MANGALORE UNIVERSITY

DEPARTMENT OF POST GRADUATE STUDIES & RESEARCH IN PHYSICS
MANGALORE UNIVERSITY
MANGALAGANGOTHRI 574199

SYLLABUS FOR CHOICE BASED CREDIT SYSTEM FOR THE TWO YEAR (FOUR SEMESTER) POST GRADUATE DEGREE PROGRAMME IN M.Sc. (RADIATION PHYSICS)

FOR THE DEGREE
OF
MASTER OF SCIENCE
IN RADIATION PHYSICS

DEPARTMENT OF PHYSICS
MANGALAGANGOTHRI

MANGALORE UNIVERSITY
DEPARTMENT OF PHYSICS

REGULATIONS AND SCHEME OF EXAMINATIONS FOR TWO – YEAR (FOUR SEMESTERS) MASTER'S DEGREE COURSE IN RADIATION PHYSICS FOR CHOICE BASED CREDIT SYSTEM

Title of the Programme

The programme shall be called Master of Science in Radiation Physics – M Sc (Radiation Physics)

Eligibility for Admission

The candidates who have passed the three year B Sc degree examination of Mangalore University or any other University considered equivalent there to, with Physics as major / optional subject/special subject are eligible for the programme provided they have studied Mathematics as major/optional/special/minor/subsidiary subject for at least two years and secured a minimum of 45% (40% for SC/ST/Category-I candidates) marks in Physics and Mathematics.

Course Pattern Highlights:

i) The M.Sc (Radiation Physics) PG Programme shall comprise "Core" and "Elective" subjects. The "Core" subjects shall further consists of "Hard" and "Soft" papers. Hard core papers shall have 4 credits; soft core paper shall have 3 or 4 credits. Open electives shall have 3 credits. Total credit for the programme shall be 92 including open electives.

ii) Core papers are related to the discipline of the M.Sc (Radiation Physics) programme. Hard core papers are compulsorily studied by a student as a core requirement to complete the programme of M.Sc (Radiation Physics). Soft core papers are elective but are related to the discipline of the programme. Two open elective papers of 3 credits each shall be offered in the II and III semester by the department. Open elective will be chosen from an unrelated programme within the faculty or across the faculty.

iii) Total credit for the M.Sc (Radiation Physics) programme is 92. Out of the total 92 credits of the programme, the hard core (H) shall make up 60.47 % of the total credits; soft core (S) is 39.53 % while the open electives (OE) will have a fixed 6 credits (3 credits - 2 papers).

DEPARTMENT OF POSTGRADUATE STUDIES AND RESEARCH IN PHYSICS
PROPOSED CBCS COURSE STRUCTURE

Semester	Theory (Hard Core)/ Soft core	Credits	Practicals Soft/ Hard	Credits	Theory (Elective) Soft/hard	Credits	Theory (Open Elective)	Credits	Projects Hard/soft	Credits	Total credits
I	4 H	4x4=16	2 S	6	-	-	-	-	-	-	22
II	4 H	4x4=16	2 S	6	-	-	1	3	-	-	25
III	2 H	2x4=8	2 S	6	2 S	2x4=8	1	3	-	-	25
IV	2 H	2x4=8	-	-	2 S	2x4=8	-	-	1 H	4	20

Total credit from all the four semesters (I, II, III and IV): 22+25+25+20 = 92

Details of course and credits for four semesters:

Hard core credits with %	Soft core credits with %	Total credits hard+ soft without open elective	Open elective credits	Total credits hard +soft+ open elective
52 (60.47)	34 (39.53)	86	6	92

NOTE:

FIRST SEMESTER: The first semester consists of four theory papers which are hard core (4 hours per week for each paper and shall carry 4 credits for each paper) and two practicals (soft core 6 hours per week for each practical paper and each practical paper carries 3 credits). The duration of the lab is 3 hours. The students have to come twice a week for each of the practical paper.

SECOND SEMESTER: The second semester consists of four theory papers which are hard core (4 hours per week for each paper and shall carry 4 credits for each of the papers) and two practical (soft core 6 hours per week for each practical paper and each practical paper shall carry 3 credits). The duration of the lab is 3 hours. The students have to come twice a week for each of the practical paper. In addition there shall be an open elective paper to be opted by the student from other departments. The open elective course is a soft core paper (3 hours per week and shall carry 3 credits).

THIRD SEMESTER: The third semester consists of four theory papers, two hard core papers and two soft core papers. The two hard core are of 4 hours duration per week and shall carry 4 credits. The two soft core papers are of 4 hours duration per week and shall carry 4 credits. The two practical papers are soft core papers (6 hours per week and shall carry 3 credits for each of the practical paper). The duration of the lab is 3 hours for each practical. The students have to come twice a week for each of the practical papers. In addition there is an open elective course to be opted by the student from other departments. The open elective is a soft core paper (3 hours per week and shall carry 3 credits).

FOURTH SEMESTER: The fourth semester consists of four theory papers, two hard core papers and two soft core papers. The two hard core papers are of 4 hours duration per week and shall carry 4 credits. The two soft core papers are of 4 hours duration per week and shall carry 4 credits. There shall be a compulsory project work which has to be under taken by all the students of the fourth semester. The project work is a hard core having 8 hours per week with 4 credits.

MANGALORE UNIVERSITY

M Sc (Radiation Physics) Scheme of Examination, Marks and Credits

SEMESTER	Theory/practicals	Exam. hours	Marks end Semester + Internal assessment	Credits	Total
I Semester	4 Theory papers (hard core)	3 hrs each	70 + 30* each	4 x 4 = 16	400
	2 practicals (soft core)	3 hrs each	70 + 30* each	2 x 3 = 6	200
II Semester	4 Theory papers(hard core)	3 hrs each	70 + 30* each	4 x 4 = 16	400
	2 practicals (soft core) One open elective (theory)	3 hrs each 3 hrs	70 + 30* each 70 + 30* each	2 x 3= 6 1x3 =3	200 100
III Semester	4 Theory Papers i) Two hard core (4 credits) ii)Two soft core (4 credits)	3 hrs each	70 + 30* each	2x 4 = 8 2 x 4 = 8	400
	2 practicals (soft core) One open elective (theory)	3 hrs each 3 hrs	70 + 30* each 70 + 30* each	2 x 3 = 6 1 x3=3	200 100
IV Semester	4 Theory Papers i) Two hard core (4 credits) ii)Two soft core (4 credits)	3 hrs each	70 + 30* each	2 x 4 = 8 2 x 4= 8	400
	Project (hard core)		100	1 x 4 = 4	100
			Grand Total	92	2500

*Internal Assessment

NOTE:
BASIS FOR INTERNAL ASSESSMENT:

Internal assessment marks in theory papers shall be based on two tests in each theory paper and the total internal assessment marks for each subject is 30. Practical internal assessment marks is based on viva voce and practical records in the semesters and carries 30 marks for each practical paper.

Project Report: There shall be a project in the fourth semester for all the three specializations. The project report shall be in the form of a project report/dissertation and carries 100 marks and has 4 credits. A dissertation/project report shall be evaluated by two examiners, one external and one internal from out of the panel of examiners prepared by the B.O.S, and approved by the University.

Question paper pattern for hard core and soft core (4 credits)

PATTERN

The examination marks for hard core (4 credits), soft core (3/4 credits) and open elective (3 credits) theory paper is 70.

Each hard/soft theory paper syllabus is divided into 4 units. The semester ending examination will be aimed at testing the student's proficiency and understanding in every unit of the syllabus. The blue print for the question paper pattern is as follows: Each question paper will consists of 5 parts I, II, III, IV and V. Each of the parts from Part I to Part IV carries 15 marks. Each Part consists of two questions and one question from each part is to be chosen. Part V is compulsory which consists of four questions (one from each part) and two questions are to be answered. Part V carries 10 marks. The model question paper is given below.

M.Sc. Degree Examination

RADIATION PHYSICS

PHYRADH: XXX: Model paper (CBCS)

(Hard Core/Soft core (4 credits))

Time: 3 Hours

Max.Marks: 70

Note: Answer any **four** questions choosing **one** from each of the Parts **I** to **IV** and **two** questions in Part **V.**

PART - I

1

(15)

OR

2.

.

(15)

PART - II

3

(15)

OR

4

(15)

PART - III

5

(15)

OR

6

(15)

PART - IV

7

(15)

OR

8

(15)

PART V

9 Answer **any two** of the following: (2x5=10)

a)
b)
c)
d)

Question paper pattern for soft core (3 credits) and open elective

PATTERN

Each soft/open elective theory paper syllabus is divided into 3 units. The semester ending examination will be aimed at testing the student's proficiency and understanding in every unit of the syllabus. The blue print for the question paper pattern is as follows: Each question paper will consists of 4 parts I, II, III and IV. Each of the parts from Part I to Part III carries 18 marks. Each Part consists of two questions and one question from each part is to be chosen. Part IV is compulsory which consists of six questions (two from each part) and four questions are to be answered. Part IV carries 16 marks. The model question paper is given below.

M.Sc. Degree Examination

RADIATION PHYSICS
PHYRADS YYY: Model paper (CBCS)

(Soft core (3 credits)/Open elective)

Time: 3 Hours

Max.Marks: 70

Note: Answer any **three** questions choosing **one** from each of the Parts **I** to **III** and **four** questions in Part I**V.**

PART - I

1

(18)

OR

2.
.

(18)

PART - II

3

(18)

OR

4

(18)

PART - III

5

(18)

OR

6

(18)

PART IV

9 Answer **any four** of the following: (4x4=16)

a)
b)
c)
d)
e)
f)

PRACTICAL EXAMINATION: Semester end practical examination for each practical paper in all the semesters is for 100 marks. Maximum marks for final practical examination shall be 70. The marks shall be awarded in the examination based on the procedure, conduct of the practicals, results and viva related to the practicals. Remaining 30 marks is for internal assessment.

