Panjab University, Chandigarh-160 014 (India)

(Estted. under the Panjab University Act VII of 1947- enacted by the Govt. of India)

Faculty of Science

Syllabi

For

M.Sc. Medical Physics

(Session 2023-24)

Introduction

Medical Physics is an established clinical specialty with wide ranging application in Radiotherapy planning and treatment. It can be defined as embracing all applications of radioactive sources in the treatment of cancerous and non cancerous disease. The student of Medical Physics also gains knowledge about different equipments used in Radiotherapy planning and treatment and their quality assurances. There is ample scope of research in area of medical physics. The students will also be imparted to training and teach. Therefore, medical Physics syllabus has been prepared in such a way that it will make the student a good clinical physicist, researcher and a teacher after qualifying this course. As this is a specialized branch of medicine and is multidisciplinary in nature, it requires skilled/trained manpower.

Aims and Objectives

First year of the teaching/training will be mainly in the Panjab University in the Centre for Medical Physics.

FIRST YEAR

First Semester

Theory = 300 Marks (4 Papers of 75 marks each)
Practicals = 200 Marks (4 Practicals of 50 marks each)
Total Marks = 500 Marks

Code	Theory Paper	Marks	Credits
MPHY 11T	Cytology and Fundamental Anatomy of Human Body	15+60=75	**3**
MPHY 12T	Radiation Detection and Measurements	15+60=75	**3**
MPHY 13T	Radiation Physics and Professional Ethics	15+60=75	**3**
MPHY 14T	Radiation Biology	15+60=75	**3**
	Practicals		
MPHY 11P	Cytology and Fundamental Anatomy of Human Body	**50**	**2**
MPHY 12P	Radiation Detection and Measurements	**50**	**2**
MPHY 13P	Radiation Physics and Professional Ethics	**50**	**2**
MPHY 14P	Radiation Biology	**50**	**2**

Second Semester

Theory = 300 Marks (4 Papers of 75 marks each)
Practicals = 200 Marks (4 Practicals of 50 marks each)
Total Marks = 500 Marks

Code	Theory Paper	Marks	Credits
MPHY 21T	Basic Physiology and Cancer Biology	15+60=75	**3**
MPHY 22T	Analog and Digital Electronics	15+60=75	**3**
MPHY 23T	Applied Mathematics, Biostatistics and Computer Applications	15+60=75	**3**
MPHY 24T	Bio-Medical Applications of Radioisotopes	15+60=75	**3**
	Practicals		
MPHY 21P	Basic Physiology and Cancer Biology	**50**	**2**
MPHY 22P	Analog and Digital Electronics	**50**	**2**
MPHY 23 P	j		

SECOND YEAR

Third Semester

Theory = 300 Marks (4 Papers of 75 marks each)
Practicals = 200 Marks (4 Practicals of 50 marks each)
Total Marks = 500 Marks

Code	Theory Paper	Marks	Credits
MPHY 31T	Radiotherapy Equipments and Quality Assurances	15+60=75	**3**
MPHY 32T	Medical Imaging equipments and Quality Assurances	15+60=75	**3**
MPHY 33T	Radiation Dosimetry	15+60=75	**3**
MPHY 34T	Teletherapy Treatment Planning	15+60=75	**3**
	Practicals		
MPHY 31P	Radiotherapy Equipments and Quality Assurances	**50**	**2**
MPHY 32P	Medical Imaging equipments and Quality Assurances	**50**	**2**
MPHY 33P	Radiation Dosimetry	**50**	**2**
MPHY 34P	Teletherapy Treatment Planning	**50**	**2**

Fourth Semester

Theory = 300 Marks (4 Papers of 75 marks each)
Practicals = 200 Marks (4 Practicals of 50 marks each)
Total Marks = 500 Marks

Code	Theory Paper	Marks	Credits
MPHY 41T	Brachytherapy Treatment Planning and Radiobiological Models	15+60=75	**3**
MPHY 42T	Clinical Dosimetry and Standardization	15+60=75	**3**
MPHY 43T	Radiation Protection and Radiation Safety	15+60=75	**3**
MPHY 44T	Advances in Radiotherapy and Special Techniques	15+60=75	**3**
	Practicals		
MPHY 41P	Brachytherapy Treatment Planning and Radiobiological Models	**50**	**2**
MPHY 42P	Clinical Dosimetry and Standardization	**50**	**2**
MPHY 43P	Radiation Protection and Radiation Safety	**50**	**2**
MPHY 44P	Advances in Radiotherapy and Special Techniques	**50**	**2**

THIRD YEAR

Medical Physics Internship	=	**500 Marks**
Dissertation & Viva	=	**500 Marks**
Total Marks	=	**1000 Marks**

Code	**Internship, Dissertation & Viva:**	**Marks**	**Credits**
MPHY INT	Medical Physics Internship (* & **)	100 + 400 = 500	**20**
MPHY DIS	Dissertation & Viva	100 + 400 = 500	**20**

* Continuous evaluation

**Midterm evaluation

M.Sc. Medical Physics Syllabus

FIRST YEAR - FIRST SEMESTER

Paper – I
CYTOLOGY AND FUNDAMENTAL ANATOMY OF HUMAN BODY(45 Lectures)

INTRODUCTORY CYTOLOGY
Cell Physiology and Biochemistry -

5.

