Ministry of Health and Family Welfare

Allied Health Section 2015-16

सत्यमेव जयते

Model Curriculum Handbook

MEDICAL RADIOLOGY AND IMAGING TECHNOLOGY

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Contents

CONTRIBUTORS TO DRAFTING AND REVIEW

MEDICAL RADIOLOGY AND IMAGING TECHNOLOGY TASKFORCE

1. Dr. C. Kesavadas, Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram ……...……Task group Chairperson-I
2. Dr. S.C Bansal Post Graduate Institute of Medical Education and Research, Chandigarh…….Task group Chairperson-II
3. Dr. Madhavan Kutty, Amrita institute of Medical Sciences, Amrita University, Kochi
4. Dr. Sandhya C.J, Amrita institute of Medical Sciences, Amrita University, Kochi
5. Dr. Dinesh M, Amrita institute of Medical Sciences, Amrita University, Kochi
6. Mr. Jawatz. T. Shibi, Amrita Centre for Allied Health Sciences, Amrita University, Kochi
7. Ar. A. Y Lakshmi, Sri Venkateswara Institute of Medical Sciences, Tirupati
8. Dr. Srikanth Moorthy, Amrita institute of Medical Sciences, Amrita University, Kochi
9. Dr. Roshan Livingstone, Christian Medical College, Vellore
10. Mr. Mohan Bhagwat, Hamdard University, New Delhi
11. Mr. Pawan Kumar Popli, All India Institute of Medical Sciences, New Delhi
12. Mr. Ramesh Sharma, All India Institute of Medical Sciences, New Delhi
13. Dr. B. B. Thukral, Safdarjung Hospital, New Delhi
14. Dr Madhusudhan K S, All India Institute of Medical Sciences, New Delhi
15. Mr. Sunil Kakkar, Deen Dayal Upadhyay Hospital, New Delhi
16. Mr. Usman Khan, All India Institute of Medical Sciences, New Delhi
17. Dr. S. Elangovan, Jawaharlal Institute of Post Graduate Medical Education and Research, Puducherry
18. Mr. Lalit Kumar Gupta, Post Graduate Institute of Medical Education and Research, Chandigarh

NATIONAL CURRICULA REVIEW COMMITTEE

1. Mr. Ali R. Rizvi, Joint Secretary (in-charge Human Resource), Ministry of Health & Family Welfare (MoHFW)- Chairman
2. Prof. Sanjay Srivastava, DDG(ME), MoHFW
3. Mr. B. S Murthy, Director (AHS), MoHFW
4. Dr. Arun Kr. Agarwal, Ex-Dean, MAMC
5. Dr. B.V. Adkoli, Educationalist, Ex-AIIMS
6. Dr. Bipin Batra, Executive Director, NBE
7. Dr. Subhash Salunke, Senior Advisor, PHFI
8. Dr. T K Jena, Professor, School of Health Sciences, IGNOU
9. Dr. Zenab Zaidi, Director, Health Sector Skill Council
10. Ms. Kavita Narayan, Director- NIAHS TSU

Project Director- Ms. Kavita Narayan

Content organizer and moderator – Ms. Namita Pandey Gupta

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
WBC	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 handbook 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.'[1]

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 (as listed Annex-1) 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.[1] 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.[2,3]

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.[2] 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[4]

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[4,5]

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[6]

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[7]

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[8]

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[9]

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.[10] 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[10]

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[11]

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.[12] [13]

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).[14]

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.[15] Lifelong, self-directed learning (SDL) has been identified as an important ability for medical graduates (Harvey, 2003)[16] 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.[15]

Thus the handbook promotes self-directed learning, apart from the usual classroom teaching and opens the platform for students who wish to engage in lifelong learning.

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.[17] 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.[18]

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.[19]

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.[11] 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.[1] 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 techniques[1,20]

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.[21]

Chapter 2
Methodology of Curriculum Development

Chapter 2: Methodology of curriculum development

With the release of the report 'From Paramedics to Allied Health: Landscaping the journey and the way ahead', the Ministry of Health and Family Welfare prioritized the key recommendations and concerns raised by various allied and healthcare professionals groups and experts as indicated in the report. One of the major recommendations in the report was the need for standardization of curriculum and pedagogic requirements for the major allied and healthcare professional courses.