MANGALORE UNIVERSITY

M Sc DEGREE PROGRAMME IN RADIATION PHYSICS: SEMESTER SCHEME

(Effective from the Academic year 2016- 2017)

C O U R S E P A T T E R N AND S C H E M E OF E X A M I N A T I O N

SEMESTER	Description of the Papers	Teaching Hrs/ week Theory	Credit Hard(H)/Soft(S)/ Open elective(OE)	Max Marks: Exam + IA = Total
I SEMESTER				
RPH 401	Methods of Mathematical Physics - I	4	4 H	70 + 30
RPH 402	Quantum Mechanics I	4	4 H	70 + 30
RPH 403	Classical Mechanics	4	4 H	70 + 30
RPH 404	Electrodynamics	4	4 H	70 + 30
RPP 405	Physics Practicals I (General)	6	3 S	70 + 30
RPP 406	Physics Practicals II (Electronics)	6	3 S	70 + 30
II SEMESTER				
RPH 451	Mathematical Physics II	4	4 H	70 + 30
RPH 452	Quantum Mechanics II	4	4 H	70 + 30
RPH 453	Nuclear and Radiation Physics	4	4 H	70 + 30
RPH 454	Condensed Matter Physics and Electronics	4	4 H	70 + 30
RPE 455	Energy studies	3	3S (OE)	70 + 30
RPP 456	Physics Practicals III (General)	6	3 S	70 + 30
RPP 457	Physics Practicals IV (General)	6	3 S	70 + 30

III SEMESTER				
RPH 501	Atomic and Molecular Physics	4	4 H	70 + 30
RPH 502	Thermodynamics and Statistical Physics	4	4 H	70 + 30
RPS 503	Radiation Physics I	4	4 S	70 + 30
RPS 504	Radiation Physics II	4	4 S	70 + 30
RPE 505	Radiation Sources and Hazards	3	3 S (OE)	70+30
RPP 506	Radiation Physics - Practicals I	6	3 S	70 + 30
RPP 507	Radiation Physics - Practicals II	6	3 S	70 + 30
IV SEMESTER				
RPH 551	Lasers, Vacuum Techniques and Cryogenics	4	4 H	70 + 30
RPH 552	Astrophysics and Relativity	4	4 H	70 + 30
RPS 553	Radiation Physics- III	4	4 S	70 + 30
RPS 554	Radiation Physics- IV	4	4 S	70 + 30
RPP 555	Project work	8	4 H	70+30

RPH 401: METHODS OF MATHEMATICAL PHYSICS I [52 Hrs.]

Unit I Vector analysis and curvilinear coordinates: Integration of vector functions - line integrals, surface integrals and volume integrals - vector theorems without proof (Gauss, Green's and Stokes') and their applications in physics.

Generalized coordinates - elements of curvilinear coordinates - transformation of coordinates - orthogonal curvilinear coordinates - unit vectors - expression for arc length, volume element. The gradient, divergence and curl in orthogonal curvilinear coordinates. Laplacian in orthogonal curvilinear coordinates, spherical polar coordinates, cylindrical coordinates. [13 hrs]

Unit II Matrices and complex variables: Matrix representation of linear operators, Hermitian and unitary operators, Hilbert space. Diagonalisation of matrices – simultaneous diagonalisation.

Complex variables and integral transforms: Review of functions of a complex variable – Cauchy Riemann conditions. Contour integrals. Cauchy integral theorem, Cauchy integral formula. Taylor and Laurentz series. Zero isolated singular points, simple pole, m^{th} order pole. Evaluation of residues. The Cauchy's residue theorem. The Cauchy principle value. Evaluation of different forms of definite integrals. A digression on Jordan's lemma. [13 hrs]

Unit III Partial differential equations: Review of system of surfaces and characteristics. First order partial differential equations for a function of two variables.

Linear second order partial differential equations. Classification into elliptic, parabolic and hyperbolic types.

Boundary value problems - solutions by method of separation of variables - solution of 1-, 2- and 3- dimensional wave equation and diffusion equation in Cartesian, plane, cylindrical and spherical polar coordinates. [13 hrs]

Unit IV Special functions: Review of power series method for ordinary differential equations – description of beta and gamma functions.

Bessel functions – solution of Bessel's equation - generating function and recurrence relations – orthogonality of Bessel functions.

Legendre polynomials – solution of Legendre equation – generating function and recurrence relations – orthogonality property of Legendre polynomials.

Solution of Hermite equation – Hermite polynomials – generating functions and recurrence relations. [13 hrs]

Text Books:

1. Arfken G, 'Mathematical Methods for Physicists' (Academic Press)
2. Harper C, 'Introduction to Mathematical Physics' (PHI, 1978)
3. Chattopadhyaya P K, 'Mathematical Physics' (Wiley Eastern, 1990)

4. Harry Lass, 'Vector and Tensor Analysis' (McGraw Hill, 1950)
5. Mary L Boas, 'Mathematical Methods in the Physical sciences' (John Wiley, 1983)
6. Joshi A W, 'Matrices and Tensors in Physics' (Wiley Eastern, 1995)
7. Ayres F, 'Differential Equations' (Schaum series, McGraw Hill)
8. Spiegel M R, 'Vector Analysis' (Schaum series, McGraw Hill, 1997)
9. Ayres F, 'Differential Equations' (Schaum series, McGraw Hill)
10. Sneddon I A, 'Elementary Partial Differential Equations' (McGraw Hill, 1957)

Reference Books:

1. Bose A K and Joshi M C, 'Methods of Mathematical Physics' (Tata McGraw Hill, 1984)
2. Sokolnikoff and Redheffer, 'Mathematics of Physics and Modern Engineering, (McGraw Hill, 1958)
3. Irving J and Mullneu N, 'Mathematics in Physics and Engineering' (Academic Press, 1959)
4. Kreysig E, 'Advanced Engineering Mathematics' (Wiley Eastern, 1969)
5. Mathews J and Walker R L, 'Mathematical Methods of Physics' (W A Benjamin, Inc, 1979)

RPH 402: QUANTUM MECHANICS I **[52 hrs.]**

Unit I General formulation of quantum mechanics

Schrodinger wave equation - review of concepts of wave particle duality, matter waves, wave packet and uncertainty principle. Schrodinger's equation for free particle in one and three dimensions - equation subject to forces. Probability interpretation of the wave function, probability current density - normalisation of the wave function, box normalisation, expectation values and Ehrenfest's theorem. [13 hrs]

Unit II Fundamental postulates of QM

Representation of states, dynamical variables - Adjoint of an operator. Eigen value problem - degeneracy. Eigenvalues and eigenfunctions. The Dirac-delta function. Completeness and normalisation of eigen functions. Closure. Physical interpretation of eigen values, eigen functions and expansion coefficients. Momentum eigen functions. [13 hrs]

Unit III Stationary states and eigen value problems

The time independent Schrodinger equation - particle in square well - bound states - normalised states. Potential step and rectangular potential barrier - reflection and transmission coefficients - tunnelling of particles.

Simple harmonic oscillator - Schrodinger equation and energy eigen values - Energy eigen functions. Properties of stationary states. [13 hrs]

Unit IV Angular momentum, parity and scattering

Angular momentum operators, eigen value equation for L^2 and L_z - Separation of variables. Admissibility conditions on solutions - eigen values, eigen functions. Physical interpretation. Concept of parity. Rigid rotator. Particle in a central potential - radial equation.

Three-dimensional square well. The hydrogen atom - solution of the radial equation - energy levels. Stationary state wave functions - bound states. Theory of scattering - the scattering experiment, differential and total cross-section, scattering amplitude, method of partial waves, scattering by a square well potential. [13 hrs]

Text Books:

1. Powell and Crassman, 'Quantum Mechanics'(Addison Wesley, 1961)
2. Mathews P M and Venkatesan K, 'A Text Book of Quantum Mechanics' (Tata McGraw Hill, 1977)
3. Ghatak A K and Lokanathan S, 'Quantum Mechanics', III Edn. (McMillan India, 1985)
4. Sakurai J J, 'Modern Quantum Mechanics', Revised Edn. (Addison Wesley, 1994)

Reference Books:

1. Cohen Tannoudji C, Diu B and Laloe, 'Quantum Mechanics', Vol. I (John Wiley, 1977)
2. Schiff L I, 'Quantum Mechanics', III Edn. (McGraw Hill, 1968)
3. Shankar R, 'Principles of Quantum Mechanics' (Plenum, 1980)
4. French A P and Taylor E F, `An introduction to Quantum Physics' (W W Norton, 1978)
5. Gasirowicz, 'Quantum Physics' (Wiley, 1974)
6. Wichmann E H, 'Quantum Physics' (McGraw Hill, 1971)

RPH 403 : CLASSICAL MECHANICS **[52 hrs]**

Unit I System of Particles: Centre of mass, total momentum, angular momentum and kinetic energy of a system of particles, Newton's laws, conservation of linear momentum, angular momentum and energy. Lagrangian Formulation: Constraints and their classification, degree of freedom, generalized co-ordinates, virtual displacement, D'Alembert's principle, Symmetry of space and time: Conservation of linear momentum, angular momentum and energy.

[13 hrs]

Unit II Hamiltonian formalism: Generalized momenta, Hamiltonian function, Physical significance and the Hamilton's equations of motion, Examples of (a) The Hamiltonian of a particle in a central force field, (b) the simple harmonic oscillator. Principle of least action: derivation of equation of motion, variation and end points.

Canonical transformations: Generating functions (four basic types), examples of canonical transformations, the Harmonic oscillator in one dimension, Poisson brackets, equations of motion in terms of Poisson brackets, properties of Poisson brackets (anti-symmetry, linearity and Jacobi Identity), The Hamilton-Jacobi equation, Solution of linear harmonic oscillator using Hamilton-Jacobi method.

[13 hrs]

Unit III Central Forces**:** Definition and characteristics. Reduction of two particle equations of motion to the equivalent one-body problem, reduced mass of the system, conservation theorems (First integrals of the motion), equations of motion for the orbit, classification of the orbits, conditions for closed orbits, Kepler's laws of planetary motion. Newton's law of gravitation.

Scattering in Central Force Field: general description of scattering, cross-section, impact parameter, Rutherford scattering, centre of mass and laboratory co-ordinate systems.

Motion in a Non-inertial reference frames: Motion of a particle in a general non-inertial frame of reference, motion of pseudo forces, equation of motion in a rotating frame of reference, the Coriolis force, deviation due east of a falling body, the Foucault pendulum.

[13 hrs]

Unit IV Rigid body dynamics: Degrees of freedom of a rigid body, angular momentum and kinetic energies of a rigid body, moment of Inertia tensor, principal moment of inertia, Euler angles, Euler's equations of motion for a rigid body, Torque free motion of a rigid body, precession of earth's axis of rotation.