FIRST YEAR - FIRST SEMESTER

Paper – II

RADIATION DETECTION & MEASUREMENTS (45 Lectures)

Basics of Solid State Physics:

Crystal lattice: Bonding force and energy bands in solids: Bonding force in solids, Energy bands, Metals, semiconductors, and insulators. Direct and indirect semiconductors.

Charge carriers in semiconductors: Electrons and holes, Effective mass, Intrinsic Material, Extrinsic Material, Fermi levels

Drift of carriers in electric and magnetic fields: Conductivity and mobility, Drift and resistance, effects of temperature and doping on mobility, high fields effects, Hall effect.

Crystal structure Crystalline state- Periodic structure, cubic Lattice, Planes and directions, the Diamond Lattice, Basic definitions- Lattice and basis-Lattice translational vector-Primitive cells and unit cells – Wigner –Seitz cell – Indexing of planes, directions and positions of atoms-crystal systems – Bravais lattices - Simple crystal structures (Hexagonal close packed structure, NaCl, CsCl, Diamond structure, Cubic ZnS structure), Growth of single-crystal Ingots

X-ray diffraction – Laue's treatment-Braggs treatment – Laue's method-Rotating crystal method-Powder method.

Optical Properties : Absorption processes- Photoconductivity – Photoelectric effect – Photovoltaic effect–Photoluminescene, Thermoluminescence, Fluorescence, Radioluminesce, Phosphorescence

Colourcentres – Types of colourcentres, F-Centre, Generation of colourcentres.

Gas filled detectors

Theory of ionization chamber, design consideration in an ionization chamber, operating voltage, theory and construction of condenser type of chambers and thimble chambers; gas multiplication, Proportional counters-

Semiconductor Diode Detectors: Semiconductor Properties, Semiconductors as Radiation

FIRST YEAR - FIRST SEMESTER

Paper – III
RADIATION PHYSICS AND PROFESSIONAL ETHICS (45 Lectures)

Electromagnetic Waves: Time varying fields and Maxwell's equations, potential function, electromagnetic boundary

Radiation generators

X-ray generators: Physics of X-ray production -Inner-shell vacancy decay, Characteristic x-ray radiation, Auger effect, fluorescent yield, X-ray tube, Anode, Cathode filament, High voltage generation, voltage rectification, operating characteristics.

Particle accelerators: Motion of charged particles in electric field, magnetic field and ExB fields, Relativistic particles,

Linear Accelerators: The Resonant transformer generator, Cockcroft-Walton generator, Van De Graff Generator, Tandem Accelerator, Cyclotron, Synchro-Cyclotron,Betatron, Linear-Accelerator, Klystron and Magnetron. Travelling and Standing Wave Acceleration – Microtron, Electron Synchrotron, Proton synchrotron,Accelerator facilities in India.

Professional Ethics

Profession and professionalism, Elements of professionalism - altruism, honesty, integrity,

6. Curry,T.S. Dowdey and J.E. Murry,R.C,

FIRST YEAR - FIRST SEMESTER

Paper – IV
RADIATION BIOLOGY(45 Lectures)

Radiation Chemistry: direct and indirect effects of radiations, radiation chemical yields and G-values, formation of free radicals, radiolysis of water, radiation effects on simple chemical systems, interactions of free radicals with several solutes. Direct versus indirect effects in aqueous solutions. Reactions in aqueous, organic and inorganic solutions.

Interaction of radiation with living cells:Direct action, indirect action, radiolysis of water-Free radical interaction with bio molecules including DNA, radiation effects on cell: cell cycle- DNA strand breaks, energy metabolism, synthetic processes, chromosomes, chromosomal type aberrations and repair, chromatid type aberrations, sub chromatid aberrations, relation between aberration structure and the mitotic and meiotic cycles. Radiation effects on cell division.

Radiation Molecular Biology

Radiation Effects on Major Organ Systems
Effects of radiation on skin and blood forming organs (Spleen, bone marrow, Lymphoid tissue, thymus) and blood constituents, vascular system, digestive system, respiratory system, urinary system, nervous system, endocrine system, immune system reproductive system, embryo Sterility.

