D. Y. PATIL EDUCATION SOCIETY, KOLHAPUR
(DEEMED TO BE UNIVERSITY)

Centre for Interdisciplinary Research
Department of Medical Physics

M.Sc. Medical Physics

(Credit System)

BL-MP-01- About the course

M. Sc. Medical Physics course is basically a two years course which is approved by Atomic Energy Regulatory Board (AERB), Government of India. M. Sc. Medical Physics course, being a specialization course designed to train the young pool of PG students as qualified medical physicist and radiation safety officers (RSO) in the field of cancer radiation therapy. Medical physics is one of the fastest growing areas of employment for physicists. They play a crucial role in radiology, radiation therapy and nuclear medicine. These fields use very sophisticated and expensive equipment and medical physicist or responsible for much of its plan, execution, testing and quality assurance.

The M.Sc. Medical Physics students are getting the exposures form the various cancer hospitals during practical and their M.Sc. Project work. Our students are exposed to field training in various cancer hospitals all over India. After completion of the 2 years course, students undergo one-year internship according to AERB regulations in order to work as a Medical Physicist in the hospital.

BL-MP-02- Vision Mission and Goal

Vision: "To offer diverse Medical Physics program to establish and maintain the standards of the students of Medical Physics in the disciplines of Diagnostic Imaging, Radiation Oncology and Nuclear Medicine".

Mission: To promote professional growth by offering state-of-the-art postgraduate program in Medical Physics in India and abroad.

Goals:

- The goal of the course is to cultivate an educational environment which provides the full spectrum of learning opportunities in clinical medical physics, radiation oncology and radiobiology.
- The curriculum is flexible and designed to enable a student to optimize their learning experience throughout their two years program.
- It is an expectation that upon the completion of the program a student will be an outstanding "Radiation Oncology Physicist" capable of making an immediate impact in either an academic or community practice setting.

BL-MP-03- Outcome of the program

- The student will be well versed with the concept of Physics (specifically radiation e.g., X-rays, Gamma rays etc.) which can be used for medical applications.
- The student will learn different advanced techniques (e.g., 3D CRT, IMRT, IGRT, Brachy therapy, etc.) involved in the treatment of cancer.
- Culture of Interdisciplinary research will be seeded through collaborations with various Cancer hospitals.

Students will get the job opportunities as below:

- The students have tremendous opportunities to work as a clinical medical physicist in various leading hospitals all over India with attractive salary packages.
- The students have opportunities to work as an Assistant Professor where there are courses of M.Sc. Medical Physics.
- The students can work as a Scientist in the Research institutes.
- The students can also work as dosimetrists in various companies providing radiation measuring devices.
- The students also have opportunities to pursue higher studies in India and abroad in related field.

BL-MP-04- Syllabus

Course Structure & Distribution of Credits.

M.Sc. Medical Physics Program consists of total 16 theory courses, total 4 practical lab courses spread over 4 semesters. 16 theory courses and 4 practical lab courses and one project will be common and compulsory to all the students. Each theory course will be of 4 (four) credits, a practical lab course will be of 4 (four) credits and a project will be of 8 (eight) credits. A student earns 24 (twenty-four) credits per semester and total 96 (ninety-six) credits in 4 semesters. The course structure is as follows,

Theory Courses

Semester-I	Paper I	Paper-II	Paper-III	Paper-IV
	Mathematical Physics (MP101)	Solid State Physics (MP102)	Electronics and Instrumentation (MP 103)	Classical and Quantum Mechanics (MP 104)
	Paper-V	**Paper-VI**	**Paper-VII**	**Paper-VIII**
Semester-II	Electrodynamics (MP201)	Nuclear Physics (MP 202)	Radiation Physics & Radiation (MP 203)	Anatomy and Physiology (MP 204)
	Paper-IX	**Paper-X**	**Paper-XI**	**Paper-XII**
Semester-III	Radiation Detectors and Instrumentation (MP 301)	Radiation Dosimetry and Standardization (MP 302)	Clinical and Radiation Biology (MP 303)	Medical Imaging (MP 304)
	Paper-XIII	**Paper-XIV**	**Paper-XV**	**Paper-XVI**
Semester-IV	Nuclear Medicine and Internal Dosimetry (MP 401)	Radiation Therapy - Teletherapy (MP 402)	Radiation Therapy-Brachytherapy (MP 403)	Radiation Safety (MP 404)

One Year – Residency Training
On successful completion of M. Sc. Medical Physics course, all students are required to undergo **one-year** internship at AERB recognized institutes. This is a mandatory requirement for becoming qualified medical physicists and appearing in the RSO examination.

Practical Lab courses

Semester-I	Lab course 1	Group A (MPP101)	Group B (MPP102)
Semester-II	Lab course 2	Group A (MPP201)	Group B (MPP202)
Semester-III	Lab course 3	Group A (MPP301)	Group B (MPP302)
Semester-IV	Lab course 4	Practical (MPP401)	Project (MPP402)

PROGRAM OUTCOMES
After completion of the program, the student will be able to:

Program outcome (PO)	
PO1	Knowledge and Skills
PO2	Planning and Problem-solving abilities
PO3	Communication
PO4	Research Aptitude
PO5	Professionalism and Ethics
PO6	Leadership
PO7	Societal Responsibilities
PO8	Environment and Sustainability
PO9	Lifelong Learner

PO1. Possess knowledge of basics human anatomy, Nuclear & Radiation Physics, Diagnostic radiology, Radiotherapy, Brachytherapy, Nuclear Medicine, Radiation Detection, Dosimetry, Radiation Biology, and Radiation Safety as recommended by the Atomic Energy Regulatory Board (AERB) Mumbai / International Regulatory agencies.

PO2. Demonstrate an ability to apply the knowledge acquired through the state-of-the art radio therapeutic techniques and medical imaging for providing and ensuring safety treatment for the needy human.

PO3. Develop communication skills to communicate effectively in interviews, patient, colleagues, healthcare sector, industries, academia for collaborative research by explaining their ideas with good interpersonal and workplace-based skills.

PO4. To do research in radiation application in cancer treatment, Radiation Measurement, Radiation Biology, Artificial Intelligence application on Radiation Therapy, Cancer diagnosis, handling and maintenance radiation therapy installation and instrumentation.

PO5. Develop understanding and implementation of ethics in profession, research, society, workplace, clinical research and human trials.

PO6. Develop leadership skills, to work effectively and efficiently, logical reasoning, time management, values required for self- directed and lifelong learning, soft skills for professional development and execute their professional roles in society as Medical Physicist/Radiation Safety officers.

PO7. Develop character with good moral values, human values, good social behavior, gratitude, honesty, ethics, safety, hygiene, responsibility, confidence, tolerance and critical thinking.

PO8. Able to contribute in environment and sustainable development to achieve the national sustainable development goals.

PO9. This course is helpful for lifelong learning in Medical Physics stream.

Semester I

M.Sc. Medical Physics Program for Semester-I consists of four theory courses and one laboratory course consisting two groups of practical. The details are as follows:
Theory Courses (4): 16 hours per week (One lecture of one-hour duration)

Theory Paper	Subject	Lectures (h)	Credits
Paper I: MP101	Mathematical Physics	60	04
Paper II: MP102	Solid State Physics	60	04
Paper II: MP103	Electronics and Instrumentation	60	04
Paper IV: MP104	Classical and Quantum Mechanics	60	04
Total		**240**	**16**

Practical lab courses (2): 16 hours per week

Practical Lab Course 1	Practical Lab Sessions (h)	Credits
MPP101 (Group A)	120	04
MPP102 (Group B)	120	04
Total	240	08

Course Outcome
Paper I: MP101: Mathematical Physics

At the end of the course student will be able to:

CO1. Comprehend the knowledge of matrices, differential equations, integral transforms and its special functions to enable problem analysis and solving.
CO2. To understand the various special functions of differential equations and Fourier integral transform.
CO3. Understand the probability and statistical distributions, Central tendency, computational programming to collect, analyse, interpret data, and apply relevant statistical tests to make a scientific report.
CO4. To understand the deviation and distribution for various physical data.
CO5. To provide the correlation and regression analysis to find the relation between two sets of data.
CO6. To teach various types of statistical distribution and uses for small to very large sampling sizes.

Paper II: MP102: Solid State Physics
At the end of the course student will be able to:

- **CO1.** Understand the basics of crystal structure and its various types of bonding.
- **CO2.** Know about the band structure in conductor, direct and indirect semiconductor and insulator.
- **CO3.** Understand the basic physics of solids such as thermal behaviour and magnetic characteristics in view of its usage in medical instrumentation.
- **CO4.** Learn the Einstein's, Debye's theories and lattice vibrations.
- **CO5.** Learn phenomenon of superconductivity, fluorescence and phosphorescence, thermo luminescence, Electroluminescence and to identify, analyse and solve the problem associated with it.
- **CO6.** Understand the superconductivity and various types of luminescence, Fluorescence and Phosphorescence and LASER etc.,

Paper III: MP103: Electronics and Instrumentation
At the end of the course student will be able to:

- **CO1.** Know the concepts various junction like p-n, BJT, JEFT, MOSFET, UJT and SER.
- **CO2.** To understand the various diode construction and its circuits.
- **CO3.** Understand the principles of various Oscillators for constructing electronic circuits.
- **CO4.** To know functioning of transducers and thermos couple-based thermometers.
- **CO5.** Capable of how the logic and integrated circuits digital data is generated.
- **CO6.** Explain the concepts of amplifier AC-DC converter, various dose rate meters and radiation detectors circuits.

