KERALA UNIVERSITY OF HEALTH SCIENCES

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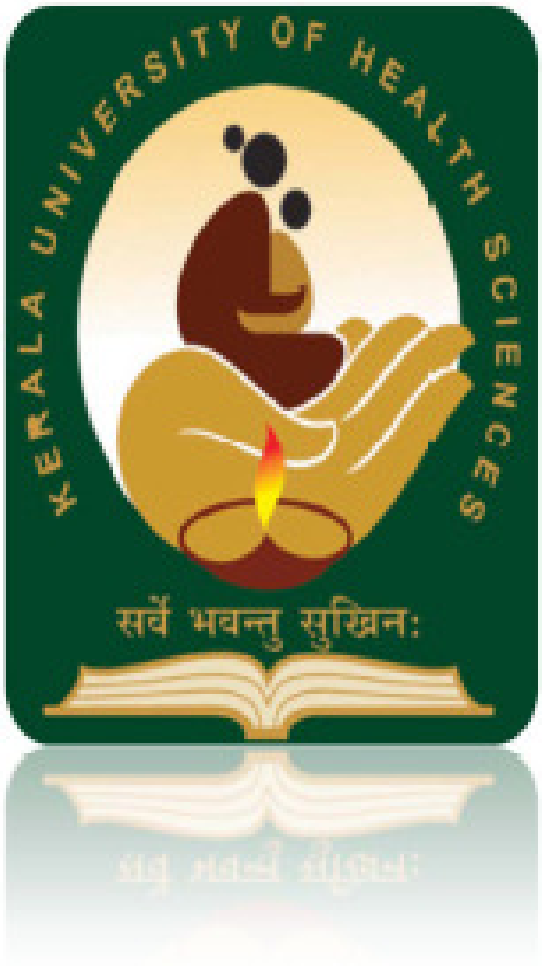

REGULATIONS, CURRICULUM AND SYLLABUS

of

Post M.Sc. Diploma in Radiological Physics (Dip RP)

(with effect 01.06.2014 onwards)

CONTENTS

KERALA UNIVERSITY OF HEALTH SCIENCES

RULES AND REGULATIONS FOR POST M.SC DIPLOMA IN RADIOLOGICAL PHYSICS COURSE.

1. Introduction

1.1 Preamble

Post M.Sc. Diploma in Radiological Physics conducted by the Kerala University of Health Sciences is in accordance with the recommendations and approval of the Atomic Energy Regulatory Board (AERB) for the safe use of radiation in health care.

1. 2 Title of the Program

The program shall be called Post M.Sc Diploma in Radiological Physics, abbreviated as Dip RP.

2. Aims and Objectives

2.1 Goal

The course has been designed to train the student to acquire the skill and competence to use radiation safely on patients in diagnosis and therapy. It is insisted that the course be conducted only in a teaching institution attached to a hospital having modern Radiotherapy and Diagnostic Imaging facilities and has to be taught by Medical Physics Faculty.

2.2 General Objectives

This PG Diploma will enable the successful candidate to perform Medical Physics issues, a few of which are mentioned below:

1. Radiological safety of patients and staff.
2. Site Plan preparation and obtaining permission from AERB for setting up diagnostic radiology and radiotherapy installations.
3. Commissioning of radiotherapy installations.
4. Periodic Quality Assurance of radiotherapy and diagnostic radiology equipment.
5. Treatment Planning in radiotherapy.
6. Teaching Medical Radiation Physics to undergraduate, post graduate medical and paramedical students.
7. Undertaking research work related to use of radiation for diagnosis and therapy.

2.3 Components of Curriculum

There will be 8 theory papers and 2 practicals besides internal assessment.
One month will be allotted for Project Work.

Theory:

1. Radiation Physics, and Radiation Generators – 50 hours
2. Radiological Mathematics – 50 hours
3. Radiation dosimetry and Standardisation - 50 hours

4. Radiation Detectors and Instrumentation–50 hours
5. Clinical and Radiation Biology- 50 hours
6. Medical Imaging -50 hours
7. Radiation Therapy -50 hours
8. Radiation Safety- 50 hours

Practical:

1. Radiation Detection and Measuring Instruments – 40 hours
2. Medical Imaging – 40 hours
3. Planning and Dosimetry in Radiotherapy – 40 hours
4. Quality Assessment of Radiotherapy equipment– 60 hours
5. Quality Control, Acceptance testing and Calibration of radiological equipment – 20 hours.

Project Work: 150 hours

Internship: one year

3. Regulations

3.1 Eligibility for Admission

1. BSc with Physics as main subject.
2. M.Sc. Physics conducted by any of the Universities in India or equivalent with 60% marks in aggregate of the subjects. In case of Grade System, Grade to percentage of marks conversion scheme obtained from University should be submitted along with the application.

3.2 Selection of Students:

If only limited number of candidates apply- depending on the number of approved seats- ranking can be done on the marks scored in the qualifying examination (M.Sc) and Interview (20 marks). In case of a large number of applicants, admission should be made on the basis of an entrance test with objective type questions of 2 hours duration followed by an interview that carries 20 marks.

The entrance examination shall have 100 marks; multiple choice type and they would cover subjects as detailed below:
M.Sc Level Physics - 60 marks
B.Sc. Subsidiary level Mathematics – 20 marks
B.Sc. Subsidiary level Chemistry – 10 marks
Basic Human Physiology and Anatomy – 10 marks
Interview – 20 marks

3.3 Registration

A candidate on admission shall apply to the University for Registration by making a formal application in the prescribed format. Original mark lists of the qualifying examination, transfer certificate from the previous institution, allotment letter from the Institution who conducted the admission process, equivalency and migration

certificate where ever needed, should be attached with the application, along with the prescribed fees.

3.4. Duration of the course:

Two years: including one year mandatory internship in the Institution in Radiodiagnosis, Radiotherapy and Nuclear Medicine.

3.5. Medium of instruction

English

3.6. Attendance

A candidate is required to put in at least 80% attendance in theory and 100% in practical subjects separately in the recognized institution approved for the same.

3.7. Department

Only a Medical Physics/Radiation Physics department, defined as an independent academic entity of a teaching institution, shall be permitted to conduct the post M.Sc. Dip RP program. The Institution should have well-established Departments of Radiotherapy with Teletherapy and Brachytherapy facilities, Nuclear Medicine and Diagnostic Radiology Services with CT and MRI. The Medical/Radiation Physics Department should have lab facilities and also possess all radiation measuring tools required for calibration of equipment and radiation protection

3.8. Faculty

There shall be a minimum of three regular faculty members (full time teachers) with requisite post graduate qualification in Medical/Radiation Physics with Ph.D and experience. A minimum of one Professor, One Associate Professor / Reader and one Assistant Professor / Lecturer should be available.

3.9 Student Teacher Ratio

This will depend on the infrastructure facilities available in the institution and not on the number of teachers alone.

3.10 Training Program

Radiological Safety Officer (RSO) Approval by Atomic Energy Regulatory Board:

RSO eligibility is to be obtained for all candidates. The examination for the same shall be conducted as directed by Atomic Energy Regulatory Board or any other agency approved by Atomic Energy Regulatory Board as per the AERB regulations. Students qualifying this examination will be eligible for RSO.