Applications of Radionuclides in Biology
Concept of uptake of radionuclides in the organ of interest, effective half life/ biological half life in specific organs and whole body. **^{51}Cr** labeling with red blood cells: applications in blood volume measurement, spleen uptake, red cell survival studies, red cell volume and proteins turn over. Theoretical aspects of tracer techniques and basic requirements for radiotracer investigations.
^{59}Fe absorption studies, Techniques for studying absorption of labeled substance, ^{59}Fe turn over studies, plasma iron clearance
^{58}Co/^{57}Co: Applications in schilling's test of vitamin B12 absorption, double tracer technique and whole body counting
^{60}Co: in cancer treatment, gamma knife
^{32}P applications in polycythemia vera and leukemia
^{14}C applications in urea breath test, Radiorespirometry, in vitro uptake and turnover studies using ^{14}C glucose, ^{14}C amino acids and fatty acids.
^{45}Ca, **^{65}Zn** and **^{3}H** metabolic studies and other biomedical applications.

PRACTICALS

List of experiments is same as mentioned in Paper IV (Second semester). Students are expected to perform at least 6 experiments in each semester. The experiments performed in first semester cannot be repeated in second Semester.

1. To determine the turnover of ^{14}C glucose in liver slices using radiorespirometric technique.
2. To demonstrate that tritium labeled thiamidine is incorporated in DNA
3. To study in vivo incorporation of ^{14}C uracil in RNA.
4. To determine the in-vitro uptake of ^{14}C labeled amino acids in the given organ slices.
5. To study the bio-kinetics of ^{45}Ca in understanding its metabolism in bone when administered in an animal.
6. To study the effects of ionizing radiations on the activities of enzymes
7. Use of gamma ray scintillation counter for measuring in vivo thyroid uptakes following administration of carrier-free ^{131}I.
8. To study the influence of carrier on in- vivo uptake carrier free ^{131}I by the thyroid.
9. To find out the bio-distribution of a given radionuclide in a given animal.
10. To label the red blood cells using ^{51}Cr and to determine the efficiency of labeling.
11. To find out the average life span of red blood cells by using ^{51}Cr radionuclide
12. To determine the blood volume of a given animal using ^{51}Cr labeled red blood cells.
13. To measure the blood volume of a given animal using ^{99}Tc labeled red blood cells.
14. To prove that spleen is the storehouse of worn out red blood cells by using ^{51}Cr labeled red blood cells.
15. To find out the target / non target ratio of ^{99m}Tc labeled pharmaceuticals.
16. To determine the biological half life of ^{99m}Tc O_4^- and labeled pharmaceuticals.

Books for references:

1. Alison P Casserette, Radiation Biology
2. Uma Devi, Handbook of Radiation Biology
3. Erij J. Hall, 6th Edition

FIRST YEAR - SECOND SEMESTER

Paper – I
BASIC PHYSIOLOGY AND CANCER BIOLOGY (45 Lectures)

HUMAN PHYSIOLOGY

Respiratory system: General physiological functions of respiratory system, Nose and nasal cavities –

BIOLOGY OF CANCER

Classification, nomenclature and definition of neoplasm: Transformed cells and cell lines, cancer cells differentiation, alterations in cancer cell behavior, diminished contact inhibition and defects in cell to cell metastasis.

Cancer Invasion and Metastasis: Stages of metastasis (Invasion, local extention, discontinuous extention), transport of cancer cells to distant sites

PRACTICALS

1. Demonstration of micronucleus assay.
2. To perform DNA fragmentation assay.
3. To perform COMET assay for DNA damage.
4. To study apoptosis using TUNEL assay.
5. To estimate proteins in serum and tissues.
6. To study chormosomonal aberrations.
7. To study the cell proliferation using MTT assay.
8. To study muscular activity using actophotmotometer.
9. To study locomotor functions by rotarod.
10. To study learning and memory process using moris water maze and plus maze

Books for references:

1. Wolfgang Kuehnel, G A

FIRST YEAR - SECOND SEMESTER

Paper – II
ANALOG AND DIGITAL ELECTRONICS (45 Lectures)

Semiconductor devices - pn-junction, forward and reversed bias, Rectification circuits, power supplies, Monolithic voltage regulators and filters, Voltage multipliers, clippers.

PNP and NPN junction transistors, transistor current components, CB, CE and CC configurations,Biasing of transistors, Transistor switching action, Small signal equation and equivalent circuits for transistors, Field effect transistor (FET), MOFET.

