BASAVATARAKAM INDO-AMERICAN CANCER HOSPITAL & RESEARCH INSTITUTE

భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

IIT Hyderabad & Basavatarakam Indo-American Cancer Hospital & Research Institute

jointly announce

MSc in Medical Physics

Atomic Energy Regulatory Board (AERB) Approved Course

Mode: Self-Sponsored

Eligibility: BSc with 60%
(Physics as mandatory subject)

Selection: Interview

Duration: 3 years
(2Y-Course work & 1Y Internship)

Total Credits: 90 Credits
66 Credits (2 Y) + 24 Credits (1 Y)

Fee Structure: INR 12,000 per Credit

Key Dates:

Application: Aug 12, 2022

Interview: Aug 19, 2022

Commencement: Sep 01, 2022

Link to apply: https://zfrmz.in/qUO4K01nF5ewAt7BQJle

Vision and Mission

Medical Physics is a branch of applied physics that uses physics principles, methods, and techniques in practice and research to prevent, diagnose, and treat human diseases with a specific goal of improving human health and well-being.

The student will have the knowledge of radiological physics principles, practice, radiation biology, radiation safety, regulations, instrumentation, site planning, commissioning of radiation generators and regulatory approvals, quality control procedures, clinical studies (diagnostic and therapeutic), patient care and management related to the fields of medical physics, radiation oncology, nuclear medicine, radiology, etc. After finishing the program, these students will be eligible to work as a **"Medical Physicist"/ "Radiological physicist"** in cancer hospitals**, Asst. Professor of medical physics/ Lecturer in medical/radiation physics** in the teaching hospitals, and **scientific officer in research institutes**. After successfully completing the course, students should appear for written and oral examinations @BARC for eligibility to work as Radiological Safety Officers (approved by AERB). The program has a mandatory Medical Physics and clinical internship for one year at the clinical partner hospital after successfully completing the course results.

General Information

- **Participating Departments:** Physics**,** Bio-Medical Engineering Departments of IIT Hyderabad (***Institute no. TS-87563***)
- **Partnering Centers/Institute:** Basavatarakam Indo American Cancer Hospital and Research Institute (BIACH&RI); AERB eLORA ID: AP-00023
- **Program Mode:** Self-Sponsored
- **Minimum Eligibility:** BSc with Physics as one of the main subjects.
- **Selection Criteria:** Candidates from the above background can apply directly to IIT Hyderabad admissions. The Applications will be screened based on the Marks obtained in the qualifying degree.
- **Duration:** 2 years of Course work and 1-year mandatory Medical Physics Internship in an AERB-recognized institute (internship will start only after successful completion of course work and declaration of course results).
- **Total Credits:** 66 Credits (in 2 years course) + 24 credits (Internship) (1 Year)
- **Payment:**
  Through SBI Collect
  https://www.onlinesbi.com/sbicollect/icollecthome.htm?corpID=372897

Semester Wise Curriculum

Semester 1	Credits
Nuclear physics (PHY)	**1**
Electrodynamics (PHY)	**3**
Mathematics for Physics (PHY)	**2**
Quantum Mechanics (PHY)	**3**
Computational Physics (Numerical Techniques and Programming) (PHY)	**3**
Radiation Physics & Radiation Sources (PHY)	**2**
Anatomy and Pathophysiology (BME)	**3**
Radiation Biology (BME): Interaction of Radiation with Cells & Biological Effects of Radiation	**1**
Total (Semester 1)	**18**

Semester 2	Cre
Solid State Physics (PHY)	**3**
X-ray Physics (PHY)	**2**
Accelerator Physics & Teletherapy Machines (PHY)	**1**
Radiation Detection, Measurement and Instrumentation (PHY) (2+1 lab)	**3**
Medical imaging (BME)	**3**
Radiation dosimetry & standardization (BIACH)	**3**
Radiation Measuring & Monitoring Instruments (BIACH)	**1**
Total (Semester 2)	**15**

Semester 3	Credits
Biological Basis of Radiotherapy & Biological models (BIACH)	**1**
Biomedical Devices (Lab) (BME)	**2**
Clinical Radiation Oncology (BIACH)	**1**
External Beam Therapy & treatment planning (BIACH)	**2**
Brachytherapy Physics & Treatment planning (BIACH)	**1**
Physics of Nuclear Medicine (BIACH)	**1**
Radiological Mathematics (PHY)	**2**
Lasers and Photonics in medicine (PHY)	**2**
Solid State Physics and Electronics Lab (PHY) (Lab)	**2**
Medical Physics Lab I (BIACH)	**3**
Total (Semester 3)	**17**

Semester 4	Credits
Commissioning and Quality control Standards for Radiation Therapy Equipment: Acceptance, commissioning of RT equipment, Computerized Treatment Planning and quality control (BIACH)	**2**
Advanced Radiation Therapy techniques (BIACH)	**2**
Radiation Hazards, Standards and Professional Aspects: a) Radiation Protection standards, b) Radiation Hazard Evaluation, Control & emergency preparedness c) Professional aspects and role of a Medical Physicist in radiological facilities (BIACH)	**2**
Planning of Radiation installations and Regulatory Aspects (BIACH)	**1**
Handling of Radioactive materials (BIACH) Radioactive transport, handling, Waste disposal, Legislation & regulatory requirements	**2**
Medical Physics Lab II (BIACH)	**3**

Computational modelling of biological systems (PHY)	**2**
English for Communications (IIT)	**1**
Industry Lectures (P/F)	**1**
Total (Semester 4)	**16**

Semester 5	Credits
Internship in Medical Physics I* (Clinical Attachment)	**12**
Semester 6	**Credits**
Internship in Medical Physics II* (Clinical Attachment)	**12**

Note:

- Students will be admitted in semesters 5 & 6 only after successfully completing 2 years of course (4 semesters) and announcing results.
- *Semesters 5 and 6 are clinical internships for one year and are attached with BIACH.

Total Credits: 66 Credits (in 2 years course) + 24 credits (Internship) (1 Year).

General academic rules and procedures

IIT Hyderabad academic system follows a Credit system for all Programs. The total number of credits and the evaluation pattern for each course are proposed by the respective course coordinator, recommended by the department and the Institute curriculum committee, and approved by the Senate before it is implemented.

Credits:

- A credit is a measure of the teacher-student interaction in a classroom. In general, a certain quantum of academic work measured in terms of credits is laid down as the requirement for a particular degree.
- A student's performance/progress is measured by the number of credits they have earned, i.e., completed satisfactorily. The grade point average is calculated based on the course credits and grades obtained by the student.
- A minimum grade point average is required to be maintained for satisfactory progress and continuation in the Program. Further, a minimum number of earned credits and a minimum grade point average should be acquired to qualify for the degree.
- The credits associated with a course are dependent upon the number of hours of instruction per week in the course span.

- **Typically, a three-credit theory course will have 45 contact hours of instruction (running for an entire semester and having three hours of instruction in a week). Similarly, an entire semester lab course will have one 3-hours lab session in a week and is equivalent to 2-credits.**

Exam Pattern:

- The course coordinator/instructor has full responsibility for conducting the course, coordinating the work of other members of the faculty and teaching assistants involved in that course, administering assignments, conducting the tests as well as moderating and awarding the grades.
- Semester-wise performance assessment of every registered student is carried out through various modes of examinations. The Instructor has to announce the modes of evaluation and distribution of weightage for each assessment at the beginning of the course.
- **Theory Courses:** Every course with more than one credit, in general, has two assessments, namely one mid-semester examination and a final end-semester examination, in addition to regular quizzes, class tests, home assignments, group assignments, class presentations, viva voce etc. as instructed by the course coordinator. Makeup for any absence from in-semester evaluations like mid-sem/tests/quizzes will be at the instructor's discretion. Instructors need to be convinced that the reasons for absence are genuine.
- **Laboratory Courses:** The assessment in a laboratory course will be based on turn-to-turn supervision of the student's work, their performance in viva-voce examinations and group discussions, and the quality of their work as prescribed through laboratory journals, and an end-semester test that contains an experiment or a written examination.
- **Projects:** Projects are supervised and need regular interaction (at least once a week) with the supervisor. The student has to submit a project report and defend it in front of a panel of examiners, upon which the final grade is awarded.