The MoHFW has identified 12 priority professional streams in the phase-I for the purpose of standardization. The expertise of over 50 leading public and private allied and healthcare educational institutions for 12 different disciplines has been sought as part of this exercise. Additionally, international experts from Canada, Sweden, USA and UK are also being roped in, to arrive at a comprehensive and globally acceptable set of educational standards based on a skills and competencies approach. The opinions were sought from experts for all the courses, though curricula for the following two professions were not redesigned as they fall under the ambit of regulatory body- Rehabilitation Council of India governed by Ministry of Social Justice and Empowerment –

- Audiology and Speech Pathology
- Orthotics and Prosthetics

The National Skills Development Agency has also developed the National Skills Qualification Framework (NSQF). Under the aegis of the NSDA, the Healthcare Sector Skill Council (HSSC) has undertaken a similar process for a few entry level allied and healthcare courses (Certificate and Diploma level). The focus of Ministry of Health and Family Welfare is thus to preempt duplication of efforts and arrive at a comprehensive set of minimum standards for the allied and healthcare professions but for higher level professional qualifications. This would ensure that the key considerations and obligations of both the public and the private sector are adequately addressed.

In view of the above, the Ministry of Health and Family Welfare instituted 12 National Curricula Redesign Taskforce groups comprising of academicians and professionals from the best institutes and colleges across the country. These people served as subject experts and redesigned the curricula based on a standardized framework developed by the NIAHS TSU (National Initiative for Allied Health Sciences-Technical Support Unit), which is the technical arm supporting this project. The final curriculum has been reviewed and approved by the National Curricula Review Committee (NCRC), (constituted by the MoHFW), that consists of experts with versatile and immense experience in their respective streams, to assess the applicability of the curricula drafted in view of the healthcare system as a whole.

Steps undertaken in the curricula review process –

1. Curricula were sought from various States and institutions across the country in response to which the NIAHS TSU reviewed–
    a. 118 curricula of allied and healthcare courses (different levels and different professions) from 10 states across the country;
    b. 133 curricula of various allied and healthcare courses collected during phase-I of the NIAHS project.
2. Literature review – a comprehensive literature review was undertaken resulting in a detailed curriculum of the allied and healthcare courses, which included competency and skills-based models followed nationally as well as internationally, methodologies of curriculum development, assessment protocols, and many such aspects of curriculum development.

The literature review helped the TSU to develop a reference document that comprised of a standard framework for a competency-based curriculum to be followed for the curricula review and redesign. A detailed mapping of all the resources was undertaken and shared with the taskgroup experts via email.

3. Constitution of the National Curricula Redesign Taskforces for various professional groups – Specific taskforces were then instituted comprising of technical as well as subject experts who were engaged in the process of redesigning the curriculum.
4. Constitution of the National Curricula Review Committee (NCRC) – The NCRC comprising of experts with versatile and immense experiences of their respective domain, was then constituted for final review and approval on the curriculum drafted by the taskforce and NIAHS TSU.
5. National Curricula Redesign Taskforce Consultations– a series of consultations were conducted with subject experts including both regional and national taskgroup experts to develop a 'skill and competency' framework for education and career pathways. The consultations were facilitated by the NIAHS TSU members and were led by the chairperson of the group. Post this, the draft version and recommendations were compiled by the TSU members and sent to the experts for final review and consent.
6. Local consultations – These were also conducted in different hospitals and other healthcare settings to get suggestions, feedbacks and ideas from the subject experts for their respective curricula.
7. Response draft – Comments and suggestions were received on the draft and a response draft curriculum was prepared, which was then re-circulated for final consent and validation by the taskgroup experts.
8. Submission and approval of draft curriculum – The final draft of the curriculum handbook was then submitted by the taskforce chairman to the National Curricula Review Committee for approval and final sign-off.
9. Public opinion – The handbook was uploaded to seek public opinion from national and international experts, students, faculty, and practitioners of the respective professional groups.
10. Final approval by the NCRC- The comments and suggestions by the public were then reviewed and considered for any possible modification by the taskforce group. The final approval and sign off for the overall structure was then sought from NCRC.
11. Dissemination- The final handbook (guidelines) is disseminated by the Ministry of Health and Family Welfare for further adoption and incorporation by institutes/universities as applicable to ensure standardization.

Chapter 3
Background of the profession

Chapter 3: 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.

