Chaudhary Bansi Lal University, Bhiwani

(A State University established under Haryana Act No. 25 of 2014)

Examination Scheme
&
Syllabus
For
M.Sc. - PHYSICS
(SEMESTER- I to IV)
(w.e.f. 2019-20)

Chaudhary Bansi Lal University, Bhiwani

(A State University established under Haryana Act No. 25 of 2014)

Study & Evaluation Scheme
of
M.Sc. PHYSICS
Summary

Programme : M.Sc. (PHYSICS)
Duration : Two-year full time (Four Semesters)
Medium : English
Minimum Required Attendance : 75%
Total Credits : 123

Assessment/Evaluation

Internal Marks	Major Test (End Semester Exam) Marks	Total Marks
20	80	100

Internal Evaluation (Theory)

Minor Test	Attendance	Assignment	Total Marks
10	5	5	20

Duration of Examination

Major Test (End Semester Exam)	Internal (Minor Test)
3 hrs.	1 ½ hrs.

To qualify the course, a student is required to secure a minimum of 40% marks in aggregate including the Major Test (End Semester Examination) and internal evaluation. A candidate who secures less than 40% of marks in a course shall be deemed to have failed in that course. The student should have obtained at least 40% marks in aggregate to qualify the semester.

Note:* *The students should be involved in extracurricular activities through Hobbies Club (Non CGPA) such as Poetry, Science Club, Drama etc. and will be awarded a letter grade at the completion of M. Sc.

Question Paper Structure

There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.

Chaudhary Bansi Lal University, Bhiwani

Scheme of Examination for M.Sc.-PHYSICS

Semester-I (w.e.f. 2019-20) **Credits= 32** **Marks=800**

Sr. No.	Course/ Paper Code	Courses	Type of Course	Credit			Contact Hours Per Week			Examination Scheme			Total Marks
				Theory (L+T)	Practical /Seminar	Total	Theory (L+T)	Practical /Seminar	Total	Major Test (End Semester Exam)	Internal Assessment	Practical/ Seminar	
1	19PHY-101	Mathematical Physics	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
2	19PHY-102	Classical Mechanics	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
3	19PHY-103	Quantum Mechanics-I	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
4	19PHY-104	Electronic Devices and Circuits-I	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
5	19PHY-105	Communication Skills	A.E.C.C.	2+0	--	2	2+0	--	2	80	20	--	100
6	19PHY-106	IT Fundamentals	S.E.C.	2+0		2	2+0	--	2	80	20	--	100
7	19PHY-107	Physics Laboratory-I		--	4	4	--	8	8	--	20	80	100
8	19PHY-108	Physics Laboratory-II		--	4	4	--	8	8	--	20	80	100
Total						32			40				800

C.C. = Core Course **S.E.C.=Skill Enhancement Course** **A.E.C.C.= Ability Enhancement Compulsory Course**

Note: L-Lecture, T-Tutorial

Chaudhary Bansi Lal University, Bhiwani
Scheme of Examination for M.Sc.-PHYSICS

Semester-II(w.e.f. 2019-20) Credits= 31 Marks=725

Sr. No.	Course/ Paper Code	Courses	Type of Course	Credit			Contact Hours Per Week			Examination Scheme			Total Marks
				Theory (L+T)	Practical /Seminar	Total	Theory (L+T)	Practical /Seminar	Total	Major Test (End Semester Exam)	Internal Assessment	Practical/ Seminar	
1	19PHY-201	Quantum Mechanics-II	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
2	19PHY-202	Nuclear and Particle Physics	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
3	19PHY-203	Solid State Physics	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
4	19PHY-204	Electronic Devices and Circuits-II	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
5	19PHY-205	Physics Laboratory-III		--	4	4	--	8	8	--	20	80	100
6	19PHY-206	Physics Laboratory-IV		--	4	4	--	8	8	--	20	80	100
7	19PHY-207	Seminar	S.E.C.	--	1	1	--	2	2	--	--	--	25
8	19PHY-208	Open Elective -I	O.E.C.	2	0	2	2	--	2	80	20	--	100
Total						31			40				725

C.C. = Core Course S.E.C.= Skill Enhancement Course O.E.C. = Open Elective Course

Note: 1. L-Lecture, T-Tutorial

2. For Open Elective-I, students will have to choose a course from the list of open electives offered by other Departments of the University.

Chaudhary Bansi Lal University, Bhiwani
Scheme of Examination for M.Sc.- PHYSICS

Semester-III (w.e.f.2019-20) **Credits= 31** **Marks=725**

Sr. No.	Course/Paper Code	Courses	Type of Course	Credit			Contact Hours Per Week			Examination Scheme			Total Marks
				Theory (L+T)	Practical /Seminar	Total	Theory	Practical /Seminar	Total	Major Test (End Semester Exam)	Internal Assessment	Practical/ Seminar	
1	19PHY 301	Electrodynamics	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
2	19PHY 302	Atomic & Molecular Physics-I	C.C.	4+1	--	5	4+1	--	5	80	20	--	100
3	*Any one of the following subject electives/specializations* Discipline Specific Elective I		D.S.E.	4+1	--	5	4+1	--	5	80	20	--	100
4	*Any one of the following subject electives/specializations* Discipline Specific Elective II		D.S.E.	4+1	--	5	4+1	--	5	80	20	--	100
5	19PHY 305	Physics Laboratory-V		--	4	4	--	8	8	--	20	80	100
6	19PHY 306	Physics Laboratory-VI		--	4	4	--	8	8	--	20	80	100
7	19PHY 307	Seminar	S.E.C	--	1	1	--	2	2	--	--	--	25
8	19PHY 308	Open Elective -II	O.E.C	2	0	2	2	--	2	80	20	--	100
Total						31			40				725

C.C. = Core Course, D.S.E. = Discipline Specific Elective, O.E.C. = Open Elective Course, S.E.C.= Skill Enhancement Course

Note: 1. L-Lecture, T-Tutorial

2. The Discipline Elective Courses will be selected only in combination from the table given below i.e. if one select 19PHY 303A from DSE I then accordingly he/she will have 19PHY304Aas another course from DSE II.

Discipline Specific Elective I		Discipline Specific Elective II	
19PHY 303A	Radiation Physics	19PHY 304A	Condensed Matter Physics-I
19PHY 303B	Material Science-I	19PHY 304B	Nuclear Physics-I
19PHY 303C	Physics of Nano-materials	19PHY304C	Electronics-I

3.The Discipline Elective Courses can be offered depending upon the availability of the resources and faculties.

4. For Open Elective-II, students will have to choose a course from the list of open electives offered by other Departments of the University

Chaudhary Bansi Lal University, Bhiwani

Scheme of Examination for M.Sc. - PHYSICS.

Semester-IV (w.e.f. 2019-20) Credits= 29 Marks=750

Sr. No.	Course/ Paper Code	Courses	Type of Course	Credit			Contact Hours Per Week			Examination Scheme			Total Marks
				Theory (L+T)	Practical /Seminar	Total	Theory	Practical /Seminar	Total	Major Test (End Semester Exam)	Internal Assessment	Practical/ Seminar	
1	19PHY 401	Statistical Mechanics	C.C.	4+1	--	5	4+0+1	--	5	80	20	--	100
2	19PHY 402	Atomic & Molecular Physics-II	C.C.	4+1	--	5	4+0+1	--	5	80	20	--	100
3	*Same electives/specializations are to be taken as in Semester III* Discipline Specific Elective III		D.S.E.	4+1	--	5	4+0+1	--	5	80	20	--	100
4	*Same electives/specializations are to be taken as in Semester III* Discipline Specific Elective IV		D.S.E.	4+1	--	5	4+0+1	--	5	80	20	--	100
5	19PHY 405	Physics Laboratory-VII		--	4	4	--	0+8+0	8	--	20	80	100
6	19PHY 406	Physics Laboratory-VIII		--	4	4	--	0+8+0	8	--	20	80	100
7	19PHY 407	Seminar	S.E.C.	--	1	1	--	2	2	--	--	25	25
Total						29			38				725

C.C. = Core Course, D.S.E. = Discipline Specific Elective, O.E.C. = Open Elective Course, S.E.C.= Skill Enhancement Course

Note: 1. L-Lecture, T-Tutorial

2. The same Discipline Specific Elective Courses are to be taken as in semester III and only in combination from the table given below i.e. if one selects 19PHY 303A from DSE I then accordingly he/she will have 19PHY403Aas one course from DSE III and 19PHY404A as another course from DSE IV

Discipline Specific Elective III		Discipline Specific Elective IV	
19PHY 403A	Computational Physics	19PHY 404A	Condensed Matter Physics-II
19PHY 403B	Material Science-II	19PHY 404B	Nuclear Physics-II
19PHY 403C	Experimental Techniques	19PHY404C	Electronics-II

3.The Discipline Elective Courses can be offered depending upon the availability of the resources and faculties.

Duration - 2 Years (4 Semesters) **Total credits-123**

Total Marks – 2975

M.Sc.-PHYSICS
SEMESTER-I

19PHY-101

Mathematical Physics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Matrices and Integral Transforms

Matrices: Orthogonal, Unitary and Hermitian matrices, Eigenvalues and eigenvectors of matrices, Matrix diagonalization
Integral Transforms: Fourier Transforms, Properties of Fourier Transform, FT of derivatives**,** Fourier sine Transforms, Fourier cosine Transforms Laplace transform, properties of Laplace transforms, Laplace transform of derivatives, Laplace Transform of integrals, Inverse Laplace Transform by partial fractions method.

Unit- II

Differential Equations

Solution of linear differential equation of first and second order with constant coefficients,ordinary point, singular point, series solution around an ordinary point, series solution arounda regular singular point; the method of Frobenius, Wronskian and getting a second solution,Solution of Legendre's differential equation, Solution ofBessel's differential equation, Solution of Laguerre and Hermite'sdifferential equations.

Unit - III

Special Functions

Bessel Functions: Bessel functions of the first kind $J_n(x)$, Generating function, Recurrence relations, Bessel Integrals, Orthonormality of $J_n(x)$;

Legendre PolynomialsP$_n$(x) :Generating function, Recurrence relations and special properties, Rodrigue's formula, Orthonormalityof $P_n(x)$;

HermitePolynomials: Generating function, recurrence relations,orthonormal property, Rodrigue's formula.

LaguerrePolynomials: Generating function, recurrence relations,orthonormalproperty,Rodrigue's formula.

Unit - IV

Functions of a complex variable and calculus of residues

Complex algebra, Functions of a complex variable, Analytic function, Cauchy-Riemann conditions Cauchy's integral theorem, Cauchy's integral formula; Taylor and Laurent expansions; Singularities; Cauchy's residue theorem, Cauchy principle value, Singular points and evaluation of residues, Jordan's Lemma,

Evaluation of definite integrals of the type: $\int_0^{2\pi} f(\sin\theta, \cos\theta)\, d\theta$; $\int_{-\infty}^{\infty} f(x)dx$; $\int_{-\infty}^{\infty} f(x)e^{iax}dx$using Cauchy's residue theorem.

