



UNIVERSITY OF CALICUT

Abstract

General and Academic - Faculty of Science - Syllabus of MSc Radiation Physics under CCSS PG Regulations 2019 with effect from 2019 Admission onwards -Modified - Implemented - Orders Issued

G & A - IV - J

U.O.No. 15916/2019/Admn

Dated, Calicut University.P.O, 11.11.2019

- Read:-*
1. U.O.No. 4500/2019/Admn Dated 26.03.2019
 2. U.O.No. 9546/2019/Admn Dated 19.07.2019
 3. UO Note No. 1016/EX-II-ASST-3/2014/P.B Dated 27 .07 .2019
 4. Letter dated 06.08.2019 from the Chairman, Board of Studies in Radiation Physics
 5. Remarks of the Dean, Faculty of Science

ORDER

The Regulations under Choice-based Credit Semester System for Post Graduate Programmes (CCSS-PG -2019) of all Teaching Departments / Schools of the University of Calicut w.e.f 2019 admissions has been implemented vide paper read first above.

The Scheme and Syllabus of MSc Radiation Physics programme under CCSS PG Regulations 2019 with effect from 2019 Admission onwards has been implemented, vide paper read second above.

The Examination branch pointed out some discrepancies in the implemented syllabus of MSc Radiation Physics with effect from 2019 admns onwards, vide paper read third above and the Chairman, Board of Studies in Radiation Physics has submitted the modified syllabus of MSc Radiation Physics under CCSS PG Regulations 2019 with the following modifications in the syllabus, vide paper read fourth above.

1. Page No.7- **Name of Course title of RPH4C24** is changed in to **Quality assurance, acceptance testing and Commissioning of Radiation System.**
2. Page No.7- **Name of Course title of RPH4E26A** is changed in to **Modern Trends in Radiology and Radiotherapy.**
3. Page No.32- Course code **RPH3C27** changed in to **RPH4C27**
4. Model Question paper of first semester attached with the syllabus

The Dean, Faculty of Science has approved the modified syllabus of MSc Radiation Physics programme in tune with the new CCSS PG Regulations with effect from 2019 Admission onwards, vide paper read fifth above.

Under these circumstances , considering the urgency, the Vice Chancellor has accorded sanction to implement the modified scheme and syllabus of M Sc Radiation Physics Programme in accordance with the new CCSS PG Regulations 2019, in the University with effect from 2019 Admission onwards, subject to ratification by the Academic Council.

The modified Scheme and Syllabus of MSc Radiation Physics Programme in accordance with CCSS PG Regulations 2019 ,is therefore implemented with effect from 2019 admn. onwards. U.O No. 9546/2019/Admn dated 19.07.2019 stands modified to this extent.

Orders are issued accordingly. (Modified Syllabus appended).

Biju George K

Assistant Registrar

To

The HoD, Department of Physics
Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/DoA/EX and EG
Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

Section Officer

SCHEME, REGULATIONS AND SYLLABUS

FOR THE

M.Sc. RADIATION PHYSICS COURSE
(Revised for 2019 Admission Onwards)

UNIVERSITY OF CALICUT

UNIVERSITY OF CALICUT

SCHEME AND REGULATIONS FOR **M.Sc. RADIATION PHYSICS COURSE.** (REVISED FOR 2019 ADMISSION)

I. TITLE OF THE PROGRAMME:

The program shall be called Master of Science (M.Sc) Degree in Radiation Physics.

II. ABOUT THE COURSE: M.Sc. Radiation Physics course is a highly specialized multidisciplinary course in Applied Physics. The course will emphasis on the interaction of radiation with human body, application in radiotherapy and the safety measures. The course has immense job potential as highly demanded **Medical Physicists** and **Radiological Safety Officers** in Advanced Hospitals, Industrial and Research Organizations in India and abroad as well as faculty, researchers, dosimetrist etc

III. ELIGIBILITY FOR ADMISSION: A pass in B.Sc. Physics as core subject, with Mathematics as one of the subjects, from University of Calicut or equivalent with 60% marks in aggregate of the subjects or equivalent grade.

IV. ADMISSION CRITERIA: The admission is made on the basis of the performance in the entrance test of the objective type/ short answer questions of 2 hours duration with the syllabus of B.Sc. Physics of the University of Calicut

V. DURATION OF THE COURSE : 3 years T-wo years course work + One year Internship/Field training
– Four semesters each of 6 months followed by internship/clinical training of 12 months-
A project work is to be submitted during the period.

VI. MEDIUM OF INSTRUCTION – English

VII. PROGRAMME STRUCTURE

1. The programme shall include three types of courses, viz. Core courses, Elective courses and Audited Courses.
2. There shall be a field training/ internship for one year for those who opt for jobs as Radiological Safety Officer (RSO) and Medical Physicists. A project work is also is to be carried out during this period.
3. Total credit for the program shall be 100 (eighty). The audit courses carry a total of 4 credits and it is over and above 82. The pattern of distribution of the 82 credits is as detailed below :
 - i)Total credits for the core courses (theory, practicals, Viva-voce and project) shall be 74. Out of this the total credits for comprehensive viva-voce and project work combined together shall be 10 (eight) subject to a minimum of 4 (four) credit for project work.
 - ii)Total credits for Elective courses shall be 8.

Table 1. Structure of the Programme

Programme Duration	M.Sc Radiation Physics
Accumulated minimum credits required for successful completion of programme	82
Minimum credits required from Core courses (including viva-voce)	74
Minimum credits required from Elective courses	8
Total number of credits to be acquired for fulfilling the profession (excluding audit course)	100

5. Audit courses :

In addition to the above courses for the mandatory requirement of a programme there will be two compulsory courses - **Ability Enhancement Course (AEC)** & **Professional Competency Course (PCC)** each with 2 credits, and these courses are to be done within the first two semesters. The credits will not be counted for computing the overall SGPA/CGPA of the student. The concerned department shall conduct examination for these courses and shall intimate /upload the results of the same to the University on the stipulated date during the III Semester. The student has to obtain only minimum pass requirements in these two courses. The broad framework of the compulsory audited courses are given hereunder.

Audit course 1 - Presentation of seminar in the related topic is to be done

Audit course 2- developing a computer program in the specific topics in radiology may be done as

VIII. ATTENDANCE – A candidate is required to put in at least 80% attendance in theory and practical subjects separately in the recognized institution approved for the same or affiliated to the University of Calicut. This has to be determined on a semester basis.

IX. SCHEME OF CLASSES:

Every semester will have the course distribution with appropriate number of theory and practicals. The theory subjects shall have lectures for a total duration of around 80 hours each and the practical classes will be of about 70 hours each. This works out to be about 500 hours teaching per semester including tutorial. It shall be split suitably at the rate of six days per week. The fourth semester will accommodate the project work also. The

classes per day shall work out as 4 hours for theory and 3 hours for practical. Working days per week – 6.

Failure in Semester:

A candidate who has failed in the I semester shall be promoted to II and III semester but will not be allowed to attend the IV semester classes until he/she cleared the 1st semester subjects. Candidate failed in any semester will not be allowed to do the internship/field training until the backlog papers are cleared.

Discontinuation: No discontinuation is allowed in normal basis. However if a student has to discontinue the course in any semester due to the reasons of not his own, and he has paid the fee for the semester, he can be re-admitted to the semester in later time, if the coordinator is fully satisfied with the reason. In such cases he has to complete the course work as per the regulations of the newly admitted batch he is re-admitted and appear for the examinations accordingly. This provision is conditional on the availability of seats and facility.

X. PROJECT WORK:

Every candidate must do a project work under an approved supervisor (approved by the Coordinator) in a topic having relevance to the application of radiation in medicine, industry, agriculture and research in the 5/6th semester. The project thesis should be submitted to the University. The supervisor should certify about the satisfactory completion of the project. Students must present their project work before a committee constituted by the course coordinator. Project Report must be submitted within two months from the last working day of the final semester

XI. INTERNSHIP/ FIELD TRAINING:

Total duration of the internship/clinical training will be 1 year (as prescribed by the AERB). It should be done under the supervision of a designated academic staff member of recognized institute. The supervisor must certify to the adequacy of the field training on the basis of the thesis report submitted by the candidate. The students should necessarily present at least one seminar on the basis of the field training and the record of the field training must be duly certified by the designated officer in the centre and the Course Coordinator.

(The students should pay the charges for clinical training as required by the institution).

XII. RADIOLOGICAL SAFETY OFFICER (RSO) approval by AERB:

The University shall initiate steps for registering for the examination for Radiological Safety Officer (Level III Medical) certification, for all candidates. The examination for the same shall be conducted by Radiological Physics and Advisory Division (RPAD) of DAE as per the regulations of the Atomic Energy Regulator Board (AERB). Students qualifying this examination will be eligible for RSO. Candidate completing one year clinical training are eligible for this examination. Student should attend and qualify the RSO examination at their own capacity.

XIII. SCHEME OF EXAMINATION:

Theory papers: Each paper is of three hours duration – Maximum marks 100

End semester examination	70 marks
Continuous valuation	30 marks*

Practical Examination: Three hours duration – Maximum marks 100

End semester:	70 marks
Continuous evaluation:	30 marks*

* Continuous evaluation is based on the regular performance in attendance -4 marks, internal tests (best 2 out of 3)- 12 marks, Assignments 8 marks, seminars (6 marks).

Vivavoce: There will be an end semester viva-voce, distributed on all papers of the semester, for all the four semester. Maximum marks for the viva voce will be 50 marks in each semester.

Project work: Total marks: 200

Project Record :	100
Presentation and viva:	100

Total Marks: 2800 (650+650+750+750)

Mark Distribution: Semester I-IV: 2800 (750+750+650+650)
Project Report : 120*
Presentation and viva: 80*

* Project marks are for qualitative evaluation only and not to be included in consolidation. (Viva may include project work and clinical training)

Total Marks:	2800
Total credits	100
Minimum credits required to pass	82

Classification of results

Minimum marks for a pass: Theory 40% (equivalent grade of C) minimum per paper and an aggregate of 50% (equivalent grade of B) - separately for theory and practical. There is no paper minimum for practicals. Evaluation of internship and project work is only for qualitative purpose only. Minimum grade required will be 50% or equivalent. Project and internship will not be accounted for grading and consolidation. University will issue certification to the effect as,

1. The candidate has successfully undertaken project work carrying 6 credits
2. The candidate has successfully completed one year internship/ clinical training carrying 12 credits

The Semester grade point Average (SGPA) and final grade(Cumulative Grade Point Average CGPA) will be calculated as follows.

$$SGPA = (C1*G1 + C2*G2 + \dots Cn*Gn)/(C1 + C2 + \dots Cn)$$

Where Ci, C2.. Cn are the credits of each paper and G1,G2 ..Gn are the grade scored in the respective papers. Same procedure will be followed for CGPA for the entire course work.

Presently the Following mark based grade will be followed

Mark range (in %)	Grade point	Letter grade	Class
80 - 100	8.0-10.0	O	Outstanding
70 - 79	7.0-7.9	A+	Excellent
60 - 69	6.0-6.9	A	Very Good
55-59	5.5 – 5.9	B +	Good
50 - 54	5.0-5.4	B	Average (SGPA pass minimum)
40 – 50	4.0-4.9	C	F in CGPA) (Paper pass minimum)
< 40	< 4.0	F	F in paper
Course incomplete		I	Course incomplete
* Fractional percentages should to be rounded off to the next whole number)			

XIII.

Award of the Certificate:

M.Sc Radiation Physics Degree certificate will be awarded to the successful candidates only after successful completion of the course as detailed above. However those who are not interested in Medical Physicists/RSO they can be issued certificates for four semester M.Sc course without undergoing field training/internship and project work.

Semester-wise break-up.....

XIV. SEMESTER VISE BREAKE-UP OF COURSE CONTENT:

SEMESTER I:

RPH1C01	Mathematical Methods in Physics	21 credits 4 credits
RPH1C02	Classical Mechanics	2 credits
RPH1C03	Basic Electronics	4 credits
RPH1C04	Introductory Nuclear Physics	4 credits
RPH1C05.	Basics of Electrodynamics	2 credits
RPH1C06	Interaction of Radiations with Matter	2 credits
RPH1C07	Electronics Practical	2 credits
RPH1C08	Comprehensive semester viva voce	1 credit
RPH1A01	Audit course 1-Ability enhancement- Presentation skill	2 credits

SEMESTER II

RPH2C09	Quantum mechanics	21 credits 4 credits
RPH2C10	Anatomy, Physiology and Radiobiology	4 credits
RPH2C11	Radiation Detection, Measurement and Instruments	4 credits

RPH2C12	Numerical Techniques and Computer programming	2 credits
RPH2C13	Radiation Physics Fundamental	2 credits
RPH2C14	Practicals in Computer applications	2 credits
RPH2C15	Practicals in Instrumentation in Radiology	2 credits
RPH2C16	Comprehensive viva voce	1 credit
RPH2A02	Audit course 2-Professional competency course-	2 credits

SEMESTER III **21 credits**

RPH3C17	Radiation Hazards safety, evaluation and control	4 credits
RPH3C18	Physics of Medical Imaging	4 credits
RPH3C19	Physics of radiotherapy	4 credits
RPH3C20	Nuclear Medicine	4 credits
RPH3C21	Practicals in Radiation Detection and Measuring Instruments	2 credits
RPH3C22	Practicals in Medical Imaging	2 credits
RPH3C23	Comprehensive viva voce	1 credit

SEMESTER IV: **19 credits**

RPH4C24	Quality assurance, acceptance testing and Commissioning of Radiation systems	4 credits
RPH4E25A	Radiotherapy Treatment Planning	4 credits
RPH4E25B	Industrial and research applications of radiation	4 credits
RPH4E26A	Modern trends in Radiology and Radiotherapy	4 credits
RPH4E26B	Recent developments in industrial applications of radiations	4 credits
RPH4C27	Practicals in Radiotherapy	2 credit
RPH4C28	Practicals in Radiotherapy Planning and Dosimetry	2 credits
RPH4C29	Practicals in Q/A and calibration of radiological equipments	2 credits
RPH4C30	Comprehensive viva voce	1 credits

SEMESTER V & VI **18 credits**

RPH5E31	Project work	6 credits
RPH6E32	Field training	12 credits

Total credits 100

SYLLABUS

The syllabus gives an outline of the topics to be covered during the course. However the course being one of Applied Physics having relevance to many fields like medical imaging, radiotherapy, use of radioactive nuclides etc. recent developments should be adequately taken care of in the teaching program with greater emphasis to the applied nature of the subjects.

