DEPARTMENT OF ALLIED HEALTH SCIENCES

Scheme & Syllabus of

Integrated B.Sc. (Hons/Hons. with Research) - M.Sc. Medical Imaging Technology

Programme under National Education Policy 2020

(w.e.f. 2024-25)

GURU JAMBHESHWAR UNIVERSITY OF SCIENCE & TECHNOLOGY, HISAR

(Established by State Legislature Act 17 of 1995)

'A+' GRADE NAAC Accredited

Guru Jambheshwar University of Science and Technology
Hisar-125001, Haryana
('A+' NAAC Accredited State Govt. University)

Scheme of Examination for Integrated Five Years Programme

(UG Four Years Programme (Interdisciplinary) + PG One Year Programme)

Name of the Programme: Integrated B.Sc. (Hons/Hons with Research)-M.Sc. Medical Imaging Technology

According to National Education Policy-2020

Scheme-D

Semester-V

Type of Course	Course Code	Course Title		Credits	Contact Hours	Internal Marks	External Marks	Total Marks	Exam Duration (Hrs)
Discipline Specific Course	24MIT0501T	Basic Techniques in CT Technology		3	3	20	50	70	3
	24MIT0501P	Basic Techniques in CT Technology Lab		1	2	10	20	30	—
	24MIT0502T	Radiation Safety in Diagnostic Radiology		3	3	20	50	70	3
	24MIT0502P	Radiation Safety in Diagnostic Radiology Lab		1	2	10	20	30	—
	24MIT0503T	Quality Assurance in Diagnostic Radiology and Regulatory Requirements		4	4	30	70	100	3
Vocational Course	—	To be opted from the pool of Vocational Course	Theory	2	2	15	35	50	2
			Lab	2	4	15	35	50	—
Skill Enhancement Course	—	Internship#		4	---	100	—	100	—
Total	—	—		20	20	220	280	500	—

Semester-VI

Type of Course	Course Code	Course Title		Credits	Contact Hours	Internal Marks	External Marks	Total 0Marks	Exam Duration (Hrs)
Discipline Specific Course	24MIT0601T	Basic Techniques in MRI Technology		3	3	20	50	70	3
	24MIT0601P	Basic Techniques in MRI Technology Lab		1	2	10	20	30	—
	24MIT0602T	Introduction to Nuclear Medicine Techniques		3	3	20	50	70	3
	24MIT0602P	Introduction to Nuclear Medicine Techniques Lab		1	2	10	20	30	—
	24MIT0603T	Ultrasound Techniques		4	4	30	70	100	3
Minor Course	—	To be opted from the pool of MIC		4	4	30	70	100	3
Vocational Course	—	To be opted from the pool of Vocational Course	Theory	2	2	15	35	50	2
			Lab	2	4	15	35	50	2
Total	—	—		20	24	150	350	500	—

Note:
Four credits of internship, earned by a student during summer internship after 2nd or 4th semester will be taken into account in 5th semester of a student who pursue 3-year UG program without taking exit option.

Basic Techniques in CT Technology

Course Code: 24MIT0501T **Course Credits:** 3 **Mode:** Lecture-based **Type:** Core **Contact Hours:** 3 Hour per week **Examination Duration:** 3 hours	**Course Assessment: Max. Marks: 70 (Internal: 20; External: 50)** For the end-semester examination, the examiner is required to set seven questions in all. the first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 2.5 marks each. In addition to those six more questions will be set, two questions from each unit. The students shall be required to attempt four questions in all selecting one question from each unit in addition to compulsory Question No. 1. All questions shall carry equal marks i.e.12.5 marks.

Rationale

This course provides students with a comprehensive understanding of the fundamental principles of Computed Tomography (CT) and its technological applications. It emphasizes the relationship between CT scans, patient safety, and various CT protocols to optimize image quality and diagnostic utility.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **CO1:** Demonstrate foundational knowledge of computed tomography principles and system components.
   (RBT Level: L1 – Remember)
2. **CO2:** Explain the functioning and applications of CT imaging techniques.
   (RBT Level: L2 – Understand)
3. **CO3:** Perform CT imaging procedures while ensuring patient safety and image quality.
   (RBT Level: L3 – Apply)
4. **CO4:** Analyze CT images to identify artifacts and optimize scanning protocols.
   (RBT Level: L4 – Analyze)
5. **CO5:** Evaluate the effectiveness of CT techniques in clinical diagnostics and suggest improvements.
   (RBT Level: L5 – Evaluate)

Course Content:

Unit 1:

Introduction and History
Basic principles of CT, CT generations and evolution, CT instrumentation and detectors, and an introduction to axial and helical CT along with slip ring technology.
Safety and Professional Responsibilities
Safety considerations in CT scanning, the role of the medical imaging technologist in CT procedures, documentation in CT scanning, and quality assurance practices in CT.

Unit 2:

Image Processing and CT Protocols
Data acquisition in CT, image pre-processing and reconstruction techniques, algorithms for image reconstruction, image display and post-processing techniques, common CT artifacts and ways to minimize them, and image quality enhancement strategies.

Unit 3:

CT Protocols and Applications

CT protocols for different body parts, dental scan protocols, CT protocols for angiography and perfusion, the use of CT contrast media and administration methods, CT-guided interventional procedures, multi-detector CT technology, isotropic imaging and its applications, advanced CT scanners (including Cardiac CT, Flash CT, Dual Energy, and Dual Source Scanners), and CT fluoroscopy, including its principles and techniques.