Suggested Readings:

1. Mathematical Methods for Physicists (4th edition) by G. Arfken.
2. Mathematical Methods for Physicists (6th edition) by Arfken and Weber.
3. Mathematical Physics by P.K. Chattopadhyay.
4. Mathematical Physics by B.S.Rajput.
5. Matrices and Tensors for Physicists, by A. W. Joshi.
6. Mathematical Physics by Mathews and Walkers
7. Mathematics for Physicists by Mary L Boas

M.Sc.-PHYSICS
SEMESTER-I

19PHY-102
Classical Mechanics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I
Introduction to Classical Mechanics

Survey of Elementary Principles and Lagrangian Formulation :Newtonian mechanics of one and many particle systems; conservation laws, constraints, their classification; D' Alembert's principle, Lagrange's equations; dissipative forces generalized coordinates and momenta; integrals of motion; symmetries of space and time and their connection with conservation laws; invariance under Galilean transformation

Unit - II
Lagrangian and Hamiltonian formulations

Hamilton's principle, Derivation of Lagrange's equations from Hamilton's principle, Principle of Least Action and its applications.
Legendre transformation and the Hamiltonian equations of motion, the physical significance of the Hamiltonian, Cyclic coordinates, Rauthian procedure and equations, Derivation of Hamiltonian equations from variation principle
Canonical Transformation; Derivation of Generating functions, examples, properties.

Unit - III
Poisson bracket and theory of small oscillations

Poisson bracket, special cases of Poisson bracket, Poisson theorem, Poisson bracket and canonical transformation, Jacobi identity and its derivation, Lagrange bracket and its properties, the relationship between Poisson and Lagrange brackets and its derivation, the angular momenta and Poisson bracket.
Theory of small oscillations: Formulation of the problem, Eigenvalue equation, frequencies of free vibrations and normal coordinates, free vibrations of a linear triatomic coordinates.

Unit - IV
Two-body central force problem and H-J theory

Two body central force problem: Reduction to the equivalent one body problem, the equation of motion and first integrals, classification of orbits, the Virial theorem, the differential equation for the orbit, integrable power law in time in the Kepler's problem, the Laplace-Runge-Lenz vector, scattering in central force field.
Hamilton-Jacobi (HJ) Theory: H-J equation and their solutions, use of H-J method for the solution of harmonic oscillator problem, Hamilton's principle function, Hamilton's characteristic function and their properties.

Suggested Readings:

1. Classical Mechanics (3rd ed., 2002) by H. Goldstein, C. Poole and J. Safko, Pearson Edition
2. Classical Mechanics by John R Taylor.
3. Classical Mechanics by N C Rana and P S Joag
4. Classical Mechanics by H Goldstein
5. Classical Mechanics by A.Sommerfeld
6. Introduction to Dynamics by I perceival and D Richards

M.Sc.-PHYSICS
SEMESTER-I

19PHY-103

Quantum Mechanics-I

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

General formulation of Quantum Mechanics

Recapitulation of basic concepts: Why quantum mechanics? Two-slit experiment with radiation and particles, wave and particle nature of EM radiation, Davisson and Germer experiment, wave function, Schrödinger wave equation, Expectation values, Ehrenfest theorem; Interpretative postulates of quantum mechanics: Dynamical variables as Hermitian operators, Eigenvalues and eigenfunctions, Expansion in eigenfunctions; Orthonormality of eigenfunctions, Closure property, Probability function and expectation value, Co-ordinate and momentum representations of wave function, Commutation rule and the uncertainty relation;

Unit - II

Matrix formulation of Quantum Mechanics

Preliminaries: Hermitian and unitary matrices, Transformation and diagonalization of matrices, Matrices of infinite rank, Representation of dynamical variables and wave functions as matrices, Change of basis, Hilbert space representation; Dirac's ket and bra notations; Time-development of quantum system: Schrödinger, Heisenberg and interaction pictures, Link with classical equations of motion, Quantization of a classical system, Matrix theory of the harmonic oscillator: Spectrum of eigenvalues and eigenfunctions, Matrices for position, momentum and energy operators (energy representation).

Unit - III

Solution of three-dimensional systems

Particle in a cubical box, one dimensional harmonic oscillator, the three dimensional harmonic oscillator in both Cartesian and spherical polar coordinates, eigenvalues, eigenfunctions and the degeneracy of the states; Schrodinger equation for two body system. The hydrogen atom problem:energy eigenvalues, radial eigenfunctions, radial probability distribution and degeneracy.

Unit - IV

Quantum theory of Angular Momentum

Orbital angular momentum operator **L**, Cartesian and spherical polar co-ordinate representation, Commutation relations, Orbital angular momentum and spatial rotations, Eigenvalues and eigenfunctions of $\mathbf{L}^2$ and L_z, Spherical harmonics; General angular momentum **J**: Eigenvalues and eigenfunctions of $\mathbf{J^2}$ and J_z, Matrix representation of angular momentum operators, Spin angular momentum, Wave function including spin (Spinor); Spin one-half: Spin eigenfunctions, Pauli spin matrices; Addition of angular momenta, Clebsch-Gordan coefficients and their calculation for $j_1= j_2 =1/2$, $j_1=1$, $j_2 =1/2$ and $j_1= j_2 =1$.

Suggested Readings:

1. Quantum Mechanics (3rd edition) by L. I. Schiff
2. Quantum Mechanics (2nd edition) by B. H. Bransden and Joachain
3. Quantum Mechanics (3rd edition) by S. Gasiorowicz
4. Quantum Mechanics (3rd edition) by E. Merzbacher
5. Quantum Mechanics by John L. Powell and B. Crasemann
6. Quantum Mechanics by A. K. Ghatak and S. Loknathan
7. Introductory Quantum Mechanics (4th edition) by Richard L. Liboff
8. Quantum Mechanics: Concepts and Applications (2nd edition) by N. Zettili
9. Principles of Quantum Mechanics by Ishwar Singh Tyagi

M.Sc.-PHYSICS
SEMESTER-I

19PHY-104

Electronic Devices And Circuits-1

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Basics of semiconductor devices

Semiconductor : Band gap, types of semiconductor: intrinsic and extrinsic, direct and indirect band gap. Charge densities in p and n type semiconductor, conduction by charge drift and diffusion. **Diodes** : P-N diode, characteristics of P-N diode, Applications (Half and full wave rectifier, Clipper, clamper); Zener diode, difference between avalanche and zener breakdown, characteristics of zener diode, Applications of zener diode. **Bipolar junction transistor (BJT)** : Transistor biasing, configurations : CB, CE, CC. Relation between α and β, early effect in transistors, Load line and Q-point, Stability factor and stabilizing circuits, h-parameter analysis of BJT .

Unit - II

Field Effect Transistor (FET)

Junction field effect transistor (JFET) : Basic circuit and operation of JFET, Types of JFET: n channel JFET & p channel JFET, Characteristics of JFETs, Advantages and disadvantages of JFET. Small signal analysis of FETs. FET biasing, FET as voltage variable resistor(VVR). **Metal oxide semiconductor Field effect transistor (MOS-FET) :** Basic circuit and operation of MOSFET, Types of MOSFETs, Characteristics of MOSFET, comparison between depletion and enhancement MOSFET, Applications of FET.

Unit - III

Feedback in Amplifiers and network theorems

Network theorems : node theorem, mesh theorem, Millman's theorem, thevenin's theorem, Norton's theorem and superposition theorem. **Feedback in amplifiers :** General theory of feedback,Negative feedback circuit : Voltage-series feedback, voltage shunt feedback, current series feedback, current shunt feedback. Advantages of negative feedback. Analysis of different feedback circuits : change in input and output impedances for negative feedback circuits. Emitter follower : circuit analysis (input and output impedances, voltage and current gain), Darlington Emitter follower, Boot strapping.

Unit - IV

Power amplifiers and regulators

Power amplifiers: Introduction, Difference between voltage amplifier and power amplifier, Class A power amplifier, Transformer coupled class A amplifier, harmonic distortion in amplifiers, class A push-pull amplifier. Class B power amplifier, class B push-pull amplifier, Class AB operation. **Electronic voltage regulators:** Basic introduction**,** Zener diode as voltage regulator, Single BJT shunt and series regulators, feedback regulators, current regulator, overload and short circuit protection.

Suggested Readings :

1. Integrated Electronics by J. Millman and C.C Halkias (Tata – McGraw Hill)
2. Electronics devices and circuit theory by Robert L. Boylestad (Pearson)
3. Semiconductor devices – Physics and technology by S. M Sze (Wiley)
4. Fundamentals of electronics by J. D. Ryder (Prentice Hall Publication)
5. Electronics devices and circuits, by David A. Bell (oxford).
6. Network analysis by Van valkenburg
7. Electronic devices and circuits by Y.N bapat

M.Sc.-PHYSICS
SEMESTER-I

19PHY-105

Communication Skills

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Human Communication

Verbal and Non Verbal Communication, Barriers to communication; the seven C"s of effective communication. Preparing for interviews, CV/ Biodata, Group Discussion, Public Speaking, Mass Communication.

Unit –II

Greeting and Introducing

Making Requests, Asking for and Giving Permission, Offering Help, Giving Instructions and Directions, Art of Small Talk, Participating in Conversations, Making a Short Formal Speech, Describing People, Places, Events and Things.

Unit-III

Science Communication

Introduction to scientific search engines, technical writing and science communications. Research publications, patents, copyright, and trademark. Indian contribution in physics

Unit-IV

Personality Development Skills

Personal Grooming; Assertiveness; Improving Self-Esteem; Significance of Critical Thinking; Confidence Building; SWOC analysis.

Emotional intelligence: Recognizing and Managing Emotions and Situations; Stress and Anger Management; Positive Thinking; Developing Sense of Humour.

Suggested Readings:

1. Kumar, Sanjay and PushpLata. English for Effective Communication. OUP, 2016.
2. Mohan, Krishna and Meera Banerji. Developing Communication Skills 2nd ed. Trinity Press,2013
3. Dutt, P. Kirammai and GeethaRajeevan et. At. A Course in Communication Skills. Foundation Books , CUP, 2016.

M.Sc.-PHYSICS
SEMESRTER-I

19PHY-106

IT Fundamentals

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit-I

Basic Concept of Information Technology (IT)

Introduction, Characteristics, Evolution, Generation and Applications of Computers. Basic Computer organization, Input and Output devices, Central Processing Unit, Memory and Storage unit. Types of Software, Free and Open Source Software, Operating System, Types of Operating System, Function of Operating System. Information Technology, Components and Role of Information Technology. IT, Internet and Social Media.

Unit-II

Basic tools (MS Office)

MS Word: Creating, Editing, Saving and Printing of text documents. Formatting, Editing, Inserting Tables, Page Breaks and Mail Merge.

MS Excel: Spreadsheet basics, Creating, Editing, Saving and Printing of Spreadsheet. Working with functions and formulas, Graphical representation of data. Charts and graphs in excel, Error Functions, Interpretation and analysis of data.

