M.Sc. in Medical Physics 2 Years (4 Semesters)

Overview: The M.Sc. in Medical Physics is a specialized postgraduate program that merges the fields of physics and medicine, providing students with the knowledge and skills required to apply physics principles in medical settings. This program focuses on the use of physics in medical imaging, radiology, radiation therapy, and nuclear medicine. Students are trained to use advanced technologies and methodologies for the diagnosis, treatment, and management of diseases, particularly cancer.

Medical physicists play a crucial role in ensuring the safety and effectiveness of medical devices and procedures, working in hospitals, research institutes, and healthcare facilities. The M.Sc. in Medical Physics provides both theoretical and practical knowledge of radiation physics, imaging techniques, radiotherapy, and medical instrumentation, preparing students for roles in clinical, research, and industrial settings.

Affiliated Institution: School of Medical Sciences and Technology, Malla Reddy Vishwavidyapeeth (Deemed to be University)** The minimum eligibility for M.Sc. in Medical Physics is a pass in B.Sc with at least 50% marks in qualifying exam.

Key Highlights:

- **Interdisciplinary Knowledge**: Combines principles from physics, engineering, and medicine to prepare students to work effectively in healthcare environments.
- **Radiation Therapy & Medical Imaging**: Study the physics behind radiation therapy techniques like external beam radiotherapy, brachytherapy, and medical imaging techniques, including MRI, CT scans, and X-rays.
- **Advanced Medical Technologies**: Exposure to the latest developments in medical technologies, such as proton therapy, particle beam therapy, and nuclear medicine.
- **Clinical Training**: Hands-on experience through clinical placements in hospitals, allowing students to work with medical equipment and directly contribute to patient care.
- **Safety and Quality Assurance**: Training in the safety protocols and quality assurance procedures necessary to ensure accurate and safe treatment delivery in medical settings.
- **Research Opportunities**: Engagement in medical physics research, contributing to advancements in medical technologies, radiation protection, and new diagnostic or therapeutic techniques.

Course Curriculum:

The M.Sc. in Medical Physics is typically a two-year program consisting of theoretical coursework, laboratory work, and clinical training.

Year 1:

Core Modules:

- **Introduction to Medical Physics**: Overview of the role of medical physicists in healthcare, including medical imaging, radiotherapy, and radiation protection.
- **Radiation Physics**: Study the fundamental principles of radiation, radiation interaction with matter, and its medical applications in imaging and therapy.
- **Medical Imaging Techniques**: Focus on the physics of medical imaging modalities such as X-ray, CT, MRI, ultrasound, and nuclear medicine.
- **Radiation Protection and Safety**: Learn about radiation safety standards, dosimetry, and radiation protection protocols to ensure the safe use of radiation in medical procedures.
- **Biological Effects of Radiation**: Study how ionizing radiation interacts with biological tissues, the potential risks, and the therapeutic effects of radiation.
- **Mathematics and Computation in Medical Physics**: Applications of mathematical models, statistics, and computational techniques in analyzing medical physics data and solving clinical problems.

Practical Training:

- Laboratory-based training in radiation detection, dosimetry, and basic medical imaging techniques.
- Clinical observation in hospitals or medical centers, working alongside radiologists, oncologists, and radiation therapists.

Year 2:

Advanced Modules:

- **Radiotherapy Physics**: Detailed study of the physics behind radiotherapy techniques, including treatment planning, dose calculations, and quality assurance in radiotherapy departments.
- **Imaging for Diagnosis and Therapy**: Focus on advanced medical imaging techniques, including PET, MRI spectroscopy, and functional imaging methods used in diagnosis and treatment planning.
- **Nuclear Medicine and Positron Emission Tomography (PET)**: Study the principles of nuclear medicine, radiopharmaceuticals, and imaging techniques used to diagnose and treat diseases.
- **Clinical Medical Physics**: Explore the clinical aspects of medical physics, including patient-specific treatment planning, equipment calibration, and real-time monitoring during procedures.
- **Medical Instrumentation**: Learn about the design, operation, and maintenance of medical instruments used in diagnostics and treatment, such as linear accelerators and radiation detectors.
- **Research Methodology in Medical Physics**: Training in conducting research, analyzing data, and presenting findings related to medical physics, including ongoing developments in the field.

