M.Sc. Degree

IN

MEDICAL PHYSICS

CURRICULUM & SYLLABUS

(From the academic year 2023-24 onwards)

DEPARTMENT OF MEDICAL PHYSICS

SCHOOL OF PHYSICS

BHARATHIDASAN UNIVERSITY

TIRUCHIRAPPALLI – 620024

TAMILNADU, INDIA

JULY 2023

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024

CURRICULUM - M.Sc. (MEDICAL PHYSICS - University Department)

(For the students admitted during the academic year 2023 - 2024 onwards)

Programme Code: 2PSMPH

SEMESTER – I

Course Code	Course Title	Credits	Total No. of Credits in the Semester
MP101	Mathematical Physics	**5**	**28**
MP102	Atomic and Nuclear Physics	**5**	
MP103	Solid State Physics	**5**	
MP104	Electronics and Instrumentation	**5**	
MP105	Basic Radiation Physics	**4**	
MP111	Electronics and Solid State Physics Laboratory	**4**	
	Total Credits	**28**	
MP131	Value added course - Extra credit	**2**	
MP141	MOOC Course - I/SWAYAM/NPTEL/coursera - Extra credit	**2**	

SEMESTER – II

Course Code	Course Title	Credits	Total No. of Credits in the Semester
MP201	Human Anatomy and Physiology	**4**	**22**
MP202	Radiation Dosimetry and Standardization	**4**	
MP203	Radiation Detectors and Instrumentation	**4**	
MP204	Physics of Radiation Therapy	**4**	
MP211	Radiation Physics Laboratory	**4**	
MP251	Non-Major Elective (NME) – I	**2**	
	Total Credits	**22**	
MP231	Value added course - Extra credit	**2**	
MP241	MOOC Course - II/SWAYAM/NPTEL/Coursera - Extra credit	**2**	

SEMESTER – III

Course Code	Course Title	Credits	Total No. of Credits in the Semester
MP301	Physics of Nuclear Medicine and Internal Dosimetry	**4**	**22**
MP302	Clinical Radiation Biology	**4**	
MP303	Physics of Diagnostic Radiology	**4**	
MP304	Treatment Planning and Advanced Radiotherapy Techniques	**4**	
MP311	Medical Physics Laboratory	**4**	
MP351	Non-Major Elective (NME) – II	**2**	
	Total Credits	**22**	
MP331	Value added course - Extra credit	**2**	
MP341	MOOC Course – III - Extra credit	**2**	

SEMESTER – IV

Course Code	Course Title	Credits	Total No. of Credits in the Semester
MP401	Radiation Safety	**4**	**18**
MP402	Advanced Medical Imaging	**4**	
MP421	Project Work	**10**	
MP431	Value added course - Extra credit	**2**	
	Total Credits	**18**	
Total number credits at the end of the Programme (Except Value added and MOOC courses)			**90**

Total minimum credits required for completing M.Sc. Programme in Medical Physics is 90 (Excluding value added and MOOC courses)

NON-MAJOR ELECTIVE (NME) COURSES

M.Sc. Medical Physics students are required to register for non-major elective courses offered by other departments or centers during their II and III semesters. The non-major elective courses offered by the Department of Medical Physics are designed for students from other disciplines or departments.

MOOC COURSES

M.Sc. Medical Physics students have the option to enroll in one free online MOOC (Massive Open Online Course) per semester to earn an additional 2 credits. Credits will be awarded upon submission of the course completion certificate.

Value added courses (Offered in the Department of Medical Physics)

Course Code	Course Title	Credits
MP431	Python Programming for Medical Physics	**2**

Value added courses (Offered in the Department of Physics)

Stress management and personality development

Computer Aided Drafting and Glass Blowing Practice

Analytical Equipment - Skill Development; Energy storage and devices

Clean and Green Energy; Symbolic Computations

Real Time Data Acquisition; Complex System Modeling and Analyses

Distribution of Marks

A. THEORY

1. Continuous Internal Assessment

Average of three (3) Internal Test	: 20 Marks
Assignment, Seminar, Quiz, e-assessment etc.	: 05 Marks
Total	**: 25 Marks**

2. End Semester Examination	**: 75 Marks**
Minimum Marks Required for CIA	: 10 Marks
Minimum Marks Required for End Semester Examination	: 30 Marks
Total Marks Required for Earning the Credits	: 50 Marks

B. LABORATORY

1. **Continuous Internal Assessment**

Average of Marks Awarded in the Record Note Book for the Experiments done during Regular Laboratory Hours	: 40 Marks

2. ***Final Comprehensive Examination***

For the Experiment carried out during the Final Examination	: 40 Marks
Viva-voce Examination	: 20 Marks
Total	**: 100 Marks**
Minimum Total Marks Required for Earning the Credits	: 50 Marks

C. PROJECT

Marks Awarded for 2 Reviews (20+20) (CIA)	: 40 Marks
Evaluation of the Dissertation	: 40 Marks
Viva-voce Examination	: 20 Marks
Total	**: 100 Marks**
Minimum Total Marks Required for Earning the Credits	: 50 Marks

Pattern of Question papers for End Semester Examination

Part A: Objective Type Questions	: 15 × 01 = 15 Marks
Part B: Descriptive/Problem Solving type	: 05 × 12 = 60 Marks
Total	**: 75 Marks**

Programme Specific Outcome

PO1 *Demonstrate a comprehensive understanding of fundamental physical, biological, and mathematical principles underlying medical physics.*

PO2 *Apply theoretical knowledge to practical clinical scenarios, including radiation therapy, diagnostic imaging, and nuclear medicine.*

PO3 *Critically analyze scientific literature and research findings to evaluate and interpret data in medical physics.*

PO4 *Develop innovative solutions to complex medical physics problems, such as designing new treatment plans or optimizing imaging techniques.*

PO5 *Assess the effectiveness of medical physics interventions and technologies, including evaluating treatment outcomes and quality assurance procedures.*

PO6 *Identify, analyze, and solve problems in medical physics, such as troubleshooting equipment malfunctions or optimizing treatment plans.*

PO7 *Effectively communicate complex scientific concepts to both technical and non-technical audiences, including patients, healthcare professionals, and the public.*

PO8 *Adhere to ethical principles and professional standards in medical physics practice, including maintaining patient confidentiality and complying with regulatory requirements.*

PO9 *Conduct independent research projects and contribute to the advancement of medical physics through original research and innovation.*

PO10 *Collaborate effectively with healthcare professionals from diverse backgrounds to improve patient care and optimize the delivery of medical physics services.*

MP101 - MATHEMATICAL PHYSICS

L	T	P	C
4	1	0	5

60 Hrs. Lectures

Objectives

- *Master fundamental mathematical concepts essential for medical physics, including electromagnetic theory and quantum mechanics.*
- *Utilize mathematical methods to solve problems in wave propagation, heat conduction, and other physical phenomena.*
- *Grasp the principles of probability and statistics for data analysis, experimental design, and uncertainty quantification in medical physics.*
- *Employ statistical methods to analyze experimental data, evaluate equipment performance, and assess measurement uncertainty in medical physics.*
- *Learn numerical techniques and Monte Carlo simulations to solve complex physical problems, especially in radiation transport and dosimetry.*

Unit 1: Vector Calculus, Matrices and Complex Analysis

Scalar and vector fields - Gradient - Divergence, curl and Laplacian - line, surface, volume integrals-Theorems of Gauss, green and Stokes-Applications, Vector operators in curvilinear coordinates Eigen Value, Problem, diagonalization and similarity transformation; Analytic functions - Conformal mapping - Simple and Bilinear transformation - Applications - Cauchy's integral Theorem and integral formula - Taylor's and Laurent's series - singularities - Zeros, Poles and Residue theorem - contour integration with circular and semi-circular contours.

Unit 2. Fourier, Laplace Transforms and Partial Differential Equations

Fourier series-Harmonic analysis - Fourier transform - Properties - transforms of simple functions and derivatives-convolution theorems - Laplace's transform - properties - Transform of simple functions and derivatives-periodic functions - Convolution theorem - Application to solve differential equation. Transverse vibration of a string - Wave equation-one dimensional heat conduction - diffusion equation – two dimensional heat flow - Laplace's equation-method of separation of variables - Fourier series solution in Cartesian coordinate.

Unit 3: Probability and Basic Statistical distributions

Probability - addition and multiplication laws of probability, conditional probability, population, variants, collection tabulation and graphical representation of data. Introduction to 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.

Unit 4: Counting and Medical Statistics

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

Unit 5: Numerical, Monte Carlo and Computational Tools

Why numerical methods, accuracy and error 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 2/3 rule Simpson's three-eighth rule; Picard's method, Taylor's method, Euler's method the modified Euler's method, Runge-Kutta method.

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, inverse random sampling technique including worked examples, integration of simple I - D integrals including worked examples

Unit 6: Practicum (Not for final examination)

Linear system equations- Eigen values and vectors of a matrix - Identify the power series expansion of a function - Multivariable functions - First order ordinary differential equation - Higher order linear ordinary differential equation with constant coefficients - Trapezoidal and Simpson's rules - Runge-Kutta method

Books for Study

[1] L. A. Pipes and L. R. Harvill, *Applied Mathematics for Engineers and Physicists* (McGraw-Hill Book Co., New York, 1980).

[2] Sathya Prakash, *Mathematical Physics with Classical Mechanics* (Sultan Chand & Sons, New Delhi, 2015)

[3] M. K. Venkatraman, *Advanced Mathematics for Engineers & Scientists* (National Publishing Co., Madras, 1994).

[4] S. Rao, *Introduction to Biostatistics and Research Methods, 5th Ed.* (PHI Learning Pvt. Ltd., 2012)

[5] W. Wallace, *Nuclear Medicine: Radiation Physics, Safety and Counting Statistics* (CreateSpace Independent Publishing Platform, 2016)

[6] S. S. Sastry, *Introductory Methods of Numerical Analysis, 4th Ed.* (PHI Learning, Delhi, 2017).

Reference

[1] E. Butkov, *Mathematical Physics* (Addison Wesley, New York, 1973).

[2] E. Walpole et al., *Probability and Statistics for Engineers and Scientists* (Pearson Education, 2002).

[3] M. L. Boas, *Mathematical methods in the Physical Sciences, 2nd Ed.* (John Wiley & Sons., New York, 1983).

[4] G. Arfken and H. H. Weber, *Mathematical Methods for Physicists, 4th Ed.* (Prism Books, Bangalore, 1995).

Outcome

[CO1] *Mastered fundamental mathematical concepts essential for medical physics, including electromagnetic theory and quantum mechanics (K1, K2)*

[CO2] *Utilized mathematical methods to solve problems in wave propagation, heat conduction, and other physical phenomena (K3, K4, K5)*

[CO3] *Grasped the principles of probability and statistics for data analysis, experimental design, and uncertainty quantification in medical physics (K1, K2).*

[CO4] *Employed statistical methods to analyze experimental data, evaluate equipment performance, and assess measurement uncertainty in medical physics (K4, K5).*

[CO5] *Learned numerical techniques and Monte Carlo simulations to solve complex physical problems, especially in radiation transport and dosimetry (K2, K6).*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	L	M	L	L	L	L
CO2	S	S	M	M	M	S	L	L	L	M
CO3	S	M	S	M	S	M	L	L	M	L
CO4	M	S	S	M	S	S	M	L	L	M
CO5	M	S	M	S	M	S	L	L	S	M

S-Strong; M-Medium; L-Low

MP102 - Atomic and Nuclear Physics

L	T	P	C
4	1	0	5

60 Hrs. Lectures

Objectives

- *Learn the historical development of atomic models and apply quantum mechanics to explain atomic structure and spectra.*
- *Understand the quantum mechanical properties of electrons, analyze atomic spectra, and explore the periodic trends in the properties of elements.*
- *Study the properties of nuclear forces, apply quantum mechanics to nuclear models, and calculate nuclear binding energies.*
- *Learn about the different types of radioactive decay, apply quantum mechanics to explain decay processes, and explore nuclear fission.*
- *Analyze nuclear reactions, apply conservation laws, and calculate reaction cross-sections to understand nuclear reaction mechanisms.*

Unit 1: Atomic Structure of Matter

Thomson, Rutherford Model - Bohr's theory of Hydrogen atom - Drawbacks of these models - Bohr's correspondence principle - Sommerfeld extension to Bohr model - Frank and Hertz experiment - Types of spectra - Emission and absorption line spectra - Fluorescence and Phosphorescence - Characteristics of Vector atom model - Related Problems

Unit 2: Alkali spectra, space quantization and Periodicity

Angular and magnetic momenta - Orbital angular momentum - Electron spin and quantum number-Total angular momentum and magnetic moment of electron - Magnetic quantum numbers - spin orbit interaction - LS Coupling scheme - selection rules - Pauli exclusion principle - Electron configuration of atom - Periodic Table - Zeeman effect - Lande's - g-factor - Paschen back effect - Stark effect - Stern Gerlach experiment - Hyperfine structure of spectral lines.

Unit 3: Nuclear force and binding

Properties of nuclear force - Ground state properties of deuteron - square well solution of deuteron; Low energy neutron proton scattering - limits of energy for the scattering of different partial waves - Binding energy - Weizacker's semi empirical mass formula - Evidence of shell effects - Single particle energy levels for infinite square well, harmonic oscillator with spin orbit potential - Application of shell model for spin and parity.

Unit 4: Radioactive disintegration

Properties of radioactive rays - Law of radioactivity - Radioactive equilibrium - Radioactive series - Range of alpha particles - Alpha spectrum and Fine structure - Alpha particle disintegration Energy - Gamow's theory of Alpha decay - Energies of Beta decay - Beta ray Spectra - Pauli's neutrino hypothesis - Properties of neutrino - Gamma emission - Selection rules-internal conversion - Application of semi empirical formula for alpha decay - mass parabola for stability of nuclei against beta decay - Fission process on the basis of liquid drop model-Nuclear fission energetic-stability limits against spontaneous fission - Potential for fission-Bohr - wheeler model.

Unit 5: Nuclear reactions

Types of nuclear reaction - Conservation laws in nuclear reactions- Balance of Mass and Energy in nuclear reactions - The Q equation and its solution-Proton, deuteron, neutron and alpha induced reactions-cross section of nuclear reactions - separation of center of mass motion in two body problem - Partial wave method for scattering and reaction cross section - Compound nucleus hypothesis - Breit Wigner one level formula.

Unit 6: Practicum (Not for final examination)

Discovery of radioactivity - growth and decay of radioactivity - successive disintegration and displacement law - radioactive equilibrium - radon gas - unit of radioactivity - mean life of a radioactive substance - measurement of decay constant - half-lives for complex decays.

Books for Study and Reference

[1] A. Beiser, S. Mahajan, and S. Rai Choudhury, Co*ncepts of Modern Physics* 7th Ed. (McGraw Hill McGraw Hill Education, 2017)

[2] B. H. Bransden and C.J. Joachain, Physics of Atoms and Molecules, 2nd Ed. (Prentice Hall, 2003).