MS Power Point: Power Point Basics, Opening, Viewing, Creating, and printing Power Point Presentation. Adding custom animations. Work with Graphics and Media.

Unit-III

MATLAB

Introduction, The MATLAB environment, Fundamentals, Creations, Indexing, Information, Resizing, Reshaping, and Sorting of matrices. Numeric classes, characters and strings. Arithmetic, relational and logical operators in MATLAB.

Unit-IV

Information Science

Introduction to Social Media, Measuring, Monitoring, and Analyzing Social Media Trends and Impact.

History of Internet, Intranet, Web Browsers, Search Engine, Applications of Internet, Qualitative idea of E-Commerce, Internet Payment Systems and Multimedia

Classical and quantum computers (Basic idea)

Suggested Readings:

1. Computer fundamentals – P.K. Sinha, Priti Sinha
2. Fundamentals of computers – E. Balagurusamy
3. Getting started with MATLAB- Rudrapratap

M.Sc.-PHYSICS
SEMESTER-I

19PHY-107

Physics Laboratory I

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note: ***In this course, students will complete at least 5experiments in a semester as per allotment by the teacher in-charge of the Laboratory. There shall be end- semester laboratory examination wherein each student will be required to perform at least one experiment as per paper. The practical examination evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.***

E1 To study Regulated Power Supply.

E2 The comparative study of CE, CB and CC amplifier.

E3 To determine experimentally the drain characteristics of a given MOSFET.

E4 To study of Network Theorems.

E5 To study the characteristics of FET.

E6 To study of characteristics of a PN junction with varying temperature and to find the energy band gap of semiconductor.

E7 To study the output waveforms of push-pull amplifier in different classes of operation.

E8 To study the clipping and clamping circuits.

E9 To study the rectifier and filter circuits.

E10 To study h-parameter of transistor in CE configuration.

Note:

Break up of internal assessment marks (practical paper)	
Internal Viva-voce	Attendance (>75% 5 marks and >85% 10 marks)
10	10

The distribution of percentage marks in practical papers (End-Semester examinations) as follows:		
Experiment	Viva-voce	Lab report
50	20	10

M.Sc.-PHYSICS
SEMESTER-I

19PHY-108

Physics Laboratory II

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note: ***In this course, students will complete at least 5experiments in a semester as per allotment by the teacher in-charge of the Laboratory. There shall be end- semester laboratory examination wherein each student will be required to perform at least one experiment as per paper. The practical examination evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.***

G1 To study B-H curve of a given ferrite sample and find energy loss in case of ferrite Core.

G2 To verify the existence of different harmonics and measure their relative amplitudes using Fourier Analysis kit.

G3 To determine the capacitance of a parallel plate Capacitor using Capacitance andpermittivity kit

G4 To calibrate the prism spectrometer with mercury vapor lamp and hence to find out theCauchy's constant.

G5 To find Flashing and Quenching voltage of Neon gas and determine the capacitance of aunknown capacitor.

G6 To determine the value of e/m i.e. specific charge for an electron by Helical Method.

G7 To find the velocity and compressibility of solid/ liquid sample using UltrasonicInterferometer.

G8 To determine Planck's Constant (h) by measuring the voltage drop across light-emitting diodes (LEDs) of different colors.

G9 To study Cathode ray oscilloscope
(a) Measurement of Frequency
(b) Phase Difference

Note:

Break up of internal assessment marks (practical paper)	
Internal Viva-voce	Attendance(>75% 5 marks and >85% 10 marks)
10	10

The distribution of percentage marks in practical papers (End-Semester examinations) as follows:		
Experiment	Viva-voce	Lab report
50	20	10

M.Sc.-PHYSICS
SEMESTER-II

19PHY-201

Quantum Mechanics-II

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit – I

Approximate methods for bound states-I

Stationary perturbation theory: Non-degenerate case- First-order and second-order corrections to energy eigenvalues and eigenfunctions, Perturbation of an oscillator (harmonic and anharmonic perturbations), Ground state of Helium atom; Degenerate case- Removal of degeneracy in second order, First-order Stark effect in n=2 state of Hydrogen; Rayleigh-Ritz variational method: Ground and excited states, Application to ground state of Helium.

Unit II

Approximate methods for bound states-II

The WKB approximation: General formulism, validity, the connection formulae; First-order Time-dependent perturbation theory, Transition probability for constant and harmonic perturbations, Transition to a group of final states- The Fermi golden rule.
Interaction of an atom with em radiation (semi-classical treatment), Transition probability for induced absorption and emission, electric dipole transition and selection rules; Magnetic dipole transitions;
Forbidden transitions; Higher order transitions;

Unit III

Quantum theory of Scattering-I

Scattering experiments and cross-sections, Laboratory and centre-of-mass systems, Scattering amplitude and cross-section; Method of partial waves: Phase shift, Differential and total cross-sections, Relation between phase shift and scattering potential, Convergence of partial-wave series, Scattering by a finite square well, Scattering by a hard-sphere potential, Born series, First Born approximation, Scattering of an electron by a screened Coulomb potential in Born approximation and validity criterion; Scattering of two identical spinless bosons, and spin-1/2 fermions.

Unit IV

Many-particle systems

Many-particle Schrodinger wave equation; Identical particles: Physical meaning of identity, Principle of indistinguishability and its consequences, Exchange operator, Symmetric and anti-symmetric wave functions, Connection between spin, symmetry and statistics, Fermions and bosons; Spin and total wave function for a system of two spin ½ particles, Pauli exclusion principle and Slater determinant; Application to the electronic system of the helium atom (para- and ortho helium).

Suggested Readings:

1. Quantum Mechanics (3rd edition) by L. I. Schiff
2. Quantum Mechanics (2nd edition) by B. H. Bransden and Joachain
3. Introduction to Quantum Mechanics (2nd edition) by David J. Griffiths
4. Quantum Mechanics by A. K. Ghatak and S. Loknathan
5. A Textbook of Quantum Mechanics by P. M. Mathews and K. Venkatesan
6. Quantum Mechanics by John L. Powell and B. Crasemann
7. Quantum Mechanics: Concepts and Applications (2nd edition) by N. Zettili

M.Sc.-PHYSICS
SEMESTER-II

19PHY-202

Nuclear and Particle Physics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*.

Unit –I

The Deuteron

Two nucleon problem and nuclear forces:The deuteron: binding energy, dipole moment quadrupole moment and the evidence of non-central (Tensor) force, spin dependence of nuclear force. Nucleon-nucleon scattering; s-wave effective range theory, charge independence and charge symmetry of nuclear forces, iso-spin formalism.

Unit II

Nuclear Models

Types of nuclear reactions: compound and direct nuclear reactions, Reaction cross – section, Balance of mass and energy in nuclear reactions, Q equation and its solution; Liquid drop model: Similarities between liquid drop and nucleus, semi-empirical mass formula, Bohr-Wheeler theory of fission, Merits and limitations of Liquid drop model; Shell model: Experiment evidences for shell effect, Magic numbers, Main assumptions of single particle shell model, Spin-orbit coupling in single particle shell model, Estimation of spin, parities and magnetic moments of nuclei by single particle shell model.

Unit - III

Radioactive Decays, Nuclear Forces and Nuclear Reactions

Nuclear Decays: Alpha (α) decay, α- disintegration energy, Range of α-particles, Range – energy relationship for α-particles and Geiger – Nuttall law; Beta decay, Pauli’s neutrino hypothesis, Fermi theory of beta decay, Kurie plot, selection rules for beta decay, Fermi and Gamow-Teller Transitions, Parity non-conservation in beta decay, Detection and properties of neutrino; Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules; Internal conversion, Nuclear isomerism

Unit - IV

Particle Physics

Units in high energy physics; Classification of particles- fermions and bosons, particles and antiparticles; Strange particles, Basic idea of different fundamental types of interactions with suitable examples; Quark flavors and their quantum numbers, Quarks as constituents of Hadrons, Qualitative idea of Quark confinement and asymptotic freedom, necessity of introducing colour quantum number , Unitary groups; classification of elementary particles, charge conjugation, Time reversal. Higg’s boson , dark matter (Basic)

Suggested Readings:

1. Introduction to Experimental Nuclear Physics by R. M. Singru.
2. Nuclear Physics by S.N Ghoshal.
3. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy
4. Introduction to High Energy Physics (2nd edition) by D. H. Perkins.
5. Introductory Nuclear Physics by Kenneth S. Krane (Wiley, New York)
6. Introductory Nuclear Physics by Y.R. Waghmare (Oxford – IBH, Bombay)
7. Nuclear and particles physics by B.R. Martin (JhonWiley and Sons)

M.Sc.-PHYSICS
SEMESTER-II

19PHY-203

Solid State Physics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note***: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.***

Unit - I

Crystal structure

Recapitulation of basic concepts: Bravais lattice and Primitive vectors; Primitive, conventional and Wigner-Seitz unit cells; Determination of crystal structure by diffraction: Reciprocal lattice and Brillouin zones (examples of sc, bcc and fcc lattices), Bragg and Laue formulations of X-ray diffraction by a crystal and their equivalence, Laue equations, Ewald construction, Brillouin interpretation, Crystal and atomic structure factors, Structure factor of the bcc and fcc lattices.

Unit - II

Lattice dynamics and thermal properties

Classical theory of lattice vibration (harmonic approximation): Vibrations of crystals with monatomic basis- Dispersion relation, First Brillouin zone, Group velocity, Two atoms per primitive basis- acoustical and optical modes; Quantization of lattice vibration: Phonons, Phonon momentum, Inelastic scattering of neutrons by phonons; Thermal properties: Lattice (phonon) heat capacity, Einstein Model of heat capacity.

Unit - III

Electronic properties of solids

Free electron gas model in three dimensions: Density of states, Fermi energy, Effect of temperature, Heat capacity of the electron gas, Experimental heat capacity of metals, Thermal effective mass, Electrical conductivity and Ohm's law, Motion in magnetic fields and Hall effect; Failure of the free electron gas model and Band theory of solids: Periodic potential and Bloch's theorem, Kronig-Penney model, Periodic, extended and reduced zone schemes of energy band representation, Number of orbitals in a band, Classification into metals, semiconductors and insulators; Tight binding method and its application to sc and bcc structures.

Unit - IV

Superconductivity

Experimental survey: Superconductivity and its occurrence, Destruction of superconductivity by magnetic fields, Meissner effect, Type I and type II superconductors, Isotope effect; Theoretical survey: Thermodynamics of the superconducting transition, London equation, Coherence length, Microscopic theory: Qualitative features and predictions of the BCS theory, BCS ground state; Flux quantization in a superconducting ring; Dc and Ac Josephson effects; High T_c superconductors (introduction only).