SEMESTER I

RPH1C01. MATHEMATICAL METHODS IN PHYSICS

4 CREDITS

1. **Vectors and Tensors:** Rotation of coordinates, Orthogonal curvilinear coordinates, Gradient, Divergence and Curl in orthogonal curvilinear coordinates, Rectangular, cylindrical and spherical polar coordinates, Laplacian operator, Laplace's equation – application to electrostatic field and wave equations, Vector integration, Definition of Tensors, Contraction, Direct products, quotient rule, Pseudo tensors, Dual tensors, Levi Cevita symbol, irreducible tensors
(14 hours)
2. **Matrices :** Basic properties of matrices (Review only), Orthogonal matrices, Direction Cosines, Orthogonality Conditions, Euler angles, Hermitian and Unitary matrices, Similarity and unitary transformations, Diagonalization of matrices, Eigen Vectors, Eigen values, Normal Matrices, Normal Modes Of Vibration-Example CO₂ molecule.
(16 hours)
3. **Second Order Differential Equations:** Partial differential equations in Physics, Separation of variables, Singular points, Ordinary series solution, Frobenius method, A second solution, Self-adjoint differential equation, eigen functions and values, Boundary conditions, Hermitian operators, their properties, Schmidt orthogonalization, Completeness of functions (18 hours)
4. **Special functions :** Gamma function, Beta function, Delta function, Dirac delta function, Bessel functions of the first and second kinds, Generating function, Recurrence relation, Orthogonality, Neumann function, Spherical Bessel function, Legendre polynomials, Generating function, Recurrence relation, Rodrigues' formula, Orthogonality, Associated Legendre polynomials, Spherical harmonics, Hermite polynomials, Laguerre polynomials (20 hours)
5. **Fourier Series :** General properties, Advantages, Uses of Fourier series, Properties of Fourier series, Fourier integral, Fourier transform, Properties, Inverse transform, Transform of the derivative, Convolution theorem, Laplace transform (12 hours)

Textbook :

1. G.B.Arftken and H.J.Weber : "Mathematical Methods for Physicists Ed.6,2001,Academic Press

Reference books :

1. J.Mathews and R.Walker : "Mathematical Methods for Physics"(Benjamin, New York)
2. L.I.Pipes and L.R.Harvill : "Applied Mathematics for Engineers and Physicists (3rd Edition)" (McGraw Hill)
3. Erwin Kreyzig : "Advanced Engineering Mathematics - 8th edition" (Wiley)
4. M. Greenberg : "Advanced Engineering Mathematics – 2nd edition " (Pearson India 2002)
5. A.W.Joshi, Matrix and Tensors (John Wiley, New York)

RPH1C02 : CLASSICAL MECHANICS**(2 CREDITS)**

1.Lagrangian and Hamiltonian Formulation : Preliminary ideas about Constraints and Generalized coordinates, D'Alemberts principle and Lagrange's equation, Velocity dependent potentials, Simple applications of Lagrangian formulation, Hamilton's Principle, Conservation theorems and symmetries, Lagrange's equation from Hamilton's principle, Two- body central problems, Equivalent one -body and one dimensional problem, Kepler problem, Inverse square law of force, Laplace-Lenz vector, Scattering in a central force field, Transformation to lab coordinates. Exercises (18 hours)

2.Hamiltonian Formulations: Legendre Transformation and Hamilton's equations, Cyclic co-ordinates and conservation theorems, Principle of least action, Canonical transformations and examples, Infinitesimal canonical transformations, Poisson brackets and other canonical invariants, Equation of motion in Poisson bracket form, Angular momentum Poisson brackets, Hamilton-Jacobi equation, Hamilton's principal and characteristic function, H-J equation for the linear harmonic oscillator, Separation of variables, Action-angle variables, H-J formulation of the Kepler problem, H-J equation and the Schrödinger equation. (19 hours)

Books for study : Goldstein, Classical Mechanics, 3rd Edition. Addison Weley

References:

1. V.B.Bhatia : "Classical Mechanics" (Narosa Publications, 1997)
2. N.C.Rana and P.S.Joag : "Classical Mechanics" (Tata McGraw Hill, 2011)
3. R.G.Takwale and P.S.Puranik : "Introduction to Classical Mechanics" (Tata McGraw Hill, 1978)
4. Atam P. Arya : "Introduction to Classical Mechanics, " (2nd Edition, Addison Wesley, 1998)

RPH1C03. BASIC ELECTRONICS –**4 CREDITS**

1. Transistor Amplifier :BJT: Biasing and ac models, voltage amplifiers, power amplifiers (EP 11:3 – 11-5), emitter follower , differential amplifier, **FET**: h-parameters, FET small signal model, biasing the FET, analysis of common source and common drain amplifiers and the high frequency response, FET as VVR and its applications. **MOSFET**: circuit symbol and equations, small signal model Digital MOSFET circuits. **(16 hours)**

Texts: 1.Electronic principles, Malvino 6th Edition, Tata McGrows Hills India
2.Integrated Electronics, Millman and Halkias, Tata McGrows Hills India

2. Microwave and Photonic Devices: Tunnel diode, Transferred electron devices, Negative differential resistance and device operation, Radiative transitions and optical absorption, Light emitting diodes (LED) –Visible and IR, Semiconductor lasers - materials, operation (population inversion, carrier and optical confinement, optical cavity and feedback, threshold current density),Photo-detectors, Photoconductor (Light dependent resistor- LDR) and photodiode, p-n junction solar cells - short circuit current, fill factor and efficiency **12 hours)**

Books for study:1. S. M. Sze, "Semiconductor Devices- Physics and Technology", John Wiley & Sons,

3. Operational Amplifier: Dual input differential amplifier DC and AC analysis, Op-Amp, block diagram representation, analysis of a typical Op-Amp equivalent circuit ideal Op-Amp characteristics, equivalent circuit, open loop configurations, Op-Amp parameters input offset voltage & current, input bias current, output offset voltage, CMRR, Op-Amp with negative feedback: voltage series feedback amplifier: gain, input & output impedances, Frequency response, compensating networks **(14 hours)**

Text: Op-Amps and Linear Integrated Circuits: 3rd Edition, R. A. Gayakwad, PHI

4. OPAMP Applications: Summing, scaling and averaging amplifiers, Analog integrator and differentiator Electronic analog computation, Active filters: Butterworth filters (low & high orders), Low pass, High pass, band pass (wide & narrow band) and band reject filters, Oscillators: Phase shift, Wein bridge, Quadrature oscillators, Square, triangular and saw-tooth wave generators, comparators, zero crossing detectors, Schmitt trigger **(12 hours)**

Texts: 1. Op-Amps and Linear Integrated Circuits: 3rd Edition, R. A. Gayakwad, PHI
2. Integrated Electronics, Millman and Halkias, TMH India.

5. Digital Electronics: Arithmetic circuits: adder, adder/subtractor, ALU, RS, JK and JK MS flip-flops, Registers: types of registers, SISO & 7491, SIPO & 74164, PIPO, 74198, applications of shift registers. Counters: asynchronous counter & 7493A, decoding gates, synchronous counters, 7490A, decade counters. D/A-A/D converters, Memory & memory addressing

Microprocessors and Microcontrollers: Microprocessor, architecture of 8085: Bus organization, Registers, memory, block diagram of 4 bit register, memory map, tri-state buffer, 8085 functional pin diagram, control & status signals, microprocessor communication and bus timing (memory read/write operations), address data demultiplexing, microcontrollers, architectural overview and block diagram of microcontrollers, functional pin diagram of Atmega16 microcontroller. **(16 hours)**

Texts: 1. Digital Principles and Applications: 6th Edition, Leach, Malvino and Saha, (Tata McGraw Hill).
2. Microprocessor Architecture and Programming and Application, Ramesh S. Gaonkar, (New Age Publishers.)
3. The 8051 Microcontroller: 2Ed, Kenneth J. Ayala, Thomson, (Delmar)
4. Atmega16 microcontroller data sheet available (from Atmel website.)

General references:

1. Electronic devices and circuit theory, Robert L. Boylestad & L. Nashelsky – Pearson Education.
2. Electronic devices, 5th Edition, Floyd, Pearson Education.
3. Alen Motorshed
4. Microelectronic Circuits: Analysis & Design, M. H. Rashid, PWS Publishing
5. Linear Integrated circuits, D. R. Choudhuri, S. Jain, (New Age International)
6. Fundamentals of Microprocessors and Microcomputers, 2nd Edition, B. Ram, Dhanapathi Rai & Sons.
7. Embedded C Programming and the Atmel AVR, Barnett, O’cull, Cox, Cengage Learning.

RPH1C04. INTRODUCTORY NUCLEAR PHYSICS

4 CREDITS

1. **Nuclear Forces:** Four basic forces - Gravitational, Electromagnetic, Weak and Strong - Relative strengths, Properties of the nucleus, size, binding energy, angular momentum, The deuteron and two-nucleon scattering experimental data, Simple theory of the deuteron structure, Low energy n-p scattering, characteristics of nuclear forces, Spin dependence, Tensor force, Scattering cross sections, Partial waves, Phase shift, Singlet and triplet potentials, Effective range theory, p-p scattering. **(14 hours)**
2. **Nuclear Decay:** Basics of alpha decay and theory of alpha emission. Beta decay, Energetics of beta decay, Fermi theory of beta decay, Comparative half-life, Allowed and forbidden transitions, Selection rules, Parity violation in beta decay. Neutrino. Energetics of Gamma Decay, Multipole moments, Decay rate, Angular momentum and parity selection rules, Internal conversion, Lifetimes. **(18 hours)**
3. **Nuclear Models, Fission and Fusion:** Shell model potential, Spin-orbit potential, Magnetic dipole moments, Electric quadrupole moments, Valence Nucleons, Collective structure, Nuclear vibrations, Nuclear rotations, Liquid drop Model, Semi-empirical Mass formula, Energetics of Fission process, Controlled Fission reactions. Fusion process, Characteristics of fusion, solar fusion, Controlled fusion reactors. Critical conditions, four factor formula **(16 hours)**
4. **Nuclear reactions:** Nuclear Reactions, Energetics of nuclear reactions, conservation laws, scattering and reaction cross- sections, theoretical calculation, measurement of cross-section, Nuclear reaction models-compound nucleus reactions, Direct reactions, resonance reactions, statistical theory, optical potential, heavy ion reactions. **(16 hours)**
5. **Reactor Physics:** Interaction of neutrons with matter, Nuclear Fission, Neutron Chain Reacting Systems, Criticality, Multiplication Factor, Neutron balance conditions for criticality, Conversion and Breeding, Types of nuclear reactors, Reactor Power, Fuel Burnup, Neutron transport in reactors, Neutron current density, Equation of Continuity, Fick's law, Diffusion Equation, Neutron moderation, Leathery, Multiscattered neutrons, Fermi Age theory, Age equation, Solutions to the age equation, Elastic moderation time, Slowing down kernels, Neutron absorption with moderation and fission, Weak absorption, Resonance escape, Thermal neutron spectra, Reactor Power, Criticality for reactor geometries. **(16 hours)**

Books for study

1. H. Enge : Introduction to Nuclear Physics" (Addison Wesley)
2. John. R. Lamarsh, Introduction to Nuclear Reactor Theory, Addison Wesley, USA

Reference:

2. H.S.Hans: Nuclear Physics – Experimental & theoretical (New Age International 2001)
3. Kenneth S Krane, Introductory nuclear physics, (Wiley india, 2012)
4. S.B.Patel, An introduction to nuclear Physics, (New Age International)
5. George I. Bell and Samuel Glasstone, Nuclear Reactor Theory, Van Nostrand Reinhold Company, USA

RPH1C05. BASICS OF ELECTRODYNAMICS

2 CREDITS

1. Electrodynamics: Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell's equations, Potential formulations, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell's stress tensor. **(14 hours)**

2. Transmission lines, Wave guides and cavity resonators: Transverse electromagnetic waves along a parallel plate transmission line, General transmission line equations, Wave characteristics on finite transmission lines, General wave behavior along uniform guiding structures, Rectangular wave guides, Cavity resonators **(10 hours)**

3. Electromagnetic Radiation: Retarded potentials, Jefimenkos equations, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion. Radiation reaction, Physical basis of radiation reaction **(16 hours)**

Text:

1. David K. Cheng : " Field and Wave Electromagnetics" (Addisson Wesley)

Reference books :

1. J.D.Jackson : "Classical Electrodynamics" (3rd Ed.) (Wiley,1999)
2. David Griffiths : " Introductory Electrodynamics" (Prentice Hall of India, 1989)
3. Podgorsak, Ervin B: "Radiation Physics for Medical Physicists" (Springer, 2010)
4. Helmut Wiedemann: "Particle Accelerator Physics"(3rd Ed.)(Springer, 2007)

RPH1C06. INTERACTION OF RADIATIONS WITH MATTER

2 CREDITS

1. Interaction of electromagnetic radiation with matter (14 hours)

Thomson scattering - Photoelectric absorption – Angular distribution of photoelectrons –Compton effect, Compton process – Klein Nishina cross-section – Scattering coefficients

–angular distribution of Compton electrons – Pair production – Annihilation radiation, electrons – energy momentum conservation, Photo nuclear reactions,– Attenuation – Linear, mass attenuation coefficients- Total absorption coefficients. Absorption and scattering coefficients and cross sections.

2. Interaction of electrons and heavy charged particles with Matter (16 hours)

Classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, Cerenkov radiation, Electron, Absorption, Scattering, Excitation and Ionization. Values of w in different media, radioactive collision– Radiation energy loss (bremsstrahlung)– Range of beta particles, Range straggling, absorption of beta particles and back scattering, self absorption . Interaction of heavy charged particles with matter –Energy loss by collision, maximum energy loss in a single collision, range energy relation- Bragg curve, specific ionization, Bethe-Bloch formula for collision, stopping power and radiation stopping power

3. Interaction of Neutrons with Matter (10 hours)

Neutron capture Neutron sources, properties, energy classification, Elastic and inelastic scattering coefficients and cross sections– Energy transfer and logarithmic energy decrement, Inelastic scattering, Nuclear reaction, Dependence on E and Z, (n, p), (n, 2n), (n, f) and other reaction, Neutron activation, Radio- isotope production. Familiarization of standard data libraries

STANDARD BOOKS FOR STUDY

1. E.B Podgorsak : "Radiation Physics for Medical Physicists". Springer, USA
2. F.H.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.

REFERENCES

1. R.D Evans : "The Atomic Nucleus" (Tata -McGraw Hill Publishing Company)
2. G.F.Knoll : "Nuclear Radiation Detectors" (Willy international, New york)
3. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
4. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981.
5. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
6. W.R.Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981.
7. F.M Khan : "Physics of Radiation Therapy"- Fourth Edition
8. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.