Research Project/Dissertation:

- In the second year, students will undertake a research project, where they will apply medical physics principles to a specific problem or question, such as developing new imaging techniques, improving radiation therapy methods, or optimizing safety protocols. The project culminates in a dissertation.

Career and Academic Opportunities:

Career Opportunities:

Graduates of the M.Sc. in Medical Physics have a wide range of career options in healthcare, research, and the technology industry. Career roles include:

- **Clinical Medical Physicist**: Work in hospitals or medical centers, providing support for radiology and oncology departments, ensuring the safe use of medical devices, and participating in treatment planning.
- **Radiotherapy Physicist**: Specialize in the application of physics principles to radiation therapy, ensuring accurate dose delivery and treatment planning for cancer patients.
- **Medical Imaging Physicist**: Focus on the development and optimization of imaging technologies, ensuring the quality and accuracy of diagnostic images.
- **Nuclear Medicine Physicist**: Work with nuclear medicine technologies, using radiopharmaceuticals for imaging and treatment, and ensuring safe and effective use of radiation in clinical settings.
- **Health and Safety Consultant**: Advise healthcare institutions on radiation safety protocols, dosimetry, and regulatory compliance.
- **Medical Equipment Developer**: Work with medical device companies to develop, test, and improve medical imaging and radiation therapy equipment.
- **Research Scientist**: Conduct research in academic or private sectors, focusing on new technologies in medical imaging, radiation treatment, or radiation safety.
- **Regulatory Affairs Specialist**: Work with government agencies or healthcare organizations to ensure compliance with health and safety regulations related to medical devices and radiation use.

Academic Opportunities:

Graduates may choose to further their education through:

- **Ph.D. in Medical Physics**: Focus on specialized research areas such as advanced imaging technologies, radiation therapy, or radiation safety. A Ph.D. prepares students for academic and research positions.
- **Postdoctoral Research**: Engage in advanced research projects in the field of medical physics, contributing to the development of new diagnostic or therapeutic methods.
- **Medical Degree (MD)**: Some students may choose to pursue a medical degree, focusing on the clinical application of medical physics.

Research Prospects:

- **Advanced Imaging Techniques**: Research in improving existing imaging technologies (such as MRI, PET, or CT) for better diagnostic accuracy and patient outcomes.

- **Radiotherapy Innovations**: Development of new radiotherapy methods, such as proton therapy or stereotactic radiotherapy, which offer precise tumor targeting with reduced side effects.
- **Radiation Protection**: Research focused on improving radiation protection standards, ensuring safe use of radiation in both clinical and research settings.
- **Medical Device Development**: Innovating and improving medical devices used in diagnostics and treatment, including radiation therapy equipment and medical imaging systems.
- **Computational Methods in Medical Physics**: Applying computational models and algorithms to improve diagnostic techniques, treatment planning, and real-time monitoring of patients.

Professional Opportunities:

- **Certified Medical Physicist**: Certification from recognized bodies like the American Board of Radiology (ABR) or the British Institute of Radiology (BIR) is often required to practice as a clinical medical physicist.
- **Radiation Safety Officer**: Certification in radiation safety and regulation may be pursued to specialize in ensuring safe radiation practices in hospitals or research facilities.
- **Medical Physics Society Membership**: Joining societies like the American Association of Physicists in Medicine (AAPM) or the European Federation of Organisations for Medical Physics (EFOMP) can provide access to professional resources, conferences, and networking opportunities.

Higher Education and Research Prospects:

- **Ph.D. in Medical Physics**: Students may pursue advanced research in medical physics, specializing in areas such as radiation therapy, imaging technology, or radiation safety.
- **Postdoctoral Fellowships**: Postgraduate research opportunities at research institutes or academic institutions focused on developing new technologies and techniques in medical physics.