It is a known fact that with the career advancement, the nomenclature will also vary and will also depend on the sector and profile of the professional. Considering the 10 NSQF levels designed by the NSDA, the following level progression table has been proposed by the taskforce to map the nomenclature, career pathways and progression in different sectors of professional practice for medical radiology and imaging technologist. **The proposed progression is for further discussion and deliberation, the implementation time of the same may vary depending on the current system and regulations in place**.

The table 2 below indicates the various channels of career progression in three distinct sectors such as clinical setting, academic and industry (management/sales or technical) route. It is envisaged that the radiology and imaging technologist will have two entry pathways – students with diploma or baccalaureate. The level of responsibility will increase as the career progresses and will starts with **level four (4)** for diploma holders and **level five (5**) for baccalaureate holders. The table also indicates the corresponding level of qualification with experience required by the professional to fulfill the requirements of each level. Considering the degree of patient dealing, the government aims to phase out the Diploma and PG Diploma level courses and promote Bachelor and Master Degree courses. In the academic front, as per UGC guidelines, to work at the position of a Lecturer/Assistant Professor, the candidate must attain a Master's degree. At present as there are limited master degree seats in medical radiology and imaging technology thus it has been decided that eventually provisions will be made to provide bridge courses for PG Diploma holder

for certain number of years to bring them at par with the master's level courses and universities will be promoted to start master degree courses. The table also indicates that career progression is upto the level 10, however it needs to be stated that the ultimate signatory authority on patient prescription stands with the physician/doctor (radiologist) on role in terms of the clinical interpretation, the director of the unit (clinical route) will be the ultimate authority for the management responsibilities, the final authority for the clinical decisions will be with the radiologist. However, the technologist may sign the computer generated report considering the fact that there is no interpretation of the report needed at that point.

Table 2 Nomenclature based on career progression for medical radiology and imaging technologist (Proposed)

Levels	Nomenclature in various sectors			Qualification and experience
	Clinical	Academic	Industry/ Management	
Level 4	Junior Medical Radiology and Imaging Technologist (Jr. MRIT)(Grade-A to Grade-B to Grade-C promotion every 4 Years)	-	Technical Associate	Diploma in Medical Radiology and Imaging Technology, (DMRIT)
Level 5	Medical Radiology and Imaging Technologist (MRIT)	-	Medical Radiology and Imaging Technologist	BSc. in Medical Radiology & Imaging Technology (BSc.MRIT)
Level 6	Senior Medical Radiology and Imaging Technologist (Sr. MRIT) (Grade-A to Grade-B to Grade-C promotion every 4 Years for BSc. MRIT only)	Tutor/ Demonstrator	Senior Medical Radiology and Imaging Technologist	BSc. MRIT with 4 Years of experience at Level 5 / BSc.MRIT with MSc in Medical Radiology & Imaging Technology (MSc. MRIT) for academic.
Level 7	MRIT Technical Officer (MRIT TO)	Assistant Professor (PG only)	MRIT Technical Officer	4 years of experience at level 6 with MSc. MRIT or preferably PhD with MSc. MRIT for academic.
Level 8	MRIT Senior Technical Officer (MRIT STO)	Associate Professor	MRIT Senior Technical Officer	4 years of experience at level 7 with MSc. MRIT or PhD in the specialty with MSc. MRIT with 4 years' experience at level 5/6 /7 for academic
Level 9	MRIT Chief Technical Officer (MRIT CTO)	Additional Professor	Additional Director MRIT	4 years of experience at level 8 with MSc. MRIT or PhD in the specialty with MSc. MRIT with 4 years of experience at level 8 for academic
Level 10	Chief Manager/ MRIT Head/ Director	Professor /Principal	Director – MRIT	4 years of experience at level 9 with MSc. MRIT and PhD in the specialty

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.[22] 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.

Entry requirements

- Candidate should have passed 10 + 2 with science.
- Minimum percentage of marks: 50% aggregate and 55%in PCB.
- Separate entrance exam should be incorporated for these student who wants to purse allied and healthcare course,

OR

- Direct entry for the student who has appeared and cleared national level entrance exam such as CPMT etc. on basis of ranks and limited seats would be offered to such students.

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.

- **2.5 year programme (including 6 months of clinical training/internship)- Diploma level**
- **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, however the curriculum has not indicated any prescriptive guidelines for that level apart from mapping it on the career and qualification map.