Suggested Readings:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin
3. Applied Solid State Physics by Rajnikant
4. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
5. Principles of the Theory of Solids (2nd edition) by J. M. Ziman

M.Sc.-PHYSICS
SEMESTER-II

19PHY-**204**

Electronic Devices and circuits –II

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Operational Amplifier (Op-Amp)

Differential amplifier : CMRR, emitter coupled supplied with constant current, transfer characteristics of differential amplifier, differential DC amplifier. Op-Amp : op-amp parameter and their measurements, Block diagram, Open loop configurations, characteristics of open loop configuration, Closed loop configurations, virtual ground concept, universal balancing techniques. Positive feedback configurations : Schmitt trigger.

Unit - II

Applications of Op-Amp

Summing and scaling, Integrator, differentiator, Filters(LPF, HPF, BPF, BRF, APF),logarithmic and anti-logarithmic amplifier. Voltage follower, voltage to current and current to voltage converter. Bridge amplifier, AC coupled amplifier. DAC and ADC : parameters of DAC, binary weighted resistor DAC, R-2R ladder DAC, Types of ADC : counter type, successive approximation type, flash type, dual slope integrator type.

Unit - III

Multivibrators and Oscillators

Switching circuit of a transistor, switching time in a transistor, multivibrators, Astable multivibrator, Emitter coupled Astable multivibrator, Monostable multivibrator, Emitter coupled monostable multivibrator, Bistable multivibrator, Schmitt trigger (Emitter coupled Binary) : opration and circuit, hysteresis, applications. **Oscillators** : Introduction, the oscillatory circuit, essentials of transistor circuits, Low frequency oscillators (R-C phase shift, weins bridge oscillator), high frequency oscillators (Heartly oscillator, collpits oscillator).

Unit - IV

Optoelectronic devices

Radiative and nonradiative transistions, basic construction, Basic construction, operation, characteristics and application of solar cell, light dependent resistance(LDR), photodiodes, avalanche photodiode, p-i-n photodiode, metal semiconductor photodiodes, light emitting diodes, semiconductor diode lasers, photo transistor, reistance thermometers, thermocouples and thermisters.

Suggested Readings:-

1. Integrated Electronics by J. Millman and C.C Halkias (Tata – McGraw Hill)
2. Electronics devices and circuit theory by Robert L. Boylestad (Pearson)
3. Semiconductor devices – Physics and technology by S. M Sze (Wiley)
4. Semiconductor Physics and Devices by Donald A Neamen (Tata-McGraw Hill)
5. Fundamentals of electronics by J. D. Ryder (Prentice Hall Publication)
6. Electronics devices and circuits, by David A. Bell (oxford).
7. Network analysis by Van valkenburg
8. Electronic devices and circuits by Y.N bapat

M.Sc.-PHYSICS
SEMESTER-II

19PHY-205

Physics Laboratory III

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note: In this course, students will complete at least 5experiments in a semester as per allotment by the teacher in-charge of the Laboratory. There shall be end- semester laboratory examination wherein each student will be required to perform at least one experiment as per paper. The practical examination evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

G1 To determine the wavelength of He-Ne laser light using an engraved scale as a diffraction grating

G2 To study the count rate per second with change of applied voltage for a GM counter.

G3 Demonstration of energy quantization using the Frank-Hertz Experiment

G4 Lattice dynamic kit

a) Study of the Dispersion relation for the “Monoatomic Lattice” and Comparison with theory.

b) Determination of the Cut-off frequency of the Monoatomic Lattice.

c) Study of the Dispersion relation for the Di-atomic Lattice, Acoustical mode and Energy gap and Comparison with theory .

G5 To determine the Dielectric constant of polar and non-polar liquids .

G6 Determination of Ionization Potential of Lithium

G7 Determination of Half Life of 'In / Li/Hg .

G8 Stefan’s constant by the black Copper radiation plates (Electrical method).

Note:

Break up of internal assessment marks (practical paper)	
Internal Viva-voce	Attendance (>75% 5 marks and >85% 10 marks)
10	10

The distribution of percentage marks in practical papers (End-Semester examinations) as follows:		
Experiment	Viva-voce	Lab report
50	20	10

M.Sc.-PHYSICS
SEMESTER-II

19PHY-206

Physics Laboratory IV

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note: In this course, students will complete at least 5experiments in a semester as per allotment by the teacher in-charge of the Laboratory. There shall be end- semester laboratory examination wherein each student will be required to perform at least one experiment as per paper. The practical examination evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

E1 To study the V-I characteristics of semiconductor diode laser.

E2 To study the characteristics of optoelectronic devices.
E3 Measurement of Hall Coefficient of given semiconductor.

E4 To study the frequency response of low pass, high pass and Band pass filter.

E5 To study of Schmitt trigger using Operational amplifier.

E6 To study the characteristics (illumination, I-V, Power-load) of a solar cell..

E7 Astable, monostable and Bistable multivibrator.

E8 To study the applications of operational amplifier(summing ,integrator differentator).

Note:

Break up of internal assessment marks (practical paper)	
Internal Viva-voce	Attendance (>75% 5 marks and >85% 10 marks)
10	10

The distribution of percentage marks in practical papers (End-Semester examinations) as follows:		
Experiment	Viva-voce	Lab report
50	20	10

M.Sc.-PHYSICS
SEMESTER-III

19PHY-301

Electrodynamics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit – I

Review of Electrostatics and Magnetostatics

Poisson and Laplace equations, Solution of Laplace equation in Rectangular coordinates and spherical coordinates, electrostatic boundary conditions, energy stored in continuous charge distribution, Multipole expansion: potential at large distances, the monopole and dipole terms, Electric field in matter: Bound current, field inside dielectrics, Electric displacement, susceptibility and energy stored in dielectrics.

Magnetic vector potential, Magnetostatic boundary conditions, multipole expansion of the vector potential, field of a magnetized object: Bound current, magnetic field inside matter, Ampere's law in Magnetized material, boundary conditions, magnetic susceptibility and permeability.

Unit II

Electromagnetic Waves and Radiation by Moving Charges

Faraday's Law, induced Electric Field, energy in magnetic fields, Maxwell's equation in free space and matter, charge and energy conservation: Poynting's theorem, Newton's third law in electrodynamics, Maxwell's stress tensor, conservation of momentum. Wave equation, Electromagnetic wave in vacuum, energy and momentum of EM wave, EM wave in matter, Reflection and Refraction of electromagnetic waves at a plane interface between dielectrics, Fresnel relations, Brewster's angle, Wave propagation in conducting media: absorption and dispersion, Wave guides: TE and TM modes in rectangular wave guides.

UNIT-III

Potential, fields and Radiations

Potential formulation: Scaler and vector potential, Gauge transformations, Coulomb and Lorentz Gauge, Retarded potentials, Lienard-Wiechart potentials and fields due to moving point charge, Dipole radiation: Electric dipole radiation and magnetic dipole radiations, Total power radiated by moving charge: Larmor's formula and its relativistic generalization, Radiation reaction.

Unit - IV

Electrodynamics and Relativity

The Special theory of relativity, Lorentz transformation and basic kinematic results of special relativity, structure of space-time, Review of Four vectors and Lorentz transformation in four dimensional space, Mathematical properties of the space-time of special relativity, Electromagnetic field tensor and covariance of Electrodynamics under Lorentz transformation.

Suggested Readings:

1. Introduction to Electrodynamics by D. J. Griffiths.
2. Classical Electrodynamics by J.D. Jackson
3. Electrodynamics by S. P. Puri.
4. Introduction to Electrodynamics by A. Z. Capri and P. V. Panat.
5. Introduction to Plasma Physics by F. F. Chen.
6. Introduction to Plasma Theory by D. R. Nicholson.

M.Sc.-PHYSICS
SEMESTER-III

19PHY-302

Atomic and Molecular Physics-I

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit – I

Atomic Physics

Physical interpretation of quantum numbers, Pauli principle, Terms for equivalent & non-equivalent electron atom, Space Quantization: Stern-Gerlach experiment, Normal & anomalous Zeeman effect, Stark Effect, Paschen–Back effect;, Spectrum of He-atom, spectra of alkali elements, and fine structure in alkali spectra, Intensities of spectral lines: General selection rule; Hyperfine structure of Spectra lines: Isotope effect and effect of Nuclear Spin, width of spectral lines.

Unit - II

Molecular Physics

Diatomic molecules and their rotational spectra: Types of molecules, Diatomic linear symmetric top, asymmetric top and spherical top molecules, Rotational spectra of diatomic molecules as a rigid rotator, Isotope effect in rotational spectra, energy levels and spectra of non-rigid rotor, intensity of rotational lines,

Unit - III

Vibrational Spectra of diatomic molecules

Born Oppenheimer approximation, Vibrational coarse structure of electronic bands, Progression and sequences, Vibrational energyof diatomic molecule , Diatomic molecules as a simple harmonic oscillator , Energy levelsand spectrum , Morse potential energy curve, Molecules as vibrating rotator , vibrationspectrum of diatomic molecules , PQR Branches,

Unit - IV

Electronic Spectra of diatomic molecules and Fluoescence

Intensity of electronic bands-Frank Condon Principle, Dissociation and pre-dissociation, Dissociation energy; Rotational fine structure of electronic bands, The Fortratparabole, Vibrational coarse structure diatomic molecules; Fluorescence :Fluorescence and Phosphorescence and their mechanism.

Suggested Readings:

1. Principles of fluorescence spectroscopy by Joseph R. Lakowicz
2. Atomic spectra & atomic structure, Gerhard Hertzberg: Dover publication, New York.
3. Molecular structure & spectroscopy, G. Aruldhas; Prentice – Hall of India, New Delhi.
4. Fundamentals of molecular spectroscopy, Colin N. Banwell& Elaine M. McCash, Tata McGraw –Hill publishing company limited.
5. Introduction to Atomic spectra by Raj Kumar
6. Spectra of diatomic molecules by Gerhard Herzberg
7. Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987).

M.Sc.-PHYSICS
SEMESTER-III

19PHY-303A

RADIATION PHYSICS

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit- I

Sources of Radiations: X-rays: Characteristic X-rays, Bremsstrahlung radiations, synchrotron radiation, Cherenkov radiation, Cosmic rays: Discovery, Nature of a cosmic rays, soft and hard component, and Geometric effects on cosmic rays; Terrestrial radiations: Radon gas and Radioactive isotopes of lighter elements, Radiation quantities and units: Activity, KERMA, Exposure, Dose, Equivalent Dose, Effective Dose, Annual Limit on Intake (ALI).

Unit- II

Interaction of radiation (basic) ; Active Vs Passive detector, Gas filled radiation detectors: ionization chambers, proportion counters, GM counters, and Spark counter. Scintillation (organic/inorganic) counter; Solid State Detector: Solid State Nuclear Track Detector (SSNTD), Semiconductor Detectors (Junction type detector), Thermo – Luminescent Dosimeters (TLD), Chemical detectors (Photographic Emulsions Films).

