MASTER OF SCIENCE IN MEDICAL PHYSICS

REGULATIONS

ELIGIBILITY

The candidates for admission to the first year of the Master Degree Programme of Medical Physics shall be required to have passed in B.Sc. (Physics) with 60% and above aggregate marks and Mathematics as one of the ancillary subject in regular study from a recognized university or an Examination accepted as equivalent thereto by the Academic Council of the College, subject to such conditions as may be prescribed there to are permitted to appear and qualify for the Master of Science (Medical Physics) Degree Examination of this College after a course of study of two academic years. The candidates who studied B.Sc., (Physics) through correspondence and Open University stream of University education are not eligible.

ADMISSION CRITERIA:

The admission is made on the basis of an entrance test (objective type / or Short answer questions) for a duration of Two Hours. The level of entrance Examination is from Under Graduate Physics syllabus contents. Rank list shall be prepared on the basis of equal weightages for both the qualifying examination and entrance examination.

The entrance examination shall have 100 marks, multiple choice type, or short answer questions – covering subjects as detailed below:

Physics of B. Sc. standard - 60 marks

B. Sc. Subsidiary level Mathematics – 20 marks

B. Sc. Subsidiary level Chemistry – 20 marks

OBJECTIVES OF THE COURSE:

The Curriculum is designed to attain the following learning goals which students shall accomplish by the time of their Post Graduation:

1. The aim of this course is designed to enable a student to optimize their learning and their research experience to improve health by developing and implementing for medicine in Biology.

2. To associate in development of new methods & techniques for the radiotherapy treatment of various diseases.

3. To have correct diagnosis of the diseases and subsequent proper implementation of radiotherapy to cure of patient.

4. To develop radiotherapy treatment managerial skills and trained Radiation Physicists.

5. At the end of the course the student must have an in depth knowledge in the field of Medical Physics and Radiation Safety.

M.Sc-Medical Physics (Students admitted from 2015 – 2016 onwards)

SCHEME OF EXAMINATIONS

SUBJECT CODE	SUBJECT	INS. HRS / WEEK	EXAMINATIONS				
			Exam Duration (Hrs	CA	CE	Total Marks	Credit Points
SEMESTER –I							
15PMP13A	**Core-I:** Introductory Nuclear Physics	5	3	25	75	100	4
15PMP13B	**Core-II:** Fundamental Radiation Physics	6	3	25	75	100	4
15PMP13C	**Core-III:** Electronics and Biomedical Instrumentation	5	3	25	75	100	4
15PMP13D	**Core-IV:** Anatomy and physiology as Applied to Oncology and Imaging	6	3	25	75	100	4
15PMP13E	**Core-V:** Solid State Physics	5	3	25	75	100	4
15PMP13P	**Core Practical -I:** Electronics	**3**	3	80	120	200	8
		30				**700**	**28**
SEMESTER –II							
15PMP23A	**Core-VI:** Mathematical physics	4	3	25	75	100	4
15PMP23B	**Core-VII:** Radiation Detectors and Instrumentation	5	3	25	75	100	4
15PMP23C	**Core-VIII:** Physics of Radiation Therapy	5	3	25	75	100	4
15PMP23D	**Core-XI:** Physics of Radiology Imaging	5	3	25	75	100	4
15PMP23E	**Core-X:** Radiation Dosimetry and Standardisation	5	3	25	75	100	4

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15PMP23P	**Core Practical-II:** Medical Physics	6	3	80	120	200	8
		30				**700**	**28**
SEMESTER –III							
15PMP33A	**Core-XI:** Advanced Radiotherapy Physics	6	3	25	75	100	4
15PMP33B	**Core-XII:** Physics of Nuclear Medicine	6	3	25	75	100	4
15PMP33C	**Core-XIII:** Radiation Biology	6	3	25	75	100	4
15PMP33P	**Core Practical-III:** Medical Physics	6	3	80	120	200	8
		24				**500**	**20**
SEMESTER –IV							
15PCR43A	**Core-XIV:** Radiation Hazards Evaluation and Control	6	3	25	75	100	4
15PMP43V	Project Work and Viva-Voce	24		100	150	250	10
		30				**600**	**14**
					TOTAL	**2250**	**90**

Note: To get an eligibility for appearing the RSO Examination, the M.Sc. Medical Physics Students should undergo the Clinical Training for a period of one year after completing the M.Sc Programme.

FOR COURSE COMPLETION

Students have to Complete the following Subjects:

1. Core papers in I, II, III and IV Semesters.
2. Core practical in I,II and III Semesters .
3. Project and Viva - Voce in IV Semester
4. Summer training Programme:

4.1 During Second Semester vacation the students should carry out for 30 days summer training programme. It consists of posting the students in major cancer hospitals across the country as field training.

4.2 Students have to undergo not less than three month of clinical Medical Physics training programme during third semester at Kovai Medical Center and Hospital.

Total Credit Distribution

Subjects	Credits	Total		Credits	Cumulative Total
Core Theory	4	14 x 100	1400	56	90
Core Practical	8	3x 200	600	24	
Core Project	10	1x250	250	10	
Total			**2250**	**90**	**90**

15PMP13A	CORE- I: INTRODUCTORY NUCLEAR PHYSICS	SEMESTER - I

Total Credits: 4
Hours per week: 5

OBJECTIVES:

The subject aims to build the concepts regarding:

1. Basic knowledge about Nucleus and Radioactive decay types
2. Classification of accelerators.
3. Nuclear electronic and techniques.

CONTENTS

UNIT – I: NUCLEUS

General properties of nuclei – constituents of nuclei, nuclear size, nuclear radii, nuclear mass –nuclear units- atomic mass unit, eV- binding energy - systematic of binding energy - mass defect, mass excess, packing and binding fraction - discovery of radioactivity – radioactive decay- activity, half life, mean life, decay constant - radioactive series – radioactive equilibrium- secular, transient, non equilibrium.

UNIT – II: RADIOACTIVE DECAY TYPES

Alpha decay – energetics and spectrum- beta decay and its energies – origin of continuous beta spectrum- neutrino hypothesis – properties of neutrino- nuclear isomerism- gamma decay – nature of gamma rays- internal conversion – positron emission- electron capture- nuclear fission and it's discovery - energy release in fission - nature of the fission fragments - energy distribution between the fission fragments - fissile and fertile materials - spontaneous fission - source of energy in stars - nuclear reactions and its types - conservation laws - Q values - cross section.

UNIT – III: PARTICLE ACCELERATORS

Introduction - classification and performance characteristics of accelerators - industrial, medical and research applications – resonant transformer – cascade generator - Van de Graff generator - cyclotron - betatron - syncro cyclotron- linear accelerator - microtron– electron syncrotron – proton syncrotron – details of accelerator facilities in India.

UNIT – IV: NUCLEAR MODELS, FISSION AND FUSION REACTORS

Shell model, Liquid drop model - fission - energetics of fission process, controlled fission reactions - chain reaction – basics of reactor - Gas cooled reactors - advanced gas cooled reactors- pressurized water reactor - boiling water reactor - heavy water reactor - breeder reactor. Fusion process - characteristics of fusion - solar fusion -controlled fusion reactors - critical conditions - four factor formula.