Paper IV: MP104: Classical and Quantum Mechanics
At the end of the course student will be able to:

- **CO1** Learn the basic mathematical tools like variation calculus to mechanical systems and able to compute Lagrangian and Hamiltonian equation of motion.
- **CO2** Understand about the central force problem, phase space, canonical transformation and Hamilton Jacobi technique.
- **CO3** Solve the hydrogen atom problem to calculate energy levels by quantum mechanics.
- **CO4** Learn the Schrodinger equations to solvable simple problems.
- **CO5** Understand the quantum mechanical angular momentum algebra and spin.
- **CO6** Compute corrections in energy and wave functions by approximation technique

Semester II

M.Sc. Medical Physics Program for Semester-II consists of four theory courses and one laboratory course consisting two groups of practical. The details are as follows:
Theory Courses (4): 16 hours per week (One lecture of one-hour duration)

Theory Paper	Subject	Lectures (h)	Credits
Paper V: MP201	Electrodynamics	60	04
Paper VI: MP202	Nuclear Physics	60	04
Paper VII: MP203	Radiation Physics and Radiation Generators	60	04
Paper VIII: MP204	Anatomy and Physiology	60	04
Total		240	16

Practical lab courses (2): 16 hours per week

Practical Lab Course 2	Practical Lab Sessions (Hrs)	Credits
MPP201 (Group A)	120	04
MPP202 (Group B)	120	04
Total	240	08

Paper V: MP201: Electrodynamics
At the end of the course student will be able to:

CO1. Interpret the deeper meaning of the Maxwellian field equations and account for their symmetry and transformation properties. Define and derive expressions for the energy both for the electrostatic and magneto statics fields.
CO2. Learn the basics of analog electronics such as ICs, CCDs, RC and LC
CO3. Calculate the electromagnetic radiation from localised charges which move arbitrarily in time and space, taking into account retardation effects. Formulate and solve electrodynamic problems in relativistically covariant form in four-dimensional space time
CO4. Learn the transmission of electromagnetic waves through wave guide.
CO5. Understand the basics of electromagnetic radiations, particle accelerators and radiation reactions.
CO6. Know the electric, magnetic fields, electric potential and vector potentials for point charge and radiation emitted by moving charges.

Paper VI: MP202: Nuclear Physics
At the end of the course student will be able to:

- **CO1.** Familiarize with the properties of an atom and nucleus to know various interesting branches such as radioactivity, fission and fusion reactions, nuclear reactors, nuclear power plants, particle physics etc. that has huge applications for the benefits of society.
- **CO2.** Gain knowledge how ionizing radiation interacts with matter, how it affects living organisms and how it is used as a therapeutic technique and radiation safety practices.
- **CO3.** Understand the nuclear models and various decay process like Alpha, Beta, and Gamma.
- **CO4.** Familiarize with the electromagnetic spectrum, radiation sources, types and its properties.
- **CO5.** Learn the various nuclear reactions by examples and experiments.
- **CO6.** Familiarize with the four basics of in nature, its relative strength and various classification of elementary particles.

Paper VII: MP203: Radiation Physics and Radiation Generators
At the end of the course student will be able to:

- **CO1.** Understand the basic of radioactivity, Natural radioactive series, Artificial production of radioactivity and various decay modes.
- **CO2.** Gain functional knowledge regarding need for radiological protection and the sources and approximate level of radiation exposure for treatment purposes.
- **CO3.** To learn the construction and working of different types of particle accelerators.
- **CO4.** Learn the construction of X-ray generator used in Diagnostic radiology.
- **CO5.** Learn the various ionizing radiation interaction with matter (Electron, Photon, Neutron).
- **CO6.** To learn the penetration and linear energy stopping powers of various radiations.

Paper VIII: MP204: Anatomy and Physiology
At the end of the course student will be able to:

- **CO1.** Learn about the human anatomy, physiology and biophysics, exploring its performance as a physical machine.
- **CO2.** Understand the digestive system and its functions
- **CO3.** To study cell, tissue and bony structures and functions.
- **CO4.** To learn about mouth, teeth, oesophagus, stomach, small and large intestine, blood circulatory system and function of heart.
- **CO5.** To understand the respiratory, reproduction and excretory system.
- **CO6.** To know the importance of pituitary gland, brain and spinal cord functions.

Semester III

M.Sc. Medical Physics Program for Semester-III consists of four theory courses and one laboratory course and a project equivalent to one laboratory course. The details are as follows:
Theory Courses (4): 16 hours per week (One lecture of one-hour duration)

Theory Paper	Subject	Lectures (h)	Credits
Paper IX: MP 301	Radiation Detectors and Instrumentation	60	04
Paper X: MP 302	Radiation Dosimetry and Standardization	60	04
Paper XI: MP 303	Clinical and Radiation Biology	60	04
Paper XII: MP 304	Medical Imaging	60	04
Total		240	16

Practical lab courses (2): 16 hours per week

Practical Lab Course 3	Practical Lab Sessions (h)	Credits
MPP301 (Group A)	120	04
MPP302 (Group B)	120	04
Total	240	08

Paper X: MP301: Radiation Detectors and Instrumentation
On successful completion of the course, the students will be able to:

CO1 Describe the principle of radiation detection which includes design and construction, working principle of various detectors

CO2: Get knowledge about the detector to be used for different radiation types.

CO3 Explain about Radiation measuring & monitoring instruments and their physical significance.

CO4 Explain about instruments used for personnel monitoring (Radiation worker's dose monitoring) and area monitoring (Radiation facility survey- to evaluate the radiation level in workplace and follow the safety precautions).

CO5 Acquire knowledge on how to take radiation safety precautions while dealing with unsealed radioactive sources and familiar with dose measuring and monitoring instruments used in nuclear medicine department.

CO6. Know about contamination monitors for alpha and beta radiations and their use in various places.

Paper X: MP302: Radiation Dosimetry and Standardization
At the end of the course student will be able to:

CO1. Learn the basics units of radiation, natural and artificial radioactive source productions.
CO2. Understand the Technical Report Serious-277 & Technical Report Serious-399 protocols and its formalism.
CO3. Understand the primary & secondary standards Neutron dosimeters, working principles of GM counter and chemical dosimetry for its clinical applications.
CO4. Understand the standardization of HDR- ^{192}Ir, ^{60}Co and ^{125}I.
CO5. Know the chemical dosimetry and its applications in radiation measurements.
CO6. Learn the various radiation counting instruments like beta, gamma, and GM counters.

Paper XI: MP303: Clinical and Radiation Biology
At the end of the course student will be able to,

CO1. Understand the structure and behaviour of normal and abnormal cells, Gain the knowledge about the biological effects of radiation.
CO2. Understand the various therapies such as radiation therapy, chemotherapy, Hormone therapy and immunotherapy for cancer treatment and understand the 4Rs of radiation biology and time dose relationship of tumour.
CO3. Understand the ionizing radiation effects on living organisms
CO4. Know the radio-biological impact on living cells, tissue at the DNA, cellular, organ, and whole body.
CO5. Understand the radiobiological model of fractionated radiation therapy.
CO6. Understand the optimization of the Radiotherapy plans through biological aspects to enhance clinical outcome.

Paper XII: MP304: Medical Imaging
At the end of the course student will be able to,

CO1. Learn the physical principle and components of conventional and digital radiography techniques including Computed Tomography (CT), MRI and Ultrasound Imaging.
CO2. Understand the fundamentals of physics with emphasis on medical imaging
CO3. Learn physical principles of diagnostic radiology, radiography techniques, image quality and quality assurance.
CO4. Learn the basics of thermography and its applications
CO5. Understand the various radio pharmaceuticals, thyroid uptake system, and gamma camera.
CO6. Know the radioactive dilution methods to identify the unknown subject radioactivity.

Semester IV

M.Sc. Medical Physics Program for Semester-IV consists of four theory courses and one laboratory course and a project equivalent to one laboratory course. The details are as follows:
Theory Courses (4): 16 hours per week (One lecture of one-hour duration).

Theory Paper	Subject	Lectures (h)	Credits
Paper XIII: MP401	Nuclear Medicine and Internal Dosimetry	60	04
Paper XIV: MP402	Radiation Therapy- Teletherapy	60	04
Paper XV: MP403	Radiation Therapy- Brachytherapy	60	04
Paper XVI: MP404	Radiation Safety	60	04
	Total	240	16

Practical lab courses (2):16 hours per week

Practical Lab Course 4	Practical Lab Sessions (h)	Credits
MPP401 (Practical)	120	04
MPP402 (Project)	120	04
Total	240	08

The candidate shall be awarded the degree of Master of Science in Medical Physics after completing the course and meeting all the evaluation criteria.
(On successful completion of M. Sc. Medical Physics course, all students are required to undergo **one-year** internship at AERB recognized institutes. This is a mandatory requirement for becoming qualified medical physicists and appearing in the RSO examination).

Paper XIII: MP401: Nuclear Medicine and Internal Dosimetry
At the end of the course student will be able to:

- **CO1.** Gain knowledge about different imaging techniques such as PET; evaluate image quality parameters (resolution, contrast, and noise) using quality assurance techniques.
- **CO2.** Learn about Internal dosimetry and the production of radionuclide for its uses in Nuclear Medicine.
- **CO3.** Gain knowledge about the radionuclides production and their application in Nuclear Medicine and In-vivo and in-vitro techniques.
- **CO4.** Understand about the radionuclide imaging techniques.
- **CO5.** Learn the principles of PET/SPECT and their working principle.
- **CO6.** Learn the basics of Internal dosimetry and its dose evaluation techniques.

Paper XIV: MP402: Radiation Therapy-Teletherapy
At the end of the course student will be able to:

CO1. Know about development of kV beam therapy and ^{60}Co treatments, working principles of the beam modifying devices, clinical electron beams and its applications, various quality assurance used in radiation therapy departments.
CO2. Know the basics of radiation beam central axis dosimetry parameters, beam modifiers and shaping devices.
CO3. Learn the role of radiation therapy for the treatment of various cancers.
CO4. Understand the specialized procedures of radiation therapy for cancer treatment.
CO5. Learn the modern radiation dose delivery techniques, such as IMRT, IGRT, rotational therapy, SRS/SRT, TBI, TSET, and SBRT.
CO6. Know about the machine commissioning, quality, dosimetry and treatment planning.

Paper XV: MP403: Radiation Therapy-Brachytherapy

At the end of the course student will be able to,

CO1. Understand various brachytherapy techniques used in cancer treatment, AAPM Task Group 60 Protocols, Computers and its applications in brachytherapy treatment planning such as algorithm's, DICOM, PACS etc.,
CO2. Understand the various classification of brachytherapy by treatment time, placement of source, manual or remote after loading, Low dose rate or High dose rate etc.,
CO3. Learn the brachytherapy special techniques and treatment planning.
CO4. Understand the special advance techniques in radiotherapy which includes Total Skin Electron Therapy (TSET), Stereotactic radiosurgery/ radiotherapy (SRS/SRT), Intensity Modulated Radiation Therapy (IMRT), and Image Guided Radiation Therapy (IGRT) etc.,
CO5. Understand the different types of protocols used in brachytherapy techniques.
CO6. Understand the computers and their application in treatment planning systems.