3.11. Log Book

A log book has to be maintained by all students and this has to be reviewed by the HOD

of the department periodically. Periodic assessment has also to be done in the department by the teachers. Log book is to be submitted at the time of practical

examination for perusal by examiners. A model of the Log book is given in **Item No.4.4.**

3.12. Field Training and Project work:

Field training will be an integral part of the course. The candidates will be posted in Imageology (Radiology), Nuclear Medicine, Radiation Physics and Radiotherapy Divisions of the institution during the course duration under an approved supervisor of the Faculty. A field training report must be submitted to the Supervisor at the end of every posting. Every candidate must do a project work also under an approved Faculty supervisor in a topic having relevance to the application of radiation in medicine. The supervisor must certify to the adequacy of the field training and Project Work on the basis of the thesis reports submitted by the candidate. The students should necessarily present at least one seminar on the basis of the Project work. The record of the field training must be duly certified by the designated Faculty member.

3.13. Internship:

One year Internship in the Institution where the course is conducted is an additional component of the Curriculum without which the Degree will not be awarded. The candidate is eligible for a Stipend during internship, from the Institution.
The final result will be declared only after the satisfactory completion of both field training, project work and internship.

3.14. Examination:

The classes will be more practical and clinically oriented. There will be weekly assessment of students.
Scheme of Examination and Distribution of Marks for Post-M.Sc DipRP
Examination will be conducted at the end of first year. Internship will be allowed only after passing the theory papers, practicals and viva.
The duration of each theory paper will be 3 hours.
There will be two practical examinations each of four hours duration.

SUBJECT	Min Marks	Max marks
Theory Papers : Internal		
Paper I: Radiation Physics and Radiation Generators	50	100
Paper II: Radiological mathematics	50	100
Paper III: Clinical and Radiation Biology	50	100
Paper IV: Medical imaging	50	100
External:		
Paper V: Radiation Dosimetry and Standardisation	50	100
Paper VI: Radiation Detectors and Instrumentation	50	100

Paper VII: Radiation Therapy	50	100
Paper VIII: Radiation Safety	50	100
Practical Examination		
Paper I: Radiation Detection and Measuring Instruments, Medical Imaging, Quality Control, Acceptance testing and calibration of radiological equipment.	50	100
Paper II: Planning and Dosimetry in Radiotherapy; Quality Assessment of Radiotherapy equipment	50	100
Record Work	5	10
Viva-voce	20	40
Project Work		
Project Record	50	100
Presentation and Viva	25	50
Grand Total	600	1200

There will be one external examiner, one internal examiner and one skilled assistant for the Practical examination and viva voce.

3.15. Criteria for Pass

Minimum marks for a pass: Theory 50% minimum per paper and an aggregate of 50% - separately for theory and practical.

3.16. Declaration of Class

Award of Class and Distinction: 75% of aggregate marks or more at the first appearance– Pass with Distinction.
60% or above of the total aggregate – Pass in First class
50 to 60% of the aggregate – Pass in Second Class.

3.17. Award of the Certificate:

Post M.Sc Diploma in Radiological Physics (Dip RP) will be awarded to the successful candidates by the Kerala University of Health Sciences (KUHS) only after successful completion of the course as detailed above

3.18. Migration and Transfer

Migration and Transfer to other institutions within the University will not be allowed during the course of study.

4. COURSE CONTENT

4.1 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 open radio nuclides etc. recent developments should be adequately taken care of in the teaching program. The syllabus described may show a certain overlap and the same is to give greater emphasis to the applied nature of the subjects and to ensure continuity.

PAPER I –RADIATION PHYSICS & RADIATION GENERATORS (50 hours)

Nuclear Physics:

Radioactivity- General properties of alpha, beta and gamma rays- Laws of radioactivity- Laws of successive transformations – Natural radioactive series – Radioactive equilibrium – Alpha ray spectra- Beta ray spectra- Theory of beta decay- Gamma emission - Electron capture- Internal conversion - Nuclear isomerism- Artificial radioactivity- Nuclear cross sections- Elementary ideas of fission and reactors-Fusion.

Particle accelerators

Particle accelerators for industrial, medical and research applications- The resonant transformer-cascade generator- Van De Graff Generator-Pelletron-Cyclotron- Betatron- Synchro-Cyclotron- linear accelerators, wave guides and complete details about medical accelerators, Production and properties of micro waves – Magnetron, Klystron- Travelling and standing wave acceleration- Microtron- Electron Synchroton- Proton synchrotron. Details of accelerator facilities in India.

X-ray Generators

Discovery – Production and properties of X-rays – Characteristic and continuous spectra- Design of hot cathode X ray tube- Basic requirements of medical diagnostic, therapeutic and industrial radiographic tubes- rotating anode tubes- Hooded anode tubes- Industrial X-ray tubes- X-ray tubes for crystallography- Rating of tubes- Safety devices in X-ray tubes- Rayproof and shockproof tubes- Insulation and cooling of X-ray tubes- Mobile and Dental units- Faults in X-ray tubes- Limitations on loading.

Electric Accessories for X-ray tubes- Filament and high voltage transformers- High voltage circuits-Half wave and full-wave rectifiers- Condenser discharge apparatus- Three phase apparatus- Voltage doubling circuits- Current and voltage stabilizers- Automatic exposure control- automatic Brightness control- Measuring instruments- measurement of kV and mA - timers- Control Panels- Complete x-ray circuit- Image intensifiers and closed circuit TV systems- Modern Trends.

Interaction of Radiation with Matter (oriented towards Radiology):

Interaction of electromagnetic radiation with matter– Exponential attenuation- Thomson scattering - Photoelectric and Compton process and energy absorption – Pair production – Attenuation and mass energy absorption coefficients- Relative importance of various processes.

Interaction of charged particles with matter: – Classical theory of inelastic collisions with atomic electrons- Energy loss per ion pair by primary and secondary ionization- Dependence of collision energy losses on the physical and chemical state of the absorber- Cerenkov radiation- Electron absorption process- Scattering, Excitation and Ionization- Radiative collision– Radiation energy loss (bremsstrahlung)– Range-energy relation-continuous slowing down approximation (CSDA) – straight ahead approximation and detour factors- transmission and depth dependence methods for determination of particle penetration- empirical relations between range and energy- Back scattering.

Passage of heavy charged particles with matter –Energy loss by collision- Range energy relation- Bragg curve- Specific ionization- Stopping Power- Bethe-Bloch formula.

Interaction of neutrons with matter – scattering –capture- Neutron induced nuclear reactions.

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. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981.
3. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
4. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
5. Christensen 'Physics of Diagnostic Radiology' Lea and Febiger – Philadelphia (1990).

6. W.R.Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981.
7. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.
8. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.

PAPER II – RADIOLOGICAL MATHEMATICS (50 hours)

Probability, Statistics and Errors

Probability- addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data.

Basic ideas of statistical distributions, frequency distributions, averages or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis.

Application to radiation detection- uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit.

Binomial distribution, Poisson distribution, Gaussian distribution, exponential distribution- additive property of normal variates, confidence limits, Bivariate distribution, correlation and regression, Chi-Square distribution, t-distribution, F-distribution.

