ANNUXURE C

RULES AND REGULATIONS

FOR THE

M.Sc. RADIATION PHYSICS COURSE

(Revised for 2013 Admission)

UNIVERSITY OF CALICUT

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RULES AND REGULATIONS FOR **M.Sc. RADIATION PHYSICS** COURSE.
(REVISED FOR 2013 ADMISSION)

I. TITLE OF THE PROGRAMME:
The programme 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.

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 qualifying examination and an 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 and on general knowledge in human physiology and anatomy

Physics of B.Sc. level - 60 %
Mathematics of B.Sc. Subsidiary level – 20%
Chemistry of B.Sc. Subsidiary level – 10%
Basic Human Physiology and Anatomy – 10%

V. DURATION OF THE COURSE : Two years course work – Four semesters each of 6 months followed by clinical training of 12 months in two semesters. A project work is to be submitted during the period.

VI. MEDIUM OF INSTRUCTION – English

VII. 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.

VIII. 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.

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.

IX. 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 4th 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

X. FIELD TRAINING:
Total duration of the 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).

XI. RADIOLOGICAL SAFETY OFFICER (RSO) approval by AERB:
The University shall initiate steps to get 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 risk

XII. 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: Four 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: **3000** **(650+650+750+750+200)**

Mark Distribution: Semester I-IV: 2800 (750+750+650+650)

Project Report : 120

Presentation and viva: 80

(Viva may include project work and clinical training)

Total Marks: **3000**

Total credits **100**

Classification of results

Minimum marks for a pass: Theory 40% (equivalent grade of D) minimum per paper and an aggregate of 50% (equivalent grade of C) - separately for theory and practical. There is no paper minimum for practicals.

Presently the Following mark based grade will be following.

Mark range (in %)	Grade point	Letter grade	Class
> 90	9.0-10.0	A+	Excellent
80 - 89	8.0-8.9	A	Distinction
70 - 79	7.0-7.9	B+	I Class
60 - 69	6.0-6.9	B	I Class
50 - 59	5.0-5.9	C	II Class (Pass minimum)
40 – 50	4.0-4.9	D	F in CGPA) (Paper pass minimum)
< 40	< 4.0	I	Course incomplete
* Fractional percentages should to be rounded off to the next whole number)			

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

SGPA = (C1*G1 + C2*G2 +....Cn*Gn)/(C1 + C2 +....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.

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 clinical training.

Semester-vise break-up.....

XIV. SEMESTER VISE BREAKE-UP OF COURSE CONTENT:

SEMESTER I:		**21 credits**
RPH1C01	Mathematical Methods in Physics	4 credits
RPH1C02	Classical Mechanics	2 credits
RPH1C03	Basic Electronics	4 credits
RPH1C04	Introductory Nuclear Physics	4 credits
RPH1C05	Interaction of Radiations with Matter	2 credits
RPH1C06	Electronics Practical	2 credits
RPH1C07	Nuclear Physics Practicals	2 credits
RPH1C08	Comprehensive semester viva voce	1 credit
SEMESTER II		**21 credits**
RPH2C09	Quantum mechanics	4 credits
RPH2C10	Anatomy, Physiology and Radiobiolgy	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
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 Radiotherapy system	4 credits
RPH4C25	Radiotherapy Treatment Planning	4 credits
RPH4C26	Modern trends in Radiology and Radiation therapy	4 credits
RPH4C27	Practicals Dosimetry 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**
RPH5C31	Project work	8 credits
RPH6E32	Field training	10 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 CO_2 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.Arfken 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)
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

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. Eexercises (18 hours)

Text : Goldstein, Sections 1.3 – 1.6, 2.1 – 2.3, 3.10, 3.11, 8.1, 8.5, 8.6, 9.1, 9.2

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 Schrodinger equation. (19 hours)

Text : Goldstein, Sections 9.1, 9.2, 9.4 - 9.6, 10.1 – 10.5, 10.7, 10.8

References:

RPH1C03. BASIC ELECTRONICS – 4 CREDITS

1. TRANSISTOR AMPLIFIERS

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 devise 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)**

Text: 1. "Semiconductor Devices- Physics and Technology" - S. M. Sze., John Wiley and Sons, (8.2, 8.4, 9.1, 9.2, 9.3 - 9.3.3, 9.4, 9.5 – 9.5.3)