Assessment Rubric: Course grades

- The grading in IITH is relative and based on the Instructor's perception of an average performance.
- At the end of the course, based on continual evaluation throughout the course (in the form of assignments, pop quizzes and examinations), a student is given one of eight passing letter grades, namely, A+, A, A-, B, B-, C, C-, and D carrying credit points of 10, 10, 9, 8, 7, 6, 5, and 4, respectively, or fail (F) grade carrying zero credit points.
- Upon obtaining the above pass grades, the student is deemed to 'earn' those course credits.
- If a student gets a Fail (F) grade, no credits are earned for that course. A Fail (F) grade implies that the student has to go through the entire course again.
- Supplementary exams will be conducted for medical cases only. The student will be awarded whatever grade is stipulated for the marks obtained. To avail this, the student

must submit the medical certificate at the time of joining the institute after the medical break.

- Grading Transparency: Students may be allowed to see the answer sheets within five days after the final exam or as informed by the instructor.
- The course grades are expected to be submitted by the course instructor within one week of the end of that course, and the grades are announced to the student at the end of each segment.

SPGA/CGPA calculation

- The academic performance of a student is calculated using two parameters viz., Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA).
- The SGPA is the weighted average of the grade points obtained in all the courses registered by the student during the semester. For example, if a student passes five courses (Theory/Labs/Projects/ Seminar etc.) in a semester with credits C1, C2, C3, C4 and C5, and their grade points in these courses are g1, g2, g3, g4 and g5 respectively, then their SGPA is equal to:

$$SGPA = \frac{(C1 * g1) + (C2 * g2) + (C3 * g3) + (C4 * g4) + (C5 * g5)}{(C1 + C2 + C3 + C4 + C5)}$$

- The CGPA indicates the overall academic performance of a student. It is computed to two decimal places, in the same manner as the SGPA, except that here we consider all the courses registered up to and including the latest completed semester.
- CGPA is linearly mapped to a scale of 10 and indicates an equivalent percentage of marks.

Participating Institutes

The program is being offered under the partnership of the premier Technology Institute IIT Hyderabad along with one of the leading Cancer Hospital, Basavatarakam Indo American Cancer Hospital and Research Institute (BIACH&RI). The two Institutes have been collaborating on the research, clinical and academic front for over 5 years with a strong MOU and agreement between the two.

The Faculty from IITH collaborate with BIACH&RI on carrying out clinical research and trials with joint research projects.

BIACH&RI will be carrying out the attached medical physics internship for all candidates of the program as per AERB guidelines. The internship will be for one year (2 semesters carrying a credit of 24). The evaluation pattern for the clinical internship has been explained in the previous section.

National Advisory Board

With the vision of creating a world-class program at IIT Hyderabad, The Institute has constituted an advisory Panel for the Medical Physics Program at IIT Hyderabad with leading Medical Physicists and Radiation Oncology Clinicians on Board.

- Dr N R Jaganathan; Former Professor, Nuclear Magnetic Resonance Department, All India Institute of Medical Sciences, New Delhi
- Dr Prakit Kumar, Head, Medical Physics, All India Institute of Medical Sciences, New Delhi
- Dr J P Agarwal, Professor & Head, Department of Radiation Oncology, Tata Memorial Hospital, Mumbai 400012
- Dr Nagraj Huilgol, Radiation Oncologist, Nanavati Hospital, Mumbai

Detailed Curriculum

Semester 1

Nuclear Physics [PH] (1 credit)

Nuclear Physics- Radioactivity - Natural Radioactivity: Basic nuclear processes and introduction to various radiation sources, isotopic masses and abundances, the disintegration constant, half-life, mean-life, successive radioactive transformation, units of radioactivity
General properties of alpha, beta and gamma rays - Laws of radioactivity - Laws of successive transformations - Natural radioactive series - Radioactive equilibrium - Alpha ray spectra - Beta ray spectra - Theory of beta decay - Gamma emission - Electron capture - Internal conversion - Nuclear isomerism - Artificial radioactivity - Nuclear cross sections - Elementary ideas of fission and reactors – Fusion

References:

1. R R Roy; B P Nigam, Nuclear physics theory and experiment, New York, Wiley [1967]
2. M A Preston; Rajat K Bhaduri, Structure of the nucleus, Boca Raton, FL: CRC Press, 2018.

Electrodynamics [PH5210/EP3110] (3 credits)

Electric field, Divergence and curl of electrostatic fields, electric potential, work and energy in electrostatics, conductors, Special techniques to solve Laplace's equations, separation of variables and Multiple expansion, Polarization, Field of a polarized object, Electric displacement and linear dielectrics, Lorentz force law, Biot-Savart Law, magnetic vector potential, magnetization, the field of a magnetized object, linear and nonlinear media. Electromotive force, Electromagnetic induction, Maxwell's equations, conservation laws, Poynting theorem, Maxwell's stress tensor, conservation of momentum, Electromagnetic waves, Electromagnetic waves in vacuum and matter, Absorption and Dispersion, Wave Guides, Potentials and fields, Gauge transformations, Dipole radiation, Power radiated by a point charge, Maxwell's equations in the matter, Boundary conditions, Poynting's theorem, Newton's third law in Electrodynamics, Maxwell's stress tensor, Conservation of Momentum, Electromagnetic waves in vacuum, and matter, absorption and dispersion, Guided waves.

References:

1. Introduction to Electrodynamics, 3rd Edition, by David J. Griffiths
2. Classical Electrodynamics: John David Jackson

Mathematics for Physics [EP1118] (2 credits)

Vectors and scalars, Vector differentiation, Gradient, Divergence and Curl, Multiple integrals, Vector integration- ordinary integrals of vectors, Line integrals, surface integrals, Volume Integrals Divergence Theorem, Stokes Theorem, Curvilinear Coordinates, Orthogonal Curvilinear coordinates, cylindrical coordinates, spherical polar coordinates- unit vectors, Arc length, Gradient, divergence and Curl in Curvilinear systems, Analytic functions- Introduction to complex numbers, complex powers, the topology of the complex plane, complex functions and limits, elementary functions, analyticity and the Cauchy Riemann relations, Cauchy's theorem - contour integration and Cauchy's theorem, harmonic functions Series representation of analytic functions- convergent series of analytic functions, Taylor series, zeros and singularities, Calculus of residues - calculation of residues, residue theorem

References:

1. P. Dennery and A. Krzywicki; Mathematics for Physicists; Dover Publications
2. Vector Analysis - Murray. R. Spiegel, Arfken and Weber
3. Mathematical methods for Physicists; Academic Press

Quantum Mechanics [PH5230/EP3210] (3 credits, core)

Many particle system, Time independent perturbation theory for non-degenerate and degenerate energy levels, variational method, WKB approximation and applications, time-dependent perturbation theory, Fermi-golden rule, adiabatic approximation, sudden approximation. Scattering experiments and cross-sections, general features of scattering in the presence of potential, partial wave analysis, scattering by square well, scattering by hard sphere potential, born approximation, and applications. Elements of relativistic quantum mechanics, the Klein-Gordon equation, the Dirac equation, Dirac matrices, spinors, positive and negative energy solutions, physical interpretations, the non-relativistic limit of Klein-Gordon and Dirac equations, equation of continuity and probability current density.