Counting and Medical Statistics

Statistics of nuclear counting – Application of Poisson's statistics – Goodness – fit tests – Lexie's divergence coefficients – Pearson's chi-square test and its extension – Random fluctuations. Evaluation of equipment performance- Signal-to-noise ratio Selection of operating voltage- Preset of rate meters and recorders- Efficiency and sensitivity of radiation detectors- statistical aspects of gamma ray and beta ray counting- special considerations in gas counting and counting with proportional counters- statistical accuracy in double isotope technique.

Sampling and sampling distributions-confidence intervals. Clinical study designs and clinical trials. Hypothesis testing and errors. Regression analysis.

Numerical methods:

Why numerical methods, accuracy and errors on calculations-round-off error, evaluation of formulae. Iteration of solving $x = g(x)$, Initial Approximation and Convergence criteria, Newton-Raphson method. Taylor series, approximating the derivation, numerical differentiation formulas. Introduction to numerical quadrature, Trapezoidal rule, Simpson's rule, Simpson's Three-Eighth rule, Boole

rule, Weddle rule. Initial value problems, Picard's method, Taylor's method, Euler's method, modified Euler's method, Runge – Kutta method.

Monte Carlo: Random variables, discrete random variables, continuous random variables, probability density function, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, law of large number, central limit theorem, random numbers and their generation, tests for randomness, inversion random sampling technique including worked samples, integration of simple I-D integrals including worked samples.

Computational Tools and Techniques:

Computational packages: Overview of programming in C++, MATLAB/Mathematica and Statistica in data analysis and graphics.

STANDARD BOOKS FOR STUDY AND REFERENCES

1. L.A.Pipes, Applied Mathematics for Engineers and Physicists – McGraw Hill Book Co., 1980.
2. E.Butkov, Mathematical Physics – Addison Wesley Co., London 1973.
3. E.Kreyzsig, Advanced Engineering Mathematics – Wiley Eastern Ltd., 1980.
4. M.K.Venkataraman, Advanced Mathematics for Engineers and Scientists – National Publications Co., Madras, 1986.
5. A.Arfken: Mathematical Methods for Physicists (Academic Press).
6. S.S.Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, New Delhi, 1979.
7. S.C.Gupta and V.K.Kapoor, Elements of Mathematical Statistics, Sultan Chand and Sons, New Delhi, 1983.
8. S.Ramani, N.V.Koteswara Rao and R.Nagarajan, A test book on Computer Programming, M.M.C School of Management, Bombay 1984.
9. Venkataraman, Numerical Methods in Science and Engineering, National Publishing Co, Madras, 1986.

PAPER III - RADIATION DOSIMETRY AND STANDARDISATION (50 hours)

Radiation quantities and units

Radiometry- particle flux and fluence- Energy flux and fluence- Cross Section- Linear and mass attenuation coefficients- Mass energy transfer and mass energy absorption coefficients-Stopping power - LET- Radiation chemical yield-W value- Dosimetry-Energy imparted; The roentgen; Absorbed dose- Kerma- 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)

Radiation Sources:

Radiation Sources - Natural and artificial radioactive sources – Large scale production of isotopes – Reactor produced isotopes – Cyclotron produced isotopes – Fission products – industrial uses – Telecobalt and Brachy Cesium sources - Gold seeds – Tantalum wire - ^{125}Iodine sources – Beta ray applicators – Thermal and fast neutron sources – Preparation of tracers and labeled compounds – Preparation of radiocolloids.

Dosimetry & Standardisation of X and Gamma Ray Beams

Standards- Primary and Secondary Standards, Traceability, Uncertainty in measurement. Charged Particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/ Exposure. Limitations of FAIC.
Bragg-Gray Theory, Mathematical expression describing Bragg-Gray principle and its derivation. Burlin and Spencer- Attix cavity theories. Transient Charged particle Equilibrium (TCPE), Concept of $D_{gas,}$ Cavity ion chambers, Derivation of an expression for sensitivity of a cavity ion chamber. General definition of calibration factor- N_x,N_k, $N_{D,air}$, $N_{D,W}$. IAEA TRS 277: Various steps to arrive at the expression for D_W starting from N_x. TRS 398: $N_{D,W,Q}$: $N_{D,W}$: $K_{Q,Q0}$: K_Q, Derivation of an expression for $K_{Q,Q0}$. Calorimetric standards- Intercomparison of standard.

Measurement of Dw for External beams from ^{60}Co teletherapy machines: Reference conditions for measurement, Type of ion chambers, Phantom, Water proof sleeve, Derivation of an expression for machine timing error, Procedure for evaluation of temperature and pressure correction: Thermometers and pressure gauges. Measurement of temperature and pressure. Saturation correction: derivation of expression for charge collection efficiency of an ion chamber based on Mie Solution. Parallel plate, cylindrical and spherical ion chambers, Ksat, Two voltage method for continuous and pulsed beams, Polarity correction. Measurement of Dw for high energy photon beams from Linear accelerators: Beam Quality and Index, quality correction coefficient, Cross calibration, Measurement of Dw for high energy electron beams from linear accelerators: Beam quality, index, correction coefficient, Cross calibration using intermediate beam quality, Quality Audit Programs in Reference and Non-reference conditions.

Standardisation of brachytherapy sources- Apparent activity- Reference Air Kerma Rate- Air Kerma Strength- Standards for HDR ^{192}Ir and ^{60}Co sources- Standardisation of ^{125}I and beta sources- IAEA TECDOC 1274- room scatter correction. Calibration of protection level instruments and monitors.

Neutron Standards and Dosimetry:

Neutron classification, neutron sources, Neutron standards- primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese

sulphate bath system, precision long counter, Activation method. Neutron spectrometry, threshold detectors, scintillation detectors & multispheres. Neutron dosimetry, Neutron survey meters, calibration, neutron field around medical accelerators.

Standardisation of Radionuclides

Methods of measurements of radioactivity – Defined solid angle and 4π counting – Beta-Gamma coincidence counting – Standardization of beta emitters and e-capture nuclides with proportional, G.M and scintillation counters- standardization of gamma emitters with scintillation spectrometers, – Ionisation chamber methods – Gas counting – Extrapolation chamber – Routine sample measurements with radioisotopes – re-entrant ionization chamber methods, Liquid counters – Window-less counting of liquid samples – Measurement of neutron flux – Activation and absorption methods – Methods using (n, γ) and (n, p) reactions – Determination of the yield of neutron sources- space integration methods – Solid State detectors.

Radiation Chemistry and Chemical Dosimetry:

Definitions of free radicals and G-value- kinetics of radiation chemical transformations-LET and dose-rate effects- Radiation chemistry of water and aqueous solutions, peroxy radicals, pH effects- Radiation Chemistry of gases and reactions of dosimetry interest- Radiation polymerisation, effects of radiation on polymers and their applications in dosimetry- Formation of free radicals in solids and their applications in dosimetry- Description of irradiators from dosimetric view point-Dosimetry principles- Definition of optical density, molar absorption coefficient, Beer – Lambert law, spectrophotometry- Dose calculations- Laboratory techniques- Reagents and procedures- Requirements for an ideal chemical dosimeter- Fricke Dosimeter- FBX dosimeter- Free radical Dosimeter- Cerric Sulphate dosimeter- Other high and low level dosimeters- Applications of chemical dosimeters in Radiotherapy and industrial irradiators.

