FACULTY OF SCIENCE

SYLLABI

FOR

M.Sc. MEDICAL PHYSICS

1\textsuperscript{st} to 4\textsuperscript{th} SEMESTER

EXAMINATION 2011-2012
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

The postgraduate training program is aimed at developing skilled technical manpower in Medical Physics. They should be able to demonstrate high standards of professional skills, competence/leadership qualities.

Duration of Course

Total Duration= 3 years
(2 Academic Years + 1 year internship in the radiotherapy department of PGIMER, Chandigarh)

No. of Seats

General seats = 8
NRI = 02
Total seats/year = 10

Admission Criteria:

Eligibility/Qualification

Admission to M.Sc. Course in Medical Physics will be B.Sc. First class with Physics as one of the core subjects from a recognized University.

Admission

Admission to M.Sc. course in Medical Physics will be through Entrance Test, to be conducted by the Panjab University. The candidates should have passed the graduation (BSc) from a recognized university/institute with at least 60% marks. While deciding the final merit of the entrance test, a weightage shall also be given to the B.Sc marks obtained by the candidate, as per the university rules. The cut off percentage marks secured in the entrance test will also be as per the University rules.

Syllabus

The broad outlines of the course are annexed and had been prepared keeping in view the guidelines/requirements of AERB, BARC, Mumbai.
Teaching and Training
The Panjab University departments (Departments of Biophysics & Physics) and the Department of Radiotherapy of PGIMER shall impart the teaching and training to the students jointly. However, few other departments of these Institutes may also be involved in this teaching programme.

First year of the teaching/training will be mainly in the Panjab University in the Departments of Biophysics & Physics under the Institute for Emerging Areas in Science and Technology.

Second year of the teaching and the clinical training shall be mainly in the Department of Radiotherapy at PGIMER, Chandigarh.

Academic training alone does not make a medical physicist. In addition, a certification from the BNRS (for the Radiation Safety Officer) to the students is required for the competence in the handling of the patients care and running the radiation facilities independently.

Dissertation
Every student shall be allotted a project under a supervisor in the beginning of the third year.

Assessment and Evaluation
In addition to regular internal assessment, theory and practical examinations will be held at the end of first and second semesters of each year.

Award of M.Sc. Degree
The candidates shall have to obtain a minimum of 50% marks in aggregate in theory and 50% marks in aggregate in practicals after each academic session, failing which, the candidate shall be reverted back and shall be awarded M.Sc degree in Medical Physics after fulfilling the conditions. The Panjab University, Chandigarh shall award the final degree.
FIRST YEAR

First Semester

Theory = 300 Marks (3 Papers of 100 marks)
Practicals = 150 Marks (3 Practicals of 50 marks each)
Total Marks = 450 Marks

A. Theory Papers

1. Anatomy . 100 Marks
2. Applied Mathematics, Biostatistics and Computer Applications. 100 Marks
3. Radiation Physics. 100 Marks
Total = 300 Marks

B. Practicals

1. Anatomy 50 Marks
2. Applied Mathematics, Biostatistics and Computer Applications. 50 Marks
3. Radiation physics. 50 Marks
Total = 150 Marks

Second Semester

Theory = 300 Marks (3 Papers of 100 marks each)
Practicals = 150 Marks (3 Practicals of 50 marks each)
Total Marks = 450 Marks

A. Theory Papers

1. Fundamentals of Electronics and Biomedical instrumentation. 100 Marks
2. Radiation Detection and Measurements. 100 Marks
3. Radiation Biology and Radioisotopes applications. 100 Marks
Total = 300 Marks

B. Practicals

1. Fundamentals of Electronics and biomedical instrumentation. 50 Marks
2. Radiation Detection and Measurements. 50 Marks
3. Radiation Biology and Radioisotopes applications. 50 Marks
Total = 150 Marks
SECOND YEAR

Third Semester

Theory = 300 Marks (3 Papers of 100 marks each)
Practicals = 150 Marks
Total = 450 Marks

A. Theory Papers
   1. Radiotherapy & Imaging Equipment & Quality Assurance. 100 Marks
   2. Radiation Dosimetry & Standardization. 100 Marks
   3. Radiation Safety. 100 Marks
   Total = 300 Marks

B. Practicals
   1. Radiotherapy & Imaging Equipment & Quality Assurance. 50 Marks
   2. Radiation Dosimetry & Standardization. 50 Marks
   3. Radiation Safety. 50 Marks
   Total = 150 Marks

Fourth Semester

Theory = 300 Marks (3 Papers of 100 marks each)
Practicals = 150 Marks
Total = 450 Marks

A. Theory Papers
   1. Radiation Therapy – Teletherapy Treatment Planning. 100 Marks
   2. Radiation Therapy – Brachytherapy Treatment Planning. 100 Marks
   3. Recent advances in treatment planning. 100 Marks
   Total = 300 Marks

B. Practicals
   1. Radiation Therapy – Teletherapy Treatment Planning. 50 Marks
   2. Radiation Therapy – Brachytherapy Treatment Planning. 50 Marks
   3. Recent advances in treatment planning. 50 Marks
   Total = 150 Marks

THIRD YEAR

Total 300 marks

A. Internship, dissertation & viva 300 marks

Instruction for the Examiners:

There shall be 12 short-answer type questions in each paper, and the students have to attempt 10 questions. Each paper shall be of three hours duration.
SEMESTER I

Paper – I : ANATOMY (50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

GROSS ANATOMY (32 LECTURES)

Anatomy and Imaging: Anatomical planes, diagnostic imaging techniques.

BACK: Component parts (bones, muscles, vertebral canal, spinal nerves, dermatomes), regional anatomy (vertebrae, joints, ligaments, musculature), Back surface anatomy.

THORAX: Component parts (thoracic wall, thoracic aperture, diaphragm, mediastinum, pleural cavities, thorax surface anatomy.

ABDOMEN: Component parts (wall, abdominal cavity, inferior thoracic aperture, diaphragm, pelvic inlet, surface anatomy, defining surface projection, kidney and spleen position.

