FACULTY OF SCIENCE

SYLLABI

FOR

M.Sc. MEDICAL PHYSICS

1st to 4th SEMESTER

EXAMINATION 2013-2014

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FIRST YEAR

First Semester

Theory = 400 Marks (4 Papers of 100 marks each)
Practicals = 200 Marks (4 Practicals of 50 marks each)
Total Marks = 600 Marks

A. Theory Papers
1. Fundamental Anatomy 100 Marks
2. Applied Mathematics, Biostatistics and Computer Applications 100 Marks
3. Radiation Physics 100 Marks
4. Radiation Biology 100 Marks
Total = 400 Marks

B. Practicals
1. Fundamental Anatomy 50 Marks
2. Applied Mathematics, Biostatistics and Computer Applications 50 Marks
3. Radiation Physics 50 Marks
4. Radiation Biology 50 Marks
Total = 200 Marks

Second Semester

Theory = 400 Marks (4 Papers of 100 marks each)
Practicals = 200 Marks (4 Practicals of 50 marks each)
Total Marks = 600 Marks

A. Theory Papers
1. Basic Physiology and Cancer Biology 100 Marks
2. Fundamentals of Electronics and Biomedical Instrumentation. 100 Marks
3. Radiation Detection and Measurements 100 Marks
4. Radioisotope Applications and Radiation Safety 100 Marks
Total = 400 Marks

B. Practicals
1. Basic Physiology and Cancer Biology 50 Marks
2. Fundamentals of Electronics and biomedical Instrumentation 50 Marks
3. Radiation Detection and Measurements 50 Marks
4. Radioisotope Applications and Radiation Safety 50 Marks
Total = 200 Marks
SECOND YEAR

Third Semester

Theory = 400 Marks (4 Papers of 100 marks each)  
Practicals = 200 Marks (4 Practicals of 50 marks each)  
Total Marks = 600 Marks

A. Theory Papers
1. Radiotherapy Equipments and Quality Assurances 100 Marks
2. Medical Imaging equipments and Quality Assurances 100 Marks
3. Basics of Radiation Dosimetry 100 Marks
4. Teletherapy Treatment Planning 100 Mark  
Total = 400 Marks

B. Practicals
1. Radiotherapy Equipments and Quality Assurances 50 Marks
2. Medical Imaging equipments and Quality Assurances 50 Marks
3. Basics of Radiation Dosimetry 50 Marks
4. Teletherapy Treatment Planning 50 Marks  
Total = 200 Marks

Fourth Semester

Theory = 400 Marks (4 Papers of 100 marks each)  
Practicals = 200 Marks (4 Practicals of 50 marks each)  
Total Marks = 600 Marks

A. Theory Papers
1. Brachytherapy Treatment Planning and Radiobiological Models 100 Marks
2. Clinical Dosimetry and Standardization 100 Marks
3. Principles of Radiation Protection and Radiation Safety 100 Marks
4. Recent advances in Radiotherapy and Special Techniques 100 Marks  
Total = 400 Marks

B. Practicals
1. Brachytherapy Treatment Planning and Radiobiological Models 50 Marks
2. Clinical Dosimetry and Standardization 50 Marks
3. Principles of Radiation Protection and Radiation Safety 50 Marks
4. Recent advances in Radiotherapy and Special Techniques 50 Marks  
Total = 200 Marks

THIRD YEAR

Internship, dissertation & viva 300 Marks
M.Sc. Medical Physics Syllabus

FIRST YEAR - FIRST SEMESTER

Paper – I

FUNDAMENTAL ANATOMY (40 Lectures)

INTRODUCTORY CYTOLOGY (6 Lectures)
Cell: Cell wall and cell membrane, structure and functions of endoplasmic reticulum (ER), mitochondria, golgi complex, nucleus, lysosomes.

MICROSCOPIC ANATOMY (11 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.

GROSS ANATOMY (23 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.
Head and Neck: Component parts (skull, cervical vertebrae, hyoid bone, soft palate and muscles in the head and neck).
Abdomen: Component parts (wall, abdominal cavity, inferior thoracic aperture, diaphragm, pelvic inlet), surface anatomy, defining surface projection, Liver, kidney and spleen position, gallbladder, pancreas.
Pelvis: component parts (Pelvic inlet, pelvic walls, pelvic outlet, pelvic floor, pelvic cavity and perineum).
Lower and Upper limb: Component parts (bones and joints, muscles)

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, prostate) using light microscope.
8. To visualise microanatomical view of reproductive system of female (ovary, fallopian tube, uterus) using light microscope.
9. To visualise microanatomical view of nervous system (neuron, neuroglia, gross anatomy of brain) 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 alkaline phoshatase, acid phophatase, SGOT and SGPT

Paper – II

APPLIED MATHEMATICS, BIOSTATISTICS AND COMPUTER APPLICATIONS

(40 Lectures)

Numerical Methods: (10 Lectures)
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, Trapezoidal 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

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

The basic idea of significance tests, Tests of hypothesis for the parameters of normal distribution (two sample problems also) including testing for population proportions. Confidence intervals for the parameters of normal distribution (two sample problems also).