Reference Books:

1. Computed Tomography: Physical Principles, Clinical Applications, and Quality Control – Author: Euclid Seeram, Publisher: Elsevier Health Sciences, 2014
2. Technologists: A Comprehensive Text – Author: H. S. Khandpur, Publisher: Tata McGraw-Hill Education, 2008
3. Computed Tomography: Physics and Technology. A Self-Assessment Guide – Author: K. K. Jain, Publisher: Springer, 2010

Basic Techniques in CT Technology Lab

Course Code: 24MIT0501P **Course Credits:** 1 **Mode:** Practical-based **Type:** Core **Contact Hours:** 2 Hours per week **Course Assessment:** Max. Marks: 30 (Internal: 10; External: 20)	**Course Assessment: Max. Marks: 30 (Internal: 10; External: 20)** For the end-semester practical examination, the assessment will be done by an external examiner appointed by the Controller of Examination along with the internal examiner, preferably the lab course coordinator, appointed by the Chairperson of the Department.

Rationale

The practical component of this course is designed to provide students with hands-on experience in operating CT equipment, positioning patients, executing scanning protocols, and applying post-processing techniques. It aims to ensure that students can independently perform and interpret CT scans while maintaining patient safety and image quality.

Course Outcomes

Upon successful completion of this practical course, students will be able to:

1. **CO1:** Demonstrate fundamental skills in operating CT equipment and executing scanning protocols.
   (RBT Level: L3 – Apply)
2. **CO2:** Apply appropriate patient positioning techniques to ensure comfort and image accuracy during CT scans.
   (RBT Level: L3 – Apply)
3. **CO3:** Analyze CT images to identify and troubleshoot common artifacts affecting image quality.
   (RBT Level: L4 – Analyze)
4. **CO4:** Evaluate CT scan quality to ensure diagnostic efficacy and patient safety.
   (RBT Level: L5 – Evaluate)
5. **CO5:** Implement quality assurance and safety procedures in CT imaging practices.
   (RBT Level: L5 – Evaluate)

List of Experiments

Introduction and History

- Demonstration of the different generations of CT scanners.
- Hands-on practice with CT instrumentation and detectors.
- Operating axial and helical CT modes, including hands-on experience with slip ring technology.
- Explanation and demonstration of CT scan setups in real-time.

Image Processing and CT Protocols

- Acquiring raw CT data and performing image pre-processing tasks.
- Hands-on practice with image reconstruction using algorithms (e.g., filtered back projection, iterative reconstruction).
- Performing image post-processing tasks like multiplanar reformatting and 3D reconstruction.
- Identification and troubleshooting of CT artifacts (motion artifacts, beam hardening, etc.).
- Understanding and improving image quality through various techniques and strategies.

CT Protocols and Applications

- Execution of CT protocols for different body parts (head, chest, abdomen, etc.).
- Practice with dental scan protocols and CT angiography protocols.
- Administering contrast media and understanding the different techniques used in CT contrast administration.
- CT-guided interventional procedures – basic concepts and hands-on demonstration.
- Using multi-detector CT systems for improved resolution and faster scanning.
- Applying advanced CT techniques, such as isotropic imaging, cardiac CT, and Flash CT, through simulated exercises.

Safety and Professional Responsibilities

- Understanding and implementing safety protocols in the CT suite.
- Role-playing patient management scenarios, including patient positioning and reassurance.
- Documentation of CT procedures, including recording patient data, scan parameters, and post-scan notes.
- Hands-on quality assurance checks for CT equipment functionality, ensuring accurate and safe operation.
- Management of post-contrast reactions and ensuring patient safety during the process.

Reference Books:

1. Computed Tomography: Physical Principles, Clinical Applications, and Quality Control – Author: Euclid Seeram, Publisher: Elsevier Health Sciences, 2014
2. Technologists: A Comprehensive Text – Author: H. S. Khandpur, Publisher: Tata McGraw-Hill Education, 2008
3. Computed Tomography: Physics and Technology. A Self-Assessment Guide – Author: K. K. Jain, Publisher: Springer, 2010
4. The CT Handbook: Optimizing Protocols for Today's Feature-Rich Scanners – Author: William H. Leach, Publisher: Springer, 2015

Radiation Safety in Diagnostic Radiology

Course Code: 24MIT502T **Course Credits:** 3 **Mode:** Lecture-based **Type:** Core **Contact Hours:**3 hours per week **Examination Duration:** 3 Hours	**Course Assessment: Max. Marks: 70 (Internal: 20; External: 50)** For the end-semester examination, the examiner is required to set seven questions in all. the first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 2.5 marks each. In addition to those six more questions will be set, two questions from each unit. The students shall be required to attempt four questions in all selecting one question from each unit in addition to compulsory Question No. 1. All questions shall carry equal marks i.e.12.5 marks.