Paper XVI: MP404: Radiation Safety

At the end of the course student will be able to:

CO1. Understand the basics of radiation protection standards, ICRP recommendations as ALARA principle, radiation accidents, how to control radiation hazards and safety precautions and principles of monitoring.

CO2. Describe about safety in the medical, industrial, agricultural and research uses of radiation.

CO3. Learn different applications of radio isotopes in industry (industrial radiography, well logging, gamma irradiators).

CO4. Understand the principles of radioactive waste management and different disposal facilities for radioactive waste.

CO5. Learn about the principals of safe transportation of radioisotopes and the standard procedures and safety protocols for these activities.

CO6. Acquire knowledge about legislation, atomic energy act (radiation protection), radiation emergencies and their medical management.

Semester –I

PAPER I: MP101: MATHEMATICAL PHYSICS (60 lectures, 4 credits)

UNIT I: MATRICES AND DIFFERENTIAL EQUATIONS (15 h)

Matrices, inverse, orthogonal and unitary matrices, independent elements of a matrix, eigenvalues and eigenvectors, diagonalization, complete orthonormal sets of functions second order linear ODEs with variable coefficients, solution by series expansion, Calay-Hamilton theorem and applications, similar matrices and diagonalizable matrices, eigen values of some special complex matrices, quadratics forms, problems

UNIT II: SPECIAL FUNCTIONS OFDIFFERENTIAL EQUATIONS AND INTEGRAL TRANSFORMS (15h)

Legendre, Bessel, Hermite and Laguerre equations, physical applications, generating functions, recursion relations, Laplace transform, first and second shifting theorems, inverse LT by partial fractions, LT of derivative and integral of function. Complete orthonormal set of second order differential equation

UNIT III: PROBABILITY, STATISTICS, AND ERRORS (15 h)

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. Statistics of nuclear counting: Application of Poisson's statistics - goodness-of-fit tests -Lexie's divergence coefficients, Pearson's chi-square test and its extension, random fluctuations, evaluation of equipment performance, Signal-to-noise ratio, selection of operating voltage, preset of rate meters and recorders, efficiency and sensitivity of radiation detectors, statistical aspects of gamma ray and beta ray counting, special considerations in gas counting and counting with proportional counters, statistical accuracy in double isotope technique, sampling and sampling distributions, confidence intervals, clinical study designs and clinical trials, hypothesis testing and errors, regression analysis.

UNIT IV: NUMERICAL METHODS, COMPUTATIONAL TOOLS & TECHNIQUES (15 h)

Need for 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 1/3rule, Simpson's 3/8rule, Boole rule, Weddle rule, initial value problems, Picard's method, Taylor's method, 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.

BOOKS FOR STUDY AND REFERENCE:

1. Pipes L.A. & L.R. Harvil, Applied Mathematics for Engineers and Physicists (3rd Edition), Mc Graw-Hill Book Co., New York, 1970.
2. Mary. L. Boas, Mathematical methods in the Physical Sciences (2nd edition), John Wiley & Sons., New York, 1983.
3. E. Butkov, Mathematical Physics, Addison Wesley, New York, 1973.
4. E. Walpole, R.M. Myers, S.L. Myers, K. Ye, "Probability & Statistics for Engineers and Scientists (9th edition)", Pearson Education, 2012.
5. Sathya Prakash, Mathematical Physics, Sultan Chand & Co., New Delhi, 2004.
6. M.K. Venkatraman, Advanced Mathematics for Engineers & Scientists, National Publishing co., Madras, 1994.
7. G. Arfken and H.H. Weber, Mathematical Methods for Physicists (4th edition), Prism Books, Bangalore, 1995.

PAPER II: MP102: SOLID STATE PHYSICS (60Lectures, 4 credits)

UNIT I: CRYSTAL STRUCTURE AND BONDING OF SOLIDS (15 h)

Crystalline and amorphous solids, translational symmetry, Elementary ideas about crystal structure, lattice and bases, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, lattice planes, simple cubic, fcc. and bcc, lattices, Laue and Bragg equations. determination of crystal structure with X-rays, Seven crystal systems and 14 Bravais lattices, Wigner-seitz unit cell Different types of bonding- ionic, covalent, metallic, Van-der Waals and hydrogen, band theory of solids, periodic potential and Bloch theorem, energy band structure.

UNIT II: STRUCTURE OF SOLIDS, DIELECTRIC, AND MAGNETIC PROPERTIES OF MATERIAL (15 h)

Band structure in conductors, direct and indirect semiconductors and insulators (qualitative discussions); free electron theory of metals, effective mass, drift current, mobility and conductivity, Wiedemann-Franz law. Hall effect in metals: Phenomenology and implication, Drift velocity and relaxation time, transport relation, the mean free path in metals, the electrical conductivity and thermal conductivity of metlas, dielectric properties of insulators, the Fermi energy levels and temperature dependence, Electronic, ionic and dipolar polarizability, local fields, induced and oriented polarization, molecular field in a dielectric; Clausius- Mosotti relation, dia, para and ferro-magnetic properties of solids, Langevin's theory of diamagnetism and Para magnetism, quantum theory of Para magnetism, Curie's law, ferromagnetism: spontaneous magnetization and domain structure; temperature dependence of spontaneous magnetisation; Curie-Weiss law, explanation of hysteresis.

UNIT III: LATTICE VIBRATIONS AND LATTICE VACANCIES (15 h)

Elastic and atomic force constants; dynamics of a chain of similar atoms and chain of two types of atoms; optical and acoustic modes; interaction of light with ionic crystals, Einstein's and Debye's theories of specific heats of solids, Lattice vacancies, diffusion, colour centres: F centres, other centres in alkali halides.

UNIT IV: SUPERCONDUCTIVITY AND LUMINESCENCE IN SOLIDS (15 h)

Introduction (Kamerlingh- Onnes experiment), effect of magnetic field, Type-I and Type-II superconductors, Isotope effect, Meissner effect, BCS pairing mechanisms, Ideas about High-Tc superconductors, Types of Luminescence, The Frank-Condon Principle, Fluorescence and phosphorescence, Thermo luminescence, Electroluminescence, LASER (Characteristics', applications and advantages), Einstein coefficient.

BOOKS FOR STUDY AND REFERENCE:

1. C. Kittel, Introduction to Solid State Physics (8^{th} edition), John Wiley and Sons, New York, 2004.
2. M. A. Omar, Elementary Solid-State Physics: Principles and Applications, Addison-Wesley Publishing Company, Inc, USA, 1975.
3. J. Dekker, Solid State Physics, Macmillan India, 2000
4. S. O. Pillai, Solid State Physics, New Age International, India, 2006.
5. J. P. Srivastava, Elements of Solid-State Physics, Prentice Hall India Pvt., Limited, India, 2004.
6. R.J. Elliot and A.F. Gibson, An Introduction to Solid State Physics and Applications, McMillan, London, 1928.
7. D.W. Snoke, Solid State Physics: Essential Concepts, Person Education, 2009

PAPER III: MP103: ELECTRONICS AND INSTRUMENTATION. (60 lectures, 4 credits)

UNIT I: SEMICONDUCTOR DEVICES **(15 h)**

Characteristic curves and physics of p-n junction; Schottky, tunnel and MOS diodes; bipolar junction transistors (BJT), junction field effect transistor (JFET), metal oxide semiconductor field effect transistor (MOSFET), uni-junction transistor (UJT) and silicon-controlled rectifier (SCR), optoelectronic devices (photo-diode, solar cell, LED, LCD and photo transistors) diffusion of impurities in Si, growth of oxide.

Op-amp: Introduction, input modes andop-amps with negative feedback, open-loop response - mathematical operations, analog simulation, OTAs, CFOAs, active filters.

UNIT II: ANALOG ELECTRONICS **(15 h)**

Oscillators- principles, types, frequency stability, response, the phase shift oscillator, Wein bridge oscillator, oscillator with RC feedback circuits (RC and LC), relaxation oscillators, linear and nonlinear oscillators, 555 timer as an oscillator, IC voltage regulators, evolution of ICs, CCDs, multi-vibrators, classification, selection of a transducer, strain gauge, displacement transducer (capacitive, inductive, differential transformer, photo electric and piezoelectric transducers), strain flow measurements, thermistor and thermo couple based thermometers for measuring temperature.

UNIT III: DIGITAL ELECTRONICS **(15 h)**

Introductory digital concepts, overview of logic functions, fixed function integrated circuits, programmable logic devices, digital integrated circuits, NAND and NOR gates building block, X-OR gate, simple combinational circuits, half and full address, functions of combinational logic, flip flops and related devices, counters, shift registers, memory and storage (ROM, RAM and EPROM), microprocessor and microcontroller basics (Intel 8085).

UNIT IV: ELECTRONICS FOR NUCLEAR DEVICES **(15 h)**

Preamplifier, AC-DC converter, Pulse shaper, Isolator, High range gamma survey meter circuit, scintillation dose rate meter, scintillator photodiode X-ray detector, pocket monitor, general purpose contamination monitor, discriminator single channel analyser, linear gate, time to amplitude converter.

BOOKS FOR STUDY AND REFERENCE:

1. S. M. Sze, K.K. Ng, Physics of semiconductor devices (3rd edition), Wiley-Inter science, New York, 1969.
2. P. Horowitz and W. Hill, "The art of electronics', (2nd edition), Cambridge university press, Cambridge, 1995.

3. A. P. Malvino, "Electronic principles', (6th edition), Tata McGraw Hill Publ. Co. Ltd., New Delhi, 1999.
4. T. L. Floyd, Electronic devices', (6th edition), Pearson Education Inc., New Delhi, 2003.
5. R. F. Coughlin and F. F. Driscoll,' Operational amplifiers and linear integrated circuits', (6th edition), Pearson Education Inc., New Delhi, 2001.
6. M. Lakshmanan and K.Murali, Chaos, 'Chaos in nonlinear Oscillators', World Scientific, Singapore, 1996.
7. T. L. Floyd, Digital Fundamentals, (8th edition), pearson education Inc., New Delhi, 2003.
8. S. Brown and Z. Vranesic,' Fundamentals of digital logic with Verilog design', Tata McGraw Hill Publ Co. Ltd., New Delhi, 2003.
9. H. Skalsi, "Electronic instrumentation (2nd edition), Tata McGraw Hill Publ. Co. Ltd., New Delhi,2004.