PELVIS: component parts (Pelvic inlet, pelvic walls, pelvic outlet, pelvic floor, pelvic floor, pelvic cavity and perineum).

LOWER AND UPPER LIMBS: Component parts (bones and joints, muscles)

HEAD and NECK: Component parts (skull, cervical vertebrae, hyoid bone, soft palate and muscles in the head and neck.

MICROSCOPIC ANATOMY (10 Lectures)

Basic tissue: Epithelial tissue-electron microscopic structure and various structural modifications.
Connective tissue: Blood and its formed elements, loose connective tissue, extracellular components, fixed cellular elements.
Muscle: Structural and molecular organization of muscle and mechanism of muscle contraction.
Nervous tissue: Neurons, neuroglial cells and nerve fibre. Mechanism of myelination and synapse

INTRODUCTORY CYTOLOGY & BIOLOGY OF CANCER (8 Lectures)

Cell: Cell wall and cell membrane, Structure and functions of Endoplasmic reticulum (ER), mitochondria, golgi complex, nucleus, lysosomes.
Brief introduction of structure and function of carbohydrates, proteins /enzymes, nucleic acids, lipids.
Cell signaling, glycolytic and TCA cycles.
Classification, nomenclature and definition of neoplasms. Transformed cells and cell lines, cancer cells differentiation, alterations in cancer cell behavior, diminished contact inhibition and defects in cell to cell metastasis.

Books:
5. De Robertis : Cell and Molecular Biology, 8th ed. (BI Publication)
6. R.L. Drake, Vogl & Mitchell : Gray’s Anatomy for students (Elsevier)
Practicals

1. To identify different parts of a human skeleton
2. To identify types of epithelial tissue: (squamous, stratified, pseudostratified) systems using light microscope.
3. To visualise microanatomical view of musculoskeletal system using light microscope.
4. To visualise microanatomical view of Respiratory system (Larynx, pharynx, trachea, principal bronchi, lungs) systems using light microscope.
5. To visualise microanatomical view of Digestive system (esophagus, stomach, small and large intestine, rectum)
7. To visualise microanatomical view of Reproductive system of male: Testes, Ductes deferens, Seminal vesicle, prostrate using light microscope.
8. To visualise microanatomical view of Reproductive system of female: Ovary, fallopian tube, uterus using light microscope.
10. To make block and cut section of the embedded tissue with the help of microtome and finally make a slide. To stain the sectioned tissue and prepare a permanent slide after H/E staining.
11. To determine TLC, red blood cell counts using hemocytometer
12. To study DLC in blood smear.
14. Estimation of activities of enzymes viz alakaline phoshatase, Acid phophatase, SGOT and SGPT

Paper – II: APPLIED MATHEMATICS, BIOSTATISTICS AND COMPUTER APPLICATIONS (50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Numerical Methods: (15 Lectures)

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, Newton Raphson method.

Taylor series, approximating the derivation, numerical differentiation formulas. introduction to numerical quadrature, Trapezodial rule, Simpson’s rule, Simpson’s three-eighth rule, Boole rule, Weddle rule. Initial value problems, Picard’s method, Taylor’s methods, Euler’s method, the modified Euler’s method, Runge-Kutta method.

Monte Carlo : Random variables, discrete random variables, continuous random variables, probability density function, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, law of large number, central limit theorem, random
numbers and their generation, tests for randomness, inversion random sampling technique including worked examples, integration of simple 1-D integrals including worked examples.

**Probability, statistics and errors (20 Lectures)**

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

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

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

Binomial distribution, Poisson distribution, Gaussian distribution, exponential distribution-additive property of normal variates, confidence limits, bivariate distribution, correlation and regression, chi-square distribution, t-distribution, F-distribution.

**Counting and medical statistics (8 Lectures)**

Statistics of nuclear counting-application of Poisson statistic- 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 consideration 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.

**Computational Tools & Techniques: (7 Lectures)**

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

**Books:**

5. F.E. Croxton : Elementary Statistics with Applications in Medicine and the Biological Sciences (Dover Publications).
8. Deitel & Deitel : C++ How to Program (Prentice Hall of India).
Practicals

1. To demonstrate the use of C++ for scientific applications.
2. To study various Basic Linux commands for scientific applications.
3. To study structural and conformational characteristics of various bio-molecules using molecular modeling.
4. Demonstration of SPSS statistical software.
5. Demonstration of Matlab statistical software.
6. Demonstration in Excel and Power point.

Paper – III: RADIATION PHYSICS (50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Radiation Physics (25 Lectures)

Time varying fields and Maxwell’s equations, potential function, electromagnetic boundary conditions, wave equations and their solutions, time harmonic fields. Plane electromagnetic waves: plane waves in lossless media, plane waves in lossy media, group velocity, flow of electromagnetic power and the Poynting vector, normal incidence at a plane conducting boundary, oblique incidence at a plane dielectric boundary. Wave guides and cavity resonators: general wave behaviour along uniform guiding structures, parallel-plate wave guide, rectangular and circular wave guides, dielectric wave guides, cavity resonators.

Radioactivity and decay laws: Types of radiation (a, β, γ, n, X-ray), decay modes, probability and decay constant, physical half life, mean life. Natural radioactivity & decay series, secular equilibrium, artificial radioactivity, beta particle spectrum, internal conversion, general aspects of gamma decay, gamma energy decay, Nuclear isomerism.

Nuclear reactions: nuclear reaction, cross-section, conservation laws, artificial transmutation, discovery of neutron, neutron classification, neutron sources, neutron activation, nuclear fission, fission products, fissile materials, diffusion and slowing down of neutrons, various types of reactors - fusion and thermo nuclear reactions.

Radiation generators (12 Lectures)


Interactions of x and γ rays with matter: (8 lectures)

Scattering vs absorption: coherent scattering, photoelectric effect, Compton effect, pair production, annihilation radiation, photonuclear disintegration. Total and true absorption coefficients, attenuation
of photon beams: attenuation, energy transfer, and energy absorption, exponential attenuation equation, attenuation coefficients, half-value layer, beam geometry.