Conclusion:

The **M.Sc. in Medical Physics** is a rigorous and rewarding program that prepares students to play a crucial role in the healthcare industry. By applying principles of physics to medicine, graduates contribute to improving diagnostic accuracy, enhancing treatment effectiveness, and ensuring the safety of radiation-based medical procedures.

With growing demand for skilled medical physicists in clinical, research, and industrial settings, this program offers excellent career opportunities, as well as prospects for further education and research in a rapidly advancing field. Whether working in radiation therapy, medical imaging, or nuclear medicine, graduates of the M.Sc. in Medical Physics will be at the forefront of medical technology, helping to improve patient care and outcomes.

Labs

1. Radiation Physics & Dosimetry Lab

- **Radiation Measurement & Detection:**
  - ✓ Ionization chambers (thimble, parallel-plate, well-type)
  - ✓ Geiger-Muller counters & scintillation detectors
  - ✓ TLD (Thermoluminescent Dosimeters) & OSL (Optically Stimulated Luminescence) dosimeters
  - ✓ Radiochromic films for dose distribution

- **Radiation Sources:**
  - ✓ X-ray tubes for exposure experiments
  - ✓ Sealed radioactive sources (Cs-137, Co-60) for calibration

- **Dosimetry Systems:**
  - ✓ Water phantom systems for radiation dose measurements
  - ✓ MOSFET and semiconductor dosimeters

2. Medical Imaging Lab

- **Radiographic & Fluoroscopy Systems:**
  - ✓ Digital X-ray systems
  - ✓ C-arm fluoroscopy units

- **Advanced Imaging Modalities:**
  - ✓ MRI simulation software & phantoms
  - ✓ CT scanner (or CT simulation software)
  - ✓ PET & SPECT phantom-based analysis

- **Image Processing & Analysis:**
  - ✓ DICOM viewer & PACS (Picture Archiving and Communication System)
  - ✓ MATLAB, ImageJ for medical image processing

3. Radiation Therapy & Treatment Planning Lab

- **Linear Accelerator (LINAC) Training:**
  - ✓ Access to LINAC (or virtual LINAC simulation)
  - ✓ IMRT, VMAT treatment planning modules

- **Brachytherapy Setup:**
  - ✓ Remote afterloading brachytherapy unit
  - ✓ HDR & LDR brachytherapy applicators

- **Treatment Planning Software:**
  - ✓ Eclipse, Monaco, or RayStation for radiotherapy planning
  - ✓ Monte Carlo simulations for dose calculation

4. Nuclear Medicine & Radiation Protection Lab

- **Radionuclide Handling & Imaging:**
  - ✓ Gamma cameras & SPECT/CT phantom studies
  - ✓ Positron Emission Tomography (PET) simulation
- **Radiation Shielding & Protection:**
  - ✓ Lead aprons, thyroid shields, and radiation monitors
  - ✓ Dosimeter badge monitoring systems
- **Environmental Radiation Monitoring:**
  - ✓ Airborne & surface contamination detectors
  - ✓ Radiation area survey meters

5. Computational & Theoretical Physics Lab

- **Monte Carlo & AI-based Simulations:**
  - ✓ MCNP, GEANT4 for radiation transport modeling
  - ✓ MATLAB, Python for dose optimization
- **Artificial Intelligence in Medical Physics:**
  - ✓ AI-based segmentation & tumor detection software
  - ✓ Deep learning for image enhancement

PROGRAM OUTCOMES (POs)