Categorical data: measurements scales, tests of associations, Chi-square test, Yate’s correction. Sensitivity, Specificity, Predictive value and ROC curve, Analysis of variance (ANOVA), one way and two way classifications, Multi-variate analysis of variance (MANOVA).

Non Parametric Statistics: Sign-test, Wilcoxon-signed rank test, Mann Whitnet U-statistic

**Counting and Medical Statistics (5 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 an 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.

**Computational Tools & Techniques: (5 Lectures)**
Computational packages: Overview of programming in C++, MATLAB/Mathematica, and SPSS/STATISTICAL in data analysis and graphics.
Practicals

1. To demonstrate the use of various scientific languages like FORTRAN, C++ for scientific applications.
2. To study various DOS 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 software.
6. Demonstration in Excel and Power point.

Paper – III

RADIATION PHYSICS     (40 Lectures)

Radiation Physics (15 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 of radioactivity, types of radiation (α, β, γ, X-ray, n), decay processes; decay modes, probability and decay constant. Radioactivity, decay equation, physical half life, mean life; radioactive series- natural radioactive series & artificial radioactivity; beta particle spectrum; K-electron capture; Cerenkov radiation, characteristic radiation, auger effect, fluorescent yield and Bremsstrahlung radiations, metastable state and isomeric transition, internal conversion, general aspects of gamma decay, gamma energy decay

Nuclear reactions, nuclear energy levels; nuclear isomerism., Bombardment, Conservation Laws, compound nucleus, artificial transmutation, discovery of neutron, nuclear reaction cross section, neutron activation nuclear fission, fission products, fissile materials, diffusion and slowing down of neutrons, various types of reactors - fusion and thermo nuclear reactions.

Radiation Units (6 Lectures)

Units of radioactivity: Becquerel, Curie, specific activity, carrier free activity, resonance absorption and mossbauer effect. 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.

**Radiation generators (12 Lectures)**


**Interactions of x and γ rays with matter: (7 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.

**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.
Paper – IV
RADIATION BIOLOGY (40 Lectures)

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 (10 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 and independent cell systems: Target Theory, multitarget theory, target size, multihit theory, multitarget multihit theory.
Differential cell response: Criteria of radiosensitivity, 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 on Major Organ Systems (8 Lectures)
Radiation effects on major organ systems: Hematopoietic system (Spleen, bone marrow, Lymphoid tissue, thymus) and Blood, Vascular system, Digestive system, Respiratory system, Urinary system, Nervous system, Reproductive system, Endocrine system and Immune system.

Modification of Radiation Injury (3 lectures)
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.

Radionuclides in Biology (15 lectures)
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.
$^{59}\text{Fe}$ absorption studies, Techniques for studying absorption of labeled substance, $^{59}\text{Fe}$ turn over studies, plasma iron clearance

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

$^{60}\text{Co}$: in cancer treatment, gamma knife

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

$^{14}\text{C}$ applications in urea breath test, Radiorespirometry, in vitro uptake and turnover studies using $^{14}\text{C}$ glucose, $^{14}\text{C}$ amino acids and fatty acids.

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

**Practicals**

1. To determine the turnover of $^{14}\text{C}$ 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 $^{14}\text{C}$ uracil in RNA.
4. To determine the in-vitro uptake of $^{14}\text{C}$ labeled amino acids in the given organ slices.
5. To study the bio-kinetics of $^{45}\text{Ca}$ in understanding its metabolism in bone when administered in an animal.
6. To label the red blood cells using $^{51}\text{Cr}$ and to determine the efficiency of labeling.
7. To find out the average life span of red blood cells by using $^{51}\text{Cr}$ radionuclide
8. To determine the blood volume of a given animal using $^{51}\text{Cr}$ labeled red blood cells.
9. To prove that spleen is the storehouse of worn out red blood cells by using $^{51}\text{Cr}$ labeled red blood cells.
FIRST YEAR - SECOND SEMESTER

Paper – I
BASIC PHYSIOLOGY AND CANCER BIOLOGY (40 lectures)

HUMAN PHYSIOLOGY (20 Lectures)

Thyroid: Thyroid hormone production, hormonal control.
Heart: The heart as a pump, normal ECG, methods of recording ECG
Respiratory system: General physiological functions of respiratory system.
Endocrine system: Brief description of endocrine organs, their hormones, functions of the hormones, diseases produced by excess or deficiency of the hormones.
Nervous System: Structure, function and organization of nervous system, signal transmission at synapses
Functions of Digestive system: Brief study of different digestive juices and their functions
Urinary systems: Physiology of urine formation
Reproductive system: Oogenesis and ovulation in females, spermatogenesis in males.

