiodes and Avalanche Photodiodes.

[18 hours] [Book 2 & 3]

MODULE III: NONLINEAR OPTICS

Introduction nonlinear optical phenomena, nonlinear optical interactions, second-harmonic generation, sum – and difference – frequency generation, optical parametric oscillation, third order polarization, intensity - dependent refractive index, third order polarization (general case), parametric vs nonparametric process, saturable absorption, two-photon absorption, stimulated Raman scattering, nonlinear susceptibility, classical anharmonic oscillator, noncentrosymmetric media, Miller's rule, centrosymmetric media, influence of inversion symmetry on second order nonlinearity, time domain description of optical nonlinearties, Kramers-Kronig relations in nonlinear optics, Phase matching, Angle tuning, optical parametric oscillations, Self focusing, Optical Phase Conjugation, Degenerate Four-Wave Mixing, Optical Bistablity and Switching, Pulse propagation and Temporal Solitons.

[18 hours] [Book 4]

MODULE IV: NANOPHOTONICS

Foundations of Nanophotonics: Confinement of Photons and Electrons, Propagation Through a Classically Forbidden Zone: Tunneling, Localization Under a Periodic Potential: Bandgap, Cooperative Effects for Photons and Electrons, Nanoscale Optical Interactions, Nanoscale Confinement of Electronic Interactions, Quantum Confinement Effects, Nanoscale Electronic Energy Transfer. Near-Field Interaction and

Quantum-Confined Materials: Quantum Wells, Quantum Wires, Quantum Dots Quantum Rings, Manifestations of Quantum Confinement, Optical Properties, Quantum-Confined Stark Effect, Dielectric Confinement Effect, Single-Molecule Spectroscopy, Quantum Confined Structures as Lasing Media, Metallic nanostructures and their applications.

[18 hours] [Book 5]

TEXT BOOKS:

1. Optical Fibre communication - J. M. Senior. Prentice Hall India (1994)
2. Laser fundamentals - Willium T. Silfvast, Cambridge University Press, Second Edition (1995)
3. Fundamentals of Photonics – Saleh & Teich, Wiley Interscience
4. Nonlinear Optics – Robert W. Boyd, Academic Press
5. Nanophotonics: P. N. Prasad, Wiley Interscience (2003)

REFERENCE:

1. Quantum Electronics, A. Yariv, John Wiley & Sons
2. Understanding Fiber Optics, J. Hecht, CreateSpace
3. Photonic Devices, J. M. Liu, Cambridge University Press
4. Modern Optics, B. D. Guenther, Oxford University Press
5. Guided- Wave Optics, C. C. Chen, Wiley.

SEMESTER IV

PG4PHYEB04-ELECTRONIC COMMUNICATION AND DIGITAL SIGNAL PROCESSING

MODULE – I: TRANSMISSION AND RADIATION OF EM WAVES

Transmission lines – Basic Transmission lines characteristics – Transmission line parameters – Transmission line equations for loss less lines (Telegrapher equations) – General travelling wave solution for loss less lines – Transient response of lossless Transmission lines – Reflection coefficient – Lattice diagram, Applications: Over and Under driven Transmission lines – Sinusoidal steady state response of Transmission lines - Characteristics of lossy Transmission lines – Terminated Transmission lines – Impedance transformation - Transmission lines s reactive circuit elements – Complex reflection coefficient – Standing waves – Impedance matching – Quarter Wave transformer

[Book 1 - 3]

Antennas – Antenna equivalent circuits – Coordinate system – Radiation fields – Polarization – Isotropic Radiator – Power gain

[Book 4]

Retarded potential – radiation from an ac current element – monopoles and dipoles – power radiated from a dipole

[Book 5]

Four Antenna types

[Book 6]

[18 hrs]

MODULE – II: DIGITAL SIGNAL PROCESSING

Basic concepts and applications, Sampling of continues signal, Signal reconstruction, Anti-aliasing, A-D, D-A conversion – Quantization

Digital signals – Generation - Linear Time Invariant, Casual systems – Difference equations and Impulse responses – Bounded-in and bounded-out stability – Digital convolution