Interactions of particulate radiation: Directly and indirectly ionizing particles, Elastic and inelastic collisions with orbital electrons and the nucleus, linear energy transfer, specific ionization, mass stopping power, range.

**Radiation Units (5 Lectures)**

Units of radioactivity: Becquerel, Curie, specific activity, carrier free activity, Quantities and units: Dose, Roentgen unit of exposure, radiation sensitivity of biological materials, radiation absorbed dose (RAD, Gray), radiation weighting factor , Relative biological effectiveness (RBE), Quality factors, Roentgen Equivalent man (REM), Sievert , equivalent dose, effective dose, collective equivalent dose, total effective dose equivalent.

**Books:**

2. I. Kaplan : Nuclear Physics (Narosa Pbl. House)
3. R.E. Lapp : Nuclear Radiation Physics (Prentice Hall)
4. L. Slack & K. Way : Radiations from Radioactive Atoms (Govt. Print. Off.).
5. R. Oliver : Radiation Physics in Radiology (Springer).

**Practicals:**

1. To measure Half Value Layer's of β and γ emitters and determine linear mass absorption coefficients.
2. To study the factors producing background counts.
3. To study self absorption using beta emitting radioisotopes.
4. To study the back scatter of beta particle.
5. To study the absorption of radiation by solvents and to determine the counting errors originating from sample geometry.
6. To study how to avoid certain errors in handling carrier free solutions.
7. To determine absorption coefficients of biological tissues with β and γ radioactive sources of different energies.
8. To study the change in activity of a sample consisting of two independently decaying radioisotopes.
9. To study the statistics of radioisotopic measurements and observe the effect of background on the counting statistics.
10. To determine the half lives of radioactive isotopes
SEMESTER -II

Paper – I: FUNDAMENTALS OF ELECTRONICS AND BIOMEDICAL INSTRUMENTATION

(50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Semiconductor devices (10 Lecturers)
Intrinsic and extrinsic semiconductors, n-type and p-type semiconductors, pn-junction properties forward and reversed bias, Zener diode, photo diode, PNP and NPN junction transistors, transistor current components, CB, CE and CC configurations, field effect transistor (FET), metal oxide filed effect transistor (MOFET). Simple ideas on operational amplifier, OPAMP, their characteristics and applications.

Digital Circuit System (8 Lectures)
Boolean algebra and logic gates: OR, AND, NOT, NOR, NAND and EXOR gates and their truth table flip-flops, shift registers, counters, decoders and encoders, analog to digital converter and digital to analog converters. Microprocessors and associated peripherals, power supplies-regulated power supplies using IC’S, AC-DC converter and RF power supplies, switching mode power supplies, AC regulators.

Electric accessories for X-ray tubes (5 Lectures)
Filament and high voltage transformers, high voltage circuits, 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 intensifier and close circuit TV System, modern trends.

Radiography (7 Lectures)
High–voltage radiography, low voltage radiography, contrast media, radiographic grids, magnification radiography, digital radiography.
Single crystal scintillation camera, scintillation camera operation, multiple-crystal scintillation camera, tomography, computed tomography, reconstruction algorithm, scan motions, SPECT & PET.

Nuclear Magnetic Resonance and MRI (10 Lectures)
Angular momentum of the nucleus, Magnetism and the Magnetic Dipole, Moment, MDM in a magnetic field, MDM for Rotating Charges, Larmor Frequency, Energy States for Nuclear Spin Systems. NMR parameters, Magnetization Vector, RF Field, the rotating coordinate system, Free induction decay, T1 and T2 relaxation, Mechanisms for relaxation, spin-Echo Techniques, Use of Fourier Transforms. Instrumentation -NMR System. Magnetic resonance as probe of the body-MRI, Gradient magnetic fields, Slice Selection, Phase Encoding, Frequency Encoding; Safety Considerations, Recent Developments, Functional MRI.

Biomedical Ultrasound & Medical Laser (8 Lectures)
Ultra sound generators, properties of ultrasound waves and its propagation in biological tissues, pulse echo techniques, Doppler principle, ultrasound motion senses, dynamics of blood flow, physiological effects of ultrasound in therapy. Adverse effects of ultrasound waves.
Introduction to laser, principle of operation of laser, laser tissue interaction, different types of LASER. Attenuation of LASER in medicine, adverse effects of LASER.

Fiber optic scopes (2 lectures)
Snell’s law, total internal reflection, fiber optics as waveguides, image conduits made with fiber optics. Medical fiber optic scopes: their construction, fiber size, image resolution, coherent versus incoherent bundles, use of CCD cameras.
Books:


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.
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

Paper – II: RADIATION DETECTION & MEASUREMENTS (50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Interaction of charged particle with matter: (5 lectures)
Absorption process, scattering ionization and excitation, Bethe’s equation, radiation energy loss (bremsstrahlung), range of beta particles, backscatter and self absorption, Cerenkov radiation. Interaction of alpha particles, heavy nuclei and fission fragments with matter: Energy loss by collision, range-energy relation and Bragg curve, specific ionization, stopping power.

Interaction of neutrons with matter: (4 lectures)
Neutron capture, elastic scattering, energy transfer and logarithmic energy decrement, inelastic scattering, dependence on E and Z, (n, p), (n, x), (n, y) and other reactions, neutron activation.

Gas filled detectors (5 Lectures)
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- design and characteristics. Geiger-Mueller counters – design consideration, dead time and recovery time, operation.

Scintillation detectors-Organic and Inorganic scintillation detectors (6 Lectures)
Scintillation detector principles- light collection and mounting, scintillation characteristics- light output, decay time, photo peaks, Compton valley, edge and plateau, backscatter peak, iodine escape peak, annihilation peak. Liquid scintillation counters: composition of liquid scintillator (scintillation
cocktail): primary solute, secondary, solute and organic solvent (toluene, 1, 4 dioxane, anthracene) and solubilizing agents for tissues, coincidence circuits and display. Quenching and quench correction methods: Internal standard method, external standard method and channel ratio.