References:

1. Quantum Mechanic by Stephen Gasiorowicz
2. Principles of Quantum Mechanics by R. Shankar
3. Advanced Quantum Mechanics by J.J. Sakurai
4. Quantum Mechanics by Bransden and Joachain

Computational Physics [PH6170] (3 credits)

Introduction to programming (Python/MATLAB/C++/C/Fortran95), Numerical differentiation and integration, Monte Carlo methods, Curve fitting, Linear and nonlinear regression, Roots and optimization of multivariable functions, Solution of nonlinear equations, Numerical matrix computing, Numerical Fourier analysis, Numerical solutions of ordinary and partial differential equations, Numerical solution of Physics problems (Wave equation, Poisson equation, heat equation, Laplace equation, Schrodinger equation, Nonlinear dynamics, Ising model, Statistical mechanics, molecular dynamics etc.)

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 method, Euler’s method, the modified Euler’s method, Runge-Kutta method

References:

1. Computational Physics by Tao Pang
2. Computational Physics by R. H. Landau, M. J. Paez and C. C. Bordeianu

Radiation Physics & Radiation Sources (PHY) (2 credits)

Interaction of photon with Matter (orientation towards radiology): Coherent Scattering-Absorption of Gamma rays by matter, photoelectric absorption, Compton scattering, electron-positron pair production, Linear and mass absorption coefficient of gamma rays in the matter. Total attenuation coefficient - Importance of Various Types of Interactions- Exponential law, half value layer & simple calculations

Interaction of Heavy Charged Particles with Matter: Energy loss of Heavy Charged Particles by Atomic Collisions, Stopping Power of Heavy Charged Particles, The Bragg Curve, Bethe Bloch Formula, Energy and Range Straggling, Delta Rays, Cerenkov radiation.

Interaction of electrons and positrons with Matter: Classical theory of inelastic collisions with atomic electrons - Collision loss, Energy loss per ion pair by primary and secondary ionization - Dependence of collision energy losses on the physical and chemical state of the absorber, multiple coulomb scattering, Stopping Power and Range for Electrons, Synchrotron Radiation. Cerenkov radiation - Electron absorption process – Scattering Excitation and Ionization - Radiative collision - Bremstrahlung - Range energy relation - Continuous slowing down approximation (CSDA) - straight ahead approximation and detour factors - transmission and depth dependence methods for determination of particle penetration - empirical relations between range and energy - Backscattering.

Interaction of neutrons with matter - scattering - capture – Neutron-induced nuclear reactions – an elastic and inelastic scattering of neutrons, neutron activation, radioisotope production. Slow Neutron Interactions, Fast Neutron Interactions, Neutron cross-sections, slowing down of neutrons.

Radiation Sources of electromagnetic radiation, Natural and artificial radioactive sources - Large scale production of isotopes - Reactor produced isotopes - Cyclotron produced isotopes - Fission products - Telecobalt and Brachy sources – gold seeds- Beta ray applicators - Preparation of tracers and labelled compounds-Preparation of radiocolloids, Neutron Sources.

Radiation quantities & units Particle flux and fluence – Energy flux and fluence – Cross Section – Linear and mass attenuation coefficients - Mass energy transfer and mass energy absorption coefficients - Stopping power - LET - Radiation chemical yield - Wvalue - Dosimetry - Energy imparted - Absorbed dose - Kerma - Exposure - Air kerma rate constant - Charged particle equilibrium (CPE) – Relationship between Kerma, absorbed dose and exposure under CPE - Dose equivalent - Ambient and directional dose equivalents [(H*(d) and H'(d)] - Individual dose equivalent penetrating Hp(d) - Individual dose equivalent superficial Hs(d), Given dose, Incident Dose, Skin Dose, Model Dose, Integral dose

References:

1. Radiation Detection and Measurement: Glenn F. Knoll
2. Techniques for Nuclear and Particle Physics Experiments: W. R. Leo
3. Nuclear Physics: D C Tayal
4. Nuclear Radiation Detectors: SS Kapoor and VS Ramamurthy
5. Nuclear Physics: Irving Kaplan

Anatomy and Pathophysiology

Cell physiology and biochemistry - Structure of the cell - Types of cells and tissue, their structures and functions - Organic constituents of cells - Carbohydrates, fats, proteins and nucleic acids - Enzymes and their functions - Functions of mitochondria, ribosomes, golgi bodies and lysosomes - Cell metabolism - DNA as concepts of gene and gene action - Mitotic and meiotic cell division - Semi conservative DNA synthesis, Genetic variation Crossing over, mutation, chromosome segregation - Heredity and its mechanisms.

This course is intended for a basic understanding of human physiology and anatomy from a physicist's perspective. The students need to understand different physiological systems and their dysfunction by applying engineering and mathematics knowledge. The important systems which may be covered are the respiratory, renal, endocrine, gastrointestinal tract, cutaneous, and other relevant systems.

Anatomy and physiology as applied to radiodiagnosis and radiotherapy

Anatomy and physiology as applied to radiodiagnosis and radiotherapy - Structure & function of organs and systems & their common diseases: Skin, Lymphatic system, Bone and muscle, Nervous, Endocrine, Cardiovascular, Respiratory, Digestive (Gastro-Intestinal), Urinary, Reproductive, Eye and ear.

Anatomy of the human body, nomenclature & Surface anatomy, Radiographic Anatomy (including cross-sectional anatomy - identify the different organs/ structures on plain x-rays, CT scans and other available imaging modalities. Normal anatomy & deviation for abnormalities.
Tumour pathology and carcinogenesis, standard pathological features of cancers and interpretation of clinicopathological data

References:

1. G M Cooper, The Cell, A molecular Approach, Sinaur Assoc. Oxford University Press, 8th Ed. (2018).

2. Ganong's Review of Medical Physiology. Kim E. Barrett, Heddwen Brooks, Scott Boitano, Susan M. Barman. McGraw-Hill Education, 24th edition.

2. Guyton and Hall Textbook of Medical Physiology, by John E. Hall, the 12th Edition.

Radiation Biology (BME)

Interaction of Radiation with Cells
Radiolytic products of water and their interaction with biomolecule- Nucleic acid, proteins, enzymes, fats- Influence of oxygen, temperature- Cellular effects of radiation-Mitotic delay, chromosome aberrations, mutations and recombinations-Giant cell formation, cell death recovery
from radiation damage- potentially lethal damage and sublethal damage recovery-Pathways for the repair of radiation damage. Law of Bergonie and Tribondeau.Survival curve parameters-Model for radiation action- Target theory- Multihit, multitarget- repair mis repair hypothesis-Dual action hypothesis-Modification of radiation damage- LET, RBE, dose rate, dose fractionation-Oxygen and other chemical sensitisers- Anoxic, hypoxic, base analogs, folic acid and energy metabolism inhibitors-Hyperthermic sensitization- Radioprotective agents.

Somatic effects of radiation - Physical factors influence somatic effects - Dependence on a dose, dose rate, type and energy of radiation, temperature, anoxia, - Acute radiation sickness - LD 50 dose - Effect of radiation on skin and blood-forming organs, digestive tract - Sterility and cataract formation - Effects of chronic radiation exposure - Induction of leukaemia - Radiation Carcinogenesis - Risk of carcinogenesis - Animal and human data - Shortening of life span - In-utero exposure - Genetic effects of radiation - Factors affecting the frequency of radiation-induced mutations - Dose-effect relationship - first generation effects - Effects due to mutation of recessive characteristics - Genetic burden - Prevalence of hereditary diseases and defects - Spontaneous mutation rate - Concept of doubling dose and a genetic risk estimate.