UNIT – V: NUCLEAR ELECTRONICS AND TECHNIQUES

Preamplifiers – amplifiers - single channel analyzers - counting statistics - energy measurements. Introduction to spectroscopy - definition of energy spectra - measurement of an integral spectrum and differential spectrum - energy resolution of a detection system, multichannel analyzer - calibration of MCA - charged particle spectroscopy, energy straggling- Time of Flight Spectrometer – detector telescopes (E d E / h detectors)– position sensitive detectors.

TEXT BOOKS

1. *Enge. H* ,1983. **Introduction to Nuclear Physics**, 1st Edition, Addison Wesley publisher.
2. *Goshal. S. N*, 1997. Nuclear **Physics**, 4th Edition, S. Chand Ltd publisher.
3. *Stefaan Tavernier*, 2010. **Experimental Techniques in Nuclear and Particle Physics**, 4th Edition, Springer publisher.

REFERENCE BOOKS

1. *Kenneth Krane. S*, 1987. **Introductory Nuclear Physics,** 3rd Edition, John Wiley and Springer publisher.
2. *MuraleedharaVarier. M*, 2009. **Nuclear Radiation Detection, Measurements and Analysis**, 2nd edition, Narosa publisher.

15PMP13B	CORE –II: FUNDAMENTAL RADIATION PHYSICS	SEMESTER - I

Total credit: 4
Hours per week:6

OBJECTIVES

The subject aims to build the concepts regarding:

1. Basic knowledge about Non ionizing Radiation
2. X-ray Production
3. Interactions with matter

CONTENTS

UNIT- 1: NON IONIZING RADIATION

Different sources of non ionizing radiation - radio frequency, microwaves, infrared, visible and ultra violet radiation production, physical properties and their interaction with tissues - electrical impedance and biological impedance – Thermography, Radio frequency ablation.

Lasers: Theory and mechanism- interaction of laser radiation with tissues - photothermal -photochemical - photoablation - electromechanical effect - lasers in dermatology, oncology and cell biology.

UNIT-2: X-RAY GENERATORS

Discovery - production - properties of X-rays -characteristics 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 – maintenance of X-ray tube unit.

Filament and high voltage transformers - highvoltage 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 – flat panel technology.

UNIT-3: INTERACTION OF PHOTONS WITH MATTER

Ionization–photon beam exponential attenuation–Rayleigh scattering – Thomson scattering - Photoelectric effect – Compton effect - energy absorption – Pair production – attenuation, energy transfer and mass energy absorption coefficients – relative importance of various types of interactions.

UNIT-4: 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 – 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.

Interaction of heavy charged particles- Energy loss by collision – range energy relation – Bragg curve – specific ionization – stopping power – Bethe Bloch formula

UNIT-5: INTERACTION OF NEUTRONS WITH MATTER

Neutron Sources – properties – energy classifications – elastic and inelastic scattering coefficients and cross sections – energy transfer and logarthimic energy decrement-nuclear reactions – dependence on E and Z – (n,p), (n,2n), (n,f) and other reactions – neutron activation, radio isotope production.

TEXT BOOKS

1. *MarkolfNeimz. H*, 1996. **Laser-Tissue Interactions**, 3rd Edition, Springer Verlag publisher.
2. *Johns. H. E and Cunningham*, 1984. **The Physics of radiology**, 4th Edition, Charles C Thomas Publishers.
3. *Attix. F. H*, 2004. **Introduction to Radiological Physics and Radiation Dosimetry**, 4th Edition, Viley VCH, Verlog publisher.

REFERENCE BOOKS

1. *Podgarsak. E. B*, 2010. **Radiation Physics for Medical Physicists**, 2nd Edition, Springer Verlag publisher.
2. *Podgarsak. E. B*, 2005. **Radiation Oncology Physics: Handbook for Teachers and Students**, IAEA, Vienna publisher.
3. *Curry,T.S. Dowdey and J.E. Murry,R.C,*1984. **Christensen's introduction to the Physics of diagnostic radiology**, 3rd Edition, Philadelphia,Lea&Febiger publisher.
4. *Chesney,D.N. &Chesney,M.O*, 1984. **X-ray equipment for student radiographers,** 3rd Edition, Mosby publisher.

15PMP13C	CORE- III: ELETRONICS AND BIOMEDICALINSTRUMENTATION	SEMESTER – I

Total credit: 4
Hours per week:5

OBJECTIVE:

The subject aims to build the concepts regarding:

1. Basic and Digital Electronics
2. Familiarize with Biomedical Instrumentation

CONTENTS

UNIT- 1: BASIC ELECTRONICS

Zener diode - characteristics - voltage regulator circuits - bipolar junction transistors - CB and CE configuration characteristics. FET, MOSFET-principle of operation – characteristics - JFET Amplifier. Op-Amp-circuit symbol-ideal Op-Amp characteristics-CMRR-applications: adder, subtractor, analog integrator, analog differentiator, voltage-to-current converter, current-to-voltage converter and logarithmic amplifier.

UNIT- 2: DIGITAL ELECTRONICS

Logic gates - Boolean algebra - Boolean laws – De-Morgan's theorem - implementation of logic circuits from truth table – sum-of-products method – products-of-sum method - combinational circuits: multiplexer and de-multiplexer circuits - BCD to decimal decoders
Seven segment decoders - decimal to BCD encoder - arithmetic building blocks: half-adder and full-adder - digital comparator.

Flip Flops: RS, Clocked RS, D-Flip Flop, edge-triggered D flip flop – J K flip flop-sequential logic circuits: registers - shift registers – applications. Counters: ripple counters up, down and up-down ripple counters - asynchronous and synchronous counters- A/D and D/A converters.

UNIT- 3: MICROPROCESSOR

8085A- architecture and pin configuration - basic 8085 instructions – assembly language programming.

UNIT- 4: PHYSIOLOGICAL ASSIST DEVICES

Cardiac pacemakers – natural and artificial pacemakers-pacemaker batteries-defibrillator-A.C./D.C synchronized defibrillator – stimulators – bladder stimulators – heart lung machine various types of oxygenators- kidney machine – hemodialysing units – peritonealdialysis.

UNIT-5: BIOELECTRIC SIGNAL RECORDING AND CLINICAL EQUIPMENTS

Bioelectric potentials – resting and action potentials –surface, needle and micro electrodes - flame photometer – Spectroflurophotometer – pH meters – audiometer – endoscopes.

TEXT BOOKS

1. *Santanue Chattopadhyay*, 2006. **a text book of Electronics**, 1st Edition, New Central Book Agency publisher. Kolkata,

2. *Malvino. A. P and Leach. D. P*, 1994. **Digital Principles and Applications**, 5th Edition, Tata McGraw-Hill Publishing Co publisher, New Delhi.