Small oscillations**:** types of equilibriums, Quadratics forms for kinetic and Potential energies of a system in equilibrium, Lagrange's equations of motion, Normal modes and normal frequencies, examples of (i) longitudinal vibrations of two coupled harmonic oscillators, (ii) Normal modes and normal frequencies of a linear, symmetric, tri-atomic molecule.

[13 hrs]

Text Books:

1. Classical Mechanics, H Goldstein , (Addison Wesley, 1980)
2. Classical mechanics, H. Goldstein, C. Poole, J. Safko, (3rd edition, Pearson Educations Inc. 2002).
3. Classical mechanics, K. N. Srinivasa Rao, (University press,2003).
4. Classical mechanics, N. C. Rana and P. S. Joag, (Tata McGraw-Hill,1991).
5. Classical dynamics of particles and systems, J. B. Marion, (Academic press,1970).
6. Introduction to Classical mechanics, R.G.Takwale and P.S.Puranik, (Tata McGraw-Hill 1983).
7. Classical Mechanics, J C Upadhyaya, (Himalaya Publishing House,2005)
8. Classical Mechanics, G. Aruldhas, (Prentice Hall of India,2008)

Reference Books

1 Classical mechanics, L. D. Landau and E. M. Lifshitz, (4th edition, Pergamon press 1985).
2 Lagrangian and Hamiltonian Mechanics, M.G. Calkin, (World Scientific, 1996)
3 Analytical Mechanics, G R Fowles, Holt, Rinehart (1977).
4 Classical Mechanics, Walter Greiner, Springer India (2006).
5 Analytical Mechanics, K A Gamalnath, Narosa, (2011).
6 Classical Mechanics, A K Saxena, CBS Publishers

RPH 404 : ELECTRODYNAMICS **[52 hrs]**

Unit I **Electrostatics and Magneto statics:**

Gauss's law and applications, Electric Potential, Poisson's equations, Work, energy in electrostatics. Laplace's equations and its solution in one, two and three dimensional problems (Cartesian co ordination). Boundary conditions and uniqueness theorem. Method of images and applications. Multipole expansion. Electric dipole field, redo pot, Field inside a dielectric- special problems involving linear dielectric, Biot –Savart law and applications, Ampere's law and applications,

Magnetic vector potential, Boundary conditions. Multipole expansion of vector potential. Review of magnetisation. Magnetic field inside matter, The field of a magnatized object. [13 hrs]

Unit II **Electromagnetic waves**:

Review of Maxwell's equations, formulating electrodynamics using scalar and vector potentials, Gauge transformations. Coulomb gauge and Lorentz gauge. Energy and momentum of electromagnetic waves. Propagation through linear media, reflection and transmission of electromagnetic waves: plane waves in conducting media, skin depth, dispersion of electromagnetic waves in non conductors, wave guides, transmission of electromagnetic waves in rectangular wave guide. [13 hrs]

Unit III **Electromagnetic Radiation**:

Retarded potentials. Electric and magnetic dipole radiation. Lienard-Wiechert potentials. Fields of a point charge in motion, slowly moving, Power radiated by a point charge oscillation, Larmour formula,

Review of Lorentz transformations, Four vectors, Magnetism as a relativistic phenomenon, Lorentz transformation of electric and magnetic fields, The electromagnetic field tensor notation, potential formulation of electrodynamics. [13 hrs]

Unit IV **Plasma Physics:**

Plasma - definition, Debye shielding distance, hydromagnetic equations. Motion of charged particle in (a) uniform magnetic field (b) electric and magnetic fields at not angled (c) space dependent magnetic field. Adiabatic invariants, the equation of motion of a plasma fluid, magnetic pressure, plasma confinement, Pinch effect, Plasma as a conducting fluid, Drift velocities, Plasma oscillations, Plasma waves, Propagation of electromagnetic waves in plasma. Magnetic mirrors. [13 hrs]

Text Books:

1. D.J. Griffiths, 'Introduction to Electrodynamics', III Edn. (PHI, 2003)
2. B.B. Laud 'Electromagnetics' (New age International PVT. LTD)
3. P. Lorrain and D. Corson, 'Electromagnetic field and waves'(CBS)
4. I.S Grant and W.R. Phillips 'Electromagnetism' (John Wiley and sons Ltd.)
5. Pramanik, 'Electromagnetism' (PHI,2010)
6. J.D. Jackson, 'Classical Electrodynamics' (Wiley eastern,2003)
7. Reitz J R, Milord F J, Christy R W, 'Foundations of Electromagnetic Theory', III

Edn. (Narosa Publishing House, 1990)

8. Purcell E M, `Electricity and Magnetism', II Edn. (McGraw Hill, 1985)
9. A.R. Choudhari, 'The Physics of fluids and plasmas' (Cambridge UP 1998)
10. Chen Francis, 'Plasma Physics', II Edn. (Plenum Press, 1984)
11. Bitten Court J A, 'Fundamentals of Plasma Physics' (Pergamon Press, 1988)
12. Paul Bellan, 'Fundamentals of Plasma Physics' (CUP 2006)

Reference Books:

1 Sommerfeld A, 'Mechanics' (Academic Press, 1964)
2 Krauss John D, 'Electromagnetics', II Edn. (Tata McGraw Hill, 1973)
3 Singh R N, 'Electromagnetic Waves and Fields' (Tata McGraw Hill, 1991)

RPP 405: PHYSICS PRACTICALS I (General)

1 Characteristics and efficiency of a GM counter.
2 Study the beta ray attenuation in matter.
3 Determination of energy gap of a semiconductor.
4 Susceptibility by Quinke`s method.
5 Modes of vibration of a fixed free bar
6 Temperature dependence of Hall coefficient.
7 Magnetic susceptibility of hydrated copper sulfate.
8 To study the variation of magnetoresistance of a sample with the applied magnetic field.
9 To determine the strength of an α-source using SSNTD.
10 Transition temperature of a ferroelectric material
11 Dielectric constant of a given material.

*** Additional experiments may be included.**

RPP 406 : PHYSICS PRACTICALS II (Electronics)

1 Clipping and clamping circuits
2 Differentiator & integrator circuits
3 Logic gates.
4 UJT characteristics - relaxation oscillator.
5 Opamp circuits - voltage to current converter, current to voltage converter, active limiter and active clamper.
6 Active filters – high pass, low pass, band pass and band stop
7 MOSFET common source amplifier.
8 BJT differential amplifier.
9 Voltage regulator (with series pass transistor) / 3 pin regulator.
10 Wein bridge oscillator.

*** Additional experiments may be included.**

RPH 451 MATHEMATICAL PHYSICS II [52 Hrs.]

Unit I Tensor analysis: Introduction - rank of a tensor. Transformation of coordinates in linear spaces - transformation law for the components of a second rank tensor. Contra-variant and covariant and mixed tensors - First rank tensor, higher rank tensors, symmetric and antisymmetric tensors. Tensor algebra - outer product - contraction - inner product - quotient law. The fundamental metric tensor - associate tensors. Line element and Metric Tensor, Christoffel's Symbols of first and second kind, Length of a vector, Angle between vectors, Geodesics, Covariant derivative, Tensor form of Gradient, Divergence and Curl

[13 hrs]

Unit II Fourier series: Fourier integral and Fourier transform - definition - special form of Fourier integral and properties. Convolution theorem involving Fourier transform. Applications of Fourier transforms. Laplace transform - Convolution theorem involving Laplace transforms. Applications of Laplace transforms. [13 hrs]

Unit III Green's Functions and Integral Equations: Green's function for one, two and three dimensional equations, Eigen function expansion of Green's functions, Fredholm and Volterra type integral equations, solution with separable kernels, Neumann series method. Non-homogeneous integral equations. [13 hrs]

Unit IV Groups - subgroups - classes. Invariant subgroups - factor groups. Homomorphism and Isomorphism. Group representation - reducible and irreducible representation. Schur's lemmas, orthogonality theorem. Decomposing reducible representation into irreducible ones. Character of a representation, character table, Construction of representations. Representation of groups and quantum mechanics. Lie groups and Lie algebra. Generators of Unitary Groups, Three dimensional rotation group SO(3), SU(2) and SU(3) groups. The homomorphism between SU(2) and SO(3) groups.

[13 hrs]

Text Books:

1. Chattopadhyaya P K, 'Mathematical Physics' (Wiley Eastern, 1990)
2. Joshi A W, 'Introduction to Group Theory' (Wiley Eastern, 1995)
3. Spiegel M R, 'Vector Analysis' (Schaum series, Tata McGraw Hill, 2009)
4. Joshi A W, 'Matrices and Tensors in Physics' (Wiley Eastern, 199
5. Arfken G, 'Methods of Mathematica Physics, (Academic Press 2005)
6. Kreyszig, Advanced Engineering Mathematics, (New Age International, 2004)

Reference Books:

1. Sokolnikoff and Redheffer, 'Mathematics of Physics and Modern Engineering, (McGraw Hill, 1958)
2. Irving J and Mullneu N, 'Mathematics in Physics and Engineering' (Academic Press, 1959)
3. Mary L Boas, 'Mathematical Methods in the Physical Sciences' (John Wiley, 1983)
4. Mathews J and Walker R L, 'Mathematical Methods of Physics' (W A Benjamin, Inc, 1979)

5. Sreenivasa Rao K N, ‘The Rotation and Lorentz Groups and Their Representations for Physicists’ (John Wiley & sons, 1988)
6. N.Hammermesh,’Group Theory’,(Addison-Wesley,1964)
7. M.Tinkham,’Group Theory and Quantum Mechanics’,(McGraw-Hill,1964)
8. E.Butkov, ’Mathematical Physics’, (Addison-Wesley,1968)
9. P.M.Morse and H.Feshbach,’Methods of Theoretical Physics’, (Interscience,1953)

RPH 452: QUANTUM MECHANICS II **[52 hrs.]**

Unit I Matrix formalism of quantum mechanics

Linear vector spaces - orthogonality and linear independence, bases and dimensions, completeness, Hilbert's spaces. Hermitian operators. Bra and Ket notations for vectors. Representation theory. Schwartz's inequality theorem - proof of Heisenberg uncertainty relation.

[13 hrs]

Unit II Quantum dynamics

Equations of motion - Schrodinger and Heisenberg picture - quantum Poisson bracket. Harmonic oscillator problem solved by matrix method.