**General systems for operation and detection (10 lectures)**
- Neutron detectors: Basic principles and applications.
- Well counter – Geometry factor, dual radionuclide counting.
- Radiation calorimetry, photographic dosimetry. Chemical dosimetry: salient feature of chemical dosimeters. Spectrophotometry: Beer-Lambart's Law, definition of transmittance and absorbance (optical density), molar absorption and coefficient, Fricko dosimeter, FBX dosimeter, ceric, sulphate dosimeter, Low dose level dosimeters (aqueous benzoic acid, terephthalic acid, aqueous trimesic acid); High dose level dosimeters (red perspex HX, polyvinyl chloride, radio chromic dye and cellulose triacetate films).

**Thermo luminescent Dosimeters & Autoradiography (8 Lectures)**
- Physics of TLD, characteristics TLD phosphors, glow curves, dose and energy response, sensitivity and application in-dosimetry and personnel monitoring devices.
- Use of photographic emulsions stripping film technique, dipping method, grain density counting and track counting, X-ray films, intensifying screens, fluoroscopy.

**Semiconductor detectors (4 Lectures)**
- Semiconductors junction and surface barrier detectors, high purity germanium detectors, their response and, characteristics.

**Instruments for counting, gamma ray spectrometry (5 lectures)**
- PM tubes, preamplifiers, amplifiers, pulse height analyzers, coincidence & anti coincidence circuits, TPHC, MCA, scalers and timers, high voltage supply, gamma ray spectrometry.

**Whole body counting studies (3 Lectures)**
- Whole body counting: principles of whole body counting, design of whole body counting system, stationary systems, single and multiple crystal systems, chair geometry, moving systems, calibration of whole body system, clinical and other applications of whole body counters.

**Books:**
2. W.R. Leo : Techniques for Nuclear and Particle Physics experiments (Narosa).

**Practicals**
1. To prepare FBX dosimeter and check its linearity with different radiation exposures.
2. To estimate the radiation dose absorbed by different organs by using FBX dosimeter.
3. To determine the energy resolution of spectrometer and effect of scatter in source volume
4. To learn the mode of operation of a scintillation counter and its operating characteristics.
5. To identify unknown radionuclide on the basis of its principal energy by using scintillation counter
6. To determine the radiation response of thermo luminescent dosimeter (TLD)
7. To find out the spectrum of energies emitted by a radioisotope by using gamma ray – spectrometer.
8. Gamma ray spectrometry with a single channel analyzer.
9. Effect of EHT and gain on spectrometer using a mixture of two radionuclides.
10. Demonstration of liquid scintillation counter.
11. To determine the plateau of GM tube and find out the dead time/ resolving time of GM counter.
12. To determine the efficiency of GM counter and find out the strength of the unknown radioactive source.
13. To demonstrate how well type gamma ray spectrometer can be used as a whole body counters for small animals.
14. To demonstrate the retention of activity in organ of interest or whole body by using scintillation counter and whole body counter.

Paper – III: RADIATION BIOLOGY AND RADIOISOTOPE APPLICATIONS (50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Radiation Chemistry (4 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.

Radiation Biology (12 Lectures)
Radiation effects on Cell: membrane, energy metabolism, synthetic processes, chromosomes, chromosomal type aberrations, 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 proteins, nucleic acids, carbohydrates, lipids, polymerases, transferases, isomerases and anti-oxidative enzymes.
Radiation effects on microorganisms and independent cell systems: target Theory, multitarget theory, target size, multihit theory, multitarget multihit theory.
Differential cell sensitivity: Criteria of sensitivity, factors affecting sensitivity, average interphase chromosomal volume, ploidy, nuclear factors, cytoplasmic factors, categories of mammalian cell sensitivity, specific classifications of mammalian cell sensitivity.

Radiation Effects (10 Lectures)
Radiation effects on major organ systems: Hematopoietic system, vascular system, digestive system, respiratory system, urinary system, nervous system, reproductive system, endocrine system and immune system.
Modification of radiation injury: Physical modifications of radiation injury, relative biological effectiveness, linear energy transfer, dose rate effect, chronic irradiation, biological factors influencing radiation response, age, diet, genetic constitution, oxygen concentration, temperature etc.
Acute radiation effects: Lethality, acute radiation syndrome in mammals, effects of prenatal development, radiation effects on regeneration.
Bio-medical applications of radionuclides (20 Lectures)

Thyroid radioactive uptake measurements: Tracer dose, use of carrier, standard and phantom, shielding and collimation, factors affecting thyroidal radioactive iodine uptake, PBI-131, thyroid stimulation test, thyroid clearance rate thyroid suppression test, perchlorate discharge test, uptake of radiolabel T3 by red cells, T3 charcoal test. Introduction to treatment of hyperthyroidism and thyroid carcinoma.

$^{125}$I applications: Radio-immuno assays of T3, T4, TSH and other hormones, uptake by thyroid and treatment of thyroid disorders

$^{51}$Cr labeling with red blood cells: applications in blood volume measurement, spleen uptake, red cell survival studies, red cell volume, proteins turn over.

$^{59}$Fe absorption studies. $^{59}$Fe turn over studies, plasma iron clearance

$^{58}$Co/$^{57}$Co: Applications in schelling’s test of vitamin B12 absorption, double tracer technique and whole body counting

$^{60}$Co: Treatment of different carcinomas, gamma knife

$^{32}$P applications in polycythemia vera and leukemia

$^{99m}$Tc applications in medical imaging of different organs and dynamic/function studies.

$^{14}$C applications in urea breathe test, whole body counting, $^{14}$C Glycologholic breath test, palmitic acid, Radio-respirometry, in vitro uptake studies using $^{14}$C glucose, $^{14}$C amino acids and $^3$H thymidine

$^{45}$Ca, $^{65}$Zn and $^3$H metabolic studies and other biomedical applications.

