### M.Phil (Medical Physics)

#### Semester I

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**Total No. of Credits: 33**

#### Electives for M.Phil (Medical Physics)

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OBJECTIVE:
- To provide the basics of laser tissue interaction applied to various treatments
- To give a detailed description of the interaction mechanisms of laser with biological tissues and providing an updated review of clinical applications of laser.

UNIT I LASER CHARACTERISTICS AS APPLIED TO MEDICINE AND BIOLOGY 12
Laser tissue interaction – photophysical process - photobiological process - absorption by biological systems - different types of interactions - thermal - photochemical (one photon and multiphoton) - electro mechanical - photo ablative process.

UNIT II LASER - TISSUE INTERACTIONS 12
Optical properties of tissues (normal and tumor) - experimental methods to determine the reflectance, transmittance, absorption and emission properties of tissues. Laser systems in medicine and biology - Ruby, Nd-YAG, Ar ion, CO$_2$, Excimer, Gold vapour laser - beam delivery system and control.

UNIT III SURGICAL AND THERAPEUTIC APPLICATIONS OF LASERS 12

UNIT IV LASERS IN PHOTO DIAGNOSIS 12

UNIT V LASER SAFETY 12
Protection standards for lasers - safety regulations - specific precautions - medical surveillance.

TOTAL: 60 PERIODS

OUTCOME:
- Can safely employ lasers appropriately with the knowledge of their wavelength and power for various biological applications.

REFERENCES:
OBJECTIVE:
- To expose the student with various mathematical methods for numerical analysis and Statistical significance.
- To impart knowledge on systems of equation, probability statistics and error analysis.

UNIT I NUMERICAL INTERPOLATION, DIFFERENTIATION AND INTEGRATION
- Newton’s forward and backward interpolation formulae - Lagrange’s interpolation formula for unequal intervals - Error in polynomial interpolation and Newton’s interpolation formula - Numerical differentiation - Maximum and minimum of a tabulated function - Numerical integration - Trapezoidal rule - Romberg’s method - Simpson’s rule - Practical applications of Simpson’s rule.

UNIT II NUMERICAL SOLUTION OF ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

UNIT III EMPIRICAL LAWS AND CURVE FITTING
- Linear law and laws reducible to linear law - method of moments - method of group averages - principle of least squares - Fitting of straight line and parabola.

UNIT IV STATISTICS
- Measures of central tendency, mean, median, mode, dispersion, standard deviation, root mean square deviation, moments, skewness and kurtosis - Application to radiation detection. Binomial distribution, Poisson’s distribution, Gaussian distribution, exponential distribution, bi-variant distribution, correlation and regression - Chi-Square distribution, t distribution - F – distribution – error propagation.

UNIT V RESEARCH METHODOLOGY
- Introduction - Defining research problem - research design - Important concepts - different research design - basic principles of experimental design - sampling design - steps and types of sampling design. Purpose and problem statements - Literature review - Frameworks - Research questions and hypotheses - Multimethod research.

OUTCOME
- Can fit the data points to an appropriate curve with better correlation.
- Analyse the given set of data points for better discriminate using the knowledge of statistics.
- Estimate the errors involved in the experimental measurements.

REFERENCES
OBJECTIVE:
- To expose the students with the theoretical concepts of Solid State Physics.
- To impart knowledge on crystal structure and binding, electronic properties, lattice dynamics, dielectric & optical properties and magnetic and superconducting properties of materials.

UNIT I  CRYSTAL STRUCTURE AND BINDING  12
Symmetry - crystal lattice - unit cell (conventional and Wigner-seitz unit cell) - crystal structures - crystallographic point groups and space groups - reciprocal lattice - Brillouin zone - force between atoms - cohesive energy - bonding in solids - ionic, covalent, metallic and hydrogen bonded crystals.

UNIT II ELECTRONIC PROPERTIES 12
Free electron theory (classical and quantum) - electronic specific heat - electrical and thermal transport - failures of free electron model - periodic crystalline potential - Bloch theorem - formation of energy bands - classification of solids - effective mass and concept of hole - intrinsic and extrinsic semiconductors - direct and indirect bandgap of semiconductors - Fermi surface of metals.

UNIT III LATTICE DYNAMICS 12
Vibrational modes of mono and diatomic lattices - quantization of lattice vibration - lattice specific heat theories (Einstein and Debye models) - phonon momentum - scattering of neutrons by phonons - neutron diffraction - lattice thermal conductivity - normal and Umklapp process – anharmonicity and thermal expansion.