Unit-III

Biological Effects of Ionizing Radiation: Introduction, Cell Biology: Structure and function of living cell, cell division-mitosis, meiosis and differentiation, central dogma of molecular biology, genetic codes-DNA, RNA and Proteins; Effect of Radiation on Cell: inhibition of cell division, chromosome aberrations, genes mutation, and cell death; Biological effects of Radiation on Human: Somatic Effects (Early effect) and Stochastic effect (Late effect)

Unit-IV

Principles of Radiological Protection: Justification of Practice, Optimization of Practice, and Dose Limitations; Internal Exposure, Dose Limit for (i) Radiation Workers (ii) Public, Occupational Exposure of Women, Apprentices and Students; Production of Radioisotopes and Labeled Compounds: Introduction, Separation of Isotopes, Production of labeled compounds, Specific Activity of labeled compounds, Storage, Quality, and Purity of Radio-labeled compounds.

Suggested Readings:

1. Radiation Detection and Measurement by Glenn F. Knoll (John Wiley & Sons, Inc).
2. Concepts of Modern Physics by Arthur Beiser, S Mahajan, and S Rai Choudhury (Mc Graw Hill Education).
3. Radiation Oncology Physics: a handbook for teachers and students; International Atomic Energy Agency Vienna, 2005.
4. Practical knowledge for Handling Radioactive Sources by Dr. Claus Grupen.
5. Introduction to Radiological Physics and Radiation Dosimetry by Frank Herbert Attlx
6. Radiation Biology: a handbook for teachers and students; International Atomic Energy Agency Vienna, 2010.
7. Student Solutions Manual to accompany Radiation Detection and Measurement by Glenn F. Knoll (John Wiley & Sons, Inc).
8. Nuclear and Particle Physics by S. L. Kakani and ShubhraKakani (Viva books).

M.Sc.-PHYSICS
SEMESTER-III

19PHY-303B

Material Science-I

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Imperfections in Solids

Point Defects: vacancy, substitutional, interstitial, Frenkel and Schottky defects, equilibrium concentration of Frenkel and Schottky defects**;** Line Defects: slip planes and slip directions, edge and screw dislocations, Burger's vector, cross-slip, glide and climb, jogs, dislocation energy, super & partial dislocations, dislocation multiplication, Frank Read sources; Planar Defects: grain boundaries and twin interfaces; Dislocation Theory – experimental observation of dislocation, dislocations in FCC, HCP and BCC lattice.

Unit - II

Mechanical Properties

Stress Strain Curve; Elastic Deformation: atomic mechanism of elastic deformation and anisotropy of Young's modulus, elastic deformation of an isotropic material; Anelastic and Viscous deformation; Plastic Deformation: Schmid's law, critically resolved shear stress; Strengthening Mechanisms: work hardening, recovery, recrystallization, strengthening from grain boundaries, low angle grain boundaries. yield point. strain aging, solid solution strengthening, two phase aggregates, strengthening from fine particles; Fracture: ideal fracture stress, brittle fracture-Griffith's theory, ductile fracture.

Unit - III

Microstructure

Solid Solutions and Intermediate Phases: phase rule, unitary & binary phase diagrams, Lever rule, Hume-Rothery rule; Free Energy and Equilibrium Phase Diagrams: complete solid miscibility, partial solid miscibility-eutectic, peritectic and eutectoid reactions, eutectaid mixture; Nucleation, Growth and Overall Transformation Kinetics; Martenstic Transformation; The Iron-Carbon System: various phases, phase diagram, phase transformations, microstructure and property changes in iron-carbon system; Ceramics: glass transition temperature, glassformers, commercial ceramics, mechanical properties. high temperature properties.

Unit - IV

Materials Processing and Characterization

Ion Implantation: introduction, ion implantation process, depth profile, radiation damage and annealing effects of trace-impurities, implantation induced alloying and structural phase transformation; Rutherford Backscattering Spectrometry (RBS): principle, kinematics of elastic collision, shape of the backscattering spectrum, depth profiles and concentration analysis, applications; Elastic Recoil Detection Analysis (ERDA): basic principle, kinematics, concentration analysis, depth profiling, depth resolution, applications; Secondary Ion Mass Spectroscopy (SIMS): basic principle, working, yield of secondary ions and applications.

Suggested Readings:

1. Material Science by J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rawlings
2. Mechanical Metallurgy by G. E. Dieter
3. Ion Implantation by G. Dearnally
4. Fundamentals of Surface and Thin Film Analysis by L. C. Feldman and J. W. Mayer
5. Surface Analysis Methods in Material Science by D. J. O'Connor, B. A. Sexton and R. St. C. Smart (Eds), Springer Series in Surface Sciences 23

M.Sc.-PHYSICS
SEMESTER-III

19PHY-303C

Physics of Nano-materials

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit-I

Review of Density of States

Free electron theory (qualitative idea) and its features, Idea of band structure, Metals, insulators and semiconductors, Concept of effective Mass, Density of States in Bands, Variation of Density of States with Energy, Variation of Density of States and Band Gap with Size of Crystal, Electronic Structure From Bulk to Quantum Dot, Electronic States in Direct and Indirect Semiconductor Nano-crystals, Excitions in Direct and Indirect Band Gap Semiconductors,

Unit - II

Reduced Dimensional systems

Quantum Confinement, Electron confinement in One, Two and Three Dimensional Infinitely Deep Square Well Potentials, Density of States and Optical Absorption in Quantum Well, Quantum wires: Electron Wave Function and Energy, Density of States, Quantum Dots: Electron Wave Function and Energy, Density of States, Idea of Hetero-junction LED, Quantum Well Laser and Quantum Dot Laser, Coulomb Blockade and Single Electron Transistor.

Unit - III

Synthesis/Fabrication of Nanomaterials/Nanostructures

Bottom up and Top down Approaches for Synthesis of Nano Materials, Synthesis of Zero-Dimensional Nanostructures (Nanoparticles): Sol-Gel Process, Synthesis inside Micelles or Using Micro-Emulsions and Growth Termination, Epitaxial Core-Shell Nanoparticles, Ball Milling, One-Dimensional Nanostructures (Nanowires, Nanorods Nanotubes): Vapor (or solution)-liquid-solid (VLS or SLS) growth and Size Control, Electrochemical deposition, Lithography, Two-Dimensional Nanostructures (Thin Films & Quantum Wells): Molecular Beam Epitaxy (MBE), MOCVD, Cluster Beam Evaporation, Ion Beam Deposition, Chemical Bath Deposition Technique

Unit - IV

Characterization of Nanomaterials/Nanostructures

Effect of Particle Size and Strain on Width of XRD Peaks of Nanomaterials, Determination of Crystallite/Particle Size and Strain in Nanomaterials Using Debye Scherrer's Formula and Williamson–Hall's Plot, Transmission Electron Microscopy: Basic principle, Brief Idea of Set up, Sample Preparation, Imaging Modes (Dark & Bright Field), Selected Area Electron Diffraction, Photoluminescence (PL) Spectroscopy: Basic Principle and idea of Instrumentation, Shift in PL Peaks with Particle Size, Determination of Alloy Composition in Thin Films of Compound Semiconductors, Estimation For Width of Quantum Wells, Raman Spectroscopy: Basic Principle and idea of Instrumentation.

Suggested Readings:

1.The Physics of Low Dimensional Semiconductors John H. Davies Cambridge Uni.Press.
2.Nanotechnology- An Introduction J.J. Ramsden William Andrew Elsevier
3. Nano-optoelectronics Sensors & Devices Ning Xi & King w. Chiu Lai –W.A.Elsevier
4. Quantum Heterostructures- Microelectronics & Optoelectronics V.V. Mitin, V.A. Kochetp & M.A. Stroscio Cambridge University Press
5. Nanostructures & Nanomaterials Synthesis, Properties & Applications G. Cao Imperial College Press
6. Introduction to Nanotechnology C.P.Poole Jr. & F.J. Owens - John Wiley & Sons
7. Nanotechnology M. Wilson, K. Kannangara, G. Smith, M. Simmons & B. Raguse

M.Sc.-PHYSICS
SEMESTER-III

19PHY-304A

Condensed Matter Physics-I

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Semiconductor crystals and Fermi surfaces & metals

Semiconductor crystals: Band gap, Direct and indirect absorption processes, Motion of electrons in an energy band, Holes, Effective mass, Physical interpretation of effective mass, Effective masses in semiconductors, Intrinsic carrier concentration; Intrinsic mobility; Fermi surfaces and metals: Fermi surface and its construction for square lattice (free electrons and nearly free electrons), Electron orbits, Hole orbits, Open orbits; Wigner-Seitz method for energy bands, Cohesive energy; De Hass-van Alphen effect.

Unit - II

Optical properties of solids

Dielectric function of the free electron gas, Plasma optics, Dispersion relation for em waves, Transverse optical modes in a plasma, Transparency of alkalis in the ultraviolet, Longitudinal plasma oscillations, Plasmons and their measurement; Electrostatic screening, Screened Coulomb potential, Mott metal-insulator transition, Screening and phonons in metals; Optical reflectance, Kramers-Kronig relations, Electronic inter-band transitions, Excitons: Frenkel and Mott-Wannierexcitons; Raman effect in crystals.

Unit - III

Dielectrics and Ferroelectrics

Polarization, Macroscopic electric field, Dielectric susceptibility, Local electric field at an atom, Dielectric constant and polarizability, Clausius-Mossotti relation, Electronic polarizability, Classical theory of electronic polarizability; Structural phase transitions; Ferroelectric crystals and their classification; Landau theory of the phase transition; Anti-ferroelectricity, Ferroelectric domains; Piezoelectricity, Ferroelasticity.

Unit - IV

Magnetism

Diamagnetism and paramagnetism: Magnetic susceptibility, Langevin diamagnetism equation, Quantum theory of diamagnetism; Quantum theory of paramagnetism-Curie law, Hund's rules, Paramagnetic susceptibility of conduction electrons; Ferromagnetism and anti-ferromagnetism: Ferromagnetic order, Mean field theory- Curie-Weiss law; Electrostatic origin of magnetic interactions, Magnetic properties of a two-electron system, Singlet-triplet (exchange) splitting in Heitler-London approximation; Spin Hamiltonian and the Heisenberg model; Spin waves-magnons, Bloch $T^{3/2}$ law; Neutron magnetic scattering (principle); Ferromagnetic domains: Magnetization curve, Bloch wall, Origin of domains; Antiferromagnetic order and magnons.

Suggested Readings:

1. Introduction to Solid State Physics (7th edition) by Charles Kittel
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin
3. Applied Solid State Physics by Rajnikant
4. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
5. Principles of the Theory of Solids (2nd edition) by J. M. Ziman

M.Sc.-PHYSICS
SEMESTER-III

19PHY-304B

Nuclear Physics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Particle Identification

Basic principle of ΔE-E detector telescopes, short range charged particles ΔE-E telescope, methods of particle identification using semiconductor and gaseous detectors, ΔE-E time of flight spectroscopy; Event by event particle identification system for heavy ion induced reaction analysis; neutron-gamma discrimination; Modem Gas Detectors: basic principle and operation of split anode ionization chamber, position sensitive ionization chamber, position sensitive proportional counter & multi wire proportional counter.