Radioactive decontamination and waste disposal: (4 lectures)

Radioactive decontamination of labs, clothes, hands, glassware, gloves, metals, plastics, paints and bricks, decontamination of person, decontamination of room Radioisotopic waste, general principles, liquid and solid waste, storage and transport of waste, disposal of solid, liquid and gaseous effluents/waste, decaying storage transfer to authorized personal, management of sealed and unsealed sources.

Books:

1. P.A. Casserette : Radiation Biology (Prentice Hall)

Practicals

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.
SEMESTER -III

Paper – I:  Radiotherapy & Imaging Equipment & Quality Assurance (Total lectures 70)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

RADIOThERAPY EQUIPMENTS

Radiation sources (7 Lectures)

Artificial Radioactive Sources: large scale production of isotopes, reactor produced isotopes, cyclotron produced isotopes, fission products, containers for sources, self shielding, gamma ray sources for medical and industrial uses, telegamma sources, radium needles, tubes and plaques, cobalt needles and gold seeds, tantalum wire, beta ray applicators, thermal and fast neutron sources; preparation of tracers and labeled compounds, Preparation of radio colloids;

Use of radium, Co-60, Ir-192, Cs-137, Ta-82 and Au-198, Iodine-125, Palladium-103 for surface, interstitial and intracavitary applications; radium implants, treatment with Sr-90, P-32 and other beta applicators.

Teletherapy Equipment (15 Lectures)

Orthovoltage X rays, Therapeutic x-ray (<300 kVp) construction and working, High Energy gamma rays, Cs Teletherapy,
Cobalt Teletherapy Machine – principle constructions and working of Cobalt 60 Teletherapy.

High Energy X rays, Linear Accelerator: Energy considerations; Working principle and construction; Operational theory of wave guides, Bending magnet systems, Photon beam Delivery, Electron beam delivery, Beam energy, Monitor chamber, Linac collimation systems - Primary and secondary collimators, Multileaf collimators, Other collimation systems, Radiation and light fields (including field size definition).

Simulators: Mechanical and Radiographic Operation, Fluoroscopy and Intensifiers, CT, Simulation Machinery, CT Simulation Operation.

Proton Beam and heavy charge particle accelerating machine: Production of high energy particle with cascade, Van-de-Graff generators, Cyclotrons, Betatron, Proton Synchrotrons

Brachytherapy Equipment (8 Lectures)

Radium needle, tubes, Preloaded and after loading Manual Cs needle/tubes LDR.
Remote after loading LDR machine – Construction and working principles.

Micro Selectron HDR –Construction and working principles, Micro Selectron PDR – Construction and working principles.

Temporary Implant sources – eye applicator, Permanent Implant sources, Endovascular Brachytherapy in cardiology.

Nuclear Medicine (12 Lectures)

Physics of Nuclear Medicine: Radioisotopes in medical diagnosis; scintillation counters, properties of radioisotopes; units of dosage, specific activity; effective half-life; diagnostic use of radioisotope in vivo and in vitro procedures
Rectilinear Scanners and Gamma Cameras: Single head scanners, design criteria, resolution, sensitivity measurements, linearity, Multiple Window spatial resolution, Uniformity, Energy resolution, choice of collimators, Dual head scanners; Gamma cameras: Anger type camera, Single and Dual Head Camera, resolution sensitivity measurements, collimators, comparison between Gamma cameras and scanners, quality control in instrumentation

Use of I-131 for diagnosis of hypo and hyper thyroidism, blood volume studies using RIHSA and Cr-51; Red cell survival studies using Cr-51; studies of iron metabolism, diagnostic test using Vitamin B-12 labeled with radio cobalt; circulation studies with Na-24, cardio vascular studies, tumour localization;

Bone scanning, principle, agents for bone scanning, Mo99, Tc99m, indications for bone scanning, various agents for one scanning, interpretation, pitfalls in bone scanning, limitations, radiopharmaceuticals used for brain scanning, technique with technetium per technetate, the normal clinical applications, radiopharmaceuticals in liver scanning comparison, technique with 99m Tc, Sulphur scans, pitfalls, clinical applications; Ga in Clinical Studies: Energy spectrum of 67Ga optimization of parameters for 67Ga scanning. Clinical applications

Display Systems: Criteria for evaluation of radioisotope imaging systems in terms of concentration ratios, Radioisotope systems comparison between black and white and color displays, observers visual response curves and determination of detection contracts, ROC curves

Dynamic Studies using Radioisotopes: Saturation; analysis; dynamic methods, activation analysis, models of body compartments, deconvolution techniques, the occupancy principle etc


**PET and PET/CT (5 Lectures)**

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

**Imaging Equipments (Diagnostic)**

**X-Ray Technology: (8 Lectures)**


**Computer Tomography (5 Lectures)**
Principles of Computer Tomography, Basic principles of data accumulation, storage, image reconstruction and display, CT numbers, different generations of CT machines, reasons for higher contrast and resolution, various scan configurations, modern developments like Cone Beam CT, Spiral CT, 3D reconstruction; Characteristics at X-ray tubes in CT units, Detectors and detector configurations in various generations, Mathematics of image reconstruction and display, algorithms for imaging reconstruction, back projection, interactive methods, analytical methods; Characteristics of image display systems, image quality, quantum mottle, Resolution – Spatial and contrast resolution, Artifacts – Motion artifacts – Streak Artifacts – Beam-hardening Artifacts – Ring Artifacts;

**Ultrasound (5 Lectures)**

**Nuclear Magnetic Resonance and MRI (5 Lectures)**
Angular momentum of the nucleus, electro angular momentum, orbital angular momentum, Magnetism and the Magnetic Dipole, Moment, MDM in a magnetic field, MDM for Rotating Charges, Angular Momentum and Precession, Larmor Frequency, Energy States for Nuclear Spin Systems. NMR parameters, Magnetization Vector, RF Field, the rotating coordinate system, Free induction decay, T1 and T2 relaxation, Mechanisms for relaxation, spin-Echo Techniques, Use of Fourier Transforms. Instrumentation, Magnets, Resistive Coil Air Core Magnets, Superconducting Magnets, RF Coils, Study of NMR spectrum and schematic arrangement for a nonimaging NMR System. Principles of MRI, Gradient Coils, Slice Selection, Phase Encoding, Frequency Encoding; The Spin Echo Imaging Sequence, Image Reconstruction; Multi Slice Imaging; Multi Echo Imaging, Contrast Enhancement, T1 and T2 Weighted Images, Signal to Noise Ratio; Safety Considerations, Recent Developments, Functional MRI.
Books:

15. A.L. Baert and K. Sartor: Diagnostic Nuclear Medicine, 2nd ed.; (Springer).
19. J.F. Fowler: Nuclear Particles in Cancer Treatment (Adam Hilger Ltd.)