PRACTICALS:-

RPH1C07. ELECTRONICS PRACTICALS – (70 Hours) 2 CREDITS
(Minimum 12 expts. are to be carried out)

1. Measurement of L, C and R by Universal bridge
2. Series resonance and Q of a coil
3. Two stage RC coupled amplifier – frequency response
4. Construction of a voltage multiplier – Measurement of Ripple
5. Characteristics of a regulated power pack using 2N3055
6. DC voltage regulator using OPAMP
7. Feedback amplifier
8. Construction of an oscillator
9. Multivibrator- Monostable and astable
10. Low pass and high pass filter -first and second order
11. OPAMP circuits – Inverting and non inverting amplifiers
12. Integrator and differentiator circuit using OPAMP
13. Simple D/A converter – Ladder type
14. Coincidence and anti-coincidence timed circuits
15. Pulse shaping circuits
16. Microprocessor experiments (Addition, subtraction, division and multiplication – 8 bit using 8085)

SEMESTER II

RPH2C09. QUANTUM MECHANICS–

4 CREDITS

1. Formulation of Quantum Mechanics: Vector spaces, The Hilbert space, Dimensions and basis, Operators and properties, Representation of vectors and operators, Commutator, Functions of operators, Eigen values and eigen vectors, Matrix representation of bras, kets and operators, Coordinate and momentum representations and their connection, The fundamental postulates Probability density, Superposition principle, Observables and operators, The uncertainty principle **(16 Hours)**

2. Quantum Dynamics : The equation of motion, Schrödinger, Heisenberg and the Interaction pictures of time development, The linear harmonic oscillator in the Schroedinger and Heisenberg pictures, Hydrogen atom problem **(24 hours)**

3. Theory of Angular Momentum: Angular momentum operators, Matrix representation of angular momentum operators, Pauli spin matrices, Orbital angular momentum, The hydrogen atom, Addition of angular momenta, Clebsh-Gordon coefficients, Simple examples **(12 hours)**

4. Symmetry and Conservation Laws : Space-time symmetries, Space translation and conservation of linear momentum, Time translation and conservation of energy, Space rotation and conservation of angular momentum, Space inversion and time reversal, Identical particles, Construction of symmetric and anti symmetric wave functions, Slater determinant, Pauli exclusion principle, Bosons and Fermions, Spin wave functions for two electrons, The ground state of He atom, Scattering of identical particles **(12 hours)**

5. Scattering : Classical approach for Scattering in a central force field- alpha scattering, Transformation to lab coordinates. Quantum mechanical approach -Scattering cross section and scattering amplitude, Low energy scattering by a central potential, The method of partial waves, Phase shifts, Optical theorem, Convergence of partial wave series, Scattering by a rigid sphere, Scattering by a square well potential, High energy scattering, Scattering integral equation and Born approximation **(14 hours)**

Books for study: N.Zettili, Quantum Mechanics – Concepts and applications (John Wiley&Sons, 2004)

Reference books :

1. V.K.Thankappan : “Quantum Mechanics” (Wiley Eastern)
2. L.I. Schiff : “Quantum Mechanics” (McGraw Hill)
3. P.M.Mathews and K.Venkatesan : “A Textbook of Quantum Mechanics” (TataMG Hill)
5. J.J.Sakurai : “Modern Quantum Mechanics” (Addison Wesley)
6. A.Ghatak and S.Lokanathan : “Quantum Mechanics” (Macmillan)

RPH2C10. ANATOMY, PHYSIOLOGY AND RADIOBIOLOGY

4 CREDITS

1. Basic Anatomy : Introduction to the Human Body, Skeletal System, Muscular System, Nervous Tissue, Central Nervous System, Peripheral and Autonomic Nervous Systems, Cardiovascular System, Lymphatic System and Body Immunity, Respiratory System, Digestive System, Urinary System, Water and Electrolyte Balance, Reproductive System, Xray anatomy, CT/MRI anatomy surface anatomy applied to RD and RT **(16 hours)**

2. Clinical Aspects of Radiation Oncology: Biology of cancer and tumor, categories of disease, treatment modalities-Radiation therapy, Surgery, Chemotherapy, Hormone Therapy, Immunotherapy & radionuclide therapy, Benign and malignant disease, Methods of spread of malignant disease, Treatment intent, Curative & Palliative **(12 hours)**

3. Radiation Chemistry and Cell Kinetics: Elements of cell biology, Action of ionizing radiation on living cells –Direct and indirect actions, effects at Molecular level, Radiation Chemistry, Stochastic Nature Of Energy Transfers Cellular Levels, Reactions Of The Products of Water Radiolysis, G Value, Expression Of Yield In Radiation Chemistry, Products Of Radiolysis, Fricke Dosimeter Direct And Indirect Action, Recombination, Restitution and Repair, DNA Structure And Radiation Damage, Theories And Models For Cell Survival, Clonogenic Survival, Biological Survival Curves, Development Of The Target Theory Model, MultitargetSingleHit Survival, Molecular Models For Cell Death, Molecular Theory Of Radiation Action, Survival Curve And Its Significance, Significance Of Shoulder On The Survival Curve, Repair Of Sublethal Damage, Repair Of Potentially Lethal Damage, **(18 hours)**

4. Radiobiological Concepts: Linear energy transfer and its effect, Tumor lethal dose, tissue tolerance dose and therapeutic ratio, Radiobiological effectiveness (RBE), Oxygen effect, Oxygen enhancement ratio(OER), Five R's of Radiobiology, TCP/NTCP Time dose fraction(TDF) basis for dose fractionation in radiotherapy Concept of nominal standard dose (NSD), Linear Quadratic models, AlphaBeta concepts. BED, Rate equations Sensitizers and Protectors, Reduction of side effects. Somatic effects of radiation –Acute radiation sickness –LD50 dose –Effect of radiation on skin –Blood changes –Sterility – Cataract formation –Effects of chronic exposure to radiation. Doubling dose and its effect on genitic equilibrium, Tissue structure and radiation effect, Radiation effect on fetus, Fractionation and its effect, effect on different systems dependence on dose and dose rate, tolerance limits for various systems, acute radiation syndrome, effects of low level irradiation, effects relevant to women, fetus and children **(22 hours)**

5. Modifiers and Dose limits: Modification Of The Radiation Response, Role of Water Temperature And Radiation Damage, Oxygen Effect, Modification of The Radiation Response, Hypoxia And Radiosensitivity in Tumor Cells, Late Effects of Radiation on Normal Tissues, Nonstochastic/ Deterministic Effects Stochastic Effects, Fractionation and protraction of exposure in the modification of late radiation injury, Stochastic Effects Radiation Carcinogenesis, Biological Modifiers, Cell Kinetics, Cell Cycle Control Mechanisms, RTOGs, IMAMI and CONTEC recommendations **(14 hours)**

Books for study

1. Radiobiology- Hand book for teachers and students, TC-42, IAEA,2010

Reference:

1. Delmar's "Fundamentals of Anatomy & Physiology", Thomson LearningUSA, 2001

2. A LANGE medical book "Basic Radiology" 2nd Edition, The McGrawHill2011

3. Edward L. Alphen, "Radiation Biophysics" Academic Press, Second Edition.

4. EJ Hall and Amato J Glaccia, " Radiobiology for the Radiologist", 7th Edn., Lippincott Williams &Wikins, USA

5. IAEA, AERB , NCRP PUBLICATIONS ON DOSE LIMITS.

RPH2C11. RADIATION DETECTION, MEASUREMENT AND INSTRUMENTS

4 CREDITS

1. Gas filled , Scintillation Detectors: Relationship Between Voltage and Charge Collected -characteristic curve, Different Types of Gas-Filled Detectors, Ionization Chambers, Proportional Counters, Geiger-Mueller Counters, Gas-Flow Counters, Rate Meters Scintillation detectors, Inorganic (Crystal) Scintillators , Organic Scintillators , Gaseous Scintillators , The Relationship Between Pulse Height and Energy and Type of Incident Particle , The Photomultiplier Tube, Assembly of a Scintillation Counter and the Role of Light Pipes, Dead Time of Scintillation Counters, Sources of Background in a Scintillation Counter, Resolving time and resolving power of detectors. **(14 hours)**

2. Semiconductor, Thermo luminescent Dosimetry Miscellaneous Detectors:: Different Types of Semiconductor Detectors - Surface-Barrier Detectors - Diffused-Junction Detectors - Silicon Lithium-Drifted [Si(Li)] Detectors - Germanium Lithium-Drifted [Ge(Li)] Detectors - germanium (Ge) Detectors -CdTe and HgI Detectors - Radiation Damage to Semiconductor Detectors , Detector Telescopes (E-dE Detectors), Position-Sensitive Detectors. Thermo luminescent dosimetry; process and properties, photon energy dependence, fading, residual TL and annealing for reuse, repeated read out of TLDs, TL- instrumentation, beta, gamma extremity dosimetry, ultra thin TLDs, graphite/boron carbide mixed TLDs, glow curve analysis, -common TLD materials, their characteristics, energy dependence and method of use. Chemical dosimetry, Organic and inorganic systems, Fricke dosimeter, FBX dosimeter, Free radical dosimeter – Ceric sulphate dosimeter, Other high and low level dosimeters, Applications in Radiotherapy and industrial irradiators, Glass dosimetry, Calorimetry, Instruments of personal monitoring, films, digital pocket dosimeters ,Radiation survey meter, Contamination monitors ,gamma ray spectrometer, whole body monitor etc. , Thermal and fast neutron survey meters **(20 hours)**

3. Neutron Detectors, Spectroscopy: The BF₃ Counter, ⁶Li- Counters, ³He proportional counter, Fission Chambers, Neutron Detection by Foil Activation (Activation counter), Detection of Fast Neutrons using Threshold Activation Reactions (Threshold Detector), The Time-of-Flight Method, Bubble chambers, Sources of Radiation, Irradiation of the Sample, Counting of the Sample, Analysis of the Results, Advantages and Disadvantages of the Activation Analysis Method ,Measurement of neutron flux -Activation and absorption methods, CR -39 films, SSNTD, Albedo Dosimeter, Manganese Bath, Precision long Counter. **(16 hours)**

4. Nuclear Instrumentation: NIM Concept, High-Voltage Power Supply, Preamplifier, Amplifier, Oscilloscope, -Differentiating Circuit- Integrating Circuit- Delay Lines- Pulse Shaping- Timing- Coincidence -Anti coincidence Measurements, Pulse-Shape Discrimination, Discriminator- Single-Channel Analyzer (SCA). energy measurements, introduction to spectroscopy: Definition of Energy Spectra, Measurement of an Integral Spectrum and Differential Spectrum, Energy Resolution of a Detection System, Multichannel Analyzer (MCA) -calibration, Timer, Analog-to-Digital Converters (ADC). Time of flight spectrometer, charged particle spectroscopy, Measurement of energy straggling, **(16 hours)**

4. **Counting Statistics and error analysis:** Characterization of data, Statistical models- binomial - poisson -normal distributions, Application of statistical models -checkout for consistency -precision of single measurement, Error propagation- sum -difference -multiplication- division -mean value of combination, Optimization of counting experiments, Limits of detectability, Distribution of time intervals -successive events -time to next event -scaled event -Error analysis- Accidental and systematic errors, error distribution and error function, error in numerical computations and propagation of errors, applications in calibration of instruments, standards in overall error estimation, applications to evaluation of noise in amplifier system, examples of medical statistics for follow up studies **(14 hours)**

BOOKS FOR STUDY

1. Nicholas Tsoufanidis - Measurement and Detection of Radiation, second edition
2. G.F.Knoll, Radiation detection and measurements, 3rd edn, John Wiley, New York

AND REFERENCES

1. W.E. Burcham & M. Jobes – Nuclear and Particle Physics – Longman (1995)
2. Mcknlly, A.F., Bristol, Adam Hilger , Thermoluminescence Dosimetry-Medical Physics Handbook 5,,CRC Press, USA
3. W.J.Meredith and J.B.Massey “Fundamental Physics of Radiology” John Wright and sons, UK, 1989.
4. J.R.Greening “Fundamentals of Radiation Dosimetry”, Medical Physics Hand Book Series Adam Hilger Ltd., USA

RPH2C12. NUMERICAL TECHNIQUES AND COMPUTER PROGRAMMING 2 CREDITS

1. **Roots of transcendental equations** : Location theorem, Bisection (half interval) method- Method of false position (Regula Falsi), Graphical Method, Newton-Raphson method, Geometric significance, inherent error, convergence of Newton Raphson method, Special procedure for Algebraic equations, Iteration Method, Geometry and convergence of iteration process. **(10 hours)**

2. **Interpolation and curve fitting** : Errors in polynomial interpolation, Detection of errors, Linear interpolation, Interpolating polynomials, Lagrange interpolating polynomial, Difference calculus, Detection of errors, Newton forward and backward difference formulae, Least squares curve fitting(linear and nonlinear), **(9 hours)**

3. **Numerical integration and Ordinary differential equations** : Numerical differentiation, Maximum and minimum value, Numerical integration, Trapezoidal and Simpson’s methods, Newton Cote’s method, Gauss quadrature, Solution of ordinary differential equations – Euler’s Maclaurin method, Runge-Kutta methods, **(9 hours.)**

4. **Determinants and matrices:** Evaluation of numerical determinants, Cramer's rule, Successive elimination of unknowns-division by leading co-efficients, Gauss method,solution by inversion of matrices:Solution of equation by matrix methods, Systems soluble by Iteration and condition for convergence. The Eigenvalue problem- Eigen values of asymmetric tridiagonal matrix-Householder's method-QR method, Enough Exercises **(12 hours)**

5. C Programming fundamentals (to be taught as a part of practicals) : Constants and variables, Data types, Type declaration of variables, Symbolic constants, Arithmetic operators, Increment and decrement operators, Conditional operator, Bitwise operators, Hierarchy, Arithmetic expressions, Logical operators and expressions, Assignment operators, Arithmetical and assignment statements, Mathematical functions, Input/output statements, Formatted I/O, Relational operators, Decision making and branching, Go to, if, if...else, switch statements, Looping, While, do and for, Arrays, Handling characters and strings, Functions and voids, Structures, Pointers(elementary ideas only), File operations (defining, opening, reading, writing, updating and closing of files **(20hours)**)

Books for study :

1. S.S.Shastry : “Introductory methods of Unnumerical analysis” (Prentice Hall of India,1983)
2. E.Balaguruswamy : “Programming in ANSI C” (Tata-McGraw Hill, 1992)

Reference Books :

1. V. Rajaraman : “Programming in C”, PHI
2. J.H. Rice : Numerical methods-software and analysis (McGraw Hill, 1983)
3. J.B. Scarborough: Numerical mathematical analysis (Oxford and IBH, 6th Edn)

RPH2C13. RADIATION PHYSICS FUNDAMENTAL

2 CREDITS

1.Radiation Quantities and Units: Radiation quantities and units – Radiometry , Particle flux and fluence, Energy flux and fluence, Cross section, Mass energy transfer and mass absorption coefficients, LET - Radiation chemical yield – W value – Dosimetry – Energy imparted –Absorbed dose- Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose, Concepts of collective dose – KERMA- CEMA, XEMA, TERMA, Exposure, Air kerma rate constant – Charged particle equilibrium (CPE) – Relationship between kerma, absorbed dose and exposure under CPE, Dose equivalent, Ambient and directional dose equivalents [(H*(d) and H'(d)], individual dose equivalent penetrating Hp(d), Individual dose equivalent superficial Hs(d). **(20 hours)**

2. Standards and Measurement of Ionizing Radiation: Standards – Primary and Secondary Standards, Traceability, Uncertainty in measurement. Bragg-gray principle and air wall chamber, Standardization of X-ray, electrons and gamma ray beams: Determination of exposure and air kerma, conditions for the realization of exposure, ionization chamber for low, medium and high energy x-rays and gamma rays, determination of absorbed dose, -Bragg Gray theory and its validity, Burlin’s theory for measurement for radiation quantities, design of free air chambers(FAIC), thimble chamber, chamber calibration, Electrometers, Parallel plate chambers, Ion collection, Polarity effect, Measurement of exposure, Radiation absorbed Dose, Kerma, Relation between Dose, Kerma and exposure. Calculation of Absorbed Dose from Exposure. Effective point of measurement. Calibration of secondary standards-Calibration factors- Concepts of protocols **(20 hours)**

BOOKS FOR STUDY

1. F.A.Attix “Radiation Dosimetry” Vol I-III, Academic press New York, 1985.
2. ICRU Report No. 85, Journal of ICRU Vol. 11 No1.(2011) Oxford University Press
3. H.E.Jones, J.R.Cunnigham, “The Physics of Radiology” Charles C.Thomas, NY, 1980

REFERENCES

1. W.J.Meredith and J.B.Massey “Fundamental Physics of Radiology” John Wright and sons, UK, 1989.
2. W.R.Hendee, Medical Radiation Physics, Year Book – Medical Publishers Inc. London, 1981.
3. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.
4. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981