STANDARD BOOKS FOR STUDY AND REFERENCES

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, Medical Physics, North Holland publishing Co, New York, 1981.
3. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
4. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
5. W.R.Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981.
6. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.
7. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.

PAPER IV – RADIATION DETECTORS AND INSTRUMENTATION (50 hours)

Medical Electronics

Semiconductor diodes-JFET-MOSFET-IC. OPAM and their characteristics-Differential Amplifier- OPAM systems- Applications-Addition, subtraction, Integration and Differentiation-Active amplifiers-Pulse Amplifiers- Decoders and Encoders- Microprocessors and associated peripherals-Power supplies- Regulated power supplies using ICs- DC-DC converter and RF power supplies- Switching mode power supplies- AC regulators

Principles of Radiation Detection

Principles of radiation detection and measurement: Gas filled detectors- ionization chambers-Theory and design- Construction of condenser type chambers and thimble chambers- Gas multiplication- proportional counters, GM counters-Characteristics of organic and inorganic counters- Dead Time and Recovery Time-Scintillation detectors- semiconductor detectors- Chemical systems- Radiographic and Radiochromic films- Thermo luminescent dosimeters (TLD)- Optically stimulated Luminescence Dosimeter (OSLD), Radiophotoluminescent dosimeters-Neutron Detectors- Nuclear Track emulsions for fast neutrons- Solid State Nuclear Track (SSNTD) detectors- Calorimeters – New Developments.

Radiation Measuring & Monitoring Instruments

Dosimeters based on condenser chambers- Pocket chambers- Dosimeters based on current measurement- Different types of electrometers- MOSFET, Vibrating condenser and varactor bridge types-, Secondary standard therapy level dosimeters- Farmer Dosimeters- Radiation Field Analyser (RFA)- Radio isotope calibrator- multipurpose dosimeter- Water phantom dosimetry systems - Brachytherapy dosimeters- Thermo luminescent dosimeter readers for medical applications- Calibration and maintenance of dosimeters.

Instruments for personnel monitoring- TLD badge readers- PM film densitometers-Glass dosimeter readers- Digital pocket dosimeters using solid state devices and GM counters- Teletector- Industrial gamma radiography survey meter- Gamma area (zone) alarm monitors- Contamination monitors for alpha, beta and gamma radiation- Hand and Foot monitors- Laundry and Portal Monitors- Scintillation monitors for x ray and gamma radiations-Neutron monitors-tissue equivalent survey meters-flux meters, dose equivalent monitors- Pocket neutron monitors-Teledose systems.

Instruments for counting and spectroscopy- Portable counting systems for alpha and beta radiation – gamma ray spectrometers- Multichannel Analyser- Liquid scintillation counting systems, RIA counters- Whole body counters- Air Monitors for radioactive particulates and gases. Details of commercially available instruments and systems.

STANDARD BOOKS FOR STUDY AND REFERENCES

1. W.E. Burcham & M. Jobes – Nuclear and Particle Physics – Longman (1995)
2. G.F.Knoll, Radiation detection and measurements
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 No.6 Adam Hilger Ltd., Bristol 1981.
5. Practical Applications of Radioactivity and Nuclear Radiations, G.C.Lowental and P.L.Airey, Cambridge University Press, U.K., 2001

PAPER V- CLINICAL AND RADIATION BIOLOGY (50 hours)

Cell Biology:

Cell Physiology and Biochemistry- Structure of the cell- Types of cells and tissue, their structures and functions- Organic constituents of cells- carbohydrates, fats, proteins and nucleic acids- Enzymes and their functions- Functions of mitochondria, ribosomes, golgi bodies and lysosomes- Cell metabolism- DNA as concepts of gene and gene action- mitotic and meiotic cell division- Semi conservative DNA synthesis, Genetic variation crossing over, mutation, chromosome segregation- Heredity and its mechanisms.

Anatomy, Physiology and Pathology

Anatomy and physiology as applied to radiodiagnosis and radiotherapy –Structure and function of organs and systems and their common diseases: Skin, Lymphatic system, Bone and muscle, Nervous, Endocrine, Cardiovascular, Respiratory, Digestive (Gastro-Intestinal), Urinary, Reproductive, Eye and ear.

Anatomy of human body, nomenclature and Surface Anatomy, Radiographic anatomy (including cross sectional anatomy)- identify the different organs/structure on plain x-rays, CT scans and other available imaging modalities. Normal anatomy and deviation for abnormalities.

Tumour pathology and carcinogenesis, common pathological features of cancers and interpretation of clinic-pathological data.

Interaction of Radiation with Cells

Action of radiation on living cells ––Radiolytic products of water and their interaction with biomolecule- Nucleic acid, proteins, enzymes, fats- Influence of oxygen, temperature- Cellular effects of radiation-Mitotic delay, chromosome aberrations, mutations and recombinations-Giant cell formation, cell death recovery from radiation damage- potentially lethal damage and sublethal damage recovery-Pathways for repair of radiation damage. Law of Bergonie and Tribondeau.

Survival curve parameters- Model for radiation action- Target theory- Multihit, multitarget- repair misrepair hypothesis- Dual action hypothesis- Modification of radiation damage- LET,RBE, dose rate, dose fractionation- Oxygen and other chemical sensitisers- Anoxic, hypoxic, base analogs, folic acid and energy metabolism inhibitors-Hyperthermic sensitization- Radio-protective agents.

Biological Effects of Radiation

Somatic effects of radiation – Physical factors influencing somatic effects- Dependence on dose, dose rate, type and energy of radiation, temperature, anoxia- Acute radiation sickness – LD 50 dose – Effect of radiation on skin and blood forming organs, digestive tract– Sterility and Cataract formation – Effects of chronic exposure to radiation – Induction of leukemia- Radiation carcinogenesis- risk of carcinogenesis- Animal and human data - shortening of life span – In-utero exposure-Genetic effects of radiation – Factors affecting frequency of radiation induced mutations- Dose-effect relationship- first generation effects- Effects due to mutation of recessive characteristics- Genetic burden- Prevalence of hereditary diseases and defects- Spontaneous mutation rate- Doubling dose and genetic risk estimate.

Clinical Aspects of Medical Imaging and Radiation Oncology:

Radiation Therapy, Surgery, Chemotherapy, Hormone therapy, Immunotherapy and Radionuclide therapy. Benign and malignant disease, Methods of spread of malignant disease, Staging and Grading Systems, Treatment intent- curative and palliative, Cancer prevention and public education and early detection and screening.

Site specific signs, symptoms, diagnosis and management: Head and Neck, Breast, Gynaecological, Gastro-intestinal tract, Genito-urinary, Lung and Thorax, Lymphomas and Leukemias and other cancers including AIDS related cancers.

Patient management on treatment- side effects related to radiation and dose- Acute and late- monitoring and common management of side effects- Information and communication.