UNIT IV DIELECTRIC AND OPTICAL PROPERTIES 12

UNIT V MAGNETIC PROPERTIES AND SUPERCONDUCTIVITY 12

TOTAL: 60 PERIODS

OUTCOME:
- Can differentiate the materials based on their structure, electric, magnetic properties and optical properties

REFERENCES
OBJECTIVE:
- To provide the knowledge for use of various spectroscopic methods in bioanalysis and Imaging.
- To enrich them with knowledge about various Optical components and their importance.

UNIT I TISSUE OPTICS
Structure of cells and tissues – light-matter interactions - physical models and mechanism. Specific features of living tissues from the point of optics. Relations of scattering and absorption in tissues - interaction of lasers with tissues – Thickness and optical properties of appropriate skin layers - Skin pigments (melanin, bilirubin, carotene, hemoglobin) and their spectra - Blood composites and their spectral properties - difference between oxygenated and deoxygenated hemoglobin absorption spectra.

UNIT II LIGHT PROPOGATION IN TURBID MEDIA

UNIT III OPTO ELECTRONIC DEVICES

UNIT IV PHOTONIC IMAGING TECHNIQUES
Lifetime based Imaging – Confocal Microscopy-Two Photon excitation Fluorescence Microscopy Near field imaging- Biological and biomedical applications-OCT, elastography - Laser Doppler perfusion monitoring & imaging – Thermal imaging for medical diagnosis.

UNIT V BIOMEDICAL DIAGNOSTICS

TOTAL: 60 PERIODS

OUTCOME:
- Can design block diagram for their specific applications
- Can employ their knowledge in determining the optical properties.
- Apply the knowledge about biomedical optics to improve the diagnostic efficiency of diseases.

REFERENCES:
OBJECTIVE:
- To expose the students with theoretical aspects of laser theory and its applications.
- To provide knowledge on laser theory, resonators and switching theory, gas & liquid lasers, solid state & semiconductor lasers and their applications.

UNIT I  LASER THEORY  12
Absorption - Spontaneous and stimulated emission - Einstein’s coefficients - threshold conditions for laser action - Line broadening, Mechanism - Lorentzian and Doppler line shapes - Small signal gain - Gain coefficient - gain saturation - Rate equations for 3 and 4 level systems.

UNIT II  RESONATORS AND SWITCHING THEORY  12
Resonant cavity - Fox and Li - Boyd and Gorden's theory on resonators - modes - Spot size - Types of resonators - Mode selection - Q switching theory and technique - Mode locking theory and technique.

UNIT III  GAS AND LIQUID LASERS  12
He-Ne, Argon Ion, Carbon dioxide, Nitrogen - Metal vapour - Gas dynamics - Excimer - Free electron lasers - Dye lasers-organic dyes - Pulsed and CW dye lasers - Threshold conditions - Pumping configurations.

UNIT IV  SOLID STATE AND SEMICONDUCTOR LASERS  12

UNIT V  APPLICATIONS  12

TOTAL: 60 PERIODS

OUTCOME
- Employ lasers with the basic knowledge about lasers for material characterization, interferometry, velocimetry and medical applications at their fundamental frequency and higher harmonic

REFERENCES
OBJECTIVE:
- To import the basic knowledge about the concepts of Ultrasonics, their action mechanism
- To educate about medical application of Ultrasonics and their safety
- To provide the knowledge on propagation of ultrasonic waves in medium & determination of its velocity, ultrasonic transducers, absorption of ultrasonic radiation and applications of ultrasonics.

UNIT I  ULTRASONIC PROPAGATION IN SOLIDS AND LIQUIDS  12
Propagation of Ultrasonics waves in solids – Plane wave propagation - Relation of the velocity of sound to the elastic properties – Adiabatic and Isothermal elastic constants – Ultrasonic propagation in liquids – Internal pressure and free volume calculations.

UNIT II  DETERMINATION OF VELOCITY OF PROPAGATION OF ULTRASONICS  12
Pulse Echo methods – Phase comparison methods – Pulse superposition – Measurements at high Pressure and high temperature–Transducer Coupling materials.

UNIT III  ULTRASONIC TRANSDUCERS  12
Piezoelectric and magnetostrictive transducers – Equivalent circuits – Efficiency – Transducer mounting – Linear and sector transducers – Variable frequency systems.

UNIT IV  ABSORPTION OF ULTRASONIC RADIATION  12

UNIT V  MEDICAL APPLICATIONS OF ULTRASONICS  12

TOTAL : 60 PERIODS

OUTCOME:
- Can employ the gained knowledge in extracting elastic constants of a material and thus can deduce transverse and longitudinal velocity of sound.
- Employ ultrasound in medical diagnostics by mimicking the biological condition or invivo condition

REFERENCES
OBJECTIVES:
- To enrich the knowledge about microscopes
- To educate the types of microscopes, their resolution, image contrast and depth of investigation

UNIT I  OPTICAL MICROSCOPY  12

UNIT II  SCANNING ELECTRON MICROSCOPY  12
Basic design of the scanning electron microscopy – types of electron source - Modes of operation– Backscattered electrons – secondary electrons- typical forms of contrast– Resolution and contrast – enhancement – Specimen Preparation - applications of SEM.