RPH2C14- PRACTICALS IN COMPUTER APPLICATIONS

Minimum experiments. to be carried out 12. (70 Hours) 2

CREDITS

1. Solution of quadratic equation
2. Curve fitting methods- Least squares, chi square,
3. Error estimation in curve fitting with - in Gaussian, exponential, polynomial
4. Numerical interpolation
5. Numerical Integration(Simpson’s method)
6. Numerical solution of first order differential equation by Runge_Kutta method Simulation (BASIC / C)
7. Quantum mechanical particle in a box
8. Bouncing ball
9. Phase space plots for damped and undamped oscillator
10. Transmission coefficient for a potential barrier
11. Evaluation of pi (p) using montecarlo
12. Simulation detector response
13. Alpha scattering
14. Attenuation of radiations
15. Dose evaluation using stopping power table

RPH2C15. PRACTICALS IN INSTRUMENTATION IN RADIOLOGY (70 Hours) 2 CREDITS

(Minimum 12 expts. to be carried out)

1. GM counter – characteristics – plateau and variation of pulse height with applied voltage and resolving time
2. GM counter – Statistics of counting
3. GM counter – Inverse square law properties
4. Gamma ray spectroscopy using NaI(Tl) -characteristics – plateau and variation of pulse height with applied voltage
5. Scintillation spectrometer – Calibration and determination of unknown energy
6. Measurement of linear and mass attenuation coefficients for a gamma ray beam using GM counter
7. Measurement of range of Beta rays (1) in air (2) in material like aluminum and calculation of absorption coefficients- GM counter – Feather Analysis – end point energy
8. Absorption of Gamma rays from different isotopes -energy and Z dependence
9. Alpha spectroscopy using solid state detectors- determination of energy
10. Experiments with solid state nuclear track detector(SSNTD)
11. Resolution of Scintillation counter at various energies
12. Resolution of Ge/Si detector at various energies

13. Gamma Spectrometer - Compton scattering- angle -energy relation
14. Determination of half life of a short lived isotope
15. Characteristics of a flow type proportional counter
16. Measurement of radioactivity using an isotope calibrator
17. Measurements using radiation monitor

SEMESTER III

RPH3C17. RADIATION HAZARD, SAFETY, EVALUATION AND CONTROL

4 CREDITS

1. Radiation Hazard : Radiation Hazard- external, internal hazard, Radiation Hazard Evaluation by Calculation and measurement. Calculation of specific gamma constant. RHM, RMM, Area monitoring, personal monitoring Internal Hazard Evaluation by Calculation and measurement – inhalation, ingestion, and Absorption, Physical Decay, Biological Decay. Bioassay, Whole Body counter. Internal Radiation hazard Evaluation and Control, contamination on work surfaces, person and samples – Internal radiation hazards – Radio toxicity of different radio nuclides and the classifications of laboratories – General requirements of class A, class B and class C laboratories – Basic Principles for control of contamination, -Methods of decontamination.

Effects of distance, time and shielding – Shielding calculations, Alpha, Beta, Neutron Shielding, Shielding thickness calculation, Narrow Beam/ good geometry, Broad beam geometry, HVT, TVT , relation between TVT and HVT **(18 hours)**

2. Transport of Radioactive Material: Introduction, Regulatory aspects, Objective of the regulations, Radioactive Material, Special form Radioactive Material, A1, A2 values, Determination of A1/ A2 values of radionuclides, Contamination, Exclusive Use, Low specific activity material, Surface Contaminated object, Shipment under special arrangement, Package- Excepted package, Industrial (IP-1, IP-2, IP-3) package, Type A package, Type B package, type B(U) /(M), Type C package. Contents limit for package, General requirements for all types of packages, Additional requirements for packages transported by Air, Requirements for Type A , B(U), B(M), C packages, Test Procedures: Test for special form radioactive material, Tests for different types of packages- Type A, Type B(U),B(M) and Type C. Approval and Administrative Requirements, Contamination level for packages, Categories of packages, Transport Index, Radiation level on Surface, Marking , Labeling and Placarding. Consignor's Responsibility, Emergency Response Requirements on transport accidents. **(16 hours)**

3. Radiation waste Disposal: Disposal of radioactive wastes, Sources of radioactive waste, Classification of wastes, Permissible levels and authorization, Disposal of liquid wastes, Treatment techniques, for solid, liquid and gaseous effluents, permissible limits for disposal of wastes, Sampling technique for water, air and solid, ecological considerations, general methods of disposal, management of radioactive waste in hospital and research establishments, Meteorological parameters. Emergency preparedness, emergency handling, graded approach, site emergency. Safe custody of sources- procedures for issue for applications - methods of eventual disposal. **(14 hours)**

4. Administrative and legislative aspects of radiation protection: Aims of Radiological Protection, need for protection, System of Radiological Protection, - Justification,

Optimization, Dose Limit, Types Of Radiation Exposure- Fetus Dose, Radiation trainee Dose limit, external and internal exposure, additive risk model and multiplicative risk model, risk coefficients, Emergency/ Interventions, ICRP and AERB recommendations, Atomic Energy Act, Radiation Protection Rules (RPR). Applicable Safety Codes, Standards, Guides and Manuals. Regulatory Control – Licensing, Inspection And Enforcement. Responsibilities of Employers, Licensees, Radiological Safety Officers And Radiation Workers
(16 hours)

5. Safety Concern on Therapy/Diagnostic/Brachytherapy Room Planning: Shielding materials, Site selection, Area requirements, Parameters used for shielding calculations, Use factor, work load, Occupancy Factor, TVT, HVT, Radiation dose- Permissible limits, Calculation of Shielding thickness for the walls and ceiling- primary wall, secondary wall, Maze wall and its importance, Width of Primary barrier, Calculation of secondary thickness, scattered radiation, leakage radiation, Radiation at Door level. Neutron dose shielding in high energy Linac. Workload of x-ray machine, Shielding calculation for diagnostic X-ray rooms, Dose due to primary, leakage, scattered radiations, Lead lining of the Door. Brachytherapy Room calculation for Manual after loading, Remote After loading and HDR.
(16 hours)

STANDARD BOOKS FOR STUDY AND REFERENCES

1. NCRP, ICRP, ICRU, IAEA, AERB Publications.
2. S.P.Yaremonenko, “Radiobiology of Humans and Animals”, MIR Publishers, Moscow, 1988.
3. R.F. Mold “Radiation Protection in Hospitals” Adam Hilger Ltd. Bristol, 1985.
4. A.Martin and S.A.Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
5. Herman Cember. “Introduction to Health Physics”

RPH3C18. PHYSICS OF MEDICAL IMAGING

4 CREDITS

1. X-Ray Production, X-Ray Tubes and Generators: Discovery of X-rays, Production and properties of x-rays, X-ray tubes, X-ray tube insert, tube housing, filtration and collimation, X-ray generator -function and components, -circuit design, Timers in radiography. Factors affecting x-ray emission, Power rating and heat loading, x-ray exposure rating charts. Nature of Cooling, Safety devices in X-ray tubes, Mammography - X-ray tube design, X-ray generator and phototimer system, compression scattered radiation and magnification, screen-film cassettes and film processing, Ancillary procedures, radiation dosimetry.
(16 hours)

2. Screen-Film Radiography and Film Processing: Basic geometric principles of radiographic image, Latent image, screen-film system, construction and Characteristics, optical density, contrast, speed and latitude, Types of films, intensifying screens – construction and action, Types of screens-rare earth, Fluoroscopic, Film exposure, Radiographic grids. Film processing, Automatic Film Processing, artifacts, Processor QA, Contrast and dose in radiography, scattered radiation in projection Radiography, reduction of patient dose, patient dose measurement, dose level for diagnostic procedures, methods to reduce patient dose. Image Quality –Unsharpness, Spatial resolution, Contrast, contrast agents, Image Noise, Image distortion and artifacts, detective quantity efficiency, sampling and aliasing in digital images, contrast-detail curves
(16 hours)

3. Computed Tomography and Other X-ray techniques: Basic principles, Historical development, Detectors and detector arrays , Details of acquisition, Reconstruction algorithms, Radon Transform, Back Projection, Filtered Backprojection, Iterative Reconstruction, ML-EM, Digital image display, scan motions, x-ray sources, collimation, X-ray detectors, viewing system, Radiation Dose, Image quality, Artifacts, Fluoroscopy, image intensification, Digital fluoroscopy, Automatic Brightness Control, Cine fluorography, Xeroradiography-. Digital Radiography- Thermography-Basic principles, scanning techniques, radiation dose to patients, Radiography of welds-casting and forgings, Microradiography, Autoradiography, Flash radiography, X-ray diffraction analysis. **(16 hours)**

4. Ultrasound: Basic principles, Characteristics of sound, nature and production of ultrasound, interaction of ultrasound with matter, Transducers and their design, Piezoelectric effect, frequency response of transducers, various types of transducers, Ultrasound beam properties, Image data acquisition, Dynamic range, Different scan modes-A,B,M modes, Two-Dimensional image display and storage Real time scanning, Principles of Gray-scale imaging, significance of gain and gain compensation, pulse rate and its significance, Resolution and frequency, depth and frequency, Image quality, artifacts, Doppler techniques and principles of colour Doppler , System performance and QA, Acoustic power and biological effect of ultrasound **(16 hours)**

5. Nuclear Magnetic Resonance (NMR) and MRI: Magnetisation properties, Generation and detection of magnetic resonance signals, Interaction of nuclei with a static magnetic field, Rotation and precession, Interaction of nuclei with radiofrequency wave, induction of a magnetic resonance signal in a coil, Quantum mechanical interpretation, Bulk magnetisation, relaxation processes:T1 and T2, Relaxation times (T1 and T2) quality assurance, acceptance testing and commissioning of radiation system for biologic materials. Pulse sequences, spin echo, Inversion recovery, Gradient recalled echo, signal from flow, perfusion and diffusion contrast, Magnetisation transfer contrast, Principles of MRI, Localisation of MR signal, k-space data acquisition and image reconstruction, 3d Fourier transform image acquisition, image characteristics, angiography and magnetisation transfer contrast, artifacts, instrumentation, safety and bioeffects. **(16 hours)**

STANDARD BOOKS FOR STUDY AND REFERENCES

1. Diagnostic radiology for teachers and students, IAEA Publication, *Pub1564*
2. N. Smith and A. Webb , Introduction to Medical Imaging Physics, Engineering and Clinical Applications 2011,Cambridge University Press
3. W.J. Meredith and J.B. Massey “Fundamental Physics of Radiology” John Wright and Sons, UK, 1989
4. Christensen ‘Physics of Diagnostic Radiology’ Lea and Febiger – Philadelphia (1990).
5. W.R. Hendee, “Medical Radiation Physics”, Year Book – Medical Publishers Inc. London, 1981
6. P. Sprawls, Magnetic Resonance Imaging: Principles, Methods and Techniques, Medical Physics Publishing, Madison (2000)

RPH3C19. PHYSICS OF RADIOTHERAPY

4 CREDITS

Unit 1: Basic Therapy Physics: Electromagnetic Radiation, Nuclear Transformation, Decay Process, Radioactive Equilibrium, Modes of Radioactive Decay, Nuclear Reactions, Activation of Nuclides, Nuclear reactors, physics of X-ray Production- Bremsstrahlung, Characteristic, X-ray Spectra, Clinical Radiation generators- Kilovoltage units, Grenz Ray, Superficial therapy, Deep therapy, Megavoltage, Vande Graff, Medical linear accelerators and its components, Magnetron, Klystron, Betatron, Microtron, Cyclotron, Co-60 teletherapy unit, Source description, Source Housing, Penumbra, Heavy particle beam, **(16 hours)**

Unit 2: Dose Distribution and Dosimetric Calculations: Phantom, Depth Dose Distribution, PDD, factors effecting PDD, Mayneord factor, TAR, Dose Calculation, SAR, TPR, Collimator factor(Output factor) , Phantom scatter factor, TMR, Accelerator calculations- SSD technique and SAD technique. SPR, SMR, Isodose chart, Measurements of Isodose curves, Parameters of Isodose curves, Wedges Filters, Combination of Radiation fields, Parallel opposed Field, Integral Dose, Multiple Fields, Isocentric, Rotation Therapy, Wedged field technique, Wedge Angle, ICRU 23/ 60 target volumes, ICRU reference Points. **(16 hours)**

Unit 3: Treatment Planning

Acquisition of patient data, Body Contours, Localization of Internal Structures, Treatment simulation, Treatment Verification, Electronic Portal Imaging, Correction for contour irregularities, Corrections for Tissue Inhomogenities, Absorbed Dose within Inhomogenities, Tissue Compensators, 2D Compensators, 3D Compensators, Patient positioning, XYZ isocenter Setup. Field Blocking, Custom Blocking, Multi Leaf Collimators, Skin Dose, Separation of Adjacent Fields, Guidelines for field matching. **(16 hours)**

Unit 4: Electron therapy: Electron Interaction, Rate of energy loss, Electron Scattering, Depth- Dose Curve, Absorbed Dose determination, Use of Films, Solid Phantoms, Central Axis Depth- Dose Curves, Isodose Carves, Field Flatness and symmetry, Electron source, X-ray Contamination, Choice of Energy- Treatment Planning, Use of bolus, External shielding, Total Skin Irradiation, Large Field Techniques, Treatment Planning Algorithms - Fermi-eyes principle, **(12 hours)**

Unit 5:Brachytherapy: Radiative Sources in Brachytherapy, criteria for source selection Use of Radium and radiumsubstitutes, Co-60, Ta-82 ,Cs-137 Ir-192, I-125 and Au-198, specification of source strength-activity,exposure rate equivalent mass of radium, apparent activity,airkerma strength, Calibration of exposure rate constants- open air measurements,well type ion chamber, calculation of dose distribution-sievert integral-effect of inverse square law absorbed dose in tissue, TG-43, isodose curves,Systems of Implant dosimetry-peterson parker system,quimbi system,paris system,computer system Computer Dosimetry-localization of sources, implantation techniques- surface mould, interstitial, Intracavity,-Dose specification : Cancer of Uterine Cervix-Manchester system Dose rate considerations and classification of brachytherapy techniques — Low dose rate (LDR), high dose rate (HDR) and pulsed dose rate (PDR), Afterloading techniques Advantages and disadvantages of manual and remote afterloading techniques- temporary and permanent implants **(20 hours)**

STANDARD BOOK FOR STUDY

Radiotherapy handbook for teachers and students, IAEA publication

REFERENCES

1. F.M. Khan “ Physics of Radiation Therapy” 2010- Fourth edition.
2. F.A.Attix “Radiation Dosimetry” Vol I-III, Academic press New York, 1985.
3. F.M. Khan “ Physics of Radiation Therapy” 2010- Third edition
4. H.E.Jones, J.R.Cunnigham, “The Physics of Radiology” Charles C.Thomas, NY, 1980.
5. W.R.Hendee, “Medical Radiation Physics”, Year Book – Medical Publishers Inc London, 1981.
5. R.F.Mould, “Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.
- 6..S.C.Klevenhagen “Physics of Electron Beam Therapy” Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
7. J.R.Greening “Fundamentals of Radiation Dosimetry”, Medical Physics Hand Book, ADAM Hildre, 1981

RPH3C20. NUCLEAR MEDICINE

4 CREDITS)

1: Introduction to Nuclear Medicine: Nuclides and Radioactive Processes, Nuclides and Their Classification, Nuclear Structure and Excited States of a Nuclide, Radionuclide and Stability of Nuclides, Radioactive Processes and Conservation Laws, Radioactivity: Law of Decay, Calculation of the Mass of a Radioactive sample, Specific Activity, Problems on Radioactive Decay, Average Life, Biological Half-Life, Effective Half-Life, Statistics of Radioactive Decay , Mean, Standard Deviation, Random error, Systematic error, Accuracy, Variance, Poisson distribution, standard deviation, probable error, resolving time and loss of counts, sample counting procedures. **(16 hours)**