BIOLOGY OF CANCER (12 Lectures)
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.
Cancer Invasion and Metastasis: Stages of metastasis (Invasion, local extention, discontinuous extention), transport of cancer cells to distant sites

MOLECULAR BIOLOGY (8 Lectures)
DNA structure, Replication and Repair, RNA synthesis and Translation

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 chromosomal aberrations.
7. To study the cell proliferation using MTT assay.
8. To study muscular activity using actophotomotometer.
9. To study locomotor functions by rotarod.
10. To study learning and memory process using moris water maze and plus maze.
Semiconductor devices (14 Lecturers)

Theory of semiconductors; Conduction in crystals, energy band (qualitative). Intrinsic and extrinsic semiconductors, n-type and p-type semiconductors, majority and minority carriers. pn junction properties forward and reversed bias, PNP and NPN junction transistors, transistor current components, CB, CE and CC configurations Small signal equation and equivalent circuits for transistors, Field effect transistor (FET), Metal oxide filed effect transistor (MOFET), Special devices- SCR, Diac-Triac, Unijunction transistor (UJT), Opto-isolator, Zener diode, Tunnel diode, Schottky diode and photodiode; Fabrication and integrated circuits, Simple ideas on operational amplifier, OPAMP, their characteristics and applications.

Digital Circuit System (6 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, Multiplexing and de-multiplexing 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.

Circuits (5 lectures)

Pulse shaping oscillators, regulators, PM tubes, preamplifiers, pulse height analyzers, SCA, MCA, coincidence & anti coincidence circuits, equivalent circuits

Transducers (5 Lectures)

Properties and the principle of transducers: Resistive transducer, thermoresistors, thermistors, Pontemetric transducers, magnetoresistive transducers and their biomedical applications. Inductive transducers, single inducers, mutual inducers, capacitive transducer, biological capacitors.

Biomedical Ultrasound & Medical Laser (10 Lectures)


Introduction to laser, principle of operation of laser, laser tissue interaction, Different types of LASER. Attenuation of LASER in medicine, adverse effects of LASER
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 – III

RADIATION DETECTION & MEASUREMENTS (40 Lectures)

Interaction of charged particle with matter: (6 lectures)
Absorption process, scattering ionization and excitation, Bethe’s equation, radiation energy loss (bremstrahlung), 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: (3 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 (4 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. Pulse height selector and resolution of energies, FWHM an energy calibration, geometric efficiency, intrinsic efficiency, Bismuth germanate detector, barium Fluoride detector, technetium orthosilicate detectors, ytirium orthosillicate detector, semiconductor detectors. Ge(li) detector, Si(Li) detector, Cadmium zinc-telluride detector.
Liquid scintillation counters (3 lectures): composition of liquid scintillator (scintillation cocktail): primary solute, secondary, solute and organic solvent (toluene, 1, 4 dioxane, anthracene) and solublizing 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 (6 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, Fricke 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 (5 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 (2 lectures)
Semiconductors junction and surface barrier detectors, high purity germanium detectors, their response and, characteristics.

Instruments for counting, gamma ray spectrometry (3 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.

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 – IV
RADIOISOTOPE APPLICATIONS AND RADIATION SAFETY (40 Lectures)

BIO-MEDICAL APPLICATIONS OF RADIONUCLIDES (20 Lectures)
Thyroid radio active 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. 

\(^{131}\)I therapy for treatment of hyperthyroidism, thyroid follicular carcinoma.

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

\(^{123}\)I applications

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

\(^{201}\)Tl/\(^{82}\)Rb – myocardial uptake/perfusion imaging, \(^{67}\)Ga for scintigraphy of tumors and infections,

\(^{18}\)FDG in brain, heart and tumor imaging

Radonuclides in therapy- \(^{89}\)Sr, \(^{186}\)Re-HEDP, \(^{153}\)Sm-EDTMP, lutetium-177

RADIATION PROTECTION (10 lectures)
Principles of radiation protection – Quantities used in radiation protection, justification of practice, optimization of protection and Individual dose and risk limits, regulatory aspects of radiological safety, control of internal and external hazards..
Radioactive waste disposal - 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, disposal of solid, liquid and gaseous effluents/waste, decaying storage transfer to authorized personal, management of sealed and unsealed sources.