[3] G. K. Woodgate, Elementary Atomic Structure, 2nd Ed. (Oxford University Press, 1983).

[4] S. L. Kakani and S. Kakani, (Modern Physics, Viva Publications, 2015).

[5] S.B. Patel, Nuclear Physics: An Introduction (New Age International, 2012).

[6] D. C. Tayal, Nuclear Physics, (Himalaya Publishing, 2011).

[7] S. N. Ghosal, Nuclear Physics (S. Chand, New Delhi, 1997).

[8] K.S. Krane, Introductory Nuclear Physics, (Wiley India, 1955).

Outcome

[CO1] *Traced the historical development of atomic models and applied quantum mechanics to explain atomic structure and spectra (K1, K3).*

[CO2] *Understood the quantum mechanical properties of electrons, analyzed atomic spectra, and explored periodic trends in elemental properties (K2, K4)*

[CO3] *Studied the properties of nuclear forces, applied quantum mechanics to nuclear models, and calculated nuclear binding energies (K1, K3, K5)*

[CO4] *Learned about different types of radioactive decay, applied quantum mechanics to explain decay processes, and explored nuclear fission (K1, K3, K4)*

[CO5] *Analyzed nuclear reactions, applied conservation laws, and calculated reaction cross-sections to understand nuclear reaction mechanisms (K3, K4, K5)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

MAPPING WITH PROGRAMME OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	L	M	L	L	M	L
CO2	S	M	M	L	M	M	L	L	M	L
CO3	S	S	M	M	S	S	M	M	M	L
CO4	S	S	M	M	S	S	M	M	M	L
CO5	S	S	S	S	S	S	M	M	S	M

S-Strong; M-Medium; L-Low

MP103 - SOLID STATE PHYSICS

L	T	P	C
4	1	0	5

60 Hrs. Lectures

Objectives

- *Understand the fundamental concepts of crystal structures, diffraction, and interatomic forces.*
- *Grasp the theory of lattice vibrations and their impact on the thermal properties of solids.*
- *Analyze the electronic band structure of metals, semiconductors, and insulators to predict their electrical and optical properties*
- *Explore the origins of magnetic phenomena and their quantum mechanical description.*
- *Evaluate the potential applications of superconductivity in various technological fields, considering the limitations and challenges associated with current superconducting materials*

Unit 1: Crystal Physics

Types of lattices - Miller indices - Simple crystal structures - Crystal diffraction - Bragg's Law- Reciprocal lattice (*sc, bcc, fcc*) - Laue Equations - structure factor - Atomic form factor - Types of crystal binding - Cohesive energy of ionic crystals - Madelung constant - Inert gas crystals - Van der Waals - London Equation - Metals - Hydrogen bonded crystals.

Unit 2: Lattice Dynamics

Monoatomic Lattice - Lattice with two atoms per primitive cell - First Brillouin Zone - Group and Phase velocities - Quantization of lattice vibrations - Phonon momentum - Inelastic scattering by photons - Einstein's model and Debye's model of specific heat - Thermal expansion - Thermal conductivity - Umklapp processes.

Unit 3: Theory of Metals and Semiconductors

Free electrons gas in three dimensions - Electronic heat capacity – Wiedemann - Franz Law - Hall effect - Band theory of metals and semiconductors - Bloch theorem - Kronig-Penny model - Semiconductors - Intrinsic carrier concentration - Mobility - Impurity conductivity - Fermi surfaces and construction - Experimental methods in Fermi surface studies - de Haas Van Alphen effect.

Unit 4: Magnetism

Elementary ideas of dia, para and ferro magnetism - quantum theory of paramagnetism - Rare earth ion - Hund's rule - Quenching of orbital angular momentum - Adiabatic demagnetization - Quantum theory of ferromagnetism - Curie point - Exchange integral - Heisenberg's interpretation of Weiss field - ferromagnetic domains - Bloch wall - Magnons - Thermal excitation of magnons - Curie temperature and susceptibility of ferrimagnets - Theory of anti-ferromagnetism - Neel temperature.

Unit 5: Superconductivity

Experimental facts - occurrence - Effect of magnetic fields - Meissner effect - Entropy and heat capacity - Energy gap - Microwave and infrared properties - Type I and Type II superconductors - thermodynamics of super conducting transition - London equation - Coherence length - BCS theory - Single particle tunnelling - Josephson tunnelling - DC and AC Josephson effects - High temperature superconductors - SQUIDS.

Unit 6: Practicum (Not for final examination)

Demonstration of monoatomic and diatomic lattice vibrations - Demonstration of Powder X-Ray diffraction pattern - Determination of Hall coefficient, Hall voltage, type of carrier, mobility of charge carriers and carrier concentration.

Books for Study

[1] Kittel, *Introduction to Solid State Physics, 8th Ed.* (Wiley, New York, 2012).

[2] S. O. Pillai, *Solid State Physics, 7th Ed.* (New Age International, New Delhi, 2014).

Reference

[1] M. Ali Omar, *Elementary Solid State Physics - Principles and Applications* (Addison-Wesley, London, 1974).

[2] N. W. Ashcrof and N. D. Mermin, *Solid State Physics* (Harcourt College Publishers, Philadelphia, 1976).

[3] J. S. Blakemore, *Solid State Physics, 2nd Ed.* (Cambridge University Press, Cambridge, London, 1985).

[4] J. Dekker, *Solid State Physics* (Macmillan India, 2000).

[5] T. P. Sheahen, *Introduction to High-Temperature Superconductors* (Plenum press, New York, 1994).

[6] J. R. Christman, *Fundamentals of Solid State Physics* (John Wiley & Sons, New York, 1988).

[7] J. P. Srivastava, *Elements of Solid State Physics* (Prentice-Hall of India, 2006)

[8] http://nptel.ac.in/courses/115105099/

[9] http://nptel.ac.in/courses/115106061/

Outcome

[CO1] *Understood the fundamental concepts of crystal structures, diffraction, and interatomic forces (K1, K2)*

[CO2] *Grasped the theory of lattice vibrations and their impact on the thermal properties of solids (K2, K4)*

[CO3] *Analysed the electronic band structure of metals, semiconductors, and insulators to predict their electrical and optical properties (K4. K5)*

[CO4] *Explored the origins of magnetic phenomena and their quantum mechanical description(K2, K4)*

[CO5] *Evaluated the potential applications of superconductivity in various technological fields, considering the limitations and challenges associated with current superconducting materials (K5, K6)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	*PO1*	*PO2*	*PO3*	*PO4*	*PO5*	*PO6*	*PO7*	*PO8*	*PO9*	*PO10*

CO1	S	M	L	L	L	M	L	L	L	L
CO2	S	M	M	L	M	M	L	L	L	L
CO3	S	S	S	M	S	S	M	L	M	L
CO4	S	M	M	M	M	M	M	L	M	L
CO5	S	S	S	S	S	S	M	M	S	M

S-Strong; M-Medium; L-Low

L	T	P	C
4	1	0	5

MP104 - ELECTRONICS AND INSTRUMENTATION

60 Hrs. Lectures

Objectives

- *Understand the characteristics and applications of various semiconductor devices and the basics of integrated circuit fabrication.*
- *Apply operational amplifiers to design and analyze linear and non-linear circuits for various applications.*
- *Analyze the sources and effects of electronic noise and understand techniques to mitigate its impact.*
- *Explore the principles and applications of optoelectronic devices, including light sources, detectors, and displays.*
- *Grasp the fundamentals of digital electronics, microprocessor, and microcontroller architecture, and apply them to programming and interfacing devices.*

Unit 1: Semiconductor Devices and IC Fabrication

Semiconductor diodes - JFET - MOSFET - Thyristors - SCR and Triac - characteristics and ratings power control using thyristors power - IGBT - Switch mode DC power supplies -basics of Integrated Circuits.

Unit 2: Application of Semiconductor Devices

Operational amplifiers (op-amps) and their characteristics - Differential Amplifier - Operational amplifier systems - Op-amp Applications - Addition, subtraction, Integration and Differentiation - Active filters - Oscillators - Pulse Amplifiers - Regulated power supplies using IC's - Switching mode power supplies - AC regulators - Instrumentation amplifiers - V to I and I to V converter - Op - Amp circuits using diodes – Op-amp comparators - Sample and Hold circuits - Log and Antilog amplifiers - Multiplier and Divider - Electronic analog computation - Schmitt Trigger - Astable, Mono-stable Multivibrator - Triangular wave generator.

Unit 3: Electronic Noise

Noise in Electronics due to ionizing radiation, radiation damage; radiation hardening techniques in manufacture and in application - characteristics.

Unit 4: Opto Electronic Devices

Light sources and Displays: Light emitting diodes - surface emitting LED - edge emitting LED - Seven segment display - LDR - Diode lasers – homo and hetero junction semiconductor lasers - Photo detectors: Basic Parameters - Photo Diodes - p-i-n photo diode - Solar Cells - Photo Transistors - IR and UV Detectors.

Unit 5: Digital Electronics, Microprocessors and Micro Controllers

Binary adders and subtractors – flip-flops – binary counters – shift registers - decoders and encoders - multiplexer and de-multiplexer - A/D and D/A converters. Introduction to Microprocessors: Architecture, families , example of manufactures' specific features; Programming, Input and Output timers and Interrupts, interfacing memory and I/O devices - Memory address space and data organization - Segment registers and Memory segmentation generating a memory address - I/O address space - Addressing modes - comparison of 8086 and 8088 - Basic 8086/8088 configuration - Minimum mode - Maximum mode; Introduction to Microcontrollers - Comparison with Microprocessors - study of Microcontroller (MC 51 Family) - Architecture, Instruction Set , Addressing modes and its programming.

Unit 6: Practicum (Not for final examination)

The logic gates - Design simple combinational and sequential logic circuits - Construct a quantum mechanical model - the behavior of a system at microscopic level - Identify functions of digital multimeter, cathode ray oscilloscope - concepts of light in optical fibers, light wave communication systems - CRO, Signal generator, spectrometer, polarimeter - physical parameters of gates - transducers - measurement of physical variables

Books for Study

[1] P. Malvino, *Electronic principles* (Tata McGraw-Hill, New Delhi, 2011).

[2] T.L. Floyd, *Electronic devices* (Pearson Education Inc., New Delhi, 2012).

[3] P. Horowitz and W. Hill, *Art of electronics* (Cambridge University Press, New Delhi, 2006).

[4] Y.-C. Liu and G. A. Gibson, *Microprocessor Systems: The 8086/8088 family Architecture, Programming & Design, 2nd Ed.* (Pearson Education India, 2015)

[5] P. Mathur, *Introduction to Microprocessors, 3rd Ed.* (Tata McGraw-Hill, New Delhi, 2001).

Reference

[1] P.Bhattacharya. Semiconductor Optoelectronic Devices (Pearson Education Inc., New Delhi, 2002).

[2] H. S. Kalsi, Electronic Instrumentation (Tata McGraw-Hill, New Delhi, 2004).

[3] W.D.Cooper, Electronic Instrumentation and Measurement Techniques (Prentice Hall of India, 1991).

Outcome

[CO1] *Understood the characteristics and applications of various semiconductor devices and the basics of integrated circuit fabrication (K2, K3)*

[CO2] *Applied operational amplifiers to design and analyze linear and non-linear circuits for various applications (K3, K4)*

[CO3] *Analyzed the sources and effects of electronic noise and understood techniques to mitigate its impact (K2, K4)*

[CO4] *Explored the principles and applications of optoelectronic devices, including light sources, detectors, and displays (K2, K3)*

[CO5] *Grasped the fundamentals of digital electronics, microprocessor, and microcontroller architecture, and applied them to programming and interfacing devices (K2, K3)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	L	M	L	M	L	L	L	L
CO2	M	M	M	M	M	S	M	L	L	M
CO3	M	M	S	M	S	S	M	L	L	L
CO4	M	M	M	M	M	M	M	L	M	L
CO5	M	M	M	M	M	S	M	L	L	L

S-Strong; M-Medium; L-Low

MP105 - Basic Radiation Physics

L	T	P	C
4	1	0	4

60 Hrs. Lectures

Objectives

- *Understand the types of ionizing and non-ionizing radiation, their properties, and their interactions with matter.*
- *Learn about the principles and components of X-ray generators, their applications, and safety measures.*
- *Explore the design and operation of various particle accelerators used in medicine, industry, and research.*
- *Understand the mechanisms of interaction of photons with matter, including photoelectric, Compton, and pair production processes.*
- *Study the interaction of charged particles and neutrons with matter, including energy loss processes, range, and scattering.*

Unit 1: Ionizing and Non-ionizing Radiation

Electromagnetic spectrum - Different sources of Non Ionizing radiation, Radio-frequency, Microwaves, Infrared, Visible and Ultra violet radiation production, physical properties and their interaction with tissues.

Radiation quantities and units - Radiometry - particle flux and fluence - energy flux and fluence -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) - Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effected dose - Concepts of collective dose - KERMA-CEMA - Exposure - Air kerma rate constant - Charged particle equilibrium (CPE) - Relationship between kerma, absorbed dose and exposure under CPE -Dose equivalent

Unit 2 : X-Ray Generators

Discovery - Production - Properties of X-rays - Characteristics and continuous spectra - Design of hot cathode X-ray tube - Basic requirements of medical diagnostics, therapeutic and industrial radiographic tubes - Rotating anode tubes - Hooded anode tubes - Industrial X-ray tubes - Safety devices in X-ray tubes - X ray tubes for crystallography- rating of tubes - Safety devices in X-ray tubes - Ray proof and shock proof 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 - Filament and high voltage transformers - High voltage circuits - Half wave and full wave rectifiers - condenser discharge apparatus - Three phase apparatus - voltage doubling circuits - current and voltage stabilisers - Automatic exposure control - Automatic Brightness Control - Measuring instruments - Measurement of kV and mA - timers - Control Panels - Complete X-ray circuit- Image intensifiers and closed circuit TV systems - Modern trends.

Unit 3: External Beam Therapy Equipment

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 Tele-cobalt units - source design - beam collimation and penumbra - trimmers and breast cones. Particle accelerators for industrial, medical and research application - The Resonant transformer - Cascade generator - Van De Graff Generator - Pelletron - Cyclotron - Betatron - Synchro-Cyclotron - Linear Accelerator - Klystron and magnetron - Travelling and Standing Wave Accelerations - Design and working of medical electron linear accelerators - beam collimation - asymmetric collimator - multi-leaf collimator - dose monitoring - electron contamination - Microtron - Electron Synchrotron - Proton synchrotron.

Unit 4: Interaction of Photons with Matter

Interaction of electromagnetic radiation with matter - Photoelectric and Compton process and energy absorption - Pair production - Attenuation and mass energy absorption coefficients - Relative importance of various processes.