2: Production Of Radio Nuclides and Detectors used: Use of unsealed sources in diagnosis and treatment, details of radionuclide including decay schemes, method of preparation, storage and handling, nature of pharmaceutical preparations. Isotopes, Selection of Isotopes, carrier free, Radiopharmaceuticals , Production of Radionuclide, Radionuclide generator. Instruments used in radiation detection and measurement in nuclear medicine, GM systems, liquid scintillators, solid scintillators, and electronic circuits for a scintillation detector, single and multi channel analysers, Pulse height spectroscopy. In Vitro radiation detection-Well type NaI(Tl) Scintillation detectors, 4π β - γ coincidence counting , Routine sample measurements with radioisotopes – re-entrant chamber methods, Liquid counters – Window-less counting of liquid samples ,statistics of isotopes counting, **(16 hours)**

3: In vitro- In vivo Procedures: Uptake studies, thyroid uptake, details of instruments used, method of uptake measurement, determination of plasma volume using a well counter, time dependence studies like life of erythrocytes, Studies with radioactive tracers, uses of isotopes like C14, P32, Cr51, Co57, Co58, Ga67, Tc99m, I123, I131, Xe133, 111In, Au198, Tl 201. uses of whole body counters, – Circulation studies with Na-24 iron physical principles of isotopes, dilution analysis, multiple compartment system, measurement of circulation time, renal, liver, lung, cerebral function studies, In-vitro

procedures, RIA kit, Treatment of thyrotoxicosis, thyroid cancer with Iodine, use of phosphorus -32 for therapy, Treatment of Polythaemia Vera and leukemia with P-32, patient doses. Use of colloidal gold and chromic phosphate in the treatment of malignant effusions – Calculation of treatment doses. **(16 hours)**

4: Emission Tomography: Imaging using radio nuclides, rectilinear scanner, the Anger Camera – Principles of construction, use and maintenance. Different types of Collimators. Basic principles and Problems, Focal plane Tomography, Emission Computed Tomography, Single Photon Emission Computed Tomography. Various Image Reconstruction Techniques SPECT, Positron emission tomography (PET), principles of PET imaging, clinical applications. Working of Medical Cyclotron, Radioisotopes produced and their characteristic. **(16 hours)**

5: QA of Nuclear Medicine equipments, Room Design and Safety concern

QA in the preparation of radio- pharmaceuticals, QA in imaging, flood phantom. QA of Gamma Camera- Spatial Resolution (intrinsic resolution, collimator resolution, Scatter resolution), geometric efficiency. Handling of radioactive materials, radiation units, permissible radiation exposures, ALARA, radiation protection measures, nuclear medicine special laboratory procedures. Planning of nuclear laboratories for diagnostic and therapeutic procedures- Categories of Nuclear Medicine laboratories (category 1, 2, 3, 4), Equipments and accessories, Staff requirements, shielding requirements in diagnostic and therapy nuclear medicine laboratories. Delay tank system. Site planning for cyclotron – PET/CT facility. **(16 hours)**

STANDARD BOOKS FOR STUDY AND REFERENCES

1. Nuclear Medicine handbook for teachers and students, IAEA Publications
2. W.H.Blahd, “Nuclear Medicine”, McGraw Hill Co., New Delhi, 1980.
3. H.N.Wagner, “Principles of Nuclear Medicine”, W.B.Saunders Co, London, 1970.
4. Herbert (John) & D.A.Rocha, Text Book of Nuclear Medicine, Vol 2 & 6, Lea and Febiger, Philadelphia, 1984.
5. Ramesh Chandra, “ Nuclear Medicine Physics- The Basics Nuclear Medicine Physics: The Basics, 6th Edition” ©2004
6. 6. Safety Report Series No. 40 “ Applying Radiation Safety Standards in Nuclear Medicine “ – IAEA
7. “ Nuclear Medicine Resources Manual” INTERNATIONAL ATOMIC ENERGY AGENCY VIENNA, 2006

RPH3C21 – PRACTICALS IN RADIATION DETECTION AND MEASURING INSTRUMENTS (Minimum 12 expts. to be carried out) (70 HOURS) 2 CREDITS

1. Efficiency of G.M. Counter
2. Efficiency of NaI(Tl) and semiconductor detectors
3. Measurement of exposure time of X-ray units using spinning top.
4. Study of dependence of exposure on factors like kV, mA, time and distance.
5. Measurement of HVL and TVT of an X-ray beam
6. Energy dependence of HVT and TVT of an Xray beam
7. Liquid scintillation counter
8. Use of a large volume ion chamber for monitoring
9. Thermo luminescent dosimeter
10. Measurement of contamination level and methods of decontamination.
11. Auto radiography of discrete sources

12. Contamination monitoring of discrete sources
13. Use of isotope calibrator
14. Film dosimetry
15. Fricke dosimetry

RPH3C22 -PRACTICALS IN MEDICAL IMAGING

Minimum 12 expts. to be carried . (70 Hours)2 CREDITS

1. Standard procedures for processing of an exposed film
2. Study of safe light and light proof nature of dark room
3. Study of speed of an intensifying screen
4. Latitude of a film screen combination
5. Testing of collimator and field congruence
6. Measurements of KVp, mAS for an X-ray unit
7. Study of radiation level around an X-ray tube head
8. Working of automatic processing systems
9. Patient dose measurements in diagnostic radiology
10. Study of effectiveness of filters
11. Preparation of processing chemicals
12. Use of a sensitometer
13. Measurement of point-spread function
14. Measurement of edge-spread function
15. Measurement of Line-spread function

SEMESTER IV

RPH4C24. QUALITY ASSURANCE, ACCEPTANCE TESTING AND COMMISSIONING OF RADIATION SYSTEMS 4 CREDITS

1: Need for Quality Assurance: Need for quality assurance, Goals of QA, Physics Staffing, Personnel Requirements for Clinical Radiation Therapy, Roles and Responsibilities. Documentation And Quality Assurance, Definition Of Terms - Quality Control, Quality Assurance, advantages of a Code of Practice based on standards of absorbed dose to water, Expression of uncertainties, The International Measurement System, The IAEA/WHO network of SSDLs, Standards of absorbed dose to water, **(14 hours)**

2: Dosimetric Protocols and QA for Radiation Therapy: Different Protocols For Dosimetry- TRS 277, TRS-398, TG51, TG-43 *ND,W*-BASED FORMALISM, Correction For The Radiation Quality Of The Beam, *K_q,Q_o* Ionization Chambers, Phantoms, Calibration Of Ionization Chambers, Determination Of Absorbed Dose To Water, Electric check, Mechanical Checks, Dosimetric Checks, Protection Checks for Co- 60 and Linacs, - field size, alignment of radiation and optical fields, safety system and warning lights, symmetry and parallelism of collimation jaws, energy stability, Daily Checks in C0 60 and LINAC. Brachy therapy – QA of sources, Leakage and Contamination, Source Strength Verification, Uniformity of Activity, QC of Applicator, Dwell Position Verification, QC of treatment Unit, Radiation Safety, HDR Source Transport, Type A package, Source Transfer Process and safety Concern in HDR. **(16 hours)**

.....3: **Quality Assurance tests in Diagnostic Radiology:** Details of medical diagnostic X-ray equipment and manufacturer, Mechanical Characteristics and Display Indicators, QA tests for diagnostic X-ray machine, Air kerma rate at table top, Resolution of the imaging system, Radiation leakage levels from X-Ray tube housing & Collimator at 1m from the focus, Radiation protection survey. Darkroom QC , Intensifying Screen Cleaning Procedure, Darkroom Integrity or Fog Test, Mechanical tests for CT - Alignment of table to gantry, Gantry tilt, Positioning of the patient support, patient positioning accuracy, Collimation test, Accuracy of kV, mA Irradiation Time (t), Reproducibility, Radiation Dose test, Noise, Mean CT number and Uniformity, Low contrast resolution, Calibration methods, duration of dose delivery, documentation of physical parameters, quality indices, Magnetic resonance imaging (MRI), Phantom materials, resonance frequency, signal to noise ratio, image uniformity, spatial linearity, high contract spatial resolution, slice thickness, slice position separation, image artifacts, **(18 hours)**

4: Quality Assurance tests for TPS: AAPM Task Group 53 Quality Assurance for Clinical Radiotherapy Treatment Planning (1998) and IAEA Technical Report Series No. 430 Commissioning and Quality Assurance of Computerized Treatment Planning Systems for Radiation Treatment of Cancer (2005). Digitizer Accuracy, Image Acquisition and Display, Hard copy Output Accuracy, Monitor Unit Check – Open and Wedge Fields, Isodose Checks, Clinical Isodose/Monitor Unit Check, Electron Monitor Unit and PDD Check, Operating Consistency of IMRT Dose Optimization Software, HDR Treatment Planning QA, Prostate Seed Treatment Planning QA **(14 hours)**

5: Commissioning, Acceptance tests and Decommissioning Procedures: Acceptance /QA tests for Co-60 Teletherapy, Medical linear Accelerators and Brachytherapy, Mechanical Tests, Electrical Tests, Photon Beam Characteristics, Electron Beam Characteristic, Dose Monitoring System, Treatment table, Radiation Leakage, Protection Survey, essential Equipments for Commission and Decommission. Decommissioning Process for Radioactive Sources, Depleted Uranium, Medical Linacs Brachytherapy , Equipments required, Pocket dosimeters and others , Transport of Sources, Survey for Contamination. **(18 hours)**

STANDARD BOOKS FOR STUDY

1. NCRP, ICRP, ICRU, IAEA, AERB Publications on QA.
2. TRS-398, TRS 277, TRS 430 IAEA Technical Series
3. TG 51, TG 21, TG 43, TG 53 AAPM Task Group
4. Treatment Planning in Radiation Oncology, Faiz M.Khan Roger A.Potish

RPH4E25A. RADIOTHERAPY TREATMENT PLANNING 4 CREDITS

1. Dosimetric Parameters, Dose Distribution and Scatter Analysis

Target Volume Definition and Dose Prescription Criteria (ICRU 50, ICRU 62 and ICRU 83), Gross tumor volume (GTV), Clinical target volume (CTV), Planning target volume (PTV) etc Dose prescription point, isodose line, or isodose surface, Photon Beams: Dose Modeling and Treatment Planning , Single-field dose distribution, Parameters influencing isodose curves and isodose surfaces, Combination of fields, Wedged and angled fields, Corrections for SSD, missing tissue, and inhomogeneities, Dose specification and normalization. **(14 hours)**

2. Manual and Computerized Treatment Planning Methods

Photon Beams: Treatment Planning, Acquisition of isodose data, Computer hardware
Common algorithms: Convolution, superposition, pencil beam, Dimensionality (2D, 2.5D, and 3D treatment plans), Non-coplanar plans, Treatment planning with asymmetric collimators, Treatment planning with wedges (hard, dynamic, and virtual), Treatment planning with multileaf collimators (MLCs), Compensator design, 3-D treatment planning, Inverse planning objectives and techniques. Optimization methods, Treatment planning with Monte Carlo techniques, Biological modifiers/optimization, Clinical Photon Beams: Patient Application, Patient data acquisition, Contours, Contouring Images from CR, CT, MRI, US, PET, Fusion Techniques Conventional simulator techniques, Positioning/immobilization, Use of contrast, markers, Image parameters/optimization, Block cutting, Compensators, Bolus, CT-simulator techniques, Scout view images, Virtual simulation Digitally reconstructed radiographs (DRRs), CT number and (electron) density relation and calibration, Special considerations, Skin dose, Field matching, Integral dose, Dose-volume histograms (DVHs): Differential and integral
(18 hours)

3. Electron Beam Therapy-Treatment Planning and Dose Calculation

Effects of patient and beam geometry - Air gap, Beam obliquity, Irregular patient surface, Internal heterogeneities: bone, fat, lung, air, Dose algorithms, Analytical algorithms (e.g., Fermi-Eyges based pencil beam), Monte Carlo algorithms, Clinical commissioning, Quality assurance of treatment plans, Treatment planning techniques- Energy and field size selection, Bolus: Constant thickness and shape, Collimation: Inserts, skin, internal, Field abutment techniques Photon-electron mixed beams, Special electron treatment techniques, Total skin irradiation, Total limb irradiation, Electron arc therapy, Intraoperative electron therapy, Total scalp irradiation, Craniospinal irradiation, Conformal therapy
(16 hours)

4. Techniques of Radiotherapy Planning for all The Malignancies in The Body

Concept of therapeutic ratio, TCP, NTCP, organs at risk, TD50/5 table and doses, Individual organ tolerances, Patient care before and during radiotherapy Indications and RT techniques for tumors Skin, Head and Neck, Oral cavity, Pharynx, CNS, Thyroid, Lung, Breast, lymphomas, Esophagus and stomach, Pancreas and liver, Rectum, Anus, Prostate, pediatric tumors, Indications for systemic irradiation, Curative /Palliative RT, Nodular treatment, Dose-fractionation, Hypo and hyper, Accelerated radiotherapy, Concomitant radiotherapy and chemotherapy, Concomitant radiotherapy and hypoxic sensitizers, Gaps in treatment delivery, Inter-fractional motion,
(16 hours)

5. Brachytherapy- Treatment Planning and Dose Calculation

Purposes of Brachytherapy Treatment Planning, Prescription points for vaginal cylinder, T&O, esophagus, endobronchial, and bile duct treatments, Treatment site, disease, prescribed doses, isodose line /prescription points, isotopes, applicators used, Contrast, markers, skin wires, Target and critical organs, Applicator insertion, T&O implants, total source strength and exposure time (or dose), Seeds-alone vs. boost prostate implants, indexer lengths, Catheter numbering in interstitial implants, Use of spacers, ICRU Report 58 Quantities, RTOG 95-17, Accelerated Partial Breast Brachytherapy, Differential DVH for Optimized Plan, Simplified analytical solutions(unfiltered line source Sievers

integral), Use of classical implant systems(Manchester, Quimby, Paris) for interstitial implants
(16 hours)

STANDARD BOOKS FOR STUDY AND REFERENCES

1. Faiz M.Khan, Treatment Planning in Radiation Oncology, LWW publication, 2nd ed.
2. S.C.Klevenhagen “Physics of Electron Beam Therapy” Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
3. Ann Barrett, Jane Dobbs, Stephen Morris and Tom Roques. “Practical Radiotherapy Planning” Fourth Edition- 2009
4. R.F.Mould, “Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.

RPH4E25B.- INDUSTRIAL AND RESEARCH APPLICATIONS OF RADIATIONS

UNIT 1. Industrial application of radiation: Principles of industrial radiography with x ray and gamma ray, radiographic exposure devices, photographic film technique, radiographic contrast, definition and sensitivity, intensifying screens and pentameters,

UNIT 2. Principle and measurement of thickness and level in different application, density and moisture hydrogen in hydrocarbons, well logging, composition analysis. Principle of operation of consumer products using radiation sources fire detector, baggage inspection systems, static eliminator, luminous paints and gas mantles.

UNIT 3. Industrial radiation processing, gamma chambers, radiation sterilization, irradiation of food and medical products. Ion exchange techniques – Physical basis of separation – Cation and anion exchangers – Removal of impurities of interfering substance – Concentration of trace constituents – Applications.