Angular momentum - angular momentum operator, commutation relations - raising and lowering operators - eigen values and eigen functions of L^2 and L_z - addition of two angular momentum - Clebech-Gordan coefficients - the 3-j symbol - Pauli spin matrices. [13 hrs]

Unit III Approximation methods

Perturbation theory for discrete levels - equations in various orders of perturbation theory - non-degenerate and degenerate cases, simple examples. Time dependent perturbation theory.

The variation method - the hydrogen molecule - exchange interaction. The WKB method. [13 hrs]

Unit IV Relativistic quantum mechanics and elements of second quantisation

Klein-Gordan equation for a free particle - Dirac equation - Dirac matrices - Dirac equation for central fields - negative energy solution, spin and magnetic moment of the electron.

Transition from particle to field theory. Second quantisation of the Schrodinger, Klein, Dirac and Electromagnetic equations (qualitative). Creation and annihilation operators - commutation and anti-commutation relation and their physical implications. [13 hrs]

Text Books:

1. Thankappan V K, 'Quantum Mechanics' (Wiley Eastern Ltd., 1985)
2. Ghatak A K and Lokanathan S, 'Quantum Mechanics' (Macmillan, India, 1984)
3. Mathews P M and Venkatesan K, 'Text Book of Quantum Mechanics' (Tata McGraw Hill, 1976)
4. Powell J L and Crasemann B, 'Quantum Mechanics' (Addison Wesley, 1961)

Reference Books:

1. Schiff L I, 'Quantum Mechanics', III Edn. (McGraw Hill, 1969)
2. Merzbecher E, 'Quantum Mechanics', III Edn. (John Wiley & Sons, 1998)
3. Shankar R, 'Principles of Quantum Mechanics' (Plenum, 1980)
4. Sakurai J J, 'Modern Quantum Mechanics' Revised Edn. (Addison-Wesley, 1994)
5. Edmonds, 'Angular Momentum in Quantum Mechanics' (Princeton University Press, 1960)

RPH 453: NUCLEAR AND RADIATION PHYSICS [52 hrs]

Unit I General properties of the nucleus and nuclear decay

Constituents of nucleus and their properties. Mass of the nucleus-binding energy. Charge and charge distribution. Spin statistics and parity. Magnetic moment of the nucleus. Quadrupole moment. **[**13 hrs]

Nuclear decay - Alpha decay - quantum mechanical tunnelling - wave mechanical theory. Beta decay - continuous beta ray spectrum - neutrino hypothesis. Fermi's theory of beta decay - Kurie plots and ft-values - selection rules. Detection of neutrino - non-conservation of parity in beta decay. Gamma decay - selection rules - multipolarity - Internal conversion (qualitative only).

Unit II Interaction of radiations and radiation detectors: Interactions of electrons with matter - Specific energy loss, Coulombic mode of interactions, radiative mode of energy loss, electron range and transmission curves.

Interaction of gamma rays with matter - Elastic scattering, photoelectric effect, Compton scattering, Klein-Nishina formula (qualitative) and pair production processes, cross section, gamma ray attenuation, linear and mass absorption coefficients.

Radiation detectors - Gas filled counters - general features - ionization chamber, proportional counter and GM counter.

Radiation quantities and units - radiation exposure, absorbed dose, equivalent dose and effective dose [13 hrs]

Unit III Ionising radiations and applications: Sources of ionising radiations in the environment – terrestrial radiation sources and radionuclides, cosmic radiations and cosmogenic radionuclides. Technologically enhanced radiation sources. Artificial radiation sources artificial radionuclides. Production of radioisotopes using reactors. Application of radioisotopes in medicine, agriculture and industry. Radiation shielding (qualitative treatment).

Nuclear Models: Liquid drop model - semi empirical mass formula, stability of the nuclei against beta decay, mass parabola. Shell model (qualitative) **[**13 hrs]

Unit IV Nuclear reactions - Cross section for a nuclear reaction. 'Q' equation of a reaction in laboratory system - threshold energy for a reaction. Centre of mass system for nucleus-nucleus collision. Non-relativistic kinematics. Relation between angles and cross sections in lab and CM systems.

Reactor physics: fission chain reaction. Slowing down of neutrons - moderators. Conditions for controlled chain reactions in bare homogeneous thermal reactor. Critical size. Effect of reflectors. Brief introduction of nuclear fuel cycle. Breeder Reactors. [13 hrs]

Text Books:

1. Segre E, 'Nuclei and Particles', II Edn. (Benjamin, 1977)
2. Knoll G F, Radiation Detection and Measurement', II Edn. (John Wiley, 1989)
3. Eisenbud M, 'Environmental Radioactivity' (Academic Press, 1987)
4. Ghoshal S N, 'Atomic and Nuclear Physics', Vol. I & II (S Chand & Company, 1994)

Reference Books

1. Patel S B, ‘Nuclear Physics - An Introduction’ (Wiley Eastern, 1991)
2. Krane K S, ‘Introductory Nuclear Physics’ (John Wiley, 1988)
3. Roy R K and Nigam P P, ‘Nuclear Physics - Theory and Experiment’ (Wiley Eastern Ltd., 1993)
4. Singru R M, ‘Experimental Nuclear Physics’ (Wiley Eastern, 1972)
5. Zweifel P F, ‘Reactor Physics’, International Student Edn. (McGraw Hill, 1973)
6. Kapoor S S and Ramamurthy V S, ‘Radiation Detectors’ (Wiley Eastern, 1986)
7. Henry Semat & John R AlBright, ‘Introduction to Atomic and Nuclear Physics’ V Edn. (Chapman & Hall, 1972)
8. Burcham W E, ‘Nuclear Physics’, II Edn. (Longman, 1963)
9. Mann W B, Ayres R L and Garfinkel, ‘Radioactivity and its Measurements’ (Pergamon Oxford, 1980)
10. Little field T A and Thorley N ‘Atomic and Nuclear Physics’, II Edn. (Nostrand Co., 1988)

RPH 454: CONDENSED MATTER PHYSICS and ELECTRONICS [52 hrs]

Unit I Elementary Crystallography and X-ray diffraction Elementary Crystallography**:** Concept of Crystallography, unit cell, primitive and non-primitive, base, Bravais lattice in two and three dimension, crystal structure, coordination numbers, Miller indices, Crystal structures of NaCl, CsCl, diamond, zinc blende and copper. Close packing system.

X ray diffraction**:** Scattering of X rays by an electron, by an atom and by a crystal. Atomic scattering factor, Bragg law. Geometric structure factor. Systematic absences. Reciprocal lattice - its properties, Ewald's sphere - its construction. Laue and powder experimental methods.

Lattice Vibration**:** Properties of lattice waves, chain of identical atoms and a diatomic linear chain, quantisation of lattice vibrations, phonon, phonon momentum, elastic scattering by phonon, phonon-phonon interaction, anharmonicity and thermal expansion, problems. [13 Hrs]

Unit II Free Electron Theory and Band Theory of Solids: Free electron in one dimensional potential well, three dimensional potential well, quantum state and degeneracy, density of states, Fermi Dirac Statistics and distribution with temperature, free electron theory of metals, Fermi energy above 0 K, Electronic specific heat. Electrical conductivity of metal,. Relaxation time and mean free path, Wiedemann-Franz law. Failures of free electron model. Kronig-Penney mode and Effective mass. Classification of solids - metal, semiconductors, insulators. intrinsic and extrinsic semiconductors. Carrier concentration in intrinsic semiconductors, impurity states-donor states, acdeptor states, thermal ionisation of donors and acceptors, temperature effects of mobility, Electrical conductivity of semiconductor. [13 Hrs]

Unit III Phasors and devices

Phasors - Phasor relations for R, L and C - Sinusoidal steady state response of a series RLC circuit. Fourier series - trigonometric form of Fourier series - complex form of Fourier series. Application of Fourier and Laplace transforms in circuit analysis. BJT, JFET and MOSFET devices. Voltage divider bias. Small signal analysis of BJT and FET amplifiers in CE/CS configuration. UJT characteristics and its use in a relaxation oscillator. SCR characteristics and its use in ac power control [13 hrs]

Unit IV Operational amplifiers and Digital electronics

BJT differential amplifier. Operational amplifier - voltage/current feedback concepts (series & parallel). Inverting and noninverting configurations. Basic applications of opamps - comparator and Schmitt trigger. IC555 timer - monostable and astable multivibrators. Crystal oscillator using opamp. Voltage regulators – three terminal and SIMPS Tristate devices. Decoders and encoders. Multiplexers and demultiplexers with applications. Digital to analog conversion with R/2R network. Analog to digital conversion using flash technique. [13 hrs]

Text Books:

1. Hayt W H, Kemmerly J E & Durbin S M, 'Engineering Circuit Analysis', VI Edn. (McGraw-Hill, 2002).
2. Boylestad R L, 'Introductory Circuit Analysis', VIII Edn. (Prentice Hall, 1997)
3. Boylestad R L & Nashelsky L, 'Electronic Devices & Circuit Theory', VIII Edn. (Prentice Hall, 2002).
4. Floyd T L, 'Electronic Devices', V Edn. (Pearson Education Asia, 2001).
5. Gayakwad R A, 'Opamps and Linear Integrated Circuits', III Edn. (PHI, 1993).
6. Floyd T L, 'Digital Fundamentals', VII Edn. (Pearson Education Asia, 2002).
7. Cullity B D and Stock S R, 'Elements of X-ray diffraction', III Edn. (PH, 2001)
8. Ashcroft F W & Mermin N D, 'Solid State Physics' (Harcourt, 1976)
9. Verma A R and Srivastava O N, 'Crystallography Applied to Solid State Physics', II Edn. (New Age, 1991)
10. Kittel C, 'Introduction to Solid State Physics', IV Edn. (Wiley Eastern, 1974)
11. Cullity B D and Stock S R, 'Elements of X-ray diffraction', III Edn. (Prentice-Hall, 2001)
12. Ashcroft F W & Mermin N D, 'Solid State Physics' (Harcourt, 1976)
13. Verma A R and Srivastava O N, 'Crystallography Applied to Solid State Physics', II Edn. (New Age, 1991)
14. McKelvey J P 'Solid State and Semiconductor Physics' (Robert E. Kreiger, 1982)
15. Kittel C, 'Introduction to Solid State Physics', IV Edn. (Wiley Eastern, 1974)
16. Omar M A, 'Elementary Solid State Physics' (Addison Wesley, 1975)
17. Dekker A J, 'Solid State Physics' (Macmillan, 1971).
18. Singh J, 'Semiconductor Devices' (John Wiley, 2001)
19. M A Wahab " Solid State Physics" Narosa Publication, second edition 2005

Reference Books:

1. Alexander C K and Sadiku M N O, 'Fundamentals of Electric Circuits' (McGraw Hill International Edition, 2000)
2. Donald Neamen, 'Electronic Circuit Analysis and Design' II Edn. (Tata McGraw Hill, 2002)
3. Sedra A & Smith K C, 'Microelectronics', IV Edn. (Oxford University Press, India, 1998)
4. Horenstein M N, 'Microelectronic Circuits and Devices', II Edn. (PHI, 1996).