Rationale

Radiation protection is crucial to reduce unnecessary exposure to ionizing radiation and minimize its harmful effects. Ionizing radiation has become an essential diagnostic tool in the medical field for diagnosing and treating various medical conditions. This course aims to familiarize students with radiation physics, protection practices, radiation types, dosimetry, and radiation safety regulations. The course will focus on the biological effects of radiation, the importance of dose limits, equipment design for protection, and how to implement safety measures for both patients and medical personnel.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **CO1:** Understand and recall the principles of radiation protection and safety standards.
   (RBT Level: L1 – Remember)
2. **CO2:** Explain the biological effects of radiation and regulatory guidelines.
   (RBT Level: L2 – Understand)
3. **CO3:** Apply radiation safety practices to minimize exposure to patients and staff.
   (RBT Level: L3 – Apply)
4. **CO4:** Analyze radiation doses and interpret safety data for diagnostic procedures.
   (RBT Level: L4 – Analyze)
5. **CO5:** Assess and implement strategies for radiation safety compliance in medical imaging environments.
   (RBT Level: L5 – Evaluate)

Course Content:

Unit 1:

Radiation Quantities and Units

Radiation Quantities and Units: Radiation- Radioactivity- Sources of radiation - natural radioactive sources -cosmic rays' terrestrial radiation - - man made radiation sources. Units of radiation - Quality factor - Flux-Fluence-Kerma- Exposure- Absorbed dose- Equivalent Dose- Weighting Factors-Effective Dose - Occupational Exposure Limits - Dose limits to public.

Unit 2:

Biological Effects of Radiation

Biological Effects of radiation: Ionization, excitation and free radical formation, hydrolysis of water, action of radiation on cell-Chromosomal aberration and itsapplication for the biological dosimetry-Effects of whole body and acute irradiation, dose fractionation, effects of ionizing radiation on each of major organ system including fetus -Somatic effects and hereditary effects- stochastic and deterministic effects-Acute exposure andchronic exposure-LD50 - factors affecting radio sensitivity. Biological effects of non-ionizing radiationlike ultrasound, lasers, IR, UV and magnetic fields

Unit 3:

Radiation Detection and Measurements

Radiation detection and Measurements: Ionization of gases- Fluorescence and Phosphorescence -Effects on photographic emulsion. Ionization Chambers – proportional counters- G.M counters-scintillation detectors – liquid semiconductor detectors – Gamma ray spectrometer. Measuring systems – free air ionization chamber – thimble ion chamber – condenser chamber – Secondary standard dosimeters – film dosimeter – chemical dosimeter- Thermoluminescent Dosimeter. - Pocket Dosimeter-Radiation survey meter- wide range survey meter -zone monitor-contamination monitor -their principal function and uses. Advantages & disadvantages of various detectors &its appropriateness of different detectors for different type of radiation measurement. Dose and Dosimetry, CT Dose Index (CTDI, etc.), Multiple Scan Average Dose (MSAD), Dose Length Product (DLP), Dose Profile, Effective Dose, PhantomMeasurement Methods, Dose for Different Application Protocols, Technique Optimization. Dose area product in fluoroscopy and angiography systems, AGD in mammography

Radiation Protection

Radiation protection: Radiation protection of self and patient- Principles of radiation protection, time - distance and shielding, shielding - calculation and radiation survey –ALARA- personnel dosimeters (TLD and film batches) - occupational exposure. Radiation Hazard evaluation and control: Philosophy of Radiation protection, effects of time, Distance & Shielding. Calculation of Work load, weekly calculated dose to radiation worker & General public good work practice in Diagnostic Radiology. Planning consideration for radiology, including Use factor, occupancy factors, anddifferent shielding material.

Reference Books:

1. "Radiation Protection in Diagnostic X-Ray Imaging" by Euclid Seeram and Patrick C. Brennan, Publisher: Elsevier, 2019.
2. "Development of Radiation Protection in Diagnostic Radiology" by Stewart C. Bushong, Publisher: Elsevier, 2013.
3. "Textbook of Radiological Safety" by Thayalan K, Publisher: Jaypee Brothers Medical Publishers, 2010.
4. "Radiation Protection in Medical Radiography" by Statkiewicz Sherer, Publisher: Elsevier, 2019.

Radiation Safety in Diagnostic Radiology Lab

Course Code: 24MIT0502P **Course Credits:** 1 **Mode:** Practical-based **Type:** Core **Contact Hours:** 2 Hours per week **Course Assessment:** Max. Marks: 30 (Internal: 10; External: 20)	**Course Assessment: Max. Marks: 30 (Internal: 10; External: 20)** For the end-semester practical examination, the assessment will be done by an external examiner appointed by the Controller of Examination along with the internal examiner, preferably the lab course coordinator, appointed by the Chairperson of the Department.

Rationale

The aim of the practical course is to provide students with hands-on experience related to radiation safety in diagnostic radiology. It will cover the use of radiation protection techniques, methods for measuring radiation exposure, and the application of these techniques to minimize harmful radiation effects. Students will also get a chance to work with radiation protection equipment and learn the best practices for patient and personnel safety.

Course Outcomes

Upon successful completion of this course, students will be able to:

1. **CO1:** Demonstrate proficiency in handling radiation detection and measurement instruments.
   (RBT Level: L3 – Apply)
2. **CO2:** Apply radiation safety principles to minimize exposure during diagnostic radiology procedures.
   (RBT Level: L3 – Apply)
3. **CO3:** Analyze radiation hazards and biological effects to implement effective protection measures.
   (RBT Level: L4 – Analyze)
4. **CO4:** Evaluate the performance and accuracy of radiation monitoring devices used in clinical settings.
   (RBT Level: L5 – Evaluate)
5. **CO5:** Maintain and ensure compliance with radiation safety standards to protect patients and healthcare personnel.
   (RBT Level: L5 – Evaluate)

List of Experiments

1. Radiation Quantities and Units
Students will work with different radiation measurement devices to calculate exposure, dose, and other radiation parameters. They will practice determining quantities like kerma, absorbed dose, and equivalent dose using standard calibration protocols.