References:

1. Radiation Biology for Medical Physicists by C. S. Sureka and Christina Armpilia

2. Understanding Radiation Biology: From DNA Damage to Cancer and Radiation Risk - Kenneth Chadwick CRC Press, 15-Nov-2019

Semester 2

Solid State Physics [EP3200/PH6268/PH6200:](3 credits, core)

Crystal structure, Wave diffraction and Reciprocal lattice, Free electron Fermi gas, Band theory of solids, Lattice Vibrations and phonons, Thermal properties, Semiclassical theory of transport, Magnetism and magnetic systems, Dielectrics and Ferroelectrics, Semiconductors, Optical processes and excitons, Superconductivity, Nanostructures

References:

1. C. Kittel, Introduction to Solid State Physics, 8th Edition
2. Solid state Physics by N. W. Ascroft and N. D. Marmin
3. Condensed Matter Physics by M. P. Marder

X-ray Physics (PHY) (2 Credits)

Course content: Discovery, Production and properties of X-rays, Characteristic and continuous X-ray spectra, Design of hot cathode X-ray tube,
Basic requirements of medical diagnostic, therapeutic and industrial radiographic tubes, rotating anode tubes, Industrial X-ray tubes, X-ray tubes for crystallography,
Rating of tubes - Safety devices in X-ray tubes - Rayproof and shockproof tubes Insulation and cooling of X-ray tubes, Mobile and Dental units, Faults in X-ray tubes and Limitations on loading. Electric Accessories for X-ray tubes - Filament and high voltage transformers - High voltage circuits - Half-wave and full-wave rectifiers - Condenser discharge apparatus - Three phase apparatus - Voltage doubling circuits - Current and voltage stabilisers - Automatic exposure control - Automatic Brightness Control- Measuring instruments - Measurement of kV and mA - timers –
Control Panels - Complete X-ray circuit - Image intensifiers and closed-circuit TV systems
Various types of X-ray generators - single phase, 3-phase, effects of heat on the tube, line focus principle, primary and secondary radiation, minimizing deleterious effects of radiations.

References:

1. An Introduction to X-Ray Physics, Optics, and Applications - Carolyn A. MacDonald
1. Radiation oncology physics: A Handbook for teachers and students. IAEA publications 2005. 2. F.M.Khan, The Physics of Radiation Therapy, Third Edition, Lippincott Williams and Wilkins, U.S.A.,2003. 3. H. E. Jones, J. R. Cunningham, The Physics of Radiology, Charless C. Thomas, New York, 2002.

Accelerator Physics & Teletherapy Machines (1 credit)

Accelerator Physics

Principles of particle acceleration, particle accelerators for industrial, medical and research applications, The Resonant transformer, Cascade generator, Van De Graff Generator, Pelletron, Cyclotron, Betatron, Synchrocyclotron, Microtron - Electron Synchrotron-Proton synchrotron, Linear Accelerator, Klystron and magnetron, Travelling and Standing Wave Accelerations.

Application of Mega electron Volt beams in cancer treatment: Cobalt teletherapy, Construction and working of Telecobalt units, source design, beam collimation and penumbra, trimmers and breast cones, beam shutter mechanism, performance comparison with linac.

Teletherapy Machines

Specifications, operation, and use of telecobalt unit and its accessories include wedges, breast cone, and trays. Description of low kilo electron volt therapy X-ray units: Grenz-ray, CXRT, orthovoltage therapy. Spectral distribution of kilovolt X-rays and effect of filtration, thoraeus filter.

Design and working of medical electron linear accelerators, beam collimation, asymmetric collimator, multi-leaf collimator, dose monitoring, electron contamination, Microtron, Electron and Proton synchrotron, accelerator facilities in India, linac accessories (MLC, EPID, Electron applicators)

References:

1. Particle Accelerator Physics Basic Principles and Linear Beam Dynamics - Helmut Wiedemann
2. The Physics & Technology of Radiation Therapy, 2nd Edition - Patrick N. McDermott and Colin G. Orton

Radiation Detection, Measurement, and Instrumentation (PHY) (3 Credits)

Course content: General Properties of Radiation Detectors: Detector Response, Energy Resolution, Response time, detector efficiency, Dead time

Gaseous Ionization Detectors: Ionization and transport phenomena in gases, Transport and electrons and ions in gases, Radiation dose measurement with ion chambers, Avalanche multiplication, The Multiwire Proportional Chambers, Proportional Counters.

Geiger-Muller Counters: The Geiger discharge, Fill gases, quenching, time behaviour, the Geiger counting plateau, design features, counting efficiency, time-to-first count method, GM counter survey meters

Scintillator detectors and Photomultipliers: Organic scintillators, inorganic scintillators, Light Output response, Introduction to photomultipliers, photocathode, electron multiplications, photomultiplier tube characterization, operating parameters, time response and resolution, dark rate and noise, exposure to ambient light and magnetic fields, scintillator coupling to photomultiplier tubes, light guides, Scintillation gamma-ray spectrometers, electron spectroscopy with scintillators,

Semiconductor detectors: Basic semiconductor properties, The action of ionizing radiation in semiconductors, Semiconductors as radiation detectors, semiconductor diode detectors, position-sensitive detectors, Germanium Gamma-ray detectors, operation of semiconductor detectors, Other Solid-State Detectors,

Neutron Detection: Slow neutron detection methods, fast neutron detection and spectroscopy.

References:

1. Radiation Detection and Measurement, Glenn F. Knoll
2. Techniques for Nuclear and Particle Physics Experiments, W. R. Leo
3. Introduction to experimental particle physics, Richard Fernow

Medical Imaging (BME) (3 Credits)

Course content: This course provides a broad overview of different imaging modalities, their ability to image the human body, and their clinical applications.

Interactions of X-rays with the human body, the differential transmission of the x-ray beam, spatial image formation, visualisation of spatial image, limitations of projection imaging technique Viz. Superimposition of overlying structures and scatter, applying contrast media and projections at different angles to overcome superimposition of overlaying structures. Radiography techniques: Prime factors (kVp, mAs and SID/SFD), the influence of prime factors on image quality, selection criteria of prime factors for different types of imaging, different types of projection and slices selected for imaging, objectives of radio-diagnosis,

patient dose Vs image quality Filters: inherent and added filters, the purpose of added filters, beryllium filter, filters used for shaping Xray spectrum (K-edge filters: holmium, gadolinium, molybdenum). Scatter reduction: Factors influencing scatter radiation, objectives of scatter reduction, contrast reduction factor, scatter reduction methods; beam restrictors (diaphragms, cones/cylinders & collimators), grids (grid function, different types of stationary grids, grid performance evaluation parameters, moving grids, artefacts caused by grids, grid selection criteria), air gap technique Intensifying screens: Function of intensifying screens, screen function evaluation parameters, emission spectra and screen film matching, conventional screens Vs rare earth screens

Radiographic Film: Components of radiographic film, physical principle of image formation on film, double and single emulsion film, sensitometric parameters of the film (density, speed, latitude etc.), QA of film developer Image quality: Image quality parameters; sources of un-sharpness, reduction of un-sharpness, factors influencing radiographic contrast, resolution, factors influencing resolution, evaluation of resolution (point spread function (PSF), line spread function (LSF), edge spread function (ESF), modulation transfer function (MTF)), focal spot size evaluation QA of conventional diagnostic X-ray equipment: Purpose of QA, QA protocols, QA test methods for performance evaluation of x-ray diagnostic equipment

Xeroradiography, mammography, Interventional radiology, digital radiography (CR and DR systems), digital subtraction techniques, Conventional tomography (principle only), orthopantomography (OPG), Computed Tomography (CT), QA of CT equipment

Magnetic Resonance image - proton density, relaxation time T1 & T2 images - Image characteristics - MRI system components - Magnets, Magnetic fields, Gradients, Magnetic field shielding, Radio Frequency systems, computer functions - Imaging process – Image artefacts – MRI safety.

Ultrasound Imaging: Interaction of sound waves with body tissues, production of ultrasound - transducers – acoustic coupling - image formation - modes of image display - colour Doppler

Linear Systems model, SPECT, PET, Diffuse Optical Tomography, Optical spectroscopy, and Optical Coherence Tomography.