Unit 5: Interaction of 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 - Bremsstrahlung - Range energy relation - Continuous slowing down approximation (CSDA) - transmission and depth dependence methods for determination of particle penetration - empirical relation between range and energy - Back scattering - Passage of heavy charged particles through matter - Energy loss per collision - Range energy relation - Bragg curve - Specific ionization - stopping Power - Bethe Bloch formula - Interaction of neutrons with matter - scattering - capture - neutron induced nuclear reactions.

Unit 6: Practicum (Not for final examination)

Alpha, beta and gamma radioactivity - Mechanisms of Particle Accelerators - Linear Accelerator and its mechanisms-X-ray production-Radiation with matter oriented towards radiology - Radiation effects related to radiology and therapy.

Books for Study

[1] K. Thayalan, Basic Radiological Physics, 2nd Ed. (Jaypee Brothers Medical Publishers, New Delhi, 2017).

[2] F. M. Khan, The Physics of Radiation therapy, 3rd Ed. (LIppincott Williams & Wikins, Philadelphia, 2003).

[3] H. E. John and J. R. Cunningham, Physics of Radiology, 4th Ed., (Charles C Thomas Pub. Ltd,. 1983).

[4] W. R. Hendee, Medical Radiation Physics, (Year Book Medical Publishers Inc., London, 2003).

Reference

[1] R. E. Lapp, Nuclear Radiation Physics (Prentice-Hall Inc., New York, 1948).

[2] L. Slack and K. Way, Radiations from Radioactive Atoms in frequent use, (United States Government Printing Office, Washington, 1959).

[3] K. S. Krane, Introductory Nuclear Physics (John-Wiley, New York 1987).

Outcome

[CO1] *Understood the types of ionizing and non-ionizing radiation, their properties, and their interactions with matter (K1, K2)*

[CO2] *Learned about the principles and components of X-ray generators, their applications, and safety measures (K1, K3, K5)*

[CO3] *Explored the design and operation of various particle accelerators used in medicine, industry, and research (K2, K4)*

[CO4] *Understood the mechanisms of interaction of photons with matter, including photoelectric, Compton, and pair production processes (K2, K3)*

[CO5] *Studied the interaction of charged particles and neutrons with matter, including energy loss processes, range, and scattering (K1, K3, K4)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	L	M	M	L	L	L	L
CO2	S	S	M	M	M	M	M	S	M	M
CO3	S	S	M	S	M	S	M	L	S	M
CO4	S	S	M	M	M	M	M	L	M	L
CO5	S	S	M	M	S	S	M	L	M	M

S-Strong; M-Medium; L-Low

MP111 - Electronics and Solid State Physics Laboratory

L	T	P	C
0	0	4	4

60 Hrs. Practical

Objectives

- *Understand the principles of voltage regulation and design a Zener regulated power supply.*
- *Design and implement practical circuits for analog-to-digital and digital-to-analog conversion.*
- *Analyze the characteristics of field-effect transistors and their applications in electronic circuits.*
- *Design and implement combinational logic circuits, including adders, subtractors, and logic gates.*
- *Explore the design and operation of sequential logic circuits, such as counters, shift registers, and multivibrators.*
- *Apply microprocessor-based systems to perform arithmetic operations and data processing tasks.*
- *Conduct experiments to determine fundamental physical constants, such as Planck's constant and the wavelength of light.*
- *Investigate the properties of materials, including crystal structure and energy band gaps, using techniques like X-ray diffraction and I-V characterization.*

List of Experiments

1. Zener regulated power supply and percentage of regulation.
2. Construction of 12V-Dual and variable power supply.
3. Analog to Digital and Digital to Analog conversion.
4. OP-Amp applications- Adder, Subtractor, Differentiator and Integrator.

5. OP-AMP - filters (1) Low pass (2) High pass (3) Band pass (4) Notch filter and D/A Converter - Ladder Type.
6. Characteristics of field effect transistor (FET)
7. Truth table verification for NOT, AND, OR, NAND, NOR, XOR, NAND and NOR universal gates.
8. Half adder& full adder, and half subtractor & full subtractor using gates.
9. Multivibrator using 555 IC & sine wave generator.
10. Shift register using 7476 IC serial in - serial out.
11. 7490 counter decoder, 7-segment display studies.
12. 8-bit addition, subtraction, multiplication and division using P 8085 kit.
13. 16-bit addition, subtraction 2;s compliments using P8085 kit.
14. Determination of Planck's constant - Photoelectric Effect.
15. Determination of Wavelength of He-Ne Laser using grating.
16. Determination of Melting Point of crystalline materials
17. Refractive Index of crystals using He-Ne Laser
18. Forbidden Energy gap in PN junction
19. X - Ray Powder diffraction - Determination of cell parameter and indexing lattice planes
20. I-V characteristics of Light Emitting Diodes

Outcome

[CO1] *Understood the principles of voltage regulation and designed a Zener regulated power supply (K1, K6)*

[CO2] *Designed and implemented practical circuits for analog-to-digital and digital-to-analog conversion (K6)*

[CO3] *Analyzed the characteristics of field-effect transistors and their applications in electronic circuits (K3, K4)*

[CO4] *Designed and implemented combinational logic circuits, including adders, subtractors, and logic gates (K3, K6)*

[CO5] *Explored the design and operation of sequential logic circuits, such as counters, shift registers, and multivibrators (K2, K3)*

[CO6] *Applied microprocessor-based systems to perform arithmetic operations and data processing tasks (K3)*

[CO7] *Conducted experiments to determine fundamental physical constants, such as Planck's constant and the wavelength of light (K3, K5)*

[CO8] *Investigated the properties of materials, including crystal structure and energy band gaps, using techniques like X-ray diffraction and I-V characterization (K3, K4)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10
CO1	M	L	L	L	L	M	L	L	L	L
CO2	M	L	L	M	L	M	L	L	L	L
CO3	M	M	M	M	L	M	L	L	L	L
CO4	M	L	L	M	L	M	L	L	L	L

CO5	M	L	L	M	L	L	L	L	L	L
CO6	M	M	M	M	M	M	L	L	M	L
CO7	S	L	M	L	L	M	L	L	L	L
CO8	S	L	M	M	M	M	L	L	L	L

S-Strong; M-Medium; L-Low

MP201 - HUMAN ANATOMY AND PHYSIOLOGY

L	T	P	C
4	1	0	4

60 Hrs. Lectures

Objectives

- *Understand the fundamental concepts of human anatomy, including cellular structure, tissues, organ systems, and skeletal and muscular systems.*
- *Explore the functions of the digestive, circulatory, and respiratory systems, including the processes of digestion, blood circulation, and gas exchange.*
- *Learn about the endocrine, reproductive, and nervous systems, including hormone function, reproductive processes, and neural mechanisms.*
- *Understand the structure and function of the excretory system and the sensory organs, including the kidneys, skin, eyes, ears, nose, and tongue.*
- *Apply radiographic anatomy and tumor pathology to interpret medical images and understand the characteristics of cancer.*

Unit 1: Definitions and Surface Anatomy

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 Upper Extremity, Lower Extremity etc. - the muscular system -the thoracic cage - the media-sternum, the diaphragm the abdominal cavity and abdominal regions - anatomy of the heart. Superior Extremities, Inferior Extremities, Ossification centres, Bone of Upper Limb, Radius and ulna, surface marker of Thorax, Abdomen, Head and Neck.

Unit 2: Digestive, Circulatory and Respiratory System

Functions of mouth, tongue, teeth, oesophagus, Salivary Glands, stomach, small intestine, Duodenum, large intestine , Jejunum, Ileum Pancreas, Liver, Biliary System.- 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, Plasma, artery, vein, capillaries and heart structure and functions - Physiological properties of heart muscle, cardiac dynamics - EEG - blood pressure and its regulation. Physical laws of respiration - Nose, Pharynx, Bronchi - Trachea - Lungs and its functions - oxygen transport -Physiology of Respiration - Lung Volume and capacity, control, gas exchange.

Unit 3: Endocrine system, Reproductive System and Nervous System

Pituitary glands and its functions - functions of adrenal, thyroid, Pancreas etc. secretion - chemistry - physiological actions, effects on removal effect on removal effect on administration, hormonal assay detailed molecular mechanism of hormone action - Insulin. (a) Male Reproductive System - Testis, Functions, ducts, Male infertility (b) Female Reproductive System: Ovaries, Fallopian Tube, Vagina, Breast, reproductive Cycle, Menstruation, Maturation, Fertilization. Brain and spinal cord - its functions - central nervous system and Autonomic Nervous system functions - Physiology of special senses of hearing, taste vision

Unit 4: Excretory System and Sensory System

Kidney and its functions - Formation and Excretion of Urine, Urethra, Urinary Bladder, Urethra, Micturation. Skin - Eye - Ear - Nose - Tongue.

Unit 5: Radiographic Anatomy and Tumour Pathology

Radiographic Anatomy (including cross sectional anatomy - identifies the different organs/ structure on plain X-rays), CT scans and other available imaging modalities. Normal anatomy and deviation from abnormalities- Tumour pathology and carcinogenesis- Common pathological features of cancers and interpretation of clinico-pathological data.

Unit 6: Practicum (Not for final examination)

Surface of the anatomy - Digestive, circulatory, Respiratory system - Endocrine, Reproduction, Excretory, Nervous and Sensory system - concepts in Anatomy Physiology & Pathology - Radiographic Anatomical structures - anatomic structures and its functions - anatomical terms related to radiation oncology - anatomy and physiology related with cancer.

Books for Study

[1] Ross and Wilson, *Anatomy and Physiology in Health and Illness*, 9th edition, Anne Waugh, Allison Grant, 2010.

[2] B. D. Chaurasia, *Handbook of General Anatomy*, 5th Ed. (CBS Publishing, 2018).

Reference

[1] C. H. Best and N. B. Taylor, *A Test in Applied Physiology* (Williams & Wilkins Company, Baltimore, 1986).

[2] C. K. Warwick, *Anatomy and Physiology for Radiographers* (Oxford University Press, 1988).

[3] W. H. Hollinshead, C. Rosse, and P. Gaddum-Rosse, *Hollingshead's Text Book of Anatomy, 5th Ed.* (Lippincott Williams & Wilkins, 1997).

Outcome

[CO1] *Understood the fundamental concepts of human anatomy, including cellular structure, tissues, organ systems, and skeletal and muscular systems (K1, K2)*

[CO2] *Explored the functions of the digestive, circulatory, and respiratory systems, including the processes of digestion, blood circulation, and gas exchange (K2, K3)*

[CO3] *Learned about the endocrine, reproductive, and nervous systems, including hormone function, reproductive processes, and neural mechanisms (K2, K3)*

[CO4] *Understood the structure and function of the excretory system and the sensory organs, including the kidneys, skin, eyes, ears, nose, and tongue (K2, K3)*

[CO5] *Applied radiographic anatomy and tumor pathology to interpret medical images and understand the characteristics of cancer (K3, K4)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	L	L	L	M	L	L	L	L
CO2	S	M	M	L	M	M	L	L	L	L
CO3	S	M	M	L	M	M	L	L	L	L

CO4	S	M	M	L	M	M	L	L	L	L
CO5	S	S	M	M	S	S	M	L	M	L

S-Strong; M-Medium; L-Low

L	T	P	C
4	1	0	4

MP202 - Radiation Dosimetry and Standardization

60 Hrs. Lectures

Objectives

- *Understand the principles of radiation dosimetry, including standards, calibration techniques, and measurement of dose for various radiation sources.*
- *Grasp the concepts of brachytherapy source standardization, including reference air kerma rate, air kerma strength, and calibration methods.*
- *Learn about neutron sources, neutron standards, and neutron dosimetry techniques, including neutron spectrometry and survey meters.*
- *Explore the methods of measuring radioactivity, including defined solid angle, 4π counting, and scintillation spectrometry, for various radionuclides.*
- *Understand the principles of radiation chemistry, the effects of radiation on matter, and the application of chemical dosimetry for radiation dose measurement.*

Unit 1: Dosimetry and Standardisation of X and Gamma Beams

Standards - Primary and Secondary Standards, Traceability, Uncertainty in measurement, Charged particle Equilibrium (CPE), Free air ion chamber (FAIC), Design of parallel plate chamber, Measurement of air kerma/exposure. Limitations of FAIC. Bragg - Gray theory, Mathematical expression describing Bragg Gray principle and its derivation. Burlin and Spencer Attix Cavity theories. Transient Charged Particle Equilibrium (TCPE), Concept of Dgas, Cavity ion Chambers, Derivation of an expression for sensitivity of a cavity ion chamber. General definition of calibration factor as per IAEA TRS277 and TRS398 - AAPM TG51 protocols - Derivation of an expression for K_q, q_o factors - Calorimetric standards - Inter-comparison of standard.

Measurement of Dw for External beams from Co-60 tele therapy 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, Measurement of Dw for high - energy photon beams from Linear accelerators: Beam quality index, beam quality correction coefficient, Cross calibration.

Measurement of Dw for high - energy electron beams from Linear accelerators: Beam quality index, beam quality correction coefficient, Cross calibration using intermediate beam quality. Quality audit programmes in reference and non-reference conditions

Unit 2: Standardization of Brachytherapy Sources

Apparent activity - Reference Air Kerma Rate - Air Kerma Strength - Standards for HDR Ir-192 and Co-60 Sources - Standardization of I-125 and beta sources - Specification and calibration of Brachytherapy sources - RAKR and AKS - IAEA TECDOC 1274 - room scatter correction.

Unit 3: Neutrons Standards and Dosimetry

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

Unit 4: Standardization of radio-nuclides

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

Unit 5: Radiation Chemistry and Chemical Dosimetry

Definitions of free radicals and G-value- Kinetics of radiation chemical transformations - LET and Dose - rate effects - Radiation Chemistry of water and aqueous solutions, per-oxy radicals, pH effects - Radiation chemistry of gases and reactions of dosimetry interest - Radiation polymerization, effects of radiation on polymers and their applications in dosimetry - Formation of free radicals in solids and their applications in dosimetry - Description of irradiators from dosimetric view point - Dosimetry principles - Definitions of optical density, molar absorption coefficient, Beer - Lamberts law, spectro-photometry - Dose calculations - Laboratory techniques - Reagents and procedures - Requirements for an ideal chemical dosimeter - Fricke dosimeter - FBX dosimeter - Free radical dosimeter - Ceric sulphate dosimeter - Other high and low level dosimeters - Applications of chemical dosimeters in Radiotherapy and Industrial irradiators.

Unit 6: Practicum (Not for final examination)

Calibration of tele Co-60 therapy unit and high energy accelerator for photon and electron - Calibration of high dose rate (HDR) brachytherapy - Source loading procedure in tele Co-60 unit and HDR brachytherapy unit. Maintenance and care of dosimeters.

Books for Study

[1] F.H. Attix, *Introduction to Radiological Physics and Radiation Dosimetry* (Viley - VCH, Verlog, 2004).