2. Biological Effects of Radiation
Students will use models or simulation systems to observe the effects of radiation on cells, tissues, and organs. They will simulate both acute and chronic exposure scenarios and evaluate the effects on biological systems, such as chromosomal damage, organ dysfunction, and stochastic effects.

3. Radiation Detection and Measurements
Students will be introduced to the practical use of equipment such as ionization chambers, GM counters, scintillation detectors, and thermoluminescent dosimeters (TLD). They will use these devices to

measure radiation levels in controlled environments, understand their working principles, and learn the best practices for radiation measurement.

4. Radiation Protection; Principles of Radiation Protection and ALARA
Students will engage in practical simulations and real-world examples where they apply shielding techniques, calculate the optimal distance for radiation exposure, and minimize exposure time. They will learn how to assess radiation risks and implement protective measures based on ALARA guidelines.

5. Radiation Hazard Evaluation and Control
In this session, students will learn to perform radiation hazard assessments, calculate the workload, and determine the dose to radiation workers and the general public. They will apply concepts of shielding materials and evaluate the use of protective barriers in a radiology department.

Reference Books:

1. "Radiation Protection in Diagnostic X-Ray Imaging" by Euclid Seeram and Patrick C. Brennan, Publisher: Elsevier, 2019.
2. "Development of Radiation Protection in Diagnostic Radiology" by Stewart C. Bushong, Publisher: Elsevier, 2013.
3. "Textbook of Radiological Safety" by Thayalan K, Publisher: Jaypee Brothers Medical Publishers, 2010.
4. "Radiation Protection in Medical Radiography" by Statkiewicz Sherer, Publisher: Elsevier, 2019.

Quality Assurance in Diagnostic Radiology and Regulatory Requirements

Course Code: 24MIT0503T **Course Credits:** 4 **Mode:** Theory **Type:** Core **Contact Hours:** 4 hours per week **Examination Duration:** 3 hours	**Course Assessment: Max. Marks: 100 (Internal: 30; External: 70)** For the end-semester examination, the examiner is required to set nine questions in all. the first question will be compulsory consisting of seven short questions covering the entire syllabus consisting of 2 marks each. In addition to those eight more questions will be set, two questions from each unit. The students shall be required to attempt five questions in all selecting one question from each unit in addition to compulsory Question No. 1. All questions shall carry equal marks. i.e. 14 Marks.

Rationale

Quality assurance (QA) in diagnostic radiology ensures that radiological equipment performs optimally to provide accurate images with minimal exposure to patients. It is essential for radiological technologists to understand and carry out various quality assurance procedures that ensure the safety and efficiency of radiological practices. This includes proper equipment maintenance, understanding regulatory requirements, and following procedures to reduce unnecessary radiation exposure.

Course Outcomes

By the end of this course, students will be able to:

1. **CO1:** Understand quality assurance concepts and regulatory requirements in diagnostic radiology.
   (RBT Level: L1 – Remember)
2. **CO2:** Explain quality control processes to ensure equipment performance and safety.
   (RBT Level: L2 – Understand)
3. **CO3:** Implement quality assurance protocols and maintain diagnostic imaging equipment.
   (RBT Level: L3 – Apply)
4. **CO4:** Analyze quality data to identify and resolve issues in radiological practice.
   (RBT Level: L4 – Analyze)
5. **CO5:** Evaluate compliance with standards and improve quality management in radiology services.
   (RBT Level: L5 – Evaluate)

Course Content:

Unit 1:

Objectives of Quality Control

Objectives of quality Control: Improve the quality of imaging thereby increasing the diagnostic value; to reducethe radiation exposure; Reduction of film wastage and repeat examination; to maintain the various diagnostic andimaging units at their optimal performance.

Quality assurance activities: Equipment selection phase; Equipment installation and acceptance phase; Operationalphase; Preventive maintenance.

Quality assurance programme at the radiological faculty level: Responsibility; Purchase; Specifications; Acceptance; Routine testing; Evaluation of results of routine testing; Quality assurance practical exercise in theX ray generator and tube; Image receptors from processing; Radiographic equipment; Fluoroscopic equipment; Mammographic equipment; Conventional tomography; Computed tomography; Film processing, manual and automatic; Consideration for storage of film and chemicals; Faults tracing; Accuracy of imaging-image distortion for digital imaging devices. LASER printer calibration.

Unit 2:

QA in Diagnostic Radiology
Various quality assurance methods, such as checking filtration, contact between film and intensifying screens, contrast verification, and beam alignment. focal spot size, tube current linearity, high-voltage tube resolution, grid alignment, and QA for specific modalities like CT and digital radiography.

Unit 3:

Regulatory Requirements in Diagnostic Radiology
Role of national regulatory bodies and their safety standards. It includes the organization and enforcement of regulations that ensure diagnostic radiology equipment is safely maintained. The responsibilities of radiology professionals, including technologists, in ensuring the regulatory compliance of diagnostic equipment, are emphasized.

Unit 4:

Responsibilities of Licensees, Registrants, and Employers
Roles of licensees and employers in maintaining safe operational standards. Enforcement of regulatory requirements, proper equipment maintenance, and safe operation of radiology equipment, including regular cleaning, maintenance of automatic processors, and managing logbooks for equipment status and maintenance.

Care and Maintenance of Diagnostic Equipment
Preventive maintenance of diagnostic radiology equipment. Principles of routine care for radiology equipment on a daily, weekly, monthly, quarterly, and annual basis. Special care techniques for mobile equipment.