Special devices- UJT, SCR, Diac-Triac, Opto-isolator, Zener diode, Schottky diode,Tunnel diode, Solar cells, photodiode, p-i-n diode; phototransistor, LED and Semiconductor LASER. LCD and LED based displays. Opto electronic devices, Optical fibre communication

Transducers - Properties and the principle of transducers, Resistive transducer, thermoresistors, Inductive transducers, Thermoelectric, Piezoelectric, Magnetostrictive, Hall effect type, Electromechanical, Accelerometer, Photoelectric,Ionization, Electrochemical their biomedical applications. Charge coupled dev خه

PRACTICALS

1. To measure AC voltage signal and its frequency using an oscilloscope and to study NPN & PNP transistor and characteristic of multivibrator.
2. To use an Oscilloscope as a display for studying the half wave rectifier and to set up LC filter circuit, L and C filter circuits and study the waveform obtained on the oscilloscope. Find the ripple factor in each case.
3. Two stage RC coupled amplifier - frequency response.
4. Construction of a voltage multiplier.
5. Characteristics of a regulated power pack.
6. OPAMP circuits - Inverting and non inverting amplifiers.
7. Integrator and differentiator circuit using OPAMP.
8. To demonstrate ECG in normal and treated animals.
9. To demonstrate electrical impedances in biological tissues.

Books for references:

1. A.P. Malvino and D.P. Leach, Digital Principles and Applications (Tata McGraw-Hill Publishing Co, New Delhi, 1996)
2. Curry,T.S.Dowdey and J.E. Murry,R.C, Christensen's introduction to the Physics of diagnostic radiology(Philadelphia,Lea&Febiger)
3. A.P. Mathur, Introduction to Microprocessors (Tata McGraw-Hill Publishing Co, New Delhi, 2005)
4. Introduction to Solid State Physics, 7th Ed, C. Kittel, John –Wiley & Sons (Asia) Pvt Ltd., New Delhi, 1996.
5. Ben Streetman, Sanjay Banerjee, Solid State Electronic Devices
6. R.S. Sedha, A text book of digital electronics
7. R.S. Gaonkar Microprocessor Architecture, Programming and Applications with 8085
8. Robert Boylestad Louis Nashelsky, Electronic Devices and Circuit Theory
9. Boylestad, Introductory Circuit Analysis

Binomial distribution, Poisson distribution, Gaussian distribution, Multinomial distribution, Hypergeometric distribution, exponential distribution - additive property of normal variates, confidence limits, Bivariate distribution.

Sampling and sampling distributions, Sample distribution of sample mean and sample proportions.

Significance tests, Tests of hypothesis for the parameters of normal distribution including testing for population proportions. Confidence intervals for the parameters of normal distribution.

Chi-Square distribution, t-distribution, F-distribution.

Correlation analysis, Regression analysis, Partial and multiple.

Categorical data: measurements scales, tests of associations, Chi-square test, Yate's correction.

PRACTICALS

Computational Tools & Techniques: Working knowledge of Microsoft Excel, Word, Corel Draw, Origin, Latex and Power point.

Computational packages: MATLAB, and SPSS in data analysis and graphics.

MATLAB: Introduction to MATLAB environment, Constants, Variables and Expression, Matrices, Polynomials, I/O statements, MATLAB graphics, Data handling with Structures, Arrays with large dataset, Matrix operations in 3D and 4D datasets, Programming, Image processing toolbox – Coding, scanning and recognition, optimization toolbox, wavelet toolbox

Revisit of Numerical Methods for C++ programming and MATLAB: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.
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.

Books for references:

1. Sabine Landau and Brian S. Everitt, A Handbook of Statistical Analyses using SPSS
2. E. Balaguruswami, Object Oriented Programming by C++
3. S.S. Sastry, Introductory Methods of Numerical Analysis
4. Tao Pang, An Introduction to Computational Physics
5. MATLAB and its applications in Engineering, RK Bansal, AK Goel and M.K. Sharma, Pearson (R2007b).
6. G. Arfken and H.J. Weber, Mathematical Methods for Physicists : (Academic Press, San Diego), 2012.

PRACTICALS

1. To verify the Mechanical isoc p,G+

SECOND YEAR - THIRD SEMESTER

Paper – II

MEDICAL IMAGING EQUIPMENTS AND QUALITY ASSURANCES (45 lectures)

Diagnostic Radiology:

PhysicalPrinciple:InteractionsofX-raysw

Ultrasound:

Basics of ultrasound, nature and propagation of ultrasound-frequency, wavelength and speed, pressure, intensity and dB scale intensity of ultrasound, interaction of ultrasound with medium-Acoustic impedance , impendence of various materials, Reflection, Refraction, Absorption. Transducers and their construction and design – Characteristics of Piezoelectric Crystals – Curie Temperature – Resonant Frequency – Q factor . Fresnel Zone and Fraunhoffer Zone and their dependence on size of Transducers and frequencies, Quarter – Wave matching.

Various types of transducer- linear, focused transducer, Oscillating Transducer, Rotating Wheel Transducer. Image data acquisition – data acquisition system, ADC- receiver, Echo display modes, scan converter. Ultrasound image display- amplitude mode, Motion mode, brightness mode. 2-D, 3-D ultrasound imaging,Spatial and temporal resolution, Elasticity imaging methods, US contrast agents, Safety and biological effects.