PO	Program Outcomes
PO-1	**Fundamentals of Medical Physics-** Gain in-depth knowledge of physics principles applied in medicine, including radiation physics and imaging techniques.
PO-2	**Radiation Physics & Dosimetry-** Understand the principles of radiation interactions, dose measurements, and radiation safety protocols.
PO-3	**Medical Imaging Techniques-** Develop expertise in imaging modalities such as X-ray, CT, MRI, ultrasound, and nuclear medicine for diagnostic applications.
PO-4	**Radiotherapy & Cancer Treatment-** Learn about radiotherapy techniques, treatment planning, and quality assurance in cancer therapy.
PO-5	**Radiation Protection & Safety-** Apply radiation protection principles, including shielding, monitoring, and regulatory compliance in medical settings.
PO-6	**Instrumentation & Biomedical Engineering-** Study medical devices, detectors, and quality control of equipment used in medical physics applications.
PO-7	**Research & Computational Methods in Medical Physics-** Develop skills in simulation, modeling, and data analysis for research in radiation and imaging physics.
PO-8	**Clinical Applications & Professional Ethics-** Understand the role of medical physicists in healthcare, ethical considerations, and patient safety standards.

COURSE STRUCTURE – M.Sc. Medical Physics

SEMESTER – I

Sl. No.	Broad Category	Course Code	Name of the Subject/Practical	Contact hours/week			Credits
				L	**T**	**P**	
1.	**Major (Core)**	MSMP101	Basics of Atomic and Nuclear Physics	2	1	0	3
2.		MSMP102	Applied Anatomy & Physiology for Medical Physics	2	1	0	3
3.		MSMP103	Radiation Physics and Radiation Generators	2	1	0	3
4.		MSMP104	Electronics and Instrumentation	2	0	2	3
5.	**Minor** Select any two minor courses, each worth 3 credits, for a maximum of 6 credits per semester	MSMP105	1. Radiation Protection & Safety Regulations 2. Biophysics & Radiation Interactions with Matter 3. Biomedical Instrumentation & Sensors	2	0	2	6
			4. Computational Methods in Medical Physics 5. Introduction to Artificial Intelligence in Medical Imaging 6. Research Methodology & Biostatistics	2	0	2	
6.	**Skill Enhancement Courses**	MSMP106	1.Medical Imaging Techniques (X-ray, CT, MRI, Ultrasound)	0	0	2	2
			2. Radiation Measurement & Dosimetry	0	0	2	
			Total	12	3	10	**20**
Total Contact Hours				**25**			

Course outcome for the MAJOR courses in M.Sc. Medical Physics

Course Name	Course Outcomes
Basics of Atomic and Nuclear Physics	- Understand the fundamental concepts of atomic structure, nuclear forces, and radioactivity. - Explain nuclear reactions, decay processes, and radiation interactions with matter. - Analyze the principles of quantum mechanics and their applications in medical physics. - Evaluate the role of nuclear physics in radiation therapy and diagnostic imaging. - Apply knowledge of atomic and nuclear physics to radiation protection and safety.
Applied Anatomy & Physiology for Medical Physics	- Understand the structure and function of human organ systems relevant to medical physics applications. - Explain the physiological mechanisms of radiation interaction with biological tissues. - Analyze the effects of ionizing and non-ionizing radiation on different organ systems. - Evaluate anatomical considerations in radiological imaging, radiation therapy, and nuclear medicine. - Apply anatomical and physiological knowledge to optimize medical imaging techniques and radiation treatment planning.
Radiation Physics and Radiation Generators	- Understand the principles of radiation production, interaction, and attenuation. - Explain the working mechanisms of radiation generators, including X-ray tubes, linear accelerators, and nuclear reactors. - Analyze dosimetric principles and radiation measurement techniques. - Evaluate the clinical applications of radiation in diagnostics and therapy. - Apply radiation physics knowledge to ensure safe and effective use of medical radiation sources.
Electronics and Instrumentation	- Understand the fundamentals of electronics, including circuit design, semiconductors, and signal processing. - Explain the working principles of medical instrumentation used in imaging and radiation therapy. - Analyze the role of detectors, sensors, and amplifiers in medical physics applications. - Evaluate the integration of electronics in modern diagnostic and therapeutic equipment. - Apply knowledge of electronics and instrumentation to troubleshoot and maintain medical devices.