Practicals:

1. Q. A. testing of a diagnostic X-ray unit.
4. Measurement of KVp, mAS, Timer of an X-ray Unit.
5. Q. A. testing of CT machine.
6. To perform Quality Control of Planar Gamma Camera, Flood field for Scintigraphy.
7. To demonstrate the Quality Control of SPECT System.
8. To study iso-response curves of different collimators of a Gamma Camera.
9. Dark room practicals e.g. preparation of Developer and Fixer and X-ray film development, fixation and washing.
10. Q.A of an ultrasound machine.
11. QA of an MRI machine.
Paper – II : Radiation Dosimetry & Standardization (Lectures 50)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Radiation Beam Quality and Dose (15 Lectures)

Monoenergetic and Heteroenergetic bremsstrahlung beams: Energy spectra for bremsstrahlung beams; Effects of electron energy, filtration, beam geometry; Homogeneity coefficient; Effective energy; Clinical indices for megavoltage beams (e.g., PDD at reference depth)

Dose quantities and units: Kerma; Exposure; Absorbed dose; Dose equivalent; RBE dose; Calculation of absorbed dose from exposure Bragg-Gray cavity theory.

Principles of Radiation Detection:


Radiation Measurement and Calibration (15 Lectures)

Dose and Relationships: Radiation Absorbed Dose - definition and units; Relationship between Kerma, Exposure, and Absorbed Dose; Bragg-Gray Cavity Theory; Stopping Powers.

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

Factors affecting in dose measurement: Correction Factors, Calibration of Kilovoltage Beam.


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.


Radiation Measuring & Monitoring Instruments: (20 Lectures)


Books:
1. Joseph Magill and Jean Galy : Radioactivity, Radionuclides & Radiation (European Commission Joint Research Centre).
2. IAEA TRS 374 : Calibration of Dosimeters used in Radiation Therapy.

Practicals
1. Gamma ray spectrometry with a single channel analyzer
2. Effect of EHT and gain on spectrometer using a mixture of two radionuclides
3. Study of energy dependence of a pocket dosimeter and a survey meter
4. Liquid scintillation counting
5. Thermo luminescent Dosimeter
6. Autoradiography
7. To demonstrate the principles of liquid scintillation counting and the measure the activities of $^{14}$C and $^3$H by using liquid scintillation counter.
8. To find out the spectrum of energies emitted by a radioisotope by using gamma ray spectrometer.
9. To identify unknown radionuclide on the basis of its principal energy by using scintillation counter.
10. To prepare FBX dosimeter and check its linearity with different radiation exposures.
11. To estimate the radiation dose absorbed by different organs by using FBX dosimeter.
12. To determine the energy resolution of spectrometer and effect of scatter in source volume
13. To determine the plateau of GM tube and find out the dead time/resolving time of GM counter.
14. To determine the efficiency of GM counter and find out the strength of the unknown radioactive source.
15. To measure the absorption coefficients of different materials with gamma rays and beta particles.
16. To learn the mode of operation of a scintillation counter and its operating characteristics.
Paper – III: Radiation Safety

RADIATION PROTECTION STANDARDS (70 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Acute and Chronic effects of Whole Body Irradiation (5 Lectures)

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

Principles of Radiation Protection (15 Lectures)

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, collective equivalent dose, total effective dose equivalent, radiation dose limits, maximum permissible doses- (IRCP recommendations). Basis for exposure limits for occupational exposure, ALARA, exposure of embryo /fetus younger persons, occupational exposures, members of the public, risks associated with recommended limits. Design of radiation labs, types of labs, security of sources and radioactive cautions signs and labels. Dos and Don'ts in radiation protection practice. Personal monitoring film badges, TLD badge, use of survey meters and dose calibrators, use of dose constraints for staff and pregnant women.

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 departments and teletherapy departments and radioisotope laboratories – Particle accelerators protective equipment – handling of patients – waste disposal facilities – radiation safety during source transfer operations special safety features in accelerators, reactors.

Radioactive decontamination and waste disposal (5 Lectures)

Radiation decontamination of labs, clothes, hands, glassware, gloves, metals, plastics, paints and bricks. Radioisotopic waste disposal of solid, liquid and gaseous effluents/ waste, decaying storage transfer to authorized personal, management of sealed sources, quality management program, misadministration of radiopharmaceuticals, release of patients administered with radiopharmaceuticals.


Disposal of radioactive wastes – General methods of disposal, management of radioactive waste in medical, industrial, agriculture and research establishments.

Regulatory Aspects & Licensing (8 Lectures)

The Atomic Energy Act, Rules issued under the Act, Surveillance procedures issued under the Rules, Notifications issued under RPR, 1971, AERB Safety Directive, Safety code for Radiotherapy, radiodiagnosis and NM facility, Duties of Medical physicist/ Technologists/ Radiopharmacists /RSO, Regulatory clearance-Approval of Radiotherapy, Radiodiagnosis and NM Lab, Physician & RSO, Regulatory consent, authorisation- for disposal of radioactive waste and safe transport of Radioactive materials. Ethics, registration of radiopharmaceuticals and their use. Historical background of legislation in the atomic energy field, need for control of radiation 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 Limits, Protection Regulations, Basic

**Planning & Design of Radiation Centers & Radiotherapy Equipment Rooms (10 Lectures)**

Design and safety aspects of planning a Nuclear medicine department, radiotherapy department, cyclotron facility and PET centre. Planning of medical radiation installation, both therapeutic and diagnostic, which includes construction of room for cobalt, linear accelerator, high dose rate brachytherapy machine, simulator and CT simulator.