PAPER IV: MP104 CLASSICAL AND QUANTUM MECHANICS (60 lectures, 4 credits)

UNIT I: VARIATIONAL PRINCIPLE, HAMILTONIAN, AND CANONICAL TRANSFORMATIONS (15 h)

Hamilton's principle, Hamiltonian, generalized momentum, constant of motion, Hamilton's canonical equations of motion, deduction of canonical equations from Variational principle, principle of least action, proof of principle of least action, Applications of Hamilton's equations of motion, examples of Hamilton equation of motion, generating functions, illustrations of canonical transformations, condition for transformation to be canonical

UNIT II: SPECIAL RELATIVITY IN CLASSICAL MECHANICS (15 h)

Special theory of relativity, Lorentz transformation and its consequences, Lorentz Tensor, Elastic Scattering, Mass energy relation, Lagnrangian formulation for relativistic mechanics, Particle accelerating under constant force, Hamiltonian formulations, Particle in Electro-magnetic field

UNIT III: FORMALISM OF QUANTUM MECHANICS (15 h)

Need for Quantum mechanics, Wave particle duality, relation between group velocity and phase velocity, Heisenberg's Uncertainty principle, Schrödinger time dependent and time independent wave equations, Application of Schrödinger time independent wave equation to particle in one dimensional rigid box, Step potential, reflection and transmission coefficients, Solution of radial Schrödinger equation to obtain energy values, scanning tunnelling microscope, problems

Unit IV: QUANTUM DYNAMICS AND THEORY OF RADIATION (15 h)

Rotations and angular momentum commutation relations, spin ½ system and finite rotations, SO (3), SU (2) and Euler rotations, eigenvalues and eigenstates of angular momentum, orbital angular momentum, addition of angular momentum, Semiclassical theory of radiation, transition probability for absorption and induced emission, electric dipole and forbidden transitions, selection rules.

BOOKS FOR STUDY AND REFERENCE:

1. H. Goldstein, C. Poole, J. Safko, Classical Mechanics (3rd edition), Addison Wesley, Cambridge, 1980.
2. N.C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1991.
3. R. G. Takwale and P. S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill Education, New Delhi, 1999.
4. S. L. Gupta, V. Kumar and R. C. Sharma, Classical Mechanics, Pragati Prakashan Meerut, 2000.
5. Ghatak, S. Lokanathan, Quantum Mechanics: Theory and Applications, Kluwer Academic Publishers, London, 2004.
6. J. J. Sakurai, Modem Quantum Mechanics, Addison Wesley Publication Company Inc.USA, 1933.
7. L. I. Schiff, Quantum Mechanics, Tata McGraw Hill Education, New Delhi, 1949.
8. M. Mathews, K. Venkatesan, Quantum Mechanics,Tata McGraw Hill Education, New Delhi, 1978.

Semester – II

PAPER V: MP201: ELECTRODYNAMICS (60 lectures, 4 credits)

UNIT I: MAXWELL'S EQUATIONS AND E.M. WAVES (15 h)

Review of four-vector and lorentz transformation in four-dimentional space, electromagnetic field tensor in four dimensions and Maxwell's equations: microscopic and macroscopic forms (revision), conservation of the bound charge and current densities, E.M. wave equations in waveguide of the arbitrary cross section: TE and TM modes; Rectangular and circular waveguides, hybrid modes, concept of LP modes.

UNIT II: TIME –DEPENDENT POTENTIALS AND FIELDS (15 h)

Scalar and vector potentials: coupled differential equations, Gauge transformations: Lorentz and Coulomb Gauges, Retarded Potentials, Lienard –Wiechert Potentials, Fields due to a charge in the arbitrary motion.

UNIT III: RADIATION FROM ACCELERATED CHARGES AND RADIATION REACTION (15 h)

Fields of charge in uniform motion, applications to linear and circular motions: cyclotron and synchrotron radiations, Power radiated by point charge: Larmour's formula, angular distribution of radiated power, Cerenkov radiation and Bremsstrahlung (qualitative treatments), radiation reaction: criteria for validity, Abraham–Lorentz formula, physical basis of radiation reaction, self force.

UNIT IV: FORMULATION OF COVARIANT ELECTRODYNAMICS (15 h)

Contravariant and co-variant four-vectors and their products, tensors of rank two and their differentiation, co-variant form of Maxwell's equations: four–potential and four current, E.M. field tensor: its curl and divergence.

BOOKS FOR STUDY AND REFERENCE:

1. D.J. Griffiths, Introduction to Electrodynamics (3rd edition),Prentice Hall, New Jersey, 1999.
2. J.R. Reitz, F.J. Milford & R.W. Christy, Foundation of E.M. Theory (3rd edition), Addison Wesley, New Jersey, 1979.
3. J.D. Jackson, Classical Electrodynamics (3rd edition),Wiley Eastern, New York, 1975.
4. S.P. Puri, Classical Electro dynamics, Tata McGraw Hill Education, New Delhi,1990.

PAPER VI: MP202: NUCLEAR PHYSICS (60 lectures, 4 credits)

UNIT I: BULK PROPERTIES OF NUCLEI (15 h)

Nuclear mass, charge, size, binding energy, spin and magnetic moment, Isobars, isotopes and isotones; mass spectrometer (Bainbridge), Spin and parity. Nature of forces between nucleons, nuclear stability and nuclear binding.

UNIT II: NUCLEAR STRUCTURE AND UNSTABLE NUCLEI (15 h)

The liquid drop model (descriptive) and the Bethe-Weizsacker mass formula, application to stability considerations, extreme single particle shell model (qualitative discussion with emphasis on phenomenology with examples).

(a) Alpha decay: alpha particle spectra – velocity and energy of alpha particles. Geiger- Nuttal law. (b) Beta decay: nature of beta ray spectra, the neutrino, energy levels and decay schemes, positron emission and electron capture, selection rules, beta absorption and range of beta particles, Kurie plot. (c)Gamma decay: gamma ray spectra and nuclear energy levels, isomeric states. Gamma absorption in matter – photoelectric process, Compton scattering, pair production (qualitative).

UNIT III: NUCLEAR REACTIONS (15 h)

Conservation principles in nuclear reactions. Q-values and thresholds, nuclear reaction cross-sections, examples of different types of reactions and their characteristics. Bohr's postulate of compound nuclear reaction, Ghoshal's experiment.

Discovery and characteristics, explanation in terms of liquid drop model, fission products and energy release, spontaneous and induced fission, transuranic elements. Chain reaction and basic principle of nuclear reactors. Nuclear fusion: energetics in terms of liquid drop model.

UNIT IV: ELEMENTARY PARTICLES (15 h)

(a) Four basic interactions in nature and their relative strengths, examples of different types of interactions. Quantum numbers – mass, charge, spin, isotopic spin, intrinsic parity, hypercharge. Charge conjugation. Conservation laws. (b) Classifications of elementary particles – hadrons and leptons, baryons and mesons, elementary ideas about quark structure of hadrons – octet and decuplet families.

BOOKS FOR STUDY AND REFERENCE:

1. W.N. Cottingham and D. A. Greenwood, An Introduction to Nuclear Physics, Cambridge University Press, 1986.
2. B. L. Cohen, Concepts of Nuclear Physcics, Tata McGraw Hill Education, New Delhi, 1971.
3. S. N. Ghoshal, Atomic and Nuclear Physics, S. Chand, New Delhi, 1997.
4. S. B. Patel, Nuclear Physics: An Introduction, New Age International, New Delhi, 1991.
5. E. Segre, Nuclei and Particles (2nd edition), W.A. *Benjamin* Inc., 1977.

6. J.S. Lilley, Nuclear Physics: Principles and applications (1st edition), John Willey and Sons (Asia) Pvt. Ltd., 2001.
7. J. Basdevant, J. Rich and M. Spiro, Fundamentals in Nuclear Physics: from Nuclear Structure to Cosmology, Springer- Verlag New York, 2005.
8. A. Seiden, Particle Physics: A Comprehensive Introduction, Persian Education, 2004.

PAPER VII: MP203: RADIATION PHYSICS AND RADIATION GENERATORS (60 lectures, 4 credits)

UNIT I: RADIOACTIVITY (15 h)

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.

UNIT II: PARTICLE ACCELERATORS (15 h)

Particle accelerators for industrial, medical and research applications: the resonant transformer, Cascade generator, Van De Graff Generator, Pelletron, Cyclotron, Betatron, Synchro-Cyclotron linear accelerator, Klystron and magnetron, travelling and standing wave acceleration, Microtron, electron synchrotron, proton synchrotron, details of accelerator facilities in India.

UNIT III: X-RAY GENERATORS (15 h)

Discovery, production, properties of X-rays, characteristics and continuous spectra, design of hot cathode X-ray tube, basic requirements of medical diagnostic, therapeutic and industrial radiographic tubes, rotating anode tubes, hooded anode tubes, industrial X-ray tubes, X-ray tubes for crystallography, rating of tubes, safety devices in X-ray tubes, ray proof and shockproof tubes, insulation and cooling of X-ray tubes, mobile and dental units, faults in X-ray tubes, limitations on loading, electric accessories for X-ray tubes, ilament 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 stabilizers, automatic exposure control, automatic brightness control, measuring instruments: Measurement of kV and mA, timers, control panels, complete X-ray circuit, image intensifiers and closed circuit TV systems, modern trends.

UNIT IV: INTERACTION OF RADIATION WITH MATTER (ORIENTED TOWARDS RADIOLOGY) (15 h)

Interaction of electromagnetic radiation with matter, exponential attenuation, Thomson scattering, photoelectric and Compton process and energy absorption, pair production, attenuation and mass energy absorption coefficients, relative importance of various processes. interaction of charged particles with matter, classical theory of inelastic collisions with atomic electrons, energy loss per ion pair by primary and secondary ionization, dependence of collision energy losses on the physical and chemical state of the absorber, Cerenkov radiation, electron absorption process, scattering excitation and ionization, radiative collision, Bremmstrahlung: range energy relation, continuous slowing down approximation (CSDA), straight ahead approximation and detour factors, transmission and depth dependence methods for determination of particle penetration, empirical relations between range and energy, back scattering, passage of heavy charged particles through matter, energy loss by collision, range Energy relation, Bragg curve, specific ionization, stopping power, Bethe Bloch Formula, interaction of neutrons with matter, scattering, capture, neutron induced nuclear reactions.

BOOKS FOR STUDY AND REFERENCE:

1. E.B. Podgorsak, Radiation Oncology Physics, IAEA Publication, Austria, 2005.
2. F. M. Khan, The Physics of Radiation Therapy (3rd edition), LIPPINCOTT WILLIAMS & WILKINS, USA, 2003.
3. H. E. Jones, J. R. Cunnighum, Physics of Radiology (4th edition), Charles C Thimas, USA, 1983.
4. W. J. Meredith & J. B. Massey, Fundamental Physics of Radiology (3rd edition), John Wright & Sons Ltd. 1977.
5. W. R. Handee, Medical Radiation Physics, Year Book Medical Publishers Inc., London, 2003.

PAPER VIII: MP204: ANATOMY AND PHYSIOLOGY (60 lectures, 4 credits)

UNIT I: DEFINITIONS (15 h)

Applications, History: Cells, structure and functions, sex cells, early development, the tissues, the systems, skin, cartilage and bone, bacteria, inflammation, injection, ulceration, neoplasm, bones, the skeleton, joints, the skeletal system, the skull, vertebral column, thorax etc., the muscular system, the thoracic cage, the mediastinum, the diaphragm the abdominal cavity and abdominal regions, anatomy of the heart.

UNIT II: DIGESTIVE SYSTEM (15 h)

Functions of mouth, tongue, teeth, esophagus, stomach, small intestine, large intestine, digestion and assimilation of carbohydrates, fats and proteins, gastric juice, pancreatic juice, function of liver and spleen, blood and circulatory system, blood and its composition, RBC and WBC, blood grouping, coagulation of blood, artery, vein, capillaries and heart structure and functions: Physiological properties of heart muscle, cardiac dynamics: EEG, blood pressure and its regulation.

UNIT III: RESPIRATORY, REPRODUCTION AND EXCRETORY SYSTEMS (15 h)

Physical laws of respiration: Trachea, lungs and its functions, oxygen transport, nervous regulation of respiration, hormonal control over reproduction, kidney and its functions, water and electrolyte metabolism.

UNIT IV: ENDOCRINE SYSTEM AND NERVOUS SYSTEM (15 h)

Pituitary glands and its functions: Functions of adrenal, thyroid etc, secretion chemistry, physiological actions, effect on removal effect on administration, hormonal assay detailed molecular mechanism of hormone action.

Brain and spinal cord: its functions, central nervous system and autonomic nervous system functions, physiology of special senses of hearing, taste vision etc.

BOOKS FOR STUDY AND REFERENCE:

1. H. Best and N. B. Taylor, A Test in Applied Physiology, Williams and Wilkins Company, Baltimore, 1999.
2. K. Warrick, Anatomy and Physiology for Radiographers, Oxford University Press, 2001.
3. J. R. Brobek, Physiological Basis of Medical Practice, Williams and Wilkins, London, 1995.

Semester –III

PAPER IX: MP301: RADIATION DETECTORS AND INSTRUMENTATION (60 hours, 4 credits)

UNIT I: PRINCIPLES OF RADIATION DETECTION (15h)

Basic principles of radiation detection, gas filled detectors, ionisation chambers, theory and design, construction of condenser type chambers and thimble chambers, gas multiplication, proportional and GM counters, characteristics of organic and inorganic counters, dead time and recovery time, scintillation detectors, semiconductor detectors, chemical systems, radiographic and radio chromic films, thermo luminescent dosimeters (TLD), optically stimulated luminescence dosimeters (OSLD), radiophoto luminescent dosimeters, neutron detectors, nuclear track emulsions for fast neutrons, solid state nuclear track (SSNTD) detectors, calorimeters

UNIT II: RADIATION MEASURING & MONITORING INSTRUMENTS (15h)

Dosimeters based on condenser chambers, pocket chambers, dosimeters based on current measurement, different types of electrometers, MOSFET, vibrating condenser and varactor bridge types, secondary standard therapy level dosimeters, farmer dosimeters radiation field analyser (RFA), radioisotope calibrator, multipurpose dosimeter, water-phantom dosimetry systems, brachytherapy dosimeters, thermoluminescent dosimeter readers for medical applications, calibration and maintenance of dosimeters.

UNIT III: INSTRUMENTS FOR PERSONNEL AND AREA MONITORING (15h)

Instruments for personnel monitoring, TLD badge readers, PM film densitometers, glass dosimeter readers, digital pocket dosimeters using solid state devices and GM counters. Teletector, industrial gamma radiography survey meter, gamma area (Zone) alarm monitors, contamination monitors for alpha, beta and gamma radiation, hand and foot monitors, laundry and portal monitors, scintillation monitors for X and gamma radiations, neutron monitors, tissue equivalent survey meters, flux meter and dose equivalent monitors, pocket neutron monitors, tele dose systems.

UNIT IV: NUCLEAR MEDICINE INSTRUMENTS (15h)

Instruments for counting and spectrometry, portable counting systems for alpha and beta radiation, gamma ray spectrometers, multichannel analyser, liquid scintillation counting system, RIA counters, whole body counters, air monitors for radioactive particulates and gases.

BOOKS FOR STUDY AND REFERENCE:

1. W.J. Price, Nuclear Radiation Detection (2nd edition), McGraw-Hill, New York, 1964.
2. B.I Stepanor., Theory of Luminescence (1st edition). Print ISSN,1968.

3. Glenn F Knoll. Radiation Detection & Measurement (4th edition), John Wiley & Sons, august-2010.
4. Albert Paul Malvino, Electronics Principles. McGraw-Hill Higher Education; 7th edition, May 1, 2006.
5. Robert L. Boylestad, Electronics Devices and Circuit Theory, Prentice Hall,6th edition 1996
6. Paul-Horowitz, Art of Electronics (3rd edition), Cambridge University Press, April 9, 2015
7. R.A Greiner, Semiconductor Devices & Application (1st edition), McGraw-Hill Inc., US, December 1961.
8. R.H. Crawford, MOSFET in Circuit Design (1st edition), McGraw-Hill Education ,1967.

Paper X: MP302: Radiation Dosimetry and Standardization (60 hours, 4 credits)

UNIT I: RADIATION QUANTITIES AND UNITS AND RADIATION SOURCES (15h)

Radiation quantities and units, Radiometry, Particle flux and fluence, energy flux and fluence, cross section, linear and mass attenuation coefficients, mass energy transfer and mass energy absorption coefficients, stopping power, LET, radiation chemical yield, W value - dosimetry - energy imparted, absorbed dose, kerma, exposure, air kerma rate constant, charged particle equilibrium (CPE), relationship between Kerma, absorbed dose and exposure under CPE, transient Charged Particle Equilibrium (TCPE), dose equivalent, ambient and directional dose equivalents [(H*(d) and H'(d)], individual dose equivalent penetrating Hp(d), individual dose equivalent superficial Hs(d)

UNIT II: DOSIMETRY & STANDARDIZATION OF X AND GAMMA RAYS BEAMS (15h)

Standards - primary and secondary standards, traceability, uncertainty in measurement.), free Air Ion Chamber (FAIC), design of parallel plate FAIC, measurement of air kerma/ exposure, Limitations of FAIC, Bragg-gray theory and mathematical derivation,Burlin and Spencer attix cavity theories, concept of Dgas, Cavity ion chambers, derivation of an expression for sensitivity of a cavity ion chamber General definition of calibration factor - N_X, N_K, N_D, air, $N_{(D,W)}$. IAEA TRS 277: various steps to arrive at the expression for DW starting from N_X. TRS398: $N_{(D,W,Q)}$: $N_{(D,W)}$:$K_{Q,Q0}$:K_Q , derivation of an expression for $K_{(Q,Q0)}$. calorimetric standards – inter comparison of standard measurement of DW for external beams from ^{60}Co teletherapy machines: reference conditions for measurement, type of ion chambers, phantom, waterproof sleeve, derivation of an expression for machine Timing error, procedure for evaluation of temperature and pressure correction: thermometers and pressure gauges. measurement of temperature and pressure. saturation correction: derivation of expression for charge collection efficiency of an ion chamber based on Mie theory. parallel plate, cylindrical and spherical ion chambers, Ksat, Two voltage method for continuous and pulsed beams, polarity correction.

UNIT III: DOSIMETRY AND STANDARDIZATION OF X-RAY, ELECTRON BEAMS, AND NEUTRON STANDARDS (15h)

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 DW for high energy electron beams from linear accelerators: Beam quality, beam quality index, beam quality correction coefficient, cross calibration using intermediate beam quality. quality audit programmes in reference and non-reference conditions.

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 & multispheres, neutron dosimetry, neutron survey meters, calibration, neutron field around medical accelerators.

UNIT IV: RADIATION CHEMISTRY AND CHEMICAL DOSIMETRY (15h)

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 polymerisation, 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 dosimetric view point, dosimetry principles, Beer- lambert's law, spectrophotometry, dose calculations, laboratory techniques, Reagents and procedures, requirements for an ideal chemical dosimeter, Fricke dosimeter, FBX dosimeter, free radical dosimeter, Ceric sulphate dosimeter, applications of chemical dosimeters in radiotherapy.

BOOKS FOR STUDY AND REFERENCE:

1. Joseph Magill and Jean Galy. Radioactivity Radionuclides Radiation, European Commission Joint Research Centre, Institute for Transuranium Elements, P. O. Box 2340, 76125 Karlsruhe, Germany (1st edition), Springer-Verlag Berlin Heidelberg, 2005.
2. IAEA TRS 374, Calibration of Dosimeters used in Radiation Therapy.
3. F. H. Attix. Introduction to Radiological Physics and Radiation Dosimetry, Viley- VCH, Verlog, 2004.
4. William H Beierwaltes Clinical Use of Radioisotopes, Philadelphia, Saunders, 1957.

PAPER XI: MP303: CLINICAL AND RADIATION BIOLOGY (60 hours, 4 credits)

UNIT I: CELL BIOLOGY AND INTERACTION OF RADIATION WITH CELLS (15h)

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, golgibodies 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.

Action of radiation on living cells, radiolytic products of water and their interaction with biomolecules, Nucleic acids, proteins, enzymes, fats, influence of oxygen, temperature, cellular effects of radiation, Mitotic delay, chromosome aberrations, mutations and recombination's, giant cell formation, cell death recovery from radiation damage-potentially lethal damage and

sublethal damage recovery, pathways for repair of radiation damage. law of Bergonie and Tribondeau.

Survival curve parameters, model for radiation action, target theory - multihit, multitarget - repair miss-repair hypothesis, dual action hypothesis, modification of radiation damage, LET, RBE, dose rate, dose fractionation, oxygen and other chemical sensitizers, anoxic, hypoxic, base analogs, folic acid, and energy metabolism inhibitors, hyperthermic sensitization, radio-protective agents.

UNIT II: BIOLOGICAL EFFECTS OF RADIATION (15h)

Somatic effects of radiation, physical factors influencing somatic effects, dependence on dose, dose rate, type and energy of radiation, temperature, anoxia, Acute radiation sickness -LD 50 dose, effect of radiation on skin and blood forming organs, digestive tract – sterility and cataract formation, effects of chronic exposure to radiation, 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 frequency of radiation induced mutations, dose-effect relationship, first generation effects, effects due to mutation of recessive characteristic, genetic burden, prevalence of hereditary diseases and defects, spontaneous mutation rate, concept of doubling dose and genetic risk estimate.

UNIT III: CLINICAL ASPECTS OF MEDICAL IMAGING & RADIATION ONCOLOGY (15h)

Radiation therapy, surgery, chemotherapy, hormone therapy, immunotherapy & radionuclide therapy, benign and malignant disease, methods of spread of malignant disease, staging and grading systems, treatment intent, curative & palliative, cancer prevention and public education and early detection & screening. site specific signs, symptoms, diagnosis and management: head and neck, breast, gynaecological, gastro-Intestinal tract, genito-Urinary, lung & thorax, lymphomas & leukemias & other cancers including AIDS related cancers.

Patient management on treatment - side effects related to radiation and dose, acute & Late – monitoring and common management of side effects, information and communication.

Professional aspects and role of medical physicists: General patient care, principles of professional practice, medical terminology, research & professional writing, patient privacy - ethical & cultural issues. legal aspects - confidentiality, informed consent, health and safety.

UNIT IV: BIOLOGICAL BASIS OF RADIOTHERAPY AND TIME DOSE FRACTIONATION (15h)

Physical and biological factors affecting cell survival, tumour regrowth and normal tissue response -non-conventional fractionation scheme and their effect of reoxygenation, repair, redistribution in the cell cycle - high LET radiation therapy. Time dose fractionation, basis for dose fractionation in beam therapy, concepts for nominal standard dose (NSD), roentgen equivalent therapy (RET), time dose fractionation (TDF) factors and cumulative radiation effects (CRE), gap correction, linear and linear quadratic models.

BOOKS FOR STUDY AND REFERENCE:

1. Meschan. Normal Radiation Anatomy, Philadelphia-London Saunders, 1951
2. Hollinshead W.H. Text Book of Anatomy (2nd edition), Harper and Row, New York, NY, USA, 1967.
3. Susan B Klein Fundamentals of Radiation Biology, 2023.
4. IAEA, Radiation Biology: A Handbook for Teachers and Students, 2010.

PAPER XII: MP304: MEDICAL IMAGING (60 hours, 4 credits)

UNIT I:X- RAY GENERATORS AND ADVANCED X-RAY IMAGING SYSTEMS (15h)

Construction and working principals of stationary and rotating anode X- Ray tube, line focus principle, heel effect, filters, beam limiting devices–grids-rectifiers-filament circuits, types of generators–exposure switches–exposure timers. bremsstrahlung-characteristic line spectrum-factors affecting the x-ray spectrum-attenuation of heterogeneous and homogenous x-rays-attenuation coefficients- attenuation mechanisms radiographic image quality-factors affecting image quality-Intensifying screens diagnostic applications of X-rays-Skeletal system-soft tissues-the chest mammography– digital radiography, types of DR: image processing and documentation of Image: wet and dry image, PACS, CT: basic principle, generation of CT, helical CT, single slice and multi slice CT scan system, image reconstruction, CT artifacts, QA tests

UNIT II: MAGNETIC RESONANCE IMAGING (15h)

Basic principles – spin – processing – relaxation time – free induction decay – T1, T2 proton density weighted image – pulse sequences - basic and advance pulse sequences – MR instrumentation — image formation–localisation of the signal - factors influencing signal intensity- contrast and resolution - types of magnets – super conductors– RF transmitters –RF receivers – gradient coils – RF shielding - MR spectroscopy – MR artifacts – safety aspects in MRI – QA test.

UNIT III: DIAGNOSTIC ULTRASOUND (15h)

Ultrasonic waves, generation and detection of ultrasound-Beam characteristics, attenuation of ultrasound, specific acoustic impedance, reflection at body interfaces-coupling medium-interaction ultrasound with tissues, A scan B scan and M mode-real time scanners image clarity - resolution, axial and lateral resolution, artifacts-pulse echo imaging-obstetrics abdominal investigations echo cardiograph (UCG), The doppler effect-doppler shift, continuous wave doppler system-pulsed wave doppler systems, duplex scanning - display devices for ultrasonic imaging.

UNIT IV: DIAGNOSTICS THERMOGRAPHY AND RADIO ISOTOPES IN DIAGNOSIS (15 h)

Physics of thermography, infrared detectors, thermographic equipments, quantitative medical thermography, pyroelectric video camera, applications of thermography, radiation detectors, production of artificial radio nuclides- radio-pharmaceuticals, radio-nuclide imaging-image quality-radio-nuclide applications-radioactive tracers-uptake-dilution analysis -gamma camera.

BOOKS FOR STUDY AND REFERENCE:

1. Thomas S Curry, Christensen's Physics of Diagnostic Radiology (3rd edition), LWW 1990.
2. Noren Chesney & Muriel Chesney, X-ray equipment for radiographers (2nd edition), Blackwell Scientific Publications, 1971.
3. Jerrold T Bushberg, The Essential Physics for Medical Imaging; 3rd revised international edition, Lippincott Williams & Wilkins, November 1, 2011.
4. Catherine Westbrrok, MRI in Practice, 4th edition, Wiley-Blackwell; July 5, 2011.
5. Perry Sprawls, MRI – Medical Physics Publishing, Madison, Wisconsin-2000.
6. Hylton B Meire and Pat Farrant, Basic Ultrasound –John Wiley & Sons –NY-1994.
7. G S Pant, Advances in Diagnostic Medical Physics – Himalaya Publishing House-2006.

Semester –IV

PAPER XIII: MP401: NUCLEAR MEDICINE AND INTERNAL DOSIMETRY (60 hours, 4 credits)

UNIT I: PHYSICS OF NUCLEAR MEDICINE (15h)

Introduction to nuclear medicine, unsealed sources, production of radionuclide used in nuclear medicine; reactor based radionuclides, accelerator based radionuclides, photonuclear activation, equations for radionuclide production, 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, Life Span of RBC etc. general concept of radionuclide imaging and historical developments.

UNIT II: RADIONUCLIDE IMAGING AND DIFFERENT IMAGING TECHNIQUES (15h)

Other techniques and instruments; 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 pin hole collimator, image display and recording systems, digital image processing systems, scanning camera limitation of the detector system and electronics.

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.

UNIT III: IMAGE QUALITY PARAMETERS (15h)

Spatial resolution, factor affecting spatial resolution, methods of evaluation of spatial Resolution, contrast, noise. NEMA protocols followed for quality assurance / quality control of imaging instruments. in-vitro technique: RIA/IRMA techniques and its principles. physics of PET and cyclotron: 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 ^{131}I, use of ^{32}P and ^{90}Y for palliative treatment, radiation synovectomy and the isotopes used. concept of delay tank and various waste disposal methods used in nuclear medicine. planning and shielding calculations during the installation of SPECT, PET/CT and medical cyclotron in the nuclear medicine department.

UNIT IV: INTERNAL DOSIMETRY (15h)

Internal radiation dosimetry: different compartmental model; single compartmental model, two compartmental model with back transference, two compartmental model without back transference. classical methods of dose evaluation; beta particle dosimetry; equilibrium dose rate equation, beta dose calculation specific gamma ray constant, gamma ray dosimetry, geometrical factor calculation, dosimetry of low energy electromagnetic radiation. MIRD technique for dose calculations; basic 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. limitation of MIRD technique.

BOOKS FOR STUDY AND REFERENCE:

1. W. H. Blahd, Nuclear Medicine, McGraw Hill Co., New Delhi, 2002.
2. W. N. Wagner, Principles of Nuclear Medicine, W. B. Saunders Co., London, 1990.
3. J. Herbert and D. A. Rocha, Text Book of Nuclear Medicine, Vol. 2 and 6, Lea and Febiger Co., Philadelphia, 2002.
4. S. Webb, The Physics of Medical Imaging Medical Science Series Adam Hilger Publications, Bristol, 1990.

PAPER XIV: MP402: RADIATION THERAPY-TELETHERAPY (60 hours, 4 credits)

UNIT I: BEAM THERAPY (15h)

Description of low kV therapy x-ray units, spectral distribution of kV x-rays and effect of filtration, thoraeus filter, output calibration procedure. construction and working of telecobalt units, source design, beam collimation and penumbra, trimmers and breast cones. design and working of medical electron linear accelerators, beam collimation, asymmetric collimator, multileaf collimator, dose monitoring, electron contamination. output calibration of ^{60}Co gamma rays, high energy x-rays and electron beams using IAEA TRS 398, 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.

UNIT II: CENTRAL AXIS DOSIMETRY PARAMETERS, BEAM MODIFYING, AND SHAPING DEVICES (15h)

Tissue air ratio (TAR) back scatter/ peak scatter factor, (BSF/PSF) - 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. SAR, SMR, Off axis ratio and field factor. build-up region and surface dose. tissue equivalent phantoms. radiation filed analyser (RFA). Description and measurement of isodose curves/charts. dosimetry data resources. 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 set ups - 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.

UNIT III: CLINICAL ELECTRON BEAMS (15h)

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 electron, neutron, x-ray and gamma ray beams - neutron capture therapy - heavy ion therapy.

UNIT IV: QUALITY ASSURANCE IN RADIATION THERAPY (15h)

Precision and accuracy in clinical dosimetry, quality assurance protocols for telecobalt, medical linear accelerator and radiotherapy simulators, IEC requirements, acceptance, commissioning and. quality control of telecobalt, medical linear accelerator and radiotherapy simulators. portal and in-vivo dosimetry. electronic portal imaging devices.

BOOKS FOR STUDY AND REFERENCE:

1. H. E. Johns and Cunningham. The Physics of Radiology (4th edition), Thomas, Springfield, USA, 1983
2. Faiz M. Khan, The Physics of Radiation Therapy (3rd edition), Lippincott Williams & Wilkins, Philadelphia, 2003.
3. Faiz M. Khan, Roger A. Potish, Treatment Planning in Radiation Oncology, Williams & Wilkins, Baltimore, 1998.
4. S. Webb. The physics of three dimensional radiation therapy, Institute of Physics publishing, Philadelphia, 1993.
5. S. Webb. The physics of conformal radiotherapy, Institute of Physics publishing, Philadelphia, 1997.
6. S. Webb. Intensity Modulated radiation therapy, Institute of Physics publishing, Philadelphia, 2001.
7. S.K. Jani. CT simulation for radiotherapy, Medical Physics Publishing, Madison, WI, 1993
8. J. Van Dyk. The Modern Technology of Radiation Oncology, Medical Physics Publishing, Madison, WI, 1999.
9. S.C. Klevenhagen Physics and dosimetry of therapy Electron beams, Medical Physics Publishing, Madison, WI, 1996.
10. Thomas Bortfeld Rupert Schmidt-Ullrich, Wilfried De Neve · David E. Wazer (Editors). Image-Guided IMRT. Springer Berlin Heidelberg, 2006.

11. D. Baltas, L. Sakelliou and N. Zamboglou The Physics of Modern Brachytherapy for Oncology CRC Press, Taylor and Francis Group, 6000 Brooken Sound Parkway NW Suite 300, Boca Raton – FL 33487-2742.
12. S. H. Levitt, J. A. Purdy, C. A. Perez and S. Vijayakumar (Editors). Technical Basis of Radiation Therapy Practical Clinical Applications (4^{th} Revised Edition) Springer Berlin Heidelberg New York

PAPER XV: **MP403: RADIATION THERAPY-BRACHYTHERAPY** **(60 hours, 4 credits**)

UNIT I: BASICS OF BRACHYTHERAPY **(15h)**

Definition and classification of brachytherapy techniques, surface mould, intracavitary, interstitial and intraluminal techniques. Requirement for brachy therapy sources – Description of radium and radium substitutes -^{137}Cs, ^{60}Co, ^{192}Ir, ^{125}I and other commonly used brachytherapy sources. Dose rate considerations and classification of brachy therapy 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 brachytherapy sources - RAKR and AKS - IAEA TECDOC 1274 and ICRU 72 recommendations. point and line source dosimetry formalisms - sievert Integral - AAPM TG-43/43U1 and other dosimetry formalisms.

UNIT II: BRACHYTHERAPY TREATMENT PLANNING **(15h)**

After loading techniques, advantages and disadvantages of manual and remote after loading techniques. AAPM and IEC requirements for remote after loading brachytherapy equipment. acceptance, commissioning and quality assurance of remote after loading brachytherapy equipment. ISO requirements and QA of brachytherapy sources. integrated brachytherapy unit. brachytherapy treatment planning, CT/MR based brachytherapy planning - forward and inverse planning - DICOM image import / export from OT - record & verification. brachytherapy treatment for prostate cancer. ocular brachytherapy using photon and beta sources. intravascular brachytherapy - classification - sources - dosimetry procedures - AAPM TG 60 protocol. electronic brachytherapy (Axxent, Mammosite, etc.).

UNIT III: COMPUTERS IN TREATMENT PLANNING **(15h)**

Scope of computers in radiation treatment planning - review of algorithms used for treatment planning computations - pencil beam, double pencil beam, Clarkson method, convolution superposition, lung interface algorithm, fast Fourier transform, inverse planning algorithm, Monte Carlo based algorithms. treatment planning calculations for photon beam, electron beam, and brachytherapy - factors to be incorporated in computational algorithms. plan optimization, direct aperture optimization, beamlet optimization, simulated annealing, dose volume histograms, indices used for plan comparisons, hardware and software requirements, beam & source library generation. networking, DICOM and PACS. acceptance, commissioning and quality assurance of radiotherapy treatment planning systems using IAEA TRS 430 and other protocols.

UNIT IV: SPECIAL AND ADVANCED TECHNIQUES OF RADIOTHERAPY (15h)

Special techniques in radiation therapy, total body irradiation (TBI), large field dosimetry, total skin electron therapy (TSET), electron arc treatment and dosimetry, intra-operative radiotherapy. stereotactic radiosurgery/radiotherapy (SRS/SRT) - cone and mMLC based X-Knife, gamma knife, immobilization devices for SRS/SRT, dosimetry and planning procedures, evaluation of SRS/SRT treatment plans, QA protocols and procedures for X- and gamma knife units - patient specific QA. physical, planning, clinical aspects and quality assurance of stereotactic body radiotherapy (SBRT) and cyber knife based therapy. intensity modulated radiation therapy (IMRT), principles, MLC based IMRT, step and shoot and sliding window techniques, compensator based IMRT - planning process – inverse treatment planning immobilization for IMRT, dose verification phantoms, dosimeters, protocols and procedures, machine and patient specific QA. intensity modulated arc therapy (IMAT e.g. Rapid Arc). image guided radiotherapy (IGRT), concept, imaging modality, kV cone beam CT (kVCT), MV cone beam CT (MVCT), image registration, plan adaptation, QA protocol and procedures - special phantom, 4DCT. tomotherapy, principle, commissioning, imaging, planning and dosimetry, delivery, plan adaptation, QA protocol and procedures.

BOOKS FOR STUDY AND REFERENCE:

1. S. Webb. Intensity Modulated radiation therapy, Institute of Physics publishing, Philadelphia, 2001.
2. S.K. Jani. CT simulation for radiotherapy, Medical Physics Publishing, Madison, WI, 1993.
3. J. Van Dyk. The Modern Technology of Radiation Oncology, Medical Physics Publishing, Madison, WI, 1999.
4. Faiz M. Khan, The Physics of Radiation Therapy (3rd edition), Lippincott Williams & Wilkins, Philadelphia, 2003.
5. Faiz M. Khan, Roger A. Potish, Treatment Planning in Radiation Oncology, Williams & Wilkins, Baltimore, 1998.

PAPER XVI: MP404: RADIATION SAFETY (60 hours, 4 credits)

UNIT I: RADIATION PROTECTION STANDARDS AND PRINCIPLES OF MONITORING (15h)

Radiation dose to individuals 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, optimisation of protection and individual dose limits-adiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose – concepts of collective dose-potential exposures, dose and dose constraints – system of protection for intervention -categories of exposures – occupational, public and medical exposures - permissible levels for neutron flux - factors governing internal exposure - radionuclide concentrations in air and water - ALI, DAC and contamination levels.

Evaluation of external radiation hazards - effects of distance, time and shielding – shielding calculations - personnel and area monitoring - internal radiation hazards – radio toxicity of different radio nuclides and the classification of laboratories – control of contamination – bioassay and air monitoring – chemical protection – radiation accidents – disaster monitoring

UNIT II: SAFETY IN THE MEDICAL, INDUSTRIAL, AGRICULTURAL AND RESEARCH USES OF RADIATION (15h)

Planning of medical radiation installations – general considerations – design of diagnostic, deep therapy, tele gamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories. Evaluation of radiation hazards in medical diagnostic therapeutic installations – radiation monitoring procedures - protective measures to reduce radiation exposure to staff and patients - radiation hazards in brachytherapy departments and teletherapy departments and radioisotope laboratories - particle accelerators protective equipment - handling of patient's waste disposal facilities - radiation safety during source transfer operations special safety features in accelerators, reactors.

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

UNIT III: RADIOACTIVE WASTE DISPOSAL AND TRANSPORTOF RADIOISOTOPES (15h)

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 – ecological considerations. Disposal of radioactive wastes - general methods of disposal - management of radioactive waste in medical, industrial, agricultural and research establishments. Transportation of radioactive substances - historical background - general packing requirements - transport documents - labelling and marking of packages – regulations applicable for different modes of transport - transport by post - transport emergencies - special requirements for transport of large radioactive sources and fissile materials - exemptions from regulations – shipment approval – shipment under exclusive use – transport under special arrangement – consignor's and carrier's responsibilities.

UNIT IV: LEGISLATION, RADIATION EMERGENCIES AND THEIR MEDICAL MANAGEMENT (15h)

Physical protection of sources - safety and security of sources during storage, use, transport and disposal – security provisions: administrative and technical – security threat and graded approach in security provision national legislation – regulatory framework – atomic energy act – atomic energy (radiation protection) rules – applicable safety codes, standards, guides and manuals – regulatory control – licensing, inspection and enforcement – responsibilities of employers, licensees, radiological safety officers and radiation workers – national inventories of radiation sources -Import, export procedures Radiation accidents and emergencies in the use of radiation sources and equipment in industry and medicine - radiographic cameras and teletherapy units - loading and unloading of sources - loss of radiation sources and their tracing - typical accident cases. radiation injuries, their treatment and medical management - case histories.

BOOKS FOR STUDY AND REFERENCE:

1. Herman Camber. Introduction to Health Physics (4^{th} edition) McGraw-Hill Professional Publishing New York, USA, 2009.
2. United States. Congress. Joint Committee on Atomic Energy Atomic Energy Act 1962, Washington, Govt. Print. Off., 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, Harvard University Press, 1990.
8. Mckenzie. Radiation Protection in Radiotherapy, Institute of Physical Sciences in Medicine, ©1986.

PRACTICAL LAB COURSE 1
SEM-I MPP101 (Group A)

1. Write a C program to find the roots of quadratic equations.
2. C program for addition, subtraction and multiplication, division of two numbers.
3. Present your data by using MS-Office excel.
4. Pie chart
5. Polygon
6. Histogram
7. Scatter diagram
8. Present your data using Origin software.
9. Pie diagram
10. Scatter diagram
11. Polygon
12. To verify Simpsons and trapezoidal rule.
13. Determination of crystal structure by X-ray diffraction(XRD) technique.
14. Simple measurement of the band gap in Silicon and Germanium.
15. To study the seven crystal structure (Bravais lattices).
16. To determine the resistivity of semiconductors by Fourprobe Method.
17. Determination of the size of lycopodium particles using XRD pattern.
18. To determine crystal structure of the material of thin film from given XRD pattern
19. Face Central Cubic (FCC)
20. Hexagonal Closed Packed (HCP)

SEM-I (MPP102 Group-B)

1. To study the stair case ramp generator.
2. To find the Ripple factor and regulation of a Full-wave Rectifier with and without filter.
3. To obtain the load regulation and ripple factor of a half- wave rectifier.
    a. with Filter   b. without Filter
4. To study a stable multit vibrator with variable duty cycle using IC-555.
5. To construct a Zener diode voltage regulator and measure its line and load regulation.
6. To observe the characteristics of UJT and calculate the intrinsic stand of ratio (η).
7. Laboratory Experiments Manual for 8085 Microprocessor
8. Write 8085 assembly language program for addition of two 8-bit numbers and sum is 8 bit.
9. Write 8085 assembly language program for addition of two16-bit numbers and sum is 16 bit.
10. To verify De-Morgan's theorem using logic gates.
11. To verify the characteristic tables of D-type, R-S (Reset -Set) type T type and J-K Type Flip-Flops.
12. Using Strain gauge to find Poisson's ratio and Young's modulus.
13. To plot B-H curve in ferromagnetic material.
14. To study the current series negative feedback amplifier and determine frequency response with and without feedback.
    1. Demonstrate the concept of Millikan's oil drop experiment.
        a. i)To find the terminal velocity of the drop   ii) To find the charge on a drop.
        b. To study photoelectric effect and calculate Planck's constant using five different colored LEDs and photoelectric cell.
        c. Measure the ratio of the electron charge-to-mass (e/m) by studying the electron trajectories in a uniform magnetic field.
15. To determine Lande splitting factor (g) by ESR spectrometer.

PRACTICAL LAB COURSE 2
SEM II (MPP201 Group-A)

1. Construction and study of mode properties of planer wave guides.
2. To study the phenomena of magnetic hysteresis and calculate the retentivity, coercivity and saturation magnetization of a material using a hysteresis loop tracer.
3. Measurement of inductance using impedance at different frequency.
4. To study the Hall effect and to find out Hall coefficient and determine carrier concentration.
5. To determine the efficiency of the alpha counting system.
6. To determine the absolute activity of americium source using Radlab software.
7. To determine the Decay ratio of 230-Th alpha source.
8. To measure the Percentage Energy resolution of NaI (TL) detector for C-60 source and 137-Cs.
9. Gamma spectroscopy and linear attenuation coefficient of the (Al) using gamma radiation having energy (661.65KeV).
10. To determine the thermal neutron flux distribution for Am-Be source and source strength for same source with BF_3 counter.
11. Study of absorption of alpha and beta rays.
12. Study of statistics in radioactive measurement.

SEM II (MPP202 Group-B)

1. To study the operating plateau of the Geiger Muller tube.
2. To study natural radioactivity series and its application in medical field.
3. Study of bones (Skeleton system).
4. To determine total WBC count in human blood.
5. To determine percentage distribution of different types of WBC's in stained film.
6. To determine total RBC count.
7. Determination of Blood group.
8. To determine Bleeding time and coagulation time.
9. Estimation of Hemoglobin content of Blood.

PRACTICAL LAB COURSE 3

SEM-III (MPP301 Lab-III Group A)

1. Manual Isodose Plotting for simple 2D, 3D Plan field arrangement.
2. Measurement of Half value thickness (HVT) and tenth value thickness (TVT) of kV radiation beams by using gamma ray spectrometer.
3. Measurement of absorbed dose using an ionization chamber.
4. Radiation detection and dose measurement.
5. Study of voltage and current characteristics of an ion chamber.
6. To study the use of TLD in environment monitoring.
7. Study of TLD in medical exposure.
8. To study the working of X-ray generator.
9. To study the cyclotron and hence study its application in medical field.
10. To assess annual effective dose for indoor using survey meter.
11. To assess annual effective dose for outdoor using survey meter.
12. Construction and calibration of GM counter.
13. Calibration of radiation survey instruments.
14. Calibration of a TLDs for personnel monitoring and dose evaluation.

SEM III (MPP302 Lab III Group B)

1. To study the Mitosis and meiosis stages of cell division.
2. To study the effect of hypertonic and hypotonic saline on RBC's.
3. Osmotic fragility of RBC's.
4. Determination of arterial blood pressure.
5. To determine optimum temperature of enzyme invertase.
6. X-ray radiography & film processing.
7. Quality assurance in X-ray radiography.
8. Quality assurance in CT.
9. Quality assurance in MRI machines.
10. Quality assurance in ultrasound scanners.
11. Performance of an ultrasound scanner.
12. Quality assurance in therapy equipment.
13. Measurement of HVL of kV radiation beams.

PRACTICAL LAB COURSE 4
SEM IV (MPP401 Lab IV)

1. Attenuation experiment.
    a. Effect of atomic number.
    b. Effect of Density.
    c. Effect of Thickness.
    d. Effect of Gamma ray energy.
2. Quality assurance (QA) tests procedures of teletherapy machines.
3. Dose output measurement of photon (Co-60gamma rays and high energy x-rays) Beams used in a radiotherapy treatment.
4. Dose output measurement of electron beams used in a radiotherapy treatment.
5. Comparison of manual treatment planning and computerized treatment planning irregular fields (Using Clarkson's method.).
6. IMRT planning using treatment Planning System.
7. Measurement of symmetry and flatness of therapy beam using radiation field analyzer (RFA).
8. Percentage depth dose (PDD) and penumbra measurement of therapy beam using radiation field analyzer (RFA).
9. Quality-assurance (QA) test procedures of brachytherapy machine.
10. Source reconstruction and dose calculation for brachytherapy.
11. Integrity check and calibration of low activity brachytherapy sources.
12. AKS/ RAKR measurement of an HDR brachytherapy source using well type and cylindrical ionization chamber.
13. In-phantom dosimetry of a brachytherapy source.
14. Intra-cavitary planning of carcinoma of cervix and dose prescription using treatment planning system.
15. Survey of radioisotope laboratory and study of surface and air contamination.
16. Radiation protection survey of teletherapy installation.
17. Radiation protection survey of diagnostic radiology installation.
18. Radiation survey of linear accelerator to find the adequacy of shielding on safety point of view.
19. Radiation exposure: Effect of distance, Shielding and time.
20. Familiarization with treatment planning procedure using a computerized radiotherapy treatment planning system.
21. Room lay out planning of linear accelerator teletherapy unit.
22. Room lay out planning and radiation survey of a HDR brachytherapy unit.

SEM IV MPP402: Project

BL-MP-05- Evaluation System

The candidate shall be awarded the degree of **Master of Science in Medical Physics** after completing the course and meeting all the evaluation criteria.

A. Scheme of Examination and Passing

1. This course will have 20 % Term Work (TW)/ Internal Assessment (IA) and 80% external (University written examination of 3 hours duration for each course paper and practical examination of 3 hours duration for each practical). All external examinations will be held at the end of each semester and will be conducted by the University as per the existing norms.
2. Term work/ Internal assessment- IA (20%) and University examination (80%) - shall have separate heads of passing (i.e. 8 Marks for passing in IA and 32 Marks for passing in University examination). For Theory courses, internal assessment shall carry 20 marks and semester-end examination shall carry 80 marks for each theory course.
3. To pass, a student has to obtain minimum grade point E, and above separately in the IA a nd external examination.
4. The University (external) examination for Theory and Practical shall be conducted at the end of each Semester.
5. The candidates shall appear for the external examination of 4 Theory courses each carrying 80 marks of 3 hours duration and 2 practical courses each carrying 100 marks at the end of each semester.
6. The candidate shall prepare and submit for the practical examination a certified journal based on the practical course carried out under the guidance of a faculty member with minimum number of experiments as specified in the syllabus for each group.
7. In order to appear for the examination, His/her attendance is not less than 75% in lecture teaching and not less than 80% in practical work.
8. The candidate shall prepare the dissertation based on the Research Project for the fulfillment of Master’s Degree.

B. Standard of Passing for University Examinations:

As per ordinances and regulations prescribed by the University for semester based credit and grading system.

C. **Standard point scale for grading:**

Grade	Marks	Grade Points
O	70 & above	7
A	60-69.99	6
B	55-59.99	5
C	50-54.99	4
D	45-49.99	3
E	40-44.99	2
F(Fail)	39.99 & below	1

Grade Point Average (GPA) calculation:

1. GPA is calculated at the end of each semester after grades have been processed and afte r anygrade have been updated or changed. Individual assignments / quizzes /surprise test s / unittests / tutorials / practicals / project / seminars etc. as prescribed by University ar e all basedon the same criteria as given above. The teacher should convert his marking in to the Quality-Points and Letter-Grade.
2. Performance of a student in a semester is indicated by a number called Semester GradeP oint Average (SGPA). It is the weighted average of the grade points obtained in all the subjects registered by the students during the semester.

$$\text{SGPA} = \frac{\sum_{i=1} C_i p_i}{\sum_{i=1} C_i}$$

C_i = The number of credits earned in the i^{th} course of a semester.

p_i = Grade point earned in the i^{th} course

i = 1,2,....n represents number of courses for which the student is registered.

1. The Final remark will be decided on the basis of Cumulative Grade Point Average (CGPA) which is weighted average of the grade point obtained in all the semesters registe red by the 1 earner.

$$CGPA = \frac{\sum_{j=1} C_j p_j}{\sum_{j=1} C_j}$$

C_j = The number of credits earned in the j^{th} course upto the semester.for whic h the CGPA is calculated

p_j = Grade point earned in the j^{th} course*

j = 1,2,....n represents number of courses for which the student is registered upto the semester for which the CGPA is calculated.

* : A letter Grade lower than E in a subject shall not be taken into consideration for the calculation of CGPA

The CGPA is rounded upto the two decimal places.