UNIT 4 : Autoradiography – General considerations – Laboratory requirements – Types of photographic emulsions used – Contact and stripping film methods – Interpretation of results – Chromatography – Partition, paper and gas chromatographic methods – Mounting of samples – Suitable Solvents – Quantitative aspects – Applications.

UNIT 5. Attenuation of beta particles and electrons in paper manufacturing. Multielement analysis, thin layer activation, smoke detectors, mineral processing, coastal engineering, flow rate measurement, - gas, liquid, river flow- erosion studies-use of Cesium-, ground water management, Oceanography, effect of high energy radiation on polymers, Accelerator mass Spectroscopy.

STANDARD BOOKD FOR STUDY

4. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001
5. J.R.Greening “Fundamentals of Radiation Dosimetry”, Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.
6. U.B.Thripathi Quality assurance of Radiation therapy equipment and practice – lecture note

7. A.Martin and S.A.Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
8. NCRP, ICRP, ICRU, IAEA, AERB Publications

RPH4E26A. MODERN TRENDS IN RADIOLOGY AND RADIOTHERAPY

4 CREDITS

1: Imaging in Radiotherapy

Recent advances in Diagnostic Radiology, Digital Radiography, Digitally Subtracted Radio Graph (DRR), Xero Radiography, Mammography, New Generation Of CT-Scanners and Their Applications – CVCT, Spiral CT, CBCT, 4DCT Etc , Image Reconstruction, CT Simulation and Simulator CT, MRI and PET Imaging, Image Fusion In Radiotherapy, Portal Imaging With Gas Filled And Solid State Detectors, KV and MV Imaging.

(16 hours)

Unit 2: Introduction to Treatment planning system and Dose Calculation algorithm

Treatment Planning System (TPS), Computers In Radiotherapy, Hard Ware and Software Requirements, Development Of 3D TPS, Physics Of Treatment Planning and Various Steps In Treatment Planning Dose Calculation Algorithms- Correction Based and Model Based Algorithms, Convolution, Super Position and Montecarlo Methods, PBC, AAA And Collapsed Cone Algorithms and Dose Calculation. QA of Treatment Planning System. Gamma verification and CAP for TPS

(16 hours)

Unit 3: Multileaf collimators and Conformal Radiotherapy : Physical and Clinical Aspects of Multileaf Collimators, Quality Assurance for Multi Leaf Collimators, Dose Volume Specifications In Radiotherapy, Concepts Of GTV, CTV, ITV and PTV, ICRU-50 And ICRU-62 Guidelines, Beams Eye View, Planning Optimization Methods, Plan Evaluation, Dose Volume Histogram, DMLC, MMLC, QA Of 3DCRT Plans **(14 hours)**

Unit 4: Advancements in Conformal Radiotherapy: Intensity Modulated Radiotherapy (IMRT)-Physical and Clinical Aspects, Treatment Planning, Optimization and Delivery Methods, Quality Assurance Of IMRT- Machine Specific And Patient Specific QA in IMRT. Gamma Analysis. Concept of energy modulated therapy, Image Guided Radiotherapy (IGRT)-Physical and Clinical Aspects, Gated IGRT, Technical Requirements for IGRT. Volumetric Arc Therapy-Physical and Clinical Aspects and Quality Assurance. Tomotherapy, Particle Beam-Proton, Neutron and Heavy Ion Therapy and Adaptive Radiotherapy, Stereotactic Radio Surgery(SRS) and Stereotactic Radiotherapy (SRT)- Cranial and Extra Cranial Surgery Systems-Gamma Knife , X-Knife and Cyber knife Systems, Clinical Applications Of Cranial and Extra Cranial Radio Surgery, Concept Of SBRT-Stereotactic Body Radiotherapy. **(18 hours)**

Unit 5: Advancements in Brachytherapy: CT Based 3D Planning Systems In Brachytherapy, Use Of New Radionuclides in Brachytherapy, LDR, HDR and PDR Systems, Intra-Operative Radiotherapy, Intraluminal Radiotherapy, Prostate Implants and Ultra Sounded Guided Implants, Perineal Templates, Iodine Seeds For Prostate Cancer, Intra Vascular Brachytherapy, Dose Prescription and Plan Evaluation In Brachytherapy, QA In Brachytherapy. **(16 hours)**

REFERENCES:

1. James A Purdy, Walter H. Grant , 3D Conformal and Intensity Modulated Radiation Therapy- Physics and Clinical Applications” (Perez Publisher)
2. S. Webb, Contemporary IMRT Developing Physics and Clinical Implementation”, [9780750310048 - Book Depository](#)
3. New Technologies in Radiation Oncology, W. Schlegel, T. Bortfeld, A.L. Grosu, LLW
4. “The Physics of Conformal Therapy - Advances in Technology” by S.Webb
5. A Practical Guide to CT simulation”, by Lawrence Coy
6. 5. The Physics of Medical Imaging, S.Webb, Medical Science Series, Adam Hilger, Bristol,1984.
7. Therapeutic Applications of Monte Carlo Calculations in Nuclear Medicine” Habib Zaidi, George Sgouros- IOP, Institute of Physics Publishing, Bristol and Philadelphia

PAPER RPH4E26B- RECENT DEVELOPMENTS IN INDUSTRIAL APPLICATIONS OF RADIATIONS (70 hours)

UNIT 1: Radioisotope tracer applications – Measurement of flow rate – Determination of phosphorous and sulphur content in shell – Diffusion and vapour pressure measurements – Detection of animal and plant diseases by tracer methods – Study of photosynthesis and uptake of nutrients – Silt movement studies – Go-devil detection – Control of catalyst flow rate –

UNIT 2: Activation analysis – Wear and tear studies – Chemical analysis by activation methods – Induction of polymerization, halogenation and oxidation by radiation – Luminous dial painting – Static eliminators – Sterilization of foods and drugs – Preservation of foods, drugs, and vegetables – Radiation induced genetic changes and crop improvement – Specialized applications of radioisotopes in industry and the life sciences.

UNIT 3: Radioisotope gauges – Use of transmission gauges for measurement of thickness, density and composition – Level indicators – Use of back scatter gauges for measurements of the thicknesses of coatings etc. – Bremsstrahlung gauges – Neutron and gamma scatterings gauges. Details about current suppliers and procedures for procurement of sources

UNIT 4: Planning of radioisotope laboratories for agricultural and research institutions – Design of gamma gardens for agriculture, Design of gamma chamber, Irradiation hall, control hall, hot room- planning and management, post irradiation storing, Food irradiation: Room design- management and storing, testing and verification
Blood irradiation: Room design- management and storing, testing and verification

UNIT5: Specific Application: Leakage test, oil gas mining, smoke detection, application of AM-241 and Cf-252. Thickness measurement, container, transmission pipes, valve test, forensic and security test, DNA testing, pest control, defense applications, air traffic and marine safety.

STANDARD BOOKS FOR STUDY

1. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge University Press, U.K., 2001
2. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.
3. A.Martin and S.A.Harbisor, An Introduction to Radiation Protection, John Wiley & Sons, Inc. New York, 1981.
4. NCRP, ICRP, ICRU, IAEA, AERB Publications

RPH4C27 -PRACTICALS IN RADIOTHERAPY (Minimum 12 expts.) (70 Hours) 2 CREDITS

1. Calibration of a cobalt therapy unit
2. Acceptance testing of a cobalt therapy unit
3. Measurement of central axis percent depth dose
4. Measurement of TAR and BSF
5. Measurement of TPR and TMR
6. Use of a large volume ion chamber as an isotope calibrator
7. Penumbra trimmers
8. Plotting of combined isodose curves for parallel pair fields with various IFDs
9. Plotting of combined isodose curves for parallel pair fields for various energies photon beams
10. Combined isodose curves for oblique fields
11. Wedge fields planning
12. Dosimetry of brachytherapy / Conventional
13. Orthogonal films and calculations
14. Use of optical densitometer for field profile determination
15. In vivo dosimetry

RPH4C28 – PRACTICALS IN RADIOTHERAPY PLANNING AND DOSIMETRY Minimum expts. to be carried out 12. (70 Hours) 2

CREDITS

1. Planning and dosimetry for single field photon irradiation
2. Planning and dosimetry for multiple fields
3. Planning of a three field isocentric treatment
4. Use of TAR and TPR in practical situations
5. Study of advantages of longer SSD using isodose curves in parallel pair irradiation
6. Dosimetry for rotational treatment
7. Dosimetry for four field isocentric irradiation
8. Determination of critical organ doses in typical multi field techniques
9. Measurement of entrance and exit doses and evaluation
10. Exit dose measurement and evaluation of deep tissues in homogeneities
11. Dosimetry for a case of irradiation of maxillary antrum
12. Use of computerized treatment planning system
13. Preparation of a surface applicator and its dosimetry
14. Dosimetry of irregular fields
15. Dosimetry of a linear arrangement of brachytherapy sources

16. Dosimetry for single plane and double plane implants
17. Dosimetry for a cylindrical mould

RPH4C29- PRACTICALS IN Q/A AND CALIBRATION OF RADIOLOGICAL EQUIPMENTS (Minimum expts. to be carried out 12). (70 Hours) 2 CREDITS

1. Calibration of radiation monitor
2. Calibration of a survey meter using a standard source
3. Q.A testing of a simple diagnostic X-ray unit I
4. Q.A testing of a simple diagnostic X-ray unit II
5. Q.A testing of brachytherapy systems
6. Q.A testing of C.T units
7. Q.A testing of telecobalt therapy units
8. Routine testing of a Linac system
9. Room planning of a radiotherapy installation
10. Radiation monitoring around a teletherapy installation
11. Study of the effectiveness of protective systems in diagnostic radiology
12. Study of the effectiveness of shielding blocks in radiotherapy
13. Tracing a missing source
14. Management of emergencies in a cobalt therapy unit
15. Management of emergencies in a brachytherapy unit

RPH4C30 Comprehensive viva voce

1 credit

Chairman
PG Board of Studies in Radiation Physics
University of Calicut

.....:Name

Pages: 3))

.....Reg.No

FIRST SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2019

Radiation Physics

RPH1C01. MATHEMATICAL METHODS IN PHYSICS

(Admission 2019)

Maximum: 70 Marks

Time: Three Hours

Section A

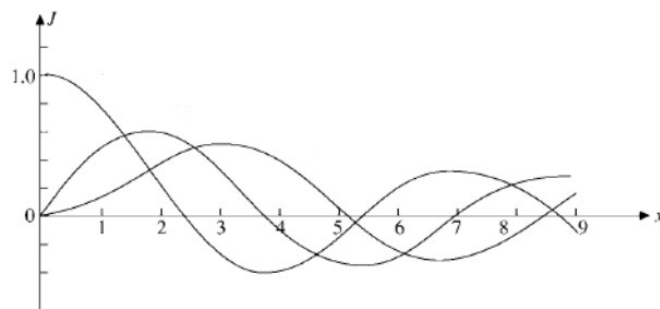
.Answer any **Six** questions

.Each questions carriers 3 marks

.Define contra-variant, covariant tensors and rank of a tensor .1

± 1 = If **A** is orthogonal, show that its determinant .2

.Identify the curves shown below and write the functions that follows each curve .3



?Explain Convolution theorem with an example .4

?What do you mean by diagonalization of matrices .5

Show that .6

$$H_{n+1}(x) = 2xH_n(x) - 2nH_{n-1}(x)$$

?Write a note on Pseudo Tensor .7

Explain with examples what you understand by a unitary matrix and a Hermitian matrix .8

(Show that $\beta(m,n) = \beta(n,m)$.9

(x 3 = 18 Marks 6)

Section B

.Answer **all** questions

.Each question carries 14 marks

a) In the spherical polar coordinate system, $q_1=r$, $q_2=\theta$, $q_3=\phi$. The .10

$x=r\sin\theta\cos\phi$, $y=r\sin\theta\sin\phi$, $z=r\cos\theta$ transformation equations are

$h_r, h_\theta \wedge h_\phi$:i) Calculate the spherical polar coordinate scale factors

$ds_i=h_i dq_i$ ii) Check your calculated scale factors by the relation

or

b) Solve the Legendre equation

.by direct series substitution $(1-x^2)y'' - 2xy' + n(n+1)y=0$

.a) Develop a series solution for Hermite's differential equation .11

$$y'' - 2xy' + 2\alpha y = 0$$

or

b) Find and discuss the normal modes of vibration of CO₂ molecule

(x 14 = 28 marks 2)

Section C

.Answer any **Four** questions

Each questions carriers 6 marks

Show that the two-index Levi-Civita symbol ϵ_{ij} is a second-rank .12
pseudotensor (in two-dimensional space). Does this contradict the uniqueness

. δ_{ij} of

Find eigen values and eigen vectors .13

$$A = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}.$$

$$\int_0^{\infty} e^{-x^4} dx = \Gamma\left(\frac{5}{4}\right) \quad \text{Show that} \quad .14$$

.Prove that if A is a Hermitian matrix, then its eigenvalues are real numbers .15

$$J_{\frac{1}{2}}(x) = \sqrt{\left(\frac{2}{\pi x}\right)} \cdot \sin x \quad \text{Prove that} \quad .16$$

$$L^{-1}\left\{\frac{4}{s-2} - \frac{3}{s+5}\right\} \quad \text{Solve} \quad .17$$

(x 6 = 24 marks 4)

---END----

.....:Name Pages: 3))

.....Reg.No

FIRST SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2019

Radiation Physics

RPH1C01. MATHEMATICAL METHODS IN PHYSICS

(Admission 2019)

Maximum: 70 Marks

Time: Three Hours

Section A

.Answer any **Six** questions

.Each questions carriers 3 marks

.Show that the product of two orthogonal matrices is orthogonal .1

The double summation $K^{ij}A_iB_j$ is invariant for any two vectors A_i and B_j . .2
 .Prove that K^{ij} is a second rank tensor

Show that Legendre's equation has regular singularities at $x=-1,1$ and .3
 .infinity

.Write short note on Bessel's function .4

.Define Tensor and Pseudo-tensor .5

Two Hermitian matrices A and B have the same eigen values. Show that A .6
 .and B are related by a unitary similarity transformation

.Define the terms ordinary, singular, regular singular points .7

$$J'_{n-1}(x) - J'_{n+1}(x) = 2J'_n(x) \quad \text{Show that} \quad .8$$

.Define the Laplace transformation convolution theorem .9

(x 3 = 18 marks 6)

Section B

.Answer **all** questions
Each question carries 14 marks

a) How do you define Fourier series and explain the properties of Fourier .10
.series

Or

$$\frac{d^2 y}{dx^2} + \frac{1}{x} \frac{dy}{dx} + \left(1 - \frac{n^2}{x^2}\right) y = 0 \quad \text{b) Solve}$$

a) Derive the expression for curl in terms of orthogonal curvilinear .11
.coordinates

Or

b) Explain the Frobenius' Method to find the solution of linear, second
(order homogenous Ordinary Differential Equation (ODE

(x 14 = 28 marks 2)

Section C

.Answer any **Four** questions
Each questions carriers 6 marks

.Show that $\Gamma\left(\frac{1}{2} - n\right)\Gamma\left(\frac{1}{2} + n\right) = (-1)^n \pi$ where n is an integer .12

$$\beta(p, q) = \frac{\Gamma(p)\Gamma(q)}{\Gamma(p+q)} \quad \text{Prove that .13}$$

Show that .14

$$\cos x = J_0(x) + 2 \sum_{n=1}^{\infty} (-1)^n J_{2n}(x) \quad \text{(a)}$$

$$\sin x = 2 \sum_{n=0}^{\infty} (-1)^n J_{2n+1}(x) \quad \text{(b)}$$

Develop the Fourier series representation of .15

$$f(t) = 0 \text{ for } -\pi \leq \omega t \leq 0 \wedge f(t) = \sin \omega t \text{ for } 0 \leq \omega t \leq \pi$$

$$L\left\{\frac{\cos at - \cos bt}{b^2 - a^2}\right\}, \text{ where } a^2 \neq b^2 \quad \text{Solve} \quad .16$$

.Define and find the expression for Euler's Angle .17

(x 6 = 24 marks 4)

-----END-----

(MODEL)
FIRST SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2019

Radiation Physics

RPH1C02-CLASSICAL MECHANICS
(2019 admission)

Time: 3 hr

Maximum:70 Marks

Part A

Answer **6** questions. Each question carries 3 Marks

- 1) What are constraints ? Explain the different types of constraints with example
- 2) Define degree of freedom. Find out the degree of freedom of a rigid body in 3-D
- 3) State and explain D'Alembert's principle.
- 4) Can a canonical transformation reveal symmetry in a physical system ? How can it be used to reduce the number of independent variables ?
- 5) Plot the equivalent one dimensional potential for an attractive inverse fourth law of force ?
- 6) What is non conservative force ? Is the Lorentz force non-conservative?
- 7) Distinguish between differential cross section and total cross section.
- 8) State Kepler's laws.
- 9) What are fundamental Poisson brackets and what is their importance?.