Course outcome for the MINOR courses in M.Sc. Medical Physics

Course Name	Course Outcomes
Radiation Protection & Safety Regulations	- Understand the principles of radiation protection, shielding, and exposure limits. - Explain the biological effects of ionizing radiation and methods to minimize exposure. - Analyze national and international radiation safety regulations (IAEA, NCRP, ICRP). - Evaluate radiation protection measures in medical, industrial, and research settings. - Apply radiation monitoring and safety protocols in clinical and laboratory environments.
Biophysics & Radiation Interactions with Matter	- Understand the fundamental concepts of biophysics and their applications in medical physics. - Explain the interactions of ionizing and non-ionizing radiation with biological tissues. - Analyze radiation dose deposition and its effects at the molecular, cellular, and tissue levels. - Evaluate the role of biophysical principles in radiation therapy and medical imaging. - Apply knowledge of biophysics to optimize radiation-based medical technologies.
Biomedical Instrumentation & Sensors	- Understand the working principles of biomedical instruments used in diagnostics and therapy. - Explain the role of sensors, transducers, and signal processing in medical applications. - Analyze different imaging modalities such as MRI, CT, PET, and ultrasound. - Evaluate the importance of calibration, maintenance, and quality assurance of biomedical devices. - Apply biomedical instrumentation knowledge to enhance patient monitoring and treatment accuracy.
Computational Methods in Medical Physics	- Understand computational techniques used in medical physics, including numerical modeling and simulations. - Explain Monte Carlo simulations, image reconstruction algorithms, and radiation transport modeling. - Analyze data processing methods for medical imaging and treatment planning. - Evaluate the role of artificial intelligence (AI) and machine learning in computational medical physics. - Apply computational tools to optimize radiation therapy planning and diagnostic imaging.
Introduction to Artificial Intelligence in Medical Imaging	- Understand the fundamentals of artificial intelligence (AI) and machine learning in medical imaging. - Explain image segmentation, enhancement, and pattern recognition techniques. - Analyze AI applications in radiology, nuclear medicine, and radiation oncology. - Evaluate the advantages, challenges, and ethical considerations of AI in healthcare.

Course Name	Course Outcomes
	- Apply AI-based approaches to improve diagnostic accuracy and treatment planning.
Research Methodology & Biostatistics	- Understand the fundamentals of research design, hypothesis formulation, and scientific writing. - Apply statistical techniques to analyze medical physics and imaging data. - Interpret results from clinical and experimental research studies. - Evaluate evidence-based medical physics research for clinical applications. - Develop skills in literature review, data presentation, and publication ethics.

M.Sc. in Medical Physics – Course Structure & Syllabus

Course Duration: 2 Years (4 Semesters)

Total Credits: 80–100

Total Teaching & Training Hours: ~3,600

Total Teaching Hours Distribution

- **Theory Classes:** ~1,200–1,500 hours
- **Practical & Laboratory Training:** ~800–1,000 hours
- **Clinical Internship & Hands-on Training:** ~800–1,000 hours
- **Research Project & Dissertation:** ~300–500 hours

Assessment Methods

Assessment Component	Weightage (%)	Details
Continuous Internal Assessment (CIA)	**40%**	Includes internal exams, assignments, presentations, case studies, and practical performance
End-Semester Examination (ESE)	**60%**	Divided into theory (40%) and practical (20%)
Mid-Semester Exams	**20%** (Part of CIA)	Two internal tests per semester

Assessment Component	Weightage (%)	Details
Assignments & Case Studies	**5%** (Part of CIA)	Research-based assignments, literature reviews, clinical case reports
Seminars & Presentations	**5%** (Part of CIA)	Oral/poster presentations on diabetes management
Practical Performance & Clinical Evaluation	**5%** (Part of CIA)	Skill-based assessments in labs/hospitals
Attendance & Participation	**5%** (Part of CIA)	Regularity in theory & practical sessions
Theory Examination (Final)	**40%** (Part of ESE)	Structured written paper covering subject knowledge
Practical Examination (Final)	**20%** (Part of ESE)	Includes viva, skill demonstration, case handling
Dissertation/Research Project	**Mandatory**	Evaluated in the final year by internal & external examiners
Clinical Internship/Training	**Pass/Fail**	Logbook-based evaluation with hospital mentor review

