M.Phil./Ph.D. Medical Physics (2021-22 onwards)

BHARATHIAR UNIVERSITY – COIMBATORE - 641046.

M.Phil./ Ph.D. -Medical Physics

(Full- Time/ Part- Time)

PART – I SYLLABUS

(For the candidates admitted from the academic year 2021-22 onwards)

PAPER I -	**RESEARCH METHODOLOGY**
PAPER II -	**Concept of radiation and diagnostic in MEDICAL PHYSICS**
PAPER III-	**1. ADVANCED RADIATION BIOLOGY**
	2. RADIOTHERAPY EQUIPMENTS
	3. MOLECULAR QUANTUM MECHANICS

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PAPER I – RESEARCH METHODOLOGY

Unit 1: Higher Education and Learning

Historical perspective – objectives and role of higher education – learning and learning hierarchy – information processing – learning events and outcomes – motivation. Teaching technology designs: Meaning, concept and scope – instructional designs: objective based, skill based, competency based, learning style based and model based.

Unit 2: Methods in Research

Meaning of Research - Objectives of Research - Motivations in Research - Types of Research -Research Approaches - Significance of Research - Research Methods v/s Methodology - Research and Scientific Methods - Research Process - Criteria of Good Research - Funding agencies. Defining the Research Problem: Research Problem - Selecting the Problem - Necessity of Techniques in defining the Problem.

Unit 3: Ethics in Research:

Locating ethics in research- Consent- Vulnerable and non-competent subjects- Privacy and confidentiality- Balancing harms and benefits: the case of randomised controlled trials- Justice in research - Science and society- Ethical issues in the new biotechnologies- Intellectual Property Right (IPR).

Unit 4: Research Design

Meaning – Need - Features of Good Design – Concepts – Types - Basic Principles of Experimental Design, Developing a Research Plan. Sample Design: Implication – Steps - Criteria for selecting a sample procedure - Characteristics of Good sampling Procedure - Types of Sample Design - Selecting Random Samples - Complex random sampling Design. Measurement and Scaling Techniques: Measurement in Research - Measurement Scales - Sources of Errors in measurement – Tests of Second measurement - Technique of developing Measurement Tools - Meaning of Scaling – Scale nClassification Bases - Important Scaling Techniques - Scale Construction Techniques.

Unit 5: Scientific Papers, Presentations and Report Writing

Organizing and writing a rough draft – searching and reviewing scientific literature – publishing in scientific journals – ethical and legal issues – scientific presentations – oral presentation – poster presentation. Preparation of research report - steps involved in writing a good report - concepts of bibliography and references. Application of Computer for Research Work: Application of Computer packages - Educational and Research resources on the Internet - Data Analysis and Display using software. Developing a Research Proposal: Format of research proposal - Individual research proposal - Institutional proposal.

Reference Books

1. E.G. Vedanayagam, ―Teaching technology for College Teachers‖, Sterling Publishers (P) Ltd., 1989.

2. C. R. Kothari, "Research Methodology Methods and Techniques‖, New Age International Pvt.Ltd., Publishers, 2nd revised edition, 2009.

3. "Syllabus on Ethics in Research", Addendum to the European Textbook on Ethics in Research, Luxembourg: Publications Office of the European Union, 2010.

4. Ranjit Kumar, ―Research Methodology: A Step by Step Guide for Beginners‖, Sage

Publications, 2nd edition, 2005.

5. Martha Davis, "Scientific Papers and Presentations‖ San Diego: Academic Press, 1997.

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PAPER II- Concept of radiation and diagnostic in MEDICAL PHYSICS

Unit 1.