3. *Mathur. A. P*, 2005. **Introduction to Microprocessors**, 3rd Edition, Tata McGraw-Hill Publishing Co, New Delhi.

REFERENCE BOOK

1. Bhattacharya. A. B, 2007. **Electronic Principles and Applications,** 2nd Edition,

New Central Book Agency, Kolkata.

15PMP13D	CORE- IV: ANATOMY AND PHYSIOLOGY AS APPLIED TO RADIATION ONCOLOGY AND RADIOLOGY IMAGING	SEMESTER – I

Total credit: 4
Hours per week:6

OBJECTIVE:

The subject aims to build the concepts regarding:

1. Structure and function of organs
2. Tumor pathology, oncology
3. Patient care

CONTENTS

UNIT- 1: STRUCTURE & FUNCTION OF ORGANS, SYSTEMS & THEIR COMMON DISEASES

Skin, Lymphatic system, Skeletal system, Nervous system, Endocrine system, Cardiovascular, Respiratory system, Digestive system (Gastro-Intestinal), Excretory system, Reproductive system, Special senses.

UNIT- 2: BASIC, RADIOGRAPHIC ANATOMY AND TUMOR PATHOLOGY

Anatomy of human body, nomenclature & surface anatomy, radiographic Anatomy (including cross sectional anatomy – Identify the different organs/structures on plain x-rays, CT scans and other available imaging modalities. Normal anatomy & deviation for abnormalities. Tumor pathology and carcinogenesis, basic pathological features of cancers and interpretation of clinico-pathological data.

UNIT- 3: CLINICAL ASPECTS OF RADIATION ONCOLOGY

Radiation therapy, surgery, chemotherapy, hormone therapy, immunotherapy & radionuclide therapy, benign and malignant disease, methods of spread of malignant disease, staging and grading systems, treatment intent – curative & palliative, cancer prevention and public education and early detection & screening- patient management on treatment – side effects related to radiation and dose – acute & late – monitoring and common management of side effects – information and communication.

UNIT- 4: SITE SPECIFIC SIGNS, SYMPTOMS, DIAGNOSIS AND MANAGEMENT

Head and Neck, Breast, Gynecological, Gastro-Intestinal tract, Genito-Urinary, Lung & Thorax, Lymphomas &Leukemias& other cancers including AIDS related cancers.

UNIT-5: PROFESSIONAL ASPECTS AND ROLE OF MEDICAL PHYSICISTS

General patient care - principles of professional practice – medical terminology – research & professional writing – patient privacy – ethical & cultural issues. Legal aspects – confidentiality, informed consent, health and safety.

TEXT BOOKS

1. *Ross and Wilson,* 2014. **Anatomy and Physiology in Health and Illness** by Anne Waugh, Allison Grant , 12th Edition, published by Churchill Livingstone.
2. *Leonard L. Gunderson MD MS FASTRO (Author), Joel E. Tepper MD(Author*) 2011. **Clinical Radiation Oncology,** 3rd edition, published by Saunders,.

REFERENCE BOOKS

1. *Hollinshead W.H*, 1997. **Text Book of Anatomy**, 5th Edition, Lippincott Williams and Wilkins
2. *Henry Gray,* 2009. **Anatomy and physiology**,30th Edition ,Philadelphia: Lea &Febiger

15PMP13E	CORE- V: SOLID STATE PHYSICS	SEMESTER I

Total credit: 4
Hours per week:5

OBJECTIVES

The subject aims to build the concepts regarding

1. The basic concepts and principles of solid state physics.
2. A clear view on magnetism which will help students to apply the magnetic concepts in radiotherapy treatment units (LINAC).

CONTENTS

UNIT-1: CRYSTAL PHYSICS

Types of lattices - miller indices - simple crystal structures - crystal diffraction - Bragg's law - reciprocal lattice (sc, bcc, fcc) - Laue equations - structure factor - atomic form factor - types of crystal binding - cohesive energy of ionic crystals - Madelung constant - inert gas crystals - Vander Waal - Landon equation - metal crystals - hydrogen bonded crystals.

UNIT-2: LATTICE DYNAMICS

Monoatomic lattices - lattice with two atoms per primitive cell - first brillouin zone - group and phase velocities - quantization of lattice vibrations - phonon momentum - inelastic scattering by phonons - Debye's theory of lattice heat capacity - Einstein's model and Debye's model of specific heat - thermal expansion - thermal conductivity - Umklapp processes.

UNIT-3: THEORY OF METALS AND SEMICONDUCTORS

Free electrons gas in three dimensions - electronic heat capacity - Wiedmann-Franz law - Hall effect - band theory of metals and semiconductors - Bloch theorem - Kronig-Penny model -semiconductors - intrinsic carrier concentration - mobility - impurity conductivity - fermi surfaces and construction - experimental methods in fermi surface studies - de Haas Van Alphen effect.

UNIT-4: MAGNETISM

Elementary ideas of dia, para and ferro magnetism - quantum theory of paramagnetism - Rare earth ion - Hund's rule - quenching of orbital angular momentum - adiabatic demagnetization - quantum theory of ferromagnetism - Curie point - exchange integral - Heisenberg's interpretation of Weiss field - ferromagnetic domains - bloch Wall - spin waves - quantization - magnons - thermal excitation of magnons - Curie temperature and susceptibility of ferrimagnets - theory of antiferromagnetism - Neel temperature.

UNIT-5: Super conductivity

Experimental facts-occurrence - effect of magnetic fields - Meissner effect - entropy and heat capacity - energy gap - microwave and infrared properties - type I and II superconductors - theoretical explanation - thermodynamics of super conducting transition - London equation - coherence length - BCS Theory - single particle tunneling - Josephson tunneling - DC and AC Josephson effects - high temperature super conductors - SQUIDS.

TEXT BOOKS

1. *Kittel. C,* 2005. **Introduction to Solid State Physics,** 7th Edition, Wiley, New York
2. *Pillai. S. O*, 2002. **Solid State Physics,** 6th Edition, New Age International, New Delhi

REFERENCE BOOKS

1. *Blakemore. J. S*, 1985. **Solid State Physics**, 2nd Edition, Publisher Cambridge University
2. *Dekker. A. J*, 1986. **Solid State Physics,** 2nd Edition**,** Macmillan India, New Delhi
3. *Pillai. S. O*, 2007. **Problems and Solutions in Solid State Physics**, 4thEdition, New Age International, New Delhi.

15PMP13P	CORE PRACTICAL–I: ELECTRONICS	SEMESTER – I

Total credit: 8
Hours per week:3

1. Zener regulated power supply and percentage of regulation.
2. Transistor characteristics- CB configuration.
3. Transistor characteristics- CE configuration.
4. Single stage R-C coupled transistor amplifier.
5. FET characteristics.
6. Single stage FET amplifier- CS configuration.
7. OP-Amp applications- Adder, Subtractor, Differentiator and Integrator.
8. Logic gates OR, AND, NOT, NOR and NAND Gates.
9. NAND gate as a universal gate.
10. Half adder and Full adder.
11. A/D and D/A converters.
12. Microprocessor programming.
13. Programs using C
14. Programs using MATLAB.
15. Programs using MATHEMATICA.
16. Programs using STATISTICA.
17. Photosensitive diodes
18. Hall effect

15PMP23A	**CORE- VI: MATHEMATICAL PHYSICS**	**SEMESTER II**

Total credit: 4
Hours per week:4

OBJECTIVES

Upon completion of this paper, the student should understand and be able to apply the following concepts:

1. Partial and total derivative
2. Calculating simple, double and triple integrals
3. Numerical calculations on finite sums

CONTENTS

UNIT- 1: 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.