Unit - II

Nuclear Electronics

Types of preamplifiers: basic idea of voltage sensitive and current sensitive pre-amplifiers, details of charge sensitive preamplifier and its applications; Amplifier Pulse Shaping Circuits: RC, Gaussian, delay-line, bipolar and zero cross-over timing circuits, pole zero cancellation and base line restorer; Coincidence Techniques: basic idea of coincidence circuit and its resolving time, basic principle of slow coincidence, slow fast coincidence and sum coincidence techniques; Single Channel Analyzer; Multi-Channel Analyzer; CAMAC Based Data Acquisition System.

Unit - III

Ion AcceleratorsandIon Beam Interaction in Solids

Ion Accelerators: Ion sources- basic features of RF ion source, direct extraction negative ions source (Duoplasmatron) and source of negative ions by Cs sputtering (SNICS); Basic principle and working of Tandom accelerator and Pelletron accelerator and its applications; Ion Beam Interaction in Soilds:Basic ion bombardment processes in solids- general phenomenon, ion penetration and stopping, ion range parameters, channelling, components of an ion implanter, energy deposition during radiation damage, sputtering process and ion beam mixing.

Unit - IV

Nuclear Reactors

Nuclear stability, fission, prompt and delayed neutrons, fissile and fertile materials- characteristics and production, classification of neutrons on the basis of their energy, four factor formula, control of reactors, reactors using natural uranium, principle of breeder reactors, fast breeder reactor & doubling time, calculation of critical size and mass of reactor; Basic principle of neutron detection; Basic concept of fusion reactors.

Suggested Readings:

1. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy
2. Introduction to Experimental Nuclear Physics by R. M. Singru
3. Techniques for Nuclear and Particle Physics Experiments by W. R. Leo
4. Radiation Detection and Measurement by G. F. Knoll
5. The Physics of Nuclear Reactions by W. M. Gibson
6. VLSI Technology by S. M. Sze

M.Sc.-PHYSICS
SEMESTER-III

19PHY-304C

Electronics-I

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit -I

Introduction and Number system: Digital signals, properties of digital signal : switching time, time period and frequency, duty cycle, difference between analog signal and digital signals. Number system : types of number system (binary, octal, decimal, hexadecimal), conversion between different number systems. Binary arithmetics, signed magnitude numbers, complement of a number system, complement arithmetic, Binary coded decimal (BCD), weighted and weighted codes, Binary to gray and gray to binary conversion.

Unit - II

Logic gates and Boolean algebra: Logic system (DC logic system, pulse logic system) Logic gates : Basic logic gates (AND, OR, NOT), Universal logic gates(NAND, NOR), Arithmetic gates (Ex-OR, Ex-NOR), AND-OR-Invert, OR-AND-Invert, Design logic gates using logic families (RTL, DTL, TTL, MOS, ECL). Boolean Algebra : Boolean laws and theorems, sum of product (SOP) and product of sum (POS) expressions, minterm, maxterm, canonical SOP and POS form expressions, Implementation of SOP/POS by using minimum number of two input NAND/NOR gates only, Logical venn Diagram.

Unit -III

Combinational circuits : Karnaugh map, Half adder, full adder, Half-subtractor, Full subtractor, multiplexer, De-multiplexer, Encoder, Decoder, Comparator, Parity checker and generator.

Unit - IV

Sequential circuits : Flip-Flops (FF) : RS latch, clocked RS flip-flop, J-K flip-flop, race around condition in J-K flip-flop, T-FF, D-FF, Characteristics equations for flip-flops, state transition diagrams for flip-flops. Master slave flip-flop. Registers: Shift registers and its applications. Counters: Parameters (mode, time period, frequency, duty cycle), types of counter: asynchronous, synchronous, reduction of states of a counter by using preset/clear.

Suggested Readings:

1. Digital Principles and Application by Leach malvino (Tata Mcgraw Hill)
2. Digital logic Design – Brain Holdsworth
3. Digital logic by J.M. Yarbrough (Thomson Publication)
4. Digital electronics by Morris Mano
5. Digital electronics by William Gothmann (Prentice publication)
6. Integrated Electronics by J. Millman and C.C Halkias (Tata – McGraw Hill)

M.Sc.-PHYSICS
SEMESTER-III

19PHY-305

Physics Laboratory V

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 4 hrs.

Note: In this course, students will complete at least 5experiments in a semester as per allotment by the teacher in-charge of the Laboratory. There shall be end- semester laboratory examination wherein each student will be required to perform at least one experiment as per paper. The practical examination evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

E1 To determine the Lande's g factor of DPPH using ESR spectrometer

E2 To determine magneto resistance of a Bismuth crystal as a function of magnetic field.

E3 To determine the heat capacity of solids

E4 To determine the Magnetic susceptibility by Guo's method .

E5 Measurement of Hall Coefficient of a given semiconductor: Identification of type of semiconductor and estimation of charge carrier.

E6 To verify Faraday Law using He-Ne Laser

E7 To determine the dielectric constant of different solid samples.

E8 Determination of e/m by normal Zeeman effect using Febry Perot Etalon

Note:

Break up of internal assessment marks (practical paper)	
Internal Viva-voce	Attendance (>75% 5 marks and >85% 10 marks)
10	10

The distribution of percentage marks in practical papers (End-Semester examinations) as follows:		
Experiment	Viva-voce	Lab report
50	20	10

M.Sc.-PHYSICS
SEMESTER-III

19PHY-306

Physics Laboratory VI

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 4 hrs.

Note: In this course, students will complete at least 5experiments in a semester as per allotment by the teacher in-charge of the Laboratory. There shall be end- semester laboratory examination wherein each student will be required to perform at least one experiment as per paper. The practical examination evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

E1 Design and construct logic gates(NOT, AND, OR, NAND, NOR, EX-OR, EX-NOR) and verify their truth tables.

E2 Realization of logic gates using only NAND/NOR gates.

E3 Construct half and full adder and verify their truth tables.

E4 Construct half and full subtractor and verify their truth tables.

E5 To study digital to analog & analog to digital conversion circuits.

E6 Semiconductor laser :determination of wavelength of LASER using Grating.

E7 Optical fibre communication :

(a) Study of losses in optical fibre.

(b) Measurement of propagation loss.

(c) Measurement of numerical aperture.

(d) Measurement of bending loss.

E8 To study the different types of Flip-Flops .

Note:

Break up of internal assessment marks (practical paper)	
Internal Viva-voce	Attendance (>75% 5 marks and >85% 10 marks)
10	10

The distribution of percentage marks in practical papers (End-Semester examinations) as follows:		
Experiment	Viva-voce	Lab report
50	20	10

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-401

Statistical Mechanics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Foundations of Statistical Mechanics: The macroscopic and microscopic states, Postulate of equal a priori probability, Contact between statistics and thermodynamics, Entropy of mixing and the Gibbs paradox, Sackur-Tetrode equation; Ensemble theory: Concept of ensemble, Phase space, Density function, Ensemble average, Liouville's theorem, Stationary ensemble; The micro canonical ensemble, Application to the classical ideal gas; The canonical ensemble, Canonical partition function, Thermodynamics of a system of non-interacting classical harmonic oscillators and magnetic system using canonical ensemble, Calculation of statistical quantities

Unit - II

The Grand canonical ensemble and grand canonical partition function, Calculation of statistical quantities, Thermodynamics of a system of classical ideal gas using grand canonical ensemble, Energy and density fluctuations; Quantum-mechanical ensemble theory: Density matrix, Equation of motion for density matrix, Quantum-mechanical ensemble average; Statistics of indistinguishable particles, Two types of quantum statistics-Fermi-Dirac and Bose-Einstein statistics, Fermi-Dirac and Bose-Einstein distribution functions using microcanonical and grand canonical ensembles (ideal gas only), Statistics of occupation numbers; Ideal Bose gas: Internal energy, Equation of state, Bose-Einstein Condensation and its critical conditions; Bose-Einstein condensation in ultra-cold atomic gases: its detection and thermodynamic properties; Black body radiations, liquid Helium.

Unit - III

Ideal Fermi gas: Internal energy, Equation of state, Completely degenerate Fermi gas, electron gas in metals, thermionic emission; Cluster expansion method for a classical gas, Simple cluster integrals, Mayer-Ursell relations, Virial expansion of the equation of state, Van der Waal's equation, Validity of cluster expansion method;

Unit - IV

Phase transitions: Construction of Ising model, Solution of Ising model in the Bragg-William approximation; Critical exponents, Landau theory of phase transition, Scaling hypothesis; One and two-dimensional Ising model; Thermodynamic fluctuations and their probability distribution law, Spatial correlations in a fluid, Connection between density fluctuations and spatial correlations; Brownian motion.

Suggested Readings:

1. Statistical Mechanics by R. K. Pathria (2nd edition)
2. Statistical Mechanics by R. K. Pathria and P. D. Beale (3rd edition)
3. Statistical and Thermal Physics by F. Reif
4. Statistical Mechanics by K. Huang
5. Statistical Mechanics by L. D. Landau and I. M. Lifshitz
6. Statistical Mechanics by R. Kubo

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-402

Atomic and Molecular Physics-II

2Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Atomic Physics

The origin of X-Rays, X-Ray emission spectra, Dependence of position of Emission lines onthe atomic number, X-Ray emission (Doublet) spectra, Satellites, Continuous X-ray Emission,X-Ray Absorption spectra.

Unit - II

Molecular Physics

Raman Effect - quantum theory - molecular polarizability pure rotational Raman spectra of diatomic molecules - vibration rotation Raman Spectrum of diatomic molecules, Intensity alternation in Raman spectra of diatomic molecules, application of Raman spectroscopy in the structure determination of simple molecules.

Unit - III

NMR Spectroscopy

NMR: Basic principles – Classical and quantum mechanical description – Bloch equations – Spin-spin and spin-lattice relaxation times – Chemical shift and spin-spin coupling, Applications of NMR spectroscopy. Mossbauer spectrometer, Isomer nuclear transition, resonance fluorescence, Mossbauer Effect, Mossbauer nuclei, Isomer shift, quadruple splitting, magnetic hyperfine structure, application of Mossbauer spectroscopy.

Unit - IV

ESR Spectroscopy

ESR spectrometer, substances which can be studied by ESR, Resonance condition, Description of ESR by Precession, Relaxation mechanisms, Features of ESR spectra (a) the g factor (b) Fine structure (c) hyperfine structure (d) ligand hyperfine structure. Applications of ESR

Suggested Readings:

1 Principles of fluorescence spectroscopy by Joseph R. Lakowicz
2 Atomic spectra & atomic structure, Gerhard Hertzberg: Dover publication, New York.
3 Molecular structure & spectroscopy, G. Aruldhas; Prentice – Hall of India, New Delhi.
4 Fundamentals of molecular spectroscopy, Colin N. Banwell& Elaine M. McCash, Tata McGraw –Hill publishing company limited.
5 Introduction to Atomic spectra by H.E. White
6 Spectra of diatomic molecules by Gerhard Herzberg
7 Concepts of Modern Physics by Arthur Beiser (McGraw-Hill Book Company, 1987).

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-403A

Computational Physics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Errors, Differentiation and Integration and

Errors: Round off errors, truncation error, machine error, random error.