Marking System & Grading

Marks (%)	Grade	Grade Point (GPA/CGPA Equivalent)	Classification
90 - 100	O (Outstanding)	10	First Class with Distinction
80 - 89	A+ (Excellent)	9	First Class with Distinction
70 - 79	A (Very Good)	8	First Class
60 - 69	B+ (Good)	7	First Class
50 - 59	B (Satisfactory)	6	Second Class
<50 (Fail)	F (Fail)	0	Fail (Re-exam Required)

Pass Criteria:

- **Minimum 50% marks in each subject** (Theory & Practical separately).
- **Aggregate of 55% required for progression** to the next semester.
- **No more than two backlogs** allowed for promotion to the final year.

Exam Pattern for Theory & Practical

A. Theory Examination Pattern

Total Marks: 100 (Converted to 40% for End-Semester Assessment)
Duration: 3 Hours

Section	Question Type	No. of Questions	Marks per Question	Total Marks
Section A	Short Answer Type (SAQ)	10 (Attempt all)	2	20
Section B	Long Answer Type (LAQ)	5 (Attempt any 4)	10	40
Section C	Case-Based/Clinical Scenario	3 (Attempt any 2)	15	30
Section D	MCQs/Objective Type	10 (Compulsory)	1	10
Total				**100**

Weightage:

- Radiation Physics & Dosimetry – 40%
- Medical Imaging & Radiotherapy Physics – 30%
- Research & Case Studies in Medical Physics – 20%
- Radiation Protection & Regulatory Compliance – 10%

Passing Criteria: Minimum **50% (50/100 marks)**

B. Practical Examination Pattern

Total Marks: 100 (Converted to 20% for End-Semester Assessment)
Duration: 4–6 Hours

Component	Marks Distribution
Clinical Case Presentation & Radiation Safety Assessment	30
OSCE (Objective Structured Clinical Examination) – Skill Demonstration	25
Medical Imaging & Radiation Therapy Techniques	20
Lab-Based Examination (Dosimetry, Radiation Protection, Quality Control of Imaging Equipment)	15
Record Work (Logbook & Assignments)	10
Total	**100**

OSCE (Skill-based Assessment) includes stations on:

- Radiation Dosimetry & Safety Measures
- Quality Assurance in Medical Imaging (X-ray, CT, MRI)
- Calibration & Maintenance of Radiation Therapy Equipment
- Interpretation of Radiological Images & Radiation Treatment Plans

Passing Criteria: Minimum 50% (50/100 marks) in practicals.

Recommended Books & E-Resources

Textbooks

- **"The Essential Physics of Medical Imaging"** – Jerrold T. Bushberg
- **"Introduction to Radiological Physics & Radiation Dosimetry"** – Frank Herbert Attix
- **"Handbook of Medical Physics"** – Bruce R. Thomadsen
- **"Physics for Radiation Protection"** – James E. Martin

E-Resources & Journals

- **International Journal of Medical Physics**
- **Medical Physics (AIP Journal)**
- **Radiological Physics & Technology**
- **World Health Organization (WHO) Radiation Safety Guidelines**

Career Opportunities After M.Sc. in Medical Physics

- **Medical Physicist** in Hospitals & Radiation Therapy Centers
- **Radiation Safety Officer (RSO)** in Nuclear & Radiological Facilities
- **Quality Assurance Specialist** in Diagnostic Imaging & Radiation Oncology
- **Research Scientist** in Medical Imaging & Radiation Dosimetry
- **Lecturer/Professor** in Medical & Allied Health Sciences