UNIT - 2: COUNTING AND MEDICAL STATISTICS

Statistics of nuclear counting - Application of Poisson's statistics - Goodness-of-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.

UNIT - 3: NUMERICAL METHODS

Why numerical methods, accuracy and errors on calculations - round-off error, evaluation of formulae. Iteration for Solving x = g(x), Initial Approximation and Convergence Criteria. Interpolations: Finite differences- Forward –Backward-Central differences-Newton-Gregory forward, backward interpolation Formulae for equal intervals-Missing terms-Lagrange's interpolation formula for unequal intervals-Inverse interpolations -Curve fitting - Principle of least squares - Discrete Fourier Transform - Fast Fourier Transform - Applications – Random waveforms and noise.

Simultaneous linear equations: Gauss elimination method - Jordan's modification. - Inverse of a matrix by Gauss - Jordan Method - Roots of nonlinear equations: Newton- Raphson method - Iterative rule -Termination criteria -Taylor series - approximating the derivation - numerical differentiation formulas - Introduction to numerical quadrature - Trapezoidal rule - Simpson's 2/3 rule - Simpson's Three-Eighth rule - Picard's method - Taylor's method - Euler's method - the modified Euler's method - Runge-Kutta method.

UNIT -4: MONTE CARLO METHOD

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 examples - integration of simple 1-D integrals including worked examples.

UNIT 5: COMPUTATIONAL TOOLS & TECHNIQUES

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

TEXT BOOKS

1. *Bajpai. A. C,callus. I. M and Fairley. J. A*, 1977. **Numerical Methods for Engineers and scientists – A students course book**, 2nd Edition, John Wiley &sons.

2. *Hoffman*, 2001. **Numerical Methods for Engineers and scientists,** 2nd Edition Revised and Expanded, Marcel Dekker Inc

3. *Kochan. S. G,* 2014. **Programming in C,** 4th Edition,CBS Publishers & Distributors, Delhi.

REFERENCE BOOKS

1. *Band W,* 1959. Introduction **to mathematical physics,** 1st, Edition**,** D. Van Nostrand Company, Inc.

2. *Croxton*, 2007. **Elementary Statistics**, 3rd Edition, Publ., New York; Korr. Nachdruck der

3. *Dahlberg G*, 2007. **Statistical Method of Medical & Biology students**, 4th Edition, G. Allen & Unwin ltd.

15PMP23B	CORE –VII: RADIATION DETECTORS AND INSTRUMENTATION	SEMESTER - II

Total credit: 4
Hours per week:5

OBJECTIVE

The subject aims to build the concepts regarding:

1. Introduction to Gas filled detectors
2. Dosimetry and protection instruments

CONTENTS

UNIT - 1: INTRODUCTION TO RADIATION MEASUREMENTS AND GAS FILLED DETECTORS

Statistical nature of radiation emission - errors, accuracy andprecision of measurements - types of errors.

Principle of gas filled detectors- relationship between high voltageand charge collected - ionization chambers - construction of condenser type chamber, thimble chambers- Gas multiplication- Proportional Counters, Geiger muller Counters - dead time and recovery time – quenching - characteristics of organic and inorganic counters.

UNIT-2: PRINCIPLES OF RADIATION DETECTION USING SCINTILLATION AND OTHER DETECTORS

Different types - the relationship between pulse height and energyand type of incident particle - photomultiplier tube - assembly of a scintillation counter and role of light pipes - dead time of scintillation counters - sources of background in a scintillation counter - resolving time – resolving power

Radiographic and Radio chromic films – Semi conductor detectors- different types-damage due to radiation- chemical systems- Thermoluminesce dosimeters (TLD) – detection process- glow curve and dose response - common TLD materials and their characteristics – fading - residual TL and annealing for reuse. Optically stimulated luminescence dosimeters (OSLD) - Radio photo luminescent dosimeters - Neutron detectors – nuclear track emulsions for fast neutrons – solid state nuclear track detectors (SSNTD) – calorimeters – new developments.

UNIT- 3: DOSIMETRY 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 – Farmers dosimeters – Radiation field analyzer (RFA) – radioisotope calibrator – multipurpose dosimeters – water phantom dosimetry systems – brachytheraphy dosimeters – Thermo luminescent dosimeter readers for medical applications – calibration and maintenance of dosimeters.

UNIT-4: PROTECTION INSTRUMENTS

TLD badge readers–PM film densitometers–glass dosimeters 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 and gamma radiations – neutron monitors, tissue equivalent survey meters – flux meter and dose equivalent monitors – pocket neutron monitors -teledose systems.

UNIT-5: NUCLEAR MEDICINE INSTRUMENTS

Instruments for counting and spectrometry – portable counting systems for alpha and beta radiation – gamma ray spectrometers – multichannel analyzer – liquid scintillation counting system – RIA counters – whole body counters – air monitors for radioactive particulates and gases-details of commercially available instruments and systems.

TEXT BOOKS

1. *Knoll. G. F, 2000*. **Radiation detection and measurement**, 3rd Edition, John Wiley publisher

2. *Meredith. W. J and Massey. J.B,*1972. **Fundamental Physics of Radiology**, 2nd Edition, John Wright and sons, UK.
3. *Nicholas Tsoulfanidis*, 1995. **Measurement and Detection of Radiation**, 2nd Edition, Taylor & Francis.

REFERENCE BOOKS

1. *Price W.J, 1964.* **Nucleus Radiation detection,** 2nd Edition**,** McGraw-Hill, New York.

2. *Kapoor. S. S and. Ramamurthy. V*, 1986. **Nuclear Radiation Detectors,** 1st Edition, New Age International (p) Ltd.

3. *Greening. J. R,* 1985., **Fundamentals of Radiation Dosimetry,Medical PhysicsHand Book Series No.6**, 2nd Edition, Adam Hilger Ltd., Bristol.

15PMP23C	CORE –VIII:PHYSICS OF RADIATION THERAPY	SEMESTER - II

Total credit: 4
Hours per week:5

OBJECTIVE:

The subject aims to build the concepts regarding

1. Basic therapy Kilovoltage generators
2. Dosimetric parameters
3. Brachytherpy

CONTENTS

UNIT-1: THERAPY BEAM GENERATORS

Kilo voltage therapy X-rayUnits - spectral distribution of kV x-rays and effect of filtration - thoraeus filter - output calibration procedure - Telecobalt units**:** Construction and working, source design, beam shutter mechanisms - beam collimation, penumbra and its types, trimmers and breast cones, isocentric gantry.