Reference Books:

1. Quality Assurance, Control and Artifacts including in field Training by Mr. Rohit Bansal
2. Quality Assurance and Control in Diagnostic Radiology and Imaging by Bhargava, CBS Publishers and Distributors
3. Quality Assurance by Dr. R. Sundhararajan, M.V. Kumudhavalli, Minal T. Harde, Thakur Publications Pvt Ltd
4. Quality Assurance in Diagnostic Radiology by J. McLemore

Semester-VI

Type of Course	Course Code	Course Title	Credits	Contact Hours	Internal Marks	External Marks	Total Marks	Exam Duration (Hrs)
Discipline Specific Course	24MIT0601T	Basic Techniques in MRI Technology	3	3	20	50	70	3
	24MIT0601P	Basic Techniques in MRI Technology Lab	1	2	10	20	30	—
	24MIT0602T	Introduction to Nuclear Medicine Techniques	3	3	20	50	70	3
	24MIT0602P	Introduction to Nuclear Medicine Techniques Lab	1	2	10	20	30	—
	24MIT0603T	Ultrasound Techniques	4	4	30	70	100	3
Minor Course	—	To be opted from the pool of MIC	4	4	30	70	100	3
Vocational Course	—	To be opted from the pool of Vocational Course	Theory 2	2	2	15	35	50
			Lab 2	2	4	15	35	50
Total	—	—	20	24	150	350	500	—

Note:

Four credits of internship, earned by a student during summer internship after 2nd or 4th semester will be taken into account in 5th semester of a student who pursue 3-year UG program without taking exit option.

Basic Techniques in MRI Technology

Course Code: 24MIT0601T **Course Credits:** 3 **Mode:** Theory **Type:** Core **Contact Hours:** 3 Hours per week **Examination Duration:** 3 hours	**Course Assessment: Max. Marks: 70 (Internal: 20; External: 50)** For the end-semester examination, the examiner is required to set seven questions in all. the first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 2.5 marks each. In addition to those six more questions will be set, two questions from each unit. The students shall be required to attempt four questions in all selecting one question from each unit in addition to compulsory Question No. 1. All questions shall carry equal marks i.e.12.5 marks.

Rationale

Magnetic Resonance Imaging (MRI) is a cutting-edge imaging technology that provides detailed anatomical images of the human body without the use of ionizing radiation. It is particularly useful for disease detection, diagnosis, and monitoring treatment progress. MRI operates by detecting changes in the alignment of protons in tissues when subjected to magnetic fields. This course is designed to introduce students to the basic principles and applications of MRI technology, including patient positioning, protocol planning, and post-processing of MRI images. Additionally, students will be trained to manage patients, handle contrast reactions, and understand MRI safety.

Course Outcomes

At the end of this course, students will be able to:

1. **CO1:** Understand fundamental principles and physics underlying MRI imaging. *(RBT Level: L1 – Remember)*
2. **CO2:** Explain MRI safety protocols and examination procedures. *(RBT Level: L2 Understand)*
3. **CO3:** Apply knowledge of imaging protocols to optimize MRI scans. *(RBT Level: L3 – Apply)*
4. **CO4:** Analyze image quality and post-processing techniques for diagnostic accuracy. *(RBT Level: L4 – Analyze)*
5. **CO5:** Evaluate MRI protocols to enhance patient safety and image outcomes. *(RBT Level: L5 – Evaluate)*

Course Content:

Unit 1:

Introduction to MRI
Basic principles of MRI, including how MRI uses magnetic fields and mechanisms in MRI, and an overview of MRI instrumentation, various types of magnets, including permanent and superconducting magnets, and the role of gradient coils, body coils, RF coils, and shim coils. Cryogens and RF shielding used in MRI systems. Radiofrequency (RF) waves to generate images. Image weighting, contrast.

Unit 2:

Encoding and Image Formation

Process of encoding and image formation in MRI. K-space, the concept of MRI pulse sequences, and how they are used to generate images. Spin Echo (SE) and Gradient Echo (GE), advanced topics in fast imaging sequences and their applications in clinical practice.

Unit 3:

Flow Phenomena and Vascular Imaging

Phenomena of flow compensation in MRI, including the different vascular imaging techniques. Topics include Digital Subtraction Angiography (DSA), Time-of-Flight (TOF) Magnetic Resonance Angiography (MRA), Phase Contrast MRA (PC-MRA), and Velocity Encoding. MR angiograms (MRA) and MR venograms (MRV), including their uses in evaluating vascular structures.
Specifics of cardiac imaging with MRI, including whole-body MRI protocols. MRI artifacts, their causes, and methods to compensate for them in clinical practice. Use of MRI contrast agents, including T1 and T2 contrast agents to enhance image quality and diagnosis.

MRI Safety and Quality Assurance

Safety in MRI environments. Safety protocols related to implants, pacemakers, and metal objects, as well as electrical and instrumental safety within the MRI suite. Bioeffects of MRI, importance of quality assurance programs in maintaining MRI equipment and ensuring patient safety.