Professional aspects and role of Medical Physicist: General patient care- Principles of professional practice- Medical terminology- Research and professional writing- Patient privacy- Ethical and cultural issues. Legal aspects- Confidentiality, Informed consent, Health and Safety.

Biological Basis of Radiotherapy

Physical and biological factors affecting cell survival tumor re-growth, normal tissue response, repair distribution in the cell cycle, Non- conventional fractionation

scheme and their effect of reoxygenation, repair, redistribution in the cell cycle-High LET radiation therapy.

Time Dose Fractionation

Time dose fractionation- Basis for dose fractionation in beam therapy- Concepts for Nominal Standard Dose (NSD), Roentgen Equivalent Therapy(RET) - Time Dose Fractionation(TDF) factors and Cumulative Radiation Effects(CRE) - Gap correction, Linear and Linear Quadratic models.

STANDARD BOOKS FOR STUDY AND REFERENCES

1. C.H.Best and N.B.Taylor "A Text in Applied Physiology" The Williams and Wilkins Company, Baltimore 1986.
2. C.K.Warrick, "Anatomy and Physiology for Radiographers" Oxford University Press 1988.
3. Aiterts B.Bray, Lewis J., Raft M., Roberts K, Watson J.D, Molecular Biology of Cell, Garland Publishing Inc. London 1983.
4. Van Holde K.E, Physical Biochemistry, Prentice Hall, New Jersey, USA 1971.
5. Contour C.R and Schimmer P.R, Biophysical Chem. Vol.I – II W.H.Freeman and Co.San Francisco, USA, 1980.
6. S.P.Yaremonenko, "Radiobiology of Humans and Animals", MIR Publishers, Moscow, 1988.

PAPER VI - MEDICAL IMAGING (50hours)

Principles of X-ray Diagnosis and Conventional Imaging

Physical principle of Diagnostic Radiology: Interaction of x- rays with human body, differential transmission of x-ray beam, spatial image formation, visualization of spatial image, limitations of projection imaging technique viz. superimposition of overlying structures and scatter, application of contrast media and projections at different angles to overcome superimposition of overlying structures.

Radiography techniques: Prime factors (kVp, mAs, and SFD/SID) - influence of prime factors on image quality, selection criteria of prime factors for different types of imaging, different type of projection and slices selected for imaging, objectives of radio-diagnosis, patient dose vs. image quality.

Filters: inherent and added filters, purpose of added filters, beryllium filter, filters used for shaping x-ray spectrum (K-edge filters: holmium, gadolinium, molybdenum)

Scatter reduction: Factors influencing scatter reduction, objectives of scatter reduction, contrast reduction factor, scatter reduction methods; beam restrictors (diaphragms, cones/cylinders and collimators), grids (grid function, different types

of stationary grids, grid performance evaluation parameters, moving grids, artifacts caused by grids, grid selection criteria), air gap technique.

Intensifying screens: Function of intensifying screens, screen function evaluating parameters, emission spectra and screen film matching, conventional screens vs. rare earth screens.

Radiographic Film: Components of radiographic film, physical principle of image formation on film, double and single emulsion film, sensitometeric parameters of film (density, speed, latitude etc.), QA of film developer.

Image quality: Image quality parameters; sources of un-sharpness, reduction of un-sharpness, factors influencing radiographic contrast, resolution, factors influencing resolution, evaluation of resolution, Point spread function (PSF), Line spread function(LSF), Edge spread function (ESF), Modulation transfer function(MTF), focal spot size evaluation.

QA of conventional diagnostic X-ray equipment: Purpose of QA, QA protocols, QA test methods for performance evaluation of x-ray diagnostic equipment.

Digital X-Ray Imaging and Computed Tomography

Xero radiography, mammography, Interventional radiology, Digital Radiography (CR and DR systems), Digital Subtraction techniques, Conventional tomography (principle only), orthopan tomography (OPG), Computed Tomography (CT), QA of CT equipment.

Nuclear Medicine and Internal Dosimetry:

Physics of Nuclear Medicine:

Introduction to Nuclear Medicine, Unsealed sources, Production of radionuclides used in Nuclear Medicine, reactor produced and accelerator based radionuclides-Photonuclear activation, Equations for radionuclide production, Radionuclide Generators and their operation principles. Various usages of Radiopharmaceuticals.

In vivo non imaging procedures, thyroid uptake, Renogram, Life span of RBC, Blood Volume studies, etc. General concepts of Radionuclide Imaging and historical developments.

Radionuclide Imaging: Other techniques and Instruments: Rectilinear scanner and its operational principle, Basic principles and design of the Anger Camera/Scintillation camera; System components, Detector System and Electronics, Different types of collimators, Design and performance Characteristics of the converging, Diverging and Pin-hole collimator, Image display and recording systems, Digital Image Processing Systems, Scanning camera, Limitations of the detector system and electronics.

Different Imaging Techniques: Basic Principles, 2D and 3D imaging techniques-basic principles and problem, Focal Plane tomography, emission computed tomography; Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET) Various image reconstruction techniques during Image formation like Back projection, Fourier based techniques, Iterative reconstruction method and their drawbacks. Attenuation correction, scatter correction, resolution correction, other requirements or sources of error.

Image Quality Parameters: Spatial resolution, factor affecting spatial resolution, methods of evaluation of spatial resolution, Contrast, Noise. NEMA Protocols for QA/QC of Imaging Instruments.

In-vitro Technique: RIA /IRMA principles and techniques

Physics of PET and Cyclotron- Principles of PET, PET Instrumentation, Annihilation Coincidence Detection, PET Detector and scanner design, data acquisition for PET, Data Correction, and quantitative aspect of PET , Working of Medical Cyclotron, Radioisotopes produced and their characteristics.

Treatment of thyrotoxicosis, thyroid cancer with Iodine, use of ^{32}Phosphorus and ^{90}Y - for palliative treatment, Radiation Synovectomy and the isotopes used. Concept of Delay tank and various Waste Disposal Methods in Nuclear Medicine.

Planning and Shielding calculations during the installation of SPECT,PET/CT and Medical Cyclotron in the Nuclear Medicine Department..

Internal Dosimetry

Internal Radiation Dosimetry: Different compartmental model; Single Compartmental Model, Two compartmental model with and without back transference, Classical methods of Dose evaluation, Beta particle dosimetry, Equilibrium Dose Rate Equation, Beta dose calculation, Specific Gamma Ray Constant, Gamma ray dosimetry, Geometrical factor calculation, Dosimetry of low energy electromagnetic radiation.

MIRD Technique for Dose calculations; Basic procedure and some practical problems, Cumulative Activity, Equilibrium Dose Constant, Absorbed Fraction, Specific Absorbed Fraction, Dose Reciprocity Theorem, Mean Dose per unit Cumulative Activity and problems related to the dose calculation. Limitation of MIRD Technique.

Magnetic Resonance Imaging (MRI):

Magnetic Resonance Image- Proton density, relaxation time T1 and T2 images- Image characteristics- MRI system components- Magnets, Magnetic fields,

Gradients, Magnetic field shielding, Radio Frequency systems, computer functions- Imaging process- Image artifacts- MRI safety.