General considerations, design of diagnostic, telegamma, accelerator installations, brachytherapy facilities and medical radioisotope laboratories; Step one: - Design dose in occupied areas (annual dose and weekly dose), Step two - Calculation of the radiation field (air kerma) in the occupied area without shielding, Step three - Attenuation by shielding barriers Teletherapy Installation: Workload, Use factor, Occupancy factor, Distance, Calculation of the primary transmission factor, Calculation of the scatter barrier transmission factor, Calculation of the leakage barrier transmission factor, Determination of barrier thickness, Consideration of neutron production in a high energy linac, Door of a linac room, Other considerations under AERB radiation safety protocol. Shielding thickness calculation under AERB radiation safety code and federal code of regulation 10 CFR20 in uptake room, imaging room, PET tomography from ambient radiation level and cyclotron.

**Potential Exposure and Emergency Plans: (5 Lectures)**

Potential exposure and safety assessment. Mitigation of consequences: emergency plans - Lost source, stuck source, Contamination, Off-site accidents, Patient accidental exposure. Radiation emergencies, preparedness and record keeping, large scale spillage, leakage of radioactivity substance to environment, accidental inhalation, death of a patient with radioactivity etc.

**Transportation of radioactive substances: (5 Lectures)**

Historical background, classification of radioactive materials, general packing requirements, transport documents, labeling and marking of packages, transport of large radioactive sources and fissile material, exemptions from regulations.

**Principles of Monitoring and Protection (5 Lectures)**


**Personnel Monitoring Devices (2 Lectures)**

Principle construction and use of different radiation protection monitors – Film badge, TLD badge and pocket dosimeter.

**Radiation Survey of the Department (2 Lectures)**

Principle and construction of radiation survey meter and gamma zone monitors

**Safety in Industrial, Agriculture and Research uses of Radiation (3 Lectures)**

Use of ionizing radiation in irradiator, industrial radiography, nucleonic gauging, well logging and research such as medical research, industrial research and agriculture research.
Legislation (5 Lectures)

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.


Books:
5. ICRP 2007 Recommendations.

Practicals

1. To measure Half Value Layer of β and γ emitters
2. To study the factors producing background counts.
3. To study self absorption using beta emitting radioisotopes.
4. To study the back scatter of beta particle.
5. To study the absorption of radiation by solvents and to determine the counting errors originating from sample geometry.
6. To study how to avoid certain errors in handling carrier free solutions.
7. To determine the half life of a radioactive material.
8. To study the change in activity of a sample consisting of two independently decaying radioisotopes.
9. To study the statistics of radioisotopic measurements and observe the effect of background on the counting statistics.
10. Radiation exposure : effect of distance, Shielding and time
11. Measurement of contamination and decontamination procedures
12. Thermal neutron attenuation in graphite, concrete and iron using a BF3 counter
FOURTH SEMESTER

Paper – I: Radiotherapy – Teletherapy Treatment Planning (50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Photons and x-rays Teletherapy: (25 Lectures)

External Beam Dosimetry Concepts (Part I) - Dosimetric Variables, Inverse Square Law, Backscatter factor, Electron Buildup, Percent Depth Dose, Mayneord F factor, TAR Correction to F factor, Equivalent Squares

External Beam Dosimetry Concepts (Part II) - Tissue air Ratio - Scatter air Ratio - Tissue phantom Ratio - Tissue maximum Ratio

System of Dose Calculations - Monitor Unit Calculations, Output Factor, Field Size Correction Factors, Collimator Scatter Factor and Phantom Scatter Factor, Beam Modifier Factors, Patient Attenuation Factors.

Calculations in Practice: SSD Technique - SSD Treatment same as SSD of Calibration, SSD Treatment Different from SSD of Calibration, SSD Treatment and SAD Calibration, SAD Technique - SAD Treatment and SAD Calibration, SAD Treatment and SSD Calibration, SAD Rotational Treatment.

Translation of Planning to Calculations - Beam Parameters, Beam Weighting, Arc rotation therapy, Irregular Fields

Simulation of patients on conventional and CT Simulator. Mould Room Procedures, Making of casts, compensators and shields

Computerized Treatment Planning: Isodose curves (beam characteristics), Surface Dose, Parallel Opposed Beam Combination, Wedge Isodose Curves, Wedge Angle and Hinge Angle, Wedge Factor, Wedge Techniques, Wedge Pair, Open and Wedged Field Combination, Skin Compensation, Beam Combination (3-,4-,6- field techniques)

Surface Corrections & Heterogeneities: Corrections for Surface Obliquities, Corrections for inhomogeneities, Linear (1-D) Attenuation Method, 2-D Methods, Volumetric Methods, Dose Perturbations at Interfaces

Adjoining fields & Special Dosimetry Problems: Two-Field Problem, Three-Field Problem, Craniospinal Gapping, Pacemaker, Gonadal Dose, Pregnant Patient

Electron Beam and Planning of Medical Radiation Installations: (25 Lectures)

Electron Beam Teletherapy:

Basic Characteristics: depth-dose/isodose characteristics, Electron interactions, CSDA and range, dose versus depth, isodoses, oblique incidence, AAPM TG-25 – energy specification – electron energy selection for patient treatment – depth dose characteristics (Ds, Dx, R100, R90, R50, Rp etc) beam flatness and symmetry – penumbra – isodose plots – monitors unit calculations – output factor formalisms – effect of air gap on beam dosimetry – effective SSD.


Field Matching and other considerations: Electron-electron Gapping, Electron photon Gapping, Electron Backscatter, inhomogeneities, Internal shielding
Particulate beam therapy – Relative merits of electron, neutron, x-ray and gamma ray beams – Neutron capture therapy – Heavy ion therapy.