Reference Books:

1. A Textbook of Magnetic Resonance Imaging by Mr. Rohit Bansal, JBD Publication
2. Tomography and Magnetic Resonance Imaging of the Whole Body (Vol. 1 & 2) by John R. Haaga and Daniel Boll, Elsevier
3. MRI in Practice by Catherine Westbrook and Caralyn Kaut, Wiley-Blackwell
4. Protocols in MRI by Catherine Westbrook, Wiley-Blackwell
5. An Introduction to the Physics and Function of Magnetic Resonance Imaging by Dominik Weishaupt, Victor D. Koechli, Borut Marincek, J.M. Froehlich, Springer

Basic Techniques in MRI Technology Lab

Course Code: 24MIT0601P **Course Credits:** 1 **Mode:** Practical **Type:** Core **Contact Hours:** 2 Hours per week	**Course Assessment: Max. Marks: 30 (Internal: 10; External: 20)** For the end-semester practical examination, the assessment will be done by an external examiner appointed by the Controller of Examination along with the internal examiner, preferably the lab course coordinator, appointed by the Chairperson of the Department.

Rationale

Magnetic Resonance Imaging (MRI) is a cutting-edge imaging technology that provides detailed anatomical images of the human body without the use of ionizing radiation. It is particularly useful for disease detection, diagnosis, and monitoring treatment progress. MRI operates by detecting changes in the alignment of protons in tissues when subjected to magnetic fields. This course is designed to introduce students to the basic principles and applications of MRI technology, including patient positioning, protocol planning, and post-processing of MRI images. Additionally, students will be trained to manage patients, handle contrast reactions, and understand MRI safety.

Course Outcomes

At the end of this course, students will be able to:

1. **CO1:** Understand MRI system components and their operational principles.
   (RBT Level: L1 – Remember)
2. **CO2:** Explain pulse sequences and their effects on image quality during MRI scanning.
   (RBT Level: L2 – Understand)
3. **CO3:** Perform patient positioning and select protocols for effective MRI image acquisition.
   (RBT Level: L3 – Apply)
4. **CO4:** Analyze MRI images to identify artifacts and apply correction techniques.
   (RBT Level: L4 – Analyze)
5. **CO5:** Evaluate safety procedures and quality control practices during MRI operation.
   (RBT Level: L5 – Evaluate)

List of Experiments

1. **MRI Instrumentation and Magnet Types**
   This practical session will allow students to familiarize themselves with various types of MRI magnets. The focus will be on the classification and types of magnets used in MRI machines, including superconducting, permanent, and resistive magnets. Students will also learn the advantages and disadvantages of each magnet type. The session will also cover gradient coils, body coils, RF coils, shim coils, ramping processes, cryogens, and the importance of RF shielding in MRI systems. Understanding these components is essential for operating MRI equipment effectively and ensuring image quality.

2. **MRI Pulse Sequences and Imaging Techniques**
   In this practical, students will focus on MRI pulse sequences such as the Spin Echo (SE) pulse sequence, Gradient Echo (GE) pulse sequence, and fast imaging sequences. Students will perform imaging using these sequences and adjust parameters to optimize results. The session will also include optimizing tissue contrast, signal-to-noise ratio, and utilizing appropriate

sequences for different imaging applications, such as brain scans, spinal cord imaging, and joint studies.

3. **Flow Phenomena and Compensation Techniques**
Students will explore the flow phenomena that can impact the quality of MRI images, such as blood flow artifacts. The practical will cover vascular imaging techniques, including Digital Subtraction Angiography (DSA), Time-of-Flight (TOF) MRA, Phase Contrast MRA (PC-MRA), and Velocity Encoding. Students will practice compensating for these flow effects to enhance the clarity and accuracy of vascular images, ensuring precise visualization of vessels and blood flow.

4. **Whole Body MRI Protocols and Artifact Compensation**
In this practical session, students will practice preparing and positioning patients for whole-body MRI imaging. They will also learn how to adjust MRI settings based on the anatomical area being imaged. Additionally, students will be trained in recognizing and compensating for MRI artifacts such as motion artifacts, susceptibility artifacts, and magnetic field inhomogeneities. Students will work on applying techniques that reduce these artifacts to ensure high-quality imaging for whole-body MRI scans.

5. **MRI Safety and Quality Assurance**
This session will focus on MRI safety protocols, ensuring students understand how to safely operate MRI equipment. Special attention will be given to patient safety, especially when dealing with implants, pacemakers, and metallic objects. The students will also perform routine quality assurance tasks such as calibrating MRI equipment and ensuring it functions optimally. The importance of safety in MRI, including electrical, metal, and instrumental safety, will be emphasized. The session will also include techniques for ensuring high-quality imaging through quality assurance practices.

Reference Books:

1. A Textbook of Magnetic Resonance Imaging by Mr. Rohit Bansal, JBD Publication
2. Tomography and Magnetic Resonance Imaging of the Whole Body (Vol. 1 & 2) by John R. Haaga and Daniel Boll, Elsevier
3. MRI in Practice by Catherine Westbrook and Caralyn Kaut, Wiley-Blackwell
4. Protocols in MRI by Catherine Westbrook, Wiley-Blackwell
5. An Introduction to the Physics and Function of Magnetic Resonance Imaging by Dominik Weishaupt, Victor D. Koechli, Borut Marincek, J.M. Froehlich, Springer

Introduction to Nuclear Medicine Techniques

Course Code: **24MIT0602T** *Course Credits:* **3** *Mode:* *Lecture-based* *Type:* *Core* *Contact Hours:* **3 Hour per week** *Examination Duration:* **3 hours**	**Course Assessment: Max. Marks: 70 (Internal: 20; External: 50)** For the end-semester examination, the examiner is required to set seven questions in all. the first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 2.5 marks each. In addition to those six more questions will be set, two questions from each unit. The students shall be required to attempt four questions in all selecting one question from each unit in addition to compulsory Question No. 1. All questions shall carry equal marks i.e.12.5 marks.