Part B

Answer any **two** questions. Each question carries 14 Marks

- 10) a) Derive the Lagrange's equations of motion from D'Alembert's principle.

OR

- b) Set up the differential equation of the orbit for planetary motion and deduce the Kepler's law
- 11) a) State and prove Hamilton Jacobi equation. Deduce the Schrodinger equation and de-Broglie relation from it.

OR

- 12) What is meant by generalised co-ordinate ? Derive Hamiltons canonical equations of motion in generalised co-ordinates and explain the significance of Hamiltonian.

Part C

Answer any 4 question. Each question carries 6 Marks

- 13) Prove $[X,[Y,Z]] + [Y,[X,Z]] + [Z,[X,Y]] = 0$
- 14) Show that the transformation $P = q \cot p$ & $Q = \log ((\sin p)/q)$ is canonical. Find the kind of generating function ?
- 15) Use Hamilton's equation to find the differential equation for planetary motion and prove that the areal velocity is constant. Assume force $f(r) = -\frac{k}{r}$
- 16) Calculate the frequency of linear harmonic oscillator by using the method of angle action variables.
- 17) A bead of mass m is constraint to move along a smooth rigid wire having the shape of hyperbola $XY = C$, Construct the Lagrangian and find the equation of motion ?
- 18) A particle of mass, m , can slide without friction on the inside of a small tube bent in the form of a circle of radius r . The tube can rotate freely about a vertical axis and has a moment of inertia I about this axis. Find the Hamiltonian and obtain Hamilton's equations of motion for this system.

(MODEL 2)
FIRST SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2019

Radiation Physics

RPH1C02-CLASSICAL MECHANICS
(2019 Admission)

Time: 3 hr

Maximum:70 Marks

Part A

Answer **6** questions. Each question carries 3 Marks

- 1) What are cyclic co-ordinates ? Show that the momentum canonically conjugate to a cyclic coordinate is a constant of motion.
- 2) Write a short note on Legendre transformation.
- 3) State and explain the principle of virtual work ?
- 4) Distinguish between Hamilton's variational principle and Hamilton's principal function (S).
- 5) The generalised work always have the dimension of work but the generalised force need not have the dimension of force. Explain
- 6) If a function $df(q_1, q_2, \dots, q_n)/dt$ is added to Lagrangian L of a system, what happened to its Lagrange's equation of motion?
- 7) Write a note on phase space. Prove that the phase space trajectory of a linear harmonic oscillator is an ellipse.
- 8) Obtain $\{ L^2, L_x \}$ Poisson bracket.
- 9) Explain the concept of configuration space.

Part B

Answer any **two** questions. Each question carries 14 Marks

- 10) a) Derive Euler Lagrange equations of motion using the calculus of variations and hence obtain Lagrange's equation of motion for a system of particle .

OR

- b) Derive the differential equation of the orbit in polar co-ordinates under a central force & discuss the general features of the orbit

- 11) a) State three Kepler's laws of planetary motion and explain their property? If the law of gravitational attraction were different from the inverse square law which of Kepler's law would still remain valid?

OR

- b) Give an account of Hamilton Jacobi theory and illustrate it by applying it to the Kepler's problem, particle moving under central force

Part C

Answer any 4 question, Each question carries 6 Marks

- 12) For what value of m and n do the transformation equations $Q = q^m \cos np$ & $P = q^m \sin np$ present a canonical transformation? Obtain the generating function.
- 13) Find the Lagrange's equation for charged particle in an electro magnetic field?
- 14) The Lagrangian of one dimensional system is $L = \frac{m}{2} \dot{x}^2 + q\dot{x} - \frac{k}{2} x^2$ where k and q are constants. What will be the corresponding Hamiltonian?
- 15) Using variational principle prove that the shortest distance between two point in plane is straight line.
- 16) A mass m , moves in a circular orbit of radius r_0 , under the influence of a central force whose potential is $-\frac{k}{r^n}$. Show that the circular orbit is stable under small oscillations if $n < 2$.
- 17) Determine the canonical transformation defined by the generating function $F_1(q, Q, T) = \frac{1}{2} m \omega(t) q^2 \cot Q$. Find also the new Hamiltonian.

FIRST SEMESTER M.Sc. DEGREE EXAMINATION, DECEMBER 2019

Radiation Physics

RPH1C03 - BASIC ELECTRONICS

(2019 Admission)

Time: Three Hours

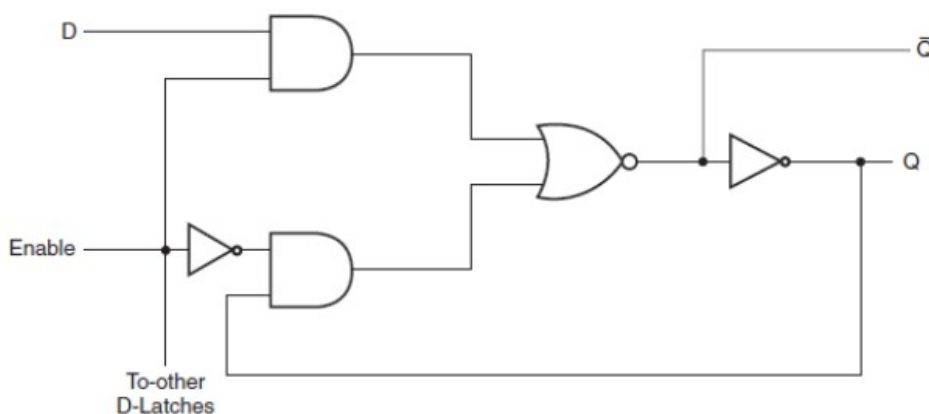
Maximum: 70 Marks

Section A

Answer any **Six** questions.

Each questions carriers 3 marks.

1. What happens to a tunnel diode when the reverse bias effect goes beyond the valley point? and justify your answer.
2. What is the need of negative feedback in an OP-amp? And what is the importance of *CMRR*?
3. Figure below shows the internal logic circuit diagram of one of the four D latches of a four-bit D latch in IC 7475. a) Give an argument to prove that the Q output will track the D input only when the ENABLE input is HIGH. b) Also, prove that the Q output holds the value it had just before the ENABLE input went LOW during the time the ENABLE input is LOW.



4. What is a clocked J-K flip-flop? What improvement does it have over a clocked R-S flip-flop?
5. Draw a transistor circuit with a CE connection. Now, what kind of troubles can you get with a circuit like this and what measurements would you make to isolate each trouble.
6. How does a sinusoidal oscillator produce an output signal without an input signal?
7. What is a photo voltaic cell and explain its operation using schematic diagrams?
8. An op-amp is used in following modes with $R_1 = 1 \text{ k}\Omega$ and $R_f = 100 \text{ k}\Omega$, $V_i = 120 \text{ mV}$ and $V_{cc} = +$ or $- 12 \text{ V}$. Find out put V_o in the following cases, a) Inverting mode, b) Non-inverting mode.
9. Write a note on Transferred Electron Devices (TED).

(6 x 3 = 18 Marks)

Section B

Answer **all** questions.

Each questions carriers 14 marks.

10. a) Briefly describe the difference between a microprocessor and a microcontroller. What are the three main constituents of a microprocessor and what is the basic function performed by each one of them. Briefly describe some of the major application areas of microcontrollers.

Or

- b) Compare the operation of BJT and JFET. Your comments should include the advantages and disadvantages of each and include at least two applications of each. Draw the drain curves and the trans-conductance curve for a JFET.
11. a) Explain the operation of LEDs and LASER diodes with schematic diagrams?

Or

- b) Explain the working of OPAMP Phase shift oscillator, Wein bridge oscillator and saw tooth wave generator with the help of diagrams and input-output characteristic plots.

(2 x 14 = 28 marks)

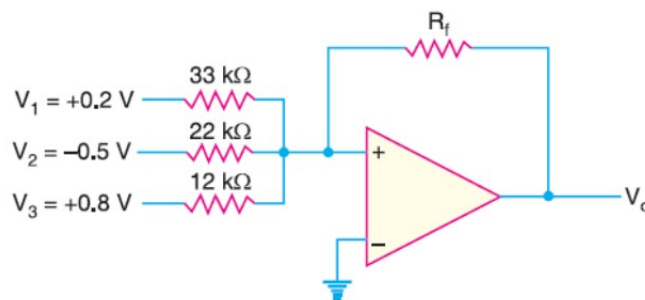
Turn Over

Section C

Answer any **Four** questions.

Each questions carriers 6 marks.

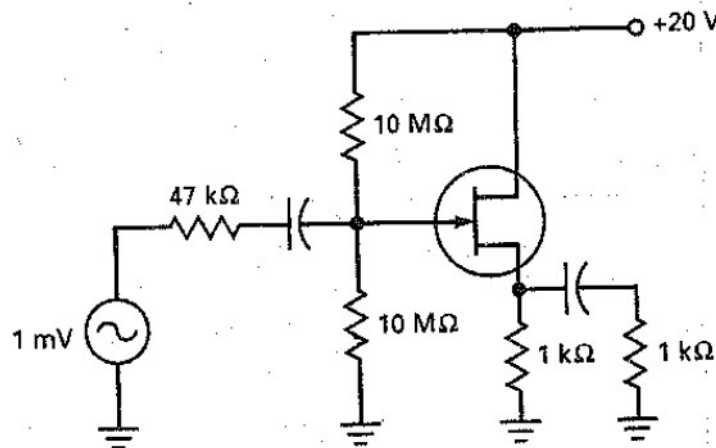
12. Calculate the output voltage of the circuit in Figure below for $R_f = 68\text{k}\Omega$.



13. Design an electronic analog computer using OPAMPs to solve the equation

$$\frac{d^2v}{dt^2} + K_1 \frac{dv}{dt} + K_2v - v_1 = 0$$

14. If $g_m = 2500 \mu\text{S}$ in the figure below, what is the output voltage of the source follower?



15. Determine the maximum operating frequency for a negative feedback opamp amplifier when the output from the amplifier can change by 0.5 V every μs . Where power supply is give as voltage is +10 and -10, $R_L = 5 \text{ k}\Omega$.

16. Design a wide band pass filter with $f_L = 100$ Hz, $f_H = 1$ kHz and a pass band gain of 4. Calculate the value of Q for this filter.
17. Design a 4 bit R-2R ladder DAC using OPAMP with required formulas.

(4 x 6 = 24 marks)

-----END---

(Pages: 3)

Name:.....

Reg.No.....

FIRST SEMESTER M.Sc. DEGREE EXAMINATION,

Radiation Physics

RPH1C03 - BASIC ELECTRONICS

(2019 Admission)

Time: Three Hours

Maximum: 70 Marks

Section A

Answer any **six** questions.

Each questions carriers **3** marks.

1. Derive an expression for the voltage gain of an inverting amplifier. What do you mean by (i) output offset voltage (ii) input offset current?
2. Explain the operation of BJT and JFET with the help of schematic diagrams.
3. Write a note on Barkhausen Criterion.
4. Sketch the circuit of a Wien bridge oscillator. What determine the frequency of oscillation? Will oscillation take place if the bridge is balanced? Explain.
5. Construct a half adder using AND and exclusive OR gate and explain its operation using truth table.
6. Justify that JFET can be used as a Voltage Variable Resistor.
7. Write a note on LDR.
8. Define the fill factor and efficiency of a solar cell?
9. Write a note on compensating networks in OPAMP.

(6 x 3 = 18 Marks)

Section B

Answer **all** questions.

Each questions carriers 14 marks.

10. a) What are the different types of register found in a typical microprocessor? Briefly describe the function of each one of them.

Or

b) What is a flip-flop? With the help of the logic diagram, describe the operation of a clocked R-S flip-flop with active LOW R and S inputs. Draw the truth table of this flip-flop if it were negatively edge triggered.

11. a) Derive the expressions for operating points (I_{CQ} and V_{CEQ}), voltage gain A_d and the input resistance R_i of the Dual Input, Balanced Output Differential Amplifier

Or

b) Explain different types of Synchronous and Asynchronous counters with the help of schematic diagrams

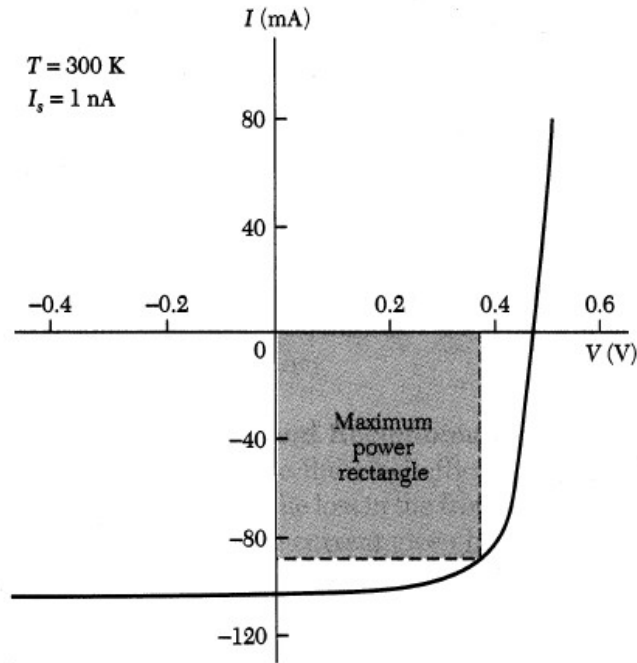
(2 x 14 = 28 marks)

Section C

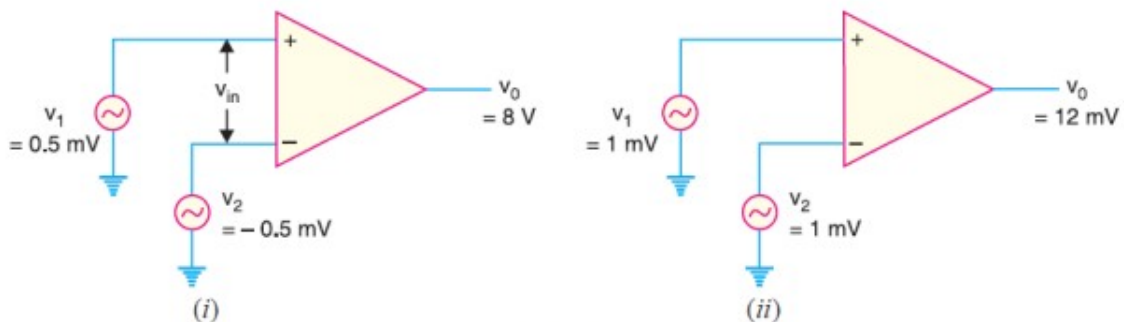
Answer any **four** questions.