[2] S. Green, *Fundamentals of Radiation Dosimetry 3rd Ed.* (Taylor & Francis group, 2010).

[3] H. E. John and J. R. Cunningham, *Physics of Radiology, 4th Ed.* (Charles C Thomas Pub. Ltd,. 1983).

[4] K. N. Govindarajan, *Advanced Medical Radiation dosimetry* (Prentice-Hall of India Pvt. Ltd, 2004).

Reference

[1] IAEA TRS 374 Calibration of Dosimeters used in radiation therapy.

[2] IAEA TRS 398 Absorbed Dose Determination in External Beam Radiotherapy.

[3] AAPM TG51 protocol for clinical reference dosimetry of external beam radiation therapy.

[4] IAEA TECDOC 1274 Calibration of Photon and Beta Ray Sources

Outcome

[CO1] *Understood the principles of radiation dosimetry, including standards, calibration techniques, and measurement of dose for various radiation sources (K1, K2)*

[CO2] *Grasped the concepts of brachytherapy source standardization, including reference air kerma rate, air kerma strength, and calibration methods (K2, K3)*

[CO3] *Learned about neutron sources, neutron standards, and neutron dosimetry techniques, including neutron spectrometry and survey meters (K1, K2)*

[CO4] *Explored the methods of measuring radioactivity, including defined solid angle, 4π counting, and scintillation spectrometry, for various radionuclides (K1, K3)*

[CO5] *Understood the principles of radiation chemistry, the effects of radiation on matter, and the application of chemical dosimetry for radiation dose measurement (K2, K3)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	M	L	M	L	L
CO2	S	S	M	M	M	S	L	M	L	L
CO3	S	M	M	M	S	S	L	M	M	L
CO4	S	M	M	M	S	M	L	M	M	L
CO5	S	M	M	M	S	M	L	M	M	L

S-Strong; M-Medium; L-Low

L	T	P	C
4	1	0	4

MP203 - Radiation Detectors and Instrumentation

60 Hrs. Lectures

Objectives

- *Understand the principles of radiation detection and the operation of gas-filled detectors, including ionization chambers, proportional counters, and Geiger-Muller counters.*
- *Explore the principles and applications of scintillation detectors, semiconductor detectors, and solid-state dosimeters, such as TLDs and OSLDs.*
- *Learn about the design and operation of various dosimeters used in medical applications, including ionization chambers, electrometers, and radiation field analyzers.*
- *Understand the principles and applications of personnel monitoring instruments, such as TLD badges, film dosimeters, and pocket dosimeters.*
- *Explore the principles and applications of counting and spectrometry instruments, including gamma-ray spectrometers, liquid scintillation counters, and whole-body counters.*

Unit 1: Principles of Radiation Detection and Gas Filled Detectors

Principles of radiation detection and measurements - Basic principles of radiation detection - gas filled detectors - Ionization chambers - Theory and design - construction of condenser type chambers and thimble chambers - Gas multiplication - Proportional and G.M. Counters - Characteristics of organic and in organic counters - Dead time and recovery time.

Unit 2: Scintillation and Nuclear Track Detectors

Scintillation detectors - Semiconductor detectors - Chemical systems - Radiographic and radio chromic films - Thermo luminescent dosimeters (TLD) - Optical stimulated luminescence dosimeter (OSLD) - Radio-photo-luminescent Dosimeter - Neutron detectors - Nuclear track emulsion for fast neutrons - Solid state nuclear track (SSNTD) detectors - Calorimeters - New Developments.

Unit 3: Dosimeters for Medical Applications

Pocket chambers - Dosimeters based on current measurements - Different types of electrometers - MOSFET, vibrating condenser and Varactor bridge types - Secondary standard therapy level Dosimeters - Farmer dosimeters - Radiation field analyser (RFA) - Radio isotope calibrator - Multipurpose dosimeter - Water phantom dosimetry systems - Brachytherapy Dosimeters - Thermo luminescent dosimeter readers for Medical Applications - Calibration and Maintenance of dosimeters.

Unit 4: Instruments for Personnel Monitoring

TLD Badge readers - PM Film Densitometers - Glass dosimeters Readers - Digital pocket dosimeters using Solid State devices and G.M counters - Tele-detector - 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 - Teledose systems.

Unit 5: Instruments for Counting and Spectrometry

Portable counting systems for alpha and beta radiations - Gamma ray spectrometers - Multi-channel analyzer - Liquid scintillation counting systems - RIA counters - Whole body counters - Air monitors for radioactive particulates and gases - commercial systems

Unit 6: Practicum (Not for final examination)

Principles of radiation detection and measurements - Detectors - Ionization chambers and its applications - the scintillation and nuclear track detectors - thermo luminescence dosimeter - optically stimulated luminescence dosimeter - gel dosimeter.

Books for Study

[1] J. T. Bushberg, et al., *The Essential Physics of Medical Imaging, 3rd Ed.* (LWW, 2011)

[2] *Radiation oncology physics: A handbook of Teachers and Students* (IAEA Publication)

[3] G. F. Knoll, *Radiation Detection and Measurement 4th Ed.* (John Wiley & Sons, 2010)

Reference

[1] F. H. Attix, Introduction to Radiological Physics and Radiation Dosimetry (Viley - VCH, Verlog, 2004).

[2] S. Tavernier, *Radiation detectors for Medical Application* (Springer, 2006).

[3] G. Lutz, *Semiconductor Radiation detector* (Springer, 1999)

[4] A.F. Mcknalay, *Thermoluminescence Dosimetry* (Bristol Adam Hilge, London, 1981).

Outcome

[CO1] *Understood the principles of radiation detection and the operation of gas-filled detectors, including ionization chambers, proportional counters, and Geiger-Muller counters (K2, K3)*

[CO2] *Explored the principles and applications of scintillation detectors, semiconductor detectors, and solid-state dosimeters, such as TLDs and OSLDs (K2, K3)*

[CO3] *Learned about the design and operation of various dosimeters used in medical applications, including ionization chambers, electrometers, and radiation field analyzers (K1, K2)*

[CO4] *Understood the principles and applications of personnel monitoring instruments, such as TLD badges, film dosimeters, and pocket dosimeters (K2, K3)*

[CO5] *Explored the principles and applications of counting and spectrometry instruments, including gamma-ray spectrometers, liquid scintillation counters, and whole-body counters (K2, K3)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	M	M	L	L	L	L
CO2	S	M	L	L	M	M	L	L	L	L
CO3	S	S	M	M	S	M	M	M	M	L
CO4	S	S	M	M	S	M	M	S	M	L
CO5	S	S	M	M	S	S	M	M	M	L

S-Strong; M-Medium; L-Low

L	T	P	C
4	1	0	4

MP204 - Physics of Radiation Therapy

60 Hrs. Lectures

Objectives

- *Understand the principles of external beam radiation therapy, including the characteristics of different radiation beams, dose distribution parameters, and treatment planning techniques.*
- *Learn about beam modifying devices and their role in shaping radiation beams to conform to tumor targets, as well as the principles of treatment planning for teletherapy, including dose calculation and field arrangement.*
- *Explore the principles and applications of photon, electron, and heavy particle therapy, including their physical characteristics, dosimetry, and clinical use.*
- *Understand the principles of brachytherapy, including different techniques, source characteristics, dose rate considerations, and treatment planning methods.*
- *Learn about advanced brachytherapy techniques, such as CT/MR-based planning, integrated brachytherapy, and electronic brachytherapy, and their applications in cancer treatment.*

Unit 1: Beam Therapy

External beam radiation therapy: kV X-rays, gamma rays, MV x-rays and electron beams - relative merits and demerits - Central axis dosimetry parameters - 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 Field analyzer (RFA). Description and measurement of iso-dose curves/charts Dosimetry data resources - Radiotherapy simulator and its applications - CT and Virtual simulations.

Unit 2: Beam Modifying Devices and Treatment Planning

Wedge filters - universal, motorized and dynamic wedges - shielding blocks, compensators and multi-leaf collimators. Treatment planning in Tele-therapy - 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 - fields arrangements - single, parallel opposed and multiple fields - corrections for tissue in-homogeneity, 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 3: Photon, Electron and Heavy Particle Therapy

Clinical electron beams - energy specifications - electron energy selection for patient treatment - depth dose characteristics (Ds, Dx.R100, R90, R50, Rp etc) - beam flatness and symmetry - penumbra - iso-dose 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; Quality assurance in radiation therapy - precision and accuracy in clinical dosimetry - quality assurance protocols for Tele-cobalt, 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.

Unit 4: Brachytherapy Techniques

Definition and classification of Brachytherapy techniques - surface mould, intra-cavitary, interstitial and intra-luminal techniques; Requirement for Brachytherapy sources - description of radium and radium substitutes - Cs-137, Co-60, Ir-192, I-125 and other commonly used Brachytherapy sources. Dose rate considerations and classification of Brachytherapy techniques - Low dose rate (LDR), medium dose rate (MDR), high dose rate (HDR) and pulse dose rate (PDR) - Paterson Parker and Manchester Dosage systems - ICRU 38 and 58 protocols - ICRU 72 and 89 recommendations - Point and line source dosimetry formalisms - Sievert integral - AAPM TG 43/43U1 and other dosimetry formalisms - Advantages and disadvantages of manual and remote after loading technique. 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.

Unit 5: Treatment Planning in Brachytherapy

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 TG60 protocol; Electronic brachytherapy - recent advances.

Unit 6: Practicum (Not for final examination)

Principles and concepts for Brachytherapy - low Kv therapy - working mechanisms of telecobalt - dosimetric data - beam modifying devices - contour delination for different sites - Clinical electron beams - beam data - Definition and classification of brachytherapy - Techniques and its applications.

Books for Study and Reference

[1] F. M. Khan, *The Physics of Radiation therapy, 3rd Ed.*, (Lippincott Williams & Wilkins, Philadelphia, 2003).

[2] F. M. Khan and R. A. Potish, *Treatment Planning in Radiation Oncology* (Williams & Wilkins, Baltimore, 1998).

[3] W. R. Hendee, *Medical Radiation Physics* (Year Book Medical Publishers Inc., London, 2003).

[4] R. F. Mould, *Radiotherapy treatment planning, Medical Physics Hand Book Series No. 7* (Bristol Adam Hilge, London, 1981).

Outcome

[CO1] *Understood the principles of external beam radiation therapy, including the characteristics of different radiation beams, dose distribution parameters, and treatment planning techniques (K2)*

[CO2] *Learned about beam modifying devices and their role in shaping radiation beams to conform to tumor targets, as well as the principles of treatment planning for teletherapy, including dose calculation and field arrangement (K2, K3)*

[CO3] *Explored the principles and applications of photon, electron, and heavy particle therapy, including their physical characteristics, dosimetry, and clinical use (K2, K3)*

[CO4] *Understood the principles of brachytherapy, including different techniques, source characteristics, dose rate considerations, and treatment planning methods (K2)*

[CO5] *Learned about advanced brachytherapy techniques, such as CT/MR-based planning, integrated brachytherapy, and electronic brachytherapy, and their applications in cancer treatment (K2, K3)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	M	L	M	L	L
CO2	S	S	M	M	S	M	L	M	L	L
CO3	S	S	M	M	S	S	M	M	M	L
CO4	S	S	M	M	M	M	M	L	M	L
CO5	S	S	M	M	S	S	M	M	M	M

S-Strong; M-Medium; L-Low

L	T	P	C
0	0	5	4

MP211 - Radiation Physics Laboratory

60 Hrs. Practical

Objectives

- *Understand the principles of operation of a Geiger-Muller counter and determine its performance characteristics.*
- *Apply statistical methods to analyze and interpret radioactive counting data.*
- *Investigate the interaction of beta particles with matter and determine their range in different materials.*
- *Study the phenomenon of backscattering of beta particles and its applications in radiation measurements.*
- *Explore the production and attenuation of Bremsstrahlung radiation and its significance in radiation shielding and dosimetry.*
- *Calibrate radiation survey instruments and pocket dosimeters to ensure accurate dose measurements.*
- *Calibrate and use thermoluminescent dosimeters for dose distribution measurements in various radiation fields.*
- *Study the absorption and scattering of gamma rays and determine their half-value layer.*

List of Experiments

1. Determination of Plateau and resolving time of a GM Counter and its application is estimating the shelf-ratio and activity of a beta source.
2. Statistics of radioactive counting.
3. Range of beta particles by Feather Analysis.
4. Back scattering of beta particles and its applications.

5. Production and attenuation of Bremsstrahlung
6. Calibration check of survey instruments and pocket dosimeters.
7. Calibration check of a G.M. Monitor.
8. Calibration of TL phosphor & TLD reader and its use in dose distribution measurements.
9. Absorption and backscattering of gamma rays - Determination of HVT.

Optional

10. Calibration of Gamma ray spectrometer [NaI(Tl), HPGe] and identification of unknown source using multichannel analyser.
11. Calibration and use of alanine dosimeter using ESR technique.
12. Calibration of a TLD personnel monitoring badge and dose evaluation.
13. Characteristics of a flow counter and beta activity measurement.

Outcome

[CO1] *Understood the principles of operation of a Geiger-Muller counter and determined its performance characteristics (K3, K4)*

[CO2] *Applied statistical methods to analyze and interpret radioactive counting data (K3. K4).*

[CO3] *Investigated the interaction of beta particles with matter and determined their range in different materials (K3, K4)*

[CO4] *Studied the phenomenon of backscattering of beta particles and its applications in radiation measurements (K3, K4)*

[CO5] *Explored the production and attenuation of Bremsstrahlung radiation and its significance in radiation shielding and dosimetry (K3, K5)*

[CO6] *Calibrated radiation survey instruments and pocket dosimeters to ensure accurate dose measurements*

[CO7] *Calibrated and used thermoluminescent dosimeters for dose distribution measurements in various radiation fields (K3, K4)*

[CO8] *Studied the absorption and scattering of gamma rays and determined their half-value layer (K3, K4)*

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyse, K5 – Evaluate, K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10
CO1	S	M	L	L	M	M	L	L	L	L
CO2	S	M	S	M	M	M	M	L	M	L
CO3	S	M	M	M	M	M	L	L	L	L
CO4	S	M	M	M	M	M	L	L	L	L
CO5	S	M	M	M	M	M	M	L	M	L
CO7	M	S	M	M	S	M	M	M	M	M
CO8	M	S	M	M	S	S	M	M	M	M

S-Strong; M-Medium; L-Low

MP251 - MEDICAL IMAGING TECHNOLOGY (NON-MAJOR ELECTIVE – I)

L	T	P	C
2	1	0	2

30 Hrs. Lectures

Objectives

- *Understand the principles of X-ray production, the design of X-ray tubes and generators, and the techniques of radiographic imaging, including conventional and digital modalities.*
- *Learn about the specific requirements for mammography and fluoroscopy, including image quality, radiation dose, and patient comfort.*
- *Grasp the principles of computed tomography, including image acquisition, reconstruction, and image quality, and the different generations of CT scanners.*
- *Understand the principles of ultrasound imaging, including sound wave propagation, transducer design, and image formation techniques, as well as the applications of Doppler ultrasound.*
- *Explore the principles of magnetic resonance imaging, including the physics of nuclear magnetic resonance, image acquisition techniques, and the factors affecting image quality.*

Unit 1: X-ray Production and Radiography

Production of X-rays: electron interaction with the target-X-ray spectra-Bremsstrahlung and characteristic X-rays. X-ray tubes: cathode and space charge effect-anode and line focus principle-stationary and rotating anode X-ray tubes. X-ray generators - power ratings and heat loading and cooling-factors affecting X-ray emission.