Principles of Gray-Scale imaging, significance of gain and gain compensation, pulse rate and its significance. Resolution of frequency and depth. Doppler ultrasound -principles of Colour Doppler frequency shift, Continuous Doppler and Pulse Doppler. Biological effects of ultrasound.

Nuclear Magnetic Resonance and MRI:

Magnetization properties of matter-diamagnetic, paramegnatic and ferromagnetic substances. Magnetic characteristic of the nucleus, Angular momentum of the nucleus, electron angular momentum, orbital angular momentum, Magnetism and the Magnetic Dipole Moment(MDM),Magnetization Vector.

MDM in a external magnetic field,-Angular Momentum and Precession, Energy States for Nuclear Spin Systems, Larmor Frequency and gyromagnetic ratio, magnetic resonance, response of the magnetization to a radiofrequency pulse, generation of Magnetic resonance signal-Free induction

PET and PET/CT:

Basic principles- detectors and image processing, procedures in PET and PETCT, source of radioisotopes from cyclotron and its basic concept, Co registration in PETCT for image fusion, Gating in PETCT studies (respiratory and cardiac gating)

Radiopharmaceuticals: Radioisotope generators, method of preparation, purity, quality and stability of radiopharmaceuticals, quality control in preparation of radiopharmaceuticals

Practicals:

1. Q. A. testing of a diagnostic X-ray unit.
2. Study of speed of intensifying screen of a film cassette.
3. Study of effectiveness of filters of an X-ray unit.
4. Measurement of KVp, mAs, Timer of an X-ray Unit and find the total filtration of an x-ray beam.
5. To find the total filtration of an x-ray beam
6. To find the effective focal spot size of the x-ray tube.
7. To check the perpendicularity of x-ray beam to image receptor and the alignment of the centre of radiation field and the centre of image receptor in the plane.
8. Q. A. testing of CT

SECOND YEAR - THIRD SEMESTER

Paper – III
RADIATION DOSIMETRY (45 Lectures)

Description of Ionizing Radiation

Consequences of the random nature of ionizing radiation: Stochastic and Non-stochastic quantities; Simple description of radiation fields by Non-stochastic quantities: Fluence and its

Instruments for counting and spectrometry – Portable counting systems for alpha and beta radiation – Gamma ray spectrometers – Multichannel Analyser – Liquid scintillation counting system – RIA counters – Whole body counters – Air body counters – Air Monitors for radioactive particulates and gases. Details of commercially instruments and systems.

Practicals

1. Study of Linearity and reproducibility of a pocket dosimeter.
2. Study of Linearity and reproducibility of a survey meter.
3. Measurement of Radiation Response using Thermo luminescent Dosimeter.
4. Radiation dose measurement with a thimble ionization chamber.
5. Calibration of a film dosimety system for dose measurement.
6. Source Strength verification of a micro-Selectron HDR Brachytherapy Machine using a wtherapy Ⓟˣ n

SECOND YEAR - FOURTH SEMESTER

Paper – I

BRACHYTHERAPY TREATMENT PLANNING AND RADIOBIOLOGICAL MODELS (45 Lectures)

Clinical aspects of Brachytherapy:

Definition,advantages and limitations as well as different methods of brachytherapy. Indications for various types of brachytherapy.

Treatment Planning of Brachytherapy

Calibration of Brachytherapy Sources: Specification of source strength, Radium Substitutes and Radioactive Isotopes Currently Used in Brachytherapy, Linear Sources, Seeds, Exposure Rate Calibration using well chamber.

Calculation of dose distributions: Biological consideration of dose, dose rate, and frac ExB S

2. Biodose Model

Concept of BED, BED for fractionated and continuous irradiation, calculation of α/β values for tumor, calculation of fraction size for alternate schedules. Normal Tissue Complication Probability and Tumor Control Probability,

3. Altered fractionation regimes

Various fractionation schedules: Conventional fractionation and Altered fractionation; hyper fractionation; Accelerated hyper fractionation - CHART schedule, concomitant boost, split course schedule; hypo fractionation and their rationale.

4. NTCP and TCP for Treatment Planning and Radiobiology of Particle beam therapy

Tissue Dose–Response Classification – γ_{50} and TD_{50}, Concepts of "Serial" and "Parallel" Tissue Dose–Response-Local vs. Global Organ Injuries and concepts of functional sub units; NTCP Models - Generalized Equivalent Uniform Dose Equation, Basic Mathematical Features of Common NTCP Functions - parallel function model and Lyman Kutcher Burman model, Tumor Control Probability- γ_{50} and TCD_{50}, Optimization of Radiotherapy using Biological Parameters:Radiobiological Models - Poisson Model, Logistic model, Probit model LKB model and Uncomplicated Tumor control modeling; Biological Optimization using Sub-volume-Based Radiobiological Models, Drawbacks to Treatment Planning Based on Dose–Volume Limit, Uncertainties in NTCP Models, Incorporating Fractionation Sensitivity.