Rationale

Nuclear medicine is a medical specialty that uses radioactive substances for diagnosis, treatment, and research of various diseases. This course introduces students to the basics of radioactivity, radiopharmaceuticals, and advanced imaging techniques such as PET and SPECT. Students will also learn radiation safety, handling radiopharmaceuticals, and managing patient care during nuclear medicine procedures.

Course Outcomes

At the end of the course, students will be able to:

1. **CO1:** Understand principles of nuclear medicine.
   (RBT Level: L1 – Remember)
2. **CO2:** Explain safety measures and handling procedures for radioactive materials.
   (RBT Level: L2 – Understand)
3. **CO3:** Apply nuclear medicine imaging protocols for accurate diagnosis.
   (RBT Level: L3 – Apply)
4. **CO4:** Analyze image quality and artifacts in nuclear medicine scans.
   (RBT Level: L4 – Analyze)
5. **CO5:** Evaluate patient safety and quality assurance in nuclear medicine practice.
   (RBT Level: L5 – Evaluate)

Course Content:

Unit I:

History, Isotopes, and Radiopharmaceuticals

History of Nuclear Medicine, Isotopes and Radionuclides: Production of Radionuclides, Transport of Radionuclides, Radioactivity: Radioactive Transformations, Specific Activity, Quality Control, Common Radiopharmaceuticals: Preparation, Handling Precautions, Radiopharmaceuticals used in Clinical Practice

Unit II:

Nuclear Medicine Imaging Systems

Gamma Camera Instrumentation: Collimator – Classification and Types, Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), Advanced Imaging Techniques: SPECT-CT, PET-CT, PET-MRI, Recent Innovations and Future Trends in Nuclear Medicine Imaging

Unit III:

Radiation Safety and Dosimetry in Nuclear Medicine

Radiation Safety Considerations in Nuclear Medicine, Types of Radiation Exposure and Risks to Healthcare Workers and Patients, Radiation Dose Calculation and Management in Nuclear Medicine, Room Layout for Nuclear Medicine Procedures, Personal Protective Equipment (PPE) and Monitoring System

Clinical Applications and Patient Management

Clinical Applications of Nuclear Medicine Imaging: Cardiology, Oncology, Neurology, and Orthopedics, Patient Care Protocols in Nuclear Medicine: Preparation, Safety, and Post-procedure Care, Handling Adverse Reactions and Late Effects from Radiopharmaceuticals, Imaging Artifact Recognition and Quality Improvement in Nuclear Medicine, Ethical and Legal Aspects in Nuclear Medicine Procedures

Reference Books:

1. Nuclear Medicine Textbook: Methodology and Clinical Applications by Duccio Volterrani, Paola Anna Erba, Ignasi Carrió, H. William Strauss (Springer)
2. Nuclear Medicine Instrumentation by Jennifer Prekeges (Jones and Bartlett Publishers)
3. Nuclear Medicine Physics: The Basics by Ramesh Chandra & Arman Rahmim (Wolters Kluwer)
4. Nuclear Medicine Technology: Procedures and Quick Reference by Pete Shackett (LWW)

Introduction to Nuclear Medicine Techniques Lab

Course Code: 24MIT0602P Course Credits: 1 Mode: Practical-based Type: Core Contact Hours: 2 Hours per week	**Course Assessment: Max. Marks: 30 (Internal: 10; External: 20)** For the end-semester practical examination, the assessment will be done by an external examiner appointed by the Controller of Examination along with the internal examiner, preferably the lab course coordinator, appointed by the Chairperson of the Department.

Rationale

The practical component of this course aims to provide students with hands-on experience and practical knowledge related to the application of nuclear medicine techniques. This includes learning the operations and handling of nuclear medicine imaging systems, working with radiopharmaceuticals, radiation safety protocols, dosimetry calculations, and patient management during procedures. The students will gain skills in managing nuclear medicine imaging systems such as gamma cameras and SPECT/PET scanners while adhering to safety standards and ethical considerations.

Course Outcomes

At the end of the practical course, students will be able to:

1. **CO1:** Understand preparation and handling of radiopharmaceuticals.
   (RBT Level: L1 – Remember)
2. **CO2:** Explain operation and setup of nuclear medicine imaging systems.
   (RBT Level: L2 – Understand)
3. **CO3:** Apply radiation safety and dosimetry in imaging procedures.
   (RBT Level: L3 – Apply)
4. **CO4:** Analyze images for artifacts and perform corrective actions.
   (RBT Level: L4 – Analyze)
5. **CO5:** Evaluate clinical applications and safety compliance in nuclear medicine.
   (RBT Level: L5 – Evaluate)

List of Experiments

History, Isotopes, and Radiopharmaceuticals

- Practical demonstration of radionuclide production and transport.
- Preparation and handling of common radiopharmaceuticals used in clinical practice.
- Quality control procedures for radiopharmaceuticals in the laboratory setting.
- Hands-on experience in the calculation of specific activity for radiopharmaceuticals.

Nuclear Medicine Imaging Systems

- Operation of a gamma camera: setting up and using the collimator.
- Simulation and practice of Single Photon Emission Computed Tomography (SPECT) imaging techniques.
- Practical operation of Positron Emission Tomography (PET) scanners, understanding the procedure and image acquisition.
- Hands-on training on advanced imaging systems: SPECT-CT and PET-CT.

- Exploration of the recent innovations in nuclear imaging, with a demonstration of PET-MRI technology.