UNIT III  TRANSMISSION ELECTRON MICROSCOPY  12

UNIT IV  ATOMIC FORCE MICROSCOPY  12
Basic concepts-Interaction force - AFM tip on nanometer scale structures- force curves, measurements and manipulations-feed back control-different modes of operation –contact, non contact and tapping mode-Imaging and manipulation of samples in air or liquid environments-Imaging soft samples. Scanning Force Microscopy-Shear force Microscopy-Lateral Force Microscopy-Magnetic Force microscopy.

UNIT V  SCANNING TUNNELING MICROSCOPY  12
Principle- Instrumentation- importance of STM for nanostructures – surface and molecular manipulation using STM -3D map of electronic structure.

OUTCOME:
- Can use various microscopes to characterize the materials to study the surface properties

REFERENCES
OBJECTIVE:
- To introduce knowledge on basics of Nanomaterials their synthesis and characterization
- To make the students understand the importance of Nanotechnology
- To make the students understand the fundamental aspects of Nanotechnology and its importance in emerging biomedical applications.

UNIT I  NANO SYSTEMS  12
Size effect and properties of nanoparticles - melting point, surface tension, wettability - specific surface area–change in optical properties, electrical properties, and mechanical properties. Quantum confinement in 3D, 2D, 1D and zero dimensional nano structures.

UNIT II  SYNTHESIS OF NANOMATERIALS  12
Top down and Bottom up approach - Gas phase condensation – Vacuum deposition -Physical vapor deposition (PVD) - chemical vapor deposition (CVD) – laser ablation- Sol-Gel- Ball milling – Electro deposition- wet chemical methods - spray pyrolysis – plasma based synthesis process (PSP) - hydrothermal synthesis – biosynthesis.

UNIT III  NANOMATERIALS FOR MEDICAL APPLICATIONS  12
Nobel nano metals - quantum dots – magnetic nano particles – carbon nano tubes and one dimensional nano structures – dendrimers – cytosine nano particles.

UNIT IV  CHARACTERIZATION  12

UNIT V  MEDICAL APPLICATIONS  12

TOTAL: 60 PERIODS

OUTCOME:
- Can synthesis medically important nanoparticles and characterize them and apply them for various diagnostic therapeutic applicatons

REFERENCES
OBJECTIVE:
- To provide knowledge based and practical skills training to support the implementation of advanced Radiotherapy techniques in India.

UNIT I   CONFORMAL RADIOTHERAPY WITH MULTI LEAF COLLIMATOR   12
MLC - different categories –commercial MLC systems — MLC acceptance testing, commissioning and safety assessment - Quality Assurance of MLCs - Leaf position detection – recent developments in MLC.

UNIT II   INTENSITY MODULATION RADIATION THERAPY   12

UNIT III   IMAGE GUIDED RADIATION THERAPY   12
Imaging techniques for guidance in Radiation therapy – clinical procedures in employing imaging technologies – Methods to manage respiratory gating - Effect of motion on the total dose distribution – 4D computed tomography imaging and treatment planning - Gated Radiation Delivery- IGRT QA protocol.

UNIT IV   VOLUMETRIC MODULATED ARC THERAPY   12

UNIT V   PARTICLE BEAM THERAPY   12
Proton beam therapy- Physics of proton beams- Equipment for proton beam therapy- configurations of proton delivery systems- treatment planning in particle therapy- Heavy ion therapy-Carbon ion therapy-Neutron therapy-Boron Neutron Capture Therapy.

TOTAL: 60 PERIODS

OUTCOME:
- To practice, all aspects of clinical medical physics with safe, accurate and effective delivery of Radiotherapy treatment

REFERENCES


MY8008  RADIATION PHYSICS AND DOSIMETRY  L T P C

4 0 0 4

OBJECTIVE:
- Design to teach basic theory and practice of Radiation and health physics
- Interaction of radiation with materials and principles of radiation detection and related quantities

UNIT I  ATOMIC STRUCTURE  12
Structure of matter - atom - nucleus - atomic mass and energy units - distribution of orbital electrons - atomic energy levels - nuclear forces - nuclear energy levels - particle radiation - electromagnetic radiation - Binding energy - General properties of alpha, beta and gamma rays.