Introduction to Ionizing Radiation and Cancer

Radiation: Definition, electromagnetic spectrum-ionization-types of radiation-Radiation quantities and units: absorbed dose, equivalent dose, effective dose-Interaction of radiation with matter: properties and hazards of ionizing radiation-biological effects-applications of radiation-radiation safety principles. Cancer: Definition, carcinogenic agents, types, stages, organization of body, genes responsible for cancer, treatment efficacy, and medical ethics

Unit 2

Diagnostic Imaging Modalities

Principle of radiation detection-Basic principles of ionization chambers, proportional counters, G.M counters and scintillation detectors. Measuring system: free ionization chamber-thimble ion chamber-condenser chamber- secondary standard dosimeter-film dosimeter-chemical dosimeter-Thermo Luminescent Dosimeter-Pocket dosimeter. Computed tomography, MRI, Ultrasonography, Digital Radiography-its principle, physics & equipment. Picture archiving and communication system (PACS)

Unit 3

Radiotherapy and techniques

Department of Radiation oncology-Duties of Medical Physicists and RSO-Treatment procedure-Overview to plan a diagnostic radiology, radiotherapy and nuclear medicine department treatment procedure and safety in Tele therapy -cobalt therapy -Linear Accelerators Electron and Photon -LDR and HDR Brachytherapy, Treatments using Nuclear medicine sources -proton and Ion beam therapy

Unit 4

X-rays:

Discovery of x-rays-X-ray production and properties: Bremsstrahlung radiations-Characteristics X-Rays, factors affecting X-ray emission spectra, X-ray quality and quantity, HVL measurements, heel effect, soft and hard X-Rays, added and inherent filtration, reflection and transmission targets. Interaction of X and gamma rays: Transmission through matter, law of exponential attenuation, half value layer, and linear attenuation coefficient-coherent scattering-photonuclear disintegration-Particle interactions. Interactions of X rays and Gamma rays in the body; fat-soft tissue-bone-contrast media-total attenuation coefficient-relative clinical importance.

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Unit 5

Introduction to Monte Carlo methods

Random variables, discrete random variables, continuous random variables, Probability density functions, discrete probability density function, continuous probability distributions, cumulative distribution function, accuracy and precision, central limit theorem, random numbers and their generation, tests for randomness, inversion random sampling technique including worked examples, integration of simple 1-D integrals including worked examples.

Books for study and references:

1. MomnaHejmadi, Introduction to cancer biology, 2nd edition, 2010
2. The Physics of radiology, H.E.Johns and Cunningham, Charles C Thomas Publishers, 1stEdition, 1984.
3. Curry,T.S.,Dowdey,J.E.,Murry,R.C.,Christensen'sintroductiontothephysicsofdiagnostic radiology, Philadelphia: Lea &Febiger, 4thEdition, 1990
4. E.B. Podgorsak, Radiation Oncology Physics: AHandbook for Teachers and Students, International Atomic Energy Agency (IAEA) publications, 2005.
5. E. B. Podgarsak, Radiation Physics for Medical Physicists, Springer Verlag,1stEdition,1996.
6. Absorbed Dose Determination in External Beam Radiotherapy: An International Code of Practice for Dosimetry based on Standards of Absorbed Dose to Water, IAEA TRS-398, 2006.
7. Ivan Lux and Laszlo Koblinger, Monte Carlo Particle Transport Methods: Neutron and Photon Calculations, 1st Edition, CRC Taylor & Francis, 1990

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PAPER III- 1. ADVANCED RADIATION BIOLOGY

Unit 1: A brief review on Cancer

Definition- Global cancer facts and figures- Characteristics and causes of cancer- Types of cancer and their definition- Cancer stem cell theory- Tumor microenvironment- Carcinogenesis: Cellular basis of carcinogenesis- Cell signaling in carcinogenesis- Genes involved in carcinogenesis- Multistep nature of carcinogenesis- Metastasis pathways- Cancer as a genetic disease- Classification of cancer- Methods for early detection, screening and diagnosis of cancer- Cancer treatment- Radiation in cancer treatment- Effects of signalling abnormalities on Radiation responses.

Unit 2: Interaction of radiation with cells

Concepts of microdosimetry- Various stages of interaction of radiation with biological system- Interaction of radiation with cell at atomic level- Interaction of radiation with cell at molecular level-Interaction of radiolysis product with biomolecules: Interaction of radiolysis product with proteins,carbohydrates and lipids, DNA damage, DNA Repair, Chromosomal and Chromatid aberrations, Dose response relationships- Effects of radiation at cellular level: Effects of radiation on cell cycle, Mechanisms of Cell Death- Non targeted effects of radiation- Intercellular communication.

Unit 3: Cell culture basics

Cell Lines: Selecting the appropriate cell line, Acquiring cell lines; Culture environment- Adherent vs Suspension culture, Media, pH, CO2, Temperature; Cell Morphology- Mammalian Cells, Insect cells.Methods, guidelines, materials and protocols: Maintaining cultured cells- Subculturing adherent- Subculturing suspension- Freezing cell- Thawing frozen cells.

Unit 4: Biological dosimetry

Introduction- Biomarkers: Cytogenetic biomarkers, Biomarkers for nucleotide pool damage and DNA damage, Biomarkers for germline inherited mutations and variants, Biomarkers for induced mutations, Biomarkers for transcriptional and translational changes and Others- Various phases of biological dosimetry: Sample collection phase, Sample processing- phase, Data analysis phase- Various techniques in biological dosimetry: Fluorescence In Situ Hybridization (FISH) technique, Comet assay, MN assay, Choromosomal aberration, Polymerization Chain Reaction (PCR), Flow cytometry, Western blot, Enzyme-linked immunosorbent assay (ELISA), and DNA Microarray technology.

Unit 5: Medical statistics

Statistics which describe data: Percentages- Mean- Median- Mode- Standard deviation; Statistics which test confidence: Confidence intervals- P values; Statistics which test differences: t tests and other parametric tests- Mann Whitney and other non-parametric tests- Chi-squared; Statistics which compare risk: Risk ratio- Odds ratio- Risk reduction and numbers needed to treat; Statistics which analyse relationships: Correlation- Regression; Statistics which analyze survival: Survival analysis- Cox regression model; Statistics which analyze

clinical investigations and screening: Sensitivity, specificity and predictive value- Level of agreement.

Text books for reference:

1. Text book on "Radiation biology for Medical Physicists", C. S. Sureka and C. Armpilia, CRC Taylor & Francis Group, USA, 2017 (Units 1, 2 and 4).

2. Handbook of "Cell Culture Basics", 2015 (Website:https://www.thermofisher.com/content/dam/LifeTech/global/promotions/global/images/aai- 2015/aai-pdfs/GibcoCellCultureBasicsHandbook.pdf) (Unit 3).

3. "Medical Statistics made easy", Michael Harris and Gordon, Taylor, Taylor & Francis Group, 2003 (Unit 5).

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PAPER III- 2. RADIOTHERAPY EQUIPMENTS

Unit 1: TELEGAMMA MACHINES

Co-60 and Cs-137 as teletherapy sources - source containers - international source capsule - effect of penumbra- Types of collimators - beam directing devices - Different Source Shutter Systems-Quality Assurance of telegamma units.

Unit 2: LINEAR ACCELERATORS

Components of modern linear accelerator-Standing and travelling wave guides, Magnetrons and Klystrons.Bending Magnet, Target, Flattening filter, Collimators. Need for high quality portal imaging - Fluoroscopic, diode, crystal, Ionization chamber detectors and film detectors, amorphous silicon - Diagnostic imaging on a linear accelerator - portal dose images, Portal Dosimetry. TelecobaltVsLinacs.

Unit 3: RADIOTHERAPY SIMULATORS

Conventional simulators - CT simulators - cone beam CT simulators (CBCT) - comparison and quality assurance of simulators - different simulation techniques - Orthogonal, Semi-orthogonal, Isocentric, Variable angle and Stereo-Shift.

Unit 4: BRACHYTHERAPY

Introduction - Manual pre loading systems- manual after loading systems - remote after loading systems -source trains(fixed and programmable) - stepping source - different types of applicators(gynecological ,esophageal, nasopharngeal, bronchial) and templates Introduction to computerized brachytherapy planning.

Unit 5: ADVANCED RADIOTHERAPY EQUIPMENTS

Superficial X-ray therapy units - Gamma knife - cyber knife - Intra operative radiation therapy units- Tomotherapy -Neutron therapy - boron neutron capture therapy (BNCT)-particle accelerators - proton therapy - carbon ion therapy.