RPE 455: ENERGY STUDIES (Open elective) (39 Hrs.)

UNIT I

Renewable energy resources: Energy and Thermodynamics, Forms of Energy, Conservation of Energy, Entropy, Heat capacity, Thermodynamic cycles: Brayton, Carnot Diesel, Otto and Rankin cycle; Fossil fuels, time scale of fossil fuels and solar energy as an option. Solar Energy for Clean Environment Sun as the source of energy and its energy transport to the earth, Extraterrestrial and terrestrial solar radiations, solar spectral irradiance, Measurement techniques of solar radiations, Estimation of average solar radiation [13 hrs]

UNIT II

Basics of the Wind energy: Wind Energy Origin and classification of winds, Aerodynamics of windmill: Maximum power, and Forces on the Blades and thrust on turbines; Wind data collection and field estimation of wind energy, Site selection, Basic components of wind mill, Types of wind mill, Wind energy farm, Hybrid wind energy systems: The present Indian Scenario. [13 hrs]

UNIT III

Biomass energy and biogas technology: Nature of Biomass as a fuel, Biomass energy conversion processes, Direct combustion: heat of combustion, combustion with improved Chulha and cyclone furnace; Dry chemical conversion processes: pyrolysis, gasification, types of gasification Importance of biogas technology, anaerobic decomposition of biodegradable materials, Factors affecting Bio-digestion, Types of biogas plants, Applications of biogas. [13 hrs]

References

1. Peter A., ‘Advances in energy systems and technology’,(Academic Press, USA, 1986).
2. Neville C.R., ‘Solar energy conversion: The solar cell’, (Elsevier North-Holland, 1978).
3. Dixon A.E. and Leslie J.D., ‘Solar energy conversion’, (Pergamon Press, New York, 1979) .
4. Ravindranath N.H., ‘Biomass, energy and environment’, (Oxford University Press, 1995).
5. Cushion E., Whiteman A. and Dieterle G., (World Bank Report, 2009).

RPP 456: PHYSICS PRACTICALS III (General)

1. Half life of K-40
2. Thermoelectric constant
3. Gamma ray Spectrum of Cs-137
4. Ferroelectric Curie temperature
5. Estimation of effect of white light (sun tracking) on energy generation by solar PV module.
6. To measure the variation of dielectric constant with temperature and verification of Curie Weiss law.
7. Verification of Inverse square law (G.M.tube)
8. Transition temperature of ferrites.
9. Temperature dependence of Hall coefficient.
10. To study the I-V characteristics of solar panel.
11. Study of Hall effect
12. To measure the variation of dielectric constant with temperature and verification of Curie Weiss law.

*** Additional experiments may be included.**

RPP 457: PHYSICS PRACTICALS IV

1. Study of interference and diffraction using He-Ne Laser
2. Ultrasonic Interferometer
3. Michelson`s Interferometer
4. Constant deviation Spectrometer
5. Quarter wave plate
6. Diffraction Haloes
7. Fresnel’s laws of reflection
8. To determine the ionization potential of given source.
9. To determine the value of Planck’s constant using photocell/LED.
10. Babinet Compensator
11. Demonstration of energy quantization using the Frank-Hertz Experiment.
12. Study of Zeeman effect: determination of e/m for an electron

***Additional experiments may be included.**

RPH 501: ATOMIC AND MOLECULAR PHYSICS (52 Hrs.)

Unit I Spectra of single and multi electron atoms: Review of atomic models. Simple spectra of hydrogen and hydrogen like ions - energy levels, quantum numbers, electron spin, Stern - Gerlac experiment, fine structure, total angular momentum, Spin-orbit coupling, hydrogen energy levels, relativistic correction, radiation corrections, transition rates, selection rules.

Exclusion principle, ground state of multi electron atoms, periodic table. Spectra of two valence atom - alkali spectra, term values, doublet structure, transition and intensity rules. Spectra of alkaline earth elements, triplet structure, penetrating and non-penetrating orbitals: LS and jj coupling. Simple spectra of trivalent atom (qualitative). Quantum mechanical treatment of fine and hyperfine structure. Zeeman effect (classical & quantum mechanical treatment) Paschen-Back effect, Stark effect.

[13 hrs]

Unit II X-ray Spectra and Resonance spectroscopy: Review of emission & absorption of X-ray spectra (critical voltage, absorption coefficient, edge, filters) regular and irregular doublet law, Auger spectra.

Spin and an applied field, nuclear magnetic resonance [both hydrogen nuclei and other than hydrogen] techniques & instrumentation, structural study, electron spin resonance spectroscopy. **[13 hrs]**

Unit III Microwave spectra, infra red spectra and Raman spectroscopy: Theory of rotational spectra of diatomic molecules - Experimental technique – Microwave spectrometer, structural information. Microwave oven.

Theory of vibrating rotator, vibration - rotation spectra, IR spectrometer. Application in chemical analysis.

Quantum theory of Raman effect. Rotational and vibrational Raman spectra. Raman spectrometer. Laser Raman studies. F T Raman spectroscopy. F T Raman spectrometer. **[13 hrs]**

Unit IV Electronic spectroscopy: Electronic spectra of diatomic molecules - coarse structure - Frank-Condon principle - rotational fine structure - formation of band head and shading of bands - determination of I, r and band origin.

Fluorescence and phosphorescence: mirror image symmetry of absorption and fluorescence bands. Basic principles of photoelectron spectra. Instrumentation. Determination of ionization potential.

Mossbauer spectroscopy: Principles of Mossbauer spectroscopy. Mossbauer spectrometer. Applications. **[13 hrs]**

Text Books:

1 Ghoshal S N, ‘Atomic and Nuclear Physics’, Vol. I & II (S Chand & Company, 1994)
2 Beiser A, `Concept of Modern Physics’ V Edn. (Tata McGraw Hill, 1997)

3 Banwell C N and E M McCash, ‘Fundamentals of Molecular Spectroscopy’, IV Edn. (Tata McGraw Hill, 1994)

Reference books:

1. Kuhn H G, ‘Atomic Spectra’, III Edn. (Benjamin, 1977)
2. Haken H & Wolf H C, ‘Atomic and Quantum Physics’, V Edn. (Springer-Verlag, 1997)
3. Henry Semat & John R AlBright, ‘Introduction to Atomic and Nuclear Physics’ V Edn. (Chapman & Hall, 1972)
4. Chatwall Gurdeep, ‘Spectroscopy’, III Edn. (Himalayas, 1994)
5. Robert Eisberg & R Resnick, ‘Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles’, II Edn. (John Wiley & Sons)
6. Straughan B P and Walker S, ‘Spectroscopy’, Vol. I, II and III (Chapmann & Hall, 1976)
7. Svanberg S, ‘Atomic and Molecular Spectroscopy’, II Edn. (Springer Verlag, 1992)
8. Herzberg, ‘Molecular Spectra and Molecular Structure’, Vol. I, II & III (Van Nostrand Co., 1966).

RPH 502: THERMODYNAMICS AND STATISTICAL PHYSICS (52 Hrs.)

Unit I Thermodynamics: Concept of entropy - principle of entropy increase - entropy and disorder. Enthalpy - Helmoltz and Gibb's functions. Maxwell's relations - TdS equations - energy equations - Heat capacity equations - heat capacity at constant pressure and volume. Phase space and ensembles - Lioullis theorem, probability - thermal equilibrium. **[13 hrs]**

Unit II Classical statistics: Boltzmann distribution, calculation of velocities - average and r.m.s veleocities Gibbs' paradox, Sackur - Tetrode equation, partition functions - translational partition funciotn, vibrational, rotational and electronic partition functions. Boltzmann equipartition theorems. Application to specific heats. **[13 hrs]**

Unit III Quantum statistics: Bosons and Fermions - Bose-Einstein and Fermi-Dirac distributions - degenerate Fermi and Bose gases - Bose-Einstein condensation - Planck's law of black-body radiation. Liquid helium - Lambda transition.

Fluctuations - Fluctuations in canonical, grand canonical and microcanonical ensembles. Number fluctuations in quantum gases. **[13 hrs]**

Unit IV Brownian motion: Langevin equation for random motion, Random walk problem. Diffusion and Einstein relation for mobility.

Time dependence of fluctuations: power spectrum of fluctuations, persistence and correlation of fluctuations. Wiener - Khinchin theorem, Johnson noise and Nyquist theorem. Shot noise, Fokker-Planck equation. **[13 hrs]**

Text Books:

1. Zeemansky M W and Dittman R H, 'Heat and Thermodynamics', VII Edn. (McGraw Hill International Edn., 1999)
2. Gopal E S R, 'Statistical Mechanics and Properties of Matter' (Macmillan, 1976)
3. Agarwal B K and Melvine Eisner, 'Statistical mechanics' (Wiley Eastern Ltd., 1991)

Reference Books:

1. Kittel C and Kroemer H, 'Thermal Physics', II Edn. (CBS Publ., 1980)
2. Chandler D, 'Introduction to Modern Statistical Mechanics' (Oxford university Press, 1987)
3. Reichl L E, 'A Modern Course in Statistical Physics' (University of Texas Press, 1980)
4. Landau and Lifshitz, 'Statistical Physics', III Edn. (Oxford, Pergamon, 1980)
5. Gupta M C, 'Statistical Thermodynamics' (New Age, 1995)
6. Reif F, 'Fundamentals of Statistical and Thermal Physics' (McGraw Hill, 1965)

RPS 503 : RADIATION PHYSICS I **[52 hrs]**

Unit I Interaction of radiation with matter

Passage of heavy charged particles through matter : Energy loss by collision, maximum energy loss in a single collision, range energy relation, Bragg curve, Specific ionization, mean excitation energies, Bethe-Bloch formula collision stopping power, radiation stopping power.