References

1. Medical Instrumentation Application and Design, John Webster Ed. John Wiley & Sons 2009

Radiation Standardization & dosimetry (BIACH) (3 Credits)

Standards - Primary and Secondary Standards, Traceability, Uncertainty in measurement. Charged Particle Equilibrium (CPE), Free Air Ion Chamber (FAIC), Design of parallel plate FAIC, Measurement of Air Kerma/ Exposure. Limitations of FAIC. Bragg-Gray theory, Mathematical expression describing Bragg-Gray principle and its derivation. Spencer Attix Cavity theories. Transient Charged Particle Equilibrium (TCPE), Concept of Dgas, Cavity ion chambers, Derivation of an expression for sensitivity of a cavity ion chamber. The general definition of calibration factor - N_X, N_K, $N_{D\ air}$, $N_{D,\ W}$. IAEA TRS277: Various steps to arrive at the expression for D_W starting from N_X. TRS398: $K_{Q,\ Q0}$, Derivation of a word for $K_{Q,\ Q0}$.

Calorimetric standards - Measurement of D_W for External beams from Co-60 teletherapy machines: Reference conditions for measurement, Type of ion chambers, Phantom, Waterproof sleeve, Derivation of an expression for machine timer error, Procedure for evaluation of Temperature and pressure correction, Parallel plate, cylindrical ion chambers, Polarity correction. Measurement of D_W for high-energy photon beams from Linear accelerators: Beam quality, beam quality index, beam quality correction coefficient, Cross calibration. Measurement of D_W for high energy Electron beams from linear accelerators: Beam quality, beam quality index, beam quality correction coefficient, Cross calibration using intermediate beam quality. Standardization of brachytherapy sources - Apparent activity - Reference Air Kerma Rate - Air Kerma Strength - Standards for HDR 192Ir and 60Co sources

Calibration of protection level instruments and monitors.

Neutron Standards & Dosimetry

Neutron classification, neutron sources, Neutron standards - primary standards, secondary standards, Neutron yield and fluence rate measurements, Manganese sulphate bath system, precision long counter, Activation method. Neutron spectrometry, threshold detectors, scintillation detectors & multi spheres, Neutron dosimetry, Neutron survey meters, calibration, and neutron field around medical accelerators.

Standardization of Radionuclides

Methods of measurement of radioactivity - Defined solid angle and 4p counting - Beta gamma coincidence counting - Standardization of beta emitters and electron capture nuclides with proportional, GM and scintillation counters - Standardization of gamma emitters with scintillation spectrometers - Ionization chamber methods – Extrapolation chamber - Routine sample measurements - Liquid counter – Windowless counting of liquid samples - Scintillation counting methods for an alpha, beta and gamma emitter - Re-entrant ionization chamber methods - Methods using (n, g) and (n, p) reactions - Determination of yield of neutron sources - Space integration methods - Solid state detectors.

Radiation Chemistry and Chemical Dosimetry

Definitions of free radicals and G-value-Kinetics of radiation chemical transformations - LET and dose-rate effects - Radiation Chemistry of water and aqueous solutions, peroxy radicals, pH effects - Radiation Chemistry of gases and reactions of dosimetry interest, Radiation polymerization, effects of radiation on polymers and their applications in dosimetry - Formation of free radicals in solids and their applications in dosimetry - Description of irradiators from the dosimetric viewpoint - Dosimetry principles - Definitions of optical density, molar absorption coefficient, Beer- Lambert's law, spectrophotometry - Dose calculations - Laboratory techniques Reagents and procedures - Requirements for an ideal chemical dosimeter - Fricke dosimeter - FBX dosimeter - Ceric sulphate dosimeter - Other high and low-level dosimeters- Applications of chemical dosimeters in Radiotherapy.

References:

1. Advanced Medical Radiation Dosimetry, Govindarajan; Prentice Hall of India (Pvt) Ltd 1992.
2. Absorbed dose determination in external beam therapy technical report series (TRS) - 381,374, 277 & 398
3. F. H. Attix. Introduction to Radiological Physics and Radiation Dosimetry, Wiley VCH, Verlog, 2004.

Radiation Measuring & Monitoring Instruments (BIACH)

Photographic film Dosimeters, Thermoluminisence dosimeters, Film badges, and Clinical dosimeters such as secondary standard Dosimeters. Dosimetry for significant field irradiation, whole body irradiation, Use of Electronic Portal Imaging in clinical dosimetry, film and ion chamber dosimetry, Optically stimulated Luminescence dosimeters (OSLD), TLD badge readers - pocket dosimeters - Gamma area (Zone) alarm monitors – Contamination monitors for an alpha, beta and gamma radiation - Hand and Foot monitors - survey meters - new developments.

References:

4. Advanced Medical Radiation Dosimetry, Govindarajan; Prentice Hall of India (Pvt) Ltd 1992.
5. Absorbed dose determination in external beam therapy technical report series (TRS) - 381,374, 277 & 398
6. F. H. Attix. Introduction to Radiological Physics and Radiation Dosimetry, Wiley VCH, Verlog, 2004.

Semester 3

Biological Basis of Radiotherapy & Biological models (1 credit BIACH)

Biological Basis of Radiotherapy: Physical and biological factors affecting cell survival, tumour re-growth and normal tissue response - non-conventional fractionation scheme and their effect on re-oxygenation, repair, redistribution in the cell cycle - High LET radiation therapy.

Biological models: Time dose fractionation Basis for dose fractionation in beam therapy - Concepts for Nominal Standard Dose (NSD) - Time dose fractionation (TDF) factors -and cumulative radiation effects (CRE) - Gap correction, Linear and Linear Quadratic models.

References:

1. The Essential Physics of Medical Imaging; Jerrold. T. Bushberg et al., Lipcontt Williams & Wilkins 2002.
2. Fundamental Physics of Radiology, W.J.Meredith, J.B. Massey
3. Radiation therapy physics William Hence,
4. Principles of radiation oncology, Perez

Biomedical devises Lab (BME) (2 Credits)

Course content: This course is intended to impart an understanding of various biosignals and explain their origin, sensing, signal conditioning and meaningful representation. This course addresses lab and practicals about working with standard biomedical instruments.

Temperature, physiological pressures and flows, volume sensing, bioelectricity from muscles and eyes, the related biological systems, and their physiology will be discussed. The course includes work involving advanced linear integrated circuit design, interfacing, and real-time processing of biosignals and understanding of the diagnostic value in biosignals will be addressed.

Temperature sensing and signal conditioning, Pressure sensing - basics of the cardio-pulmonary system, physiological pressures and sounds, invasive and non-invasive measurements. Flow and volume are sensing in pulmonary function - sensing of breathing mechanics, spirometer interface with LabVIEW, computation of volumes and capacities during a pulmonary function test, mechanical ventilation, and applications. Bioelectric sensing: Electro-oculogram & Electro-retinogram: Biopotentials of the eye, instrumentation, instrumentation, diagnostics. Electromyography - Origin, processing, detection of muscle fatigue, nerve conduction velocity test. Real-time ECG monitor with heart rate detection.