Each question carries 6 marks.

12. Calculate the open circuit voltage and the output power at a voltage of 0.35V for a solar cell shown in figure below.



13. Determine the operating points of the two transistors of a dual input balanced output differential amplifier having $R_C = 2.2 \text{ k}\Omega$, $R_E = 4.7 \text{ k}\Omega$, $R_{in1} = R_{in2} = 50 \text{ }\Omega$, $+V_{CC} = 10 \text{ V}$, $-V_{EE} = -10 \text{ V}$, $\beta_{dc} = 100$ and $V_{BE} = 0.715 \text{ V}$.
14. Calculate the mode spacing for a typical GaAs LASER with $\lambda = 0.94 \text{ }\mu\text{m}$, $n = 3.6$ and $L = 300 \text{ }\mu\text{m}$.
15. Calculate the CMRR for the circuit measurements shown in figure below.



16. Determine the operating points of the two transistors of a dual input balanced output differential amplifier having $R_C = 2.2 \text{ k}\Omega$, $R_E = 4.7 \text{ k}\Omega$, $R_{in1} = R_{in2} = 50 \text{ }\Omega$, $+V_{CC} = 10 \text{ V}$, $-V_{EE} = -10 \text{ V}$, $\beta_{dc} = 100$ and $V_{BE} = 0.715 \text{ V}$.
17. Show that the output from a differentiating circuit is derivative of the input and sketch the output waveforms from a differentiating circuit when the input is a) a saw-tooth wave b) a sine wave and c) a triangular wave.

(4 x 6 = 24 marks)

-----END---

First semester Msc Degree Examination ,
Radiation physics
RPH1C 04 INTRODUCTORY NUCLEAR PHYSICS
(2019 Admission)

Time: Three Hours

Maximum: 70 Marks

Section A

Answer any **Six** questions

Each question carries **3** marks

1. Explain quadrupole moment and its importance in nuclear physics
2. Identify the limitation of single particle model
3. Explain Curie plot for β^+ and β^- emissions and give explanation for the change in behaviour
4. Explain four factor formula and its importance
5. Explain the rotational and vibrational model explain the observed nuclear spectra
6. Deduce the relation for most possible atomic number for a given mass number from semi empirical mass formula
7. Explain the angular momentum and parity selection rules for gamma decay
8. Explain the concept of criticality in a nuclear reactor
9. Explain what is lethargy and its importance

(6x 3= 18 marks)

Section B

Answer **all** questions, Each question carries **14** marks

10. (a) Discuss Fermi theory of beta decay. Explain the selection of allowed and forbidden transition

Or

(b) Discuss deuteron problem and explain how do you deduce the properties of nuclear force?

11. (a) Explain the basic concepts of shell model and how particles are arranged in each shell. Explain how do these explain various properties of the nucleus. Discuss the limitations of shell model

or

(b) Discuss Fermi age theory. Apply Fermi age theory for a nuclear core with spherical geometry

(2x14=18 marks)

Section C

Answer any **four** questions
Each question carries **6** marks

12. The beta decay of ^{191}Os leads only to an excited state of ^{191}Ir at 171 KeV. Find the maximum Kinetic energy of beta spectrum
13. Calculate the minimum gamma ray energy required for the photo disintegration of deuteron
14. Find the energy released if two ^1_1H and ^4_2He is 1.1 MeV and 7 MeV respectively
15. Deduce the first ten nuclear energy levels using harmonic potential. How it is different from the practical condition
16. predict spin and parity of ^{210}Pb and ^{210}Bi
17. Show that the critical constant can be derived as four factor formula for a nuclear reactor of infinite dimension

(4X 6 =24 marks)

First semester Msc Degree Examination

Radiation physics

RPH1C 04 INTRODUCTORY NUCLEAR PHYSICS

(2019 admission)

Time: Three Hours

Maximum: 70 Marks

Section A

Answer any **Six** questions

Each question carries **3** marks

1. How do you say that nuclear force is spin dependent?
2. Explain how do you measure the binding energy of deuteron
3. Explain how magic numbrs are explained in shell model.
4. Explain why heavy nuclei decay by alpha emission than other nucei or particles?
5. Explain how internal conversion is different from electron capture?
6. What is isospin and its importance
7. What is collective model? Briefly explain the features of collective model.
8. What is fermi age equation and its relevance
9. Briefly explain the functioning of a breeder reactor

(6x 3= 18 mark

Section B

Answer **all** questions, Each question carries **14** marks

10. (a) Give systematics of liquid drop model. Explain how fision mechanism is explained in terms of liquid drop model.

Or

(b) Explain theory of ground state of deutron using square wave potential. Explain why there is descrepany in observed magnetic dipole moment

11. (a) discuss the kinematics of alpha decay. Give a detailed account of Gommow theory of alpha decay and expalin how the life time and energy of are accounted interms of the above

or

(b) Explain the functioning of a fission reactor. Explain the factors contributin to the criticality of a finite homogeneous reactor. From this obtain the criticality parameter for an infinite reactor

(2x14=18 marks)

Section C

Answer any **four** questions
Each question carries **6** marks

12. The scattering length for 10 MeV neutron interacting with proton at rest is found to be 20.3 fermi. Calculate the Phase shift introduced if the nuclear potential is $V_0 = -40$ MeV
13. Calculate the magnetic dipole moment for the following nuclei. $^{14}\text{N}(7)$, $^{41}\text{Ca}(20)$, $^{41}\text{Sc}(21)$
14. Identify the type of beta emission in the following decay.
 $^6\text{He} \rightarrow ^6\text{Li} (0^+ \rightarrow 1^+)$ $^{122}\text{Sb} \rightarrow ^{122}\text{Sn} (2^- \rightarrow 2^+)$ $^{76}\text{Br} \rightarrow ^{76}\text{Se} (1^- \rightarrow 0^+)$
15. Calculate the width barrier for an alpha particle of Energy 5 MeV from ^{238}U nucleus.
16. Calculate the amount of natural uranium required to be used per day for a nuclear reactor working with an average power of 1MW
17. Calculate resonance escape probability for a neutron of 100 keV in Uranium core. The resonance width of 0.027eV at an energy 6.6eV. Average energy loss per collision is 3.34eV

(4X 6 =24 marks)

MODEL QUESTION PAPER 1
FIRST SEMESTER MSc. DEGREE EXAMINATION
RADIATION PHYSICS

RPH1 C 05 BASICS OF ELECTRODYNAMICS

Time: Three Hours

Maximum: 70 Marks

Section A

Answer any **six** questions.
Each questions carries 3 marks

1. Deduce Maxwell's equation in differential form.
2. Outline general statements about electromagnetic boundary conditions.
3. Define Pointing Vector. State and prove Pointing theorem.
4. Show that the velocity of an electromagnetic wave along a parallel plate transmission line

$$u = \frac{1}{\sqrt{LC}}$$

5. Obtain general transmission line equations.
6. Write a short note on skin depth.
7. Obtain equation for Herzian dipole for far fields
8. What is radiation resistance? How is it related to radiated power and radiation efficiency?
9. Explain the β dependence on angular distribution of bremsstrahlung

(6x3=18)

Section B

Answer **both** Questions
Each carries 14 marks

10. a) State and explain Biot- Savart law. Use it to find the magnetic field due to an infinite thin straight wire carrying a current I.

Or

- b) Discuss with necessary theory, the propagation of electromagnetic waves along a parallel plate transmission line and obtain expression for characteristic impedance and propagation velocity.

11. a) Discuss on Maxwell's stress tensor. Deduce an expression for electromagnetic force in terms of Maxwell's stress tensor.

Or

- b) Derive the relation for power radiated by point charge and its angular distribution through Lienard's generalization

(2x14=28)

Section C

Answer any four questions. Each questions carries 6 marks

11. Prove that the plane electromagnetic wave propagates with the velocity of light.
12. Reformulate Maxwell's equation in vector phasor notation.
13. Derive an expression for magnetic field $H(R)$ for Transverse electromagnetic waves.
14. Deduce homogeneous vector wave equations.
15. Show that at ultra relativistic speed ($v=c$), Q_{max} for bremsstrahlung cone is $Q_{max} \approx \sqrt{1-\beta}/2$
16. A positive charge q is fired head on at a distant positive charge Q which is stationary. The velocity of q is decelerating from V_0 to 0. what is the total fraction of initial kinetic energy lost as radiation?
Assume $V_0 \ll C$

(4x6=24)

MODEL QUESTION PAPER 2

FIRST SEMESTER MSc. DEGREE EXAMINATION
RADIATION PHYSICS

RPH1 C 05 BASICS OF ELECTRODYNAMICS

Time: Three Hours

Maximum: 70 Marks

Section A

Answer any **six** questions.
Each questions carries 3 marks

1. Explain Amper's theorem and illustrate its application with an example
2. Outline general statements about electromagnetic boundary conditions between a perfect conductor and a dielectric medium.
3. Define Pointing Vector. State and prove Pointing theorem.
4. Explain dissipation in a lossy parallel plate transmission lines
5. List and explain different types of wave guides.
6. Give a brief account of cavity resonators.
7. bring out the physical significance of the complex propagation constant
8. Give equation for power radiated by a moving point charge
9. Derive Abraham Lorentz formula for radiation reaction force

(6x3=18)

Section B

Answer **both** Questions
Each carries 14 marks

10. a) Deduce non homogeneous wave equations and obtain solution for scalar potentials
Or
b) Obtain the expression for $E_x^+(z,t)$ and $H_x^+(z,t)$ for plane waves in a lossless media
11. a) Discuss with necessary theory, the propagation of electromagnetic waves along a parallel plate transmission line and obtain expression for characteristic impedance and propagation velocity.

Or

- b) Derive the equation for radiation field and power. Explain how the bremsstrahlung spectral behaviour is originating

(2x14=28)

Section C

Answer any four questions. Each questions carries 6 marks

11. Derive an expression for the electrical potential and intensity at any point on the axis due to charged ring.
12. Derive an expression for net power flow density of an electromagnetic wave.
13. Deduce an expression for electromagnetic force in terms of Maxwell's stress tensor.
14. Deduce homogeneous vector equations for TEM waves through a parallel plate transmission line from general transmission line equations.
15. If velocity field and acceleration field are instantaneously collinear, what will be the angular distribution of radiation.
16. What is the Q_{\max} for radiation produced by 500MeV photons?

(4x6=24)

(Model)
First semester Msc Degree Examination
Radiation physics
RPH1C 06 INTERACTION OF RADIATION WITH MATTER
(2019 Admission)

Time: Three Hours

Maximum: 70 Marks

Section A

Answer any **Six** questions. Each question carries **3** marks

1. Discuss about Auger electrons
2. What are photonuclear reactions?
3. Explain angular distribution of bremsstrahlung photons. How it depend up on electron energy?
4. Derive the threshold value for pair production in the electric field of an electron
5. Write note on range energy relationship associated with beta particle
6. Give a brief account on (n,n) and (n,p) interaction
7. Differentiate between linear and mass attenuation coefficients
8. Write note on Cerenkov radiation
9. Explain lethargy. What is the practical implication of lethargy?

Section B

Answer **all** questions. Each question carries **14** marks

10. (a) Elaborate on elastic scattering of electromagnetic radiation

Or

- (b) Elaborate on passage of Heavy charged particle through matter.

11. (a) Derive Bethe-Bloch expression of mass collision and explain Bragg curve

or

- (b) Discuss Compton interaction of electro magnetic radiation with matter

(2x14=18 marks)

Section C

Answer any **four** questions. Each question carries **6** marks

12. The absorption coefficient of 0.50 Mev gamma rays in aluminium is 0.2 cm⁻¹. Find the mass absorption coefficient and absorption cross section per electrons
13. At what kinetic energy does an electron have same energy loss as 6Mev alpha particle interacting with aluminium.
14. Calculate the no.of quanta emitted as Cerenkov radiation in a frequency range corresponding to wavelength in vacuum of $\lambda = 4000$ to 7000 \AA , given off by an electron

of energy 20 MeV transferring 1 cm of substance ($\mu = 1.49$)

15. The ratio of collisional loss by 2MeV proton in water is 300 MeV cm²/g . Calculate it for a 8 MeV particle in water.
16. A 10 Mev photon interact in a pair production process. If the electron emerges from the interaction with an energy of 2MeV .
17. Suppose 5% of 364 KeV photons of ¹³¹I are transmitted through a lead brick of 10 cm thickness. Calculate the HVL of the lead for I¹³¹

(4X 6 =24 marks)

(Model2)

First semester Msc Degree Examination
Radiation physics
RPH1C 06 INTERACTION OF RADIATION WITH MATTER
(2019 Admission)

Time: Three Hours

Maximum: 70 Marks

Section A

Answer any **Six** questions., Each question carries **3** marks

1. Explain the dependence of photoelectric effect Compton interaction and pair production on total attenuation coefficient
2. Derive an expression for the energy of elastically scattered neutron
3. Write note on bremsstrahlung. What is its importance?
4. Explain Cerenkov effect. How it depend up on the refractive index of the medium
5. Discuss about ionization and excitation. What is the relevance in dosimetry
6. What is linear energy transfer and its importance?
7. Obtain cross section for neutron induced reaction
8. What are the different neutron sources?
9. Explain energy and Z dependence of differential Compton cross section

(6x 3= 18 marks)

Section B

Answer **all** questions. Each question carries **14** marks

10. (a) Discuss in detail the interaction of ionizing radiation with matter.

Or

(b) Derive Bethe-Bloch expression of mass collision and explain Bragg curve

11. (a) Discuss about different interaction of neutron with matter

or

(b) Discuss photo electric interaction of electro magnetic radiation with matter

(2x14=18 marks)

Section C

Answer any **four** questions. Each question carries **6** marks

12. Calculate dE/dX for a 10 MeV α particle interacting with aluminium
13. Verify the minimum ionization for heavy charged particle that takes place at $\beta = 0.96$
14. Calculate the no. of quanta emitted as Cerenkov radiation in a frequency range corresponding to wavelength in vacuum of $\lambda = 4000$ to 7000 \AA , given off by an electron of energy 20 MeV transferring 1 cm of substance ($\mu = 1.49$)
15. The collisional energy loss by 2 MeV proton in water is $300 \text{ MeV cm}^2/\text{g}$. Calculate it for in 8 MeV particle in water.
16. A particle of mass m_1 and velocity v_1 is elastically scattered by a particle of mass m_2 at rest in laboratory at an angle θ . Find the kinetic energy transferred by particle m_1 to particle m_2
17. The mass energy transfer and mass energy absorption coefficients are 0.0271 and $0.0270 \text{ cm}^2/\text{g}$ respectively. Calculate the average fraction of energy emitted by bremsstrahlung

(4X 6 = 24 marks)