Interaction of neutrons : Neutron sources, General properties, energy classification, elastic and inelastic scattering, nuclear reaction, neutron activation and induced activity, radioisotope production, Nuclear fission. [13 hrs]

Unit II Radiation detectors

Characteristics of organic and inorganic scintillation counters, Resolving time, Semiconductor devices - physics of semiconductors, diffused junction, surface barrier and ion-implanted detectors, Examples, Semiconductor spectrometer, Analysis of pulse height of spectra, superheated drop detectors. Neutron detectors : BF_3 counters, fission chambers, activation methods, Neutron time of flight method.

Preamplifier circuits, noise, linear pulse amplifier, pulse shaping, pulse stretching, operation amplifier, Pulse discriminators, coincidence and anti-coincidence circuits. Scalers, single and multichannel analyser, charge sensitive amplifier. Principles of measurement (collimation shielding, geometry, calibration),Radiation survey instruments. [13 hrs]

Unit III Measurement of radiation exposure and dose

Particle flux and fluence, energy flux and fluence, cross section, linear and mass absorption coefficient, stopping power and LET. Exposures and its measurement, absorbed dose and its relation to exposure. Electronic equilibrium, Bragg-Gray principle and air wall chamber, Kerma, Kerma rate constant. Biological effectiveness, Equivalent dose, effective dose, Committed equivalent dose, Ambient and directional equivalent dose. Tissue equivalence. [13 hrs]

Unit IV Internal and external dosimetry

Biological half-life, effective half-life, selectivity of organs, beta particle dosimetry. Calculation of integral dose due to internal deposition, specific effective energy, annual limit on intake, derived air concentration.

Dosimeters : Primary and secondary dosimeters. Pocket dosimeters, films, TLDs. Chemical and calorimetric devices. [13 hrs]

Text Books:

1. Knoll G F, 'Radiation Detection and Measurements' (Wiley, New York, 1989)
2. Kapoor S S and Ramamurthy V S, 'Nuclear Radiation Detectors' (Wiley Eastern Ltd., New Delhi, 1986)
3. Herman Cember, 'Introduction to Health Physics' (Pergamon Press, 1983)
4. Attix F H et al, 'Radiation Dosimetry', Vol. I, II and III (Academic Press, NY, 1968)

Reference Books:

1. Glasstone S, ‘Source book on Atomic Energy’ (East West Press, New Delhi, 1975)
2. Greening J R, Bristol, Adam Hilger, ‘Fundamentals of Radiation Dosimetry’ (Medical Physics Hand Book 6, 1981)
3. Morgan K Z and Turner J E, ‘Health Physics’ (Wiley, NY, 1978)
4. Horowitx Y S, Boca Raton (eds.), ‘Thermoluminescence and TL Dosimetry’, Vol. I, II and III, (CRC Press, 1984)
5. Mann W B, Et al, ‘Radioactivity and its Measurements’ (Pergamon Oxford, 1980)
6. Dillman L T, et al, ‘Radionuclide Decay Scheme and Dose Estimation’ Society of Nuclear Medicine, NY, MIRD Pamphlet No. 10, 1975
7. Taylor L S, ‘Radiation Protection Standards’ (CRC Press, Cleveland, Ohio, 1971)
8. Richard F. Mould, ‘Radiation Protection in Hospitals Medical Sciences Series’ (Adam Hilger Ltd, Bristol and Boston, 1985)
9. Kenneth R Kase, Bjarngard B E and Attix F H, ‘The Dosimetry of ionising radiation’, Vol I & II (Academic Press, 1985 & 1987)
10. Ronald L. Kathren, ‘Radiation Protection’ (Adam Hilger Ltd. International Publishers Services, 1985)
11. Merril Eisenbud, ‘Environmental Radioactivity’ (Academic Press, Orlando, 1987)
12. James E Turner, ‘Atoms, Radiation & Radiation Protection’ (Pergamon Press, 1986)

RPS 504: RADIATION PHYSICS II **(52 hrs)**

Unit I Industrial applications of radiations

Industrial radiography: X-ray and isotope radiography. Radiographic exposure devices, design, operation and accessories.

Activation analysis : Basic principles, advantages and limitations. Time of irradiation Vs half life. Choice of detectors and irradiation. Method of estimation. Decay and special characteristics.

Tracer techniques : Industrial and medical sources, choice of tracer. Tracer kinetics. Principles of applications of tracers in hydrological and industrial systems. Nucleonic gauges : Principle and measurement of thickness and level in different applications, density and moisture, hydrogen in hydrocarbons, well logging - techniques and principles, based on absorption, transmission and scattering of gamma, beta and neutron radiations. Consumer products : Principle of operation of fire detectors, static eliminators, luminous paints and gas mantles. [13 hrs]

Unit II Production of X rays and Accelerator beams Medical and industrial accelerators – Safety aspects of medical accelerators – application of radiation in industry.[13 hrs]

Unit III Industrial radiation processing

Elements of radiation chemistry - production of free radicals, radical diffusion and formation of molecular products, G-Values, Chemical transformation. Applications of radiation processing in irradiation design and food preservation, radiation sterilization and chemical processing. Electron and gamma radiation application in polymerisation and cross linking. Radiopharmaceuticals, radiation sterilization of medical products. Polymerisation - wood, vinyl monomers, fibre boards, vulcanisation of rubber.[13 hrs]

Unit IV Radiation hazard evaluation and control

Hazard evaluation by calculation, methods of calculation, area monitoring, personal monitoring. Detection and measurement of contamination on work surface and person. Methods of decontamination. Planning of medical and industrial radiation installations. Radiation scattering, albedo, sky shine, noxious gas production.

Emergency preparedness for different types of radiation installations. Graded approach. Philosophy of response. On-site emergency and Off-site emergency. [13 hrs]

Text Books:

1. Foldiak G (ed) ‘Industrial application of radioisotopes’ (Elsevier Science Publishing company, New York, 1986)
2. John R Lamarsh, `Introduction to Nuclear Engineering’ (Addison Wesley Publishing Company, 1983)
3. Training manual for Health Physics qualification, (Level III), (compiled by Muay C D Kathuria S P, BARC, Mumbai, 1989)
4. Stewart D C, Handling Radioactivity: a practical approach for scientists and engineers, (Wiley Interscience Publication, 1981)

Reference Books:

1. Knoll G F, 'Radiation Detection and Measurements' (Wiley, New York, 1989)
2. Greening J R, Bristol, Adam Hilger, 'Fundamentals of Radiation Dosimetry' Medical Physics Hand Book 6, 1981
3. Morgan K Z and Turner J E, 'Health Physics' (Wiley, NY, 1978)
4. Mann W B, Et al, 'Radioactivity and its Measurements' (Pergamon Oxford, 1980)
5. Dillman L T, et al, 'Radionuclide Decay Scheme and Dose Estimation', Society of Nuclear Medicine, NY, MIRD Pamphlet No. 10, 1975
6. Taylor L S, 'Radiation Protection Standards' (CRC Press, Cleveland, Ohio, 1971)
7. Richard F. Mould, 'Radiation Protection in Hospitals Medical Sciences Series' (Adam Hilger Ltd, Bristol and Boston, 1985)
8. Kenneth R Kase, Bjarngard B E and Attix F H, 'The Dosimetry of Ionising Radiation' Vol I & II (Academic Press, 1985 & 1987)
9. James E Turner, 'Atoms, Radiation & Radiation Protection', (Pergamon Press, 1986)
10. 'Inter-regional Training Course on Radiation Protection', Dec. 12, 1984 to May 17, 1985, Lecture Notes, Vol. I to IV, (Compiled by Kathuria S P and Somasundaram S, BARC, Mumbai, 1985)
11. Herman Cember, 'Introduction to Health Physics' (Pergamon Press, 1983)

RPE505: RADIATION SOURCES AND HAZARDS (open elective) (39 hrs.)

Unit I Radiation Sources, Gamma chamber, Particle Accelerators – DC accelerators, Linac, Cyclic accelerators, Synchrotron Radiation Sources. Accelerator as photon, neutron and other particle sources. Accelerators in medical and industrial applications. Safety aspects of accelerators. [13 hrs]

Unit II Radiation biophysics Basic aspects of cell biology and physiology. Mechanism of direct and indirect action of radiation at cellular level. Nature of radiation damage at molecular, subcellular and cellular level. Induction of chromosomal aberrations and its application in biological dosimetry of absorbed radiation. Cell killing and induction of mutations. Physical, chemical and biological modifiers of cellular response. Radiation effects on human beings – deterministic and stochastic effects, Dose limits. [13 hrs]

Unit III Radiation hazard, evaluation, control and radiation protection
Hazard evaluation by calculation, area monitoring, personal monitoring. Detection and measurement of contamination on work surface and person. Methods of decontamination. Planning of medical and industrial radiation installations.

Radiation protection standards : Need for protection, philosophy of radiation protection. ALARA principle. Time, distance, shielding. External and internal exposure. [13 hrs]

Text Books:

1. Attix F H et al, 'Radiation Dosimetry', Vol. I, II and III (Academic Press, NY, 1968)
2. Knoll G F, 'Radiation Detection and Measurements' (Wiley, New York, 1989)
3. Erich J Hall, 'Radiology for the Radiologists', III Edn. (J B Lippincott Company, New York, 1988)
4. Herman Cember, 'Introduction to Health Physics' (Pergamon Press, 1983)

Reference Books:

1. Glasstone S, 'Source book on Atomic Energy' (East West Press, New Delhi, 1975)
2. Greening J R, Bristol, Adam Hilger, 'Fundamentals of Radiation Dosimetry',(Medical Physics Hand Book 6, 1981)
3. Morgan K Z and Turner J E, 'Health Physics' (Wiley, NY, 1978)
4. Horowitx Y S, Boca Raton (eds.), 'Thermoluminescence and TL Dosimetry', Vol. I, II and III, (CRC Press, 1984)
5. Mann W B, Et al, 'Radioactivity and its Measurements', (Pergamon Oxford, 1980)
6. Dillman L T, et al, 'Radionuclide Decay Scheme and Dose Estimation' Society of Nuclear Medicine, NY, MIRD Pamphlet No. 10, 1975
7. Taylor L S, 'Radiation Protection Standards', (CRC Press, Cleveland, Ohio, 1971)
8. Richard F. Mould, 'Radiation Protection in Hospitals Medical Sciences Series', (Adam Hilger Ltd, Bristol and Boston, 1985)
9. Kenneth R Kase, Bjarngard B E and Attix F H, 'The Dosimetry of ionising radiation', Vol I & II (Academic Press, 1985 & 1987)

RPP506: RADIATION PHYSICS – PRACTICALS I

1. Random nature of radioactive decay
2. Dead time of GCS
3. Absorption of beta rays
4. End point energy of beta particles - Feather analysis
5. Energy calibration and resolution of GRS
6. Inverse square law
7. Rest mass energy of electron

RPP507: RADIATION PHYSICS – PRACTICALS II

1. Coincidence circuit (discrete components)
2. Anticoincidence circuits (discrete components)
3. Display devices
4. Pulse stretcher
5. FET amplifer
6. Linear pulse amplifier
7. Data analysis employing PC
8. Activity calculation using NaI(Tl) spectrometer
9. Attenuation of gamma rays

RPH 551: LASER PHYSICS, VACUUM TECHNIQUES AND CRYOGENICS (52 Hrs.)