Differentiation: Numerical differentiation using Newton's forward difference formula, Backward difference formula

Integration: Trapezoidal rule, Simpson's rule,

Interpolation and extrapolation: Finite difference, forward difference, backward difference, central differences, Lagrange method.

Curve Fitting: Least-square curve fitting, straight line and polynomial fits.

Unit - II

Solution of Differential Equations (12 hrs.)

Numerical solution of ordinary differential equations: Taylor's series method, Euler's method, modified Euler's method, Forth-order Runge Kutta method,

Second order differential equations: Initial and boundary value problems, Initial and boundary value problem, Numerical solution of radial Schrodinger for hydrogen atom using Fourth order RungaKutta method (when eigenvalue is given).

Unit - III

Solution of algebraic equations and Simulation of selected physics problems

Solution of Simultaneous Linear Equations: Gaussian Elimination method, Gauss Jordan elimination method, Matrix inversion. Eigen values and Eigen vectors: Jacobi's method for symmetric matrix

Simulation: Simulation of charging and discharging of a capacitor, current in LR and LCR circuits, Computer models of LR and LCR circuits driven by sine and square functions,

Unit - IV

Computer Fundamentals And Programming With Fortran-77

Basic Computer organization: Input and output units, Storage unit, Arithmetic Logic unit, Control unit, Central processing unit.

Fortran Programming: Data types, Arithmetic & logical expression, Input-output statements, control statements, Do loop, Arrays and subscripted variables, functions and subroutines.

Reference Books:

1. R C Desai, Fortran Programming and Numerical methods, Tata McGraw Hill, New Delhi.
2. Suresh Chandra, Computer Applications in Physics, Narosa Publishing House.
3. Fortran 77 and Numerical methods, C. Xavier
4. M L De Jong, Introduction to Computation Physics, Addison-Wesley publishing company.
5. R C Verma, P K Ahluwalia and K C Sharma, Computational Physics an Introduction, New Age International Publisher.
6. S S Sastry Introductory methods of numerical Analysis, Prentice Hall of India Pvt. Ltd.
7. V Rajaraman, Computer Oriented Numerical Method, Prentice Hall of India Pvt. Ltd.
8. C Balachandra Rao and C K Santha, Numerical Methods, University Press

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-403B

Material Science-II

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Material Testing

The Tension Test: engineering stress-strain curve, true stress-strain curve, instability in tension, Considere's construction, ductility measurement, effect of strain rate on flow properties, strain rate sensitivity; notch tensile test; The Hardness Test: Brinell hardness, Meyer hardness, Vicker's hardness number and test, Rockwell hardness test, Knoop hardness number and test; The Impact Test: brittle fracture problem, notched bar impact tests-Carpy and Izod Impact tests; The Fatigue Test: fatigue failures, stress cycles, the S-N curve, fatigue limit; The Creep Test: creep curve, primary, secondary and tertiary creep, effect of temperature and stress on the creep curve.

Unit - II

Magnetic Materials

Magnetic Processes: Larmor frequency; Diamagnetism, magnetic susceptibility, Langevin's diamagnetism equation; Paramagnetism, Curie constant, density of states curves for a metal; Ferromagnetism, Curie temperature, Curie-Weiss law, exchange interactions, domain structure; Antiferromagnetism and magnetic susceptibility of an antiferromagnetic material; Ferrimagnetism and Ferrites; Paramagnetic, ferromagnetic and cyclotron-resonance.

Unit - III

Dielectice, Optical and Ferroelectric Materials

Introduction, Energy bands, dielectric constant, complex permittivity, dielectric loss factor, polarization, mechanism of polarization, classification of dielectrics-frequancy dependence of dielectric constant; Optical absorption, transmission and reflection, refractive index, color; Ferro, para and pyro-electric states, transition temperature, classification of ferro electric crystals, polarization catastrophe, Landau theory of first and second-order phase transitions, antiferroelectricity, ferro electric domains.

Unit - IV

Solid Surfaces and Analysis

Surface and its importance, selvedge depths of surface; Methods of Surface Analysis: Auger Electron spectroscopy (AES)- basic principle, methodology, composition analysis and depth profiling; X-ray photoelectron spectroscopy (XPS) or ESCA: principle, methodology and quantitative analysis; Glancing angle X-ray Diffraction (GXRD), basic concept, methodology and structural analysis; Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM): Principle, methodology and Applications in surface analysis; Atomic Force Microscopy (AFM): Basic principle, Methodology, applications in structural analysis.

Suggested Readings:

1. Material Science, J.C. Anderson, K.D. Leaver, J. M. Alexander and R. D. Rawlings
2. Mechanical Metallurgy, G.E. Dieter.
3. Electronic Processes in Materials, L. V. Azaroff and J. J. Brophy
4. Fundamentals of Surface and Thin Film Analysis, L.C. Feldman and J. W. Mayer
5. Surface Analysis Methods in Material Science, D. J. O'Connor, B. A. Sexton and R. St. C. Smart (Eds),Springer Series in Surface Sciences 23

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-403C

Experimental Techniques in Physics

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit-I

Experimental Techniques to observe the defects in Lattice: Electron Microscopy: Transmission Electron Microscope (TEM) and X-ray Diffraction Technique,Experimental methods of observing dislocations and stacking faults. Electron microscopy: Kinematical theory of diffraction contrast and lattice imaging,OpticalTechniques: Photo Luminescence, FTIR and Raman Spectroscopic techniques.

Unit-II

Surface Analytical Techniques: Electron Spectroscopies-Auger, XPS (ESCA), UV-photo emission, X-rayabsorption techniques: EXAFS, NEAFS, Secondary Ion Mass Spectroscopy (SIMS), Rutherford BackScattering (RBS) and low Energy electron diffraction techniques

Unit-III

Opto-Electronic Devices: Solar Cells, Photo Diodes, Photo-detectors, LEDs; Data Interpretation andAnalysis. Precision and Accuracy, Error Analysis, Propagation of Errors, Least Squares fitting. Linearand Non-linear curve fitting, Chi-square test, Modulation Techniques: Amplitude Modulation, FrequencyModulation

UNIT-IV

Spectroscopic and Scanning Probe Techniques: Detailed study of spectroscopic techniques: ESR(electron spin resonance) and NMR; Scanning Probe Techniques: STM (Scanning TunnelingMicroscopy), AFM (Atomic Force Microscopy), STS (Scanning Tunneling Spectroscopy)

Suggested Readings:

1. Crystal Growth and Characterization by R. Ueda and J.B. Mullin
2. Experimental Techniques of Surface Science by Woodruff and Delchar
3. Solid State Physics by Ibach and Luth
4. Solid Surfaces by Ibach
5. Solid Surfaces by Prutton
6. Physics at Surfaces by Zangwill
7. Solid State Physics by Puri&Babbar
8. X-ray Crystallography by Azaroff

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-404A

Condensed Matter Physics-II

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

Electron Transport Phenomenon

Motion of electrons in bands and the effective mass tensor (semi-classical treatment), Currents in bands and holes, Scattering of electrons in bands (elastic, inelastic and electron-electron scatterings), The Boltzmann equation, Relaxation time *ansatz* and linearized Boltzmann equation;Electrical conductivity of metals, Temperature dependence of resistivity and Matthiesen's rule; Thermoelectric effects, Thermopower, Seebeck effect, Peltier effect, The Wiedemann-Franz law.

Unit - II

Nanostructures and Electron Transport

Nanostructures; Imaging techniques (principle): Electron microscopy (TEM, SEM), Optical microscopy, Scanning tunneling microscopy, Atomic force microscopy; Electronic structure of 1D systems: 1D sub-bands, Van Hove singularities; 1D metals- Coulomb interactions and lattice couplings; Electrical transport in 1D: Conductance quantization and the Landauer formula, Two barriers in series- Resonant tunneling, Incoherent addition and Ohm's law, Coherence-Localization; Electronic structure of 0 D systems (Quantum dots): Quantized energy levels, Semiconductor and metallic dots, Optical spectra, Discrete charge states and charging energy; Electrical transport in 0 D - Coulomb blockade phenomenon.

Unit - III

Beyond the independent electron approximation

The basic Hamiltonian in a solid: Electronic and ionic parts, Born-Oppenheimer Approximation; The Hartree equations, Connection with variational principle; Exchange: The Hartree-Fock approximation, Hartree-Fock theory of free electrons- One electron energy, Band width, DOS, Effective mass, Ground state energy, exchange energy, correlation energy (only concept); Screening in a free electron gas: The Dielectric function, Thomas-Fermi theory of screening, Calculation of Lindhard response function, Lindhard theory of screening, Friedel oscillations, Frequency dependent Lindhard screening (no derivation).

Unit - IV

Many-particle physics: Second quantization formulation

Many-particle Schrodinger wave equation in first quantization, Expansion of wave function in basis of single-particle states, Symmetry of expansion coefficient, Normalized symmetric and anti-symmetric wave functions; Second quantization: Transformation of Schrodinger equation to occupation number representation (both for bosons and fermions), Many-particle Hilbert space and creation and destruction operators; Field operators, Second-quantized from of number-density operator; Application to degenerate electron gas: First and second-quantized Hamiltonian operators, $r_s$parameter, Ground-state energy in first-order perturbation theory, Contact with the Hartree-Fock result, Exchange energy.

Suggested Readings:

1. Solid State Physics: An Introduction to Principles of Materials Science (4^{th} Ed.) by H. Ibach and H. Luth
2. Introduction to Solid State Physics (8^{th} Ed.) by Charles Kittel
3. Solid State Physics by Neil W. Ashcroft and N. David Mermin
4. Electronic Structure of Materials by Rajendra Prasad
5. The Wave Mechanics of Electrons in Metals by Stanley Raimes
6. Quantum Theory of Many-particle Systems by A. L. Fetter and J. D. Walecka
7. Many-body Quantum Theory in Condensed Matter Physics by H. Bruus and K. Flensberg

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-404B

Nuclear Physics-II

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - I

The Two Nucleon Problem

Qualitative features and phenomenological potentials, Exchange forces, generalized Pauli principle. The ground state of deuteron, Range-depth relationship for square well potential. Neutron-Proton scattering at low energies (below 10 Mev), Concept of scattering length and its interpretation, Spin dependence of neutron-proton scattering, Effective range theory of n-p scattering, Coherent scattering of neutrons on ortho and para hydrogen, Magnetic moment and its importance in the determination of exact ground state of deuteron.

Unit - II

Nuclear Reaction Theory

Nuclear reactions and cross sections, Resonance : Breit-Wigner dispersion formula for $\ell = 0$, Breit-Wigner dispersion formula for all values of ℓ, The compound nucleus, Continuum theory of cross section σ_C, Statistical theory of nuclear reactions, Evaporation probability and cross sections for specific reactions, Kinematics of the stripping and pick-up reactions, Theory of stripping and pick-up reactions.