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/subtracter, 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 de-multiplexing , 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. Boylstead & 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, Cengate 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 quadruple 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 Radiation Detectors**
   Modes of Energy Deposition in the Detector, Gas detectors – Ionization chamber, Proportional counter and G M counter, Multiwire Proportion counter, Parallel Plate Avalanche Counter, Scintillation detector, Photo Multiplier Tube (PMT), Semiconductor detectors – Ge(Li), Si(Li) and HPGe detectors, surface barrier detectors, Detection of X-Rays with a Si(Li) Detector. Liquid scintillators **(16 hours)**
5. **Counting Statistics**
   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 events **(16 hours)**

Books for study and reference:

1. H.Enge : Introduction to Nuclear Physics" (Addison Wesley)
2. H.S.Hans: Nuclear Physics – Experimental & theoretical (New Age International 2001)
3. G.F.Knoll : "Nuclear Radiation Detectors" (Willy international, New york)
4. K.Muraleedhara Varier, Nuclear Radiation Detection, Measurements and Analysis (Narosa)
5. S.B.Patel, An introduction to nulcear Physics, (New Age International)

RPH1C05. INTERACTION OF RADIATIONS WITH MATTER 2 CREDITS

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

2. Interaction of electrons and heavy charged particles with Matter

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 **(16 hours)**

3. **Interaction of Neutrons with Matter**

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. **(10 hours)**

STANDARD BOOKS FOR STUDY

1. G.F.Knoll : "Nuclear Radiation Detectors" (Willy international, New york)
2. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
3. F.M Khan : "Physics of Radiation Therapy"- Fourth Edition.
4. F.A.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.
5. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, **U**U.K., 2001

REFERENCES

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

PRACTICALS:-

RPH1C06. ELECTRONICS PRACTICALS – (70 Hours) 2 CREDITS

(Minimum 8 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
5. Characteristics of a regulated power pack
6. DC voltage regulator using transistors
7. Feedback amplifier
8. Construction of an oscillator
9. Free running multivibrator
10. Construction of a scale of two.
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 circuits
15. Pulse shaping circuits

RPH1C07. NUCLEAR PHYSICS PRACTICALS – (70 Hours) 2 CREDITS

(Minimum 8 expts. to be carried out)

1. GM counter – characteristics – plateau and variation of pulse height with applied voltage
2. GM counter – Statistics of counting
3. GM counter – Feather Analysis – end point energy
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. Ge detectors calibration and determination of unknown energy
7. Study of absorption of beta rays
8. Measurement of linear and mass attenuation coefficients of an X-ray beam
9. Measurement of linear and mass attenuation coefficients for a gamma ray beam using GM counter
10. Measurement of range of Beta rays (1) in air (2) in material like aluminum and calculation of absorption coefficients
11. Determination of K-40 half life
12. Estimation of resolving time of a G.M counter

SEMESTER II

RPH2C09. Quantum mechanics– 4 credits

1. The 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 (18 hours)

2. Quantum Dynamics : The equation of motion, Schrodinger, Heisenberg and the Interaction pictures of time development, The linear harmonic oscillator in the Schroedinger and Heisenberg pictures, Hydrogen atom problem (14 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 (14 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 **(18 hours)**

5. Scattering : 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 **(16 hours)**

Textbook: 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" (TataMcGraw Hill)
4. A.Messiah : “Quantum Mechanics”
5. J.J.Sakurai : “Modern Quantum Mechanics” (Addison Wesley)
6. A.Ghatak and S.Lokanathan : “Quantum Mechanics” (Macmillan)

RPH2C10. ANATOMY, PHYSIOLOGY AND RADIOBIOLGY 4 CREDITS

1. Basic Anatomy and Physiology: Introduction to the Human Body , Cellular Chemistry , Cell Structure and Function,Tissues , Integumentary System , Skeletal System, Muscle Tissue and Mode of contraction ,Muscular System , Nervous Tissue, Central Nervous System , Peripheral and Autonomic Nervous Systems, Sensory Organs ,Endocrine System , Cardiovascular System: Blood ,Cardiovascular System:The Heart , Cardiovascular System: Vessels and Blood Circulation ,Lymphatic System and Body Immunity , Respiratory System , Digestive System, Metabolism, Nutrition, and Temperature Regulation , Urinary System , Water and Electrolyte Balance , Reproductive System **(16 hours)**