Unit I Lasers and non-linear optics

Lasers - introduction - directionality, intensity, monochromaticity, coherence.

Einstein coefficients - stimulated emission. Basic principles of lasers - the threshold condition - laser pumping.

Some specific laser systems - Neodymium lasers - He-Ne laser - ion lasers - CO_2 laser - Semiconductor lasers - dye lasers - chemical lasers - X ray lasers, free electron laser, Q switching. [13 hrs]

Unit II Holography and Non-linear optics

Principle of holography - some distinguishing characteristics of holographs - practical applications of holography.

Non-linear optics: harmonic generation - second harmonic generation - phase matching - third harmonic generation Z scan technique - optical mixing - parametric generation of light - self focussing of light. Electro optic effect.

Multiquantum photoelectric effect - two photon processes - multiphoton processes - three photon processes. [13 hrs]

Unit III Vacuum techniques

Units of vacuum - vacuum spectrum (ranges - low - medium - high - ultra high). Applications - freeze drying - vacuum coating - industrial applications. Conductance of pipes - pumping speed - throughput - pumpdown time.

Vapour pressure - vacuum gauges and the relevant range of vacuum - Pirani gauge - thermocouple gauge - Pennning gauge.

Vacuum pumps - rotary vane pump (pumping speed and ultimate pressure) - oil diffusion pump - baffle and trap - cryopump - turbomolecular pump. Vacuum feedthroughs - vacuum valves (diaphragm valve, slide valve, ball valve).[13 hrs]

Unit IV Cryogenic techniques

Overview of the techniques of liquefaction of gases (Nitrogen, Hydrogen and Helium). Gas purification - stirling cycle refrigeration and liquefaction of helium.

Properties of cryogenic fluids (Nitrogen and Helium 4). Storage and transfer of cryogenic fluids: Dewars for nitrogen and helium. Liquid level indicators and gauges.

Measurement of temperature: Resistance thermometers (metal, alloys & semiconductors). Thermocouple - (Au + Fe) Vs chromel. Magnetic thermometer.

Cooling by evaporation of helium 4 and helium 3 - cooling by adiabatic demagnetisation. Cryostats for low temperature experiments. [13 hrs]

Applications of cryogenics: Hydrogen bubble chamber - Rocket propulsion system - superconducting magnets.

Text Books:

1. Silfvast W T, ‘Laser Fundamentals’ (Cambridge University Press, 1998)
2. Ghatak A K and Thyagarajan, ‘Optical Electronics’ (Cambridge University Press 1991)
3. Laud B B, ‘Lasers & Nonlinear Optics’ (Wiley Eastern, 1985)
4. Mills D L, ‘Nonlinear Optics – Basic Concepts’ (Narosa Publishing, 1991)
5. Roth A, `Vacuum Technology’, II Edn. (North Holland, 1982)
6. Barron R F, `Cryogenic Systems’ II Edn. (Oxford University Press, 1985)
7. Wilks J and Betts D S, `An Introduction to Liquid Helium’ (Oxford University Press, 1987)

Reference Books:

1. Shen Y R, ‘The Principles of Nonlinear Optics’ (John Wiley, 1984)
2. Boyd R W, ‘Nonlinear Optics’ (Academic Press, 1992)
3. Zernike F & Midwinter, ‘Applied Nonlinear Optics’ (Wiley, 1973)
4. Oshea D C, Callen W R & Rhodes W T, ‘Introduction to Lasers & Their Applications’ (Addison Wesley, 1977)
5. Harris N S, `Modern Vacuum Practice’ (McGraw Hill, 1989)
6. O’Hanlon J F, `A User’s Guide to Vacuum Technology’ (John Wiley, 1980)
7. West C D, `Principles and Applications of Stirling Engines’ (Van Nostrand Reinhold, 1986)

RPH 552 ASTROPHYSICS AND RELATIVITY (52 Hrs.)

Unit I Astrophysics

Introduction – constellations, solstices, equinoxes, zodiac, temperature of stars and their classification, visible and invisible astronomy.

Asteroids, Comets and Meteorites.
Doppler effect. Hubble's law. Origin and evolution of solar system. Apparent and absolute magnitudes of stars. Measurement of stellar distances – method of heliocentric parallax, statistical parallax method, apparent luminosity method, spectroscopic parallax method. Variable star distances. Nova distances.[13 hrs]

Unit II Energy generation in stars. Contents of milkyway galaxy

Hertzsprung – Russel diagram – it's uses. Evolution of stars – star birth, evolution to, on and off the main sequence, evolution to the end.

White dwarfs, neutron stars, stellar explosions – nova, pulsars, black holes, binary X-ray systems and quasars.

Cosmological models – steady state and Big-Bang models. Evolution of Universe. Origin of life on earth.[13 hrs]

Unit III Theory of relativity
Special theory : review – postulates of special theory of relativity, relativity of simultaneity and Lorentz transformation equation of lengths perpendicular and parallel to relative motion; time intervals, transformation of velocities and acceleration. Stellar aberration. Doppler effect. Relativistic force law and dynamics of single particle. Equivalence of mass and energy.

4 dimensional formulation of theory of relativity - Lorentz transformation, length contraction, time dilation, covariance of laws of nature. 4 dimensional line element. 4 velocity, 4 acceleration, 4 momentum and 4 force. Fundamental equations of motion of a particle in 4 dimensional vector form.

Inertial and gravitational mass. Eotvos experiment.[13 hrs]

Unit IV General relativity

Tensor calculus – Christoffel symbols – covariant differentiation of tensors – the equation of geodesic line – the Riemann – Christoffel tensors – transformation laws for the Christoffel symbols. Stress-Strain tensors – Maxwell's equation in tensor form.

Principles of equivalence and covariance. Schwarzschild line element. Schwarzschild radius. Tests for the theory of relativity – Advance of perihelion, light trajectory in a Schwarzschild field, gravitations shift of spectral lines. Experiment of Rebka and Pound.[13 hrs]

1. Introduction to Astrophysics 'Baidyanath Basu' (PHI, 1997).
2. Michael Feilik and John Gaustad 'Astronomy the Cosmic Prospective' (John Wiley & Sons, Inc., 1990)
3. Resnik R, 'Introduction to Special Relativity' (Wiley Eastern, 1972)
4. Rindler W, 'Introduction to Special Relativity', II Edn. (Oxford University Press, 1991)

Reference Books:

1. Schutz B F, 'A First Course in General Relativity' (Cambridge University Press, 1985)
2. Feilik M, 'Astronomy – the Evolving Universe' III Edn (Harper and Row, 1982)
3. Boris A Vorontsov-Vel'yaminov, 'Essay about the Universe' (Mir Publishers, Moscow, 1985)
4. French A P, 'Special Relativity' (Thomas Nelson, 1968)
5. Moller C, Theory of Relativity II Edn. (Claredon Press, 1972)
6. Jean-Pierre-Luminet 'Black Holes' (Cambridge University Press, 1987)
7. D Mc Gillivray 'Physics and Astronomy' (McMillan, 1987)
8. Michael Berry 'Principles of Cosmology and Gravitation' (Cambridge University Press, 1976)
9. Rosser W G V, 'An Introduction of the Theory of Relativity' (ELBS – Butterworth, 1972)
10. Lord EA, Tensorl, Relativity and Cosmology' (Tata McGraw Hill, 1976)
11. Ray d'Inverno, 'Introducing Einstein's Relativity' (Oxford University Press, 1992)
12. Dixon W G, 'Special Relativity, the Foundation of Modern Physics' (Cambridge University Press, 1978)
13. Adler R, Bazin M & Schiffer M, 'Introduction to General Relativity', II Edn. (McGraw Hill, 1975)
14. Hughston L P and Tod K P, 'An Introduction to General Relativity' (Cambridge University Press)
15. Hans Stephani, 'General Relativity' II Edn. (Cambridge University Press, 1990)
16. Peter Gabrial Bergmann 'Introduction to theory of Relativity' (PHI, 1989)
17. Nigel Henbest and Heather Couper 'The Restless Universe' (George Philip, 1982)
18. Jagjit Singh. 'Great Ideas and Theories of Modern Cosmology' (Dover Publications, Inc., 1961)
19. Marc L Kutner " Astronomy a physical perspective (2^{nd} edition) Cambridge University Press 2003.

RPS553: RADIATION PHYSICS III (52 hrs)

Unit I Radiation transport

Basic concepts of radiation transport, Transport equation, Ficks's law and diffusion equation, Boundary conditions, Analytical solution to diffusion equation. Energy dependent transport and diffusion equation, slowing theory, resonance absorption. Criticality calculations. Fermi age theory. Four factor formula. Models and consequences of nuclear fission, cross sections of fission, capture, scattering and fission products. [13 hrs]

Unit II Radiation shielding

Shielding calculation for gamma radiation, choice of material, primary and secondary radiations, source geometry. Beta shielding, bremsstrahlung. Neutron shielding, scattering and absorption, activation of the shielding material, heat effects. Optimisation of shielding, shielded windows in hot cells, gamma, electron, neutron irradiation facilities. Transport and storage of containers for high activity sources. Shielding requirements for medical, industrial and research facilities including accelerator installations. [13 hrs]

Unit III Radiation biophysics

Basic aspects of cell biology and physiology. Mechanism of direct and indirect action of radiation at cellular level. Nature of radiation damage at molecular, subcellular and cellular level. Induction of chromosomal aberrations and its application in biological dosimetry of absorbed radiation. Cell killing and induction of mutations.

