REGULATIONS 2016

SYLLABUS

for Courses affiliated to the

Kerala University of Health Sciences

Thrissur 680596

POST GRADUATE COURSE IN

Diploma in Radiological Physics

Course Code: 304

(2016-17 Academic year onwards)

2016

2. COURSE CONTENT

2.1 Title of course:

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

2.2 Objectives of course

a) 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 also in therapy. It is insisted that the course be conducted only in teaching institutions attached to a hospital having modern Radiotherapy, Nuclear Medicine, and Diagnostic Imaging facilities.

b) General Objectives

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

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

2.3 Medium of instruction:

English

2.4 Course outline

Post M.Sc. Diploma in Radiological Physics is in accordance with the recommendations and approval of the Atomic Energy Regulatory Board (AERB) for the safe use of radiation in health care. Course is of two years. There will be 8 theory papers and 2 practicals. One month will be allotted for Project Work. Theory: 400hrs, Practical: 200 hours, Project Work: 150 hours.

2.5 Duration

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

2.6 Subjects

As given under clause 2.10

The concept of health care counselling shall be incorporated in all relevant areas.

2.7 Total number of hour

Theory	**Hours**
Paper I: Radiation Physics and Radiation Generators	50
Paper II: Radiological mathematics	50
Paper III: Clinical and Radiation Biology	50
Paper IV: Medical imaging	50
Paper V: Radiation Dosimetry and Standardisation	50
Paper VI: Radiation Detectors and Instrumentation	50
Paper VII: Radiation Therapy	50
Paper VIII: Radiation Safety	50
Practicals	
1. Radiation Detection and Measuring Instruments	40
2. Medical Imaging	40
3. Planning and Dosimetry in Radiotherapy	40
4. Quality Assessment of Radiotherapy equipment	60
5. Quality Control, Acceptance testing and calibration of radiological equipment	20
Project Work:	150
Internship:	one year

The classes are so proposed as to ensure a minimum of 600 hours of theory and practical classes. Working days per week – 6.

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

2.8 Branches if any with definition

Radiological Physics as applied to Diagnostic Radiology, Radiation oncology and Nuclear Medicine.

2.9 Teaching learning methods

Lecture classes, compilation works, seminars, paper presentations, group discussions, assignments, clinical / lab training etc.

2.10 Content of each subject in each year

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 AND RADIATION GENERATORS

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-Synchrotron-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 Synchrotron-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-Ray proof and shock proof 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 stabilisers-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 ionisation-

Dependence of collision energy losses on the physical and chemical state of the absorber- Cerenkov radiation- Electron absorption process- Scattering, Excitation and Ionisation- 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 ionisation- 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 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. 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

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- Pre-set 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- CLINICAL AND RADIATION BIOLOGY

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 sub-lethal 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 sensitisation- Radioprotective 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 leukaemia- 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 Leukaemias 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 tumour 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 IV - MEDICAL IMAGING.

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, visualisation 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 unsharpness, 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

Xeroradiography, mammography, Interventional radiology, Digital Radiography (CR and DR systems), Digital Subtraction techniques, Conventional tomography (principle only), ortho-pan-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 32Phosphorus and 90Y - 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", Year Book – 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 V - RADIATION DOSIMETRY AND STANDARDISATION

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 Caesium sources - Gold seeds – Tantalum wire - ^{125}Iodine sources – Beta ray applicators – Thermal and fast neutron sources – Preparation of tracers and labelled compounds – Preparation of radio colloids.

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- Inter comparison 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 – Standardisation of beta emitters and e-capture nuclides with proportional, G.M and scintillation counters- standardisation of gamma emitters with scintillation spectrometers, – Ionisation chamber methods – Gas counting – Extrapolation chamber – Routine sample measurements with radioisotopes – re-entrant ionisation chamber methods, Liquid counters – Windowless 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 VI – RADIATION DETECTORS AND INSTRUMENTATION

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- ionisation 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 Radio chromic films-Thermo-luminescent dosimeters (TLD)- Optically stimulated Luminescence Dosimeter (OSLD), Radiophoto-luminescent 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-Tele dose 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.

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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 VII – RADIATION THERAPY

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 tele cobalt units, source design- beam collimation and penumbra- trimmers and breast cones. Design and working of Medical electron linear accelerators- beam collimation- asymmetric collimator- multi-leaf 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, motorised and dynamic wedges- shielding blocks and compensators. Treatment planning in Teletherapy- target volume definition and dose prescription criteria-ICRU-50 & 62SSD and SAD set ups- two

and three dimensional localisation 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 (Ds, Dx, R_{100}, R_{50}, Rp 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, intra-cavitory 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.