Linear accelerator- Construction and working, klystron and magnetron, traveling and standing waveguide, pulse modulators and auxiliary systems, bending magnet systems, treatment beam production - X-rays - electron beam, beam collimation, asymmetric collimator, multileaf collimator, dose monitoring and beam stabilization - electron contamination- relative merits and demerits of kV x-rays, gamma rays, MV x-rays and electron beams.

UNIT-2: CENTRAL AXIS DOSIMETRY PARAMETERS

Percentage depth doses (PDD), tissue air ratio(TAR), back scatter factor/Peak scatter factor (BSF/PSF) - tissue phantom ratio (TPR) - tissue maximum ratio (TMR)- collimator scatter factor, phantom scatter factor and total scatter factors - relationship between TAR and PDD and its applications - relationship between TMR and PDD and its applications – scatter air ratio(SAR) – scatter maximum ratio(SMR)- off axis ratio field factors- surface dose and buildup region-Isodose chart- Measurementsof Isodose curves – parameters of isodose curves – Wedge filters – combination of radiation fields– Isocentric techniques – Wedged field technique – Wedge angle- ICRU 50, 62, 83 Target Volumes, ICRU reference points.

UNIT-3: TREATMENT PLANNING IN TELETHERAPY AND DOSE CALCULATIONS

Acquisition of patient data -Treatment simulation - conventional simulator- CT simulator- use of contrast, markers - Contouring Images from CR, CT, MRI, US, PET, fusion techniques- Conventional simulator techniques- Treatment verification- Correction for contour irregularities, Corrections for Tissue Inhomgenities, Absorbed Dose within Inhomogenities, Tissue Compensation – Patient Positioning /immobilization, Use of contrast, markers, Image,parameters/optimization,Block cutting, Compensators, Bolus, CTsimulator techniques, Scout view images, Virtual simulation Digitally reconstructed radiographs (DRRs), CT number and (electron) density relation and calibration - Field Blocking - Field shaping - Skin Dose, Separation of Adjacent Fields.

Treatment time and Monitor unit calculations: SSD and SAD/isocentric technique–Co-60 calculations- accelerator calculations- irregular fields- Clarkson technique for mantle and inverted Y fields - Arc/Rotation therapy.

UNIT- 4: PHYSICS OF BRACHYTHERAPY

Introduction-Brachytherapy Radioactive sources– Definition and Classification of Brachytherapy techniques –Dose rate considerations and classification of brachytheraphy techniques- Calibration of Brachytherapy Techniques – Calculations of dose distributions –Implantation techniques -classification of brachytherapy based on source loading-manual pre loading systems, manual after loading systems, remote after loading systems - advantages and disadvantages of manual and remote afterloading techniques- source trains (fixed and programmable) - stepping source - different types of applicators (gynecological, esophageal, nasopharyngeal, bronchial) and templates- temporary and permanent implants-Partial breast irradiation using balloon catheter –Systems of implant dosimetry–Dose specification cancer of cervix- AAPM TG-43/43U1 dosimetry protocol - IAEA TECDOC 1274 and ICRU 72 recommendations - AAPM TG 60 protocol.

UNIT-5: ELECTRON BEAM THERAPY

Energy specification - depth dose characteristics (Ds, Dx, R100, R90,Rp, etc.) of electron beam – Determination of absorbed dose- Characteristic of clinical electron beams – monitor unit calculations – output factor formalisms - Planning and dose calculation effects of patient and beam geometry - internal heterogeneities - treatment planning techniques – Collimation - field abutment techniques-photon electron mixed beams – Electron arc therapy.

TEXT BOOKS

1. *Faiz Khan. M, 2014. The* **Physics of Radiation Therapy**, 5th Edition, Wolterskluwer.

2. *Hendee. W. R*, 2004. **Medical Radiation Physics**, preface of 3rd Edition , Medical Publishers Inc London.

REFERENCE BOOKS

1. *Bomford. C. K, kunkler. I. H, Walter and Miller's,* 2002. **Textbook of Radiotherapy**, 6th revised edition, Churchill Livingstone.

2. *Mould. R. F, 1985.* **Radiotherapy Treatment Planning Medical Physics Hand book series No.7**, 1st Edition, Adam Hilger Ltd, Bristol.

3. *Baltas. D, Sakelliou. L and Zamboglou. N*, 2006. **The Physics of Modern Brachytherapy for Oncology,** 3rd Edition, CRC Press, Taylor and Francis Group.

4. *Godden. T. J*, 1988. **Physical aspects of Brachytherapy**, 1st Edition, Taylor & Francis.

15PMP23D	CORE- XI: PHYSICS OF RADIOLOGY IMAGING	SEMESTER - II

Total credit: 4
Hours per week:5

OBJECTIVE:

The subject aims to build the concepts regarding

1. Principles of X-ray, CT,MRI, Ultrasound
2. Quality assurance of Diagnostic Radiology

CONTENTS

UNIT1: PRINCIPLES OF X-RAY DIAGNOSIS & CONVENTIONAL IMAGING

Interactions 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 - Prime factors kVp, mAs and SID/SFD- Filters- Scatter reduction- Beam restrictors – Grids – Air gap technique- cassettes- intensifying screen, - absorption efficiency and conversion efficiency - structure of x-ray film, types of films, manual processing - film handling and storage, characteristics of x-ray film, film processing, influence of temperature and time, replenisher, dark room, Automatic film processor- Image quality, contrast resolution, noise, geometric factors, optimal quality image, artifact, beam limiting devices-QA of Diagnostic X-ray.

Different Radiography Techniques: Xero-radiography, mammography, fluoroscopy,digital subtraction techniques, orthopan tomography (OPG), CR, DR.

UNIT-2: MAMMOGRAPHYAND FLUOROSCOPY

Mammography: mammographic X-ray tube design, x-ray generator and AEC. Compression paddle, grid, collimation, filtration and HVL- Magnification- Screen film cassettes and film Processing- Digital Mammography- QA

Fluoroscopy: conventional fluoroscopy, dark room adaptation, image intensifiers, closed circuit TV systems, flat panel detectors. Modern trends in interventional Radiology-Bi-plane imaging, rotational angiography, cardiac imaging, real time imaging characteristics – filtration, continuous and pulsed fluoroscopy, high dose rate fluoroscopy, spot imaging, Digital Subtraction acquisition technique, road mapping, image magnification, last image hold, automatic exposure control, automatic brightness control, brightness gain- image quality- Radiation dose management: dose area product (DAP) meters, peak skin dose, cummulative dose and dosimetric techniques in interventional radiology - Dose management for pediatric and pregnant patients in interventional imaging, Diagnostic Reference levels and guidelines- QA