Ultrasound Imaging:

Interaction of sound waves with body tissues, production of ultrasound- Transducers- acoustic coupling- image formation- modes of image display- Colour Doppler.

STANDARD BOOKS FOR STUDY AND REFERENCES

1. J.P.Woodcock, Ultrasonic, Med. Physics Handbook Series I Adam Hilger, Bristol, 1981.
2. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981.
3. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
4. W.J.Meredith and J.B.Massey "Fundamental Physics of Radiology" John Wright and sons, UK, 1989.
5. Christensen 'Physics of Diagnostic Radiology' Lea and Febiger – Philadelphia (1990).
6. W.R.Hendee, "Medical Radiation Physics", YearBook – Medical Publishers Inc. London, 1981.
7. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.
8. Hussey M, Basic Physics and Technology of Medical Diagnostic Ultrasound, McMillan, London, 1985.
9. W.H.Blahd, "Nuclear Medicine", McGraw Hill Co., New Delhi, 1980.
10. H.N.Wagner, "Principles of Nuclear Medicine", W.B.Saunders Co, London, 1970.
11. Herbert (John) & D.A.Rocha, Text Book of Nuclear Medicine, Vol 2 & 6, Lea and Febiger, Philadelphia, 1984.
12. S.Webb, The Physics of Medical Imaging, Medical Science Series, Adam Hilger, Bristol, 1984.

PAPER VII – RADIATION THERAPY (50 hours)

Beam Therapy

Description of low kV therapy x-ray units- spectral distribution of kV x-rays and effect of filtration-Thoraeus filter – output calibration procedure..

Construction and working of telecobalt units, source design- beam collimation and penumbra- trimmers and breast cones. Design and working of Medical electron linear accelerators- beam collimation- asymmetric collimator- multileaf collimator- dose monitoring- electron contamination. Output calibration of cobalt 60 gamma rays, high energy x-rays and electron beams using IAEA TRS398, AAPM TG 51 and other dosimetry protocols. Relative merits and demerits of kV x-rays, gamma rays, MV x-rays and electron beams.
Radiotherapy simulator and its applications. CT and virtual simulation.

Central axis dosimetry parameters- Tissue Air Ration (TAR) Back scatter/Peak scatter factor (BSF/PSF)- Percentage depth dose (PDD),Tissue Phantom Ratio (TPR), Tissue Maximum Ratio (TMR)- Collimator, Phantom and total scatter factors. Relation between TAR and PDD and its application- Relation between TMR and PDD and its applications. SAR, SMR, Off axis ratio and Field factor. Build-up region and surface dose. Tissue equivalent phantoms. Radiation Field Analyser (RFA). Description and measurement of isodose curves/charts. Dosimetry data resources.

Beam modifying and shaping devices- wedge filters- universal, motorized and dynamic wedges- shielding blocks and compensators. Treatment planning in teletherapy- target volume definition and dose prescription criteria-ICRU-50 & 62-SSD and SAD set ups- two and three dimensional localization techniques-contouring- simulation of treatment techniques- field arrangements- single, parallel opposed and multiple fields- corrections for tissue inhomogeneity, contour shapes and beam obliquity- integral dose. Arc/ rotation therapy and Clarkson technique for irregular fields- mantle and inverted Y fields. Conventional and conformal radiotherapy. Treatment time and Monitor unit calculations.

Clinical electron beams- energy specification- electron energy selection for patient treatment- depth dose characteristics (D_s, D_x, R_{100}, R_{50}, R_p etc)- beam flatness and symmetry- penumbra- isodose plots- monitor unit calculations- output factor formalisms- effect of air gap on beam dosimetry- effective SSD.

Particulate beam therapy- Relative merits of electron, neutron, x-ray and gamma ray beams- Neutron capture therapy- Heavy ion therapy.

QA in radiation therapy- precision and accuracy in clinical dosimetry- quality assurance protocols for telecobalt, medical linear accelerator and radiotherapy simulators- IEC requirements- acceptance, commissioning and quality control of telecobalt, medical linear accelerator and radiotherapy simulators. Portal and in-vivo dosimetry. Electronic portal imaging devices.

Brachytherapy:

Definition and classification of brachytherapy techniques- surface mould, interstitial, intracavitary and intraluminal techniques. Requirement for brachytherapy sources-Description of Radium and radium substitutes, ^{60}Co, ^{82}Ta , ^{137}Cs, ^{192}Ir, ^{125}I and other commonly used brachytherapy sources. Dose rate considerations and classification of brachytherapy techniques- Low Dose Rate (LDR), High Dose Rate (HDR) and Pulsed Dose Rate (PDR). Paterson Parker and Manchester Dosage systems. ICRU 38 and 58 protocols. Specification and calibration of brachytherapy sources-RAKR and AKS-IAEA TECDOC 1274 and ICRU 72 recommendations. Point and line source dosimetry formalisms- Sievert Integral-AAPM TG- 43/43UI and other dosimetry formalisms.

Afterloading techniques- advantages and disadvantages of manual and remote afterloading techniques. AAPM and IEC requirements for remote afterloading

brachytherapy equipment. Acceptance, commissioning and quality assurance of RAL brachytherapy equipment. ISO requirements and QA of brachytherapy sources, Integrated brachytherapy unit.

Brachytherapy treatment planning - CT/MR based brachytherapy planning- forward and inverse planning- DICOM image import/export from OT- Record and verification. Brachytherapy of Prostate cancer. Occular brachytherapy using photon and beta sources. Intravascular brachytherapy- classification- sources- dosimetry procedures- AAPM TG 60 protocol. Electronic brachytherapy (Axxent, Mammosite, etc)

Computers in Treatment Planning:

Scope of computers in treatment planning- Review of algorithm used for treatment planning computation – Pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, Inverse Planning algorithm, Monte Carlo based algorithms. Treatment Planning calculations for photon beam, electron beam, interstitial and brachytherapy- Factors to be incorporated in computational algorithms. Plan optimization- direct aperture optimization- beamlet optimization- simulated annealing- dose volume histograms- Indices used for plan comparisons- hardware and software requirements – beam and source library generation. Networking, DICOM and PACS. Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols.

Special and Advanced Techniques of Radiotherapy

Special techniques in radiation therapy- Total Body Irradiation (TBI)- large field dosimetry- total skin electron therapy (TSET)- electron arc treatment and dosimetry- intraoperative radiotherapy.

Stereotactic radiosurgery/radiotherapy (SRS/SRT) Cone and mMLC based - X-Knife- Gamma knife- Immobilisation devices for SRS/SRT- dosimetry and planning procedures- Evaluation of SRS/SRT treatment plans- QA protocols and procedures for X and Gamma knife units- Patient specific QA. Physical, Planning clinical aspects and QA of stereotactic body radiotherapy (SBRT) and Cyber Knife based therapy.
Intensity Modulated Radiation Therapy (IMRT)- principles- MLC based IMRT- Step and shoot and sliding window techniques- Compensator based IMRT- planning process- inverse treatment planning- immobilization for IMRT- dose verification phantoms, dosimeters, protocols and procedures- machine and patient specific QA, Intensity modulated Arc Therapy (VMAT, Rapid Arc), Image Guided Radiotherapy (IGRT)- concept, Imaging modality, kV cone beam CT (kVCT), MV cone beam CT (MVCT), image registration, plan adaptation, QA protocol and procedures- special phantom, 4DCT, Tomotherapy- principle- commissioning- imaging- planning and dosimetry- delivery- plan adaptation- QA protocol and procedures.