After loading techniques- advantages and disadvantages of manual and remote after loading techniques. AAPM and IEC requirements for remote after loading 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. Ocular 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 optimisation- direct aperture optimisation- beamlet optimisation- 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- immobilisation 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.

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8. H.Handee, Radiation Therapy Physics (2nd 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 seriesNo.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 1998, Williams & Wilkins, Baltimore USA
16. NCRP, ICRP, ICRU, IAEA, AERB Publications.
17. TRS-398 IAEA Technical Series
18. TG 51 AAPM Task Group

PAPER VIII – RADIATION SAFETY

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 – Labelling 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 University 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 output 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 standardisation 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 in homogeneities, Orthogonal Films for planning.
28. Use of computerised 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.

2.11 No: of hours per subject

As given in clause 2.7

2.12 Practical training

As given in clause 2.4 and 2.10

2.13 Records

Relevant records are to be maintained for all practical work as per the direction of the HOD

2.14 Dissertation/Project Report:

As per university norms

2.15 Speciality training if any

As given in clause 2.10

2.16 Project work to be done if any

a) **Field Training**

Field training will be an integral part of the course. The candidates will be posted in Imageology (Radiology/Radiodiagnosis), 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.

b) **Project - Synopsis/protocol**

The candidates should do a project work also during field training, under an approved faculty supervisor in a topic relevant to the application of radiation in medicine. A project work synopsis/protocol based on medical radiological technology work on a current topic of relevance. Synopsis/protocol should be approved by the designated faculty member/ faculty supervisor (guide) and the HOD before starting. General/specific guidelines of the

University (KUHS) for the format and style of the project/thesis/dissertation synopsis/protocol submission should be followed.

c) **Project Submission**

The project should be certified by the supervising staff and Head of the Department and to be submitted to the University one month prior (date as notified by University) to first year university practical examination. General/specific guidelines of the University (KUHS) for the format and style of the Final project report/thesis/dissertation submission should be followed.

The project evaluation will be conducted by the internal and external examiners together in the 1st year University practical examination. If the project submitted by the candidate is rejected by examiners or the marks obtained is less than the pass mark (50%), the candidate has to do a fresh project in parent institution under direct guidance and supervision of a senior faculty. The same has to be submitted for re-examination.

The supervisor must certify to the adequacy of the field training and Project Work based on the reports submitted by the candidate. The students should necessarily present at least one seminar based on the Project work. The record of the field training must be duly certified by the designated Faculty member**.**

2.17 Any other requirements [CME, Paper Publishing etc.]

Publication / acceptance of at least 1 research paper / article in a scholarly journal is preferable.

2.18 Prescribed/recommended textbooks for each subject

As given in clause 2.10

2.19 Reference books

As given in clause 2.10

2.20 Journals

As decided by the HoD

2.21 Logbook

Shall be maintained and counter signed by HOD.

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3 EXAMINATIONS

3.1 Eligibility to appear for exams

Attendance and Condonation.

A candidate should finish (100%) of all listed practicals during regular schedule or additional hours allowed during the course and is required to have at least 80% attendance in theory, in the recognised institution approved for the same. No Condonation of attendance is permitted for PG courses.

There will be Internal Examination (University model) conducted by the Institution of study for four papers and External Examination conducted by the University for next four papers. Only those candidates who have the required attendance are eligible to appear for the examination conducted by the University.

There is no provision for supplementary batches

3.2 Schedule of Regular/Supplementary exams

The University shall conduct not more than two examinations in a year.

3.3 Scheme of examination.

Theory papers of internal examination (University examination model) will be valued by examiners appointed from the institution and of external University examinations by examiners appointed by the University. Practical examination will be conducted at the institution where course is being conducted. A project work, done at the institution where the student is registered, duly approved, will be evaluated both by internal and external examiners. Field training does not have separate marks. Only an assessment by the Supervisor which should be duly certified by him as satisfactory.

For Papers with University examination, the pattern will be of answering essays, short essays and short questions and will be of answering all questions without any choice.

3.4 Details of theory examinations

As given in clause 2.4, 3.3 and 3.5

3.5 Papers in each year

Examinations will be conducted at the end of first year. Second year Internship will be only after passing the theory papers, practicals and viva voce and after successful completion of field training and project work. The duration of each theory paper will be 3 hours. There will be two practical examinations each of 4 hours duration.

1. Distribution of marks

Subject	**Minimum Marks for pass**	**Maximum marks**
Theory Papers : Internal examinations only-(University type)		
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
Theory Papers : University examination		
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-voce	25	50
Grand Total	**600**	**1200**

3.6 Model question paper for each subject with question paper pattern

Diploma in Radiological Physics Examination

Paper V: Radiation Dosimetry and Standardisation

Time: 3 hours **Maximum Marks: 100**

(1) Answer all questions

(2) Use of Calculators/physical and mathematical tables permitted.