Transport of radioactive material and designing of radiation laboratory (5 lectures): - storage and transport of waste, transport index. Classification of radiation labs, design of areas for radioisotope laboratories, criteria for grading laboratories using unsealed radioisotopes

STOCHASTIC AND NONSTOCHASTIC EFFECTS OF RADIATION (5 Lectures)

Practicals
1. Use of gamma ray scintillation counter for measuring in vivo thyroid uptakes following administration of carrier-free $^{131}$I
2. To study the influence of carrier on in-vivo uptake carrier-free $^{131}$I by the thyroid.
3. To find out the bio-distribution of a given radionuclide in a given animal.
4. To perform perchlorate discharge test.
5. To determine the thyroid clearance test.
6. To determine the PBI-131 in blood.
7. To measure the blood volume of a given animal using $^{99m}$Tc labeled red blood cells.
8. To prove that spleen is the storehouse of worn out red blood cells by using $^{99m}$Tc labeled red blood cells.
9. To find out the target/non target ratio of $^{99m}$Tc labeled pharmaceuticals.
10. To determine the biological half life of $^{99m}$Tc $O_4^-$ and labeled pharmaceuticals.
11. To determine the Rf of radiopharmaceuticals using different solvents
SECOND YEAR - THIRD SEMESTER

Paper – I

Radiotherapy Equipments and Quality Assurances (Lectures 40)

RADIOThERAPY EQUIPMENTS

Radiation sources (10 Lectures)

Natural and 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;

Use of radium, Co-60, Ir-192, Cs-137, 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.

Linear Accelerator: High Energy X rays and Electron production, Variable Energy; 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, Multi leaf collimators, Other collimation systems, Different Quality assurance parameter checks, isocentre checks flatness, symmetry, Field size definition, penumbra

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

Treatment Planning Systems

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

Brachytherapy Equipment (15 Lectures)

Radium needle, tubes, Preloaded and after loading Manual Cs needle/tubes LDR and Iridium 192 wires LDR Brachytherapy system, source uniformity and integrity, Remote after loading LDR machine – Construction and working principles
Construction and working principles of single miniature HDR source, Construction and working principles of PDR and quality assurance tests, dwell position accuracy, auto radiograph, shutter time error, timer linearity.

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

Practicals

1. Source Strength verification of a micro-Selectron HDR Brachytherapy Machine using a well type ionization chamber.
2. Time linearity and end time error measurement of a micro-Selectron HDR Machine.
3. To verify the Mechanical and Dosimetical isocentre of collimator rotation of a Teletherapy unit using a therapy localization film.
4. To verify the Mechanical and Dosimetical isocentre of collimator rotation of a Teletherapy unit using a therapy localization film.
5. To find the congruency of radiation and optical field of a Teletherapy machine and penumbra width using a film scanner.
6. Quality Assurances of a Cobalt-60 Teletherapy unit
7. Quality Assurance and commissioning a conventional Simulator
9. Mechanical and Dosimetry verification of isocentre of a Linear Accelerator

Paper – II

Medical Imaging Equipments and Quality Assurances (Total lectures 40)

Medical Imaging Equipments

X-Ray Technology: (12 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.

Nuclear Medicine: (8 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.

Preparation of tracers and labeled compounds, Preparation of radio colloids; Bone scanning, principle, agents for bone scanning, Mo$^{99}$, Tc$^{99m}$, 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 PET/CT studies (respiratory and cardiac gating)


**Practicals:**

1. Q. A. testing of a diagnostic X-ray unit.
4. Measurement of KVp, mAs, Timer of an X-ray Unit.
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 machine.
9. To perform Quality Control of Planar Gamma Camera, Flood field for Scintigraphy.
10. To demonstrate the Quality Control of SPECT System.
11. To study iso-response curves of different collimators of a Gamma Camera.
12. Dark room practicals e.g. preparation of Developer and Fixer and X-ray film development, fixation and washing.
14. QA of an MRI machine.
Radiation Beam Quality and Dose (5 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).

Radiation quantities and units (2 Lectures): Kerma; Exposure; Absorbed dose; Dose equivalent; RBE dose; Calculation of absorbed dose from Bragg-Gray cavity theory.

Radiation Sources both Natural and Artificial (2 Lectures): Generation through Reactors and Cyclotrons.