Practicals:

1. QA for High dose rate brachytherapy machine.
2. Calibration of Ir-192 high intensity source.
3. Treatment Planning on TPS for all types of brachytherapy procedure – Intracavitary, Interstitial implant, Surface Mould and Intra-luminal brachytherapy.
4. Brachytherapy dosimetry for single and double plane implants.
5. In-vivo dosimetry in Brachytherapy procedure.
6. Auto-radiograph of different intracavitary and interstitial applicators
7. X-Ray based ICRT Brachytherapy Planning.
8. Source position verification in HDR brachytherapy.
9. Autoradiograph of different intracavitary and interstitial applicators.
10. TPS QA in Brachytherapy.
11. Radiation survey of Brachytherapy HDR unit.

SECOND YEAR – FOURTH SEMESTER

Paper – II
CLINICAL DOSIMETRY AND STANDARDIZATION(45 Lectures)

Radiation Measurement and Calibration

Dose and Relationships: Radiation Absorbed Dose - definition and units; Relationship between Kerma, Exposure, and Absorbed Dose; Bragg-Gray Cavity Theory; Spencer Attix Stopping Powers and Spencer Attix Cavity Theory; Burlin Cavity Theory of large and intermediate size cavity ionization Chamber.

Ionization Chambers: Well type, Cylindrical, Parallel-Plate, Effective Points of Measurement.

Factors affecting in dose measurement: Correction Factors, Calibration of Kilo-voltage Beam.

Dose measurement in air using a thimble ionization chamber and determination of N_{gas} calibration factor.

Calibration of Megavoltage Beams: N_{dair} and N_{dw} based Calibration of Photon beams and Electron beams; Dose calibration parameters; TRS 277 and TRS 398 for calibration of Photon and Electron Beam; TG-21 & TG-51 for calibration of Photon and Electron Beam, Calibration and dosimetry of small fieldsusing TRS 483.

Other Methods of Measuring Absorbed Dose: Calorimetry; Chemical Dosimetry; Solid State Detectors; TLDs; Diode detectors; FET detectors; Diamond detectors; Film Dosimetry - XV2 film, EDR2 film, Radio chromic film (TG-55, TG-235).

Quality assurance in radiation therapy – precision and accuracy in clinical dosimetry – quality assurance protocols for Deep X-ray Therapy machine, Telecobalt, medical linear accelerator of all types and radiotherapy simulators both conventional and CT-Simulator, High dose rate remo

SECOND YEAR – FOURTH SEMESTER

Paper – III
RADIATION PROTECTION AND RADIATION SAFETY

(45 Lectures)

Acute and Chronic effects of Whole Body Irradiation

Knowledge of various acute radiation syndromes and chronic effects of whole body irradiation.

Principles of Radiation Protection

Principles of radiation protection, time, distance, shielding. Quantities and units: Dose, radiation absorbed dose (RAD, Gray), radiation weighting factor, Relative biological effectiveness (RBE), Quality factors, Roentgen Equivalent man (REM), Sievert , equivalent dose , effective dose,

exposure at national and international levels, national control through acts with supporting regulation at central and state levels international control through specialized agencies, third party liability and insurance in the atomic energy field; ICRU and ICRP Recommendations on Dose

Duties and responsibilities of Radiation Safety Officer (RSO)

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 – Atomic Energy (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.

Practicals

1. Radiation Survey of Linear Accelerator to I tS)

General

Special Procedures

Stereotactic Radiosurgery: SRS Delivery Systems, Linac based, Gamma Knife, Robotic Linac, Simulation and immobilization/repositioning, SRS Dose prescription & treatment planning, Treatment calculations, SRS quality assurance

Image Guided Radiotherapy (IGRT)& 4D Gated Image Guided Radiotherapy: Cone beam computed tomography (MV CT and KV CT), Computed tomography Primatom, Tomotherapy, B – Mode Acquisition and Targeting (BAT) system, CyberKnife,Tomotherapy, Respiratory Gated Radiotherapy and Dynamic Adaptive Radiotherapy, Motion management, Performance testing and equipment QA.

Magnetic Resonance Imaging guided linear accelerators (MRIdian, ViewRay), Electronic brachytherapy

Particle Therapy:

Protons: Proton Beam Energy Deposition, Equipment for Proton Beam Therapy, Clinical Beam Dosimetry, Clinical Proton Beam Therapy, Treatment Planning, Treatment Delivery, Clinical Applications, Radiation therapy with neutrons, protons, light ions,Radiotherapy with beams of ^{12}C ions. comparison of ^{12}C beam with proton beam.