Radiation Safety and Dosimetry in Nuclear Medicine

- Practical application of radiation safety protocols in a nuclear medicine setting.
- Using dosimeters and radiation monitoring systems during hands-on sessions.
- Calculation of radiation doses for both healthcare workers and patients using simulation tools.
- Setting up and practicing room layouts for nuclear medicine procedures to minimize radiation exposure.
- Demonstration and usage of Personal Protective Equipment (PPE) in nuclear medicine practices.

Clinical Applications and Patient Management

- Practical simulations of clinical nuclear medicine procedures, including applications in cardiology, oncology, neurology, and orthopedics.
- Demonstration of patient care protocols: preparation, monitoring, and post-procedure care in nuclear medicine.
- Recognition and identification of imaging artifacts using clinical nuclear medicine systems.
- Managing and responding to adverse reactions and late effects from radiopharmaceuticals in clinical practice.
- Ethical considerations and legal aspects of nuclear medicine procedures, including a role-playing exercise for patient consent.

Reference Books:

1. Nuclear Medicine Textbook: Methodology and Clinical Applications by Duccio Volterrani, Paola Anna Erba, Ignasi Carrió, H. William Strauss (Springer)
2. Nuclear Medicine Instrumentation by Jennifer Prekeges (Jones and Bartlett Publishers)
3. Nuclear Medicine Physics: The Basics by Ramesh Chandra & Arman Rahmim (Wolters Kluwer)
4. Nuclear Medicine Technology: Procedures and Quick Reference by Pete Shackett (LWW)

Ultrasound Techniques

Course Code: 24MIT0603T **Course Credits:** 4 **Mode:** Lecture-based **Type:** Core **Contact Hours:** 4 Hour per week **Examination Duration:** 3 hours	**Course Assessment: Max. Marks: 70 (Internal: 20; External: 50)** For the end-semester examination, the examiner is required to set seven questions in all. the first question will be compulsory consisting of five short questions covering the entire syllabus consisting of 2.5 marks each. In addition to those six more questions will be set, two questions from each unit. The students shall be required to attempt four questions in all selecting one question from each unit in addition to compulsory Question No. 1. All questions shall carry equal marks i.e.12.5 marks.

Rationale

Ultrasound techniques are essential for diagnostic imaging in the medical field. This course will provide students with the knowledge of ultrasound properties, image acquisition, types of transducers, Doppler imaging, and safety protocols. It also includes understanding artifacts and bio-effects related to ultrasound procedures.

Course Outcomes

At the end of the course, students will be able to:

1. **CO1:** Understand the fundamental physical principles and wave propagation relevant to ultrasound imaging.
   (RBT Level: L1 – Remember)
2. **CO2:** Explain the components and safety protocols used in ultrasound systems.
   (RBT Level: L2 – Understand)
3. **CO3:** Apply clinical imaging techniques effectively using ultrasound technology.
   (RBT Level: L3 – Apply)
4. **CO4:** Analyze factors influencing image quality and optimize imaging parameters.
   (RBT Level: L4 – Analyze)
5. **CO5:** Evaluate quality assurance practices and safety standards in ultrasound imaging.
   (RBT Level: L5 – Evaluate)

Course Content:

Unit 1: Fundamentals of Ultrasound and Interaction with Matter

Properties of Ultrasound, Interaction of Ultrasound with Matter (Reflection, Refraction, Transmission, Absorption), Acoustic Impedance and the Effect of Tissue Properties, Basic Principles of Ultrasound Wave Propagation

Unit 2: Transducers and Image Display

Types of Ultrasound Transducers: Linear, Curved, Phased, and Endocavitary, Advances in the Design of Modern Ultrasound Transducers, Image Display: Display Modes (B-mode, M-mode, Doppler mode, etc.), Ultrasound Instrumentation and Controls, Image Storage and Post-Processing: Scan Converter Memory, Photographic Film, Multi-format Camera, Laser Imager, Colour and Video Thermal Printer, Computer Storage, Pre- and Post-Processing Techniques

Unit 3: Doppler Imaging and Ultrasound Contrast Agents

Doppler Principles: Continuous Wave Doppler, Pulsed Doppler, Duplex Scanning: Color Flow Imaging, Power Doppler, Harmonic Imaging and Extended Field of View in Doppler Ultrasound, Use of Ultrasound Contrast Agents in Diagnosis, Benefits and Limitations of Ultrasound Contrast Agents

Unit 4: Image Characteristics, Artefacts, and Safety Considerations

Image Characteristics and Artefacts: Recognition of Common Artefacts in Ultrasound Imaging (e.g., Shadowing, Enhancement, Reverb), Vascular, Interventional, Intraoperative, and Ophthalmic Ultrasonography, 3D and 4D Ultrasound Imaging: Principles, Applications, and Benefits, Bio-effects of Ultrasound Exposure: Thermal and Mechanical Effects, Safety Considerations and Protocols in Ultrasound Imaging, System Performance Measurements and Quality Assurance: Conventional Dopple, System Testing and Documentation.

Reference Books:

1. Ultrasound Physics and Technology by Vivien Gibbs, David Cole, Antonio Sassano (Churchill Livingstone)
2. Manual of Diagnostic Ultrasound by Philip E. S. Palmer (World Health Organization)
3. Physics and Technical Aspects of Diagnostic Ultrasound by Dinesh K. Baghel (AITBS Publishers)
4. Diagnostic Ultrasound by Carol M. Rumack, Deborah Levine (Elsevier)