Unit - III

Nuclear Models-I

Liquid drop model, Outlines of Bohr and Wheeler theory of nuclear fission, Concept of magic numbers, The properties of magic nucleus, Nuclear Shell Model, Predictions of shell closure on the basis of harmonic oscillator potential, Need of introducing spin-orbit coupling to reproduce magic numbers. Extreme single particle model and its predictions regarding ground state spin parity, magnetic moment and electric quadrupole moments.

Unit - IV

Nuclear Models-II

Nuclear surface deformations, General parameterization, Types of multipole deformations, Quadrupole deformations, Symmetries in collective space, Surface vibrations, Vibrations of a classical liquid drop, The Harmonic quadrupole oscillator, The collective angular momentum operator, The collective quadrupole operator, Quadrupole vibrational spectrum, Rotating nuclei, The rigid rotor, The symmetric rotor, The asymmetric rotor.

Suggested Readings:

1. R. R. Roy and B. P. Nigam, “Nuclear Physics: Theory and Experiment”, Wiley Eastern Limited, 1993.
2. M. K. Pal, “Theory of Nuclear Structure”, Affiliated East-West Press, New Delhi.
3. Greiner and Maruhn, “Nuclear Models”, Springer, 1996
4. W. E. Burcham, “Nuclear Physics: An Introduction”, Longman Group Limited, London, 1973.
5. R. G. Sachs, “Nuclear Theory”, Addison-Wesley Publishing Company, Cambridge, 1955.
6. K. S. Krane, “Introductory Nuclear Physics”, Wiley India Pvt. Ltd., 2008

M.Sc.-PHYSICS
SEMESTER-II

19PHY-404C

Electronics-II

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit - 1

Negative resistance devices

Tunnel diode, Backward diode, Uni-junction transistor, p-n-p-n devices, p-n-p-n characteristics, Thyristors, silicon controlled switch, SCS characteristics, L addition four layer devices, Basic circuit principles for NR switching circuits : Monostable, Bystable, Astable operations

Unit - II

Modulation and demodulation

Fundamental of modulation, frequency spectra in Amplitude modulation (AM), power in Amplitude modulated class C amplifier, Efficiency modulation, linear demodulation of AM waves, frequency conversion, Single Sideband Generation (SSB) system, Balanced modulation, filtering the signal of SSB, Phase shift method, Product detector, Explain pulse modulation in brief.

Unit - III

IC fabrication-I

Silicon planer process, crystal growth, wafer production, thermal oxidation, high pressure oxidation, concentration enhanced oxidation, chlorine oxidation, lithography & pattern transfer, etching process, factors affecting the etching process, HF-HNO_3 system, dopant addition, ion implantation, diffusion, diffusion in concentration gradient, Fick's law, diffusivity variation, Segregation, CVD, epitaxial and non-epitaxial films.

Unit - IV

IC fabrication-II

Monolithic IC technology, BJT fabrication, PNP transistor, multi-emitter schottky transistor, superbeta transistor fabrication, fabrication of FET/NMOS enhancement as well as depletion transistor, fabrication of CMOS devices, Monolithic diodes, clean rooms & their classifications.

Suggested Readings:

1. Pulse, Digital and switching waveforms by Jacob Millman and Herbert Taub.
2. Fundamental of photonics Bahaa E. A saleh, Malvin carl Teich (John Wiley and sons)
3. Optical electronics by Ajoy Ghatak and K. Thygarajan
4. Integrated Electronics by J. Millman and C.C Halkias (Tata – McGraw Hill)
5. Semiconductor devices – Physics and technology by S. M Sze (Wiley)
6. Fundamentals of electronics by J. D. Ryder (Prentice Hall Publication)
7. Electronic devices and circuit theory by Robert L. Boylestad, Louis Nashelsky

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-405

Physics Laboratory VII

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note: In this course, students will complete at least 5experiments in a semester as per allotment by the teacher in-charge of the Laboratory. There shall be end- semester laboratory examination wherein each student will be required to perform at least one experiment as per paper. The practical examination evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

G1 Band Gap of a given semiconductor material using Four-Probe method.

G2 To study fringe patterns and thickness Michelson Interferometer experiment.

G3 Lattice parameter and Miller Indices using XRD.

G4 To study the dielectric constant as a function of temperature and determine the Curie temperature.

G5 To study the plateau characteristics of a GM Counter and to find the absorption coefficient of Al-foil.

G6 To study Dielectric constant of a given material.

G7 To study the Lead Tin phase diagram.

G8 To determine Boltzmann Constant (k) make use the black body radiation and using Wien's displacement law and Stefan's law.

G9 To study the modulus of rigidity and internal friction in metals as a function of temperature.

Note:

Break up of internal assessment marks (practical paper)	
Internal Viva-voce	Attendance (>75% 5 marks and >85% 10 marks)
10	10

The distribution of percentage marks in practical papers (End-Semester examinations) as follows:		
Experiment	Viva-voce	Lab report
50	20	10

M.Sc.-PHYSICS
SEMESTER-IV

19PHY-406

Physics Laboratory VIII

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note: In this course, students will complete at least 5experiments in a semester as per allotment by the teacher in-charge of the Laboratory. There shall be end- semester laboratory examination wherein each student will be required to perform at least one experiment as per paper. The practical examination evaluation will be made on the basis of performance of students in (i) experiment, (ii) report and analysis of the experiment and (iii) viva-voce examination.

C1 Numerical Integration

C2 Numerical Differentiation

C3 Least Square fitting (Linear).

C4 Solution of second-order differential equation using Runge-Kutta method. Application: Eigenvalues and eigenfunctions of a linear harmonic oscillator using Runge-Kutta method

C5 Solution of Simultaneous Linear Algebraic equations by Gauss-Jordan elimination method. Application: Illustration of Kirchhoff's laws for simple electric circuits..

C6 Numerical solution of ordinary differential equation

C7 Charging and discharging of capacitor

C8 Simulation of planetary motion

C9 Solution of LCR circuit

C10 Solution of H-atom problem

C11 Interpretation by using Lagrangian method.

C12 Finding eigenvalues and eigenvectors of square matrices.

Note:

Break up of internal assessment marks (practical paper)	
Internal Viva-voce	Attendance (>75% 5 marks and >85% 10 marks)
10	10

The distribution of percentage marks in practical papers (End-Semester examinations) as follows:		
Experiment	Viva-voce	Lab report
50	20	10

General guidelines:

1. Each student will deliver one seminar of about 30 minute's duration on the topic to be allotted by the departmental seminar committee in both 1^{st} and 2^{nd} years of the M. Sc. Physics Course as per the schedule drawn in the beginning of each year. The marks will be awarded by the seminar committee on the basis of performance in the seminar and the seminar report submitted by the student.
2. The Discipline Specific Elective /special papers will be allotted to students on the basis of their preference cum percentage of marks in the First Semester and second examination of M. Sc. Physics.
3. The Discipline Specific Elective can be offered depending upon the availability of the resources and faculties.
4. For Open Elective paper, students will have to choose a course from the list of open electives offered by other Departments of the University.
5. If a course is being taught by two or more teachers, they should coordinate among themselves, the coverage of course material as well as the internal assessment of the students to maintain uniformity.
6. The books indicated as references are suggestive of the level of coverage. However, any other standard book may be followed.
7. In specialization courses/Discipline Specific Elective, new specializations may be added to the list from time to time keeping in view the expertise available in the Department and/or the emergence of new frontier areas of specialization.
8. New experiments in the Laboratory Courses may be added from time to time/Specialized course laboratory may be introduced depending upon the availability of the resources and faculties with intimation to PGBOS.

Open Elective Papers

For the Students of Other Departments						
The Department of Physics offers the following open elective papers to the students of other departments. A paper shall be run only if the number of students opting for it is at least 20. There will be an upper limit of 50 students in each paper. Open elective papers will be allotted by the Chairperson/HOD.						
Course Code	**Course Title**	**Credits**	**Teaching Hours per week**	**Maximum Marks**		
				Internal Assessment*	End-semester Examination	Total
19PHYOE-208 (For 2nd Semester)	Elements of Nano-Science	**2**	**2**	**20**	**80**	**100**
19PHYOE-308 (For 3rd Semester)	Radiation Effects	**2**	**2**	**20**	**80**	**100**

OPEN ELECTIVE CORSE

19PHYOE-208

Elements of Nano Science

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks.*

Unit-I

Introduction to Nanomaterials: Bottom up and Top Down approach, Classification of nanostructures: Zero dimension, one dimension and two dimensional nanostructures, Smart materials.

Unit-II

Nanostructure fabrication by Physical Methods: Physical Vapor deposition: evaporation, Molecular beam epitaxy, sputtering, comparison of evaporation and sputtering, Lithography: Photolithography, Electron Beam Lithography, X-ray lithography

Unit-III

Structural characterization: X-ray diffraction, small angle X-ray scattering, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy, Spectroscopic Techniques: UV-Visible Spectroscopy, Photo-luminescence spectroscopy, Infra-red spectroscopy, Raman Spectroscopy,

Unit-IV

Physical properties of nanomaterials: Melting points and lattice constants, Mechanical properties, Optical properties, Electrical conductivity, Superparamagnetism

ReferenceBooks:

1. Introduction to Nanotechnology – Charles P. Poole Jr. and Frank J. Owens, Wiley India Pvt. Ltd., 2007.
2. Nanomaterials – Guozhong Cao, Imperial College Press, 2004.

Note: In this paper, knowledge of basic physics at UG level is required.

OPEN ELECTIVE PAPER

19PHYOE-308

Radiation Effects

Maximum Marks-100
External Examination-80
Internal Assessment-20
Max. Time- 3 hrs.

Note*: There shall be nine questions in all. Question no. 1 shall be compulsory, consisting of eight short answer type questions covering the entire syllabus. Two questions will be asked from each unit. Student will have to attempt one question from each unit. Each question shall carry equal marks..*

Unit-I

Radiation and need for its measurement, Physical features of radiation, Conventional sources of radiation.
Exposure to natural radiation: external to the body, Radiation from cosmic rays and solar radiation,

Unit-II

Internal exposure to the body, Radioactivity arising from technological development: Possible health hazards from nuclear and laser radiations.
Maximum permissible level of radiation, radiation quantities and units of energy flux, energy fluence, cross-section.

Unit-III

Biological effects of radiation: Dose - response characteristics, Direct and indirect action, Acute effects, Delayed effects, Cumulative effect, Accidental exposure, Radiation induced chemical changes in tissues, Radiation protection procedures (diagnostics and therapy).

Unit-IV

Basic radiation safety criteria, Protection from direct radiation, Energy deposition, Effect of distance and shielding, Protection from contamination, Preparation of a safe radiation area,

Radioactive waste disposal and management: Type of radioactive waste, Airborne waste, Solid and liquid waste, Assessment of Hazard.

References Books:

1. Introduction to Radiobiology and Radiation Dosimetery - F.H. Aurix, John Wiley.
2. Techniques of Radiation Dosimetery - Eds K. Mahesh and DR Vij Wiley Eastern Limited.
3. Nuclear Energy - Raymond L. Murray Pergamon Press, N.Y.