UNIT-3: COMPUTED TOMOGRAPHY

Computed tomography scanning principle- CT number, image display- CT equipment, system design, Gantry geometry, x ray tubes, filters and collimation, Detector array – Generation of CT- Modes of CT acquisition, Axial acquisition, Helical acquisition, Cone beam acquisition, Cardiac CT, CT angiography, CT perfusion- CT image reconstruction, back projection, Filtered back projection, Fourier reconstruction, cone beam reconstruction, Iterative reconstruction, postprocessing tools, volume rendering, SSD, MPR, MIP- Image quality, Spatial resolution, Noise and factors influencing them, Quality assurance - Image artifacts, Radiation dose management: factors affecting patient dose CTDI, CTDIvol, dose length product (DLP), multiple scan average dose (MSAD)- QA of CT

UNIT-4: MAGNETIC RESONANCE IMAGING

Basics physics of MRI, magnetism, nuclear characteristics, hydrogen characteristics, magnetization vector, precession, radiofrequency and resonance, MRI signal, flip angle-Relaxation time, T1 relation time, T2 relaxation time, Comparison of T1 and T2- MR signal localization, gradient field, slice selection, phase encoding gradient, frequency encoding gradient,

composite signal, K-space- MR imaging sequences, spin echo sequence, T1 weighted image, T2 weighted image, spin density weighted image, inversion recovery, gradient recalled echo – specialized MR sequences, MR angiography, perfusion imaging, diffusion imaging, functional imaging, MR spectroscopic imaging – MR instrument and bio safety, Image quality and artifacts- QA of MRI.

UNIT 5: ULTRASOUND

Basics of ultrasound, propagation of sound, interaction of ultrasound with matter-ultrasound transducer, piezoelectric material, transducer design, transducer array- beam properties- near field-far field-side lobes-spatial resolution- image data acquisition- data acquisition systems, ADC-receiver, echo display modes, scan converter-image data acquisition, pulse echo acquisition- ultrasound image display, amplitude mode, motion mode, brightness mode- Doppler ultrasound-ultrasound image quality- image artifacts-bioeffects of ultrasound- QA of ultrasound.

TEXT BOOKS

1. *Curry,T.S. Dowdey and J.E. Murry,R.C*, 1990. **Christensen's introduction to the Physics of diagnostic radiology,** 4th Edition, Philadelphia,Lea&Febiger publisher.

2. *Bushberg,S.T; Seibert,J.A; Leidholt,E.M&Boone,J.M*, 2011. **The essential Physics of Medical imaging**, 3rd Edition, Baltimore, Williams & Wilkins publisher.

3. *Johns. H.E.& Cunningham. J.R*, 1983. **The Physics of Radiology**, 4th Edition, Springfield, III.

REFERENCE BOOKS

1. *David J. Dowsett; Patrick A. Kenny; Eugene Johnston R*, 2006. **The Physics of Diagnostic imaging,** 2nd Edition, CRC Press

2. *Farr. R. F and PJ Allisy-Roberts*, 2006. **Physics for Medical Imaging**, 2nd Edition, Saunders.

15PMP23E	CORE- X: RADIATION DOSIMETRY AND STANDARDISATION	SEMESTER – II

Total credit: 4
Hours per week:5

OBJECTIVE:

The subject aims to build the concepts regarding

1. Importance of Radiation quantities and units
2. IAEA Protocol
3. Radiation Chemistry

CONTENTS

UNIT-1: RADIATION QUANTITIES AND UNITS

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 -absorbed dose- radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose - concepts of collective dose - KERMA-CEMA - exposure - air kerma rate constant - charged particle equilibrium (CPE) - relationship between kerma, absorbed dose and exposure under CPE - dose equivalent - ambient and directional dose equivalents [(H*(d) and H'(d)] - individual dose equivalent penetrating Hp(d) - individual dose equivalent superficial Hs(d).

UNIT -2: DOSIMETRY & STANDARDIZATION OF X AND GAMMA RAYS BEAMS

Dosimetry Standards: Primary and Secondary standards, traceability, uncertainties in measurements.
Two stage energy transfer process- Electronic equilibrium: Charged Particle Equilibrium (CPE), Transient Charged Particle Equilibrium (TCPE). Brag Gray, Burlin and Spencer Attix cavity theories. Free Air Ionization chamber (FAIC) – design measurement of exposure and limitations. Cavity ion chambers- Dose in free space (Dgas) , Dose in Medium (Dmed), expression for sensitivity, - general

definition of calibration factors – Nx, Nk, ND,air, ND, w. Different types of Ion chambers- Cylindrical, parallel plate, spherical. Temperature pressure correction: Thermometers, pressure gauges. Saturation correction: Charge collection efficiency based on Mie theory. Polarity correction: Two voltage method for continuous and pulsed beam. Beam quality, beam quality index, expression for beam quality correction coefficient.

IAEA TRS277: Reference conditions, various steps to arrive at the expression for Dw starting from Nx. TRS398: Reference conditions, Various steps involved in Dw calculations. TRS 381, AAPM TG 51 and other dosimetric protocols. Calorimetric standards – inter comparison of standards.

UNIT 3: NEUTRON STANDARDS & DOSIMETRY

Neutron standards – primary standards, secondary standards - neutron yield and fluence rate measurements - manganese sulfate 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.

UNIT 4: STANDARDIZATION OF RADIONUCLIDE

Methods of Measurement of radioactivity – defined solid angle and 4Л counting – Beta gamma coincidence counting – standardization of beat emitters and electron capture nuclides with proportional, GM and scintillation counters – standardization of gamma emitters with scintillation spectrometers – ionization chamber methods – extrapolation chamber – routine sample measurements – liquid counter – windowless counting of liquid samples – scintillation counting methods for alpha, beta and gamma emitter – reentrant ionization chamber methods – methods using (n, ŕ) and (n, p) reactions – determination of yields of neutron sources – space integration methods – solids state detectors.

UNIT 5: RADIATION CHEMISTRY AND CHEMICAL DOSIMETRY

Definitions of free radicals and G-Values-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 polymerization- effects of radiation on polymers and their applications in dosimetry – description of irradiators from dosimetric view point – dosimetry principles – definitions of optical density- molar absorption coefficient- Beer – Lamberts law-

spectrophotometry – dose calculations – laboratory techniques – reagents and procedures -requirements for an ideal chemical dosimeter – Fricke dosimeter – FBX dosimeter – Free radical dosimeter – Ceric sulphate dosimeter – other high and low level dosimeters – applications of chemical dosimeters in radiotherapy and industrial irradiators.

TEXT BOOKS

1. *Attix. F. M*, 1991. **Introduction to Radiological Physics and Radiation Dosimetry**, 1st Edition, Viley– VCH, Verlog.

2. *IAEA TRS 398*, 2006. **Absorbed dose determination in Photon and Electron beams, updated version of TRS 277**

3. *AAPM TG 51*, 2014. **absorbed dose determination for photon beams,** revised version.

REFERENCE BOOKS

1. *Hendee. W. R, 2002.* **Medical Radiation Physics,** 3rd Edition, Year Book Medical Publishers Inc., London.

2. *Bentel. G. C, 1992.* **Radiation Therapy Planning**, 1st Edition, Macmillan Publishing Co., New York.