STANDARD BOOKS FOR STUDY AND REFERENCES

1. J.R Greening, Medical Physics, North Holland publishing Co, New York, 1981.
2. H.E.Jones, J.R.Cunnigham, "The Physics of Radiology" Charles C.Thomas, NY, 1980.
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", YearBook – Medical Publishers Inc. London, 1981.
6. E.J.Hall Radiobiology for Radiologists J.B.Lippincott Company, Philadelphia 1987.
7. F M Khan – The Physics of Radiation Therapy, 1984. Williams and Wilkins, Baltimore.
8. H.Handee, Radiation Therapy Physics (2^{nd} edition)
9. U.B.Thripathi Quality assurance of Radiation therapy equipment and practice – lecture note, DipRP, BARC
10. Comprehensive QA for radiation oncology- Report of AAPM radiation therapy committee task group
11. J.R.Greening "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series No.6 Adam Hilger Ltd., Bristol 1981.
12. R.F.Mould, "Radiotherapy Treatment Planning Medical Physics Hand book series No.7, Adam Hilger Ltd, Bristol, 1981.
13. S.C.Klevenhagen "Physics of Electron Beam Therapy" Medical Physics Hand Book Series No.6 Adam Hilger Ltd, Bristol, 1981.
14. F.A.Attix "Radiation Dosimetry" Vol I-III, Academic press New York, 1985.
15. Treatment Planning in Radiation Oncology, Faiz M.Khan Roger A.Potish
16. NCRP, ICRP, ICRU, IAEA, AERB Publications.
17. TRS-398 IAEA Technical Series
18. TG 51 AAPM Task Group

PAPERVIII – RADIATION SAFETY (50 hours)

Radiation Protection standards

Radiation dose to individuals from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards- historical background- International Commission on Radiological Protection and its recommendations- The system of Radiological Protection- Justification of Practice, Optimisation of Protection and individual dose limits- Radiation and Tissue weighting factors, equivalent dose, effective dose, committed equivalent and effective dose, Concepts of collective dose- Potential exposures, dose and dose constraints- System of protection for intervention- Categories of exposures- Occupational, Public and Medical Exposures- Permissible levels for neutron flux- Factors governing internal exposure- Radionuclide concentrations in air and water- ALI, DAC and contamination levels.

Principles of Monitoring and Protection

Evaluation of external radiation hazards- – Effects of distance, time and shielding – Shielding calculations – Personnel and area monitoring– Internal radiation hazards – Radio toxicity of different radio nuclides and the classifications of laboratories –– Control of contamination – Bioassay and air monitoring – Chemical protection – Radiation accidents – Disaster monitoring.

Safety in the Medical Uses of Radiation

Planning of medical radiation installations- General considerations- Design of diagnostic, deep therapy, telegamma, accelerator installations, brachytherapy facilities and Nuclear Medicine.

Evaluation of radiation hazards in medical diagnostic and therapy installations- Radiation monitoring procedures- Protective measures to reduce the radiation exposure to staff and the patients- Radiation Hazards in brachytherapy and teletherapy departments, radio isotope laboratories and particle accelerator facilities- Protective equipment- Handling of patients- Waste disposal facilities- Radiation safety during source transfer operations- Special safety features in accelerators, reactors.

Radioactive Waste Disposal

Radioactive wastes – Sources of radioactive waste – Classification of waste – Treatment techniques –for solid, liquid and gaseous effluents – permissible limits for disposal of waste- Sampling technique for water, air and solid- Geological, hydrological and meteorological parameters- Ecological considerations.

Disposal of radioactive wastes- General methods of disposal- Management of radioactive waste in medical, industrial, agricultural and research establishments.

Transport of Radioisotopes

Transportation of Radioactive materials:– Historical background – General packing requirements – Transport documents – Labeling and marking of packages – Regulations applicable for different modes of transport- Transport by Post- Transport emergencies- Special requirements for transport of large radioactive sources and fissile materials – Exemptions from regulations- Shipment approval- Shipment under exclusive use- Transport under special arrangement- Consignor's and Carrier's responsibilities.

Legislation:

Physical protection of sources- Safety and security of Sources during storage, use, transport and disposal- Security provisions: administrative and technical- security threat and graded approach in security provision.

National legislation- Regulatory framework- Atomic energy act, radiation protection rules- applicable safety codes, standards, Guides and Manuals- Regulatory Control- Licensing, Inspection and Enforcement- Responsibilities of Employers, Licensees, Radiological Safety Officers and Radiation Workers- National Inventories of radiation sources- Import, Export procedures.

Radiation Emergencies and their Medical Management

Radiation accidents and emergencies in the use of radiation sources and equipment in Industry and Medicine- Radiographic cameras and Teletherapy units- Loading and unloading of sources- Loss of radiation sources and their tracing- Typical Accident cases. Radiation injuries, their treatment and medical management- Case histories. -

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.

PRACTICALS:-

1. GM counter – Construction and calibration
2. Determination of plateau and resolving time of a G.M. Counter and its application in estimating the shelf-ratio and activity of a beta source.
3. Production and attenuation of Bremsstrahlung
4. Range of beta particles by Feather Analysis
5. Backscattering of beta particles and its applications.
6. Measurement of radioactivity using an isotope calibrator
7. Scintillation spectrometer – Calibration and determination of unknown energy
8. Absorption and back scattering of Gamma rays –Determination of HVT
9. Voltage current characteristics of an ion chamber
10. Statistics of counting
11. GM counter – Inverse square law properties, half life of a short lived isotope, effect of time, distance and shielding on radiation intensity.
12. Isotope calibrator
13. Measurement of contamination level and methods of decontamination.
14. Study of voltage and current characteristics of an ionisation chamber
15. Calibration of survey instruments and pocket dosimeters
16. QA of Films, Intensifying screen, Film-screen combination, Processing chemicals, Dark room, Safe light, Light proofing, Automatic Processor

17. Quality Assurance of a diagnostic X-ray unit.
18. Patient dose measurements in diagnostic radiology
19. Study and calibration of Thyroid uptake measurement unit.
20. Calibration and acceptance testing of a cobalt therapy unit
21. Measurement of central axis percent depth dose of photon and electron beams.
22. Dose out put measurement of electron beams used in radiotherapy treatment.
23. Calibration of a survey meter using a standard source
24. Use of optical densitometer for field profile determination
25. Calibration of a therapy level dosimeter
26. Preparation and standardization of unsealed sources
27. Treatment Planning and dosimetry for single field photon irradiation, multiple fields, use of TAR and TPR, Long SSD techniques, Rotational treatment, Critical organs, entrance and exit doses, tissue inhomogeneities, Orthogonal Films for planning.
28. Use of computerized treatment planning system
29. Management of emergencies in a cobalt therapy unit and brachytherapy unit
30. Tracing a missing source
31. Preparation of a surface applicator and its dosimetry
32. Dosimetry of irregular fields
33. AKS/RAKR measurement of HDR Brachytherapy sources using well type and cylindrical ionisation chambers.
34. In-phantom dosimetry of a brachytherapy source.
35. Dosimetry of a linear arrangement of brachytherapy sources, dosimetry for a cylindrical mould
36. Dosimetry for single plane and double plane implants
37. Q.A testing of brachytherapy systems
38. Integrity check and calibration of low activity brachytherapy sources.
39. Q.A testing of C.T units
40. Routine testing of a Linac system
41. Room planning of a radiotherapy installation
42. Survey of radioisotope laboratory and study of surface and air contamination.
43. Radiation protection survey of a teletherapy installation
44. Radiation protection survey in diagnostic radiology