Geometry of projection radiography - screen film radiography - computed radiography - charge coupled device and complementary metal - oxide semiconductor detectors - flat panel thin film transistor array detectors - scintillators and intensifying screens - absorption efficiency and conversion efficiency-Radiographic detectors and patient dose - Dual energy radiography- scattered radiation-anti scatter grid.

Unit 2: Mammography, Fluoroscopy

X-ray tube and beam filtration: cathode and filament circuit-anode and focal spot - tube port, filtration and beam quality-Half value layer. X-ray generator and photo timer system-automatic exposure control. Compression, scattered radiation and magnification. Screen-film cassettes and film processing - digital mammography - radiation dosimetry and regulation.

Fluoroscopy principle and imaging chain components-detector systems: input screen-electron optics - output screen-optical coupling to the video camera - Characteristics of Image intensifier - flat panel based detectors-automatic exposure rate control - modes of operation- image quality- radiation dose.

Unit 3: Computed tomography:

CT system design-terminology-scanning principle - CT number-image display. CT equipment components: control console-computer-gantry-couch. Generations of CT scanners. Image reconstruction: iterative method-back projection-filtered back projection-multi planar reconstruction - CT fluoroscopy. Helical and multi slice computed tomography. CT image quality, artefacts and radiation dose.

Unit 4: Ultrasound

Basics of ultrasound: Propagation of ultrasound-interaction of ultrasound with matter. Ultrasound transducer-piezo electric material- transducer design- transducer array. Image data acquisition - pulse echo operation. Image display: Amplitude mode - Brightness mode and Motion mode. Doppler ultrasound - Doppler shift- Doppler systems. Image quality, artefacts and bio effects.

Unit 5: Magnetic resonance imaging

Magnetic resonance imaging (MRI): Basics physics of MRI - magnetism-hydrogen characteristics- proton and magnetic field-magnetization vector-precession - radio frequency and resonance-flip angle. Relaxation times-T1 and T2 relaxation times and comparison. MRI signal spatial localization-gradient coils-slice selection-phase and frequency encoding. Imaging sequences: spin-echo- inversion recovery - gradient recalled echo and other specialized sequences. MRI instrumentation and bio safety. Image quality and artefacts.

Outcome

[CO1] *Understood the principles of X-ray production, the design of X-ray tubes and generators, and the techniques of radiographic imaging, including conventional and digital modalities (K2, K3)*

[CO2] *Learned about the specific requirements for mammography and fluoroscopy, including image quality, radiation dose, and patient comfort (K1, K2)*

[CO3] *Grasped the principles of computed tomography, including image acquisition, reconstruction, and image quality, and the different generations of CT scanners (K2, K4)*

[CO4] *Understood the principles of ultrasound imaging, including sound wave propagation, transducer design, and image formation techniques, as well as the applications of Doppler ultrasound (K2, K3)*

[CO5] *Explored the principles of magnetic resonance imaging, including the physics of nuclear magnetic resonance, image acquisition techniques, and the factors affecting image quality (K2, K3, K4)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	M	L	L	M	L
CO2	S	S	M	M	M	S	L	M	M	L
CO3	S	S	M	M	M	M	L	M	M	L
CO4	S	S	M	M	M	M	L	M	M	L
CO5	S	S	M	S	M	S	M	M	M	M

S-Strong; M-Medium; L-Low

MP301 - PHYSICS OF NUCLEAR MEDICINE AND INTERNAL DOSIMETRY

L	T	P	C
4	1	0	4

60 Hrs. Lectures

Objectives

- *Understand the principles of radionuclide production, including reactor-based and accelerator-based methods, and the applications of radiopharmaceuticals in nuclear medicine.*
- *Learn about in-vivo and in-vitro techniques in nuclear medicine, including thyroid uptake measurements, renography, and radioimmunoassay.*
- *Grasp the principles of radionuclide imaging, including planar imaging, single-photon emission computed tomography (SPECT), and the factors affecting image quality.*
- *Explore the principles of positron emission tomography (PET), including the physics of positron emission, detector design, and image reconstruction techniques.*
- *Understand the concepts of internal radiation dosimetry, including dose calculation methods, compartmental models, and the MIRD technique.*

Unit 1: Production of Radio-nuclides used in Nuclear Medicine

Introduction to Nuclear Medicine - Unsealed sources - Production of radionuclide used in Nuclear Medicine - Reactor based Radio-nuclides - Accelerator based Radio - nuclides - Photonuclear activation - Equations for Radionuclide production - Radionuclide Generators and their operation principles - Various usage of Radiopharmaceuticals

Unit 2: In-vivo and In-vitro Techniques

Thyroid uptake measurements - Renogram - Life Span of RBC - Blood Volume studies - General concept of radionuclide Imaging and Historical developments - In-vitro techniques: RIA / IRMA Techniques and its principles - Treatment of Thyrotoxicosis and Thyroid cancer with I-131 - Use of P-32 and Y-90 for palliative treatment.

Unit 3: Radionuclide Imaging

Planar Nuclear imaging - The Rectilinear scanner and its operational principles - 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 collimators - Image display and Recording systems - Digital Image processing systems - Scanning camera - Limitations of the detector system and electronics

Different Imaging techniques - Basic principles - Two dimensional imaging techniques - Three dimensional imaging techniques - Basic principles and problem - Focal plane Tomography - Emission computed Tomography - Single photon emission computed tomography - 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.

Image quality parameters - 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

Unit 4: Physics of Positron Emission Tomography (PET) and Cyclotron

Principles of PET - PET instrumentations - Annihilation Coincidence detection - PET Detector and Scanner design - Data acquisition for PET - Data correction and quantitative aspect of PET - PET CT, PET MRI, and Fusion imaging - Working of Medical Cyclotron - Radioisotopes Produced and their characteristics.

Unit 5: Internal Dosimetry

Internal Radiation Dosimetry - Different compartmental model - single compartmental model - Two compartmental model - Classical methods of dose evaluation - beta particle dosimetry - Equilibrium dose rate calculation beta dose calculation specific gamma ray constant, gamma ray dosimetry - Geometrical Factor Calculation - Dosimetry of Low Energy Electromagnetic radiation

MIRD technique for dose calculation - Basic procedures 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 calculation - Limitation of MIRD Techniques..

Unit 6: Practicum (Not for final examination)

Production of radionuclide used in Nuclear Medicine - Thyroid uptake measurements - Renogram - In-vitro techniques: RIA / IRMA Techniques and its principles - The Rectilinear scanner and its operational principles - Two dimensional imaging techniques- Digital Image processing systems - PET Detector and Scanner design-Radioisotopes Produced and their characteristics - Internal Radiation Dosimetry.

Books for Study

[1] S. R. Cherry, J. A. Sorensonet, and M. E. Phelps, *Physics of Nuclear Medicine, 4th Ed.* (Saunders, 2012).

[2] J. T. Bushberg, J.A. Seibert, E. M. Leidholdt Jr., and J. M Boone, *The Essential Physics of Medical Imaging, 3rd Ed.* (Lippincott Williams & Wilkins, Philadelphia, 2012).

[3] R. Chandra, *Nuclear Medicine Physics: The Basics, 7th Ed.* (Lippincott Williams & Wilkins, Philadelphia, 2012).

Reference

[1] W. H. Blahd, *Nuclear Medicine* (McGraw Hill Co., New Delhi, 1980).

[2] W. N. Wagner, *Principles of nuclear medicine* (W.B. Saunders Co., London, 1970).

Outcome

[CO1] *Understood the principles of radionuclide production, including reactor-based and accelerator-based methods, and the applications of radiopharmaceuticals in nuclear medicine (K2, K3)*

[CO2] *Learned about in-vivo and in-vitro techniques in nuclear medicine, including thyroid uptake measurements, renography, and radioimmunoassay (K1, K2)*

[CO3] *Grasped the principles of radionuclide imaging, including planar imaging, single-photon emission computed tomography (SPECT), and the factors affecting image quality (K2, K3, K4)*

[CO4] *Explored the principles of positron emission tomography (PET), including the physics of positron emission, detector design, and image reconstruction techniques (K2, K3, K4)*

[CO5] *Understood the concepts of internal radiation dosimetry, including dose calculation methods, compartmental models, and the MIRD technique (K2, K3, K4)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	M	L	L	L	M	L
CO2	M	S	M	L	M	M	L	L	L	M
CO3	S	S	M	M	M	S	M	L	M	M
CO4	S	S	M	M	M	M	L	L	M	M

CO5	S	S	M	M	S	S	L	L	M	M

S-Strong; M-Medium; L-Low

MP302 - CLINICAL AND RADIATION BIOLOGY

60 Hrs. Lectures

L	T	P	C
4	1	0	4

Objectives

- *Understand the fundamental concepts of cell biology, including cell structure, function, and the mechanisms of cell division and genetic inheritance.*
- *Learn about the effects of ionizing radiation on biological systems, including cellular damage, genetic effects, and the factors that influence radiation sensitivity.*
- *Explore the biological basis of radiation therapy, including the somatic and genetic effects of radiation, and the principles of dose fractionation and radiation sensitivity.*
- *Understand the clinical applications of radiation therapy, including the treatment of various cancers and the management of side effects.*
- *Grasp the principles of radiobiology and their application in radiotherapy, including the concepts of cell survival curves, radiation dose-response relationships, and fractionation schemes.*

Unit 1: Cell Biology

Cell Physiology and Biochemistry - Structures of the cell - Types of cells and tissues, their structures and functions therapy - organic constituents of cells - carbohydrates, fats, proteins and nucleic acids- functions of mitochondria, ribosome, Golgi bodies and lysosomes - cell metabolism - DNA as a concepts of Gene and Gene actions - Mitotic and Meiotic cell divisions - semi-conservative DNA Synthesis - Genetic variation - Crossing over - Mutation - Chromosome segregation - Heredity and its mechanisms.

Unit 2: Interactions of Radiation with Cells

Action of radiation on living cells - Radio-lytic products of water and their interactions with bio-molecules - Nucleic acids proteins, enzymes and fats -Influence of oxygen , temperature- Cellular effects of radiation - Mitotic delay, Chromosome aberrations and bio-dosimetry - mutations and re-combinations - Giant cell formation - Cell death- Recovery from radiation damage - Potentially lethal damage and sub lethal damage recovery - Pathways of repair of radiation damage - Law of Bergoni and Tribondeau. Chromosomal aberration & Bio dosimetry. Survival curve parameters - Model for radiation action -Target theory - multi-hit, multi target - repair mis-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 - radio-protective agents.

Unit 3: Biological Effects of Radiation

Somatic effects of radiation - physical factors influencing somatic effects - dependence on dose, dose rate, type and energy of radiation, temperature, anoxia - Stochastic effect & Deterministic Effect - acute radiation sickness - $LD_{50/60}$ dose - effect of radiation on skin and blood forming organs, digestive track - 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 characteristics - genetic burden - prevalence of hereditary diseases and defects - spontaneous mutation rates - concept of doubling dose and genetic risk estimate.

Unit 4: Clinical aspects of Medical Imaging and Radiation Oncology

Radiation therapy, surgery, chemotherapy, hormone therapy, immune therapy and radionuclide therapy - Benign and malignant disease - Methods of spread of malignant disease - staging and grading systems - Treatment intent - Curative and palliative - cancer prevention and public education and early detection and screening. Site specific signs, symptoms, diagnosis and management: head and neck, breast, gynaecological, gastrointestinal tract, Genito-Urinary - lung and thorax, lymphomas and leukaemia's and other cancers including AIDS related cancers. Patient management on treatment - side effects related to radiation and dose - acute and late - monitoring and common management of side effects Professional aspects and role of Medical Physicists: general patient care - principle of professional practice - medical terminology - Research and professional writing - Patient privacy - Ethical and cultural issues - Legal aspects - Confidentiality, informed consent, health and safety.

Unit 5: Biological basis of Radiotherapy

Physical and biological factors affecting cell survival, tumour re-growth and normal tissue response - non conventional fractionation scheme and their effects of re-oxygenation, repair, redistribution in the cell cycle - High LET Radiotherapy. Time Dose Fractionation - Basis for dose fractionation in beam therapy - concept for nominal standard dose (NSD), Roentgen Equivalent Therapy (RET) - Time dose Fractionation (TDF) factors and cumulative radiation effects (CRE) - gap correction, linear quadratic models.

Unit 6: Practicum (Not for final examination)

Cell Physiology and Biochemistry- cell metabolism- Action of radiation on living cells- Nucleic acids proteins, enzymes and fats - Stochastic effect & Deterministic Effect - acute radiation sickness - LD50 dose - effect of radiation on skin and blood forming organs - Induction of leukaemia - radiation carcinogenesis- Benign and malignant disease - High LET Radiotherapy. Time Dose Fractionation.

Books for Study

[1] E. J. Hall and A. J. Giaccia, *Radiobiology for the Radiologist, 7th Ed.* (Lippincottt Williams & Wilkins, 2011).
[2] S. Sureka and C. Armpilia, *Radiation Biology for Medical Physicist* (CRC Taylor & Francis, 2017).
[3] K. Thayalan, *Handbook of Radiobiology* (Jaypee Brothers Medical Publishers, New Delhi, 2017).

Reference

[1] S. P. Yaremonenko, *Radiobiology of Humans and Animals* (MIR, publishers, Moscow, 1990).

Outcome

[CO1] *Understood the fundamental concepts of cell biology, including cell structure, function, and the mechanisms of cell division and genetic inheritance (K1, K2)*

[CO2] *Learned about the effects of ionizing radiation on biological systems, including cellular damage, genetic effects, and the factors that influence radiation sensitivity (K2, K3)*

[CO3] *Explored the biological basis of radiation therapy, including the somatic and genetic effects of radiation, and the principles of dose fractionation and radiation sensitivity (K2, K3)*

[CO4] *Understood the clinical applications of radiation therapy, including the treatment of various cancers and the management of side effects (K2, K3)*

[CO5] *Grasped the principles of radiobiology and their application in radiotherapy, including the concepts of cell survival curves, radiation dose-response relationships, and fractionation schemes (K2, K3)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	M	L	L	L	L	L
CO2	S	S	M	M	S	M	L	L	L	L
CO3	S	S	M	S	S	S	M	L	M	L
CO4	M	S	M	M	S	M	M	L	L	L
CO5	S	S	M	S	S	S	M	L	M	L

S-Strong; M-Medium; L-Low

MP303 - Physics of Diagnostic Radiology

L	T	P	C
4	1	0	4

60 Hrs. Lectures

Objectives

- *Understand the fundamental principles of X-ray interaction with matter, image formation, and the limitations of conventional radiography.*
- *Learn about radiographic techniques, including the selection of exposure factors and the use of beam-restricting devices and grids to optimize image quality and minimize patient dose.*
- *Explore the principles of image intensification, the characteristics of radiographic films, and the factors affecting image quality.*
- *Understand the concepts of image quality parameters, such as spatial resolution and contrast, and the importance of quality assurance programs in maintaining the performance of diagnostic X-ray equipment.*
- *Learn about digital X-ray imaging modalities, including computed radiography, digital radiography, and digital fluoroscopy, and their advantages over conventional film-based imaging.*

Unit 1: Physical Principle of Diagnostic Radiology

Interactions of X - Rays with Human Body, Differential transmission of X - Ray beam, Spatial Image formation, Visualization of special image, Limitation of Projection imaging techniques Viz. Superimposition of overlying structures and scatter, application of contrast media and projection at different angles to overcome superimposition of overlying structures.

Unit 2: Radiography Techniques

Radiographic techniques: Prime factors (kVp, mAs and SID/SFD), Influence of prime factors on image quality, selection criteria of prime factors for different types of imaging - different type of projection and slices selected for imaging - objectives of radio-diagnosis - patience dose Vs image quality.

Filters: Inherent and added filters, purpose of added filters Beryllium Filters, Filters used for shaping X - Ray Spectrum (K-edge filters: holmium, gadolinium, molybdenum) - Scatter Reduction: Factors influencing scatter radiation - objectives of scatter reduction - Contrast reduction factor - Scatter reduction methods - Beam restrictors (diaphragms, cones/cylinders and collimators) - grids (grid function, different types of stationary grids, grid performance evaluation parameters, moving grids, artefacts caused by grids, grid selection criteria) - Air gap technique.

Unit 3: Intensifying Screens and Radiographic films

Intensifying screens: Function of intensifying screens - Screen function evaluation parameters - emission spectra and screen film matching - Conventional screens Vs rare earth screens. Radiographic films: Components of Radiographic films, physical principles of image formation on film, double and single emulsion film - sensitometric parameters of film (density, speed, latitude etc.); Quality assurance of film processing.

Unit 4: Image quality and Quality assurance

Image quality parameters - Sources of un-sharpness - Reduction on un-sharpness - Factors influencing radiographic contrast - Resolution - Factors influencing resolution - Evaluation of resolution (point spread function (PSF) - Line spread function (LSF) - Edge spread function (ESF) - Modulation transfer function (MTF) - Focal spot size evaluation. Quality assurance of diagnostic X-ray equipment - aims and objectives - protocols —Quality assurance test method for performance evaluation as per AERB norms.

Unit 5: Digital X - Ray Imaging

Xero Radiography - Mammography - Fluoroscopy - Interventional Radiology - Digital subtraction angiography - Digital Radiography (CR and DR systems) - Charged Coupled Devices (CCDS)- Flat panel detectors - Digital mammography-Digital verses analog processes - patient dose considerations - Hard copy verses soft copy display - Digital image Processing - contrast and spatial resolution in digital imaging - image artefacts.

Unit 6: Practicum (Not for final examination)

Physical Principles of x-ray Diagnosis - conventional imaging of diagnostic radiology - working and mechanisms of Mammography and Fluoroscopy units used in radiology - the Image quality parameters- QA conventional diagnostic x-ray equipment - digital Radiography - basic principle of diagnostic radiology and its image quality data.

Books for Study

[1] J. T. Bushberg, J. A. Seibert, E. M. Leidholdt Jr. and J. M. Boone, *The essential Physics of Medical Imaging*, (Lippincott, Williams & Wilkins, Philadelphia, 2012).

[2] K. Thayalan, *The Physics of Radiology and Imaging* (Jaypee Brothers Medical Publishers, New Delhi, 2014)

Reference

[1] T. S. Curry III, J. E. Dowdey and R.E. Murry Jr., *Christensen's Physics of Diagnostic Radiology* (Lippincott Williams & Wilkins, 1990)

[2] W. R. Hendee and E. R. Ritenour, *Medical Imaging Physics, 4th Ed.* (Wiley-Liss, 2002).

Outcome

[CO1] *Understood the fundamental principles of X-ray interaction with matter, image formation, and the limitations of conventional radiography (K2)*

[CO2] *Learned about radiographic techniques, including the selection of exposure factors and the use of beam-restricting devices and grids to optimize image quality and minimize patient dose (K1, K3)*

[CO3] *Explored the principles of image intensification, the characteristics of radiographic films, and the factors affecting image quality (K2, K4)*

[CO4] *Understood the concepts of image quality parameters, such as spatial resolution and contrast, and the importance of quality assurance programs in maintaining the performance of diagnostic X-ray equipment (K2, K5)*

[CO5] *Learned about digital X-ray imaging modalities, including computed radiography, digital radiography, and digital fluoroscopy, and their advantages over conventional film-based imaging (K1, K3)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	L	M	L	L	L	L
CO2	M	S	M	M	M	S	L	L	L	M
CO3	M	M	S	M	M	S	M	L	M	L
CO4	M	S	S	M	S	M	L	S	M	L
CO5	M	S	M	M	M	S	M	L	M	M

S-Strong; M-Medium; L-Low

MP304 - Treatment Planning and Advanced Radiotherapy Techniques

L	T	P	C
4	1	0	4

60 Hrs. Lectures

Objectives

- *Understand the principles of treatment planning, including the use of different algorithms and techniques for photon, electron, and brachytherapy treatments.*
- *Learn about special radiotherapy techniques, such as total body irradiation, electron beam therapy, and proton therapy, and their specific dosimetry considerations.*
- *Explore the principles and techniques of stereotactic radiosurgery and radiotherapy, including the use of specialized equipment and treatment planning methods.*
- *Understand the principles of intensity-modulated radiation therapy (IMRT), including the use of multi-leaf collimators and inverse planning techniques, and the quality assurance considerations for IMRT treatments.*
- *Learn about image-guided radiotherapy (IGRT), including the use of imaging modalities for patient positioning and treatment plan adaptation, and the specific quality assurance requirements for IGRT.*

Unit 1: Computers in Treatment Planning

Scope of computers in radiation treatment planning - Review of algorithms used for treatment planning computations - Pencil beam, double pencil beam, Clarkson method, convolution super positions, lung interface algorithms, fast Fourier transform, Inverse planning algorithm, Monte Carlo based algorithms. Treatment planning calculations for photon beam, electron beam and Brachy therapy - Factors to be incorporated in computational algorithms. Plan optimizations - 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 2: Special Techniques in Radiotherapy

Total body irradiation (TBI) - large field dosimetry - total skin electron therapy (TSET) - electron arc treatment and dosimetry - Intra-operative radiotherapy; Proton therapy - principle and beam characteristics - Intensity modulated proton therapy (IMPT)

Unit 3: Stereotactic Radiosurgery/Radiotherapy (SRS/SRT)

Cone and m MLC based X-Knife - Gamma Knife - immobilization devices for SRS/SRT - small field 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 stereo-tactic body radiotherapy (SBRT) and Cyber Knife based therapy.

Unit 4: 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).

Unit 5: Image Guided Radiotherapy (IGRT)

Concepts, imaging modality, kV cone beam CT (kVCT), Mv cone beam CT (MVCT), image registration, plan adaptation, QA protocol and procedures - special phantom, 4DCT; Tomo-therapy - principle - commissioning - imaging - planning and dosimetry - delivery - plan adaptation - QA protocol and procedures.

Unit 6: Practicum (Not for final examination)

General concepts in Radiation Therapy - Radiation Therapy for clinical application - Explain DICOM AND PACS QA OF TPS-Special techniques used in radiotherapy - Physical planning and QA of SBRT- Working and principles of MLC Based IMRT- IGRT and its QA Protocol.

Books for Study

[1] F. M. Khan, *The Physics of Radiation therapy, 3rd Ed.* (Lippincott Williams & Wikins, Philadelphia , 2003).

[2] F. M. Khan and R. A. Potish, *Treatment Planning in Radiation Oncology* (Williams & Wilkins, Baltimore, 1998).

[3] S. Webb, *Intensity-Modulated Radiation 1st Ed.* (CRC Press, 2001)

[4] P Mayles, A Nahum, and J.C Rosenwald, *Handbook of Radiotherapy Physics: Theory and Practice* (CRC Press, 2007).

Reference

[1] W.R. Hendee, *Medical Radiation Physics* (Year Book Medical Publishers, London, 1979).

[2] J. V. Dyk, *The Modern Technology of Radiation Oncology*, *Vol. 1, 2 & 3* (Medical Physics Pub. Corp., 2005).

Outcome

[CO1] *Understood the principles of treatment planning, including the use of different algorithms and techniques for photon, electron, and brachytherapy treatments (K2, K3)*

[CO2] *Learned about special radiotherapy techniques, such as total body irradiation, electron beam therapy, and proton therapy, and their specific dosimetry considerations (K1, K2, K3)*

[CO3] *Explored the principles and techniques of stereotactic radiosurgery and radiotherapy, including the use of specialized equipment and treatment planning methods (K2, K3, K4)*

[CO4] *Understood the principles of intensity-modulated radiation therapy (IMRT), including the use of multi-leaf collimators and inverse planning techniques, and the quality assurance considerations for IMRT treatments (K2, K3, K4, K5)*

[CO5] *Learned about image-guided radiotherapy (IGRT), including the use of imaging modalities for patient positioning and treatment plan adaptation, and the specific quality assurance requirements for IGRT (K1, K2, K3, K4, K5)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	L	L	L	M
CO2	M	S	M	M	M	M	L	L	M	M
CO3	M	S	S	M	M	S	M	M	M	M
CO4	M	S	M	S	S	S	M	L	M	M
CO5	M	S	M	S	S	S	M	L	M	M

S-Strong; M-Medium; L-Low

MP311 - MEDICAL PHYSICS LABORATORY

L	T	P	C
0	0	5	4

60 Hrs. Practical

Objectives

- *Understand the principles of operation of therapy-level dosimeters and their calibration procedures.*
- *Evaluate the image quality parameters of diagnostic X-ray images and perform quality assurance tests on X-ray machines.*
- *Measure the dose output of photon and electron beams used in radiotherapy and analyze their depth dose characteristics.*
- *Calibrate brachytherapy sources and perform in-phantom dosimetry to ensure accurate dose delivery.*
- *Utilize computerized treatment planning systems to design and optimize radiation therapy plans.*
- *Perform in-vivo dosimetry measurements to verify the accuracy of dose delivery to patients.*
- *Conduct radiation protection surveys to assess and mitigate radiation hazards in radiotherapy and diagnostic radiology facilities.*
- *Evaluate the leakage radiation levels of teletherapy and diagnostic X-ray equipment to ensure patient and staff safety.*

List of Experiments

1. Study of voltage and current characteristics of therapy level dosimeter.
2. Calibration of therapy level dosimeter using cross-calibration method.
3. Quality assurance of a diagnostic x-ray machine.
4. Evaluation of characteristics of a radiographic image.
5. Dose output measurement of photon (^{60}Co gamma rays and high energy x-rays) beams used in radiotherapy treatment.
6. Dose output measurement of electron beams used in radiotherapy treatment.
7. Determination of percentage depth dose of photon and electron beams.
8. Integrity check and calibration of low activity brachytherapy sources.
9. AKS/RAKR measurement of HDR brachytherapy sources using well type and cylindrical ionization chambers.
10. In-phantom dosimetry of a brachytherapy source.

11. Familiarization with treatment planning procedure using a computerized radiotherapy treatment planning system.
12. Dose planning in cancer of uterine cervix.
13. Determination of radiation field, flatness, symmetry and penumbra of external photon beam.
14. In-vivo dosimetry using TLD/OSLD/MOSFET.
15. Dose verification in IMRT.
16. Verification of mechanical and radiation isocentre of a teletherapy machine.
17. Radiation protection survey of telecobalt installation.
18. Radiation protection survey of medical accelerator installation.
19. Radiation protection survey of brachytherapy installation.
20. Leakage level measurement of teletherapy equipment.
21. Radiation protection survey of diagnostic radiology installations.
22. Leakage level measurement of a diagnostic x-ray machine.

Optional

23. Dose rate measurement of tele-therapy machines using chemical dosimeter.
24. Survey of a radioisotope laboratory and study of surface and air contamination.

Outcome

[CO1] *Understood the principles of operation of therapy-level dosimeters and calibrated them using cross-calibration methods (K2, K3)*

[CO2] *Evaluated the image quality parameters of diagnostic X-ray images and performed quality assurance tests on X-ray machines (K4, K5)*

[CO3] *Measured the dose output of photon and electron beams used in radiotherapy and analyzed their depth dose characteristics (K3, K4)*

[CO4] *Calibrated brachytherapy sources and performed in-phantom dosimetry to ensure accurate dose delivery (K3, K4)*

[CO5] *Utilized computerized treatment planning systems to design and optimize radiation therapy plans (K3, K6)*

[CO6] *Performed in-vivo dosimetry measurements to verify the accuracy of dose delivery to patients (K3, K4)*

[CO7] *Conducted radiation protection surveys to assess and mitigate radiation hazards in radiotherapy and diagnostic radiology facilities (K4, K5)*

[CO8] *Evaluated the leakage radiation levels of teletherapy and diagnostic X-ray equipment to ensure patient and staff safety (K4, K5)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10
CO1	S	M	L	L	L	M	L	L	L	L
CO2	M	L	L	L	S	M	L	L	L	L

CO3	M	S	L	L	M	M	L	L	L	L
CO4	M	S	L	L	S	S	L	L	L	L
CO5	M	S	L	M	L	L	L	L	L	L
CO6	M	S	L	L	M	M	L	L	L	L
CO7	M	L	L	L	M	S	L	L	L	L
CO8	M	L	L	L	S	M	L	L	L	L

S-Strong; M-Medium; L-Low

MP351 - Radiological Health and Safety (Non-Major Elective – II)

L	T	P	C
2	1	0	2

60 Hrs. Lectures

Objectives

- *Understand the fundamental concepts of radiation quantities and units, including exposure, dose, and dose equivalent.*
- *Learn about the biological effects of radiation, including cellular damage, genetic effects, and the factors that influence radiation sensitivity.*
- *Grasp the principles of radiation protection, including dose limits, shielding, and the control of radiation hazards.*
- *Understand the regulations and procedures for the safe transport, storage, and disposal of radioactive materials.*
- *Learn about radiation emergencies, their management, and the development of emergency response plans.*

Unit 1: Radiation Quantities and Units

Particle flux and fluence, energy flux and fluence, cross section, energy, linear energy transfer (LET), mass attenuation coefficient, mass stopping power, w-value, exposure (rate), Kerma (rate), Terma, absorbed dose (rate), activity, energy, rate constants, charged particle equilibrium (CPE), radiation weighting factors, tissue weighting factors, equivalent dose, effective dose, collective effective dose, Annual Limit of Intake {ALI}, Derived Air Concentration {DAC}, personnel dose equivalent, committed dose.

Unit 2: Radiation Biology and Radiation Protection Standards

Interaction of radiation with cells, chromosome aberrations, mutations, potentially lethal and sub-lethal damages, modification of radiation damage, LET, RBE, dose rate, dose fractionation, stochastic and deterministic effects of radiation, acute radiation sickness, LD50/60, effects of radiation on skin, blood forming organs, digestive tract and reproductive system; effects of chronic and acute exposure to radiation, induction of leukemia and radiation carcinogenesis, genetic effects of radiation, physical and biological factors affecting cell survival, chemical and hyperthermic sensitizers, radio-protectors, tumour biology, non-conventional fractionation schemes, high LET radiation therapy, radiobiological basis of radiotherapy, time dose fractionation (TDF) and gap correction, linear quadratic model.

Radiation dose to individuals from natural radioactivity in the environment and man-made sources, basic concepts of radiation protection standards, International Commission on Radiological Protection (ICRP) and its recommendations, categories of exposures, risk factors, international/national radiation protection standards-ICRP, BSS and AERB, overview of UNSCEAR recommendations, factors governing internal exposures, radionuclide concentrations in air and water and contamination levels, dose limits for occupational workers, general public, comforters and trainees.

Unit 3: Radiation Hazard Evaluation and Control

Internal and external radiation hazards, evaluation and control of external radiation hazards, individual and workplace monitoring, application of time, distance and shielding; shielding calculations, planning of medical radiation installations, shielding calculation parameters- workload (W), use factor (U), occupancy factor (T); primary and secondary protective barriers, design and shielding requirements for diagnostic X-ray facilities, telecobalt, medical accelerator, brachytherapy installations and medical radioisotope laboratories.

Radiation monitoring instruments, calibration check of monitoring instruments, radiation monitoring procedures for radiation generating equipment and installations, protective measures to reduce radiation exposures to patients and occupational workers, radiation hazards in radioisotope laboratories, protective equipment.

Unit 4: Radioactive Waste Disposal, Transport of Radioactive Material and Regulatory Aspects

Radioactive wastes, sources of radioactive waste, classification of waste, treatment techniques for solid, liquid and gaseous effluents, permissible limits for disposal of waste, sampling techniques for air, water and solid; geological, hydrological, media meteorological and ecological considerations for waste disposal, decontamination procedures.

Disposal of radioactive wastes, general methods of disposal, management of radioactive waste in medical, industrial, agricultural and research facilities.

Regulatory aspects of transport of radioactive material (RAM), introduction, terms used (e.g. Competent Authority, A1& A2 values, unilateral & multilateral approvals, special form radioactive material, special arrangement, transport index (TI) etc.), transport scenarios (routine, normal and accidental), variety of packages covered under the transport regulations (including designing, testing, transport and storage); general requirements of all packaging, requirements for transport by air mode, test requirements, preparation, marking, labeling of packages, preparation of transport documents (consignors declaration, TREM Card, instructions to the carrier & emergency preparedness in writing), responsibilities of consignor, general instructions and response to off-normal situations during transport.

National legislation, regulatory framework, relevant regulatory documents such as Act, Rules, applicable safety codes, standards, guides and manuals, radiation surveillance procedures, regulatory control- licensing, inspection and enforcement; responsibilities of employer, licensee, Radiological Safety Officer (RSO), technologist, radiation workers and radioisotope supplier.

Physical protection of sources, safety and security of sources during storage, use, transport and disposal, regulatory requirements for import/export, procurement, use, handling, transfer and disposal of radioisotopes, inventory control, security provisions: administrative and technical measures, security threat and graded approach in security provision, Radiation Protection Programme (RPP).

Unit 5: Radiation Emergencies and Medical Management, and Emergency Response Plans and Preparedness

Radiation accidents and emergencies in the use of radiation sources and equipment in radiotherapy, nuclear medicine and diagnostic radiology, radiation safety during source transfer operations, source stuck and handling procedures, loss of radiation sources, their tracing and recovery, case studies and lessons learned, Radiation injuries and medical management.

Normal and potential exposures, accident situations involving radioisotopes, elements of emergency planning and preparedness including procedures for notification and line of communication, administrative and technical procedures, emergency response accessories, responsibilities of employer, licensee, RSO, technologist, radiation workers and radioisotope/ equipment supplier in case of emergency.

Outcome

[CO1] *Understood the fundamental concepts of radiation quantities and units, including exposure, dose, and dose equivalent (K1, K2)*

[CO2] *Learned about the biological effects of radiation, including cellular damage, genetic effects, and the factors that influence radiation sensitivity (K2, K4)*

[CO3] *Grasped the principles of radiation protection, including dose limits, shielding, and the control of radiation hazards (K2, K3)*

[CO4] *Understood the regulations and procedures for the safe transport, storage, and disposal of radioactive materials (K1, K2)*

[CO5] *Learned about radiation emergencies, their management, and the development of emergency response plans (K3, K6)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	L	L	L	L	L	L
CO2	S	M	L	L	M	L	L	L	L	L
CO3	S	L	L	L	S	M	L	S	L	L
CO4	M	L	L	L	M	L	L	S	L	L
CO5	M	M	L	M	S	L	L	S	L	L

S-Strong; M-Medium; L-Low

MP401 - Radiation Safety

L	T	P	C
3	1	0	4

60 Hrs. Lectures

Objectives

- *Understand the fundamental principles of radiation protection, including dose limits, radiation weighting factors, and tissue weighting factors.*
- *Learn about the biological effects of radiation, including cellular damage, genetic effects, and the factors that influence radiation sensitivity.*
- *Grasp the principles of radiation protection in medical settings, including shielding calculations, personnel monitoring, and the control of radiation hazards.*
- *Understand the regulations and procedures for the safe transport, storage, and disposal of radioactive materials, as well as the requirements for physical protection of sources.*
- *Learn about radiation emergencies, their management, and the development of emergency response plans.*

Unit 1: Radiation Protection Standards

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, Optimization of Protection and individual dose limits - Radiation and tissue weighting factors, equivalent dose, effective dose, committed equivalent dose, committed effective dose - Concepts of collective dose - Potential exposures, dose and dose constraints - System of protection for intervention.- Categories of exposures - Occupational, Public and Medical Exposures - Factors governing internal exposures - 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 - Radio toxicity of different radio-nuclides and the classification of laboratories - Control of contamination - Bioassay and air monitoring.

Unit 2: Safety in Medical uses of Radiation

Planning of medical radiation installations - General considerations Protective measures to reduce radiation exposures to staff and patients - Radiation hazards in Brachytherapy departments and Tele-therapy departments and radioisotopes 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 radio isotope laboratories - Particle accelerator protective equipment - Handling of patients - Waste disposal facilities - Radiation safety during source transfer operations- Special safety features in accelerators, reactors.

General considerations - Design of diagnostic, deep therapy, telegamma and accelerator installations, brachytherapy facilities and medical radioisotope laboratories - shielding calculation - workload, occupancy factor, and use factor.

Unit 3: Applications and Safety in the Industrial, Agricultural and Research uses of Radiation

Physical principles of industrial radiography - Comparison of X-ray radiography and gamma radiography - Choice of source - Exposure containers - Photographic film technique - Radiographic contrast Definition of sensitivity - Intensifying screens - Pentameters; Industrial Fluoroscopy - Comparison of fluoroscopy and radiography - Image intensifier Special techniques - Micro-radiography, flash radiography - stereo radiography - X-ray diffraction - Neutron radiography and Electron radiography Physical principles in the industrial application of radioisotopes - uses of sealed sources - Radioisotope gauges - Use of transmission and scattering gauges for measurement of thickness, density and composition - Level indicators - Bremsstrahlung gauges - Beta and gamma backscattering gauges and their applications - Neutron scattering gauges - Principles and applications of X ray fluorescence techniques. Application in agriculture and research - Radioisotope tracer applications - General principles - Selection of radiotracer Dilution technique - Some examples of applications in agriculture, biology and research areas.

Planning of radiation installations and isotope laboratories in industry - Facilities for storage, handling and field operations - Planning of radioisotope laboratories for agriculture and research institutions - Design of gamma gardens for agriculture. Radiation protection measures and hazards evaluations in industrial and agricultural establishments - X and gamma ray radiography - X-ray diffraction apparatus - Radioisotope gauges - Tracer applications for radioisotopes in agriculture and industry gamma chamber - Radiation sterilization - Irradiation of food and drugs - PANBIT and ISOMED - Luminising industry - Radiation protection in Industrial Radiographic Installations - Enclosed, open top, open field and sky shine - Tritium and C-14 monitoring - Monitoring of spillage - Contamination and control.

Unit 4: Radioactive Waste Disposal and Transport of radioisotopes

Radioactive wastes- Sources of radioactive waste - 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 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 Physical protection of source - Safety and security of sources during storage, use, transport and disposal - Security provisions, administrative and technical - Security threat and graded approach in security provision.

Unit 5: Legislation, Radiation Emergencies and their medical management

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 tele-therapy 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.

Unit 6: Practicum (Not for final examination)

Basic concepts of radiation protection standards- Radiation and tissue weighting factors- General considerations Protective measures to reduce radiation exposures to staff and patients- Radiation hazards in Brachy therapy departments and teletherapy departments and radio isotope laboratories- Industrial Fluoroscopy - stereo radiography - X and gamma ray radiography - Sources of radioactive waste- Transportation of radioactive substances.

Books for Study and Reference

[1] H. Cember and T. E. Johnson, Introduction to Health Physics, 4th Ed. (McGraw Hill, 2008).
[2] K. Thayalan, Handbook of Radiological Safety (Jaypee Brothers, Medical Publishers, 2009)
[3] IAEA Safety Series 41

Reference

[1] R. F. Mould Radiation Protection in Hospital (Adam Hilger Ltd., Bristol, 1985).
[2] A. Martin, S. Harbison, K. Beach and P. Cole, An Introduction to Radiation Protection, 6th Ed. (CRC Press, 2013)
[3] AERB Radiation Protection Rules, 2004.

Outcome

[CO1] *Understood the fundamental principles of radiation protection, including dose limits, radiation weighting factors, and tissue weighting factors (K1, K2)*

[CO2] *Learned about the biological effects of radiation, including cellular damage, genetic effects, and the factors that influence radiation sensitivity (K2, K4)*

[CO3] *Grasped the principles of radiation protection in medical settings, including shielding calculations, personnel monitoring, and the control of radiation hazards (K2, K3, K4)*

[CO4] *Understood the regulations and procedures for the safe transport, storage, and disposal of radioactive materials, as well as the requirements for physical protection of sources (K1, K2)*

[CO5] *Learned about radiation emergencies, their management, and the development of emergency response plans (K3, K6)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	L	L	M	L	L	S	L	L
CO2	S	M	L	L	M	L	L	M	L	L
CO3	S	S	L	L	S	M	L	S	L	L
CO4	M	L	L	L	M	L	L	S	L	L
CO5	M	M	L	M	S	L	L	S	L	L

S-Strong; M-Medium; L-Low

MP402 - Advanced Medical Imaging

L	T	P	C
4	1	0	4

60 Hrs. Lectures

Objectives

- *Understand the fundamental principles of computer systems and their applications in medical imaging, including data storage, processing, and display.*
- *Grasp the principles of computed tomography, including image acquisition, reconstruction, and image quality, and the different generations of CT scanners.*
- *Learn about the principles of ultrasound imaging, including sound wave propagation, transducer design, and image formation techniques, as well as the applications of Doppler ultrasound.*
- *Explore the principles of magnetic resonance imaging, including the physics of nuclear magnetic resonance, image acquisition techniques, and the factors affecting image quality.*
- *Understand the concepts of computer networks, picture archiving and communication systems (PACS), and the importance of quality assurance in medical imaging.*

Unit 1: Computers in Medical Imaging

Storage and transfer of data in computers-number systems-decimal and binary form-transfer of data in digital form; Analog data and conversion between analog and digital form; Components and operation of computers - main memory - computer program and CPU - input/output bus and expansion slots -mass storage devices - keyboard and printing devices; Performance of Computer systems; Computer Software - Storage, Processing and display of digital Images.

Unit 2: Computed Tomography

Conventional Tomography (Principles only) orthopan tomography (OPG), Computed Tomography - Basic Principles - Geometry and historical development - different generations - Detectors and Detector arrays - xenon detectors - solid state detectors - Multi detector arrays - Details of acquisition - Single and Multiple array scanners - Tomographic Reconstruction - sonogram - Data processing - interpolation - simple back projection reconstruction - Filtered back projection - Bone kernels and soft tissue kernels - CT number - CT fluoroscopy - Digital image display - windowing and levelling - Multi-planar reconstruction - 3D image display - stack mode viewing - Radiation dose - dose measurement - Dose in helical and CT fluoroscopy - Image Quality - Factors affecting image quality - artefacts - QA of CT Equipment.

Unit 3: Ultrasound

Characteristics of sound - propagation of sound - wavelength, frequency and speed - Pressure, intensity and dB scale; Interactions of Ultra sound waves with body tissues - Production of ultrasound - acoustic coupling - Image formation - reflection - refraction - scattering - attenuation; Transducers - Piezoelectric materials - resonance transducers - damping block-matching layer - Multi frequency transducers - transducer arrays; Beam properties - near field - far field - side lobes - spatial resolution; Acoustic coupling - Image formation - reflection - refraction - scattering - attenuation; Image data acquisition - data acquisition systems - ADC - receiver - Echo display modes - scan converter. Image display and storage-Early B mode scanners - mechanical scanning - electronic scanning and real time display - Image storage; Biometric measurements - contrast agents - harmonic imaging - 3D imaging; Image Quality and artefacts - Doppler Ultra sound - Doppler frequency shift - continuous and pulsed Doppler - Duplex scanning - Doppler spectral interpretation - Colour flow imaging-power Doppler; Performance and Quality assurance - Acoustic power and Bio effects

Unit 4: Magnetic Resonance Imaging (MRI)

Magnetization properties - Magnetic resonance image - Proton density - Generation and detection of MR signal-free induction decay - T1 and T2 relaxation; Pulse sequences - Spin Eco T1 weighting - spin density weighting - T2 weighting; Inversion Recovery - Gradient recalled Eco - Signal from flow - Perfusion and diffusion contrast - Magnetization transfer contrast. Localization of the MR Signal -magnetic field gradients - slice select gradient-frequency encode gradient - phase encode gradient; K- Space data acquisition and Image reconstruction - 2D data acquisition- 3D Fourier transform image acquisition - Image Characteristics - Angiography and Magnetization transfer contrast - Artefacts – Instrumentation - magnet-ancillary equipment - quality control - Safety and Bio effects.