2. Clinical Aspects of Radiation Oncology: Anatomy and Physiology applied to Radiology and Radiation Therapy, Xray anatomy –CT/MRI anatomy -surface anatomy applied to RD and RT –introduction to the nature of diseases and trauma- inflammation and infection. Radiation therapy, Surgery, Chemotherapy, Hormone Therapy, Immunotherapy & Radionuclide therapy, Benign and malignant disease, Methods of spread of malignant disease, Staging and grading systems, Treatment intent – Curative & Palliative, Cancer prevention and public education and Early detection & Screening. Patient management on treatment – side effects related to radiation and dose – Acute & Late – Monitoring and common management of side effects – Information and communication **(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, Multitarget- Single-Hit 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, Tissue structure and radiation effect, Radiation effect on fetus, Fractionation and its effect, TCP/NTCP Time dose fraction(TDF) -basis for dose fractionation in radiotherapy -Concept of nominal standard dose (NSD), Linear Quadratic models, Alpha-Beta concepts. 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 genetic equilibrium, Effects 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 **(20 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 **(14 hours)**

Reference:

1. Delmar's "Fundamentals of Anatomy & Physiology", Thomson Learning-USA, 2001
2. A LANGE medical book "Basic Radiology" 2nd Edition, The McGraw-Hill- 2011
3. Edward L. Alphen, "Radiation Biophysics" Academic Press, Second Edition.
4. EJ Hall, " Radiobiology for Radiologist"-
5. IAEA, AERB , NCRP PUBLICATIONS ON DOSE LIMITS.

RPH2C11. RADIATION DETECTION, MEASUREMENT AND INSTRUMENTS

4 CREDITS

1. Introduction to Radiation Measurements: Nuclear Instrumentation Detector, NIM Concept, High-Voltage Power Supply, Preamplifier, Amplifier, Oscilloscope, -Differentiating Circuit- Integrating Circuit- Delay Lines- Pulse Shaping- Timing- Coincidence -Anticoincidence 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 -calibration, Timer, Analog-to-Digital Converters(ADC). Time of flight spectrometer, charged particle spectroscopy, Energy Straggling, **(16 hours)**

2. Gas filled , Scintillation Detectors: Relationship Between Voltage and Charge Collected -characteristic curve, Different Types of Gas-Filled Detectors, Ionization Chambers, Proportional Counters, Geiger-Muiller 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 of detectors- Resolving power of detector **(16 hours)**

3. Semiconductor, Thermo luminescent Dosimetry: 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. relative and absolute measurements, Geometry Effects, Source Effects, Detector Effects, Counting Rate and Source Strength. Thermo luminescent dosimetry; process and properties, glow curve and dose response, photon energy dependence, fading, physical form of TL material, residual TL and annealing for reuse, repeated read out of TLDs, TL instrumentation, instruments of personal monitoring, 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. **(18 hours)**

4. Neutron Detectors, Spectroscopy:

The BF3 Counter , 6Li- Counters , 3 He 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)**

5. Miscellaneous Detectors:

Chemical dosimetery**,** Organic and inorganic systems Ferrous-ferric Fricke dosimeter – FBX dosimeter – Free radical dosimeter – Ceric sulphate dosimeter – Other high and low level dosimeters – Applications of chemical dosimeters in Radiotherapy and industrial irradiators.and ceric-cerous systems – 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 **(14 hours)**

BOOKS FOR STUDY AND REFERENCES

1. Nicholas Tsoulfanidis - Measurement and Detection of Radiation, second edition
2. W.E. Burcham & M. Jobes – Nuclear and Particle Physics – Longman (1995)
3. G.F.Knoll, Radiation detection and measurements
4. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
5. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
6. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.
7. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001

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, Detectin 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, Mazimum 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 and opening, reading, writing, updating and closing of files **(20hours)**

Text Books :

1. S.S.Shastry : "Introductory methods of **U**numerical 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"
2. J.H.Rice : "Numerical methods-software and analysis" (McGraw Hill, 1983)
3. J.B.Scarborough : "Numerical mathematical analysis" (Oxford and IBH, 6th edition)