Principles of Radiation Detection: (11 Lectures)

Radiation Measuring & Monitoring Instruments: (20 Lectures)


**Practicals**

1. Study of Linearity and reproducibility of a pocket dosimeter.
2. Study of Linearity and reproducibility of a survey meter.
4. Radiation dose measurement with a thimble ionization chamber.
5. Calibration of a film dosimetry system for dose measurement.
6. Demonstration of Radiation dose profile and PDD curve measurement using RFA.

**Paper – IV**

**Teletherapy Treatment Planning (40 Lectures)**

**Photons and x-rays Teletherapy: (20 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

**Clinical aspects of treatment planning:** Define Conventional and different types of Conformal techniques. Steps in conventional and conformal radiation planning, Beam modification and beam shaping in radiotherapy. Radiation techniques used for treatment of various sites of malignancies.

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**Electron Beam and Planning of Medical Radiation Installations: (20 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 ($D_s$, $D_x$, $R_{100}$, $R_{90}$, $R_{50}$, $R_p$ 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.

**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
SECOND YEAR - FOURTH SEMESTER

Paper – I

Brachytherapy Treatment Planning and Radiobiological Models (40 Lectures)

Clinical aspects of Brachytherapy (2 lecture): Definition, advantages and limitations as well as different methods of brachytherapy. Indications for various types of brachytherapy.

Treatment Planning of Brachytherapy (10 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

Brachytherapy Treatment Planning: (10 Lectures)


Radiobiological Models

1. Time Dose and fractionation model

Radiobiology, therapeutic ratio, RBE, cell survival curves and fractionation, Time Dose Model, NSD, CRE, TDF, Modified TDF Model; Use of bio-effect models, limitations of NSD, TDF and CRE Models, LQ Model,

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

Practicals:

1. QA for High dose rate brachytherapy machine.
2. Calibration of Ir-192 high intensity source.
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

Paper – II

Clinical Dosimetry and Standardization (Total 40 Lectures)

Radiation Measurement and Calibration (40 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 Kilo-voltage Beam.

Calibration of Megavoltage Beams: \( N_{\text{dair}} \) and \( N_{\text{dw}} \) 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.

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.

Practicals

1. To find the Reproducibility and Linearity of a radiation dosimeter
2. Energy measurement of photon and electron beam of linear accelerator using TRS 398
3. Energy measurement of photon and electron beam of linear accelerator using TG 51
4. Output calibration of 6 MV/15 MV photon beam in water at an ambient environmental conditions using IAEA TRS-398 protocol.
5. To find the shutter time error of a cobalt-60 Teletherapy unit and find the output in water phantom using TRS 398 protocol
6. To find the $N_{dw,Co60}$ calibration factor of a dosimeter using cross calibration method
7. To find the $N_x$ and $N_{dair}$ from $N_{dw}$ calibration factor using TRS 277
8. To find the output of electron beam using both TRS 398 and TG51 protocols

Paper – III

Principles of Radiation Protection and Radiation Safety (40 Lectures)

Acute and Chronic effects of Whole Body Irradiation (2 Lectures)

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

Principles of Radiation Protection (6 Lectures)

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 (3 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 (5 Lectures)**

Planning & Design of Radiation generating Equipment Installation (7 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: (3 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: (3 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 (3 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 (1 Lectures)**

Principle and construction of radiation survey meter and gamma zone monitors

**Safety in Industrial, Agriculture and Research uses of Radiation (2 Lectures)**

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

**Duties and responsibilities of Radiation Safety Officer (RSO)**

**Legislation (3 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.


**Practicals**

1. Radiation Survey of Linear Accelerator to find the adequacy of shielding on safety point of view.
2. Radiation Survey of Cobalt-60 Teletherapy unit to find the adequacy of shielding on safety point of view.
4. Room lay out planning of a Linear Accelerator of dual photon energies of 6 MV and 15 MV.
5. Room Lay Out planning of a Cobalt-60 Teletherapy unit
6. Room Lay out planning and radiation survey of a HDR Brachytherapy unit
7. Room Lay out planning and radiation survey of a Conventional Simulator
8. Room Lay Out planning and radiation survey of a CT Simulator unit.
9. To find HVT and TVT of a radiation beam.
Recent Advances in Radiotherapy and Special Techniques (40 Lectures)

Imaging for Radiation Oncology: (20 Lectures)

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

Other Imaging:

Electronic Portal Imaging: Overview of electronic portal imaging devices, Types of portal imaging devices, Clinical applications of EPID technology in daily practice.

Ultrasound: Physical principles, Utility in diagnosis and patient positioning.

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 (5 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 (15 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 (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.

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

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.

**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 SYLLABUS

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.