3. *GovindaRajan*, 1992. **Advanced Medical Radiation Dosimetry,** 1st Edition, Prentice hall of India Pvt.Ltd., New Delhi.

15PMP23P	CORE PRACTICAL - II: MEDICAL PHYSICS	SEMESTER – II

Total credit: 8
Hours per week:6

List of Practical:

1. Statistics of Radioactive Counting
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. Calibration of TL Phosphor and TLD Reader and its uses in dose distribution measurements.
4. Production and attenuation of Bremmstralung.
5. Determine the range of beta particles
6. Backscattering of beta particles
7. Quality Assurance of a diagnostic X-ray machine
8. Absorption and backscattering of Gamma rays- Determination of HVT
9. Radiation protection survey of Diagnostic Radiology installation
10. Manual Treatment Planning of Two and Three fields
11. Study of Voltage-Current Characteristics of an Ion Chamber
12. Cross Calibration of Ion Chambers
13. Dose output measurement of photon (low and high energy X-ray) beams used in radiotherapy department.
14. QA of Fluroscopy (C-arm and cath lab) Interventional kVP, mAs
15. QA of Mammography
16. QA of CT scan.

15PMP33A	CORE –IX:ADVANCED RADIOTHERAPY PHYSICS	SEMESTER – III

Total credit: 4
Hours per week:6

OBJECTIVE:

The subject aims to build the concepts regarding:

1. Tumor Volume definition
2. Advanced Techniques in Radiotherapy

CONTENTS

UNIT-I: INTRODUCTION TO TREATMENT PLANNING SYSTEM AND DOSE CALCULATION ALGORITHM

Scope of computers in radiation treatment planning – review of algorithms used for treatment planning computations – 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, 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 & source library generation-networking, DICOM and PACS.

UNIT-2: ADVANCEMENTS IN CONFORMAL RADIOTHERAPY

3D conformal radiotherapy techniques- 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 (IMAT e.g. 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.

UNIT-3: STEREOTACTIC RADIOSURGERY /RADIOTHERAPY (SRS/SRT)

Cone and mMLC based X-knife – Gamma Knife – immobilization 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 quality assurance of stereotactic body radiotherapy (SBRT) and Cyber knife based therapy.

UNIT-4: ADVANCEMENTS IN BRACHYTHERAPY

Integrated brachytherapy unit.- Brachytherapy treatment planning - CT/MR based brachytherapy planning - forward and inverse planning - DICOM image import / export from OT - Record & verification. Brachytherapy treatment for Prostate cancer.Ocular brachytherapy using photon and beta sources.
Intravascular brachytherapy - classification - sources -Electronic brachytherapy (Axxent, Mammosite, etc)

UNIT-5: SPECIAL TECHNIQUES IN RADIATION THERAPY

Total body irradiation (TBI) – large field dosimetry – total skin electron therapy (TSET) – electron arc treatment and dosimetry – intraoperative radiotherapy.

Particulate beam therapy:Neutron captures therapy– carbon ion therapy – Proton Therapy – Hardon Therapy.

TEXT BOOKS

1. *Webb. S*, 2001. **Intensity Modulated radiation therapy,** 1st Edition, CRC Press

2. *FaizKhan. M, 2014.* **The Physics of Radiation Therapy**, 5th Edition, Wolterskluwer.

3. *Van Dyk. J*, 1999. **The Modern Technology of Radiation Oncology,** Volume -1 , Medical Physics Pub Corp.

REFERENCES BOOKS

1. *Webb. S,1993.* **The physics of three dimensional radiation therapy,** 1st Edition, CRC Press

2. *Levit. S. H, Purdy. J. A, Perez. C. A and Vijayakumar. S, 2006.* **Technical Basis of Radiation therapy Practical Applications**, 1st , Edition, Springer.

3. *Klevenhagen.S. C,1985.* **Physics and dosimetry of therapy electron beams,** 4th Edition, Medical Physics Pub Corp

4. *Thomas Bortfeld, Rupert Schmidt- Ullrich, Wilfried De Neve, David E Wazer*, 1993. **Image Guided Radiotherapy**, 3rd Edition, Springer Berlin Heidelberg.

15PMP33B	CORE –XII: PHYSICS OF NUCLEAR MEDICINE	SEMESTER – III

Total credit: 4
Hours per week:6

OBJECTIVE:

The subject aims to build the concepts regarding:

1. Basic idea about Nuclear medicine
2. Advanced Technique in Nuclear medicine

CONTENTS

UNIT 1: RADIONUCLIDE AND ITS PRODUCTION

Introduction to nuclear medicine- unsealed Sources- production of radionuclide used in nuclear medicine- reactor based radionuclide, accelerators based radionuclide, photonuclear activation, equations for radionuclide production, radionuclide generators and their operation principles- various usages of radiopharmaceuticals.

UNIT 2: IN-VIVO AND IN-VITRO TECHNIQUES

Thyroid uptake measurements- reno gram- life span of RBC, blood volume studies, life Span of RBC etc-general concept of radionuclide- imaging and historical developments-In-vitro techniques- RIA/IRMA techniques and its principles.

UNIT 3: EMISSION TOMOGRAPHY TECHNIQUES

Radionuclide imaging: other techniques and instruments- the rectilinear scanner and its operational principles- basic principles and design of the anger Camera / scintillation camera- system components, detector system and electronics- different types of collimators- design and performance characteristic of the parallel hole, converging, diverging and pin hole collimator- image display and recording systems- digital image processing systems- scanning camera- limitation of the detector system and electronics.

Different imaging techniques: basic principles- two dimensional imaging techniques-Three dimensional imaging techniques – basic principles and problems- focal plane tomography- emission computed tomography- single photon emission computed tomography- positron emission tomography- various image reconstruction techniques during image formation such as back projection and 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 followed for quality assurance / quality control of imaging instruments.

UNIT 4: APPLIED PET IMAGING

Principles of PET, PET instrumentations- annihilation coincidence detection- PET detector scanner design- data acquisition for PET- data corrections and quantitative aspect of PET- working of medical cyclotron- radioisotopes produced and their characteristic- treatment of thyrotoxicosis- thyroid cancer with I-131, use of P-32 and Y-90 for palliative treatment- radiation synovectomy and the isotopes used.

UNIT 5: INTERNAL RADIATION DOSIMETRY

Different compartmental model- single compartmental model- two compartmental model with back transference- two compartmental model 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 producer 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 calculations- limitation of MIRD technique.

TEXT BOOKS:

1. *J.Herbert and D.A.Rocha*, 1984. **Text Book of Nuclear Medicine**, Vol. 2 and 6, Lea and Febiger Co., Philadelphia.

2. *Blahd. W. H*, 1980. **Nuclear medicine**, 1st edition, McGraw Hill Co., New Delhi.

3. *Webb. S*, 1984. **The Physics of Medical Imaging**, 2nd Edition, Medical Science Series, Adam Hilgers Publications, Bristol.

REFERENCE BOOKS

1. *Pant. G. S*, 2003. **Advances in diagnostic Medical Physics**,3rd Edition, Mumbai : Himalaya Pub. House

2. *Wagner. W. N*, 1995. **Principles of Nuclear Medicine**, 2nd Edition, W.B.Saunders Co., London.

15PMP33C	CORE- XIII:RADIATION BIOLOGY	SEMESTER III

Total credit: 4
Hours per week:6

OBJECTIVES

Upon completion of this paper, the student should understand and be able to Apply the following concepts:

- Interaction of ionizing radiation on living cells
- Biological evaluation of ionizing radiation effects
- Time dose fraction calculation and gap correction.

UNIT 1: CELL BIOLOGY

Cell Physiology and biochemistry – structures 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.

UNIT 2: INTERACTION OF RADIATION WITH CELLS

Action of radiation on living cells – radiolytic products of water and their interaction with biomolecule – nucleic acids, 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.

Repair misrepair hypothesis – dual action hypothesis – modification of radiation damage – LET,RBE, dose rate, dose fractionation – oxygen and other chemical sensitizers – anoxic, hypoxic, base analogs, folic acid, and energy metabolism inhibitors – hyperthermic sensitization – radio-protective agents.

UNIT 3: BIOLOGICAL BASIS OF RADIOTHERAPY

Physical and biological factors affecting cell survival, tumor regrowth and normal tissue response – non-conventional fractionation scheme and their effect of reoxygenation, repair, redistribution in the cell cycle – High LET radiation therapy.

UNIT 4: RADIOBIOLOGICAL MODELS

Cell population kinetic models- survival curve parameters – model for radiation action – target theory – multihit, multitarget –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- TCP and NTCP evaluation.

UNIT 5: 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 – effects of radiation on skin and blood forming organs- digestive track – 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-effects relationship – first generation effects – effects due to mutation of recessive characteristics – genetic burden – prevalence of hereditary diseases and defects – spontaneous mutation rate – concept of doubling dose and genetic risk estimate.

TEXT BOOKS

1. *Hall. E. J*, 1987. **Radiobiology for Radiologists**, 2nd Edition, J.B.Lippincott Co., Philadelphia.
2. *Gorden Steele, 2002.* **Principles of radiobiology,** 3rd Edition, CRC Press.

REFERENCE BOOKS

1. *Perez &Bradys*, 2008. **Principlesand practice of radiation oncology**, 5th Edition, Lippincott Williams and Willins
2. *Tubiana. M, Dutreix. J*,1990. **Introduction of Radiobiology**, 1st Edition, Taylor & Francis.

15PMP33P	CORE PRACTICAL –III: MEDICAL PHYSICS	SEMESTER – III

Total credit: 8
Hours per week:6

List of Practicals:

1. Dose output measurement of electron beams used in radiotherapy department
2. Determination of Percentage Depth Dose for Photon and electron Beams
3. Verification of Mechanical and radiation isocenter of a teletherapy machine
4. Integrity check and calibration of Brachytherapy source in Remote Afterloader unit
5. AKS/ RAKR measurement of HDR Brachytherapy sources using well type and cylindrical ionization chamber.
6. Familiarization with treatment planning procedure using a computerized radiotherapy treatment planning system.
7. Dose planning in cancer of uterine cervix, Head and Neck, Esophagus.
8. Determination of radiation field, flatness, symmetry and penumbra of external photon beam.
9. Dose verification in IMRT
10. In Vivo dosimetry using TLD
11. Radiation protection survey of Medical Accelerator installation
12. Radiation protection survey of Brachytherapy Installation
13. Leakage level Measurement of Teletherapy equipment
14. Leakage level Measurement of a diagnostic X-ray machine
15. In phantom Dosimetry of a Brachytherapy source.

15PMP43A	**CORE -XIV : RADIATION HAZARDS EVALUATION AND CONTROL**	**SEMESTER - IV**

Total credit: 4
Hours per week:6

OBJECTIVE:

The subject aims to build the concepts regarding

1. Radiation protection
2. Radiation safety Legislation
3. Radiation Emergencies

CONTENTS

UNIT 1: RADIATION PROTECTION STANDARDS

Radiation dose to individuals from natural radioactivity in the environment and manmade 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 – potential exposures, dose and 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.

UNIT 2: 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 radionuclide and classification of laboratories – control of contamination – bioassay and air monitoring – chemical protection – radiation accidents – disaster monitoring.

UNIT 3: SAFETY IN THE MEDICAL USES OF RADIATION

Planning and shielding calculations of medical radiation installation – general considerations – design of diagnostic, deep therapy, telegamma, accelerators and installations, brachytherapy facilities, SPECT, PET/CT and medical cyclotron in the nuclear medicine department and medical radioisotope laboratories-evaluation of radiation hazards in medical diagnostic therapeutic installations – radiation monitoring procedures – protective measures to reduce radiation exposure to staff and patients – radiation hazards in brachytherapy department and teletherapy departments and radioisotope laboratories – particle accelerators protective equipment – handling of patients – radiation safety during sources transfer operations special safety features in accelerators, reactors.

UNIT 4: RADIOACTIVE WASTE DISPOSABLE AND TRANSPORT OF RADIOISOTOPE

Radioactive waste – sources of radioactive waste – classification of waste – treatment techniques for solid, liquid and gaseous effluents – concept of delay tank and various Waste disposal Methods used in nuclear medicine. permissible limits for disposal of waste– sampling techniques for air, water and solids – geological, hydrological and meteorological parameters – ecological considerations- disposal of radioactive wastes – general methods of disposal-transportation of radioactive substances – historical background – general packing requirements – transports documents – labeling and marking of packages – regulations applicable for different modes of transport – transports by post –transport emergencies – special requirements for transport of large radioactive sources and fissile materials – exemptions from regulations – shipments approval – shipment exclusive use – transports under special arrangement – consignors and carriers responsibilities.

UNIT 5: RADIATION SAFETY LEGISLATION AND RADIATION EMERGENCIES AND THEIR MEDICAL MANAGEMENT (SEMINAR)

Atomic Energy Act-1962, RPR-2004 and applicable safety codes- radiation accidents and emergencies in the use of radiation sources and equipment industry and medicine - radiographic cameras and teletherapy units – loading and unloading of sources – loss of radiation sources and their tracing – typical accidents cases, radiation injuries, their treatment and medical management – case his histories.

TEXT BOOKS

1. *Alan Martin*, 1998. Radiation **Protection** 3 rd Edition, published by Champman& Hall.

2. *Thayalan. K*, 2010. **Textbook of Radiological protection** 1st Edition, published by Jaypee Brothers.

REFERENCE BOOKS

1. *Shapiro J.* 1994. **Radiation Protection** 3rd Edition, Harvard University Press

2. *Mckenzie, 1986.* **Radiation protection in Radiotherapy,** 3rd Edition, Institute of Physics and Engineering in Medicine

3. *Herman Cember, 2008.* **Introduction to Health Physics,** 4th Edition, McGraw-Hill Medical.

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