Essays **[2 (9 + 5) = 28]**

1.

(a) Describe briefly the principle of NaI (Tl) scintillation detector. Draw the pulse height spectrum of Cs-137 gamma rays using NaI (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? (μ = 0.78 cm^{-1})

2.

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

(b) 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?

Short Essays **(4 x 8 = 32)**

3. Standard and field dosimeters
4. Expression for specific gamma ray constant
5. Gamma Zone monitor
6. Secondary Standard Dosimeter

Short Answers **(10 x 4 = 40)**

7. Rectal Dosimeter

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8. Contamination Monitor

9. Exposure

10. Dose

11. Kerma

12. Dose –equivalent

13. Thermoluminescent dosimeter.

14. Current type and pulse type ionisation chambers

15. Extrapolation chamber

16. BF3 Counter

Paper VI: Radiation Detectors and Instrumentation

Time: 3 hours **Maximum Marks: 100**

Answer all questions

Use of Calculators/physical and mathematical tables permitted.

Essays **[2(9 + 5) = 28]**

1.

a. Describe the working of a Graphite calorimeter with the help of a block diagram and circuit diagram. Compare the graphite calorimeter with a water calorimeter and state the advantages and disadvantages if any.

b. A cylindrical air wall chamber of radius 0.6cm with a central electrode of radius 0.06cm is used to measure continuous radiation from a cobalt unit with an exposure rate of 3000R/min with a collection voltage of 200V. Find the efficiency of ion collection. Assume kcyl = 1.19

2.

a. Describe the quenching process in a GM tube and briefly give various methods used for quenching the gas.

b. In an experiment to calculate the resolving time, a GM counter gave 1204sounts/s for source A, 1262counts/s for source B and 2162 counts/s for sources A and B together. What is the resolving time of the GM counter neglecting the background?

Short Essays **(4 x 8 = 32)**

3. Explain requirements of Insulators in Ion Chambers.
4. Describe briefly neutron detection by induced activity.
5. Describe the features of a Scintillation spectrometer.
6. Townsend balance Secondary Standard Dosimeter

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Short Answers **(10 x 4 = 40)**

7. Solid state nuclear track detector (SSNTD)
8. Film Badge
9. Pocket Dosimeter
10. G M Counter
11. Plastic Scintillator
12. Area Monitor
13. TLD Reader
14. Optically Stimulated Luminescence Dosimeter
15. Radiation Field Analyser
16. Whole Body Counter

Diploma in Radiological Physics Examination

Paper VII: Radiation Therapy

Time: 3 hours **Maximum Marks: 100**

Answer all questions

Use of Calculators/physical and mathematical tables permitted.

Essays **[2(9+5) = 28]**

1.

a. What is Percentage Depth Dose? What are the factors that influence PDD?

b. Three 6 x 10cm^2 Co-60 fields (SAD=80cm) are directed at 120^0 to each other, such that they intersect at a point which is at a depth of 10cm,12cm and 15cm respectively from the entrance surface of the three fields. If the dose rate in free space at 80cm for the given field size is 120cGy/min and the dose given at the intersection point is 300cGy/day, calculate the total treatment time if tumour dose by each field is same.

2.

a. Explain the Manchester System for treating cancer of the uterine cervix

b. Describe the quality assurance checks to be carried out in remote after loading brachytherapy.

Short Essays **(4 x 8 = 32)**

3. Simulation in Radiotherapy
4. MLC and portal imaging.
5. Characteristics of a clinical electron beam and its uses
6. Beam Modifying Devices

Short Answers **(10 x 4 = 40)**

7. Beam Flatness
8. Beta ray applicator
9. Penumbra

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10. Integral Dose
11. Patterson Parker dosage system for planar mould application
12. Radium and Substitutes
13. SRS/SRT
14. Wedge Filters
15. Monte Carlo for Photon beam
16. Total Body Irradiation

Paper VIII: Radiation Safety

Time: 3 hours **Maximum Marks: 100**

Answer all questions

Use of Calculators/physical and mathematical tables permitted.

Essays **[2 (9+5)=28]**

1.

a. Explain justification of practice and ALARA

b. A person receives an annual whole body dose of 0.02mGy of X-rays, 0.01mGy of neutrons of energy 5 keV and 0.1mGy of gamma rays. Calculate the equivalent dose received by the person in a year. Given: W_r for neutrons of energy 5keV = 5.