RPH2C13. RADIATON PHYSICS FUNDAMENTAL 2 CREDITS

1. **Radiation Quantities and Units:** Characteristics of Electromagnetic Radiation, Radiation of Energy from an Atom, 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, 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 Ionising Radition:** Standards – Primary and Secondary Standards, Traceability, Uncertainly 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)**

STANDARD BOOKS FOR STUDY

1. F.M Khan : "Physics of Radiation Therapy"- < William and Wilkins, Fourth Edition.
2. ICRU Report No. 85, Journal of ICRU Vol. 11 No1.(2011) Oxford University Press
3. F.A.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.
4. 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 8. (70 Hours) 2 CREDITS

1. Microprocessor experiments (Addition, subtraction, division and multiplication – 8 bit using 8085)
   Programmes :
2. Solution of quadratic equation
3. Least squares fitting
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

RPH2C15 – PRACTICALS IN INSTRUMENTATION IN RADIOLOGY-

Minimum experiments. to be carried out 8. (70 Hours) 2 CREDITS

1. Absorption of Gamma rays from different isotopes -energy dependance
2. Absorption of Gamma rays by different materials – Z dependence
3. Voltage current characteristics of an ion chamber
4. Gamma Spectrometer - Compton scattering
5. Experiments with solid state nuclear track detector(SSNTD)
6. Resolution of Scintillation counter at various energies
7. Resolution of Ge/Si detector at various energies
8. GM counter – Inverse square law properties
9. Determination of half life of a short lived isotope
10. Dependence of radiation intensity from a source on time, distance and shielding.
11. Study of working of ionization chamber
12. Voltage current characteristics of an ion chamber
13. Characteristics of a flow type proportional counter
14. Measurement of radioactivity using an isotope calibrator

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. Conginors 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/Brachytherpay 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. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge Universiyt Press, U.K., 2001
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.NCRP, ICRP, ICRU, IAEA, AERB Publications.
6.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, Mammograph**y -** 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, artefacts, 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. **I**mage Quality **–**Unsharpness, Spatial resolution, Contrast**,** contrast agents, Image Noise, Image distortion and artefacts, 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, Digital image display, scan motions, x-ray sources, collimation, X-ray detectors, viewing system, Radiation Dose, Image quality , Artefacts, 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, artefacts, 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, artefacts, instrumentation, safety and bioeffets. **(16 hours)**

STANDARD BOOKS FOR STUDY AND REFERENCES

1. "The Essential Physics of Medical Imaging" Jerrold T Bushberg, Second Edition 2002, LWW.
2. "Introduction to Medical Imaging Physics, Engineering and Clinical Applications" N. Smith and A. Webb 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- Kilovolage 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 Inhomgenities, 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 Algorithums, **(12 hours)**

Unit 5:Brachytherapy: Radioative Sorces in Bracytherapy, 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 ofexposure 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 sorces, implantation techniques- surface mould, interstitial, Intracavity,-Dose specification : Cancer of Cervix-manchester system Dose rate considerations and classification of brachytheraphy 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

F.M. Khan " Physics of Radiation Therapy" 2010- Fourth edition.

REFERENCES

1. F.A.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.
2. F.M. Khan " Physics of Radiation Therapy" 2010- Fourth edition.
3. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
4. 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 (T_{av}), 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, career 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 anlysers, 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,Gallium 67, Tc99m, I123, I131, Xenon 133, 111In, Au198, Thallium 201. uses ofwhole 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 Polycythaemia 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. W.H.Blahd, "Nuclear Medicine", McGraw Hill Co., New Delhi, 1980.
2. H.N.Wagner, "Principles of Nuclear Medicine", W.B.Saunders Co, London, 1970.
3. Herbert (John) & D.A.Rocha, Text Book of Nuclear Medicine, Vol 2 & 6, Lea and Febiger, Philadelphia, 1984.
4. Ramesh Chandra, " Nuclear Medicine Physics- The Basics Nuclear Medicine Physics: The Basics, 6th Edition" ©2004
5. 6. Safety Report Series No. 40 " Applying Radiation Safety Standards in Nuclear Medicine " – IAEA
6. " Nuclear Medicine Resources Manual" INTERNATIONAL ATOMIC ENERGY AGENCY VIENNA, 2006

RPH3C21 – PRACTICALS IN RADIATION DETECTION AND MEASURING INSTRUMENTS (70 HOURS) 2 CREDITS

Minimum 8 expts. to be carried out.