Target theory of cell inactivation and theoretical models for cell survival response, application of these models in therapy, food preservation, sterilization, sludge hygienization etc. Physical, chemical and biological modifiers of cellular response-dose, dose rate, dose fractionation, LET, hyperthermia oxygen, sensitizers, protectors, cell cycle stage, cellular repair processes. Law of Bergonie and Tribondeau-protocol for human cell sensitivity.

Radiation effects on human beings – deterministic and stochastic effects, parental radiation effects, radiobiological basis of risk evaluation and evolution of radiation protection standards. Dose limits. [13 hrs]

Unit IV Principles of radiation protection

Radiation protection standards : Need for protection, philosophy of radiation protection. ALARA principle. Time, distance, shielding. External and internal exposure. ICRP and AERB recommendations. Regulatory aspects of radiation protection : Atomic Energy Act, Radiation Protection Rules, Notifications, Transport regulations, Waste disposal Rules, Food irradiation rules, Licensing, Approval of devices and packages.
[13 hrs]

Text Books:

1. Glasstone S and Sesonske A, ‘Nuclear Reactor Engineering’ (CBS, Delhi, 1986)
2. Taylor L S, ‘Radiation Protection Standards’ (CRC Press, Cleveland, Ohio, 1971)
3. Kenneth J Schultz and Richard E Faw, ‘Radiation Shielding’ (Prentice Hall)

4. Erich J Hall, ‘Radiology for the Radiologists’, III Edn. (J B Lippincott Company, New York, 1988)

Reference Books :

1. Glasstone S, ‘Source book on Atomic Energy’ (East West Press, New Delhi, 1975)
2. Knoll G F, ‘Radiation Detection and Measurements’ (Wiley, New York, 1989)
3. Stewart D C, ‘Handling Radioactivity: A Practical Approach for Scientists and Engineers’ (Wiley Interscience Publication, 1981)
4. Dillman L T, et al, ‘Radionuclide Decay Scheme and Dose Estimation’, Society of Nuclear Medicine, NY, MIRD Pamphlet No. 10, 1975
5. Richard F. Mould, ‘Radiation Protection in Hospitals’, Medical Sciences Series, (Adam Hilger Ltd, Bristol and Boston, 1985)
6. Kenneth R Kase, Bjarngard B E and Attix F H, ‘The Dosimetry of Ionising Radiation’, Vol I & II (Academic Press, 1985 & 1987)
7. Arthur C. Upton et al, ‘Radiation Carcinogenesis’ (Elsevier, 1986)
8. Chilton A B, `Principles of Radiation Shielding’ (Prentice Hall Inc)
9. Price Horton B T and Spinney, ‘Radiation Shielding’, (Pergaman Press)
10. Ronald L. Kathren, ‘Radiation Protection’, (Adam Hilger Ltd. International Publishers Services, 1985)
11. Cutler J H et al, ‘The Chernobyl Accident and its Consequences’, (UKAEA, II Charler II Street, London, 1987)
12. ‘Nuclear Safety: After TMI and Chernobyl’, Ed. by Ballard G M, (Elsevier, Applied Sciences, London, 1988)
13. ‘Radiation & Health: The Biological Effects of Low Level Exposure to Ionising Radiation’, Ed. by Robin Russel Jones & Richard Sourthwood, (Wiley Medical Publication, 1987)
14. James E Turner, Atoms, Radiation & Radiation Protection, (Pergamon Press, 1986)
15. Inter-regional Training Course on Radiation Protection, Dec. 12, 1984 to May 17, 1985, Lecture Notes, Vol. I to IV, (Compiled by Kathuria S P and Somasundaram S, BARC, Mumbai, 1985)
16. Training Manual for Health Physics Qualification, (Level III), (compiled by Muay C D Kathuria S P, BARC, Mumbai, 1989)
17. Herman Cember, Introduction to Health Physics, (Pergamon Press, 1983)
18. Eicholz G G and Ann Arbor Mich, `Environmental Aspects of Nuclear Power’, (Ann Arbor Science, 1976)
19. Richard F Mould, `Radiation Protection in Hospitals Medical Science Series’, (Adam Hilger Ltd., Bristol and Boston, 1985)
20. John R Lamarsh, `Introduction to Nuclear Engineering’ (Addison Wesley Publishing Company, 1983)

RPS554: RADIATION PHYSICS IV **[52.Hrs]**

Unit I Anatomy, physiology and radiobiological basis of radiation therapy

Anatomy and physiology relevant to radiodiagnosis and radiotherapy. Structural and functional aspects of different systems – haemopoietic, digestive, cardiovascular, skeletal, nervous, reproductive and endocrine systems.

Tumour biology – growth kinetics, tumour growth delay, tumour cure. Causes of clinical radioresistance. Fractionated radiotherapy, the 4 R's of radiotherapy-repair, reoxygenation, repopulation, reassortment. New modalities of radiation therapy.

Time dose fractionation, Concept of NSD, TDF and BED. Linear quadratic model of cell survival and its applications in the radiotherapy of cancer- values. ERD/BED doses for normal tissues and tumours. BED for fractionation and brachytherapy protocols. Correction for loss of BED, Correction for incomplete repair between fractions, designing alternative schedules. [13 hrs]

Unit II Diagnostic radiology and modern trends in imaging techniques

Physical principles of x-ray diagnosis, density, contrast, detail and definition of radiograph, choice of kV, mA, filtration, FSD, screens, films, grids, contrast media, concept of modular transfer function and its applications, radiographic techniques, special procedures: Myelography, Tomography, Fluoroscopy, Pelvimetry, Film processing, Image intensifiers and television monitoring, reduction of patient dose, quality assurance in diagnostic radiology, performance standards, acceptance and QA tests, Test tools for kV, timer, focal spot size, collimator, beam alignment, high contrast, film-screen contact and grid alignment.

CT scanners and their applications, digital subtraction radiography (DSA), Magnetic resonance imaging (MRI), ultrasound, Mammography, Xeroradiography, Thermography. [13 hrs]

Unit III Beam therapy [21 hrs]

Benign and malignant tumours, Tissue tolerance dose and tumour lethal dose, Fractionation, Palliative and Curative therapy, Spectral distribution of X-rays dose measurement, check phantom, Output calibration procedures, Backscatter and central axis depth doses, Isodose curves, Wedge filters, Shielding blocks and compensators, Treatment Planning in teletherapy, Role of computers, Corrections for body inhomogenity, Contour shapes and beam obliquity, Rotation therapy and tissue air ratio, Tissue maximum ratio, Integral dose, Telegamma therapy, Megavoltage X-ray therapy, Electron contamination, particulate beam therapy, relative merits of electron, x-ray and gamma ray beams, neutron capture therapy, Modern trends, Heavy ion therapy, Adjuncts such as hyperbaric oxygen, hyperthermia, radiosensitizers and chemotherapy.

Brachytherapy : Intracavitars, interstitial techniques and advantages, criteria for source selection, radium and radium substitutes, Caesium-137, Cobalt-60, Iridium-192, Iodine-125 sources, Paterson Parker and Manchester Dosage Systems. Afterloading techniques, Manual and remote, advantages radiographic localisation of implanted sources, Beta ray applicators, Use of computers in brachytherapy dosimetry, QA in brachytherapy equipment and sources. Calibration of sources, checking of source integrity and uniformity. [13 hrs]

Unit IV Nuclear Medicine

Clinical radioisotope laboratory organization, Radio-iodine in thyroid function tests, Iodine cycle, Tri-iodothyroxine test, Indices of thyroid function, use of Technetium-99m.

Iron clearance and utilization, Red cell survival, Bleeding from GI tract, Platelet survival, Absorption studies with vitamin B-12, iron, calcium and fat-use of whole body counters.

Physical principles of isotope dilution analysis, Discussion of multiple compartment systems, Measurement of circulation time, Renal, liver, lung, cerebral function studies, Placental localisation, Nuclear cardiology. Radioisotope Scanners and cameras, Single hole and Multihole collimators for scanning, Examples of organ scans. Cyclotron - produced radionuclides, SPECT and PET, In-vitro procedures, RIA kit.

[13 hrs]

Text Books:

1. Erich J Hall, 'Radiology for the radiologists', III Edn. (J B Lippincott Company, New York, 1988)
2. Faiz M Khan, 'The Physics of Radiation Therapy'
3. Gilbert H Fletcher, 'Text book of Radiotherapy'
4. Dobbs J, Barret A , Ash D, 'Practical Radiotherapy Planning', II Ed. (Arnold, London)

Reference Books:

1. 'Inter-regional Training Course on Radiation Protection', Dec. 12, 1984 to May 17, 1985, Lecture Notes , Vol. I to IV (Compiled by Kathuria S P and Somasundaram S, BARC, Bombay, 1985).
2. 'Training Manual for Health Physics Qualification', (Level III), Compiled by Mulay C D and Kathuria S P, BARC, Bombay, 1989.
3. Meredith W J and Massay J B, 'Fundamental Physics of Radiology'
4. Govindarajan K N, Advanced Medical Radiation Dosimetry
5. Thomas S Curry, James E Dowdey, Robert C Murry, 'Christensen's Introduction to the Physics of Diagnostic Radiology'
6. Johnes H E and Cunninghum J R, 'The Physics of Radiology'
7. Schall W E, 'X-rays'
8. Young M E J, 'Radiological Physics'
9. Walter and Miller, 'A Short Book of Radiotherapy'
10. Oliver R, 'Radiation Physics in Radiology'
11. Robertson, 'Radiology Physics'
12. 'Quality Assurance and Surveillance in Diagnostic Radiology', Manual of procedures, Division of Radiological Protection, BARC, Bombay [1989)
13. Sue Griffiths and Chris Short, Radiotherapy: 'Principles to Practice-A Manual for Quality in Treatment Delivery'
14. William R Hendee and Geofferey S Ibbott, 'Radiation Therapy Physics'

15. Greene D, ‘Linear Accelerators for Radiation Therapy’
16. Greening J R, ‘Fundamentals of Radiation Dosimetry’
17. Mould R F, ‘Radiotherapy Treatment Planning’
18. Wilks R, ‘Principles of Radiological Physics’
19. Steel G C, Adams G E, Peckham M J, ‘The Biological Basis of Radiotherapy’ (Elsevier, Amsterdam, 1989)
20. Thames H D, Hendry J H, ‘Fractionation in Radiotherapy’ (Taylor and Francis, Bristol, 1987).