Major Equipment

- Elvis IIb and IV boards for analog and digital circuit design
- ECG and EMG plug-and-play amplifiers
- Audiometer system with investigation sheets
- Pacemaker system
- Defibrillator system
- Instrumented mannequin for CPR training
- Vernier biosensing kits

- Generic DAQs for biosensing and instrumentation
- Embedded development boards for prototyping
- Electronic workbenches with SMD workstations
- Generic sensor kits for prototyping

References

1. John G. Webster-Medical Instrumentation Application and Design, 4th Edition (2009)
2. Leif Sornmo, Pablo Laguna Bioelectrical Signal Processing in Cardiac and Neurological Applications Biomedical Engineering

Clinical Radiation Oncology (BIACH) (1 Credit)

Clinical and Radiation Oncology, Clinical familiarization: Surface and cross-sectional anatomy concerning radiotherapy, identify key anatomical features on x-ray/ CT images, role of radiotherapy in cancer treatment, benign and malignant tumours, primary and secondary tumours, metastasis and routes of metastases, tumour stage and grading, common cancer sites, identification of the abnormal size of organs due to primary tumours and metastases on radiological images, identification of organs at risk surrounding the tumours palliative and curative therapy,

accuracy requirement in radiotherapy, tissue tolerances, therapeutic gain, clinical targets, anatomical and physiological changes due to radiotherapy treatment, Patient-related clinical experiences. Familiarization with different professionals/ departments directly or indirectly involved in cancer radiation treatment.

References:

1. Radiobiology for the radiologists. By Erick J Hall 4th Edition
2. The physics of Radiology 4th Edition by Johns and Cunningham, Charless C Thomas Publishers Springfield, Illinois, USA
3. The Physics Of Radiation Therapy, 4th Edition By F.M.Khan.
4. Treatment Planning in Radiation Oncology 3rd Edition By F.M.Khan

External Beam Therapy & treatment planning (BIACH) 2credits

Beam collimation - asymmetric collimator - multileaf collimator - dose monitoring - electron contamination. AAPM TG 51 and other dosimetry protocols. Relative merits and demerits of kV x-rays, gamma rays, MV x-rays and electron beams. Radiotherapy simulator and its applications. CT and virtual simulations. Central axis dosimetry parameters - Tissue air ratio (TAR) Backscatter (BSF) - Percentage depth doses (PDD) - Tissue phantom ratio (TPR) - Tissue maximum ratio (TMR) - Collimator, phantom and total scatter factors. Relation between TAR and PDD and its applications - Relation between TMR and PDD and its applications. Off axis ratio- Build-up region and surface dose. Tissue equivalent phantoms. Radiation field analyzer (RFA). Description and measurement of isodose curves/charts.

Beam modifying and shaping devices - wedge filters - universal, motorized and dynamic wedges shielding blocks and compensators. Treatment planning in teletherapy - target volume definition

and dose prescription criteria- ICRU 50 and 62 - SSD and SAD setups - two and three-dimensional localization techniques - contouring - simulation of treatment techniques - field arrangements - single, parallel, opposed and multiple fields - corrections for tissue inhomogeneity, contour shapes and beam obliquity - integral dose. Arc/ rotation therapy and Clarkson technique for irregular fields - mantle
and inverted Y fields. Conventional and conformal radiotherapy. Treatment time and Monitor unit calculations. Clinical electron beams - energy specification - electron energy selection for patient treatment – depth dose characteristics (Ds, Dx, R100, R90, R50, Rp etc.) - beam flatness and symmetry - penumbra - isodose plots - monitor unit calculations - output factor formalisms - effect of air gap on beam
dosimetry - effective SSD. Particulate beam therapy - Relative merits of the electron, neutron, x-ray and gamma ray beams - Neutron capture therapy - Heavy ion therapy

References:

5. F. H. Attix. Introduction to Radiological Physics and Radiation Dosimetry, Wiley VCH, Verlog, 2004.
6. Radiobiology for the radiologists. By Erick J Hall 4th Edition
7. Absorbed dose determination in external beam therapy technical report series (TRS) - 381,374, 277 & 398

Brachytherapy Physics & Treatment planning (BIACH): 1 credit

Classification of brachytherapy techniques- surface mould, interstitial, intracavitary and intraluminal techniques. Requirement for brachytherapy sources-Description of Radium and radium substitutes commonly used brachytherapy sources. Dose rate considerations and classification of brachytherapy techniques- Low Dose Rate (LDR), High Dose Rate (HDR) and Pulsed Dose Rate (PDR). Paterson Parker and Manchester Dosage systems. ICRU 38 and 58 protocols. Specification and calibration of rachytherapy sources-RAKR and AKS-IAEA TECDOC 1274 and ICRU 72 recommendations. Point and line source dosimetry formalisms- Sievert Integral-AAPM TG- 43/43UI and other dosimetry formalisms.

After loading techniques - Advantages and disadvantages of manual and remote afterloading techniques. AAPM and IEC requirements for remote afterloading brachytherapy equipment. Acceptance, commissioning, and quality assurance of remote after loading brachytherapy equipment. ISO requirements and QA of brachytherapy sources. We integrated a brachytherapy unit.

Brachytherapy treatment planning - CT/MR based brachytherapy planning - GEC ESTRO recommendations - forward and inverse planning – DICOM image import/export from OT - Record & verification. Brachytherapy treatment for Prostate cancer. Ocular brachytherapy using photon and beta sources. Intravascular brachytherapy - classification - sources - dosimetry procedures - AAPM TG 60 protocol. Electronic brachytherapy

References:

1. Brachytherapy source calibration IAEA TEC.DOC.
2. F. H. Attix. Introduction to Radiological Physics and Radiation Dosimetry, Wiley VCH, Verlog, 2004.
3. Radiobiology for the radiologists. By Erick J Hall 4th Edition
4. Absorbed dose determination in external beam therapy technical report series (TRS) - 381,374, 277 & 398

Physics of Nuclear Medicine (BIACH) 1 credit

Introduction to Nuclear Medicine, Unsealed Sources, Production of Radionuclide used in Nuclear Medicine, Radionuclide Generators, and their operation principles. Various usages of Radiopharmaceuticals. In-vivo non-imaging procedures; Thyroid Uptake Measurements, Renogram, Life Span of RBC, Blood Volume studies etc. Historical development of Radionuclide Imaging.

The Rectilinear Scanner and its operational principle, Basic Principles and Design of the Anger Camera / Scintillation Camera; System components, Detector System and Electronics, Different types of Collimators, Design and Performance Characteristics of the Converging, Diverging and Pinhole Collimator, Image Display and Recording Systems, Digital Image Processing Systems, Scanning Camera, Limitation of the Detector System and Electronics. Different Imaging Techniques: Basic Principles, Two-dimensional Imaging Techniques, Three-Dimensional Imaging Techniques - Basic Principles and Problem, Focal Plane Tomography, Emission
Computed Tomography, Single Photon Emission Computed Tomography, Positron Emission Tomography. Various Image Reconstruction Techniques during Image formation such as Back Projection and Fourier based Techniques, Iterative Reconstruction method and their drawbacks. Attenuation Correction, Scatter Correction, Resolution Correction, Other requirements or Sources of Error. Spatial Resolution, Factor affecting Spatial Resolution, Methods of Evaluation of Spatial Resolution, Contrast, Noise. NEMA Protocols followed for Quality Assurance of Imaging Instruments.

In-vitro Technique: RIA/IRMA techniques and their principles.
Principles of PET, PET Instrumentations, Annihilation Coincidence Detection, PET Detector ad Scanner Design, Data Acquisition for PET, Data corrections and Quantitative Aspect of PET, Working of Medical Cyclotron, Radioisotopes Produced and their characteristics.
Treatment of Thyrotoxicosis, Thyroid cancer with I-131, use of P-32 and Y-90 for palliative treatment, Radiation Synovectomy and the isotopes used. Concept of Delay Tank and various Planning and Shielding Calculations during installing SPECT, PET/CT and Medical Cyclotron in the Nuclear Medicine Department.

Internal dosimetry:

Classical Methods of Dose Evaluation; Beta particle Dosimetry; Equilibrium Dose Rate Equation, Beta Dose Calculation Specific Gamma Ray Constant, Gamma Ray Dosimetry, Geometrical Factor Calculation, Dosimetry of Low Energy Electromagnetic Radiation. MIRD Technique for Dose calculations; Basic procedure and some practical problems, Cumulative Activity, Equilibrium Dose Constant, Absorbed Fraction, Specific Absorbed Fraction, Dose Reciprocity Theorem, Mean Dose per unit Cumulative Activity and Problems related to the Dose Calculations. Limitations of the MIRD Technique

References:

1. Physics of Nuclear medicine by Sorenson
2. Nuclear Medicine physics; The Basics, Ramesh Chandra, Indian edision, Lippincoii Williams & Wilkins,6th Edn,2004
3. Ramesh Chandra, Nuclear Medicine Physics (5th ed.), Lea & Febiger, Philadelphia.