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 of an X-ray beam
6. Liquid scintillation counter
7. Use of a large volume ion chamber for monitoring
8. Thermo luminescent dosimeter
9. Measurement of contamination level and methods of decontamination.
10. Auto radiography of discrete sources
11. Contamination monitoring of discrete sources
12. Use of isotope calibrator

RPH3C22 -PRACTICALS IN MEDICAL IMAGING

Minimum 8 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

SEMESTER IV

RPH4C24. QUALITY ASSURANCE, ACCEPTANCE TESTING AND COMMISSIONONG OF RADIATION SYSTEM 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, *Kq,Qo* 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, Hardcopy 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 Brachytherpay , Equipments required, Pocket dosimeters and others , Transport of Sources, Survey for Contamination. **(18 hours)**

STANDARD BOOKS FOR STUDY

1. F.A.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.
2. Treatment Planning in Radiation Oncology, Faiz M.Khan Roger A.Potish
3. NCRP, ICRP, ICRU, IAEA, AERB Publications on QA.
4. TRS-398, TRS 277, TRS 430 IAEA Technical Series
5. TG 51, TG 21, TG 43, TG 53 AAPM Task Group

RPH4C25. **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. Brachytherpay- 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, isodoseline /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 Sievertintegral), Use of classical implant systems(Manchester, Quimby, Paris) for interstitial implants **(16 hours)**

STANDARD BOOKS FOR STUDY AND REFERENCES

1. R.F.Mould, "Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.
2. S.C.Klevenhagen "Physics of Electron Beam Therapy" Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
3. F.A.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.
4. 4. Fahiz M.Khan, Treatment Planning in Radiation Oncology, LWW publication, Second Edition
5. Ann Barrett, Jane Dobbs, Stephen Morris and Tom Roques. "Practical Radiotherapy Planning" Fourth Edition- 2009

RPH4C26. 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. **(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. 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. "3D Conformal and Intensity Modulated Radiation Therapy- Physics and Clinical Applications" by James A Pondy
2. "Contemporary IMRT Developing Physics and Clinical Implementation", S. Webb
3. New Technologies in Radiation Oncology" W. Schlegel · T. Bortfeld · A.- L. Grosu
4. "The Physics of Conformal Therapy - Advances in Technology" by S.Webb
5. A Practial Guide to CT simulation", by Lowrence 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

RPH3C27 -PRACTICALS IN DOSIMETRY (Minimum 8 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
6. Use of a large volume ion chamber as an isotope calibrator
7. Calibration of a survey meter using a standard source
8. Fabrication of beam direction shells
9. Plotting of combined isodose curves for parallel pair fields with various IFDs

10. Plotting of combined isodose curves for parallel pair fields for various energies photon beams
11. Combined isodose curves for oblique fields
12. Wedge fields planning
13. Dosimetry of brachytherapy / Conventional
14. Orthogonal films and calculations
15. Use of optical densitometer for field profile determination

RPH4C28 – PRACTICALS IN RADIOTHERAPY PLANNING AND DOSIMETRY

Minimum expts. to be carried out 8. (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. Management of emergencies in a cobalt therapy unit
14. Management of emergencies in a brachytherapy unit
15. Tracing a missing source
16. Preparation of a surface applicator and its dosimetry
17. Dosimetry of irregular fields
18. Dosimetry of a linear arrangement of brachytherapy sources
19. Dosimetry for single plane and double plane implants
20. Dosimetry for a cylindrical mould

RPH4C29- PRACTICALS IN Q/A TESTING AND CALIBRATION OF RADIOLOGICAL EQUIPMENTS Minimum expts. to be carried out 8. (70 Hours) 2 CREDITS

1. Calibration of radiation monitor
2. Q.A testing of a simple diagnostic X-ray unit I
3. Q.A testing of a simple diagnostic X-ray unit II
4. Q.A testing of brachytherapy systems
5. Q.A testing of C.T units
6. Q.A testing of telecoblat therapy units
7. Routine testing of a Linac system
8. Room planning of a radiotherapy installation
9. Radiation monitoring around a teletherapy installation
10. Study of the effectiveness of protective systems in diagnostic radiology
11. Study of the effectiveness of shielding blocks in radiotherapy

RPH4C30 Comprehensive viva voce 1 credit

Chairman
PG Board of Studies in Radiation Physics
University of Calicut