4.2. Scheme of Classes and Examination:

Course Content:Theory:

1. Radiation Physics, and Radiation Generators – 50 hours
2. Radiological Mathematics – 50 hours
3. Clinical and Radiation Biology- 50 hours
4. Medical Imaging -50 hours
5. Radiation dosimetry and Standardisation - 50 hours
6. Radiation Detectors and Instrumentation–50 hours

7. Radiation Therapy -50 hours
8. Radiation Safety- 50 hours

Practical:

1. Radiation Detection and Measuring Instruments – 40 hours
2. Medical Imaging – 40 hours
3. Planning and Dosimetry in Radiotherapy – 40 hours
4. Quality Assessment of Radiotherapy equipment– 60 hours
5. Quality Control, Acceptance testing and calibration of radiological equipment – 20 hours.

The classes are so proposed as to ensure a minimum of 600 hours of theory and practical classes. The classes per day shall work out as 4 hours for theory and 3 hours for practical. Working days per week – 6.

Examination:

The classes will be more practical and clinically oriented. There will be weekly assessment of students.

Criteria for Pass

Minimum marks for a pass: Theory 50% minimum per paper and an aggregate of 50% - separately for theory and practical.

Radiological Safety Officer (RSO) Approval by Atomic Energy Regulatory Board:

RCC shall initiate steps to get RSO eligibility for all candidates. The examination for the same shall be conducted as directed by Atomic Energy Regulatory Board or any other agency approved by Atomic Energy Regulatory Board as per the AERB regulations. Students qualifying this examination will be eligible for RSO.

Field Training and Project work:

Field training will be an integral part of the course. The candidates will be posted in Imageology, Nuclear Medicine, Radiation Physics and Radiotherapy Divisions of the Centre during the course duration under an approved supervisor of the Faculty. A field training report must be submitted to the Supervisor at the end of every posting. Every candidate must do a project work also under an approved Faculty supervisor in a topic having relevance to the application of radiation in medicine. The supervisor must certify to the adequacy of the field training and Project Work on the basis of the thesis reports submitted by the candidate. The students should necessarily present at least one seminar on the basis of the Project work. The record of the field training must be duly certified by the designated Faculty member.

Internship:

One year Internship in the Institution where the course is conducted is an additional component of the Curriculum without which the Degree will not be awarded. The candidate is eligible for a Stipend during internship, from the Institution.

The final result will be declared only after the satisfactory completion of both field training , project work and internship.

4.3 Sample Question Paper of Post M.Sc DipRP

Diploma in Radiological Physics Examination

Paper IV: Radiation Dosimetry and Standardisation

Time: 3 hours **Total Marks: 100**

N.B. (1) Answer any **five** questions
(2) All questions carry **equal** marks
(3) Use of Calculators/physical and mathematical tables **permitted.**

1. (a). Define :
(i) exposure
(ii) Dose
(iii) kerma
(iv) dose –equivalent
and discuss their limitations. Give their units in conventional and SI Systems.

(b). A 1 cm^3 air cavity in a block of carbon is exposed to Cs-137 photons and a charge of 3.5 x 10^{-8} C is produced and collected from the cavity. Find the absorbed dose to the carbon, assuming that the air is at STP. Also calculate dose to water, if above carbon ion chamber is placed in a water phantom. Use the following data:
Density of air = 1.293$kg.m^{-3}$ W/e = 33.97 J/C; mass stopping power ratio (air to carbon) = 1.015 and mass absorption ratio (carbon to water) = 1.111

(c). Discuss the correction factors for the finite size of the ion chamber.

2. (a). Define specific gamma ray constant and derive an expression for the same.

(b). What are standard and field dosimeters? Explain the difference in their characteristics.

(c). 10^9 Bq of a soluble compound of P-32 is uniformly distributed in liver. What is the beta dose to liver? Use: Mass of liver = 1.8Kg; mean beta energy = 0.7 MeV.

3. Describe the working of the following Instruments with relevant diagrams:

(a) Gamma Zone monitor

(b) Secondary Standard Dosimeter

(c) Rectal Dosimeter

(d) Contamination Monitor

4. (a) Describe briefly the principle of Na I (Tl) scintillation detector. Draw the pulse height spectrum of Cs-137 gamma rays using Na I (Tl) detector and describe the features of the spectrum.

(b) A beam of 660 KeV gamma photons is normally incident on a Na I (Tl) detector of thickness 4cm. What is the intrinsic efficiency of the detector? ($\mu = 0.78\ cm^{-1}$)

5. (a) Explain a solid state film dosimeter system with the help of a block diagram. Compare the merits and demerits of film dosimeter with those of Thermoluminescent dosimeter.

(b) Discuss the suitability of films in Megavoltage radiation (photons and electrons)beam dosimetry

6. (a) Describe Current type and pulse type ionisation chambers.

(b) Explain the working of a parallel plate extrapolation chamber for beta dose measurement. Explain the function of the guard ring in the extrapolation chamber.

7. (a) Explain the formation of the depletion region in a semiconductor. How is this used as a radiation detector?

(b) Compare silicon and germanium solid state detectors.

(c) What is the voltage change produced in an air filled ion chamber of capacitance 150 pF when a 120KeV beta loses its energy in the sensitive volume of the chamber?

8. Outline the methods of thermal and fast neutron detection. Explain the working of a BF3 counter. Why is it operated in the proportional region?

4.4 MODEL OF LOG BOOK
DEPARTMENT OF ……

LOG BOOK OF POST M.Sc Diploma in Radiological Physics

1. NAME……..

2. ROLL No.

3. Address

4. DETAILS OF POSTING: To be signed by the Supervising Teacher

- Radiotherapy
- Imageology/Radiology
- Nuclear Medicine

5. PROJECT WORK: To be signed by the Supervising Teacher

6. PARTICIPATION CONFERENCES – CME PROGRAMMES

7. DETAILS OF LEAVE AVAILED

8. DETAILS OF PARTICIPATION IN ACADEMIC PROGRAMME

9. SEMINARS /SYMPOSIA PRESENTED

10. JOURNAL CLUBS

11. SPECIAL DUTIES (IF ANY)

12. INTERNAL ASSESSMENT

13. MISCELLANEOUS

14. Daily activities record (BLANK PAGES)

    ONE PAGE FOR EACH MONTH X 12 PAGES

15. Details of Internship

Signature of Student:

Signature of Supervising Teacher:

Signature of Head of Division: