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For

"Medical Radiology and Imaging Technology"

Master of Medical Radiology and Imaging Technology (MMRIT)

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Atal Bihari Vajpayee Medical University UP
Session- 2026-27 Onwards (Semester System)

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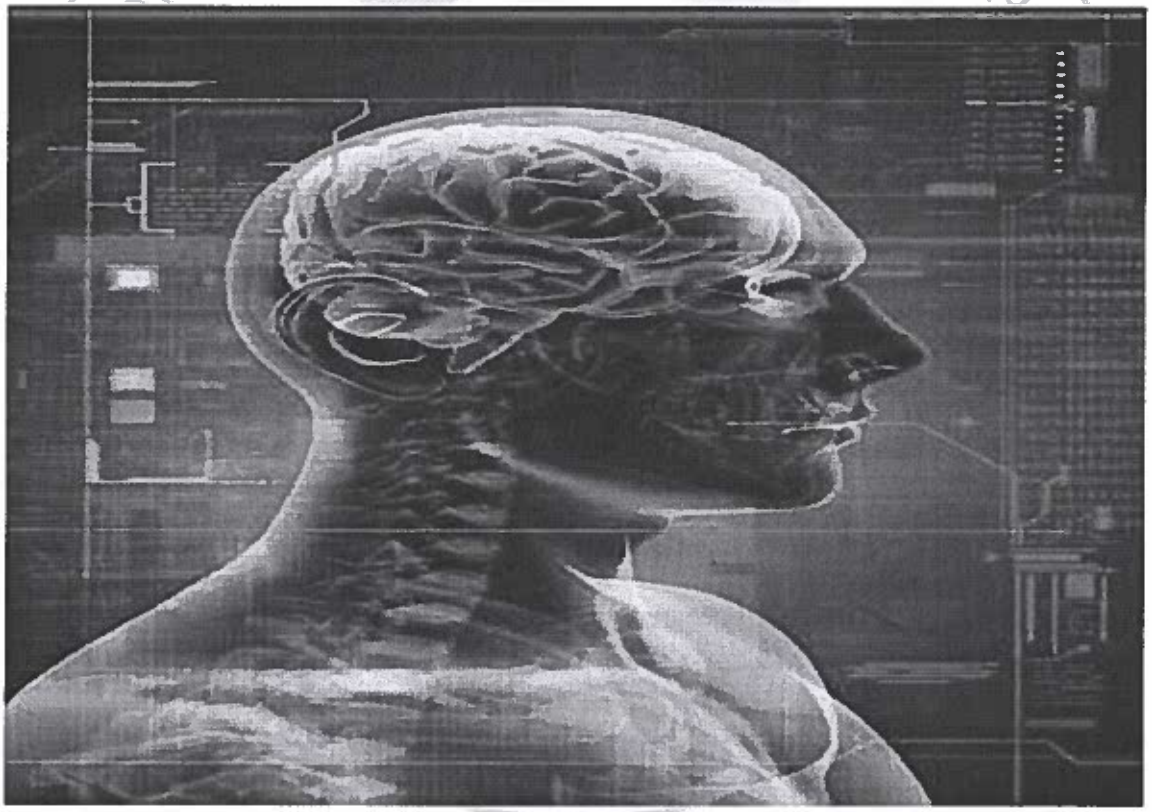
COMPETENCY BASED CURRICULUM

for

"MEDICAL RADIOLOGY AND IMAGING TECHNOLOGY"



As per NCAHP Act-2021

APPROVED SYLLABUS 2026-27 ONWARDS

Atal Bihari Vajpayee Medical University
Lucknow, UP

Contents

List of Abbreviations

2D	Two Dimensional
3D	Three Dimensional
AC	Alternate Current
ALARA	"As Low As Reasonably Achievable"
AEC	Automatic Exposure Control
AED	Automated External Defibrillator
AERB	Atomic Energy Regulatory Board
AHP	Allied and Healthcare Professional
BLS	Basic Life Support
BSc. MRIT	Bachelor of Science in Medical Radiology and Imaging Technology
BMW	Bio Medical Waste
BVM	Bag-Valve-Masks
CATS	Credit Accumulation and Transfer System
CBCS	Choice-Based Credit System
CbD	Case-based Discussion
CBSE	Central Board of Secondary Education
CEX	Mini Case Evaluation Exercise
COPD	chronic obstructive pulmonary disease
CPR	Cardiopulmonary Resuscitation
CT	Computerized Tomography
DC	Direct Current
DMRIT	Diploma in Medical radiology and Imaging Technology
DOPs	Direct Observation of Procedures
DRR	Digitally Reconstructed Radiographs
ECG	Electrocardiogram
ECTS	European Credit Transfer System
EEG	Electroencephalography
ERCP	Endoscopic Retrograde Cholangio Pancreatography
FW	Full wave
GI	Gastro Intestinal
HRCT	High-resolution computed tomography
HSSC	Healthcare Sector Skill Council
HU	Heat Unit
HVT	Half Value Thickness
HW	Half Wave
ICRP	International Commission on Radiological Protection
JCI	Joint Commission International
LDR	Low Dose-Rate
MIP	maximum intensity projection
MLC	Medico Legal Case
MLC	Multi Leaf Collimator
MSc.MRIT	Master of Science in Medical Radiology and Imaging Technology
MoHFW	Ministry of Health and Family Welfare
MPR	Multiplanar reconstruction
MRI	Magnetic Resonance Imaging
MSc	Master of Science

NAAC	National Assessment and Accreditation Council
NABH	National Accreditation Board for Hospitals & Healthcare Providers
NCRC	National Curricula Review Committee
NIAHS	National Initiative for Allied Health Sciences
NSDA	National Skills Development Agency
NSQF	National Skills Qualification Framework
OSCE	Objective Structured Clinical Examination
OSLER	Objective Structured Long Examination Record
OSPE	Objective Structured Practical Examination
PACS	picture archiving and communication system
PCA	Phase contrast angiography
PET	Positron Emission Tomography
PhD	Doctor of Philosophy
PPE	Personal Protective Equipment
PTBD	Percutaneous transhepatic biliary drainage
QA	Quality Assurance
QC	Quality Control
RBC	Red Blood Cells
RIAHS	Regional Institute of Allied Health Sciences
RPP	Radiation Protection Programme
SCA	Sudden Cardiac Arrest
SDL	Self –Directed Learning
SPECT	Single-Photon Emission Computed Tomography
TLD	Thermoluminescent Dosimeter
TSU	Technical Support Unit
TVT	Tenth Value Thickness
UGC	University Grants Commission
US	Ultrasonography
UHC	Universal Health Coverage
sWBC	White Blood Cells
WHO	World Health Organization
WWW	World Wide Web

Chapter 1
Introduction to the Handbook

Chapter 1: Introduction to the Handbook

The report 'From Paramedics to Allied Health Professionals: Landscaping the Journey and Way Forward' that was published in 2012, marked the variance in education and training practices for the allied and healthcare courses offered by institutions across the country. This prompted the Ministry of Health and Family Welfare to envisage the creation of national guidelines for education and career pathways of allied and healthcare professionals, with a structured curriculum based on skills and competencies. Thus, this handbook has been designed to familiarize universities, colleges, healthcare providers as well as educators offering allied and healthcare courses with these national standards.

Individually, created for different professional groups of allied and healthcare, this hand book aims to reduce the variation in education by comprising of a standardized curriculum, career pathways, nomenclature and other details for each profession. The change from a purely didactic approach will create better skilled professionals and improve the quality of overall patient care. In the absence of a national standard-setting authority, this handbook can also guide the thousands of young adults who choose healthcare as a profession – not as doctors or nurses but to play several other critical roles – on the appropriate course of action to enable them to be skilled allied and healthcare professionals of the future.

Who is an Allied and Healthcare Professional?

The Ministry of Health and Family Welfare, accepted in its entirety the definition of an allied and healthcare professional based on the afore-mentioned report, though the same has evolved after multiple consultations and the recommended definition is now as follows-

'Allied and healthcare professionals (AHPs) includes individuals involved with the delivery of health or healthcare related services, with qualification and competence in therapeutic, diagnostic, curative, preventive and/or rehabilitative interventions. They work in multidisciplinary health teams in varied healthcare settings including doctors (physicians and specialist), nurses and public health officials to promote, protect, treat and/or manage a person('s) physical, mental, social, emotional, environmental health and holistic well-being.'[i]

Since the past few years, many professional groups have been interacting and seeking guidance on all those who would qualify under the purview of "allied and healthcare professionals". In the healthcare system, statutory bodies exist for clinicians, nurses, pharmacists and dental practitioners; but a regulatory structure for around 50 professions is absent in India. Currently, the Government is considering these professions under the ambit of the allied and healthcare system. However, this number is subject to changes and modifications over time, particularly considering how quickly new technologies and new clinical avenues are expanding globally, creating newer cadres of such professionals.

Scope and need for allied and healthcare professionals in the Indian healthcare system

The quality of medical care has improved tremendously in the last few decades due to the advances in technology, thus creating fresh challenges in the field of healthcare. It is now widely recognized that health service delivery is a team effort involving both clinicians and non-clinicians, and is not the sole duty of physicians and nurses.[i] Professionals that can competently handle sophisticated machinery and advanced protocols are now in high demand. In fact, diagnosis is now so dependent on technology, that allied and healthcare professionals (AHPs) are vital to successful treatment delivery.

Effective delivery of healthcare services depends largely on the nature of education, training and appropriate orientation towards community health of all categories of health personnel, and their capacity to function as an integrated team. For instance in the UK, more than 84,000 AHPs, with a range of skills

and expertise, play key roles within the National Health Service, working autonomously, in multi-professional teams in various settings. All of them are first-contact practitioners and work across a wide range of locations and sectors within acute, primary and community care. Australia's health system is managed not just by their doctors and nurses, but also by the 90,000 university-trained, autonomous AHPs vital to the system.[ii,iii]

As the Indian government aims for Universal Health Coverage, the lack of skilled human resource may prove to be the biggest impediment in its path to achieve targeted goals. The benefits of having AHPs in the healthcare system are still unexplored in India. Although an enormous amount of evidence suggests that the benefits of AHPs range from improving access to healthcare services to significant reduction in the cost of care, though the Indian healthcare system still revolves around the doctor-centric approach. The privatization of healthcare has also led to an ever-increasing out-of-pocket expenditure by the population. However, many examples assert the need of skilled allied and healthcare professionals in the system, such as in the case of stroke survivors, it is the support of AHPs that significantly enhance their rehabilitation and long term treatment ensures return to normal life. AHPs also play a significant role to care for patients who struggle mentally and emotionally in the current challenging environment and require mental health support; and help them return to well-being.ii Children with communication difficulties, the elderly, cancer patients, patients with long term conditions such as diabetes people with vision problems and amputees; the list of people and potential patients who benefit from AHPs is indefinite.

Thus, the breadth and scope of the allied and healthcare practice varies from one end to another, including areas of work listed below:

- Across the age span of human development from neonate to old age;
- With patients having complex and challenging problems resulting from systemic illnesses such as in the case of diabetes, cardiac abnormalities/conditions and elderly care to name a few;
- Towards health promotion and disease prevention, as well as assessment, management and evaluation of interventions and protocols for treatment;
- In a broad range of settings from a patient's home to community, primary care centers, to tertiary care settings; and
- With an understanding of the healthcare issues associated with diverse socio-economies and cultural norms within the society.

Learning goals and objectives for allied and healthcare professionals

The handbook has been designed with a focus on performance-based outcomes pertaining to different levels. The learning goals and objectives of the undergraduate and graduate education program will be based on the performance expectations. They will be articulated as learning goals (why we teach this) and learning objectives (what the students will learn). Using the framework, students will learn to integrate their knowledge, skills and abilities in a hands-on manner in a professional healthcare setting. These learning goals are divided into nine key areas, though the degree of required involvement may differ across various levels of qualification and professional cadres:

1. Clinical care
2. Communication
3. Membership of a multidisciplinary health team
4. Ethics and accountability at all levels (clinical, professional, personal and social)
5. Commitment to professional excellence

6. Leadership and mentorship
7. Social accountability and responsibility
8. Scientific attitude and scholarship (only at higher level- PhD)
9. Lifelong learning

1. Clinical Care[iv]

Using a patient/family-centered approach and best evidence, each student will organize and implement the prescribed preventive, investigative and management plans; and will offer appropriate follow-up services. Program objectives should enable the students to:

- Apply the principles of basic science and evidence-based practice
- Use relevant investigations as needed
- Identify the indications for basic procedures and perform them in an appropriate manner
- Provide care to patients – efficiently and in a cost-effective way – in a range of settings, and maintain foremost the interests of individual patients
- Identify the influence of biological, psychosocial, economic, and spiritual factors on patients' well-being and act in an appropriate manner
- Incorporate strategies for health promotion and disease prevention with their patients

2. Communication iv[v]

The student will learn how to communicate with patients/clients, care-givers, other health professionals and other members of the community effectively and appropriately. Communication is a fundamental requirement in the provision of health care services. Program objectives should enable the students to:

- Provide sufficient information to ensure that the patient/client can participate as actively as possible and respond appropriately to the information
- Clearly discuss the diagnosis and options with the patient, and negotiate appropriate treatment plans in a sensitive manner that is in the patient's and society's best interests
- Explain the proposed healthcare service – its nature, purpose, possible positive and adverse consequences, its limitations, and reasonable alternatives wherever they exist
- Use effective communication skills to gather data and share information including attentive listening, open-ended inquiry, empathy and clarification to ensure understanding
- Appropriately communicate with, and provide relevant information to, other stakeholders including members of the healthcare team
- Use communication effectively and flexibly in a manner that is appropriate for the reader or listener
- Explore and consider the influence that the patient's ideas, beliefs and expectations have during interactions with them, along with varying factors such as age, ethnicity, culture and socioeconomic background
- Develop efficient techniques for all forms of written and verbal communication including accurate and timely record keeping
- Assess their own communication skills, develop self-awareness and be able to improve their relationships with others
- Possess skills to counsel for lifestyle changes and advocate health promotion

3. Membership of a multidisciplinary health team[vi]

The student will put a high value on effective communication within the team, including transparency about aims, decisions, uncertainty and mistakes. Team-based health care is the provision of health services to individuals, families, and/or their communities by at least two health providers who work collaboratively to accomplish shared goals within and across settings to achieve coordinated, high quality care. Program objectives will aim at making the students being able to:

- Recognize, clearly articulate, understand and support shared goals in the team that reflect patient and family priorities
- Possess distinct roles within the team; to have clear expectations for each member's functions, responsibilities, and accountabilities, which in turn optimizes the team's efficiency and makes it possible for them to use division of labor advantageously, and accomplish more than the sum of its parts
- Develop mutual trust within the team to create strong norms of reciprocity and greater opportunities for shared achievement
- Communicate effectively so that the team prioritizes and continuously refines its communication channels creating an environment of general and specific understanding
- Recognize measurable processes and outcomes, so that the individual and team can agree on and implement reliable and timely feedback on successes and failures in both the team's functioning and the achievement of their goals. These can then be used to track and improve performance immediately and over time.

4. Ethics and accountability

Students will understand core concepts of clinical ethics and law so that they may apply these to their practice as healthcare service providers. Program objectives should enable the students to:

- Describe and apply the basic concepts of clinical ethics to actual cases and situations
- Recognize the need to make health care resources available to patients fairly, equitably and without bias, discrimination or undue influence
- Demonstrate an understanding and application of basic legal concepts to the practice
- Employ professional accountability for the initiation, maintenance and termination of patient-provider relationships
- Demonstrate respect for each patient's individual rights of autonomy, privacy, and confidentiality

5. Commitment to professional excellence[vii]

The student will execute professionalism to reflect in his/her thought and action a range of attributes and characteristics that include technical competence, appearance, image, confidence level, empathy, compassion, understanding, patience, manners, verbal and non-verbal communication, an anti-discriminatory and non-judgmental attitude, and appropriate physical contact to ensure safe, effective and expected delivery of healthcare. Program objectives will aim at making the students being able to:

- Demonstrate distinctive, meritorious and high quality practice that leads to excellence and that depicts commitment to competence, standards, ethical principles and values, within the legal boundaries of practice

- Demonstrate the quality of being answerable for all actions and omissions to all, including service users, peers, employers, standard-setting/regulatory bodies or oneself
- Demonstrate humanity in the course of everyday practice by virtue of having respect (and dignity), compassion, empathy, honour and integrity
- Ensure that self-interest does not influence actions or omissions, and demonstrate regards for service-users and colleagues

6. Leadership and mentorship[viii]

The student must take on a leadership role where needed in order to ensure clinical productivity and patient satisfaction. They must be able to respond in an autonomous and confident manner to planned and uncertain situations, and should be able to manage themselves and others effectively. They must create and maximize opportunities for the improvement of the health seeking experience and delivery of healthcare services. Program objectives should enable the students to:

- Act as agents of change and be leaders in quality improvement and service development, so that they contribute and enhance people's wellbeing and their healthcare experience
- Systematically evaluate care; ensure the use of these findings to help improve people's experience and care outcomes, and to shape clinical treatment protocols and services
- Identify priorities and effectively manage time and resources to ensure the maintenance or enhancement of the quality of care
- Recognize and be self-aware of the effect their own values, principles and assumptions may have on their practice. They must take charge of their own personal and professional development and should learn from experience (through supervision, feedback, reflection and evaluation)
- Facilitate themselves and others in the development of their competence, by using a range of professional and personal development skills
- Work independently and in teams. They must be able to take a leadership role to coordinate, delegate and supervise care safely, manage risk and remain accountable for the care given; actively involve and respect others' contributions to integrated person-centered care; yet work in an effective manner across professional and agency boundaries. They must know when and how to communicate with patients and refer them to other professionals and agencies, to respect the choices of service users and others, to promote shared decision-making, to deliver positive outcomes, and to coordinate smooth and effective transition within and between services and agencies.

7. Social Accountability and Responsibility[ix]

The students will recognize that allied and healthcare professionals need to be advocates within the health care system, to judiciously manage resources and to acknowledge their social accountability.[x]They have a mandate to serve the community, region and the nation and will hence direct all research and service activities towards addressing their priority health concerns. Program objectives should enable the students to:

- Demonstrate knowledge of the determinants of health at local, regional and national levels and respond to the population needs

- Establish and promote innovative practice patterns by providing evidence-based care and testing new models of practice that will translate the results of research into practice, and thus meet individual and community needs in a more effective manner
- Develop a shared vision of an evolving and sustainable health care system for the future by working in collaboration with and reinforcing partnerships with other stakeholders, including academic health centres, governments, communities and other relevant professional and non-professional organizations
- Advocate for the services and resources needed for optimal patient care

8. Scientific attitude and Scholarship[x]

The student will utilize sound scientific and/or scholarly principles during interactions with patients and peers, educational endeavors, research activities and in all other aspects of their professional lives. Program objectives should enable the students to:

- Engage in ongoing self-assessment and structure their continuing professional education to address the specific needs of the population
- Practice evidence-based by applying principles of scientific methods
- Take responsibility for their educational experiences
- Acquire basic skills such as presentation skills, giving feedback, patient education and the design and dissemination of research knowledge; for their application to teaching encounters

9. Lifelong learning[xi]

The student should be committed to continuous improvement in skills and knowledge while harnessing modern tools and technology. Program objectives will aim at making the students being able to:

- Perform objective self-assessments of their knowledge and skills; learn and refine existing skills; and acquire new skills
- Apply newly gained knowledge or skills to patient care
- Enhance their personal and professional growth and learning by constant introspection and utilizing experiences
- Search (including through electronic means), and critically evaluate medical literature to enable its application to patient care
- Develop a research question and be familiar with basic, clinical and translational research in its application to patient care
- Identify and select an appropriate, professionally rewarding and personally fulfilling career pathway

Introduction of new elements in allied and healthcare education

Competency-based curriculum

A significant skill gap has been observed in the professionals offering healthcare services irrespective of the hierarchy and level of responsibility in the healthcare settings. The large variation in the quality of services is due to the diverse methodologies opted for healthcare education and the difference in expectations from a graduate after completion of a course and at work. What one is expected 'to perform' at work is assumed to be learned during the course, however, the course design focuses on what one is expected 'to know'. The competency-based curriculum thus connects the dots between the 'know what' and 'do how'.

The efficiency and effectiveness of any educational programme largely depends on the curriculum design that is being followed. With emerging medical and scientific knowledge, educators have realized that learning is no more limited to memorizing specific lists of facts and data; in fact, by the time the professional aims to practice in the healthcare setting, the acquired knowledge may stand outdated. Thus, competency-based education is the answer; a curricular concept designed to provide the skills that professionals need. A competency-based program is a mix of skills and competencies based on individual or population needs (such as clinical knowledge, patient care, or communications approaches), which is then developed to teach relevant content across a range of courses and settings. While the traditional system of education focuses on objectives, content, teacher-centric approach and summative evaluation; competency-based education has a focus on competencies, outcomes, performance and accomplishments. In such a case, teaching activities are learner-centered, and evaluation is continuous and formative in structure. The competency-based credentials depend on the demonstration of a defined set of competencies which enables a professional to achieve targeted goals. Competency frameworks comprise of a clearly articulated statement of a person's abilities on the completion of the credential, which allows students, employers, and other stakeholders to set their expectations appropriately.[xiixiii]

Considering the need of the present and future healthcare delivery system, the curriculum design depicted in this handbook thus will be based on skills and competencies.

Promoting self-directed learning of the professionals

The shift in the focus from traditional to competency-based education has made it pertinent that the learning processes may also be revisited for suitable changes. It is a known fact that learning is no more restricted to the boundaries of a classroom or the lessons taught by a teacher. The new tools and technologies have widened the platform and introduced innovative modes of how students can learn and gain skills and knowledge. One of the innovative approaches is learner-centric and follows the concept of **self-directed learning.**

Self-directed learning, in its broadest meaning, describes a process in which individuals take the initiative with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying resources for learning, choosing and implementing learning strategies and evaluating learning outcomes (Knowles, 1975).[xiv]

In self-directed learning, learners themselves take the initiative to use resources rather than simply reacting to transmissions from resources, which helps them learn more in a better way.[xv] Lifelong, self-directed learning (SDL) has been identified as an important ability for medical graduates (Harvey, 2003)[xvi] and so is applicable to other health professionals including AHPs. It has been proven through many studies worldwide that the self-directed method is better than the teacher-centric method of learning. Teacher-directed learning makes learners more dependent and the orientation to learning becomes subject-centred. If a teacher provides the learning material, the student is usually satisfied with the available material, whereas if a student is asked to work on the same assignment, he or she invariably has to explore extensive resources on the subject.[xv]

Credit hours vs traditional system

Recently the National Assessment and Accreditation Council (NAAC) and the University Grants Commission (UGC) have highlighted the need for the development of a Choice-Based Credit System (CBCS), at par with global standards and the adoption of an effective grading system to measure a learner's performance.[xvii] All the major higher education providers across the globe are operating a system of credits. The European Credit Transfer System (ECTS), the 'National Qualifications Framework' in Australia, the

Pan-Canadian Protocol on the Transferability of University Credits, the Credit Accumulation and Transfer System (CATS) in the UK as well as the systems operating in the US, Japan, etc. are examples of these. Globally, a need now exists for the use of a fully convertible credit-based system that can be accepted at other universities. It has now become imperative to offer flexible curricular choices and provide learners mobility due to the popularity of initiatives such as 'twinning programmes', 'joint degrees' and 'study abroad' programmes.[xviii]

In order to ensure global acceptability of the graduates, the current curriculum structure is divided into smaller sections with focus on hours of studying which can be converted into credit hours as per the international norms followed by various other countries.

Integrated structure of the curriculum

Vertical integration, in its truest sense, is the interweaving of teaching clinical skills and knowledge into the basic science years and, reinforcing and continuing to teach the applications of basic science concepts during the clinical years. (Many efforts called 'vertical integration' include only the first half of the process).

Horizontal integration is the identification of concepts or skills, especially those that are clinically relevant, that cut across (for example, the basic sciences), and then putting these to use as an integrated focus for presentations, clinical examples, and course materials. e.g. Integration of some of the basic science courses around organ systems, e.g., human anatomy, physiology, pathology; or incorporating ethics, legal issues, finance, political issues, humanities, culture and computer skills into different aspects of a course like the Clinical Continuum.

The aim of an integrated curriculum is to lead students to a level of scientific fluency that is beyond mere fact and concept acquisition, by the use of a common language of medical science, with which they can begin to think creatively about medical problems.[xix]

This innovative new curriculum has been structured in a way such that it facilitates horizontal and vertical integration between disciplines; and bridges the gaps between both theory & practice, and between hospital-based practice and community practice. The amount of time devoted to basic and laboratory sciences (integrated with their clinical relevance) would be the maximum in the first year, progressively decreasing in the second and third year of the training, making clinical exposure and learning more dominant.[xi] However it may differ from course to course depending on the professional group.

Introduction of foundation course in the curriculum

The foundation course for allied and healthcare professions is an immersive programme designed to impart the required knowledge, skills and confidence for seamless transition to the second semester of a professional allied and healthcare course. Post admission, the foundation course is designed for a period of 6 months to prepare a student to study the respective allied and healthcare course effectively and to understand the basics of healthcare system. This aims to orient the student to national health systems and the basics of public health, medical ethics, medical terminologies, communication skills, basic life support, computer learning, infection prevention and control, environmental issues and disaster management, as well as orientation to the community with focus on issues such as gender sensitivity, disability, human rights, civil rights etc. Though the flexibility to the course designers have been provided in terms of – modifying the required numbers of hours for each foundation subject and appropriate placement of the subject across various semesters.

Learning methodologies

With a focus on self-directed learning, the curriculum will include a foundation course that focuses on communication, basic clinical skills and professionalism; and will incorporate clinical training from the first year itself. It is recommended that the primary care level should have sufficient clinical exposure integrated with the learning of basic and laboratory sciences. There should also be an emphasis on the introduction of case scenarios for classroom discussion/case-based learning.

Healthcare education and training is the backbone of an efficient healthcare system and India's education infrastructure is yet to gain from the ongoing international technological revolution. The report '*From Paramedics to Allied Health: Landscaping the Journey and way ahead*', indicates that teaching and learning of clinical skills occur at the patient's bedside or other clinical areas such as laboratories, augmented by didactic teaching in classrooms and lecture theatres. In addition to keeping up with the pace of technological advancement, there has been a paradigm shift to outcome-based education with the adoption of effective assessment patterns. However, the demand for demonstration of competence in institutions where it is currently limited needs to be promoted. The report also mentions some of the allied and healthcare schools in India that have instituted clinical skill centres, laboratories and high-fidelity simulation laboratories to enhance the practice and training for allied and healthcare students and professionals. The report reiterates the fact that simulation is the replication of part or all of a clinical encounter through the use of mannequins, computer-assisted resources and simulated patients. The use of simulators addresses many issues such as suboptimal use of resources and equipment, by adequately training the manpower on newer technologies, limitations for imparting practical training in real-life scenarios, and ineffective skills assessment methods among others.i The table mentioned below lists various modes of teaching and learning opportunities that harness advanced tools and technologies.

Table 1 Clinical learning opportunities imparted through the use of advanced techniquesi[xx]

Teaching modality	Learning opportunity examples
Patients	Teach and assess in selected clinical scenarios
	Practice soft skills
	Practice physical examination
	Receive feedback on performance
Mannequins	Perform acquired techniques
	Practice basic procedural skills
	Apply basic science understanding to clinical problem solving
Simulators	Practice teamwork and leadership
	Perform cardiac and pulmonary care skills
	Apply basic science understanding to clinical problem solving
Task under trainers	Practice phlebotomy, lumbar puncture, etc.

Assessment methods

Traditional assessment of students consists of the yearly system of assessments. In most institutions, assessments consist of internal and external assessments, and a theory examination at the end of the year or semester. This basically assesses knowledge instead of assessing skills or competencies. In competency-based training, the evaluation of the students is based on the performance of the skills as per their

competencies. Hence, all the three attributes – knowledge, skills, and attitudes – are assessed as required for the particular competency.

Several new methods and tools are now readily accessible, the use of which requires special training. Some of these are given below:

- Objective Structured Clinical Examination(OSCE), Objective Structured Practical Examination (OSPE), Objective Structured Long Examination Record(OSLER)
- Mini Case Evaluation Exercise(CEX)
- Case-based discussion(CBD)
- Direct observation of procedures(DOPs)
- Portfolio
- Multi-source feedback
- Patient satisfaction questionnaire

An objective structured clinical examination (OSCE) is used these days in a number of allied and healthcare courses, e.g. Optometry, Physiotherapy, and Radiography. It tests the performance and competence in communication, clinical examination, and medical procedures/prescriptions. In physiotherapy, orthotics, and occupational therapy, it tests exercise prescription, joint mobilization/manipulation techniques; and in radiography it tests radiographic positioning, radiographic image evaluation, and interpretation of results. The basic essential elements consist of functional analysis of the occupational roles, translation of these roles ("competencies") into outcomes, and assessment of trainees' progress in these outcomes on the basis of demonstrated performance. Progress is defined solely by the competencies achieved and not the underlying processes or time served in formal educational settings. Most methods use predetermined, agreed assessment criteria (such as observation check-lists or rating scales for scoring) to emphasize on frequent assessment of learning outcomes. Hence, it is imperative for teachers to be aware of these developments and they should suitably adopt them in the allied and healthcare education system.[xxi]

Chapter 2
Background of the profession

Chapter 2: Background of the profession

Statement of Philosophy– Why this profession holds so much importance

Medical Radiology and Imaging Technology is the health profession concerned with the direct administration of radiation, primarily x-rays, in disease diagnosis and injury assessment and treatment. From the humble beginnings of plain film techniques, we are now with a wide array of imaging methods using Conventional and Digital X-rays, ultrasound, magnetic resonance and Radionuclide. Modern diagnostic radiography and Medical Imaging forms an integral part of medical practice, both in making diagnosis and also in treatment. The term "diagnostic radiography" is used to describe a variety of radiographic or x-ray examinations. These simple procedures as well as those which require the use of contrast agents, make it possible to study organs that otherwise cannot be seen. These professionals are at the heart of modern medicine.

Diagnostic radiographers employ a range of different imaging techniques and sophisticated equipment to produce high quality images of an injury or disease. They take the images using range of techniques including: X-rays, Mammography, Fluoroscopy, CT (computed tomography), MRI (magnetic resonance imaging), Nuclear medicine, Angiography etc. Medical imaging studies have been a cornerstone in medical diagnosis for decades; however, technological advances and the addition of new imaging modalities now place medical imaging among the most dynamic, expanding and high demand fields in clinical medicine.

About Medical Radiology and Imaging Technology

Radiology is a branch of medicine that uses radiation and imaging technology to diagnose and treat disease. It allows the radiologic technologist to produce images of various internal parts of the body, to aid in the detection of injury or disease by using radiations. Radiology is central to the clinical practice of medicine across a wide range of disciplines. It is the best practical way to diagnose, monitor treatment and detect progression or relapse of many important and common diseases in a minimally invasive and anatomically precise manner. As a consequence of the increasing sophistication and accuracy of clinical imaging, the utilization and importance of radiology has increased dramatically and consistently over the last 20 years. In recent years, the increasing complexity of radiologic procedures has made Medical Radiology and Imaging technology a highly specialized and sophisticated science requiring competently trained personnel to maintain a high degree of accuracy in radiographic positioning and exposure technique. A qualified Medical Imaging Technologist is skilled in both interventional and Diagnostic Radiology.

Scope of practice

Diagnostic Radiographers/technologists possess, utilize and maintain knowledge of radiation protection and safety. Radiographers have an extremely thorough understanding of the structure of the body, how the body can be affected by injury, and causes and effects of disease when taking X-ray images. Their work does include a wide range of different imaging modalities radiographers are the primary liaison between patients, radiologist and other members of the support team. They remain sensitive to needs of the patient through good communication, patient assessment, patient monitoring and patient care skills. As members of the health care team, diagnostic radiographer /technologist participate in quality improvement processes and continually assess their professional performance. They engage in continuing education to include their area of practice to enhance patient care, public education, knowledge and technical competence. Diagnostic radiographers use a range of imaging technology:

- X-ray - Penetrate through the body to examine and view internal structures
- Fluoroscopy uses X-rays to obtain real-time moving images of the internal parts of the body.
- CT (Computed Tomography) provides cross-sectional views / images of the body using computer with the help of X-Rays.
- MRI (Magnetic Resonance Imaging) - images of the different tissue types within the body using strong magnet and RF waves
- Ultrasound –uses high frequency sound waves to produce images of the structure within the body. It is well known for its use in obstetrics and gynecology. Also used to check circulation and examine the heart
- Angiography –radiological study which is used to investigate blood vessels.
- Mammography-Imaging of the soft tissue breast
- DEXA—Bone Densitometry.

Recognition of Title and qualification

The practice of medical radiography is performed by health care professionals responsible for the administration of ionizing radiation for diagnostic purposes. In addition to medical radiology and imaging technologists, they are also known as *Diagnostic Radiographers/ Imaging Technologist/ Radio-Diagnosis Technologist.*

The recommended title thus stands as the Medical Radiology and Imaging Technologists for this group of professionals.

A medical radiology and imaging technologist performs radiographic procedures at the request of practitioner. They form an indispensable part of the medical team.

Definition of Medical Radiology and Imaging Technology professionals

A radiographer or medical imaging technologist is a trained health professional who performs medical imaging by producing high quality X-ray pictures or images used to diagnose and treat injury or disease.

It is an important part of medicine and a patient's diagnosis and treatment is often dependent on the X-ray images produced.[xxii]They are responsible for producing high quality medical images that assist medical specialists and doctors to diagnose or monitor a patient's injury or illness treatment. They operate extremely technologically advanced equipment such as CT (computed tomography), MRI (magnetic resonance imaging) DSA, DEXA, mammography, CR, DR, fluoroscopy and digital mobile X-ray machines. Their roles are diverse and challenging, as radiographers are often trained in several specialist areas such as trauma radiography, mobile radiography, CT, MRI, Fluoroscopy, angiography, intervention and operation theatre mammography DEXA etc.

Education of these professionals

When developing any education program it is necessary that program planning should be outcome-based, meeting local and national manpower requirements, personal satisfaction and career potential for the professionals with supporting pathway in the development of the profession. One of the major changes is the shift from a focus based on traditional theoretical knowledge and skills to competency based education and training. Optimal education/training requires that the student is able to integrate knowledge, skills and attitude in order to be able to perform a professional act adequately in a given situation.

Thus the following curriculum aims to focus on skills and competencies based approach for learning and is designed accordingly. The curriculum is prescriptive and is designed with an aim to standardize the content across the nation.

Course duration

It is recommended that any programme developed from this curriculum should have a minimum of the following duration to qualify as an entry level professional in Medical Radiology and Imaging Technology.

- **4 year programme (including 1 year of clinical training /internship)- Bachelor's degree level**
- **2 year programme – Master's level**

The emphasis during the initial year should be on the academic content establishing a strong scientific basis and engagement with the course principles. During the second and third years of training, emphasis should be laid on process to refine the acquired theoretical knowledge and its application to clinical/reflective practice. In Bachelor degree programme minimum one year should be devoted to clinical practice and this should be on a continuum of rotation from theory to practice over the programme. The aim of the 4 year degree programme is to enable the development of the medical radiology and imaging technologist as a key member of the multidisciplinary team and to enable him/her to execute advanced preparation/ planning/delivery as well as quality assurance.

With the change in the disease dynamics and multifold increase in the cases needing diagnostic medical imaging and evaluation, it is imperative that a well-structured programme of postgraduate education is also encouraged so as to enhance research capacity within the country to widen the scope of clinical practice for the profession. **Thus, a master's degree programme is recommended with minimum of two years of education in specialized field of Medical Radiology and Imaging Technology.** The post graduate students can contribute significantly in research and academics.

PhD also play a significant role in the academic system, research and innovation.
However as per ICAHP Committee - 3 (Minimum Standards and Procedures for Award of Ph.D. Degree in MRIT in the related special fields) to be followed as per UGC Guidelines has also been incorporated in this curriculum

Teaching faculty and infrastructure (minimum standard to start the programmes)

One of the important recommendation of the task force members should be associated with the state medical colleges whereby they can make use of the available patient load and medical infrastructure as a part of their training curriculum (May be through MOU).

- Standalone institutions must have an MoU with either a medical college or hospital or healthcare facility as per the guidelines (desired number of Radiology equipment/beds/OPD etc.) defined in the curriculum to
- ensure practical exposure to the students.
- The MOU must be done with either a medical college or hospital or healthcare facility having minimum of 100 investigation per day includes of x-rays, Radiological imaging procedures, CT and MRI includes advance imaging techniques.
- MoU to also define the radiology clinical supervision of the students –institutional staff or clinical preceptors can be considered.

For the institutes to be capable of providing high quality training to the student and exposure to all the related modalities, it should have the following:[xxiii]

- Conventional X-ray Unit for routine X-ray and IVU
- Mobile X-ray unit
- Fluoroscopic unit
- Ultrasonography, Color Doppler Equipment
- Multi-slice C.T. Scan,
- Mammography
- MRI
- DSA(preferably)

The teaching faculty for the department should have a minimum of (for the 20 intake)

- 1 Professor
- 1 Assoc. Professor
- 3 Asst. Professor
- 2 demonstrators

Method of teaching and learning-

- Lecture
- Tutorial
- Problem based learning
- Small group teaching and learning
- Continuous interactive learning
- Case-based
- Project based
- Research project- Research was considered by the group to be very important in order to keep pace with other professions and to generate a research background for our own profession.
- Seminars
- Clinical conferences
- E-learning
- Skills laboratory

Job availability-

Diagnostic radiography is a fast-moving and continually changing profession, and long-term career prospects include: management, research, clinical work, teaching etc.

Employment opportunities available in a variety of settings in both rural and urban areas include:

- More generalized practice in medium to small hospitals;
- Specialized clinical practice in large academic medical hospitals and trauma centers,
- Clinics and free-standing imaging centers which may offer both special and general practice opportunities; or
- Clinical practice coupled with expanded responsibilities in quality control, education, data management and supervision, particularly in large hospitals.
- Research Scholar/ Research Assistant

- Medical imaging professionals are usually employed in the medical imaging/radiology departments of large teaching hospitals, private and country hospitals, and private radiological clinics. Graduates may work in the field of teaching, Research , Application Specialist , Radiology Technologist , Clinical Supervisor and even as a clinical research consultant. Professionals may eventually specialise in particular areas of practice, or in specific techniques such as computed tomography, ultrasound, magnetic resonance imaging or picture archiving and communication systems (PACS). Graduates may also pursue more technical careers in medical physics or biophysics, quality control, radiation health, or with equipment manufacturers. Managerial careers within medical imaging service departments are also possible, as is pursuing further education or research. The medical imaging graduates are highly regarded and employment opportunities are readily available, in both metropolitan and rural and regional areas. There is high industry demand, and you will be qualified to work anywhere in India and in many locations internationally.

The demand for qualified radio-imaging technologist is on the rise and such jobs come with well-paid salary packages. The job profile may vary according to the modality and scope of practice.

The program aims to train human resources with requisite skills in the area of medical radiology & imaging technology who can be hired in all kinds of healthcare settings including:

- Hospitals
- Diagnostic centers
- Medical Records and Transcription organizations
- Clinical and Medical Research organisations
- Pharma and Bio-Tech companies
- Medical equipment and device companies

Diagnostic radiographers provide a service for most departments within the hospital including, accident and emergency, outpatients, operating theatres and wards. Close liaison and collaboration with a wide range of other health care professionals is therefore vital. After completion of this curriculum, a Medical Radiology &Imaging Technologist gets opportunities to work at various health care institutes under designations as:

- Radiographer
- Radiological Technologist
- X-ray Technologist
- CT scan Technologist
- MRI Technologist

- Mammography Technologist
- Cathlab Technologist
- Applications Specialist
- Radiological Safety Officer
- Interventional Technologist
- Quality control Technologist
- PACS manager
- Sales and marketing of radiology industry
- Diagnostic Manager, etc.
- Other Administrative posts in Medical Imaging department & hospital.
- Teaching & research faculty in Medical colleges
- Research Scientists in Medical imaging industry

Chapter 3

Model Curriculum of Medical Radiology and Imaging Technology Courses

Chapter 3: Model Curriculum

Background

This curriculum document outlines the structure of the Medical Radiology and Imaging Technology training program, the knowledge and skills expected from the graduates at various levels. It also enumerates the nature of the various examinations and assessments that planned throughout the training program.

The aims of the recommended curriculum are to produce MRIT`S who are
- Technically and clinically competent;
- Aware of radiation safety issues and the importance of quality assurance;
- Understand the theoretical basis for evidence based practice;
- Effective members of the multidisciplinary team;
- Prepared to participate in or initiate research into practice;
- Can work according to registration requirements on the respective continents.

All aspects of medical radiological and imaging technology have been considered in the development of this curriculum together with the identification of the roles expected for different levels of MRIT`S based on their qualification and experience. The need for connecting the dots between the education and employment practices has been the road map for devising this curriculum.

Foundation course has also been designed to bring all the students at the same level of understanding with respect to basic healthcare related norms before the start of a career in a healthcare professional course. The foundation course is mandatory for all the allied and healthcare professional courses and for both entry level courses – diploma as well as degree. If a diploma holder has completed the foundation course and is willing to pursue the degree course, the candidate will directly get entry for next semester, however a pre- qualifier skill test will have to be satisfactorily completed, if not, then the candidate will have to undergo the first semester of foundation course again.

3.2 Master in Medical Radiology and Imaging Technology (MMRIT)

Master in Medical Radiology and Imaging Technology

Introduction:

Learning Objectives:

Master in Medical Radiology & Imaging Technology is specifically aimed at those candidates pursuing a professional/academic career in Radiology &Imaging Technology. It is designed to provide specialized training in the scientific principles of modern imaging sciences and in the application of these principles in the field of Radiology & Imaging Technology. It is designed as a higher degree course suitable for graduates having experience in the technology of Radiology & Imaging Technology. The objective of the programme is to train students to be qualified, patient focused, compassionate, critical thinkers for the community who are engaged in lifelong learning.

Upon successful completion of the Master course, students will have developed a broad knowledge of the principles, technology, instrumentation, recent developments and proper handling of the modern radiological and imaging equipment's and proper execution of the various radiological procedures and be able to embark upon a successful career in their chosen direction of Imaging Science research.

Expectation from the future post graduate in providing research/academics/patient care

Perform a range of radiographic/radiological examinations on patients to produce high quality images.

1. Verifying informed consent, assuming responsibility for patient needs during procedures.
2. Applying principles of ALARA to minimize exposure to patient, self and others. Starting and maintaining intravenous access as prescribed, Identifying, preparing and/or administering medications as prescribed
3. Evaluating images for technical quality, ensuring proper identification is recorded.
4. Performing diagnostic radiographic/radiological and non-interpretive fluoroscopic procedures
5. Assist radiologists and senior staff in complex radiological examinations.
6. Record imaging identification and patient documentation quickly and accurately and observes protocols.
7. Research and development of new techniques and procedures as assigned.
8. Promotes effective working relationships and works effectively as part of a department / unit / team inter and intra departmentally to facilitate the department/unit's ability to meet its goals and objectives.
9. Follows established safety practices including biohazards, exposure control plan
10. Demonstrates respect and regard for the dignity of all patients, families, visitors and fellow employees to ensure a professional, responsible and courteous environment.
11. Identifying and managing emergency situations.
12. Performing ongoing quality assurance activities.
13. Ensure safe custody of all the accessories of the X-ray/radiological unit of which he/she is in charge. Keeps the X-ray room locked when not in use.
14. Understands and observes health and safety regulations/precautions and instruction for self and others protection. He/she should wear a dosimeter during duty hours.
15. Attends all in service education program required as per hospital policy.
16. Providing education and monitoring students and other health care providers.
17. Orientation and teaching students and new employees.
18. Learns new technologies and technologies as required by the professional bodies.
19. Impart appropriate training to the students and other staff.

20. Should have management and research skills.
21. To exhibit keen interest, initiative & drive in the overall development of the Department and 'Leadership Qualities' for others to follow.
22. He / She is expected to be confident and to perform all the duties diligently with utmost sincerity and honesty.
23. Any other duty/task/work assigned by any higher authority like Director, Dean, Medical Superintendent, Head of the Department from time to time; either in "Public Interest" or in the interest of upkeep / development of the Department / Institutions.

Minimum standard to start the MMRIT programmes:
Accordance with NCAHP regulations Institution/university with having medical college with hospital setup shall be permitted an annual intake capacity of 10 admissions (maximum) annually. No shall paramedical institutes/colleges having no own medical college shall permitted to start the Master degree programme. The phase-wise requirements to be fulfilled by the applicant colleges for obtaining letter of intent and Letter of Permission for establishment of new college or increase in annual intake MMRIT admissions annually from 10 to 15 intake. Maximum of intake in the Master degree programe is 15 candidates. No shall permission of the intake to be permitted more then 15 to any institute or college.

For the institutes to be capable of providing high quality training to the student and exposure to all the related modalities, it should have the following:

- X-ray Unit (CR, DR)
- Mobile X-ray unit
- Fluoroscopic unit
- Ultrasonography, Color Doppler Equipment
- Multi-slice CT Scan
- Mammography
- DEXA
- MRI
- DSA

Note: Starting MMRIT program in CT, MRI and Breast Imaging apart from the above equipment's the institute must have state of art high end equipment in these specializations.

The teaching faculty (with annual intake of up to 10 students) for the MMRITs should have a minimum of Master in the MRIT or MRIT with PhD in relevant subject.

- 1 Professor
- 2 Assoc. Professor
- 4 Asst. Professor
- 8 demonstrators

Method of teaching and learning-

- Lecture
- Tutorial
- Problem based learning
- Small group teaching and learning
- Continuous interactive learning
- Case-based
- Project based

- Research project- Research was considered by the group to be very important in order to keep pace with other professions and to generate a research background for our own profession.
- Seminars
- Clinical conferences
- E-learning
- Skills laboratory
- Industrial visit

Infrastructure requirements:

- Minimum 4 classrooms with minimum seating capacity of 10 students
- Faculty rooms, Common rooms for students
- Auditorium/Conference room with minimum seating capacity of 150 students.
- Minimum 2000 sqft Library
- Student canteen/cafeteria

Eligibility for admission:

Selection procedure:

Bachelor in Medical Radiology & Imaging Technology (3+1)/B.Sc. Medical Technology Radio diagnosis and Imaging/ B.Sc. Radiological Technology/B.Sc. in Radiography/B.Sc. Medical Technology (X-ray) or equivalent to BMRIT with a minimum 60% marks in Bachelor. Bachelor course must be three years course and one year of internship/one year of working experience must be considered for the Master degree admission.

The selection of the candidates for admission to the course is made on merit on the basis of combined entrance examination conducted by NCAHP/NEET. The admission notice is released in all leading English Newspaper. Only those candidates will be eligible who score minimum 60% marks in the entrance test for General Category candidates and 55% of for those belonging to SC/ST category.
Selection of the candidate on the basis of Entrance examination conducted by the national commission (NCAHP) norms.

Elective specializations:

MMRIT course offers three elective broad specializations during the admissions. First and Second semesters will be having common core subjects to all the students. During the study of Third and Fourth semesters there will be a three elective broad specializations. Three elective broad specializations are as follows:

- **CT Imaging Technology**
- **MR Imaging Technology**
- **Breast Imaging Technology**

Selecting of elective broad specializations must be done during the admission itself as per ranking. There will be no option to change the elective broad specializations after the start of the academic year.

Selection of eligible candidates:

Every student, selected for admission to a MMRIT in any of the para medical institutions/university on acquiring BMRIT or an equivalent qualification thereto shall have obtained permanent registration with

the NCAHP, or any of the State Medical Council(s) or shall obtain the same within a period of three months from the date of his/her admission, failing which his/her admission shall stand cancelled.

Selection to the MMRIT course shall be based on merit obtained in the National Entrance and Eligibility Test (NEET) conducted by the central government or its authorized agency.

Accordance with NCAHP regulations Institution/university with having medical college with hospital setup shall be permitted an annual intake capacity of 10 admissions (maximum) annually. No shall paramedical institutes/colleges having no own medical college shall permitted to start the Master degree programme. The phase-wise requirements to be fulfilled by the applicant colleges for obtaining letter of intent and Letter of Permission for establishment of new college or increase in annual intake MMRIT admissions annually from 10 to 15 intake. Maximum of intake in the Master degree programe is 15 candidates. No shall permission of the intake to be permitted more then 15 to any institute or college.

Number of approved admission/seats will be distributed on elective subjects as follows:

Intake: 10 seats
MMRIT – Elective of CT Imaging Technology: 4 seats
MMRIT – Elective of MR Imaging Technology: 4 seats
MMRIT – Elective of Breast Imaging Technology: 2 seats

Duration of the course

Duration of the course: 4 semesters or 2 Years (640 hours of Theory & Practical Classes).
Total - 2560 hours

Medium of instruction:
English shall be the medium of instruction for all the subjects of study and for examination of the course.

Maximum period for completion of the course:

The maximum period for completion of MMRIT is 4 years.

If a candidate does not complete within the 4 years, he/she should re-register.

Attendance and Monitoring progress of studies:

A candidate shall study in concerned department of the Institute for the entire period as a full-time student.

No candidate is permitted to work in any other laboratory/college/ hospital/pharmacy etc. while studying.

A candidate who has a minimum of 80% attendance in theory and practical separately and who has fulfilled other requirements of the course shall be permitted to appear for the examination.

A candidate having a shortage of attendance shall repeat the exam when it is offered next.

Stipend: All students shall be paid minimum sum of Rupees 15000/- per month as stipend in all the four semesters or at par with other similar streams as per consumer price index as per NCIAHP Act.

Assessment and Evaluation

Scheme of Evaluation

The academic performance is assessed on the basis of both Continuous Internal Evaluation (CIE) assessment and End Semester Examination (ESE) in each semester. Weightage will be in the ratio of 30 % for CIE and 70 % for ESE.

Continuous Internal Evaluation (CIE)

- 30% of the total marks is allotted for CIE in each course.
- 50% of CIE shall be based on the average of marks obtained in two notified formative written tests. Absence without prior permission for a formative test shall result in scoring of the test as zero.
- The remaining 50% of CIE will be based on internal assessments in the form of evaluation of seminars, journal club presentations, case presentations, completion of assignments etc. which will be specified in the individual course curricula.
- CIE will be conducted for theory and practical for each course wherever applicable.
- A Candidate must secure at least 40% of total marks fixed for CIE in the particular course in order to be eligible to appear for the End Semester Examination for that course.

- **End Semester Examination (ESE)**

- There shall be a University Examination at the end of each semester.
- To be eligible to appear for University examination a candidate should fulfil all the following conditions
- Undergone satisfactorily the approved program of study in the course/courses for the prescribed duration
- 80% attendance separately in theory and in practical/hospital postings, in each course
- Shall have the minimum attendance requirement in all courses of that semester for the first appearance
- Secure at least 40% of total marks fixed for CIE in a particular course; and
- Fulfil any other requirement that may be prescribed by the University from time to time.
- The End Semester Examination will consist of Theory examination for all courses and in addition, Practical examination for specified courses.
- Theory examination
- Written tests with question types, pattern, duration and weightage as specified in the Course-wise curricula
- Setting of question papers and evaluation of answer scripts as per University regulations
- Practical examination
- Broad outline would be in the form of Spotters, Demonstration of equipment handling, Case based discussions.

Criteria for pass:

A Candidate has to score 50% each in theory and practical wherever applicable to be declared as pass. In case of fail, subsequently candidate has to appear for both theory and practical examination of the university in that particular course.

Attendance and appearance for Exam:

Candidates not possessing required attendance in a particular course as prescribed by University will not be allowed to take up examinations and has to appear for supplementary examination whenever university conducts exam for the particular course very next time.

Overview

Core courses (credits)	1. Radiological and Medical Physics 2. Clinical Special Radiography Positioning 3. Modern Radiological Imaging - Equipment and Physics 4. Contrast Media and Interventional Radiology 5. Modern Imaging and Special Radiological Procedures 6. Biostatistics and Research Methodology
Broad specific core courses (CT Technology)	1. Principles of CT Imaging Technology 2. CT Imaging Procedures and Scanning Protocols 3. Basic and Cross Sectional Anatomy in CT Imaging 4. Advancements in CT Technology 5. Quality Assurance, Radiation Protection and Patient care in CT Imaging 6. Basic Pathology and Image Interpretation in CT Imaging
Broad specific core courses (MRI Technology)	1. Principles of MR Imaging Technology 2. MR Imaging Procedures and Scanning Protocols 3. Basic and Cross Sectional Anatomy in MR Imaging 4. Advancements in MRI Technology 5. Planning, Safety and Patient care in MR Imaging 6. Basics Pathology and Image Interpretation in MR Imaging
Broad specific core courses (Breast Imaging Technology)	1. Principles of Breast Imaging Technology 2. Breast Imaging Procedures and Scanning Protocols 3. Basics and Cross sectional anatomy of Breast 4. Advancements in Breast Imaging Technology 5. Quality Assurance, Radiation Protection and Patient care in Breast Imaging 6. Basics Pathology and Image Interpretation in Breast Imaging

Distribution of Credits:

L – Lectures- 1 hour: 1 credit

T – Tutorial- 1 hour: 1 credit

P – Practical- 2 hours: 1 credit

Clinical (Studentship)- 3 hours: 1 credit

Curriculum Outline

Teaching and Examination Scheme															
Course Name: Master in Medical Radiology and Imaging Technology															
Duration of Program: Two Years (Four Semesters) Pattern : Full Time **Duration : 18 Weeks** Semester : **First**															
S.N.	**Course Code**	**Course Title**	**Teaching Scheme**				**Examination Scheme**								
							Theory				**Practical**				
			L (hrs/week)	**Tutorial**	**C/P (hrs/week)**	**Credits (L+T+P)**	**Exam Duration in Hrs.**	**CIE**	**ESE**	**Total**	**CIE**	**ESE**	**Total**		**Grand Total**
								Max Marks	**Max Marks**	**Max Marks**	**Max Marks**	**Max Marks**	**Max Marks**	**Min Marks**	
1.	MMRIT01	Radiological and Medical Physics	2	1	6	6	2.5	30	70	100	--	--	--	--	**100**
2.	MMRIT02	Clinical Special Radiography Positioning	2	1	6	6	2.5	30	70	100	30	70#	100	50	**200**
3.	MMRIT03	Biostatistics and Research Methodology	3	--	--	3	2.5	30	70	100	--	--	--	--	**100**
4.		MMRIT Radiology Clinical Education – part I (studentship) *	--	--	15	5	--	--	--	--	30	70	100	50	**100**
	Total		**7**	**2**	**27**	**20**	--	--	--	**300**	--	--	**100**	--	**500**

Student Contact Hours Per Week: 36**Hrs.Theory and practical periods of 60 minutes each.** Medium of Instruction: **English** Total Marks **: 500**

Abbreviations: ESE- End Semester Exam, CIE- Continuous Internal Evaluation, L - Lectures, T - Tutorial, P - Practical *Internal Assessment, # External Assessment.

*Internal Assessment (Institutional Level examination) marks are not to be counted for the grade at the end of the semester.

Teaching and Examination Scheme

Course Name: Master in Medical Radiology and Imaging Technology

Duration of Program: Two Years (Four Semesters) Pattern : Full Time **Duration : 18 Weeks**

Semester : Second

S.N.	Course Code	Course Title	Teaching Scheme				Examination Scheme										Grand Total
							Theory					Practical					
								CIE	ESE	Total		CIE	ESE	Total			
			Theory (hrs/week)	Tutorial	C/ P (hrs/week)	Credits (L+T+P)	Exam Duration in Hrs.	Max Marks	Max Marks	Max Marks	Min Marks	Max Marks	Max Marks	Max Marks	Min Marks		
5.	MMRIT04	Modern Radiological Imaging - Equipment and Physics	2	1	4	5	2.5	30	70	100	50	--	--	--	--		100
6.	MMRIT05	Modern Imaging and Special Radiological Procedures	2	1	4	5	2.5	30	70	100	50	30	70#	100	50		200
7.	MMRIT06	Contrast Media and Interventional Radiology	2	1	4	5	2.5	30	70	100	50	30	70#	100	50		200
8.		MMRIT Radiology Clinical Education - part II (studentship)*	--		15	5	--	--	--	--	--	30	70	100	50		100
	Total		7	2	27	20	--	--	--	300	--	--	--	200	--		600

Student Contact Hours Per Week: 36**Hrs.Theory and practical periods of 60 minutes each.** Medium of Instruction: **English** Total Marks **: 600**

Abbreviations: ESE- End Semester Exam, CIE- Continuous Internal Evaluation, L - Lectures, T - Tutorial, P - Practical

*Internal Assessment, # External Assessment.

*Internal Assessment (Institutional Level examination) marks are not to be counted for the grade at the end of the semester.

Teaching and Examination Scheme

Course Name: Master in Medical Radiology and Imaging Technology

Duration of Program: Two Years (Four Semesters) Pattern : Full Time **Duration : 18 Weeks**

Semester : Third (**electives of CT Technology**)

S.N.	Course Code	Course Title	Teaching Scheme				Examination Scheme									Grand Total
							Theory					Practical				
							Exam Duration in	CIE	ESE	Total		CIE	ESE	Total		
			Theory (hrs/week)	Tutorial	C/P (hrs/week)	Credits (L+T+P)		Max Marks	Max Marks	Max Marks	Min Marks	Max Marks	Max Marks	Max Marks	Min Marks	
1.	MMRIT07	Principles of CT Imaging Technology	2	1	4	5	2.5	30	70	100	50	--	--	--	--	**100**
2.	MMRIT08	CT Imaging Procedures and Scanning Protocols	3	1	4	6	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT09	Basic and Cross-Sectional Anatomy in CT Imaging	--	2	4	4	--	--	--	--	--	30	70#	100	50	**100**
4.		MMRIT Radiology Clinical Education - part III (studentship)*	--		15	5	--	--	--	--	--	30	70	100	50	**100**
	Total		**5**	**4**	**27**	**20**	--	--	--	**200**	--	--	--	**200**	--	**500**

Student Contact Hours Per Week: 36**Hrs.Theory and practical periods of 60 minutes each.** Medium of Instruction: **English** Total Marks **: 500**

Abbreviations: ESE- End Semester Exam, CIE- Continuous Internal Evaluation, L - Lectures, T - Tutorial, P - Practical

*Internal Assessment, # External Assessment.

*Internal Assessment (Institutional Level examination) marks are not to be counted for the grade at the end of the semester.

Teaching and Examination Scheme

Course Name: Master in Medical Radiology and Imaging Technology

Duration of Program: Two Years (Four Semesters) Pattern : Full Time **Duration : 18 Weeks**

Semester : Fourth (**electives of CT Technology**)

S.N.	Course Code	Course Title	Teaching Scheme				Examination Scheme								Grand Total
							Theory				Practical				
			L (hrs/week)	T	C/P (hrs/week)	Credits (L+T+P)	Exam Duration in Hrs.	CIE	ESE	Total		CIE	ESE	Total	
								Max Marks	Max Marks	Max Marks	Min Marks	Max Marks	Max Marks	Max Marks	Min Marks	
1.	MMRIT10	Advancements in CT Technology	2	1	4	5	2.5	30	70	100	50	--	--	--	--	100
2.	MMRIT11	Quality Assurance, Radiation Protection and Patient care in CT Imaging	2	1	4	5	2.5	30	70	100	50	30	70#	100	50	200
3.	MMRIT12	Basic Pathology and Image Interpretation in CT Imaging	--	--	6	3	--	--	--	--	--	30	70#	100	50	100
4.	MMRIT13	Dissertation	--	--	--	2	--	--	--	--	--	30	70#	100	50	100
5.		MRMMRIT Radiology Clinical Education - part IV (studentship)*	--	--	15	5	--	--	--	--	--	30	70	100	50	100
	Total		**4**	**2**	**29**	**20**	--	--	--	**200**	--	--	--	**300**	--	**500**

Student Contact Hours Per Week: 36**Hrs.Theory and practical periods of 60 minutes each.** Medium of Instruction: **English** Total Marks **: 500**

Abbreviations: ESE- End Semester Exam, CIE- Continuous Internal Evaluation, L - Lectures, T - Tutorial, P - Practical

*Internal Assessment, # External Assessment.

*Internal Assessment (Institutional Level examination) marks are not to be counted for the grade at the end of the semester.

Teaching and Examination Scheme																
Course Name: Master in Medical Radiology and Imaging Technology																
Duration of Program: Two Years (Four Semesters) Pattern : Full Time **Duration : 18 Weeks** Semester : Third (**electives of MRI Technology)**																
S.N.	**Course Code**	**Course Title**	**Teaching Scheme**				**Examination Scheme**									**Grand Total**
							Theory					**Practical**				
								CIE	**ESE**	**Total**		**CIE**	**ESE**	**Total**		
			Theory (hrs/week)	**Tutorial**	**C/P (hrs/week)**	**Credits (L+T+P)**	**Exam Duration in Hrs.**	**Max Marks**	**Max Marks**	**Max Marks**	**Min Marks**	**Max Marks**	**Max Marks**	**Max Marks**	**Min Marks**	
1.	MMRIT14	Principles of MR Imaging Technology	2	1	4	5	2.5	30	70	100	50	--	--	--	--	**100**
2.	MMRIT15	MR Imaging Procedures and Scanning Protocols	3	1	4	6	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT16	Basic and Cross Sectional Anatomy in MR Imaging	--	2	4	4	--	--	--	--	--	30	70#	100	50	**100**
4.		MMRIT Radiology Clinical Education - part III (studentship)*	--		15	5	--	--	--	--	--	30	70	100	50	**100**
	Total		**5**	**4**	**27**	**20**	--	--	--	**200**	--	--	--	**200**	--	**500**

Student Contact Hours Per Week: 36**Hrs.Theory and practical periods of 60 minutes each.** Medium of Instruction: **English** Total Marks **: 500**

Abbreviations: ESE- End Semester Exam, CIE- Continuous Internal Evaluation, L - Lectures, T - Tutorial, P - Practical

*Internal Assessment, # External Assessment.

*Internal Assessment (Institutional Level examination) marks are not to be counted for the grade at the end of the semester.

Teaching and Examination Scheme

Course Name: Master in Medical Radiology and Imaging Technology

Duration of Program: Two Years (Four Semesters) Pattern : Full Time **Duration : 18 Weeks**

Semester : Fourth (**electives of MRI Technology**)

S.N.	Course Code	Course Title	Teaching Scheme				Examination Scheme									Grand Total
							Theory					Practical				
							Exam Duration in Hrs.	CIE	ESE	Total		CIE	ESE	Total		
			L (hrs/week)	Tutorial	C/P (hrs/week)	Credits (L+T+P)		Max Marks	Max Marks	Max Marks	Min Marks	Max Marks	Max Marks	Max Marks	Min Marks	
1.	MMRIT17	Advancements in MR Imaging Technology	2	1	4	5	2.5	30	70	100	50	--	--	--	--	**100**
2.	MMRIT18	Planning, Safety and Patient care in MR Imaging	2	1	4	5	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT19	Basics Pathology and Image Interpretation in MR Imaging	--	--	6	3	--	--	--	--	--	30	70#	100	50	**100**
4.	MMRIT20	Dissertation	--	--	--	2	--	--	--	--	--	30	70#	100	50	**100**
5.		MRMMRIT Radiology Clinical Education - part IV (studentship)*	--		15	5	--	--	--	--	--	30	70	100	50	**100**
	Total		**4**	**2**	**29**	**20**	--	--	--	**200**	--	--	--	**300**	--	**600**

Student Contact Hours Per Week: 36**Hrs.Theory and practical periods of 60 minutes each.** Medium of Instruction: **English** Total Marks : **600**

Abbreviations: ESE- End Semester Exam, CIE- Continuous Internal Evaluation, L - Lectures, T - Tutorial, P - Practical

*Internal Assessment, # External Assessment.

*Internal Assessment (Institutional Level examination) marks are not to be counted for the grade at the end of the semester.

Teaching and Examination Scheme

Course Name: Master in Medical Radiology and Imaging Technology

Duration of Program: Two Years (Four Semesters) Pattern : Full Time **Duration : 18 Weeks**

Semester : Fourth (**electives of Breast Imaging Technology**)

S.N.	Course Code	Course Title	Teaching Scheme				Examination Scheme									Grand Total
							Theory					Practical				
								CIE	ESE	Total		CIE	ESE	Total		
			Theory (hrs/week)	Tutorial	C/P (hrs/week)	Credits (L+T+P)	Exam Duration in Hrs.	Max Marks	Max Marks	Max Marks	Min Marks	Max Marks	Max Marks	Max Marks	Min Marks	
1.	MMRIT24	Advancements in Breast Imaging Technology	2	1	4	5	2.5	30	70	100	50	--	--	--	--	**100**
2.	MMRIT25	Quality Assurance, Radiation Protection and Patient care in Breast Imaging	2	1	4	5	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT26	Basics Pathology and Image Interpretation in Breast Imaging	--	--	6	3	--	--	--	--	--	30	70#	100	50	**100**
4.	MMRIT27	Dissertation	--	--	--	2	--	--	--	--	--	30	70#	100	50	**100**
5.		MMRIT Radiology Clinical Education - part IV (studentship)*	--		15	5	--	--	--	--	--	30	70	100	50	**100**
	Total		**4**	**2**	**29**	**20**	--	--	--	**200**	--	--	--	**300**	--	**600**

Student Contact Hours Per Week: 36**Hrs.Theory and practical periods of 60 minutes each.** Medium of Instruction: **English** Total Marks : **600**

Abbreviations: ESE- End Semester Exam, CIE- Continuous Internal Evaluation, L - Lectures, T - Tutorial, P - Practical

*Internal Assessment, # External Assessment.

*Internal Assessment (Institutional Level examination) marks are not to be counted for the grade at the end of the semester.

Teaching and Examination Scheme																
Course Name: Master in Medical Radiology and Imaging Technology																
Duration of Program: Two Years (Four Semesters) Pattern : Full Time **Duration : 18 Weeks** Semester : Third **(electives of Breast Imaging Technology)**																
S.N.	**Course Code**	**Course Title**	**Teaching Scheme**				**Examination Scheme**									**Grand total**
							Theory					**Practical**				
			Theory (hrs/week)	**Tutorial**	**C/P (hrs/week)**	**Credits (L+T+P)**	**Exam Duration in Hrs.**	**CIE**	**ESE**	**Total**		**CIE**	**ESE**	**Total**		
								Max Marks	**Max Marks**	**Max Marks**	**Min Marks**	**Max Marks**	**Max Marks**	**Max Marks**	**Min Marks**	
1.	MMRIT21	Principles of Breast Imaging Technology	2	1	4	5	2.5	30	70	100	50	--	--	--	--	**100**
2.	MMRIT22	Breast Imaging Procedures and Scanning Protocols	3	1	4	6	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT23	Basics and Cross sectional anatomy of Breast	--	2	4	4	--	--	--	--	--	30	70#	100	50	**100**
4.		MMRIT Radiology Clinical Education - part III (studentship)*	--		15	5	--	--	--	--	--	30	70	100	50	**100**
	Total		**5**	**4**	**27**	**20**	--	--	--	**200**	--	--	--	**300**	--	**500**
Student Contact Hours Per Week: **36Hrs.Theory and practical periods of 60 minutes each.** Medium of Instruction: **English** Total Marks : **500** Abbreviations: ESE- End Semester Exam, CIE- Continuous Internal Evaluation, L - Lectures, T - Tutorial, P - Practical *Internal Assessment, # External Assessment. *Internal Assessment (Institutional Level examination) marks are not to be counted for the grade at the end of the semester.																

Studentship or observership must include:

- A minimum of 14 hours per week is considered as studentship in very semesters.
- Provide simulation and skill labs for practising skills specific to the program in the initial years of observership/studentship.
- Every semester must have journal club/UG teaching/Mentoring/seminars/workshops on new developments/ technologies. Check annexure for marking criteria.

- All practical skills must be supervised and recorded in a digital Logbook and skills to be evaluated after the completion of the studentship.

Dissertation:

A candidate is required to carry out a research study in select area of his/her subject, under the supervision of a faculty guide. The results of such a study shall be submitted to the University in the form a dissertation as per the prescribed format and within the date stipulated by the University.

The dissertation work is aimed at training a postgraduate candidate in research methodology and techniques. It includes identification of the problem, formulation of a hypothesis, review of literature, getting acquainted with recent advances, designing of a research study, collection of data, critical analysis, and comparison of results and drawing conclusions.

Guide:

A Guide shall be a Post MD/PhD or MMRIT with atleast 2 years of teaching experience. Each guide can take up to a maximum of three students per academic year. However a co-guide can be opted wherever required with prior permission of the Institute and University. The co-guide shall also be a postgraduate teacher recognized by the University as a guide.

Candidate shall submit synopsis to the University through the Guide and Head of the Institute on or before end of first semester or within date notified by the University, whichever earlier.

Once the synopsis is approved and registered by the University no change in the topic or Guide shall be made without the prior approval of the University.

In the event of registered Guide leaving the Institute or in the event of the death of the Guide, a change of Guide shall be permitted by the University, on the specific recommendation of the Institute.

Schedule

The following procedure and schedule shall be strictly followed:

Ethical clearance

Ethical Clearance should be obtained for a study involving any procedure on human subject. The candidate should apply for the certificate to the Ethics Committee of the Institute/University, through the Guide and present the study before the Committee for clearance. A copy of the certificate should be attached along with the synopsis forwarded at the time of submission of synopsis. All such clearance should be sought within three months of the commencement of the I semester.

Submission of synopsis

Synopsis should be vetted by guide, HOD and departmental curriculum development cell and approved by the institutional ethics committee before submission to the university. The synopsis should be submitted as per the format on or before the end of first semester, or within the date notified by the University, whichever is earlier. Once the synopsis is approved and registered by the university no change in the topic or Guide shall be made without the prior approval of the University.

Final submission of the dissertation

The dissertation complete in all respects and duly certified by the Guide/Co-guide, Course Co-ordinator/ HoD/ Director should be submitted it to the Controller of Examinations as per the date specified by the University, generally three month before commencement of University examinations.

Preparation of dissertation

The written text of dissertation shall be as per the format, shall not exceed 100 pages (cover to cover). It should be neatly typed with 1.5 line spacing on one side of the paper (A4 size: 8.27" x 11.69") and properly bound. Spiral binding should be avoided. E-submission of the dissertation is mandatory.

Scheme of evaluation

The dissertation will be evaluated at the time of university examination of IV semester by a panel of examiner (Internal and External) appointed as per guidelines of NCAHP.

Evaluation format for dissertation

Sl. No	University Evaluation	Marks Max Marks
1.	Objectives, Research Question, Literature Review	25
2.	Results and Discussion	25
3.	Viva voce	50
	Total	**100**

Criteria for pass:

A candidate is declared to have passed the examination in a subject if he secures minimum 40% of marks separately and overall 50% marks separately in theory and practical including internal assessment.

A candidate who fails in any subject shall have to appear only in that subject in subsequent examination.

Carry over benefit:

A candidate shall appear for all the subjects of that particular semester in the University examinations but failed in that semester can avail this benefit, provided:

- A candidate who fails in not more than 2 subjects in I semester is allowed to move to II semester. The candidate with back log subjects shall take both I semester backlog subjects as well as II semester subjects. The candidate with a backlog of not more than 2 subjects in II semester is allowed to go to the III semester till he/she clears all I semester subjects.
- The candidate with a backlog of not more than 2 subjects in III semester is allowed to go to the IV semester till he/she clears all II semester subjects.
- Results of candidates will be declared at the end of IV semester only when the all backlog subjects are cleared by the candidates.

Maximum attempt: No more than three attempts shall be allowed for the candidate to pass the any subjects. If he/she fails to clear any subjects within three attempts will be considered as withdrawal of the course. Grading and Classification

Re-totalling:
Re-totalling of marks is permitted only for theory papers. The University, on application within the stipulated time and remittance of a prescribed fee, shall permit a re-totalling of marks for the course/s applied. The marks obtained after re-totalling shall be the final marks awarded. There is no re-evaluation offered for any of the subjects in MMRIT.

Supplementary Examinations:

Supplementary examination shall be conducted by the university for the benefit of unsuccessful candidates. Lower semester examinations shall be conducted by the University along with current semester examinations for the benefit of unsuccessful candidates.

- A Candidate detained for lack of attendance will be barred from appearing in any one or all course/s for the supplementary examination.
- A candidate permitted to appear for the supplementary examination can improve his internal assessment marks before he takes the supplementary examination by subjecting himself to internal assessment.

Conduct and discipline:

Candidates shall conduct themselves within and outside the premises of the Institute in a manner befitting the student of an educational institution.
As per the order of Honorable Supreme Court of India, ragging in any form is considered as a criminal offence and is banned. Any form of ragging will be severely dealt with.

The following act of omission and/or commission shall constitute gross violation of the code of conduct and are liable to invoke disciplinary measures:
Ragging as defined and described by the Supreme court/Government Lack of courtesy and decorum; indecent behaviour anywhere within or outside the campus. Willful damage or stealthy removal of any property/belongings of the Institute/Hostel or of fellow candidates/citizens. Possession, consumption or distribution of alcoholic drinks or any kind of hallucinogenic drugs. Mutilation or unauthorized possession of library books. Noisy or unseemly behaviour, disturbing studies of fellow candidates. Hacking in computer systems (such as entering into other person`s domain without prior permission, manipulation and/or damage to the computer hardware and software or any other cyber crime etc.) Plagiarism of any nature. Any other act of gross indiscipline as decided by the Board of Management from time to time.
Commensurate with the gravity of offense, the punishment may be: reprimand, fine, expulsion from the hostel, debarment from an examination, disallowing the use of certain facilities of the Institution, rustication for a specific period or even outright expulsion from the Institution, or even handing over the case to appropriate law enforcement authorities or the judiciary, as required by the circumstances.
For any offence committed in (i) a hostel (ii) a department or in a classroom and (iii) elsewhere, the Chief Warden, the Head of the Department and the Head of the Institution, respectively, shall have the authority to reprimand or impose fine.
All cases involving punishment other than reprimand shall be reported to the Vice-Chancellor.
Cases of adoption of unfair means and/or any malpractice in an examination shall be reported to the Controller of Examinations for taking appropriate action.

Grading system
Letter grades and CGPA

The performance of a candidate shall be evaluated according to a Letter Grading System, based on the both CIE and ESE. The letter grades (O, S, A+,A, B, C , F and I) indicate the level of academic achievement assessed on a 10 point scale (0 to 10).

Marks Range (%)	Grade Point	Letter Grade	Descriptor	Classification	CGPA
90 & above	10	O	Outstanding	First Class with Distinction	7.50 and above
80-89	9	S	Excellent		
75-79	8	A+	Very Good		
65-74	7	A	Good	First Class	6.50 -7.49
60-64	6	B	Average	Second Class	6.00 - 6.49
50-59	5	C	Pass		5.00 - 5.99
Below 50	0	F	Fail	Fail	Less than 5.00
Absent	0	I	Absent		

For non- credit courses 'Satisfactory' (P) or 'Unsatisfactory' (F) shall be indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA

A candidate shall be considered to have completed a course successfully and earned the credits assigned, if he secures an acceptable letter grade in the range O-C. Letter grade 'F' in any course implies failure in that course and no credit is earned.

A candidate having satisfactory attendance at classes and meeting the passing standard at CIE in a course, but remained absent from
ESE shall be awarded 'I' grade in that course.

Grade Point Averages:
The overall performance of a candidate will be indicated by Grade Point Average (GPA). For each course grade points will be awarded as per a letter grading system.

Semester Grade Point Average (SGPA) is computed as follows:

$\sum$ [(course credit) X (Grade point)] for all courses with

Letter grades, including F

SGPA = ...

$\sum$ [(course credits)] for all courses with Letter grades, including F

Cumulative Grade Point Average (CGPA) is computed as follows:

$\sum$ [(course credit) X (Grade point)] for all courses for all semesters

with, Letter grades excluding F

CGPA = ...

$\sum$ [(course credits)] for all courses for all semesters with

Letter grades, excluding F

Conversion of Grades into Percentage
Formula for conversion of GPA into percentage: CGPA earned X10 = Percentage of marks scored
Illustration: (CGPA Earned 8.18 X 10) = 81.80 %

Award of Class:
The candidate, who has passed all the courses prescribed, shall be declared to have passed the program. Class will be awarded only to those who pass the entire examination in the first attempt and on the basis of the aggregate of marks scored in individual semester.

- A candidate who secures GPA $\geq$ 7.00 and above in first attempt shall be declared to have passed in 'First Class with Distinction'.
- A candidate who secures GPA $\geq$ 6.00 or more but less than 7.00 in the first attempt shall be declared to have passed in 'First Class'.
- A candidate who secures GPA $\geq$ 5.00 or more but less than 6.00 in the first attempt shall be declared to have passed in 'Second Class'.
- A candidate who secures GPA $\geq$ 4.00 or more but less than 5.00 in the first attempt shall be declared to have passed in 'Pass Class'.
- Candidates who pass the examinations in more than one attempt shall be declared as passed in 'Pass' class irrespective of the percentage of marks secured.
- An attempt means the appearance of a candidate for one or more courses either in part or full in a particular examination. If a candidate submits application for appearing for the examination but does not appear for any of the courses either in full or part in the university examination, he can appear for supplementary examination provided other conditions such as attendance requirement, internal assessment marks, etc are fulfilled and his appearing in the supplementary examination shall be considered as the first attempt.

Graduation requirements:
Candidate shall be declared eligible for the award of the degree if he or she has:

- Fulfilled all degree requirements.
- No dues to the University, Institution, departments, hostels, library etc.
- No disciplinary action pending against him.

The award of degree must be recommended by the Board of Management.

Convocation:

Degrees will be awarded in person to all eligible students who have graduated during preceding academic year at the annual convocation.

Board of examiners for each semester:

The Examination Committee shall recommend in such manner as may be determined by the State Board, names of suitable experts as the chairman of panels of Board of examiner for setting and moderating the question papers and arrange the panels of moderatorsand examiners prepared in such manner as per the guidelines of the NCAHP.

HOD of Radiology: Chairperson

Programme Co-ordinator/Course Co-ordinator/Chief of MRIT /Incharge of MRIT: Co-chairperson

Subject Experts:

External examiner (one person):

- The examiner must be subject expert.

Internal examiner (one person):

- The examiner must be subject expert.

First Semester

Subject: Radiological and Medical Physics

Subject Code: MMRIT01

RATIONALE

Radiological and Imaging Technology instrumentation and its physics are the primary pillars underlying the practice of radiological and Imaging technology and understanding the principles of radiation physics helps MMRIT to become a qualified MMRIT technologist.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Describe general physics related to imaging

CO2: Differentiate between within general radiation

CO3: Identify construction of radiology equipment's

CO4: Interpret quality of control of radiology equipment's

CO5: Differentiate between x-ray equipment's and other radiology related equipment's

CO6: Describe production of x-rays

CO7: Describe circuit system of radiology equipment's

CO8: Describe the structure and working of x-ray tube, production of x-rays

CO9: Describe the types of x-ray tube and heat dissipation methods

CO10: Explain the x-ray generator circuits

CO11: Describe the different circuit types

CO12: Describe the meters and exposure timers

CO13: List the control of scattered radiation

CO14: Describes about the fluoroscopy

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	6	6	30	70	30	70	200

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	**Basic concepts**: Units and measurements-Force, work, power and energy-Temperature and heat-SI units of above parameters. Atomic structure-atom model-Nucleus-electronic configuration-periodic table-Isotopes-Ionization-excitation-Binding energy-electron volt-Electromagnetic radiation-Quantum nature of radiation-mass energy equivalence-Fluorescence-electromagnetic spectrum.	4	5
2.	**Electricity and magnetism**: Electric charges, Coulomb's law-Unit of charge-Electric potential, unit of potential-Electric induction, capacitance and Capacitors, series and parallel connection-electric current, unit, resistance, ohm's law, electric power, Joule's law. Varying currents-Growth and decay of current in LR circuit time constant, charge and discharge of a Capacitor through a resistance and inductance. Oscillations in an LC circuit. Alternating currents: Peak and RMS values and current and voltage, circuit containing LR, CR and LCR-Power factor, series and parallel LCR circuits, DC circuit, Ohm's law, resistivity, series and parallel combination, EMF, Kirchhoff's law, heating effect of current. **Electromagnetic waves**: Introduction, Maxwell's equation, electromagnetic waves, energy density and intensity, momentum, electromagnetic spectrum and radiation in Atmosphere.	4	5
3.	**Electronics** Semiconductors; Conduction in crystals, Energy bands. Intrinsic and Extrinsic semiconductors n-type and p-type semiconductors, majority and minority carriers. Semiconductor diodes: p-n junction-properties forward and reverse bias, characteristics of p-n junction Rectifiers-Half-wave and full wave, ripple factor, Efficiency of HW and FW rectifiers. Filter circuits; Zener diode, regulated power supply. Transistors-Symbols, Transistor connections and characteristics, Transistor as an amplifier, load line analysis, operating point, types of amplifiers-voltage and power amplifiers. Feedback-negative feedback in amplifiers.	4	5
4.	**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.	4	5
5.	**Heat** Definition of heat, temperature, Heat capacity, specific heat capacity, Heat transfer-conduction, convection, radiation, thermal conductivity, equation for thermal conductivity (k), the value of k of various material of interest in radiology, thermal expansion, Newton's law of cooling,	4	5

	Heat radiation, perfect black body, Stefan law, application in Diagnostic Radiology (Heat dissipation in both stationary and rotating X-ray tubes).		
6.	**Interaction of ionizing radiation with matter**-Types of interactions of X-and gamma radiation, Photoelectric & Compton, Pair production, annihilation radiation. 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.	4	5
7.	**Exponential attenuation** (linear/mass attenuation coefficients), Half Value Thickness (HVT), Tenth Value Thickness (TVT), dependence on energy and atomic number. Radiation intensity and exposure, photon flux and energy flux density. LET, range of energy relationship for alpha, beta particles with X-Rays. **Physical quantity, its unit and measurement**: Fundamental and derived quantity, SI unit, various physical/radiation quantity used in Diagnostic Radiology and its unit.	3	5
8.	**X-ray tube:** historical aspects, construction of X-ray tubes, requirements for X-ray production(Electron source, target and anode material), tube voltage, current, space charge, early X-ray tubes(Coolidge tubes, tube envelop and housing) cathode assembly, X-ray production efficiency, advances in X-ray tubes, anode angulation and rotating tubes-line focus principle-space charge effect, tube cooling-Modern X-ray tubes-stationary anode, rotating anode, grid controlled X-ray tubes, heel effect, off focus radiation, tube insert and housing-Tube rating-Quality and intensity of x-rays-factors influencing them. **Production of x-rays:** X-ray tube, gas filled x-ray tube, construction working and limitations; stationary anode x - ray tube; construction, working, methods of cooling the anode, rating chart and cooling chart;	4	5
9.	**Rotating anode x - ray tube:** construction, working rating chart, speed of anode rotation, angle of anode inclination, dual focus and practical consideration in choice of focus, anode heel effect, grid controlled x - ray tube; effect of variation of anode voltage and filament temperature; continuous and characteristics spectrum of x - rays, inherent filter and added filter, their effect on quality of the spectrum. **Grid controlled and high-speed tubes**, focal spot size, speed of anode rotation, target angle, inherent filtration, radiation leakage and scattered radiation). Interlocking and X-ray tube overload protection.	4	5

	Heat dissipation methods, tube rating, heat units, operating conditions and maintenance and QA procedures.		
10.	**Filament current and voltage**, X-ray circuits (primary circuit, auto transformer), types of exposure switch and timers, principle of automatic exposure control (AEC) and practical operation, filament circuit, high voltage circuits, half wave, full wave rectification, three phase circuits. Types of generators, 3 phase, 6 and 12 pulse circuits-high frequency generators-falling load generators, Capacitors discharge and grid control systems. **X-ray generator circuits:** Vacuum tube diodes-semi-conductor diodes-transistor-Rectification-half and full wave-self rectification-X-ray generator; filament circuit-kilo Voltage circuit-single phase generator-three phase generator-constant potential generator-Fuses, switches and interlocks-Exposure switching and timers-HT cables-earthing.	**4**	**5**
11.	**High tension circuits:** H.T. generator for x-ray machines, three phase rectifier circuits, three phase six rectifier circuit, three phase 12 rectifier circuit, high and medium frequency circuits; capacitance filter control and stabilizing equipment; mains voltage compensator, mains resistance compensator, compensation for frequency variation, control of tube voltage, kV compensator; high tension selector switch, filament circuit, control of tube current, space charge compensation.	**2**	**2**
12.	**Meters and exposure timers:** Moving coil galvanometer: construction and working/conversion to millimeter, ammeter and voltmeter, meters commonly used in diagnostic x-ray machines, pre reading kV meter and millimeter, digital panel meters. Clockwork timers, synchronous motor timer, electronic timers, photo metric timers (fluorescent and photoelectric effect as applied in timers), ion chamber-based timers, integrated timer.	**3**	**5**
13.	**Control of scattered radiation and Beam limiting devices:** cones, diaphragms, light beam collimator, beam centering device, methods to verify beam centering and field alignment; Filters- inherent filters, added filters, heavy metal filters, grids; design and control of scattered radiation, grid ratio, grid cut-off, parallel grid, focused grid, crossed grid, grided cassettes, stationary and moving grid potter bucky diaphragms, various types of grid movements; single stroke movement, oscillatory movement and reciprocatory movement.	**2**	**5**
14.	**Fluoroscopy:** Fluorescence and phosphorescence - description, fluorescent materials used in fluoroscopic screens, construction of fluoroscopic screen and related accessories, tilting table, dark adaptation. Image intensifier - Construction and working, advantages	**4**	**5**

	over fluoroscopic device, principles and methods of visualising intensified image, basic principles of closed circuit television camera and picture tube. Vidicon camera, CCD. Automatic brightness control, automatic exposure control, chamber selection during fluoroscopy. Serial radiography: Manual cassette changer, rapid automatic film changer, basic principles of cine fluoroscopy and angiography use of grid controlled x-ray tube.		
15.	**Care and Maintenance of X-ray equipment;** General care; functional tests; testing the performance of exposure timers, assessing the MA settings, testing the available KV, measurement of focal spot of an x-ray tube, testing the light beam diaphragm, practical precautions pertaining to Brakes and locks, H.T. cables, meters and controls, tube stands and tracks as well as accessory equipment.	2	3
	Total	**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No	Radiological physics	Hours
1.	Discovery of X-ray production and properties	10
2.	Interaction of ionizing radiation with matters	10
3.	Exponential attenuation, Physical quantity, its unit and measurement	10
	Medical Physics	
4.	X-ray tube; Production of x-rays	18
5.	Rotating anode x - ray tube; Grid controlled and high speed tubes; Heat dissipation methods	10
6.	Filament current and voltage; X-ray generator circuits	10
7.	High tension circuits; Interlocking circuits; Relays	10
8.	Meters and exposure timers	10
9.	Fluoroscopy	10
10.	Care and Maintenance of X-ray equipment	10
	Total	108

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	**No. of questions**	**Marks per question**	**Total**
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Basic radiologicalphysics	K. Thayalan	Jaypee Brothers Medical Publishers (P) Limited, 2003
2.	Christinsens physics of diagnosticradiology	Curry and Dowdey	Wolters Kluwer
3.	X-Ray Equipment for Student	D.N. And M.O. Chesney	Blackwell Science Ltd
4.	A Textbook Of Radiation Physics For Radiologic Technology	Surendra Maharjan,Suraj Sah	Samiksha Publcation
5.	Radiographic Imaging (Cbs)I.C.R.P.	D.N. Chesney & M.O Chesney	CBS Publishers & Distributors
6.	An Introduction Of Physics to Diagnostic Radiography	Christensen, Curry &Dowdey	Lea&Febiger
7.	Radiological Science for technologists	Stewart C Bushong	Mosby
8.	Equipment for Diagnostic Radiography	E. Forster	Springer Dordrecht

Subject: Clinical Special Radiography Positioning

Subject Code: MMRIT02

RATIONALE

Clinical Radiography Positioning provides the students with knowledge of x-ray imaging, positioning and all the care that should be taken.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Understand the basic patient positioning during radiographic investigation.

CO2: Apply special positioning skills for different pathological and physical conditions.

CO3: Application of equipments while working in radiology departments.

CO4: Choose proper position during radiography.

CO5: Explain relative positions of x-ray tube and patient relevant exposure factors during radiography.

CO6: Explain the use of accessories.

CO7: Explain the anatomic and physiological basis of the procedure to be undertaken.

CO8: Explain the radiographic appearances of both normal and common abnormal conditions.

CO9: Prepare management and positioning of patients

CO10: Correlate of indications, contraindications of the patient

CO11: Understand the patient preparations needed before any radiological examination.

CO12: Generalize knowledge of post procedural care.

CO13: Students will be able position the patients for radiological procedures.

CO14: Knowledge of image quality in radiological images.

CO15: Management of patients in radiology department for various procedures.

CO16: Ability to handle emergency situations in radiology department.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
2	**2**	**6**	**7**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	**Principles of Radiography:** Preparation of the Room, Apparatus and Instruments Positions of the Patient: Erect, Sitting, Supine, Prone, Lateral, Oblique, Decubitus Etc. Relative position of X-Ray tube and patient, relevant exposure factors. Use of accessories such as radiographic cones, grid and positioning aids. Anatomic and Physiological basis of the procedure, Association with theory with practical work. Radiographic appearances, both normal and common abnormal conditions where elementary knowledge of the pathology involved will ensure the application of the appropriate radiographic technique. Modifications in technique for various disabilities and types of subject. Radiation protection, use of gonad shield, practical methods of reducing radiation dose to the patient.	6	5
2.	**Upper limb:** Special projections for the whole hand, fingers, wrist joint, forearm, elbow joint and humerus. Supplementary projections for Scaphoid, Carpal tunnel, Ball Catchers projections, Head of the Radius, Supracondylar fracture and Olecranon process	6	9
3.	**Lower limb:** Special projections for the whole foot, toes, calcaneum, ankle joint, leg, knee- joint, patella and femurs. Supplementary projections for Talo-Calcaneal joint, Forced projections for torn ligaments, Flat Feet, Club Feet, Intercondylar projections for loose bodies in the knee, Axial projection for Patella.	6	9
4.	**Shoulder Girdle and Thorax:** Special projections for the shoulder joint, Scapula, Acromio-Clavicular joint, Clavicle, Sternoclavicular joint, Sternum and Ribs. Supplementary projections for the axial projection of Clavicle, Bicipital groove, Coracoid process.	6	6

5.	**Vertebral Column:** Special projections for Atlanto -Occipital joint, cervical spine, Cervico- thoracic Junction, thoracic Spine, lumbar Spine, Lumbo Sacral Region, Sacrum and Coccyx. Supplementary projections for the intervertebral foramina, posterior arch of Atlas, Flexion and Extension of Cervical Spine, Scoleosis and Kyphosis, Sacro Ileac Joint.	6	6
6.	**Skull:** Special projections for cranium and facial bones; Supplementary projections for trauma, Towne's method, Sellaturcica, Optic foramina, Jugular foramina, Temporal bones, Mastoids, Petrous bone, Zygomatic arches, Orbits, Maxillae, Nasal bones, Mandible, Temporomandibular joints. Nasal Sinuses: Techniques for Frontal, Maxillary, Ethmoidal and Sphenoid Sinuses, erect and horizontal projections for fluid levels.	6	6
7.	**Pelvic girdle and hip region:** Special projections for the whole pelvis, Sacro-Ileac joints, hip joint and Neck of Femur. Supplementary projections for the greater and lesser trochanters of Femur. Frog leg projection, Ischeum, Symphysis Pubis, Ileum, Acetabulum and Congenital Dislocation of Hip, Arthrodesis. **Skeletal survey:** Skeletal survey for metabolic bone disease, metastases, hormonal disorder, renal disorders.	6	6
8.	**Dental Radiography** Technique for intra oral full mouth.- Occlusal projections Extra oral projections including orthopantomography.- Supplementary techniques. **Upper respiratory system** Technique for postnasal airways, larynx, trachea, thoracic inlet, Valsalva manoeuvre. - Phonation.	6	6
9.	**Lungs and Mediastinum:** Supplementary projections: Antero-posterior, obliques, lordotic, apical projection, use of penetrated postero-anterior projection. - Expiration technique. - Technique for pleural fluid levels and adhesions. **Abdominal viscera-** Technique for plain film examination. - Projection for acute abdomen patients. - Technique to demonstrate: Foreign bodies, Imperforate anus.	6	6

10.	**Mammography:** Basic views, special views, wire localization.	**6**	**3**
11.	**Trauma radiography/Emergency radiography**General precautions, Asepsis in techniques - Checking of mains supply and functions of equipment, selection of exposure factors, explosion risk, radiation protection and rapid processing techniques.	**6**	**3**
12.	**Soft Tissue Radiography:** High and low kilo voltage technique; differential filtration. Non - screen technique - simultaneous screen and non -screen technique. **Multiple radiography.** Uses of soft tissue radiography. **High kV Radiography:** General principles Relation to patient dose Change in radiographic contrast. **Neonatal and Paediatric Radiography** **Forensic Radiography** **Scatter elimination; beam collimation; grid ratio.** **Speed and type of grid movement**	**6**	**5**
Total		**72**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Principles of Radiography	5
2.	Upper limb	10
3.	Lower limb	10
4.	Shoulder Girdle and Thorax	10
5.	Vertebral Column	10
6.	Skull	10
7.	Pelvic girdle and hip region, Skeletal survey	5
8.	Dental Radiography; Upper respiratory system	5
9.	Lungs and Mediastinum; Abdominal viscera	10
10.	Radiography in the ward; Mammography	13
11.	Operation theatre techniques; C-arm	5
12.	Soft Tissue Radiography	10

Sr. No		Hours
	Multiple radiography High kV Radiography Scatter elimination; beam collimation; grid ratio Speed and type of grid movement Radiographic factor; application and uses	
13.	Neonatal and Paediatric Radiography; Forensic Radiography Macroradiography Localization of foreign bodies	5
	Total	108

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests • Same pattern as Summative test • Average of two to be considered • Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Atlas of Radiographic Positioning and Radiological Procedures	Philip W Ballinger, Eugene D. Frank	Mosby
2	Clarks Positioning In Radiography	Ra Swallow, E Naylor	Lippincott Williams and Wilkins
3	Merrill's Atlas of Radiographic Positioning and Procedures	Bruce W. Long & Jeannean Hall Rollins & Barbara J. Smith	Mosby
4	Bontrager'S Textbook Of Radiographic Positioning And Related Anatomy	John Lampignano and Leslie E Kendrick	Elsevier Science
5	Radiology Of Positioning And Applied Anatomy For Students And Practitioners	GarkalGs	Jaypee Brothers Medical Publishers

Subject: Biostatistics and Research Methodology

Subject Code: MMRIT03

RATIONALE:

The application of statistical techniques to scientific research in health-related fields, including medicine, biology, and public health, and the development of new tools to study these areas.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Understand the Importance of statistics course in the curriculum

CO2: Understands Statistical Terms

CO3: Possess Knowledge and Skill in the use of Basic Statistics in the analysis and interpretation of data

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	--	3	30	70	--	--	100

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	Introduction: Meaning, Definition, Characteristics of Statistics; Importance of the Study of Statistics. Branches of Statistics; Descriptive and Inferential Statistics; Variables and Their Types. Measurement Scales.	6	10
2.	Tabulation of Data: Raw Data, the Array, Frequency Distribution. Basic Principles of Graphical Representation; Types of Diagrams - Histograms, Frequency Polygons, Smooth Frequency Polygon, Commutative Frequency Curve, O give; Normal ProbabilityCurve.	6	10
3.	Measure of Central Tendency: Need For Measures of Central Tendency; Definition and Calculation of Mean; Ungrouped and Grouped Meaning, Interpretation and Calculation of Median	6	15

	Ungrouped and Grouped; Meaning and Calculation of Mode; Comparison of the Mean, and Mode; Guidelines for the Use of Various Measures of Central Tendency.		
4.	Measure of Variability: Need For Measure of Dispersion. The Range, the Average Deviation, The Variance and Standard Deviation; Calculation of Variance and Standard Deviation, Ungrouped and Grouped.	**6**	**15**
5.	Probability and Standard Distributions: Meaning of Probability of Standard Distribution, The Binominal Distribution. The Normal Distribution; Divergence from Normality - Skewness,Kurtosis	**6**	**10**
6.	Sampling Techniques: Need For Sampling - Criteria for Good Samples. Application of Sampling in Community, Procedures of Sampling and Sampling Designs Errors. Sampling Variation and Tests of Significance.	**6**	**10**
Total		**54**	**70**

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Elements of HealthStatistics	Rao.N.S	
2	An introduction ofBiostatistics	Sunder Rao	
3	Methods inBio-Statistics	B.K. Mahajan	
4	Elementary Statistics in MedicalWorkers	Inderbir Singh	
5	An Introduction to. Statistical Methods, Ram Prasad &Sons	Gupta C.B	

MMRIT Radiological Clinical Education- part I (studentship): 16 hrs/week

The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Second Semester

Subject: Modern Radiological Imaging - Equipment and Physics

Subject Code: MMRIT04

RATIONALE

Modern radiological Imaging Equipment and Physics provides the students knowledge about the modern x-ray equipment and working principle. Modern imaging techniques – including X-rays, ultrasound, CT scans and MRI – can show structures inside your body in great detail. Radiologic Physics is the study of medical imaging components, technology, and parameters in an effort to produce optimal imaging results. The goal with studying radiologic physics is to ensure you get clear images while ensuring the patient is safe from radiation.

COURSE OUTCOMES

At the end of the course students will be able to...

CO001: Describe the special radiological equipments

CO002: Describe the digital and computed radiography

CO003: Describe PACS, RIS and HIS

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
3	**1**	**4**	**6**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignmentsminimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	Modern x-ray tube: its principle, physics & equipment	5	5
2.	Digital Radiography: its principle, physics & equipment. Flat panel digital fluoroscopy and radiography system, Direct and indirect digital radiography and fluoroscopy systems. Digital radiography and Computed radiography its advantages, disadvantages and applications. Digital Portable and mobile x-ray units	5	5

3.	Dual energy x-ray absorptionometry (DEXA) scan: its principle, physics & equipment	5	5
4.	Computed radiography: its principle, physics & equipment.	5	5
5.	Mammography and Tomosynthesis: its principle, physics & equipment	5	5
6.	Modern dental equipments. Cone beam dental CT	5	5
7.	Bone mineral density test: its principle, physics & equipment	5	5
8.	Picture archiving and communication system (PACS), RIS, HIS and Teleradiology	5	5
9.	Computed Tomography	7	5
10.	Magnetic Resonance Imaging	5	5
11.	Ultrasound Imaging	5	5
12.	Hybrid Imaging	5	5
13.	Smart Simulator/virtual imaging	5	5
14.	Artificial Intelligence in Modern Radiological Imaging	**5**	**5**
Total		**72**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Modern x-ray tube: its principle, physics & equipment	5
2.	Digital Radiography	5
3.	Dual energy x-ray absorptionometry (DEXA) scan: its principle, physics & equipment	2
4.	Computed radiography	3
5.	Mammography and Tomosynthesis: its principle, physics & equipment	5
6.	Modern dental equipments. Cone beam dental CT	3
7.	Bone mineral density test: its principle, physics & equipment	2

Sr. No		Hours
8.	Picture archiving and communication system (PACS), RIS, HIS and Teleradiology	5
9.	Computed Tomography	5
10.	Magnetic Resonance Imaging	5
11.	Ultrasound Imaging	5
12.	Hybrid Imaging	5
13.	Smart Simulator/virtual imaging AI Imaging	4
Total		**54**

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.
Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S.No.	Title of Book	Author	Publication
1	Textbook of Radiology: Physics	Amol Sasane, Hariqbal Singh , Roshan Lodha	Jaypee Brothers Medical Publishers
2	The Physics Of Radiology And Imaging	THAYALAN K	Jaypee Brothers Medical Publishers
3	Christensen's Physics of Diagnostic Radiology	Thomas S. Curry (Author), James E. Dowdey (Author), Robert E. Murry (Author)	Lea &Febiger,U.S
4	Textbook Of Radiology For Residents And Technicians	BHARGAVA S. K	CBS; publishers
5	Ultrasound physics and technology	Vivien gibbs, davidcole, Antonio sassano	Churchill Livingstone;
6	Manual of Diagnostic Ultrasound	Philip E. S. Palmer (Author)	World Health Organization
7	Physics and Technical Aspects Diagnostic Ultrasound	DINESH K BAGHEL (Author	AITBS PUBLISHERS

Subject: Contrast Media and Interventional Radiology

Subject Code: MMRIT05

RATIONALE

Interventional radiology (IR) helps student MRIT to gain about the basics diagnostics and interventional procedures and to learn procedures in modalities like digital radiography CT and MRI and nuclar medicine and to increase the level of understandings and knowledge required to meet current radiologic procedures and to understand the physical principles of radiography and basic radiography positioning to perform the procedures. it a medical specialty that performs various minimally-invasive procedures using medical imaging guidance, such as x-ray fluoroscopy, computed tomography, magnetic resonance imaging, or ultrasound. IR performs both diagnostic and therapeutic procedures through very small incisions or body orifices

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Know the basic principle and physics of interventional equipment.
CO2: Know the management and positioning of patients while performing interventional radiological procedure.
CO3: Have knowledge about the indications, contraindications, contrast media, radiation dose, exposure timing and radiation safety measures for the different interventional radiological procedure.
CO4: Understand the patient preparation needed before any interventional radiological procedures.
CO5: Have knowledge about the post procedural care and safety.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
2	**1**	**4**	**5**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignments minimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	**Contrast Media**: Positive and Negative, Ionic &Non Ionic, Adverse Reactions to contrast media and patient management.	8	10
2.	Introduction to interventional procedures **DSA:** principles and types **Equipment:** Basics of angiographic equipments, single and biplane angiographic equipments, angiographic table, image intensifier, flat panel detectors, recording systems, pulseoximetry, cardiac resuscitation measure-ECG, pressure injector, catheters, needle and other tools, 3D rotational angiography, image processing, patient monitor, CO2 angiography	8	10
3.	**Interventional procedures:** Catheter- classification, types and applications, Guide wire- classification, types andapplications, Pressure Injector and Accessories,Percutaneous catheterization, Digital Subtraction Angiography, Catheterization Sites, Asepsis	8	10
4.	**Arteriography:** Head and Neck Arteriography, Pulmonary Arteriography, Coronary Arteriography, Ascending Aortography, Trans Lumbar Aortography, Renal Arteriography, Trans Femoral Arteriography **Venography:** Peripheral Venography- Lower Limb, Upper Limb, Central Venography, Superior Venacavography, Inferior Venacavography, Pelvic Venography	20	20
5.	**Safety considerations in angiography room**; room design, protective devices, radiation monitoring	5	10
6.	**Care and maintenance tests:** General care, functional test **Quality assurance program:** Acceptable limits of variation, corrective action	5	10
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
5.	Contrast Media	10
6.	Basics of angiographic equipments	10
7.	Catheter and guide wires	10
8.	Arteriography and venography procedures	20
9.	Safety considerations in angiography room	12
10.	Care and maintenance tests Quality assurance program:	10
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	The practice of interventional radiology	Karim valji	
2	Interventional radiology: a survival guide	EBIR Kessel, David, MB, BS, MA, MRCP, FRCR (Author), FRCR Robertson, Iain, MB, ChB, MRCP	Elsevier Health Sciences
3	Handbook of Interventional Radiologic Procedures	Krishna kandarpa (author), lindsay machan (author), janettedurham (author)	Lippincott Williams and Wilkins
4	Interventional Radiology: A Survival Guide	David Kessel MB BS MA MRCP FRCR EBIR, Iain Robertson MB chb MRCP FRCR	sevier Health Sciences

Subject: Modern Imaging and Special Radiological Procedures

Subject Code: MMRIT06

RATIONALE

Contrast & Special Radiological Procedures are diagnostic procedures usually performed by giving contrast through oral or intravenous to diagnose the disease. These imaging procedures are done under the guided of fluoroscopy or c-ram equipment.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Prepare management and positioning of patients while performing radiological procedures.

CO2: Correlate of indications, contraindications, contrast media, radiation dose, exposure timing and radiation safety measures for different radiological procedures.

CO3: Understand the patient preparations needed before any radiological examination.

CO4: Generalize knowledge of post procedural care.

CO5: Students will be able position the patients for radiological procedures.

CO6: Knowledge of image quality in radiological images.

CO7: Management of patients in radiology department for various procedures.

CO8: Ability to handle emergency situations in radiology department.

CO9: Precautions and care required in interventional suits.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
2	**1**	**4**	**5**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignments minimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	Introduction: General approach to Special Radiographic procedures, Responsibility of Radiology Technologist during radiological procedures, Preparation of patient for different procedures, Room layout in interventional radiology and fluoroscopy.	6	5
2.	Basics and modern Emergency Equipment's in the Radiology Department	4	5
3.	Gastrointestinal Tract: Barium Swallow; Barium Meal - Single and Double Contrast; Barium Meal Follow Through; Small Bowel Enema (Enteroclysis); Barium Enema - Gastrograffin Enema; Loopogram Advanced procedures of Gastrointestinal Tract	10	15
4.	Biliary Tract: Oral & Intravenous Cholecystography; Percutaneous Transhepatic Cholengiography; Percutaneous Transhepatic Biliary Drainage; Endoscopic Retrograde Cholengiopancreatography Advanced procedures ofBiliary Tract	10	15
5.	Urinary System: IVU (Intravenous Urography), Retrograde Pyeloureterography (RGU), Micturating Cysto Urethrography, Ascending Urethrography. Advanced procedures of Urinary System	10	15
6.	Reproductive System: HysteroSalpingogram, FTR (Fallopian Tube Recanalization) Advanced procedures of Reproductive System	5	5
7.	Respiratory System: Bronchography, Percutaneous Lung Biopsy Advanced procedures of Respiratory System	5	5
8.	Other procedures in radiology: Arthrography, Sialography, Lymphography, Sinography & Fistulography, Dacryocystography, Embolization & embolic agents Related Advanced procedures.	4	5
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
5.	General approach to special radiographic procedures, responsibility of radiology technologist during radiological procedures Contrast media and their adverse reactions to contrast media and patient management	10
6.	Procedures for gastrointestinal tract including barium studies Procedures for biliary tract	15
7.	Procedures for urinary system and reproductive system	15
8.	Procedures for central nervous system and respiratory system	15
9.	Other procedures in radiology: Arthrography, Sialography, Lymphography, Sinography & Fistulography, Dacryocystography, Embolization & embolic agents Related Advanced procedures.	17
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Radiographic Imaging (Cbs)I.C.R.P.	Bhushan and Lakkhar	Arya Publications
2	A guide to radiological procedures	Chapman	Elsevier

MMRIT Radiological Clinical Education- part II (studentship): 16 hrs/week

The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Elective – Specialization of CT Imaging Technology

Third Semester

Subject: Principles of CT Imaging Technology

Subject code: MMRIT07

Rationale: It aims to provide knowledge related to the basic working principle and construction of CT scanners and the various hardware and software mechanisms required for obtaining the cross-sectional imaging. It also gives a brief review of the history and evolution of the CT scanners.

Course Outcome

At the end of the semester student must be able to:

CO1: Should gain a comprehensive understanding of the principles behind CT imaging, including the physics and technology involved in generating cross-sectional images.

CO2: Will learn the practical aspects of CT scanning such as patient positioning, selection of appropriate protocols and the use of contrast agents.

CO3: Students should be able to explain the process of image reconstruction in CT and understand how raw data is transformed into meaningful images.

CO4: Will learn to assess CT image quality and identify common imaging artefacts, as well as strategies to minimize or correct these artefacts.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	4	5	30	70	30	70	200

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignments minimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and content	Hours	Marks
1	**Introduction to CT:** Basic principle of tomography,definition of terms, Image reconstruction from projections. AI in CT	7	10
2	Evolution of terms	3	3
3	**Process**: data acquisition and image reconstruction Image display, Processing, storage, Recording and communications	6	10
4	**Working of CT** Basic principle of CT Instrumentation Reconstruction algorithms AI in CT	10	15
5	**History of CT:** Early experiments by Godfrey Newbold Hounsfield, Allan Macleod Cormack	3	2
6	**Generations of CT** Generation of CT /Geometry	7	10
7	**Fast scanner** Helical/ Spiral scanner Applications of volume scanning AI in CT	7	7
8	**Image formation in CT** Hounsfield unit, CT windowing, CT image quality CT artifacts. Quality assurance and control in CT AI in CT	9	10
9	Merits and demerits of Computed tomography	2	3
	Total	54	70

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Introduction and History CT and Evolution of terms	6
2.	Process and Working in CT	19
3.	Generations and Image formation in CT	25
4.	Fast scanner Merits and demerits of Computed tomography	20
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Computed Tomography: Physical Principles, Clinical Applications, and Quality Control	Euclid Seeram RT(R) BSc MSc FCAMRT (Author)	Saunders
2	Computed Tomography for Technologists: A Comprehensive Text	Lois Romans	Lippincott Williams and Wilkins;
3	Computed Tomography: Physics and Technology. A Self Assessment Guide	Euclid Seeram	Wiley-Blackwell
4	The CT Handbook: Optimizing Protocols for Today`s Feature-Rich Scanners	Timothy P. Szczykutowicz	Medical Physics Publishing Corporation

Subject: CT Imaging Procedures and Scanning Protocols

Subject code: MMRIT08

Rationale

CT Procedures and Scanning Protocol course is to provide participants with a comprehensive understanding of the various procedures involved in computed tomography (CT) imaging and the principles of selecting appropriate scanning protocols for different clinical scenarios.

Outcome

At the end of the semester student must be able to:

CO1:CT procedures and scanning protocols result in high-quality images that allow radiologists and healthcare professionals to make accurate and precise diagnoses. Clear and detailed CT images aid in identifying and characterizing various medical conditions, such as tumors, fractures, infections, and other abnormalities.

CO2: Will be able to acquire Accurate CT imaging helps healthcare providers create effective treatment plans for patients. The information obtained from CT scans can guide surgical procedures, radiation therapy, and other interventions, leading to improved patient outcomes.

CO3: Must follow appropriate scanning protocols and employ dose reduction techniques to minimize the amount of radiation the patient receives during the scan. This ensures that the benefits of the CT scan outweigh any potential risks associated with radiation exposure.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	4	5	30	70	30	70	200

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignments minimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

S. No	Topic	Hours	Marks
1	**CT Head and Neck:** CT Brain, Cerebral Angiography, CT orbit, CT face with 3D post-processing, CT temporal bone, CT PNS, CT neck, neck angiography, Head and neck venography, CT cisternography	10	10
2	**CT Thorax:** CT thorax (Supine, prone, Expiratory), HRCT thorax, CT pulmonary angiography, CT aortography.	8	8
3	**CT Abdomen and Pelvis:** CT KUB, CT abdomen (Dual and triple phase), Liver, pancreas and renal protocol, CT enterography, CT pelvis, CT abdominal angiography, CT renal angiography, CT urography, CT cystogram	12	15
4	**CT Musculoskeletal System:** CT shoulder, elbow, wrist, hand, hip, femur, knee, tibia & fibula, ankle, foot. CT peripheral angiography/Venography.	8	10
5	**CT Spine:** CT whole spine, CT cervical, thoracic, lumbar and LS spine, CT sacrum & coccyx, CT Myelography. Lumbar Puncture, CSF Aspiration.	9	15
6	**Miscallaneous:** Paediatric CT, Adult Whole-body CT, CT fluoroscopy, Breast CT Imaging	7	12
	Total	**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	CT Head and Neck	10
2.	CT Thorax	10
3.	CT Abdomen and Pelvis	10
4.	CT Musculoskeletal System	10
5.	CT Musculoskeletal System	10
6.	CT Spine	10

Sr. No		Hours
7.	Miscallaneous	12
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	**Title of Book**	**Author**	**Publication**
1	Computed Tomography: Physical Principles, Clinical Applications, and Quality Control	Euclid Seeram RT(R) BSc MSc FCAMRT (Author)	Saunders
2	Computed Tomography for Technologists: A Comprehensive Text	Lois Romans	Lippincott Williams and Wilkins;
3.	Computed Tomography: Physics and Technology. A Self Assessment Guide	Euclid Seeram	Wiley-Blackwell
4.	The CT Handbook: Optimizing Protocols for Today`s Feature-Rich Scanners	Timothy P. Szczykutowicz	Medical Physics Publishing Corporation

Subject: Basic and Cross Sectional Anatomy in CT Imaging

Subject code: MMRIT09

Rationale

CT Cross Sectional Anatomy course typically aims to provide participants with a comprehensive understanding of the anatomical structures as visualized in computed tomography (CT) images. The course focuses on developing the necessary knowledge and skills to accurately interpret CT cross-sectional images of the human body.

At the end of semester student must be able to:

CO1: Participants should be able to identify and label major anatomical structures in CT cross-sectional images, including organs, bones, blood vessels, nerves, and other relevant tissues.

CO2: Will learn to interpret CT images in different planes (transverse, sagittal, and coronal) to gain a complete understanding of the spatial relationships and dimensions of anatomical structures.

CO3: Will become proficient in recognizing normal anatomy across various body regions, enabling them to distinguish variations from pathology.

CO4: Will develop the ability to identify and describe common pathological conditions and abnormalities seen in CT cross-sectional images, such as tumors, inflammation, fractures, and vascular anomalies.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
--	--	6	3	--	--	30	70	100

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignments minimum one per unit based on the curriculum.

PRACTICAL COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and content	Hours	Marks
1	Cross Sectional Anatomy of: Head Vascular supply of brain Venous supply of brain Cranial nerves	20	14
2	Neck cross sectional anatomy Vascular supply of neck Venous supply of neck	14	8
3	Thorax cross sectional anatomy Vascular supply of thorax Venous supply of thorax	18	12
4	Abdomen cross sectional anatomy Vascular supply of adomen Venous supply of abdomen	20	12
5	Pelvis cross sectional anatomy (male and female) Vascular supply of pelvis Venous supply of pelvis	16	6
6	Vertebral body and extremities	8	5
7	Muscles, ligaments and tendons	6	5
8	Upper and lower limb blood supply	6	8
	Total	108	70

Evaluation System

There will be no Theory examination at university level for this subject.

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Practical tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	**Title of Book**	**Author**	**Publication**
1	Cross Sectional Anatomy CT and MRI	Govind Chavhan, Bhavin Jankharia	Jaypee Brothers Medical Pub.
2	Cross-Sectional Anatomy for Computed Tomography	Michael L. Farkas	Springer New York
3.	Sectional Anatomy by MRI and CT	Mark W. Anderson, Michael G Fox	Elsevier Health Sciences
4.	Atlas of Human Cross-Sectional Anatomy With CT and MR Images	Donald R. Cahill, Matthew J. Orland, Gary M. Miller	Wiley

MMRIT Radiological Clinical Education- part III (studentship): 16 hrs/week

The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Fourth Semester

Subject: Advancements in CT Technology

Subject code: MMRIT10

Rationale

Advances Techniques in Computed Tomography Technology aims to provide participants with specialized knowledge and skills related to the latest advancements and cutting-edge techniques in the field of Computed Tomography (CT) imaging.

Outcome

At the end of the semester student must be able to:

CO1: Will gain a comprehensive understanding of the latest advancements and cutting-edge techniques in CT imaging. This knowledge may include advanced imaging protocols, reconstruction methods and clinical applications.

CO2: Will give a deeper understanding of advanced CT techniques, participants can potentially improve diagnostic accuracy, leading to better patient outcomes and more effective treatment planning.

CO3: Involved in research and development, the course may inspire new ideas and insights that contribute to the ongoing advancement of CT technology and medical imaging.

CO4: Completion of this advanced course may provide continuing education credits or professional development recognition for individuals in the medical field.

CO5: Acquiring knowledge and skills in advanced CT techniques could lead to expanded career opportunities or increased responsibilities within their respective workplaces.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	4	5	30	70	30	70	200

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignments minimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and content	Hours	Marks
1	**Advanced CT Imaging Techniques:** Dual-Energy CT Dynamic CT, and iterative reconstruction algorithms. Role of these techniques enhance image quality and improve diagnostic accuracy	4	3
2	**CT Angiography (CTA)**: principles and applications of CT angiography, including vascular imaging, cardiac CTA, CTPA and peripheral CTA. Role of CTA in diagnosing vascular diseases and assessing blood flow.	8	10
3	**CT Perfusion Imaging:** CT perfusion imaging and its use in assessing tissue perfusion, blood flow, and detecting cerebral or abdominal ischemia.	4	5
4	**Dual-Source CT and Multidetector CT (MDCT):** benefits of dual-source and MDCT scanners, such as reduced scan times, improved spatial resolution, and decreased radiation dose	4	5
5	**Cardiac CT Imaging**: cardiac CT imaging, including coronary artery assessment, cardiac function evaluation, and the role of CT in cardiac disease diagnosis, Calcium Scoring.	4	10
6	**Radiation Dose Optimization**: advanced techniques for optimizing CT scanning protocols to reduce radiation dose while maintaining image quality	2	3
7	**Advanced Post-processing Techniques**: advanced image post-processing techniques, such as 3D volume rendering, maximum intensity projection (MIP), and multiplanar reconstruction (MPR)	3	5
8	**CT-guided Interventions**: CT-guided procedures and interventions, including biopsy, drainage and ablation techniques	4	5
9	**Virtual CT**: Colonoscopy: the techniques used in virtual CT colonoscopy, a non-invasive method for imaging the colon and detecting polyps and other abnormalities Bronchoscopy: technique, post processing and applications.	4	5
10	**Advanced Image Reconstruction**: advanced image reconstruction techniques such as iterative reconstruction algorithms which improve image quality while reducing radiation dose.	3	5
11	**Artifact Reduction Strategies**: techniques to minimize and correct artifacts that can arise in advanced CT imaging, ensuring accurate diagnosis and interpretation	4	5
12	**Radiation Dose Management**: strategies for optimizing CT protocols to reduce radiation dose while maintaining diagnostic image quality.	2	2
13	**Contrast Media Innovations**: new contrast media agents and protocols used in CT imaging to enhance image contrast and visualization of specific tissues or pathologies, automatic contrast tracking techniques.	2	2
14	**Quality Assurance and Image Quality Assessment**: quality assurance protocols specific to advanced CT technology and the assessment of image quality.	4	3

15	**Emerging Trends in CT**: latest developments and emerging trends in CT technology, including artificial intelligence applications and new imaging advancements.	2	2
	Total	54	70

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Dual-Source CT and Multidetector CT (MDCT Advanced CT Imaging Techniques	8
2.	Radiation Dose Management Radiation Dose Optimization	6
3.	Contrast Media Innovations	4
4.	Advanced Post-processing Techniques Advanced Image Reconstruction	8
5.	Quality Assurance and Image Quality Assessment	4
6.	Emerging Trends in CT	4
7.	Artifact Reduction Strategies	8
8.	Virtual CT CT-guided Interventions	10
9.	CT Angiography (CTA) Cardiac CT Imaging	14
10.	CT Perfusion Imaging	6
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	**No. of questions**	**Marks per question**	**Total**
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Computed Tomography: Physical Principles, Clinical Applications, and Quality Control	Euclid Seeram RT(R) BSc MSc FCAMRT (Author)	Saunders
2	Computed Tomography for Technologists: A Comprehensive Text	Lois Romans	Lippincott Williams and Wilkins;
3.	Computed Tomography: Physics and Technology. A Self Assessment Guide	Euclid Seeram	Wiley-Blackwell
4.	The CT Handbook: Optimizing Protocols for Today's Feature-Rich Scanners	Timothy P. Szczykutowicz	Medical Physics Publishing Corporation

Subject: Quality Assurance, Radiation Protection and Patient care in CT Imaging

Subject code: MMRIT11

Rationale

Radiation Protection and Patient Care in CT course aims to provide participants with essential knowledge and skills related to ensuring patient safety and implementing radiation protection measures during computed tomography (CT) examinations.

Course Outcome

At the end of semester student must be able to:

CO1: Should gain a comprehensive understanding of the principles of ionizing radiation, its interaction with human tissues, and the potential risks associated with radiation exposure.

CO2: Will be familiarized with the ALARA (As Low As Reasonably Achievable) principle and learn techniques to minimize radiation dose to patients while maintaining image quality.

CO3: Should learn strategies for optimizing CT scanning protocols and adjusting parameters to achieve appropriate image quality with the lowest possible radiation dose.

CO4: Radiation Protection Guidelines: Participants will be introduced to national and international radiation protection guidelines specific to CT imaging.

CO5: Will learn proper patient positioning and centering techniques to ensure accurate imaging and reduce the need for repeat scans.

CO6: Should be aware of the unique considerations and radiation protection protocols when imaging paediatric and pregnant patients.

CO7: Will understand the use of contrast agents in CT imaging, their potential risks, and the importance of proper patient screening for allergies and contraindications.

CO8: Should understand the importance of infection control practices in the CT environment, including equipment cleaning and proper hygiene measures.

CO9: Will become aware of ethical and legal responsibilities in providing radiation protection and patient care in CT imaging.

CO10: Will be educated on safety measures and protocols to protect healthcare professionals and staff working in the CT department.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	4	5	30	70	30	70	200

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignments minimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and content	Hours	Marks
1	**Introduction of Radiation Protection**: Principles of radiation protection, ALARA/ALARP, MPD, The Role of the CT Technologist, Radiation in Pregnancy and children.	10	15
2	**Radiation quantities and units:** Factors Affecting Dose in CT, CT Dosimetry – MSAD, Bed Index, CTDIw, CTDIvol, DLP.	6	10
3	**Biological units of radiation**: Radiation detection and measurements, LET, OER, survey meters, Geiger muller counter, ionisation chambers.	6	10
4	**Radiation Hazard evaluation and control**: Scatter and Leakage radiation, ICRP guidelines for CT room design, Radiation Signage, Protective devices.	10	10
5	**AERB and ICRP guidelines:** Limits for radiation exposure	4	5
6	**Contrast media in CT**: ionic and non-ionic agents, lethal dose, contrast administration techniques, contrast tracking techniques.	4	5
7	**Radiation protection**: Radiation protection for patient and staff, personnel protective apparel. AI in radiation safety.	6	5
8	**Pre and post-procedural care in CT**: Patient transfer and Restraining techniques, Infection control and sterilization, Medical ethics and records, Patient care in special cases: Spinal injuries, Trauma, Stroke, Burns, Cardiac emergency.	8	10
	Total	54	70

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Introduction of Radiation Protection AERB and ICRP guidelines	20
2.	Radiation quantities and units Biological units of radiation	20
3.	Pre and post-procedural care in CT	5
4.	Radiation protection	10
5.	Radiation Hazard evaluation and control	12
6.	Contrast media in CT	5
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Computed Tomography: Physical Principles, Clinical Applications, and Quality Control	Euclid Seeram RT(R) BSc MSc FCAMRT (Author)	Saunders
2	Computed Tomography for Technologists: A Comprehensive Text	Lois Romans	Lippincott Williams and Wilkins;
3.	Computed Tomography: Physics and Technology. A Self Assessment Guide	Euclid Seeram	Wiley-Blackwell
4.	The CT Handbook: Optimizing Protocols for Today's Feature-Rich Scanners	Timothy P. Szczykutowicz	Medical Physics Publishing Corporation

Subject: Basic Pathology and Image Interpretation in CT Imaging

Subject code: MMRIT13

Rationale

Imaging pathology and image interpretation in computed tomography (CT) is to facilitate accurate and early detection, characterization, and evaluation of various medical conditions and abnormalities within the body. CT imaging is a non-invasive, widely available, and valuable medical imaging modality that provides detailed cross-sectional images of the internal structures of the body.

Outcome

At the end of the semester the student must be:

CO1: To Identify diseases and abnormalities at an early stage often leads to better patient outcomes.

CO2: Learn the extent and location of pathologies, aiding in precise diagnosis and treatment planning.

CO3: Will learn CT guide certain medical procedures such as biopsies, drainages, and needle aspirations.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
--	**--**	**6**	**3**	**--**	**--**	**30**	**70**	**100**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignments minimum one per unit based on the curriculum.

PRACTICAL COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and content	Hours	Marks
1.	Basic pathologies and general interpretations of Head, Face&Neck	15	10
2.	Basic pathologies and general interpretations of Vascular imaging	5	5
3.	Basic pathologies and general interpretations of Spine	15	10
4.	Basic pathologies and general interpretations of Brachial plexus,Chest, Heart and great vessels	10	5
5.	Basic pathologies and general interpretations of Breast	5	5
6.	Basic pathologies and general interpretations of Kidney, Pancreas, Liver and biliary system	13	5

7.	Basic pathologies and general interpretations of Abdomen and Pelvis	10	5
8.	Basic pathologies and general interpretations of Upper limb	10	5
9.	Basic pathologies and general interpretations of Lower Limb	10	5
10.	Basic pathologies and general interpretations of Peripheral vascular system	5	5
11.	Basic pathologies and general interpretations of Pediatric imaging	10	10
	Total	**108**	**70**

Evaluation System

There will be no Theory examination at university level for this subject.

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Practical tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	CT & MRI Pathology: A Pocket Atlas, Third Edition	Michael L. Grey, Jagan Mohan Ailinani	Snippet view
2	Normal Findings in CT and MRI	Torsten Bert Moeller, Emil Reif	
3.	Neurological Practice: An Indian Perspective	Wadia	

MMRIT Radiological Clinical Education- part IV (studentship): 16 hrs/week

The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Elective – Specialization of MR Imaging Technology Third Semester

Subject: Principles of MR Imaging Technology

Subject Code: MMRIT14

RATIONALE

The basic working principles of Magnetic resonance imaging along with the construction and equipments necessary for the image formation, processing, encoding, storage and display. To comprehend the image quality parameters, identify artifacts and assure image quality with the aid of quality assurance tests and tolerance limits.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Identify the basic physical concepts involved in MRI

CO2: Understand the various imaging parameters that determine image contrast.

CO3: Describe the various image weighting techniques and its application

CO4: To comprehend principles of gradients and spatial encoding.

CO5: Concept of K- space and its traversal involved in MR image formation.

CO6: Knowledge of image quality in MRI images.

CO7: Apply MR imaging parameters in the clinical setting and its trade-off to optimize image quality.

CO8: Ability to minimize image artifacts and understand various Quality assurance tests.

CO9: Precautions and care required during MR Imaging

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
2	**1**	**4**	**5**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignmentsminimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	**Introduction and Basic principles**: Atomic structure and motion, MR active nuclei, Hydrogen MRI, spin precession, Larmor equation, Resonance, Relaxation, T1 and T2 Times.	8	10
2.	**Image contrast and weighting**: Intrinsic and extrinsic parameters of MR Image contrast, T1, T2 and PD weighting and its applications, T2* decay, FID.	6	8
3.	**Spatial Encoding and K-Space**: Gradients, Slice selection, frequency and phase encoding, K space basic concept, its filling and traversal, Fast Fourier transform.	4	6
4.	**MRI Pulse sequences:** Spin echo sequences, Inversions recovery sequences, Gradient eco sequences, echo planar imaging, Parallel imaging.	10	10
5.	**MR Instrumentation and Safety**: Magnets- types and application, Radio waves, Coils- types and functions, Shielding, Shimming, MR scanner Construction and components, MRI safety considerations, Signage, MR Compatible/conditional/non-compatible devices. AI in MRI.	10	10
6.	**Image Parameters and quality**: SNR, CNR, Scan time, Spatial Resolution. Trade-offs between parameters.	4	8
7.	**MRI Contrast Agents**: Mechanism of action, T1 and T2 Agents, classification and applications of contrast agents, doses in adults and pediatrics, Safety considerations in pregnancy and lactation.	6	8
8.	**MRI artifacts**: Causes, appearance, remedy. Quality assurance tests and tolerance limits.	6	10
Total		54	70

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Image contrast and distinction between differently weighted images.	10
2.	Manipulating TR and TE for T1, T2 and PD weighted images.	10
3.	Identifying and manipulating various image parameters to maintain image quality	10
4.	Identifying the various types of coils and their uses. Distinction between SE and GRE sequences.	12
5.	Understanding MRI safety principles and patient screening.	10
6.	Contrast agents and its uses, dosage and administration process, time-intensity curves.	10
7.	MRI artifacts	10
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Fundamentals of MRI	Stark &Bradely	
2	MRI in practice, 4th edition	Catherine Westbrook, Carolyn Kaut Roth, and John Talbot	Wiley-Blackwell
3.	Magnetic Resonance Imaging, Physical and Biological Principles 4th edition.	Stewart Bushong and Geoffrey Clarke	

Subject: MR Imaging Procedures and Scanning Protocols

Subject Code: MMRIT15

RATIONALE

To comprehend the indications, contraindications, patient preparation, positioning, coils used and other specific considerations while performing the different MRI scan Protocols. Basic understanding of Parameter manipulation and post procedural care.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Identify the indications and contraindications for various protocols

CO2: Understand the various patient preparation aspects, including history taking and screening.

CO3: Describe the parameters and sequences used to acquire necessary images.

CO4: To comprehend principles of image quality for each type of protocol and the trade-off.

CO5: Types of coils used, positioning and landmark for each anatomical examination.

CO6: Knowledge of Post procedural care.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
2	**1**	**4**	**5**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignmentsminimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	**MRI Brain:** Routine, stroke, epilepsy, MS, tumour protocols, MR Angiography (COW), MR Venography, CSF Flow analysis.	10	14

2.	**MRI Face:** Orbit, Cochlea, OSA, Pituitary, Neck, Brachial Plexus, Sialography, Dacrocystography	7	10
3.	**MRI Upper limb protocols:** Shoulder, elbow, wrist, hand. MR Upper limb angiography/venography. Shoulder Arthrography.	9	10
4.	**MRI Lower limb Protocols:** Pelvis- bony, male and female, hip joint, knee, ankle, foot. MR Cartigram. Lower Limb Angiography/Venography.	9	10
5.	**MRI Spine:** Cervical, Thoracic, Lumbo-sacral, Flexion-Extension, Whole spine screening.Composing. MR Cisternography, Myelography.	9	12
6.	**MRI Thorax-Abdomen:** Cardiac MR, routine Abdomen, MRCP, Fetal MRI, Fistulography, MR Prostate, MR Placenta, MR Urography, Enteroclysis. Respiratory and ECG Gating techniques	5	7
7.	**All special MRI procedures** including MRCP, perfusion scan, ASL, FMRI, Cardiac MRI etc. Pediatric scan: Kitten MRI	5	7
Total		54	70

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	MRI Brain and special sequences acquired in different pathologic conditions.	10
2.	MRI Face and neck region, angiographies and various post-processing techniques involved.	10
3.	Upper and Lower limb MRI protocols for various anatomical structures.	10
4.	Fistulography, Sialography, Dacrocyctography, MRCP and the various contrasts, techniques and parameters of acquisition.	12
5.	Understanding MRI safety principles and patient screening prior to patient position in the clinical setting.	10
6.	Contrast agents and its uses, dosage and administration process, time-intensity curves.	10
7.	MR in Pregnancy	10
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	**No. of questions**	**Marks per question**	**Total**
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Musculoskeletal MRI E-Book	Major, Nancy M., Anderson, Mark W	
2.	MRI in practice, 4th edition	Catherine Westbrook, Carolyn Kaut Roth, and John Talbot	Wiley-Blackwell
3.	Magnetic Resonance Imaging, Physical and Biological Principles 4th edition.	Stewart Bushong and Geoffrey Clarke	

Subject: Basic and Cross-Sectional Anatomy in MR Imaging

Subject Code: MMRIT16

RATIONALE

To identify and understand the various anatomical structures, so that positioning and planning of protocols is performed proficiently. To also comprehend various pathological conditions and interpret images efficiently.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Identify the cross –sectional anatomical structures with ease

CO2: Understand the various post processing techniques to optimize anatomical visualization. .

CO3: Identify the various blood vessels or nerves and its anatomical correlation.

CO4: To comprehend principles of image quality for each type of protocol based on anatomical structure

CO5: Types of coils used, positioning and landmark for each anatomical examination.

CO6: Knowledge of various pathological conditions and the special sequences used to optimize its visualization.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
--	-	6	3	--	--	30	70	100

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignmentsminimum one per unit based on the curriculum.

PRACTICAL COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	**Basic Anatomy:** Anatomical Terminologies, Sectional planes, movements, Joints, surface anatomy.	12	6
2.	**Brain**: Cross-sectional Anatomy, lobes, ventricles, Brainstem, blood supply, venous sinuses, cranial nerves. Paranasal sinuses, orbits, pituitary gland.	16	10
3.	**Neck:** Major vessels – carotids, aorta, pulmonary vessels, Brachial plexus, Thyroid, cartilages, salivary glands and duct system, muscles of the back.	14	8
4.	**Upper limb:** Shoulder- rotator cuff, elbow, wrist, hand, metacarpals, carpals,phalangs, related muscles and tendons. Arterial supply and venous drainage.	14	8
5.	**Lower limb:** Pelvis- bony, male and female, hip joint, knee, ankle, foot, metatarsals, tarsals, ligaments, tendons, muscles,popliteal fossa, arterial supply and venous drainage.	14	10
6.	**Spine:** Cervical, Thoracic, Lumbar, sacrum, coccyx, ribcage, muscles attached. Spinal cord, meninges, nerve roots, vertebral disc.	12	10
7.	**Thorax:** Lungs, Heart, Mediastinum, Respiratory volumes, Esophagus, Trachea, Bronchial tree, Bronchopulmonary segments, Diaphragm.	12	8
8.	**Abdomen:** Stomach, Small and Large Intestines, Liver, pancreas, Biliary tree, Spleen, Kidneys and renal vasculature, excretory system, reproductive system (male and female), Aorta and its branches.	14	10
Total		108	70

Evaluation System

There will be no Theory examination at university level for this subject.

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Practical tests Same pattern as Summative test	50		
	Average of two to be considered Absence without prior permission to be marked as 0			
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	**Title of Book**	**Author**	**Publication**
1	Cross Sectional Anatomy CT and MRI	Govind Chavhan, Bhavin Jankharia	Jaypee Brothers Medical Pub.
2	Cross-Sectional Anatomy for Computed Tomography	Michael L. Farkas	Springer New York
3.	Sectional Anatomy by MRI and CT	Mark W. Anderson, Michael G Fox	Elsevier Health Sciences
4.	Atlas of Human Cross-Sectional AnatomyWith CT and MR Images	Donald R. Cahill, Matthew J. Orland, Gary M. Miller	Wiley

MMRIT Radiological Clinical Education- part III (studentship): 16 hrs/week

The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Fourth Semester

Subject: Advancements in MR Imaging Technology

Subject Code: MMRIT17

RATIONALE

To Stay abreast of the advancements and special procedures performed Using MRI in various conditions. The innovation in Hardware, software and post-processing techniques available for advanced image acquisition and diagnosis.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Understand the basic principles of advanced techniques of MRI

CO2: To constantly stay abreast of the latest advancements and innovations in the field of MRI

CO3: Identify the various Diffusion related processes and its applications.

CO4: To comprehend principles of magnetic susceptibility and its uses.

CO5: Advancement in the hardware, software and post-processing techniques.

CO6: Knowledge of various pathological conditions and the special sequences or protocols/procedures performed to optimize its visualization.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
2	**1**	**4**	**5**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignmentsminimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	**Flow Phenomenon:** Types of flow, mechanisms, Compensation, CSF Flow Analysis.	10	10
2.	**MRA:** Conventional Vascular imaging techniques, DSA, TOF-MRA, Phase Contrast MRA, Velocity encoding MRA	10	10
3.	**Diffusion and its advancements:** DWI, Diffusion Tensor Imaging, White matter Tractography. Physics, protocol and its applications.	4	10
4.	**MR Spectroscopy:** Metabolites, hunters angle, CHESS, STEAM, PRESS, MRS in Breast and Prostrate. Related pathologies and protocol.	10	10
5.	**fMRI:** Paradigms, Hemodynamic response function,Perfusion Imaging - DSC, DCE, ASL and its types. Protocols, Principles and applications.	6	10
6.	**Iron and Fat quantification:** Fat suppression techniques, Elastography, Quantification techniques, parameters and applications.	6	10
7.	**Miscallaneous advancements**: Sodium MRI, Portable MRI Systems, Ultra-high Magnetic field systems, MR Mammography, Synthetic MRI, Interventional MRI techniques.	6	10
Total		54	70

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Flow Phenomenon and MRA	20
2.	Diffusion and its advancements	12
3.	MR Spectroscopy and fMRI	20
4.	Iron and Fat quantification	10
5.	Miscallaneous advancements	10
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	**No. of questions**	**Marks per question**	**Total**
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Tomography and Magnetic Resonance Imaging of the Whole Body (Vol.1&II) (Saunders)	John R. Haaga (Author), Daniel Boll (Author)	Elsevier
2.	MRI inPractice	Catherine Westbrook &CaralynKaut	Wiley–Blackwell
3.	Protocols inMRI	Catherine Westbrook	Wiley-Blackwell
4.	An Introduction to the Physics and Function of Magnetic Resonance Imaging	Dominik Weishaupt , Victor D. Koechli , Borut Marincek , J.M. Froehlich	Springer

Subject: Planning, Safety and Patient care in MR Imaging

Subject Code: MMRIT18

RATIONALE

Students comprehend the effects of MRI on the human body, learn the safety aspects to prevent accidents and maintain high image quality while ensuring patient compliance and pleasant patient experience

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Understand the basic safety measures to be taken while performing MRI

CO2: To Ensure optimum patient care

CO3: Identify the various MRI compatible/conditional and non compatible devices and warn patients accordingly.

CO4: To comprehend the various hazards involved in MRI and to know how to prevent Accidents.

CO5: To learn the various MRI facility zones and other MRI Safety considerations.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	4	5	30	70	30	70	200

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignmentsminimum one per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and contents	Hours	Marks
1.	**Bioeffects of MRI:** Bio-effects of static and gradient magnetic fields, Acoustic noise, Bio-effects of radiofrequency power deposition and induced heating during MRI, SAR, Claustrophobia, anxiety and emotional distress in the MR	14	16

2.	**MRI facility design:** Site selection, MRI safety zones, Scanner room layout. Shielding techniques, Faraday Cage.	**10**	**14**
3.	**Implants:** Materials used as implants and prosthesis,cardiac devices, Patient monitoring in the MRI environment, Managing Acute situations, Screening, History, Metal Detection.	**10**	**14**
4.	**MRI Contrast Safety:** Identification and management of acute reactions related to gadolinium based contrast agents, Contrast safety in pregnancy and lactation, nephrogenic systemic fibrosis, Extravasation.	**10**	**16**
5.	**Miscallaneous Safety aspects:** Quenching, Ambient temperature, cryogen levels,Safety issues for interventional MR Systems, MRI safety guidelines, policies and procedures.	**10**	**10**
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Bioeffects of MRI	14
2.	MRI facility design	12
3.	MRI Contrast Safety	12
4.	Miscallaneous Safety aspects	16
5.	Implants	18
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			

	Total	*50*	*0.3*	*15*
	Total CIE marks			*30*

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Tomography and Magnetic Resonance Imaging of the Whole Body (Vol.1&II) (Saunders)	John R. Haaga (Author), Daniel Boll (Author)	Elsevier
2.	MRI inPractice	Catherine Westbrook &CaralynKaut	Wiley–Blackwell
3.	Protocols inMRI	Catherine Westbrook	Wiley-Blackwell
4.	An Introduction to the Physics and Function of Magnetic Resonance Imaging	Dominik Weishaupt , Victor D. Koechli , Borut Marincek , J.M. Froehlich	Springer

Subject: Basics Pathology and Image Interpretation in MR Imaging

Subject Code: MMRIT19

RATIONALE

Students comprehend the effects of MRI on the human body, learn the safety aspects to prevent accidents and maintain high image quality while ensuring patient compliance and pleasant patient experience

COURSE OUTCOMES

At the end of the course students will be able to...

- To Identify diseases and abnormalities at an early stage often leads to better patient outcomes.
- Learn the extent and location of pathologies, aiding in precise diagnosis and treatment planning.
- Will learn MR guide certain medical procedures such as biopsies, drainages, and needle aspirations.

Image-guided procedures improve accuracy, minimize risks, and reduce the need for exploratory surgeries.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
--	--	6	3	--	--	30	70	100

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable assignmentsminimum one per unit based on the curriculum.

PRACTICAL COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency.

Unit	Topic and content	Hours	Marks
1.	Basic pathologies and general interpretations of Head, Face&Neck	15	10
2.	Basic pathologies and general interpretations of Vascular imaging	5	5
3.	Basic pathologies and general interpretations of Spine	15	10
4.	Basic pathologies and general interpretations of Brachial plexus, Chest, Heart and great vessels	10	5
5.	Basic pathologies and general interpretations of Breast	5	5
6.	Basic pathologies and general interpretations of Kidney, Pancreas, Liver and biliary system	13	5
7.	Basic pathologies and general interpretations of Abdomen and Pelvis	10	5
8.	Basic pathologies and general interpretations of Upper limb	10	5
9.	Basic pathologies and general interpretations of Lower Limb	10	5

10.	Basic pathologies and general interpretations of Peripheral vascular system	5	5
11.	Basic pathologies and general interpretations of Pediatric imaging	10	10
	Total	**108**	**70**

Evaluation System

There will be no Theory examination at university level for this subject.

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Practical tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	CT & MRI Pathology: A Pocket Atlas, Third Edition	Michael L. Grey, Jagan Mohan Ailinani	Snippet view
2	Normal Findings in CT and MRI	Torsten Bert Moeller, Emil Reif	
3.	Neurological Practice: An Indian Perspective	Wadia	

MMRIT Radiological Clinical Education- part IV (studentship): 16 hrs/week

The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Elective-specialization of Breast Imaging Technology

Third Semester

Subject: Principle of Breast Imaging Technology

Subject Code: MMRIT21

RATIONALE

Mammography is a specialized imaging technique that uses low-dose X-rays to visualize and assess breast tissue.The role of imaging technologist specializing in mammography is crucial in the early detection and diagnosis of breast abnormalities, including breast cancer.

COURSE OUTCOMES

At the end of the course students will be able to...

C01: Understand the various components of the mammographic equipment, properly operate it and demonstrate thecorrect use of compression devices, filtration devices, the magnification setup, exposure controls etc.

C02: State the specifications and parameters of physical principles related to mammography (eg. half-valuelayer, focal spot size, heel effect, source-to-image distance and the minimum requirements).

C03: Explain the significance of target/filtercombinations.

C04: Differentiate between the various types of x-ray generators used inmammography.

C05: Discuss and define digitalmammography.

C06: Define compression, its usefulness and minimum and maximum requirements.

C07: State the purpose ofmagnification.

C08: Process digital images if available.

C09: Describe a picture archiving and communications system (PACS) and itsfunction.

C010: Define digital imaging and communications in medicine(DICOM).

C011: Discuss the image storage and viewing capabilities related to digitalmammography.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	4	5	30	70	30	70	200

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency:

Unit	Topic and contents	Hours	Marks
1.	**Basic Principles:** History, Xero-mammography, Screen film mammography, Physics of image formation, Mammography Instrumentation, Mammographic cassettes, X-ray tube, Filters, AEC & Console	6	10
2.	**Conventional Mammography Equipment:** C-arm x-ray tube stand, Mammography tube: Rotating vs. stationary anodes, Tube design, Anode design and configuration, Biangular targets, Focal spot: Standard sizes, Magnification size, Effective target angle, Filtration, Beam geometry, Heel effect.	8	10
3.	**Beam limiting devices:** Collimation, SID, OID, Generators: Three-phase, High-frequency and Constant potential, Homogenous x-ray beam, Ripple factor, Tube capacity (Ma output), Automatic exposure control(AEC), Grids, Compression devices, Magnification.	8	10
4.	**Digital mammography:** Detectors, Types of digital mammography systems, Image processing, CAD for mammography, technical considerations: Charged coupled device (CCD), Matrix/pixels, FOV, Resolution, SNR, CNR, AEC, Single-and Multiple exposure approach, Tele mammography.	8	10
5.	**Other aspects of digital technology:** Expense, Additional equipment, Review workstation, PACS, Laser printer, Computer-aided detection (CAD), Connectivity, Compatibility & Computer literacy of technologist, Digital imaging and communications in medicine (DICOM), HIS, RIS, EMR andHL7	10	10
6.	**Sonomammography:** Physics of USG, Instrumentation & equipment, Image quality, Breast density and influencing factors	7	10
7.	**Mammographic compression:** Rationale for breast compression, Clinical image assessment for proper breast positioning, exposure, contrast, sharpness, and noise	7	10
Total		54	70

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Basic Principles	
2.	Conventional Mammography Equipment	10
3.	Beam limiting devices	10
4.	Digital mammography	10

Sr. No		Hours
5.	Other aspects of digital technology	10
6.	Sonomammography	12
7.	Mammographic compression	10
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	**No. of questions**	**Marks per question**	**Total**
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	**Title of Book**	**Author**	**Publication**
1.	Basic radiological physics	K. Thayalan	Jaypee Brothers Medical Publishers (P) Limited, 2003
2.	Christinsens physics of diagnosticradiology	Curry and Dowdey	Wolters Kluwer
3.	X-Ray Equipment for Student	D.N. And M.O. Chesney	Blackwell Science Ltd
4.	Digital Mammography	Ulrich Bick, Felix Diekmann	

Subject: Breast Imaging Procedures and Scanning Protocols

Subject Code: MMRIT22

RATIONALE

Breast Imaging Procedures and Scanning Protocols provide the knowledge base in the type and application of interventional procedures involving breast imaging modalities.

COURSE OUTCOMES

At the end of the course students will be able to...

C01 Illustrate the sterile technique.
C02 Describe localization techniques.
C03 Describe biopsy techniques.
C04 Delineate galactography.
C05 Describe specimen imaging guidelines.
C06 Describe specimen handling and record keeping for pathologic analysis.
C07 Describe continuous patient care from pre-biopsy topostbiopsy.
C08 Define patient transport requirements pre and post biopsy.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CIE	ESE	CIE	ESE	
2	1	4	6	30	70	30	70	200

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency:

Unit	Topic and contents	Hours	Marks
1.	**Sterile Techniques:** Spread of infection: Exogenous, Endogenous, Iatrogenic and Nosocomial, Preparation of local anesthetics, contrast media, Patient allergies and alternative options. Proper glove use, hand washing technique, Skin preparation Sterile tray preparation, Disposal of items.	8	10

2.	**Localization Modalities** Mammography localization: Stereotactic biopsy : Definition, Application & Technique Wire localization: Definition, Application &Technique Ultrasound Guidance: Definition, Application &Technique MR localization: Definition, Application, Technique.	**8**	**10**
3.	**Interventional Procedures:** Cyst aspirations, Fine-needle aspiration or biopsies, Core biopsy,Vacuum-assisted breast biopsy, Galactography, Specimen Imaging: Imaging Guidelines- Core Specimen and Surgical specimens.	**6**	**10**
4.	**Patient Positioning:** Foot Placement, Arm placement, Degree of obliquity- Size of breast, Lesion location, Patient comfort	**10**	**10**
5.	**Evaluation of Images** :Positioning , Compression, Exposure, Contrast, Sharpness, Noise, Artifacts, Motion, Labeling, Collimation	**6**	**10**
6.	**Patients requiring modification of positioning techniques** :Males, Transgender patients, Kyphotic patients, Large breasts, Small breasts, Encapsulated implants, Pectus excavatum, Pectus carinatum, Protruding abdomens, Pacemaker, Wheelchair, Infuse-port (Port-A-Cath), Physically disabled, Mentally disabled, Frozen shoulder, Barrel chest, Thick axilla, Irradiated breast, Reduction mammoplasty, Postsurgical breast, Loop recorder	**10**	**10**
7.	**Image Quality Problems and remedy**: Nipple not in profile, Skin folds or wrinkling, Difficulty compressing due to patient body habitus, Incorrect or uneven compression, Superimposition of extra anatomy, Drooping of breast, Motion, Artifact.	**6**	**10**
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Sterile Techniques	10
2.	Localization Modalities	12
3.	Interventional Procedures	14
4.	Patient Positioning and Evaluation of Images	12
5.	Patients requiring modification of positioning techniques	14
6.	Image Quality Problems and remedy	10
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	**No. of questions**	**Marks per question**	**Total**
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

SUGGESTED LEARNING RESOURCES

S. No.	**Title of Book**	**Author**	**Publication**
1.	Clarks Positioning In Radiography	Ra Swallow, E Naylor	Lippincott William and Wilkins
2.	Merrill's Atlas of Radiographic Positioning and Procedures	Bruce W. Long & Jeannean Hall Rollins & Barbara J. Smith	Mosby

Subject: Basics and Cross Sectional anatomy of Breast

Subject Code: MMRIT23

RATIONALE

The knowledge of breast anatomy is of paramount importance for Imaging technology students, especially those specializing in mammography or breast imaging. Understanding breast anatomy is crucial for several reasons like proper positioning, differentiating normal and abnormal structure and image interpretation.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Describe breast structure, developmental stages, and the differences between the male and female breast.
CO2: Identify and label external and internal anatomy of the breast.
CO3: Identify and label the breakdown of the single lobe.
CO4: Identify the three arterial branches supplying the breast and the three venous drainage channels.
CO5: Describe the lymphatic system and lymphatic drainage.
CO6: Correlate breast anatomical structures to mammographic anatomical structures.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
-	**-**	**6**	**3**	**--**	**--**	**30**	**70**	**100**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

PRACTICAL COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency:

Unit	Topic and contents	Hours	Marks
1.	**Definition of the Breast:** Male vs female, breast developmental stages: Fetal, Puberty, Menstruation, Pregnancy, Lactation, Menopause, Post menopause, Breast landmarks: Quadrants, Clock face references.	**20**	**14**

2.	Gross Anatomy of the Normal Breast, Nipple, Areola, Montgomery's glands, Morgagni's tubercles, Skin: Sebaceous glands, Sweat glands, Hair follicles, Axillary tail, Breast margins, Inframammary fold, Axilla, Internal Anatomy: Fascia, Layers, Retromammary(fat)space. Breast parenchymal components, Lobes and ducts, Cooper's ligaments, stroma, Lymphatic drainage, Breast Vasculature, Pectoral muscle.	**40**	**25**
3.	**Histology of the breast:** Terminal ductal lobular unit, Extra lobular terminal duct, Intra-lobular terminal duct, Ductal sinus(acinus), Cellular components: Epithelial cells, Myoepithelial cells, Basement membrane	**20**	**16**
4.	**Mammographic Appearance of Breast:** Density variations, BIRADS, Variances, Life cycle changes, lesions and characteristic features, lesion measurement.	**28**	**15**
Total		**108**	**70**

Evaluation System

There will be no Theory examination at university level for this subject.

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Practical tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	**Title of Book**	**Author**	**Publication**
1.	Cross Sectional Anatomy CT and MRI	Govind Chavhan, Bhavin Jankharia	Jaypee Brothers Medical Pub.
2.	Cross-Sectional Anatomy for Computed Tomography	Michael L. Farkas	Springer New York
3.	Sectional Anatomy by MRI and CT	Mark W. Anderson, Michael G Fox	Elsevier Health Sciences
4.	Atlas of Human Cross-Sectional Anatomy With CT and MR Images	Donald R. Cahill, Matthew J. Orland, Gary M. Miller	Wiley

MMRIT Radiological Clinical Education- part III (studentship): 16 hrs/week

The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Fourth Semester

Subject: Advancements in Breast Imaging Technology

Subject Code: MMRIT24

RATIONALE

Advances in breast imaging techniques have been instrumental in improving the early detection, diagnosis, and management of breast conditions, especially breast cancer. These advanced techniques offer several key benefits and rationale for their adoption

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Describe the uses of computer-aided detection for mammography images.
CO2: Describe the basic theory of digital breast tomosynthesis including appropriate use.
CO3: Identify the value of biomarkers and those specific to breast imaging modalities.
CO4: Discuss dual energy contrast digital mammography and its appropriate use.
CO5: Describe the potential benefits and use of breast elastography.
CO6: Discuss the potential benefits and use of nuclear medicine studies.
CO7: Describe the use of 3-Dsonography.
CO8: Discuss the potential benefits and use of abbreviated breast MRI.
CO9: Discuss the use of computed tomography laser mammography (CTLM) and thermography

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
2	**1**	**4**	**5**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency:

Unit	Topic and contents	Hours	Marks
1.	**Computer-Aided Detection** Define, Proper protocol for use, Tool for mammography interpretation	4	6
2.	**Digital Breast Tomosynthesis (DBT):** Define, physical principle and components of DBT, Personnel training requirements (MQSA), Potential benefits, Types of images: Projection images &Reconstruction images.	8	10

3.	**Breast Imaging Biomarkers:** Breast Density assessment: Breast arterial calcification scoring, Cancer markers, MRM.	4	6
4.	**Dual Energy Contrast-enhanced Mammography** Define, Theory, Potential benefits	4	8
5.	**Breast Elastography:** Ultrasound Imaging, Basic principle, types, advantages, image interpretation.	4	6
6.	**Nuclear Medicine Studies**: Define, basic principle, Potential benefits, Types: Scintimammography, Lympho-scintigraphy, Positron emission tomography.	10	8
7.	**3-D Ultrasound Imaging**: Concept, mechanism of action, advantages, indications.	8	8
8.	**Abbreviated Breast MRI:** Define, Theory, Potential benefits	6	6
9.	**Non-ionizing techniques:** CTML, Thermal Imaging, Breast Imaging with EIS, Breast Photo Imaging	4	6
10.	**Dedicated Breast CT:** Fundamental principle, dose estimation, indications, pros and cons, protective apparel.	2	6
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	Computer-Aided Detection	8
2.	Digital Breast Tomosynthesis (DBT)	6
3.	Breast Imaging Biomarkers	8
4.	Non-ionizing techniques	8
5.	Dedicated Breast CT	8
6.	3-D Ultrasound Imaging	8
7.	Dual Energy Contrast-enhanced Mammography Breast Elastography	10
8.	Abbreviated Breast MRI	6
9.	Nuclear Medicine Studies	10
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	**No. of questions**	**Marks per question**	**Total**
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Basic radiological physics	K. Thayalan	Jaypee Brothers Medical Publishers (P) Limited, 2003
2.	Christinsens physics of diagnostic radiology	Curry and Dowdey	Wolters Kluwer
3.	X-Ray Equipment for Student	D.N. And M.O. Chesney	Blackwell Science Ltd
	Digital Mammography	Ulrich Bick, Felix Diekmann	

Subject: Quality Assurance, Radiation Protection and Patient care in Breast Imaging
Subject Code: MMRIT25

RATIONALE

Radiation Protection and Patient care provides an overview of the principles of radiation protection, including the responsibilities of the radiographer for patients, personnel and the public. This content provides the concepts of optimal patient care, including consideration for the physical and psychological needs of the patient and family. Routine and emergency patient care procedures are described, as well as infection control procedures using standard precautions. The role of the Imaging Technologist in patient education is identified.

COURSE OUTCOMES

At the end of the course students will be able to...

C01:	Identify and justify the need to minimize unnecessary radiation exposure of humans.
C02:	Explain the objectives of a radiation protection program.
C03:	Define radiation and radioactivity units of measurement.
C04:	Identify effective dose limits (EDL) for occupational and non-occupational radiation exposure.
C05:	Describe the ALARA concept.
C06:	Identify ionizing radiation sources from natural and man-made sources.
C07:	Comply with legal and ethical radiation protection responsibilities of radiation workers.
C08:	Identify appropriate applications and limitations for each radiation detection device.
C09:	Describe how iso-exposure curves are used for radiation protection.
C010:	Identify performance standards for beam-limiting devices.
C011:	Distinguish between controlled and non-controlled areas and list acceptable exposure levels.
C012:	Describe the function of federal, state and local regulations governing radiation protection practices.
C013:	Role of Radiation safety officer
C014:	Describe personnel monitoring devices, including applications, advantages and limitations for each device.
C015:	Compare values for individual effective dose limits for occupational radiation exposures (annual and lifetime).
C016:	Identify effective dose limits for the embryo and fetus in occupationally exposed women.
C017:	Distinguish between primary and secondary radiation barriers.
C018:	Demonstrate how the operation of various x-ray and ancillary equipment influences radiation safety and describe the potential consequences of equipment failure.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
2	**1**	**4**	**5**	**30**	**70**	**30**	**70**	**200**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency:

Unit	Topic and contents	Hours	Marks
1.	**ALARA Principle:** Optimizing imaging techniques and using the lowest possible radiation dose are essential components of ALARA.	10	12
2.	**Appropriate Indications and contraindications.** **Technique Optimization:** Patient education, consent and preparation, history taking, exposure factors and compression settings based on the patient's breast size and density.	10	14
3.	**Mammographic Procedure:** Collimation and Field Size, Compression, Receptor Sensitivity (reduction of patient dose), Use of AEC, Patient Comfort.	8	14
4.	**Staff Education and Training:** Radiation safety protocols, Regular continuing education and training about latest techniques and guidelines. **Quality Assurance and Audits:** Implement quality assurance programs to monitor and assess radiation dose levels, image quality, and compliance with radiation safety protocols.	8	16
5.	**Patient Care in Interventional Mammographic procedures:** **Pre-procedural care:** Knowledge of informed consent, Use of 2 patient identifiers, Hard stop process, Vital signs, Explanation of procedure, Proper documentation **During procedure:** Patient awareness, Signs of vasovagal reaction and syncope, Signs of allergic reactions to anesthesia, Anxiety, patient compliance. **Post-procedural care:** Post-procedure imaging for clip placement, compression and wound dressing, instructions and medications prescribed, Follow-up.	18	14
	Total	54	70

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		Hours
1.	ALARA Principle	15
2.	Appropriate Indications and contraindications. Technique Optimization	10
3.	Mammographic Procedure	6
4.	Staff Education and Training Quality Assurance and Audits	20
5.	Patient Care in Interventional Mammographic procedures: Pre-procedural care During procedure Post-procedural care	21
	Total	72

Evaluation System

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Written tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

Written Paper

Type of question	No. of questions	Marks per question	Total
Long Essay	2	15	30
Short Essay	8	5	40
			70
Duration (minutes)			150

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.
Distribution of marks for university examination practical exams:

ESE		CIE		Grand total
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Ultrasound physics and technology	Vivien gibbs, davidcole, Antonio sassano	Churchill Livingstone;
2.	Manual of Diagnostic Ultrasound	Philip E. S. Palmer (Author)	World Health Organization
3.	Physics and Technical Aspects Diagnostic Ultrasound	DINESH K BAGHEL (Author	AITBS PUBLISHERS
4.	Diagnostic Ultrasound	Carol M. Rumack (Author), Deborah Levine (Author)	Elsevier;
5.	Concise Textbook on Hospital Managment& Patient Care In Diagnostic Radiology	N.K.Kardam,, Lalit Agarwal	JBD Publications
6.	Patient care in radiography : with an introduction to medical imaging	Ehrlich, Ruth Ann and joanA.daly	St. Louis, Mo. : Mosby Elsevier

Subject: Basics Pathology and Image Interpretation in Breast Imaging

Subject Code: MMRIT26

RATIONALE

ImagingPathology and image Interpretationprovides the knowledge about the concepts of breast pathology detection and diagnosis. This section presents characteristics of benign and cancerous pathologies and their mammographic appearance.

COURSE OUTCOMES

At the end of the course students will be able to...

CO1: Discuss the factors and physiologic changes that will affect breast tissue composition.
CO2: Identify physical changes of the breast.
CO4: Correlate clinical breast changes with imaging findings, and comparison with previous mammograms.
CO5: Identify the mammographic appearance of pathologies.
CO6: Describe assessment categories and the recommended clinical follow up.
CO7: Identify the high risk and low risk factors limited to breast cancer.
CO8: Describe the etiology, mammographic appearance, diagnosis and treatment of benign breast pathologies.
CO9: Describe the etiology, mammographic appearance, diagnosis and treatment of malignant breast pathology.
CO10: Identify the procedures used to diagnosis breast cancer.
CO11: Describe treatment options for breast cancer.
CO12: Explain breast cancer stages 0 to IV and stage characteristics.
CO13: Explain tumor node metastasis (TNM) classifications of breast cancer.
CO14: Identify the significance of breast cancer detection through patient screening and diagnostic mammograms.
CO15: Discuss the practice of clinical breast examinations and breast self-examinations, and current evidence-based data about them.
CO16: Identify the risk factors associated with breast cancer.

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**CIE**	**ESE**	**CIE**	**ESE**	
--	--	**6**	**3**	--	--	**30**	**70**	**100**

CIE, Continuous Internal Evaluation; ESE, End Semester Evaluation; L, lecture; T, Tutorial; P, Practical

TUTORIAL ASSIGNMENTS

Tutorials should be planned to enhance learning. The faculty shall decide suitable tutorial assignments of minimum one hour per unit based on the curriculum.

PRACTICAL COMPONENTS

The following topics/subtopics should be taught and assessed in order to attain the identified competency:

Unit	Topic and contents	Hours	Marks
1.	**Breast Anomalies** Asymmetry Inverted nipples Accessory nipples Accessory breast tissue Other (e.g. congenital)	8	5
2.	**Clinical Breast Changes** Lumps: Location, Size, Pain, Mobility, Duration and Other associated indications (e.g. trauma, fever, antibiotics) Thickening: Location, Size and Duration Swelling: Location, Size and Duration Dimpling: Location, Size and Duration Skin irritation and lesions (e.g. moles, keratosis, cysts, ulcers, blisters, scaling): Location, Size and Duration Pain: Location, Duration and New Onset Discharge: Duration, New onset, Color of discharge, Ipsilateral or bilateral, Single duct or multiple ducts and Spontaneous vs. Expressed Nipple retraction, inversion, and areolar changes: Location, Duration and New Onset Edema Erythema Mammoplasty Breast Augmentation: Types: Silicone, Saline Location: Sub-glandular & Subpectoral Breast lift, Breast reduction & Other Reconstructive surgery: Autologous (e.g. TRAM flap, DIEP flap, latissimus dorsi flap), Tissue expander, Implant & Other Post surgical excision Radiation changes	20	10
3.	**Mammographic Appearance of Pathology** Masses: Definition, Location & Margins Circumscribed Ill-defined(indistinct) Lobulated Spiculated Asymmetric density: Definition & Location Focal asymmetry: Definition & Location Calcifications: Location- Dermal and Internal Causes:	20	15

	Cystic changes, Sutural, Vascular, Malignancy, Characteristics, Number(quantity), Size & Shape **Distribution:** Clustered or grouped, Segmental, Regional, Diffuse(scattered), Multiplegroups Margins Benign characteristics(typical) Coarse Rim or eggshell Milk of calcium(teacup-like) Dystrophic Vascular Skin(superficial) Secretory Fat necrosis Punctate Suspicious morphology (nondeterminate characteristics) Indistinct(amorphous) Pleomorphic, granular (clustered) Irregular Linear Casting		
4.	Reporting Terminology (e.g.BI-RADS) Assessment categories Recommendations Interpretation of imaging Density Score, BIRADS, Comparison of mammographic images with other modalities.	**10**	**5**
5.	Benign Breast Pathology Cyst, Galactocele, Fibroadenoma, Lipoma, Hamartoma(fibroadenolipoma), Papilloma, Ductal ectasia, Breast infection/abscess, Hematoma, Fat Necrosis, Radial Scar, Lymph node & Gynecomastia Etiology, Mammographic appearance, Diagnosis and Treatment	**10**	**5**
6.	Breast Cancer Classification Stage Characteristics Description Size Invasive vs. Noninvasive Lymph node involvement Spread beyond the breast Stages Stage 0	**15**	**10**

	Stage I Stage II Stage III Stage IV TNM classification characteristics TNM description Size Lymph node involvement Metastasis T –size TX T0 Tis T1, T2, T3,T4 N – lymph node involvement NX N0 N1, N2,N3 M –metastasis MX, M0, M1 Cell grade Definition Grade1 Grade2 Grade3 Multifocal Multicentric Hormone receptors andHER2 Importance oftests Estrogen Progesterone HER2		
7.	**Risk Factors Associated with Breast Cancer** Gender Age Breast density and breast composition Personal history of breast cancer Family history of breast cancer Personal history of female cancer Genetic predisposition Menses: Early age at menarche Late age at menopause Parity: Nulliparity, Primiparity Hormone replacement therapy Obesity Ethnicity Risk assessment models (e.g. Gail, Tyrer Cuzick)	**15**	**10**

8.	**Breast Cancer Detection Methods** Screening mammograms ACS and ACR guidelines Diagnostic mammograms: Clinical findings & Recall from screening Clinical examinations Women aged 20 to 40 years, every 3years Women older than 40 years, every year Breast self-examinations	**10**	**10**
Total		**108**	**70**

Evaluation System

There will be no Theory examination at university level for this subject.

Continuous Internal Evaluation (CIE)

Sl. No.	Component	Marks	Weightage	IA marks
1.	Sessional test(s)			
	Two Practical tests Same pattern as Summative test Average of two to be considered Absence without prior permission to be marked as 0	50		
	Total	***50***	***0.3***	***15***
2.	Continuous assessment			
	Seminars/Case presentations/ Logbook/ Case records/Record book/assignment			
	Total	***50***	***0.3***	***15***
	Total CIE marks			***30***

End Semester Evaluation (ESE)

There shall be practical examination for 70 marks in the subject.

Distribution of marks for university examination practical exams:

ESE		CIE		**Grand total**
Practical	Viva		Sub Total	
50	20	30	100	100

SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Clinical Breast Imaging: A Patient Focused Teaching File	Gilda Cardenosa	
2.	Interventional Breast Procedures: A Practical Approach	Cherie M. Kuzmiak	
3.	Diagnostic Ultrasound	Carol M. Rumack (Author), Deborah Levine (Author)	Elsevier;

MMRIT Radiological Clinical Education- part IV (studentship): 16 hrs/week

The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Annexures

MONITORING LEARNING PROGRESS

It is essential to monitor the learning progress of each candidate through continuous appraisal and regular assessment. It not only helps teachers to evaluate students, but also students to evaluate themselves. The monitoring be done by staff of the department based on participation of students in various teaching/ learning activities. It may be structured and assessment shall be done using checklists that assess various aspects. Model checklists are given which may be copied and used.

The learning out comes to be assessed should include:

a. Acquisition of knowledge: the methods used comprise of 'Log Book' which records participation in various teaching/ learning activities and mentoring of students. The number of activities attended and the number in which presentations are made are to be recorded. The log bookshouldperiodicallybe validated by the supervisors. Some of the activities are listed.

b. Journal Review Meeting (Journal Club): the ability to do literature search, in depth study, presentation skills, and use of audio- visual aids are to be assessed. The assessment is made by faculty members and peers attending the meeting using a checklist ***(see Model ChecklistI)***.

c. Seminars/ symposia: the topics should be assigned to the student well in advance to facilitate in depth study. The ability to do literature search, in depth study, presentation skills and use of audio- visual aids are to be assessed using a checklist ***(see Model Checklist II).***

d. Teaching skills: candidates should be encouraged to teach undergraduate students. This performance should be based on assessment by the faculty members of the department and from feedback from the undergraduate students ***(see Model Checklist III).***

e. Work diary/ Log Book- every candidate shall maintain a work diary and record his participation in the training programs conducted by the department such as journal reviews, seminars, etc. Special mention may be made of the presentations by the candidate as well as details of experiments or procedures, if any conducted by the candidate.

f. Records: records, log books and marks obtained in tests will be maintained by the Head of the Department and will be made available to the University.

Log Book

The log book is a record of important activities of the candidates during his training, Internal assessment should be based on the evaluation of log book. Collectively, log books are a tool for the evaluation of training programme of the institution by external agencies. The record includes academic activities as well as the presentations and procedures carried out by the candidate.

Procedure for defaulters: every department should have a committee to review such situations. The defaulting candidate is counseled by the guide and head of the department. In extreme cases of default the departmental committee may recommend that defaulting candidate be withheld from appearing the examination, if he fails to fulfill the requirements inspite of being given adequate chances to set himself right.

Format of Model Checklists

Checklist- I: MODEL CHECKLIST FOR EVALUATION OF JOURNAL REVIEW PRESENTATIONS

Name of the student: Date:

Name of the faculty/ observer:

Title of the paper:

Journal detail:

Sl. No.	Items of observation during presentation	Poor 0	Below average 1	Average 2	Good 3	Very good 4
1	Article chosen was					
2	Extent of understanding of scope & objectives of the paper by the candidate					
3	Whether cross- references have been consulted					
4	Whether other relevant references have been consulted					
5	Ability to respond to questions on the paper/ subject					
6	Audio- visual aids used					
7	Ability to defend the paper					
8	Clarity of presentation					
9	Any other observation					
	Total score					
Remarks						

Name and Signature of the Faculty .....

Checklist- II: MODEL CHECKLIST FOR THE EVALUATION OF THE SEMINAR PRESENTATIONS

Name ofthe student: Date:

Name of the faculty/ observer:

Title of the seminar:

Sl. No.	Items of observation during presentation	Poor0	Below average 1	Average 2	Good 3	Very good 4
1	Topic chosen was					
2	Extent of understanding of scope & objectives of the paper by the candidate					
3	Whether cross- references have been consulted					
4	Whether other relevant references have been consulted					
5	Ability to respond to questions on the paper/ subject					
6	Audio- visual aids used					
7	Ability to defend the topic					
8	Clarity of presentation					
9	Any other observation					
	Total score					
Remarks						

Name and Signature of the Faculty .....

Checklist – III: MODEL CHECKLIST FOR EVALUATION OF TEACHING SKILL

Name ofthe student: Date:

Name of the faculty/ observer:

Topic:

Under Graduate batch:

Sl no.	Items to be observed during teaching	Strong Point	Weak Point
1	Communication of the purpose of the talk		
2	Evokes audience interest in the subject		
3	The introduction		
4	The sequence of ideas		
5	The use of practical examples and/or illustrations		
6	Speaking style (enjoyable, monotonous, etc., specify)		
7	Summary of the main points at the end		
8	Ask questions		
9	Answer questions asked by the audience		
10	Rapport of speaker with the audience		
11	Effectiveness of the talk		
12	Uses of AV aids appropriately		
Remarks			

Name and Signature of the Faculty.....

Checklist- IV: CONTINOUS EVALUATION OF DISSERTATION WORK BY GUIDE/ CO- GUIDE

Name ofthe student: Date:

Name of the faculty/ observer: Topic:

Sl. No	Points of observation during presentation	Poor 0	Below average 1	Average 2	Good 3	Very good 4
1	Periodic consultation with guide/ co-guide					
2	Depth of Analysis/ Discussion					
3	Department presentation of findings					
4	Quality of Final Output					
5	Others					
	Total score					
Remarks						

Name and Signature of the Faculty

.....

.....

Cover Page

Institute/University Logo

Master in Medical Radiology and Imaging Technology

(MMRIT)

Log Book

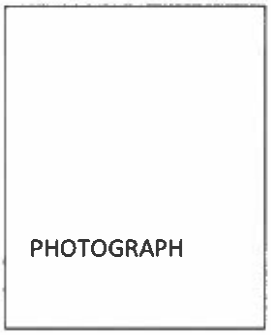
Name of the Student:

Name of the Post Graduate degree:

USN:

Batch:

PARTICULARS OF STUDENT



Name of the student:

Reg no:

Year of admission:

Year of completion:

Address :

Contact details:

Email id :

Signature of the student:

DISSERTATION DETAILS

Title of Dissertation :

Name of the Guide :

Designation of the Guide :

Name of the Co-guide :

Designation of the Co-guide :

Synopsis Presentation date :

IEC Approval :

Completion and Submission date :

CERTIFICATE

This is to certify that Mr/Ms..... has completed the training requirements for the programme Master in Medical Radiology and Imaging Technology (MMRIT) of (name of the Institute/University & address). She/He has completed all the clinical responsibilities during her/his Post-graduation training from.....to.....

Signature
Head/Programme Co-ordinator

Signature
Principal/Dean

Index		
Sl.No.	Content	Page No.

SECTION I: CLINICAL/AREA/FIELD POSTINGS

Date	Clinical/Dept /Area/Field	Particulars	Name & Signature of the staff/mentor /supervisor

SECTION II. SEMINARS PRESENTED/ATTENDED

Sl.No	Date	Topic	Signature of the Moderator

SEMINAR EVALUATION FORM

Evaluation of Seminar

Sl. No	Criteria	5 Excellent	4 Good	3 Average	2 Below Average	1 Poor
1.	Content of the Presentation					
2.	Aesthetic of slides preparation					
3.	Oratory & Presentation Skills					
4.	Audio- visual aids used					
5.	Clarity of presentation					
6.	Critical Analysis,,					
7.	Ability to respond to questions on the subject					
8.	Ability to defend the topic					
9.	Referencing					
10.	Implementation recent advancement on the topic					
Total Marks: **50**						

SEMINAR SCORE SHEET

Sl. NO.	*Date*	*Topic*	*Total Marks (Max.50)*	*Evaluations Signature*	*Co-ordinator Signature*

SECTION III. JOURNAL PRESENTED/ATTENDED

Sl.No	Date	Title	Signature Of The Faculty

JOURNAL CLUB EVALUATION

Sl. No	Criteria	5 Excellent	4 Good	3 Average	2 Below Average	1 Poor
1	Paper Selection (importance, interest, general appeal):					
2	Background Knowledge & Introduction of Topic, Questions, and Experimental System.					
3	Critical Analysis of Results, Concise and Accurate Conclusions, and Future Experiments or Implications:					
4	Slides / Visual aids: (organization, number, clarity) , Oral Presentation & Delivery: (Confidence, eye contact, rate of speech, enunciation, appropriate use of pauses)					
5	Ability to Answer Questions from the Audience. Overall Performance and Contribution toOthers Journal					
Total Marks: 25						

JOURNAL CLUB SCORE SHEET

Sl. NO.	Date	Topic	Total Marks (Max.50)	Evaluations Signature	Co-ordinator Signature

SECTION IV: Seminar taken for UG students

Sl.No	Date	Topic Taught	UG Batch	Signature of the Moderator

Review of Dissertation

Sl. No.	Date	ACTIVITY	Remarks	Signature of the Co-Guide	Signature of the Guide

SECTION V. Extension/Extra Curricular activities
(CONFERENCES/CME/WORKSHOP/TRAININGS)

SL.NO	DATE	Event	Achievements	Signature Of The Faculty

DETAILS OF ABSENCE

SL.No	Date of Absence		Reason	Signature of The faculty
	From	To		

EVALUATION OF THE LOGBOOK

Sl. No.	Items of observation during presentation	I semester	II semester	III semester	IV semester
1	Organization of the log book				
2	Adequacy of Content/ Information in the log book				
3	Punctuality				
4	Relevance of Content/ Information in the log book				
5	Shows professional conduct during the Teaching Learning session				
6	Timely submissions of Projects/Synopsis/Seminareffectively				
7	Work Relationship & Frequency of consulting faculty				
8	Overall quality of department work				
	Total Score				
	Signature of the Co-ordinator				

Scoring:
1 Poor
2 Below Average
3 Average
4 Good
5 Excellent

IMMUNIZATION FORM

SL.NO.	Vaccination	Date of vaccination	Dose

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