2.

a. What are the responsibilities of a Radiological Safety Officer as mentioned in RPR 2014?

b. What is the dose rate at 2 m from a 7.4GBq point source of Cs- 137? What is the thickness of Lead required to reduce the dose rate to less than 0.02mGy/h? If the source activity is increased to 29.6GBq, what additional thickness of Lead would be required to keep the dose rate at the same level? Given: HVL of Lead:7mm. Dose Rate Constant of Cs- 137 : 8.5 x 10^{-8} Gy-m^2/MBq-h

Short Essays **(4 x 8 = 32)**

3. The effects of whole body acute exposure of human beings to 4 Gy
4. Early effect and Late effect;
5. Factors that influence the process of radiation carcinogenesis
6. Dominant and Recessive genetic disorder

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Short Answers **(10 x 4 = 40)**

7. The materials used for neutron shielding
8. Radiation Accidents
9. Precautions for I- 131 administration for therapy of Thyroid cancer
10. Natural Background Radiation
11. Radiation weighting Factor
12. Tissue weighting factor
13. Stochastic Effect
14. Genetic and Somatic Effect
15. Annual Dose limits
16. Disposal of radioactive waste

3.7 Internal assessment component

As given in clause 3.5

3.8 Details of practical/clinical practicum

As given in clause 2.10, 2.4 and 3.5

3.9 Number of examiners needed (Internal & External) and their qualifications

Faculty members (full time teachers) with requisite post graduate qualification in Medical/Radiation Physics with Ph.D. and 3 year experience. The same qualification is prescribed for Examiner and Guide.

There will be one external examiner, one internal examiner, and one skilled assistant for the Practical examination and viva voce for University examinations. A panel of examiners will be selected by the University. The HOD concerned or immediate junior will be the chairperson.

3.10 Details of viva voce:

As given in clause 3.5 and 3.9

4 Internship

4.1 Eligibility for internship

Second year Internship will be only after passing the theory papers, practicals and viva voce and after successful completion of field training and project work.

4.2 Details of internship

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

Radiological Safety Officer (RSO) Approval by AERB and Training Program

This is part of the course. The examination for RSO eligibility 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.

4.3 Model of Internship Mark lists

Not applicable

4.4 Extension rules

The period of absence shall be compensated with the permission of the Principal/HOD. '

4.5 Details of Training given

AS per clause 2.16

5 ANNEXURES

5.1 Check Lists for Monitoring: Log Book, Seminar Assessment etc. to be formulated by the curriculum committee of the concerned Institution

a) 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 (at least once in a month). More 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.

b) Model of Log Book

LOG BOOK OF Dip RP

1. Name……
2. Roll No……..
3. Address……
4. Details Of Posting: To Be Signed By The Supervising Teacher

- Radiotherapy
- Imageology/Radiology
- Nuclear Medicine
- Radiation physics
- Others

5. Participation Conferences – CME Programmes.
6. Details Of Leave Availed.
7. Details of Participation in Academic Programmes.
8. Seminars /Symposia Presented
9. Journal Clubs
10. Special Duties (If Any)
11. Miscellaneous
12. Daily Activities Record (Blank Pages)

    Four Page for Each Month X 48 Month Pages

Signature of Student:

Signature of Supervising Teacher:

Signature of Head of Division/Co-ordinator of the course:

Institutional Requirements

a) The institution and the Department facilities

Only a Medical Physics/Radiation Physics department, defined as an independent academic entity of a teaching institution with an attached 300 bedded hospital for Radiotherapy, Medical and surgical oncology taken together, shall be permitted to conduct the post M.Sc. Dip RP program. The Institution should have well-established Departments of Radiotherapy with facilities, Nuclear Medicine and Diagnostic Radiology Services with CT and MRI. The Medical/Radiation Physics Department should have lab facilities and also all radiation measuring tools required for calibration of equipment and radiation protection.

Department	Facility	Numbers
Radiation Physics	Lab facilities for Quality Assurance (with RFA, Survey meters etc.)	1
	Class room with 16 chairs and one Table (with space adequate for 15 chairs and one Table with chair)	1
	Library (with two sets of Reference books and journals)	1
Radiotherapy	Teletherapy (Cobalt 60/LINAC)	1
	Brachytherapy (Manual/remote after loading systems)	1
	CT simulator	1
	Treatment planning system	1
Radiodiagnosis	MRI (1.5 Tesla)	1
	CT Scanner	1
	800mA Radiography-Fluoroscopy unit (Digital/IITV)	1
	500mA Radiography unit	1
	Ultrasonography Machine with colour Doppler	1
Nuclear Medicine	Gamma Camera	1
	Radio Iodine therapy Unit	1
Others		1
	Attached Hospital (300 bedded for Radiotherapy, Medical and surgical oncology)	1

b) Teacher Student Ratio

	Teacher : student
Professor	1: 2
Associate Professor/Reader	1: 2
Assistant Professor/Lecturer	1: 1
A minimum of one Professor, One Associate Professor / Reader and one Assistant Professor / Lecturer should be available to start the course and to maintain it.	