Unit 5: Computer networks and Quality assurance

Computer Networks - basic principle - local area network-large network and network linking- Long distance telecommunication links - network security; PACS and Tele radiology acquisition of digital images - network for image and data transfer - storage of images - display of images - advantage and disadvantage of PACS - security and reliability - quality control - QA in CT - Other related quality assurance as per the guidelines of AERB as part of the regulation; QA in mammography using phantoms; Performance testing and quality assurance in ultrasound and MRI using accredited phantoms.

Unit 6: Practicum (Not for final examination)

Two main areas of Medical Physics research - Medical imaging and radiation therapy - Classify noise modeling and noise ratio - Treatment planning system, and different field calculations in radiotherapy - X-ray unit, CT scan, Nuclear Medicine Facility - Calibrations of thyroid and its uptake measurement units

Books for Study

[1] J. T. Bushberg, J. A. Seibert, E. M. Leidholdt Jr. and J. M. Boone, *The essential Physics of Medical Imaging* (Lippincott, Williams & Wilkins, Philadelphia, 2012).

[2] K. Thayalan, *The Physics Of Radiology And Imaging* (Jaypee Brothers Medical Publishers, 2014)

[3] T. S. Curry III, J. E. Dowdey and R.E. Murry Jr., *Christensen's Physics of Diagnostic Radiology* (Lippincott Williams & Wilkins, 1990)

[4] H. Brown, R. H. Smallwood, D. C. Barber, P.V. Lawford and D. R. Hose, *Medical Physics and Biomedical Engineering* (CRC Press, 1998).

Outcome

[CO1] *Understood the fundamental principles of computer systems and their applications in medical imaging, including data storage, processing, and display (K1, K2, K3)*

[CO2] *Grasped the principles of computed tomography, including image acquisition, reconstruction, and image quality, and the different generations of CT scanners (K1, K2, K3, K4)*

[CO3] *Learned about the principles of ultrasound imaging, including sound wave propagation, transducer design, and image formation techniques, as well as the applications of Doppler ultrasound (K1, K2, K3)*

[CO4] *Explored the principles of magnetic resonance imaging, including the physics of nuclear magnetic resonance, image acquisition techniques, and the factors affecting image quality (K1, K2, K4)*

[CO5] *Understood the concepts of computer networks, picture archiving and communication systems (PACS), and the importance of quality assurance in medical imaging (K1, K2, K3, K5)*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	M	L	L	L	L	L
CO2	S	S	M	M	S	M	L	L	L	L
CO3	S	S	M	L	M	M	L	L	L	L
CO4	S	M	M	L	M	M	L	M	L	L
CO5	M	S	M	M	S	M	M	S	M	M

S-Strong; M-Medium; L-Low

MP421 - PROJECT WORK

L	T	P	C
-	-	-	10

Project Work Description

Project work is a crucial component of a Master's degree in Medical Physics. It provides students with the opportunity to apply their theoretical knowledge to real-world clinical scenarios, develop research skills, and contribute to advancements in the field. Typically, the project involves collaboration between the student, a faculty advisor, and a mentor from a hospital or research institution. During their final (fourth) semester, students may be permitted to spend up to six weeks at a cancer hospital or related industries to complete their fieldwork project.

Guidance for Project Work

- **Identify a Research Question:** *Work closely with your supervisor to identify a relevant and feasible research question.*
- **Literature Review:** *Conduct a thorough literature review to understand the current state of knowledge in your chosen area.*

- **Experimental Design:** *Develop a detailed experimental design, including methodology, data collection, and analysis.*
- **Data Collection:** *Collect data using appropriate techniques, such as patient records, imaging data, or dosimetry measurements.*
- **Data Analysis:** *Analyze the collected data using statistical methods and appropriate software tools.*
- **Results and Discussion:** *Interpret the results of your analysis and discuss their implications.*
- **Conclusion:** *Summarize your findings and draw conclusions based on your research.*
- **Ethical Considerations:** *Ensure that your research adheres to ethical guidelines and regulations.*

Guidelines for Writing a Master's Dissertation

The dissertation is a key requirement for completing the Master's in Medical Physics, serving as a detailed account of the project work undertaken during the final semester. It reflects the ability to integrate theoretical knowledge with practical applications in medical physics. Below are detailed guidelines to assist in preparing the dissertation:

Structure and Organization

The dissertation should follow a clear and logical structure, typically comprising the following sections:

1. **Title Page**: Include the dissertation title, candidate’s name, enrollment number, institution details, faculty advisor’s name, and mentor’s name.
2. **Abstract**: A concise summary of the research, including objectives, methods, key findings, and conclusions (around 250-300 words).
3. **Acknowledgments**: A section to thank the faculty advisor, mentor, institution, and others who contributed to the project work.
4. **Table of Contents**: List all chapters, sections, figures, and tables with page numbers.
5. **Introduction**: Present the background, significance, and objectives of the project. Include a review of the existing literature and identify the research gap that the project addresses.
6. **Methodology**: Describe the methods, materials, and procedures used during the project. Include details of any equipment, software, or data sources.
7. **Results**: Present the findings with appropriate tables, graphs, or images. Ensure clarity and accuracy.
8. **Discussion**: Analyze and interpret the results in the context of the research question. Discuss limitations and potential implications for the field.
9. **Conclusion**: Summarize key findings and suggest future research directions.
10. **References**: Use a consistent citation style (e.g., APA, MLA, or Vancouver) to list all sources cited in the dissertation.
11. **Appendices**: Include supplementary materials such as raw data, detailed calculations, or additional images, if necessary.

Writing Guidelines

- **Language and Style**: Use clear, formal, and precise academic language. Avoid jargon and ensure all technical terms are defined.
- **Formatting**: Follow the standard guidelines, including font type, size, margins, and line spacing.
- **Length**: Aim for a length appropriate to the scope of your research, typically between 40-80 pages, excluding appendices and references.
- **Figures and Tables**: Label all figures and tables clearly and provide descriptive captions. Refer to them appropriately within the text.
- **Proofreading**: Review the dissertation for grammatical, typographical, and factual errors before submission.

Ethical Considerations

- **Confidentiality**: Ensure patient data or any sensitive information is anonymized or excluded as required.
- **Acknowledgement of Contributions**: Clearly state the roles of the faculty advisor, mentor, and any collaborators.
- **Plagiarism**: Submit original work and properly cite all sources to avoid plagiarism.

Collaboration with Advisors and Mentors

- **Regular Meetings**: Schedule regular check-ins with the faculty advisor and mentor to discuss progress and receive feedback.
- **Draft Reviews**: Share drafts of each section with the advisors for feedback and incorporate their suggestions.
- **Adherence to Deadlines**: Plan the project work to meet institutional deadlines for submission and revisions.

Submission and Presentation

- **Submission**: Submit both digital and hard copies (3) of the dissertation.
- **Oral Defense**: Prepare a presentation summarizing the work for the oral defense, if required. Practice answering questions and discussing the broader implications of the project.

By following these guidelines, the students may produce a comprehensive and well-organized dissertation that effectively demonstrates the knowledge and skills gained during their Master's program.

Potential Project Areas

Here are some potential project areas for Master's students in medical physics, categorized by specialization:

Radiation Therapy

Dosimetry and Quality Assurance:

- Characterization of radiation beams from linear accelerators and brachytherapy sources

- Development and implementation of quality assurance programs for treatment planning systems and radiation delivery equipment
- Investigation of dosimetric uncertainties in complex treatment plans

Treatment Planning:

- Development and evaluation of advanced treatment planning techniques, such as intensity-modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT)
- Optimization of treatment plans for specific tumor sites and patient characteristics
- Investigation of the impact of patient motion on treatment delivery and dose distribution

Radiation Biology:

- Study of the biological effects of radiation on tumor cells and normal tissues
- Investigation of the mechanisms of radiation-induced cell death and DNA damage repair
- Development of novel radiotherapeutic approaches, such as targeted therapies and immunotherapy

Nuclear Medicine and Internal Dosimetry

Radiopharmaceutical Development and Evaluation:

- Development and evaluation of new radiopharmaceuticals for diagnostic and therapeutic applications
- Investigation of the biodistribution and pharmacokinetics of radiopharmaceuticals
- Development of new imaging techniques, such as PET/CT and SPECT/CT

Internal Dosimetry:

- Calculation of internal dose from radionuclide intake
- Development of biokinetic models for different radionuclides
- Evaluation of the impact of internal contamination on human health

Quality Assurance in Nuclear Medicine:

- Development and implementation of quality assurance programs for nuclear medicine procedures
- Evaluation of the performance of nuclear medicine imaging systems
- Investigation of the impact of patient motion on nuclear medicine image quality

Diagnostic Radiology

Image Quality and Dose Optimization:

- Evaluation of image quality parameters, such as spatial resolution, contrast, and noise
- Optimization of imaging protocols to minimize patient dose while maintaining image quality
- Development of new imaging techniques, such as digital breast tomosynthesis and spectral CT

Radiation Dose Management:

- Development of techniques to reduce patient dose in diagnostic radiology procedures
- Evaluation of the effectiveness of dose reduction techniques
- Investigation of the impact of radiation exposure on patient health

Advanced Medical Imaging Techniques

Image Processing and Analysis:

- Development of image processing algorithms for image enhancement, noise reduction, and feature extraction
- Application of machine learning techniques for image analysis and computer-aided diagnosis
- Development of new imaging modalities, such as magnetic resonance elastography and photoacoustic imaging

Image-Guided Interventions:

- Development of image-guided techniques for minimally invasive procedures, such as image-guided surgery and radiation therapy
- Investigation of the impact of image guidance on treatment accuracy and patient outcomes

Radiation Safety

Radiation Protection:

- Development and implementation of radiation protection programs for medical and industrial facilities
- Evaluation of radiation exposure levels for workers and the public
- Investigation of the effectiveness of radiation protection measures

Emergency Preparedness and Response:

- Development of emergency response plans for radiation accidents
- Training of personnel in emergency response procedures
- Evaluation of the effectiveness of emergency response drills

Treatment Planning and Advanced Radiotherapy Techniques

Treatment Planning Optimization:

- Development of advanced treatment planning techniques, such as intensity-modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT)
- Optimization of treatment plans for specific tumor sites and patient characteristics
- Investigation of the impact of patient motion on treatment delivery and dose distribution

Image-Guided Radiation Therapy (IGRT):

- Development and implementation of IGRT techniques, such as cone-beam CT and daily image guidance
- Evaluation of the impact of IGRT on treatment accuracy and patient outcomes

Radiotherapy Physics:

- Investigation of the physical principles underlying radiation therapy, including radiation interactions with matter, dose calculation algorithms, and beam quality assurance

MP431 - PYTHON PROGRAMMING FOR MEDICAL PHYSICS

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30 Hrs. Lectures

Objectives

- *Provide a solid foundation in Python programming, emphasizing its applicability in medical physics.*
- *Analyze and visualize medical data using Python.*
- *Understand libraries and tools specific to medical physics applications (e.g., image processing, data analysis).*
- *Learn the simulation of physical systems and processes relevant to medical physics using Python.*
- *Apply Python to solve real-world problems in radiation therapy, imaging, and diagnostics.*

Unit 1: Introduction to Python Programming

Python basics: syntax, data types, variables, and control structures - Functions and modular programming - File handling (text and CSV) for medical datasets - Introduction to Jupyter Notebooks for coding and documentation – Practical Examples: Loading and analyzing simple patient data - Writing Python scripts for basic calculations relevant to medical physics.

Unit 2: Numerical Computing and Data Analysis

Introduction to numerical libraries: `NumPy` and `SciPy` - Arrays and matrix operations - Data analysis and manipulation using `Pandas` - File handling: Reading and writing data (CSV, Excel) - Statistical analysis: Descriptive and inferential statistics; Practical Examples (Hands on): Simulating data and performing statistical analysis - Processing and analyzing patient datasets.

Unit 3: Visualization and Imaging

Visualization with 'Matplotlib' and 'Seaborn' - Plotting 2D and 3D graphs - Image processing basics with 'Pillow' and 'OpenCV' - Introduction to medical image formats (DICOM) - Medical image analysis with 'pydicom' and 'SimpleITK'; Practical Examples (Hands on): Visualizing radiation dose distribution - Processing and analyzing DICOM images

Unit 4: Simulations in Medical Physics

Simulating physical processes using Python - Monte Carlo methods and random number generation - Modeling radiation transport and dose calculations - Introduction to Python-based simulation tools (e.g., Geant4Py); Practical Examples (Hands on): Simulating radioactive decay - Modeling beam interactions and dose deposition

Unit 5: Machine Learning and Advanced Topics

Introduction to machine learning and AI in medical physics - Basic machine learning with `scikit-learn` - Neural networks for medical imaging with TensorFlow/PyTorch - Case studies: Tumor segmentation, radiomics, or image classification - Ethical considerations and data security in AI applications; Practical Examples (Hands on): Building a simple classification model for medical imaging - Extracting features from medical datasets

Resources Required

Software: Python (latest version), Jupyter Notebook, relevant libraries - Access to anonymized medical datasets (e.g., DICOM images, CSV files)

Reference Materials:

[1] Documentation for NumPy, Pandas, Matplotlib, OpenCV, and Scikit-image

[2] Online resources for Python in medical imaging (e.g., PyDICOM, Scikit-learn)
[3] Wes McKinney, Python for Data Analysis, 3E (Data Wrangling with pandas, NumPy, and Jupyter), O'Reilly Media, 2022 (ISBN: 9781098104009).
[4] Al Sweigart, Automate the Boring Stuff with Python, Penguin Random Hous, 2023.

Outcome

[CO1] *Provided a solid foundation in Python programming, emphasizing its applicability in medical physics (K2).*

[CO2] *Analyzed and visualized medical data using Python (K4).*

[CO3] *Understood libraries and tools specific to medical physics applications, such as image processing and data analysis (K2).*

[CO4] *Simulated physical systems and processes relevant to medical physics using Python (K6).*

[CO5] *Applied Python to solve real-world problems in radiation therapy, imaging, and diagnostics (K3).*

K1 – Remember; K2 – Understand; K3 – Apply; K4 – Analyze; K5- Evaluate; K6 – Create

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	M	L	M	L	L	L
CO2	S	S	M	M	M	S	L	L	M	L
CO3	S	M	M	M	L	M	L	L	M	L
CO4	S	M	M	S	L	M	M	L	M	L
CO5	S	S	M	M	M	S	L	L	M	L

S-Strong; M-Medium; L-Low