Discrete Fourier Transform – Fourier Series Coefficients of Periodic Digital Signals – Discrete Fourier Transform Formulae - Amplitude and Power spectrum – Spectral estimation using Window functions – Fast Fourier Transform (decimation in frequency, decimation in time)

z – transform – Properties – Inverse z transform – Solution of difference equations using the z-transform

[20 hrs] [Book 7]

MODULE – III: DIGITAL FILTERS

The difference equation and digital filtering – difference equation and transfer function – The z plane pole zero plot and stability – digital filter frequency response – basic filters – realization of digital filters (direct form I, direct form II)

Finite Impulse Response filters – Fourier transform design – Window method

Infinite Impulse Response Filter Design – IIR filter format – Bilinear transformation design method: Analog Filters Using Lowpass Prototype Transformation, Bilinear Transformation and Frequency Warping, Bilinear Transformation Design Procedure - Digital Butterworth and Chebyshev Filter Designs: Lowpass Prototype Function and Its

Order, Lowpass and Highpass Filter Design Examples, Bandpass and Bandstop Filter Design Examples

[20 hrs] [Book 7]

MODULE – IV: DSP IN COMMUNICATION

Analog Modulation – Amplitude modulation: DSB AM, Conventional AM, SSB AM – Demodulation of AM signals: DSB AM Demodulation, SSB AM Demodulation, Conventional AM Demodulation – Angle modulation

Analog-to-digital conversion – Measure of information – Noiseless coding – Huffman coding – Quantization: Scalar, uniform, nonuniform – PCM: Uniform, nonuniform

Digital transmission via carrier modulation – Carrier amplitude modulation – Demodulation of PAM signals – Carrier Phase modulation – Phase demodulation and detection – Differential Phase Modulation and Demodulation: QAM, Demodulation and detection – Carrier Frequency modulation: FSK, Demodulation and detection

[14 hours] [Book 10]

BOOK FOR STUDY:

1. Fundamentals of Engineering Electromagnetics, Rajeev Bansal, CRC Press, Taylor and Francis Group
2. Radio frequency and Microwave Communication Circuits, Second edition, Devendra K. Misra, Wiley Interscience
3. Electromagnetics for High-Speed Analog and Digital Communication Circuits, Ali M Niknejad, Cambridge University Press
4. Electronic Communications, Fourth Edition, Dennis Roddy and John Coolen, Pearson, Chapter 16
5. Electromagnetic waves and radiating systems, Jordan and Balman, Prentice Hall India
6. Antenna Theory and Design, Warren L. Stutzman, Gary A. Thiele, 3rd Ed., John Wiley & Sons, Chapter 1
7. Digital Signal Processing, Fundamentals and Applications, Li Tan, Elsevier
8. Digital Signal Processing using MATLAB V.4, Vinay K. Ingle, John G. Proakis, PWS Publishing Company

9. Digital Signal Processing, Principles, Algorithms and Applications, John G. Proakis, Dimitris G. Manolakis, Prentice Hall International.

10. Chapters 3, 4 and 7, Contemporary Communication Systems Using MATLAB, John G. Proakis, Masoud Salehi, PWS Publishing Company.

PRACTICAL COURSES

(A minimum of 12 experiments should be done and recorded in each practical course to appear for examination)

SEMESTER I

PG1PHYP01-GENERAL PHYSICS PRACTICALS

1. Y, n, σ - Cornu's method (a) Elliptical fringes and (b) Hyperbolic fringes.
2. Absorption spectrum –KMnO4 solution / Iodine vapour – telescope and scale arrangement – Hartmann's formula or photographic method
3. Frank and Hertz Experiment – determination of ionization potential
4. Hall Effect (a) carrier concentration (b) Mobility & (c) Hall coefficient.
5. Four Probe Method - Resistivity and band gap of semiconductor specimen
6. Band gap energy measurement of silicon using p-n diode
7. Magnetic Susceptibility - Quincke's method
8. Michelson Interferometer - λ and dλ - thickness of mica
9. Ultrasonic grating - elastic property of a liquid
10. B - H Curve - Hysteresis
11. Oscillating Disc - viscosity of a liquid.
12. e/m of the electron - Thomson's method
13. Characteristic of a thermistor - determination of the relevant parameters.
14. Dielectric constant of bakelite sheets - resonance method

15. Dipole moment of an organic molecule (acetone)

16. Young's modulus of steel using the flexural vibrations of a bar

17. Stefan's law of radiation – verification and determination of Stefan's constant

18. Temperature dependence of a ceramic capacitor and verification of Curie-Wiess law

19. Experiments using GM counter- absorption co-efficient of beta rays
in materials.

20. Multichannel analyzer for alpha energy determination.

21. Zeeman effect setup – measurement of Bohr magnetron

22. Photoelectric effect – determination of Plank's constant

23. Millikkan's oil drop experiment: measurement of charge

24. Linear electro-optic effect (Pockels effect) – half wave voltage

25. Silicon diode as a temperature sensor.

26. Electrical and thermal conductivity of copper and determination of
Lorentz number.

27.Constant deviation spectrometer: Absorption spectrum of $KMnO_4$and calculation of
Hartmann's constant.

28.Diffraction of light: laser and grating

SEMESTER II

PG2PHYP02- ELECTRONICS PRACTICALS

1. Differential amplifiers using transistors and constant current source - Frequency response, CMRR.
2. Voltage controlled oscillator using IC 555
3. R F Oscillator - above 1 MHz frequency measurement.
4. Differential amplifier - using op-amp.
5. Active filters – low pass and high pass-first and second order frequency response and roll off rate.
6. Band pass filter using single op-amp-frequency response and bandwidth.
7. Wein-bridge Oscillator – using op-amp with amplitude stabilization.
8. Op-amp-measurement of parameters such as open loop gain – offset voltage – open loop response.
9. RC phase shift oscillator
10. AM generation and demodulation

11. Solving differential equation using IC 741
12. Solving simultaneous equation using IC 741
13. Current to voltage and voltage to current converter (IC 741)
14. Temperature measurement using ADC and microprocessor.
15. Op-amp-triangular wave generator with specified amplitude.
16. Microprocessor- Sorting Hex numbers in the Ascending and Descending order.
17. Microprocessor- Largest and Smallest numbers in an array.
18. Microprocessor- measurement of analog voltage.
19. Microprocessor-Digital synthesis of wave form using D/A Converter.
20. Analog to digital and digital to analog converter ADC0800 & DAC0800

SEMESTER III

PG3PHYP03-COMPUTATIONAL PHYSICS PRACTICALS

1. Study the motion of a spherical body falling through a viscous medium and observe the changes in critical velocity with radius, viscosity of the medium.

2. Study the path of a projectile for different angles of projection. From graph find the variation in range and maximum height with angle of projection.

3. Study graphically the variation of magnetic field B(T) with critical temperature in superconductivity using the relationship B(T) = B0 [1 - (T/Tc)2], for different substances.

4. Discuss the charging /discharging of a capacitor through an inductor and resistor, by plotting time –charge graphs for a) non oscillatory, b) critical) oscillatory charging.

5. Analyze a Wheatstone's bridge with three known resistances. Find the voltage across the galvanometer when the bridge is balanced.

6. Study the variation in phase relation between applied voltage and current of a series L.C.R circuit with given values of L C Find the resonant frequency and maximum current.

7. A set of observations of π meson disintegration is given. Fit the values to a graph based on appropriate theory and hence calculate life time τ of π mesons.

8. Draw graphs for radioactive disintegrations with different decay rates for different substances. Also calculate the half-life's in each case.

9. Half-life period of a Radium sample is 1620 years. Analytically calculate amount of radium remaining in a sample of 5gm after 1000 years.Verify your answer by plotting a graph between time of decay and amount of substance of the same sample.

10. Plot the trajectory of a α-particle in Rutherford scattering and determine the values of the impact parameter.

11. Draw the phase plots for the following systems. (i) A conservative case (simple pendulum)

(ii) A dissipative case (damped pendulum)

(iii) A nonlinear case (coupled pendulums).

12. Two masses m1 and m2 are connected to each other by a spring of spring constant k and the system is made to oscillate as a two coupled pendulum. Plot the positions of the masses as a functionof time.

13. Plot the motion of an electron in (i) in uniform electric field perpendicular to initial velocity (ii) uniform magnetic field at an angle with the velocity. and (iii) simultaneous electric and

magnetic fields in perpendicular directions with different fieldstrengths.

14. A proton is incident on a rectangular barrier, calculate the probability of transmission for fixed values of V0 and E (V0 > E) for the width of barrier ranges from 5 to 10 Fermi, and plot the same.

15. Generate the interference pattern in Young's double slitinterferenceand study the variation of intensity with variation of distance of the screen from the slit.

16. Analyze the Elliptically and circularly polarized light based on two vibrations emerging out of a polarizer represented by two simple harmonic motions at right angles to each other and having a phase difference. Plot the nature of vibrations of the emergent light for different values of phase difference1

17. Generate the pattern of electric field due to a point charge

18. Sketch the ground state wave function and corresponding probability distribution function for different values of displacements of the harmonic oscillator.

19. Gauss elimination method for solving a system of linear equations.

20. Solving a second order differential equation using 4^{th}order Runge- Kutta method.

21. Finding the roots of a nonlinear equation by bisection method.

SEMESTER IV

PG4PHYEAP01- SPECIAL COMPUTATIONAL PRACTICALS

1. Trajectory of motion of (a) projectile without air resistance (b) projectile with air resistance
2. Phase space trajectories of a pendulum- with and without damping.
3. Phase space trajectories of a pendulum – with non-linear term.
4. Trajectory of a particle moving in a Coulomb field (Rutherford scattering) and to determine the deflection angle as a function of the impact parameter
5. Trajectory of a ion in the combined Coulomb and nuclear potential and determine the angle of scattering for different impact parameters
6. Simulation of the wave function for a particle in a box - To plot the wave function and probability density; Schrödinger equation to be solved and eigen value calculated numerically.
7. Iterates of the logistic map.
8. Bifurcation diagram for the logistic map.
9. Calculation and plotting of the Lyapunov exponents.
10. Plotting of Julia set.
11. Plotting of Mandelbrot set.
12. Creating a fractal by Iteration Function Scheme

SEMESTER IV

PG4PHYEBP01- APPLIED PHYSICS PRACTICALS

A. SOLID-STATE SEMICONDUCTOR DEVICE PHYSICS AND MICROELECTRONICS

1. Design and construct a DC voltmeter using FET.

2. Obtain the steady output side characteristics and transfer characteristics of the given MOSFET for a specified value of gate-source voltage.

3. Obtain the steady output side characteristics and transfer characteristics of the given IGBT for a specified value of gate-source voltage.

4. Study the switching characteristics of a MOSFET and IGBT and determine the timing parameters.

5. Write and execute a program to store the given set of ten numbers in the ascending order. Modify the program to arrange the numbers in the descending order. Use PC or 8051kit.

6. Write a program to find the largest of the numbers in the array of memory and store the result in a given memory location. Modify the program to find the smallest of the numbers in an array of memory. Use PC or 8051 kit.

7. Generate sine and square waves of different periods using a microcontroller 8051.

8. Control the speed of a DC motor with 8051 microcontroller using the Pulse Width Modulation method.

B. ELECTRONIC COMMUNICATION AND DIGITAL SIGNAL PROCESSING

1. Measure and plot the radiation pattern of a Horn antenna.

2. Measure the characteristic impedance and transmission line parameters of a coaxial cable.

3. VSWR Measurement: Determine the Voltage Standing Wave Ratio and Reflection Coefficient of a slotted waveguide

4. Linear and Circular Convolution of two given sequences: Write a MATLAB code to perform linear and circular convolution of two given discrete time signals using (a) CONV function in MATLAB (b) Convolution Sum formula.

5. Design and Implementation of FIR filter: Design an IIR filter that meet the following specification using Hamming window in MATLAB. Window length, N = 27, Stop band attenuation = 50 dB, Cut-off frequency = 100 Hz, Sampling frequency = 1000 Hz

6. Design and Implementation of IIR filter: Design an IIR filter in MATLAB with pass band edge frequency 1500 Hz and stop band edge at 2000 Hz for a sampling frequency of 8000 Hz, variation of gain within pass band 1 dB and stop band attenuation of 15 dB. Use Butterworth prototype design and bilinear transformation.

7. Design and Implementation of IIR filter: Design an IIR filter in MATLAB with pass band edge frequency 1500 Hz and stop band edge at 2000 Hz for a sampling frequency of 8000 Hz, variation of gain within pass band 1 dB and stop band attenuation of 15 dB. Use Chebyshev prototype design and bilinear transformation.

8. Give the necessary theory and circuit diagram of Pulse Amplitude and Pulse Width Modulations. Construct the circuit and sketch the input and output waveforms.

9. Give the necessary theory and circuit diagram of an electronic circuit that use IC – CD4046 to demonstrate Frequency modulation and demodulation. Construct the circuit and sketch the input and output waveforms.

10. Give the necessary theory and circuit diagram of an electronic circuit that use IC 7432 to realize a Multiplexer and demultiplexer. Construct the circuit and record the output.

11. Construct a voltage to frequency converter with a maximum output of 10kHz and study the output frequency as a function of input voltage. Modify the circuit to increase the output frequency to 30 kHz.

12. Construct a frequency to voltage converter and study the output voltage as a function of the input frequencies. Repeat the experiment for both sine wave and square wave input.

13. Characterize the given phase locked loop and hence find the capture range and lock range. Repeat the experiment by changing the free running frequency.

14. Setup a frequency multiplier using PLL IC 4046 to multiply the input frequency by factors 10, 6 and 8.

C. PHOTONICS

1. Characteristics of photo diode, photo transistor, LDR, LED- Determination of the relevant parameters.

2. Beam Profile of laser, spot size and divergence.

3. Temperature co-efficient of resistance of copper.

4. Data transmission and reception through optical fiber link.

5.Magneto-optic effect (Faraday effect) – Verdet's constant.

6. Study of Emission spectra of metals using constant deviation spectrometer.

7.Identification of elements of an alloy using arc and constant deviation spectrometer.

8.Solar cell characteristics
9.Bending laws of an optical fiber

10. Numerical aperture of an optical fiber

11. Diffraction of light by Cross wire and wire mesh - laser

12. Diffraction of light by single slit and double slit - laser

D. MATERIAL SCIENCE

1. Ultrasonic Interferometer – ultrasonic velocity in liquids

2. Ultrasonic Interferometer – Young's modulus and elastic constant of solids

3. Dielectric constant of a substance - resonance method

4. Determination of forbidden energy gap

5. Determination of Fermi energy of copper

6. Study of ionic conductivity in KCl / NaCl crystals

7. Thermo emf of bulk samples of metals (aluminium or copper)

8. Study of physical properties of crystals (specific heat,thermal expansion,thermal conductivity,dielectric constant)

9. Study of variation of dielectric constant of a ferro electric material with

temperature(barium titanate)

10. Study of variation of magnetic properties with composition of a ferrite specimen
11. Four probe method – energy gap
12. Energy gap of Ge or Si
13. Thin film coating by polymerisation
14. Measurement of thickness of a thin film
15. Study of dielectric properties of a thin film
16. Study of electrical properties of a thin film (sheet resistance)
17. Growth of single crystal from solution and the determination of its structural,electrical and optical properties (NaCl,KBr,KCl,NH4Cl etc.)
18. Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal
19. Observation of dislocation – etch pit method
20. Michelson Interferometer – Thickness of transparent film
21. X-ray diffraction – lattice constant
22. Optical absorption coefficient of thin films by filter photometry
23. Temperature measurement with sensor interfaced to a PC or microprocessor
24. ESR spectrometer – g factor
25. Beam profile of diode laser
26. Track width of a CD using laser beam
27. He – Ne laser- verification of Malus law, measurement of Brewster angle, refractive index of a material
28. IR spectrum of few samples
29. Strain gauge – Y of a metal beam