<u>Radiological Mathematics (PHY) (2 Credits)</u>

Probability, Statistics and Errors

Probability - addition and multiplication laws of probability, conditional probability, population, variates, collection, tabulation and graphical representation of data. Basic ideas of statistical distributions frequency distributions, averages or measures of central tendency, arithmetic mean, properties of arithmetic mean, median, mode, geometric mean, harmonic mean, dispersion, standard deviation, root mean square deviation, standard error and variance, moments, skewness and kurtosis.

Application to radiation detection - uncertainty calculations, error propagation, time distribution between background and sample, minimum detectable limit. Binomial distribution, Poisson distribution, Gaussian distribution, exponential distribution - additive property of normal variates, confidence limits, Bivariate distribution, Correlation and Regression, Chi-Square distribution, T-distribution, F-distribution

Counting and Medical Statistics

Statistics of nuclear counting - Application of Poisson's statistics - Goodness-of-fit tests - Lexie's divergence coefficients, ¬Pearson's chi-square test and its extension - Random fluctuations ¬Evaluation of equipment performance - Signal-to-noise ratio - Selection of operating voltage - Preset of rate meters and recorders - Efficiency and sensitivity of radiation detectors - Statistical aspects of gamma-ray and beta ray counting - Special considerations in gas counting and counting with proportional counters - Statistical accuracy in double isotope technique. Sampling and sampling distributions - confidence intervals. Clinical study designs and clinical trials. Hypothesis testing and errors. Regression analysis.

References:

1. Simulation, fifth edition - Sheldon M Ross

Lasers and Photonics in Medicine (PHY) (2 Credits)

Course content: Laser Characteristics: Principle of laser, continuous and pulsed lasers, different types of lasers, laser beam characteristics.

Interaction of light and tissues: Optical properties of tissues (normal and tumour) - experimental methods to determine tissues' reflectance, transmittance, absorption and emission properties. Laser systems in medicine and biology - Nd-YAG, Ar ion, CO2, Excimer - Gold vapour laser - beam delivery system and control.

Surgical Application of lasers

Evaporation and excitation techniques - sterilization - hemostasis - laryngeal surgery - cancer surgery - liver surgery - stomach surgery - gynaecological surgery - urological surgery - cardiac surgery- lasers in Ophthalmology – Dermatology and Dentistry –cosmetic surgery.

Lasers in Diagnosis and Therapy

Trace elements detection – laser-induced fluorescence studies - cancer diagnosis - photo radiation therapy of tumours - lasers in endoscopy – lasers in laparoscopy – lasers in trapping of cells and genetic engineering - biosimulation.

References:

1. Niemz, Markolf H. Laser-tissue interactions. Springer-Verlag Berlin Heidelberg, 2007. 4th Edition
2. Keiser, Gerd. Biophotonics-Concepts to Applications. Singapore: Springer, 2016.
3. Tuchin, Valery V., ed. Handbook of photonics for biomedical science. CRC Press, 2010.

Solid State Physics and Electronics Lab (PHY) 2 credits

Course Content:

- Applications of Diode
- Applications of Transistor
- Arduino Experiments
- Boolean Logic Operations using Digital ICs
- CHARACTERISTIC OF SCR and DIAC
- Characteristics of MOSFET
- Code Conversion
- Opamp
- Study of Latches and Flip-flops
- Amplitude Modulation And Demodulation
- Zeeman effect
- X-Ray Diffraction Experiments -I
- X-Ray Diffraction Experiments -II
- Electron diffraction
- Measurement of the dielectric constant of the sample with microwaves
- Magnetostriction with the Michelson interferometer
- Four probe method to measure the resistivity of a sample
- E.S.R and N.M.R.

References

1. Agarwal & Lang - Foundations of analog and digital electronic circuits
2. Millman & Halkias - Integrated electronics
3. Malvino & Bates - Electronic Principles
4. Gayakwad - Op-Amps & Linear integrated circuits

Medical Physics Lab I (BIACH) 3credits

1. Calibration of therapy level dosimeter using the cross-calibration method.
2. Dose output measurement of photon beams used in radiotherapy treatment.
3. Dose output measurement of electron beams used in radiotherapy treatment.
4. Determination of percentage depth dose of photon and electron beams.
5. AKS/ RAKR measurement of HDR brachytherapy sources using well type and cylindrical ionisation chambers.
6. Quality assurance in HDR brachytherapy
7. Familiarisation with treatment planning procedures using a computerised radiotherapy treatment planning system.
8. Dose planning in cancer of the uterine cervix
9. Determination of radiation field, flatness, symmetry and penumbra of external photon beam using RFA
10. Dose verification in IMRT using absolute dosimetry
11. Verification of mechanical and radiation isocentre of a teletherapy machine
12. Absorption and backscattering of gamma rays – Determination of HVT
13. Radiation protection survey of medical accelerator installation
14. Radiation protection survey of brachytherapy installation
15. Leakage level measurement of teletherapy equipment
16. Radiation protection survey of diagnostic radiology installations
17. Leakage level measurement of a diagnostic x-ray machine
18. Survey of a radioisotope laboratory and study of surface contamination.

References:

1. Radiation Therapy By James N Parker and Philip M Parker
2. The physics of Radiology 4th Edition by Johns and Cunningham, Charless C Thomas Publishers Springfield, Illinois, USA
3. The Physics Of Radiation Therapy, 4th Edition By F. M. Khan

Semester 4

Commissioning and Quality control Standards for Radiation Therapy Equipment (BIACH) 2 credits.

QA in radiation therapy, acceptance, commissioning, and quality assurance of telecobalt, medical linear accelerator and radiotherapy simulators - precision and accuracy in clinical dosimetry-quality. Portal and invivo dosimetry. Electronic portal imaging devices.

Scope of computers in treatment planning- Review of the algorithms used for treatment planning computation – Pencil beam, Clarkson method, convolution, superposition, fast Fourier transform, Monte Carlo-based algorithms. Treatment planning calculations. Plan optimization-direct aperture optimization- beamlet optimization- simulated annealing- dose volume histograms-Indices used for plan comparisons- hardware and software requirements, Networking, DICOM and PACS. Acceptance, commissioning and quality assurance of radiotherapy treatment planning systems.

References:

4. Radiation Therapy By James N Parker and Philip M Parker
5. The physics of Radiology 4th Edition by Johns and Cunningham, Charless C Thomas Publishers Springfield, Illinois, USA
6. The Physics Of Radiation Therapy, 4th Edition By F.M.Khan.
7. Intensity Modulated Radiation Therapy By Steve Webb, Institute of Physics Publishing Bristol and Philadelphia
8. The Modern Technology Of Radiation Oncology By Jacob Vandyk

Advanced Radiation Therapy techniques (BIACH) 2 credits

Intensity Modulated Radiation Therapy (IMRT)- principles- MLC-based IMRT- Step and shoot and sliding window techniques- immobilization for IMRT – CT simulation & planning process- inverse treatment planning- - dose verification phantoms, dosimeters, protocols and procedures-machine and patient specific QA, Volumetric modulated Arc Therapy, Image Guided Radiotherapy (IGRT)- concept, Imaging modality, kV cone beam CT (kVCT), MV cone beam CT (MVCT), image registration, plan adaptation, QA protocol and procedures- 4DCT- Respiratory gated Radiotherapy- Tomotherapy- principle- imaging- planning and dosimetry- delivery- plan adaptation- QA protocol and procedures.Physics, immobilization, CT-simulation, planning & quality assurance aspects of SRS/SRT, SBRT - Total body irradiation (TBI).