Books:

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<th>Authors</th>
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<tbody>
<tr>
<td>1</td>
<td>B.R. Thomadsen, M.J. Rivard, and W.M. Butler</td>
<td>Brachytherapy Physics (Medical Physics).</td>
</tr>
<tr>
<td>3</td>
<td>S.C. Klevenhagen</td>
<td>Physics and Dosimetry of Therapy Electron Beams (Medical Physics)</td>
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Practicals

1. Dosimetry verification of computerized treatment planning of a single and parallel opposing photon field and comparison with manual planning.
2. Dosimetry verification of computerized treatment planning of an oblique three fields technique (SAD) and comparison with manual planning.
3. Dosimetry verification of computerized treatment planning of an oblique three fields technique (SSD) and comparison with manual planning.
4. Dosimetry verification of computerized treatment planning of a four fields (SAD) box technique and comparison with manual planning.
5. Dosimetry verification of computerized treatment planning of a four fields (SSD) box technique and comparison with manual planning.
6. Computerized treatment planning and dosimetry of rotation therapy.
7. Measurement of entrance and exit doses and evaluation
Paper – II: Radiotherapy – Brachytherapy Treatment Planning (Total 50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Treatment Planning of Brachytherapy (25 Lectures)

Brachytherapy, advantages, disadvantages & methods:

Brachytherapy Sources: Radium, Cesium-137, Cobalt-60, Iridium-192, Gold-198, Iodine-125, Palladium-103 and others.

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 fractionation; calculation of dose from a point source and line source using sievert Integrals; calculation of absorbed dose distribution in water around sealed sources with AAPM TG 43 algorithm protocol, point source, line, unfiltered and filtered; optimization of dose distribution.

Systems of Implant Dosimetry: Paterson-Parker, Quimby, Memorial, Paris, Computer

Implantation Techniques: Surface Molds/Plaques, Interstitial Therapy, Intracavitary Therapy -Uterine Cervix, Milligram-Hours, Manchester System, Bladder and Rectum Dose, ICRU System, Absorbed Dose at Reference Points

Gynecological Implants: General Information (advantages/disadvantages), Remote Afterloading Units, LDR, MDR, HDR, PDR, HDR vs. LDR

Application of Physical Models like CRE & LQ for calculating dose equivalence and to device new dose regimens.

Brachytherapy Treatment Planning: (25 Lectures)

Books:

2. Faiz M. Khan : The Physics of Radiation Therapy (Lippincott Williams & Wilkins).
3. Faiz M. Khan & Roger A. Potish : Treatment Planning in Radiation Oncology (Lippincott Williams & Wilkins).

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 Intraluminal brachytherapy.
4. Brachytherapy dosimetry for single and double plane implants.
5. In-vivo dosimetry in brachytherapy procedure.

Paper – III : Recent Advances in Treatment Planning (50 Lectures)

Note: The books indicated as text-book(s) are suggestive of the level of the coverage. However, any other book may be followed.

Imaging for Radiation Oncology: (20 Lectures)

Routine Imaging: Diagnostic Imaging Physical principles, Port Films, XV- film, EDR-2 film characteristics, Processors.

Other Imaging:

Image Based Treatment Planning:
CT scans: Physical principles, Hounsfield Units, CT numbers, Inhomogeneity corrections based on CT scan images
MRI Scanning: Physical principles, T1, T2, TE, TR imaging characteristics, Advantages & limitations of MRI images for diagnosis and computerized treatment planning
PET Imaging: Physical principles, Utility for Radiation Therapy, Image Fusion, Advantages, Challenges, Techniques, Limitations

3DCRT including ICRU concepts and beam related biology
3DCRT concepts and goals vs traditional RT, comparison to protons, Technology and methods for planning, Acceptance testing of multileaf collimators, Commissioning of multileaf collimators, Quality assurance programme for multileaf collimators, Multiple volume images (CT, MR, PET,
MRSI, etc), Image processing (registration, segmentation), Virtual simulation, DRRs, Multiple beams (>4), Non-coplanar beams

Optimization methods

Biological implications of uniform vs non-uniform dose delivery, Non-biological and biological dose-volume metrics (DVHs, TCPs, NTCPs), Margins

Implications of treatment variabilities (systematic and random setup variabilities, patient breathing), ICRU 50 Prescribing, Recording and Reporting; ICRU Report 62: (Supplement to ICRU Report 50);

Algorithms of treatment planning system: General overview of various dose calculation and inverse planning optimization algorithms for photon and electrons.

Assessment of Patient Setup and Verification

Immobilization devices and methods: Table Positions, lasers, distance indicators, Immobilization methods, and Positioning methods (calibrated frames, optical and video guidance, etc)

In-the-room intra-treatment imaging (cont’d): Cone-beam CT, Ultrasound, Internal markers (e.g. implanted seeds), On-line correction of setup errors, Adaptive planning concepts,

IMRT (20 Lectures)

IMRT Delivery Systems: Commissioning of intensity modulated radiotherapy Systems, Quality assurance for intensity modulated radiotherapy Systems, Dose verification for intensity modulated radiotherapy, treatment plans Segmental MLC (SMLC) and Dynamic MLC (DMLC), Serial Tomotherapy (MIMiC), Helical Tomotherapy, Robotic Linac, Simulation and immobilization/repositioning

Dose prescription & inverse planning: Treatment calculations, IMRT quality assurance

General (10 Lectures)

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 & 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, Respiratory Gated Radiotherapy and Dynamic Adaptive Radiotherapy

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


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.
Books:

1. K.S. C. Chao, S. Apisarnthanarax, G. Ozyigit  : Practical Essentials of IMRT (Lippincot Williams & Wilkins)

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.

THIRD YEAR

Internship:

The student will undergo internship for one year at the Department of Radiotherapy, Regional Cancer Center, Postgraduate Institute of Medical Education & Research, Chandigarh.

Dissertation:

The student will also do a project and write dissertation and submit to the University one month before completion of internship.

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