Neutrons: Fast Neutron Production, Basic Interactions, Accelerator Requirements, Clinical Beam Dosimetry, Treatment Planning, Treatment Delivery, Clinical Applications, Boron Neutron Capture therapy.

Heavy ion therapy.

Other Special Procedures

Photon Total Body Irradiation: Patient Set-up, Dosimetry, Selection of energy, field size, distance, MU calculations.

Total Skin Electron beam Therapy, Electron Arc.

Special Quality Assurance procedures:

Treatment planning systems(TRS 430), On Board Imager (KV/MV),Imaigng QA (CatPhan, Leeds Test tool), End to End Test, Winston Lutz Test, Patient Specific QA

General Quality assurance procedures for conventional, 3D-CRT and SBRT procedures (TG-40, TG-142).

Practicals

1. Brachytherapy dosimetry for single and double plane implants.
2. Patient specific QA for IMRT verification using EDR2 film
3. Intracavitary planning of carcinoma of cervix and dose prescription using treatment planning system
4. Dosimetry of Interstitial brachytherapy implants using treatment planning system
5. Calibration of Portal imaging system
6. Patient specific QA for IMRT verification using 2D array ion Chamber matrix
7. IMRT planning using treatment planning system.
8. CT simulation planning and execution of patient treatment.
9. Online and off line correction for patient setup using OBI

Additional Clinical Practicals to be carried out in the 2nd year of M.Sc. Medical Physics Course.

1. Production and attenuation of bremsstrahlung.
2. Range of beta particles by Feather analysis.
3. Backscattering of beta particles and its applications.
4. Statistics of radioactive counting.
5. Study of voltage and current characteristics of an ion-chamber.
6. Calibration of survey instruments and pocket dosimeters.
7. Construction and calibration of a G.M. Monitor.
8. Calibration of a therapy level dosimeter.
9. Calibration of TL phosphor & TLD reader and its use in dose distribution measurements.
10. 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.
11. Calibration of a TLD personnel monitoring badge and dose evaluation.
12. Characteristics of a flow counter and beta activity measurement.
13. Calibration of Gamma ray spectrometer and identification of unknown sources.
14. Quality assurance of a diagnostic x-ray machine.
15. Evaluation of characteristics of radiographic image.
16. Dose output measurement of photon (Co-60 , Gamma Rays and high energy X-rays) beams used in radiotherapy treatment.
17. Dose output measurement of electron beams used in radiotherapy treatment.
18. Determination of percentage depth dose of photon and electron beams.
19. Measurement of Dosimetric parameters (Beam Profile, Depth Dose Profile, TMR etc) using a Radiation Field Analyser (RFA).
20. Measurement of head scatter factors and phantom scatter factors using a Radiation Field Analyser (RFA).
21. Integrity check and calibration of low activity brachytherapy sources.
22. AKS/RAKR P tion of

THIRD YEAR SYLLABUS

Part – I: Core Components

1. Radiotherapy Equipment (treatment and imaging) and QA

Specifications, operation and use of telecobalt unit and its accessories such as wedges, breast cone, trays (if available), medical LINAC and its accessories (MLC, EPID, Electron applicators, etc), radiotherapy simulator and its accessories; remote after-loading brachytherapy equipment and its accessories (connectors, guide tubes, applicators, needles, etc), and radiotherapy treatment planning system (RTPS), Familiarization with networking and Record and Verify systems (if available).

Purchase document preparation, tendering and selection of equipments; Acceptance testing, commissioning measurements and Quality assurance (QA) of radiotherapy treatment and imaging equipments, maintenance of QA records.

2. Beam Calibration and Dosimetry

Dosimeters, phantoms and protocols (e.g. IAEA TRS 398/TG-51) for reference dosimetry; output measurements in reference conditions of telecobalt gamma ray beams, high energy x-ray and electron beams from medical LINACs; Familiarization with radiation field analyser (RFA); Measurements of relative dosimetry parameters and factors such as PDD,TPR, TMR, Scatter factors, Wedge factor, Tray transmission factor, electron applicator output factor; Measurement of beam profiles and evaluation of flatness, symmetry and beam penumbra. Uncertainty analysis and testing the authenticity of measured data; Verification of measured data by alternate techniques such as film dosimetry; Quality assurance and up-keeping of dosimetry systems.