REFERENCE:

1. Radiation Oncology physics : A Handbook for teachers and students. IAEA publications 2005.

2. F.M.Khan,The Physics of Radiation Therapy,ThirdEdition,Lippincott Williams and Wilkins, U.S.A.,2003

3. Photodynamic therapy, By Thierry Patrice , Royal Society of Chemistry, 2004

4. Medical Applications of Lasers By D. R. Vij, K. Mahesh, Springer, 2002

5. Watmough and Ross, Hyperthermia, Blackie 1986

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PAPER – III - 3. MOLECULAR QUANTUM MECHANICS

Unit I: Many-Electron systems

The Hartree-Fock self-consistent field method - Electron correlation - The atomic Hamiltonian- The Condon-Slater rules - The Born-Oppenheimer approximation - The Hydrogen molecule ion- Approximate treatments of H_2^+ ground electronic state - Molecular orbitals for H_2^+excited states - Molecular orbital configurations of homonuclear diatomic molecules - The hydrogenmolecule – The valence bond treatment of H2 – Electron probability density

Unit II: Electron correlated methods

The Hartree-Fock method for molecules – MO treatment of heteronuclear diatomic molecules - Rayleigh-Schrödinger many body perturbation theory - Basis functions – Configuration interaction (CI) wave functions; multiconfiguration SCF (MCSCF), complete active space SCF (CASSCF), multireference CI (MRCI) – Coupled cluster methods

Unit III: Molecular properties, semi-empirical and molecular mechanics methods Population analysis – Dipole moment – Molecular geometry and conformations – Molecular vibrational frequencies and thermochemical properties – Huckel MO method – Extended Huckel method – The formulation of CNDO, INDO, MNDO, AM1 and PM3 methods – Potential energy (force field) in molecular mechanics – Various energy terms in force field – Newtonian and Hamiltonian dynamics – Phase space trajectories – Classification of dynamical systems –Determination of properties

Unit IV: Density Functional Theory

Electron density - The original idea: The Thomas-Fermi model – The traditional Thomas-Fermi and Thomas-Fermi-Dirac models – Three theorems in Thomas Fermi theory - Thomas-Fermi-Dirac-Weizsacker model – The Hohenberg-Kohn theorems – Kohn-Sham equations – Derivation of Kohn-Sham equations – Kinetic energy functional – Local density approximation (LDA) –Density gradient and kinetic energy density corrections – Adiabatic connection methods

Unit V: Reactivity parameters, TDDFT, Plane waves and Pseudopotentials

Reactivity parameters; chemical potential, electronegativity, chemical hardness, softness and Fukui function – Time-dependent density functional theory: Runge-Gross Theorem - Time-dependent Kohn-Sham equation -Linear response - Excitation energies (Casida‟s equations) - Plane waves and the Brillouin zone – Bloch‟s theorem – Integrals in K space – Choosing Kpoints in the Brillouin zone – Energy cutoffs – Pseudopotentials – Norm-conserving pseudopotentials – Ultrasoftpseudopotentials – Projection augmented waves

Books for study:

1. Quantum Chemistry – Ira. N. Levine, Vth Edition; Prentice-Hall of India, New Delhi, 2000

2. Ab initio molecular orbital theory – W. J. Hehre, L. Radom, P. V. R. Schleyer and J. A. Pople; John Wiley & Sons, New York, 1985.

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3. Essential of Computational Chemistry - Theories and Models ,IInd Edition, Christopher J. Cramer; John Wiley & Sons, England, 2004.

4. Modern quantum chemistry – Introduction to advanced electronic structure theory – Attila Szabo and Neil S. Ostlund, Dover publications INC, New York, 1996.

5. Molecular dynamics simulation – Elementary methods - J.M. Halie, John Wiley & sons, Inc., 1997

6. Density functional theory of atoms and molecules – R. G. Parr and W. Yang; Oxford University press, New York, 1989.

7. Electronic structure – Basic theory and Practical methods – Richard M. Martin, Cambridge University Press, UK, 2005

8. Time-Dependent Density-Functional Theory: Concepts and Applications – CarstenUllrich, 1st Edition, Oxford University Press, 2006

9. Density functional theory – A practical introduction – David S. Sholl, and Janice A. Steckel – John Wiley & sons, Inc., 2009