UNIT II  NUCLEAR TRANSFORMATIONS  12
Laws of equilibrium - Theory of alpha, beta decay and gamma emission - electron capture - internal conversion - nuclear isomerism - nuclear reactions - natural and artificial radioactivity - reactor and cyclotron produced isotopes - fission products.

UNIT III  INTERACTION OF RADIATION WITH MATTER  12
Ionization - Thomson Scattering - Photoelectric and Compton process and energy absorption - Pair production - Attenuation coefficient and mass energy absorption coefficient - relative importance of various types of interactions - interaction of charged particles with matter - interaction of neutron with matter - scattering - capture - neutron induced nuclear reaction – HVL – TVL.

UNIT IV  DOSIMETRIC CONCEPTS AND QUANTITIES  12

UNIT V  RADIATION DOSIMETERS  12
Introduction - Properties of dosimeters - Theory of gas filled ionization chamber - GM counter - working and different uses - recovery time and dead time - quenching - scintillation detectors - ionization chamber dosimetry systems - film dosimetry - luminescence dosimetry - semiconductor dosimetry - diamond dosimetry - Gel dosimetry - primary standards.

TOTAL: 60 PERIODS

OUTCOME:
- Can quantify different radiation units with the updated knowledge of Dosimetry protocols and to employ them in the management of malignancy.
REFERENCES:

MY8009 STEREOTACTIC RADIOSURGERY AND STEREOTATIC RADIOTHERAPY  L T P C
4 0 0 4

OBJECTIVE:
- To provide the knowledge on principle of gamma knife and linac based Radiosurgery and Radiotherapy

UNIT I STEREOTACTIC RADIOSURGERY AND STEREOTACTIC RADIOThERAPY  12

UNIT II CLINICAL INDICATIONS  12
Structure and Functioning of the brain. Clinical implications and malformations - AV AOVM, glioma, meningioma, acoustic schwanoma, pituitary adenoma and others.

UNIT III LINAC BASED RADIOSURGERY  12
Physical principles involved in the design of current linear Accelerators-Design and Characteristics - Modifications to the normal accelerators for Radiosurgery- MLC - Dosimetry of various collimators-3D calculation algorithms for non-coplanar fields-Quality assurance checks for radiosurgery-Image fusion in treatment planning and treatment evaluation.

UNIT IV QUALITY ASSURANCE  12
Scope of Computers in Radiation Treatment planning-Factors to be incorporated in computational algorithms- Cost effectiveness of Treatment Planning System -Hardware and Software requirements Periodic software and hardware Q.A checks - Installation and Quality Acceptance of TPS and Linac accessories for Radiosurgery.

UNIT V RADIOBIOLOGY OF SRS AND SRT  12
Physical and Biological factors affecting cell survival-tumor re-growth and normal tissue response-Non conventional fractionation scheme and their effect of re-oxygenation, repair redistribution in the cell cycle - High LET radiation therapy - TDF- LQ Model-Radiobiology of Radiosurgery - Radiobiology of fractionated Stereotactic Radiotherapy.

TOTAL: 60 PERIODS

OUTCOME:
- Can perform quality assurance in Linac and Gamma-knife and treat patient with respect of Radiobiological effect
REFERENCES


MY8010 THREE DIMENSIONAL CONFORMAL RADIOThERAPY

OBJECTIVE:
• To expose the students with basic concepts of conformal radiotherapy.
• To impart knowledge on three dimensional radiation therapy treatment planning, treatment optimization, conformal therapy with multileaf collimators, treatment machine features for conformal therapy, imaging for conformal radiotherapy planning.

UNIT I 3D RADIATION THERAPY TREATMENT PLANNING
Conformal radiotherapy treatment planning - Registration of two image datasets for 3D treatment planning – Summary and the NCI study of 3D therapy planning – Stages of Treatment Planning Dosimetry-Beam data Acquisition, Dosimetry with special detectors, data analysis and Input into 3D planning system – Dose verification with Phantom measurements.

UNIT II TREATMENT OPTIMIZATION

UNIT III CONFORMAL THERAPY WITH MULTI LEAF COLLIMATORS

UNIT IV MACHINE FEATURES FOR CONFORMAL THERAPY
Machine for conformal therapy with different radioactive isotopes – Tracking Units- tracking LINAC with MLC and CT combination – Universal Wedge-Dynamic Wedge- Wedges with MLC’s-Linear Accelerators with asymmetric collimators – Two Dimensional tissue Compensators.

UNIT V IMAGING FOR CONFORMAL RADIOTHERAPY PLANNING

TOTAL: 60 PERIODS
OUTCOME:
- Prepare 3D and IMRT treatment plans
- Analyze and discuss treatment plans for special cases

REFERENCES