3. External Beam Treatment Planning

Customization and creation of beam library in the RTPS; Capabilities and limitations of the RTPS, Forward and inverse planning - algorithms; Definition and localization of PTV, CTV, ITV, Organ at risks (OARs), Time and monitor unit calculations for simple treatments, time dose fractionation and gap correction; Steps of treatment planning and treatment planning procedures – patient data acquisition, contouring, immobilization, mould preparation; optimization and evaluation – DVH/ TCP/ NTCP; Planning of common treatment cases; Execution of treatment plans and supervision. Practice with conventional planning, 3D CRT, SRS/SRT, IMRT/IGRT; Acceptance testing and

6. Radiation Protection and Safety

Familiarization with regulatory requirements - safety codes and guides; Responsibilities and duties

Suggested Books:

Radiation Physics & Radiation Generators:

1. R.D. Evans, Atomic Nucleus
2. Preston M.A. Physics of Nucleus
3. Lapp R.E. Nuclear Radiation Physics
4. Segre E. Experimental Nuclear Physics
5. Slack L. Radiations from Radioactive Atoms
6. Oliver R. Radiation Physics in Radiology
7. Crouthamel C.E. Applied Gamma Rays Spectrometry.

Radiological Mathematics:

1. Hoffman. Numerical Methods for Engineers and Scientists – 2nd Edition Revised and Expanded, Marcel Dekker, Inc., 270 Madison Avenue , New York, NY 10016, Marcel Dekker AG, Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland.
2. A.C. Bajpai, I.M. Calcus and J.A. Fairley Numerical Methods for Engineers and Scientists – A student's course book, John Wiley & Sons.
3. Band W. Introduction to Mathematical Physics.
4.

Clinical and Radiation Biology:

1. Meschan. Normal Radiation Anatomy
2. Hollinshhead W.H. Text Book of Anatomy.

Medical Imaging:

1. Curry, T.S., Dowdey, J.E., Murry, R.C., (1990) Christensen's introduction to the physics of diagnostic radiology (4th ed.), Philadelphia : Lee &Febiger.
2. Bushberg, S.T., Seibert, J.A., Leidholt, E.M. & Boone, J.M. (1994) The essential physics of medical imaging, Baltimore : Williams & Wilkins.
3. Dendy, P.P & Heaton B. (2nd ed), Physics for diagnostic radiology, Bristol &Philadelphia : Institute of Physics Publishing.
4. Johns, H.E. & Cunningham, J.R (1983), The physics of radiology (4th ed), Springfield, IL : Charles C. Thomas
5. E. Seeram. X-ray imaging equipment, An Introduction (1985), Springfield , IL : Charles C. Thomas
6. Hendee, W.R. & Ritenour, R. (1993), Medical Imaging Physics (3rd ed), St. Louis : C.V. Mosbey.
7. Chesney , D.N. & Chesney, M.O., X-ray equipment for stuent radiographers (3rd ed).

Radiation Therapy

1. H.E. Johns and Cunningham. The Physics of Radiology.
2. Faiz M. Khan, The Physics of Radiation Therapy, Lippincott Williams & Wilkins, Philadelphia, 3rd edition, 2003.
3. Faiz M. Khan, Roger A. Potish, Treatment Planning in Radiation Oncology, Williams & Wilkins, Baltimore, 1998.
4. S. Webb. The physics of three dimensional radiation therapy, Institute of Physics publishing, Philadelphia, 1993.
5. S. Webb. The physics of conformal radiotherapy , Institute of Physics publishing Philadelphia, 1997.
6. S. Webb. Intensity Modulated radiation therapy, Institute of Physics publishing, Philadelphia, 2001.
7. S.K. Jani. CT simulation of radiotherapy, Medical Physics Publishing, Madison, WI, 1993.
8. J. Van Dyk. The Modern Technology of Radiation Oncology, Medical Physics Publishing, Madison, WI, 1999.
9. S.C. Klevenhagen Physics and dosimetry of therapy Electron beams, Medical Physics Publishing, Madison, WI, 1996.
10. Thomas Bortfeld . Rupert Schmidt – Ullrich, Wilfried De Neve. David E. Wazer (Editors). Image-Guided IMRT. Springer Berlin Heidelberg, 2006.
11. D. Baltas, L. Sakellious and N. Zamboglou. The Physics of Modern Brachytherapy for Oncology CRC Press, Taylor and Francis Group, 6000 Brooken Sound Parkway NW Suite 300, Boca Raton – FL 33487-2742.
12. S.H. Levitt, J.A. Purdy, C.A. Perez and S. Vijayakumar (Editors). Technical Basis of Radiation Therapy Practical Clinical Applications – 4th Revised Edition, Springer Berlin Heidelberg New York.

Radiation Safety

1. Herman Camber. Introduction to Health Physics
2. Atomic Energy Act 1962
3. AERB Radiation Protection Rules 2004
4. ICRP 1990 Recommendations
5. ICRP 2007 Recommendations
6. IAEA Basic Safety Standards 115, 1997
7. Shapiro J. Radiation Protection
8. Mckenzie. Radiation Protection in Radiotherapy
9. Mawson C.A. Management of Radioactive Wastes

****