References:

1. The physics of Radiology 4th Edition by Johns and Cunningham, Charless C Thomas Publishers Springfield, Illinois, USA
2. The Physics Of Radiation Therapy, 4th Edition By F.M.Khan.
3. Intensity Modulated Radiation Therapy By Steve Webb, Institute of Physics Publishing Bristol and Philadelphia
4. The Modern Technology Of Radiation Oncology By Jacob Vandyk

Radiation Hazards, Standards and Professional Aspects (BIACH) 2 credits

Standards:

Radiation dose from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards - Historical background - International Commission on Radiological Protection and its recommendations – The system of Radiological Protection – Justification of Practice, Optimization of Protection and individual dose limits – Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose – Concepts of collective dose- Potential exposures, dose and dose constraints –– Occupational, Public and Medical Exposures - Permissible levels for neutron flux - Factors governing internal exposure - Radionuclide concentrations in air and water - ALI, DAC and contamination levels - Familiarization with regulatory requirements safety codes and guides; Responsibilities and duties of a Medical Physicist and radiological safety officer (RSO) in radiotherapy.

Radiation Hazard Evaluation, Control & emergency preparedness

Evaluation of external radiation hazards - Effects of distance, time and shielding – Shielding calculations - Personnel and area monitoring - Internal radiation hazards – Understanding the methods for minimizing the dose to critical sites of the patients- Radio toxicity-– Control of contamination – air monitoring – Radiation accidents & emergencies and preparedness - Experience in handling emergencies

Planning of Radiation installations as per the safety and regulatory guidelines (BIACH) 1 credit

Design of diagnostic, telegamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories – Radiation monitoring procedures- Radiation hazards in brachytherapy, teletherapy departments and radioisotope laboratories- Handling of patients - Protective measures to reduce radiation exposure to staff and patients

References:

1. Christensen's Physics of Diagnostic Radiology; Christensen (Lea & Febiger) B.H. Brown, R.H. Smallwood, D.C. Barber, P.V. Lawford and D.R. Hose (1990)
2. Practical Radiotherapy planning-Dobbs (1999); Vora Medical publishers, Mumbai
3. The Physics Of Radiation Therapy, 4th Edition By F.M.Khan.
4. Treatment Planning in Radiation Oncology 3rd Edition By F.M.Khan

Handling of Radioactive materials (BIACH) 2credits

Radioactive Waste Disposal

Radioactive wastes – sources of radioactive wastes - Classification of waste - Treatment techniques -for solid, liquid and gaseous effluents – Permissible limits for disposal of waste - Sampling techniques for air, water and solids – Geological, hydrological and meteorological parameters – Disposal of radioactive wastes - General methods of disposal - Management of radioactive waste in medical establishments.

Decommissioning of radiation facility & Transport of Radioisotopes

Familiarization with national regulations about procurement, use and decommissioning of different radiotherapy equipment and sources - Transportation of radioactive substances - - General packing requirements – source transfer operations -Transport documents - Labeling and marking of packages - Regulations applicable for different modes of transport - Transport emergencies - - Exemptions from regulations – Shipment approval –Shipment under exclusive use – Transport under the special arrangement – Consignor's and carrier's responsibilities - Import, Export procedures.

Legislation & regulatory requirements

Physical protection of sources - Safety and security of sources during storage and use – Security provisions: administrative and technical – Security threat and graded approach National legislation – Regulatory framework – Atomic Energy Act – Atomic Energy (Radiation Protection) Rules – Applicable Safety Codes, Standards, Guides and Manuals – Regulatory Control – Licensing, Inspection and Enforcement – Responsibilities of Employers, Licensees, Radiological Safety Officers and Radiation Workers – Submission of safety status report to AERB – ASR, Unusual occurrences, source loss etc. Maintenance of records QA, calibration certificates of equipment, source inventory, personnel dose records, and protection survey. Orientation for RSO certification examination

Radiation dose from natural radioactivity in the environment and man-made sources. Basic concepts of radiation protection standards - Historical background - International Commission on Radiological Protection and its recommendations – The system of Radiological Protection – Justification of Practice, Optimization of Protection and individual dose limits – Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose – Concepts of collective dose- Potential exposures, dose and dose constraints –– Occupational, Public and Medical Exposures - Permissible levels for neutron flux - Factors governing internal exposure - Radionuclide concentrations in air and water - ALI, DAC and contamination levels - Familiarization with regulatory requirements safety codes and guides; Responsibilities and duties of a Medical Physicist and radiological safety officer (RSO) in radiotherapy.

Radiation Hazard Evaluation, Control & emergency preparedness

Evaluation of external radiation hazards - Effects of distance, time and shielding – Shielding calculations - Personnel and area monitoring - Internal radiation hazards – Understanding the methods for minimizing the dose to critical sites of the patients- Radio toxicity-– Control of contamination – air monitoring – Radiation accidents & emergencies and preparedness - Experience in handling emergencies

References:

1. Mckenzie. Radiation Protection in Radiotherapy
2. Atomic Energy Act 1962
3. AERB Radiation Protection Rules 2004
4. ICRP 1990 Recommendations
5. ICRP 2007 Recommendations
6. IAEA Basic Safety Standards 115, 1997
7. Shapiro J. Radiation Protection

Medical Physics Lab II (BIACH) 3 credits

1. CT simulation & planning of SRS/SRT
2. Estimation of transmission factor for wedges and blocks of a linear accelerator
3. Quality assurance in high-energy linear accelerator
4. Intracavitary brachytherapy planning & calculation using the 2D treatment planning system
5. Computerized treatment planning for 3D conformal Radiotherapy
6. Computerized CT-based planning for HDR Intracavitary brachytherapy
7. Computerized treatment planning for HDR interstitial implant brachytherapy
8. QA of Intensity Modulated Radiotherapy plan using 2D/3D dosimetry (2D array)
9. Computerized treatment planning for Tomotherapy
10. Radiation protection survey of Tomotherapy installation
11. CT simulation of Total body irradiation
12. Treatment planning of TBI using Tomotherapy
13. QA aspects of TBI
14. Design & Installation planning of high-energy linear accelerator
15. Design &Installation planning of High Dose Rate brachytherapy
16. Design &Installation planning of Diagnostic CT scanner
17. Design &Installation planning of Nuclear Medicine High Dose Therapy
18. Design & Installation planning of PET-CT scanner
19. 4D – CT simulation & planning in ca Lung
20. SBRT planning and evaluation

References:

9. Radiation Therapy By James N Parker and Philip M Parker
10. The physics of Radiology 4th Edition by Johns and Cunningham, Charless C Thomas Publishers Springfield, Illinois, USA
11. The Physics Of Radiation Therapy, 4th Edition By F.M.Khan.

Computational modelling of biological systems (PHY) (2 Credits)

Course content:

Introduction to Nonlinear Dynamics - phase plane analysis, Stability Analysis, Bifurcations, Limit cycles etc.

Biochemical Kinetics- enzyme kinetics, regulation of enzyme activity, Michaelis-Menten model, Bistability, Growth models

Gene regulation and Network modelling- metabolic networks, modelling signal transduction pathways, Oscillatory gene networks, genetic switches - mechanisms and some examples, cell-cell communication - reaction-diffusion, Turing patterns

Mechanical models – Force generation in a biological system, Vicsek model of active fluids, Toner-Tu theory, mechanics of epithelial tissues, vertex modelling.

References

1. Nonlinear dynamics and Chaos - Strogatz
2. Enzyme Kinetics for Systems Biology - H.M. Sauro
3. Kinetic Modeling in Systems Biology - Demin and Goryanin
4. Relevant research papers