Teaching faculty and infrastructure

One of the important recommendation of the task force members was that the all the NIAHS and RIAHS should mandatorily 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. 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:[23]

- 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 (preferably)
- DSA(preferably)

The teaching faculty for the department should have a minimum of [24]

- 1 Professor
- 1 Additional prof.
- 1 Assoc. Professor/ reader
- 4 Asst. Professor for lectures in different subjects, including medical physics , biomedical engineering
- 8 demonstrators
- 16 MRIT's

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.

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 and Medical Labs
- Medical Records and Transcription organisations
- 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
- Ultrasonography 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 4

Model Curriculum of Medical Radiology and Imaging Technology Courses

Chapter 4: 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.

The National Curriculum Taskforce on Medical Radiology & Imaging technology has successfully designed the career and qualification map indicating the growth opportunities for a professional in the career pathway based on the level as indicated in the National Skills Qualification Framework (NSQF). The career pathway indicates level 4 as the entry level after the completion of a minimum 2.5 years of diploma level programme in Medical Radiology & imaging Technology as well as level 5 as the entry level after completion of a minimum 4 years of Baccalaureate level programme in medical Radiology & imaging Technology. The component of the programmes starting from diploma and above has been detailed out in the coming chapters.

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.

4.1 Diploma in Medical Radiology and Imaging Technology

Diploma in Medical Radiology and Imaging Technology

Introduction:

Learning Objectives: At the completion of this course, the student should be -

1. Able to work in the hospital medical imaging department, at the patient's bedside, in the operating room or Emergency or in private imaging clinics/ centers.
2. S/he to assist the use of X-ray, CT scan, angiography, fluoroscopy, ultra sound and MRI to produce images of organs and body parts.
3. Demonstrate sufficient understanding of basic science related to the technology and be able to integrate such knowledge in his/her work.
4. Act upon his/her job description ethically keeping in mind the requirements of the community at large.
5. Demonstrate empathy and humane approach towards communities and exhibit interpersonal behavior in accordance with the societal norms and expectations.
6. To integrate the academic environment with the clinical setting.
7. Manage information to enable effective, timely, accurate, and cost-effective reporting of related information.
8. Have knowledge of Research design/practice sufficient to evaluate published studies as an informed consumer.

Expectation from the future diploma holders:

Following competencies will be expected from a student completing a diploma course in medical radiology & imaging technology. The students should be able to use initiative to prioritize, deliver and time-manage workload effectively and, when required assist senior staff to plan effective control of work flow pattern within the department.

1. Position patient safely for examination and adapt standard techniques depending on medical/surgical conditions associated with disability, illness or trauma.
2. Perform a range of radiographic examinations on patient to produce high quality images.
3. Should be able to perform radiographic procedures and assist in other radiological procedures apart from care and maintenance of equipments, Interpretation of the requisition forms. These tasks will be performed under the supervision of a qualified Medical Radiology and Imaging Technologist (MRIT).
4. Assist radiologists and senior staff in complex radiological examinations.
5. Ensure that the X-ray films/reports of the patients are sent to the delivery desk as soon as the radiologist has written the report.
6. Ensure safe custody of all the accessories of the X-ray unit of which he/she is in charge. Keeps the X-ray room locked when not in use.
7. Understands and observes health and safety precautions and instruction for self and others protection. He/she should wear dosimeter during duty hours.
8. Ensure that cardiac and respiratory stimulants are at hand, whenever any special investigations with contrast media is being undertaken.
9. Record imaging identification and patient documentation quickly and accurately and observes protocols.
10. To enter report on Radiology Info. System (RIS), answering telephone requests from medical and nursing staff, providing results from the Radiology IT system and relaying routine information where appropriate.
11. Maintaining stock levels of some in-use consumables which will require a lifting, carrying and issuing from the store.
12. To undertake training and competency assessment in relevant tasks.
13. Assist in the training of new staff in the Reception area and acclimatize in their place of posting.
14. To refer to a senior member of staff when a matter is beyond their level of competence

15. To participate in an audit in the radiology department.
16. To participate in annual staff performance reviews.
17. Ensures that the unit is not misused. Confirms that the unit and the room are cleaned at the commencement and the termination of work and additionally if required.
18. Daily account of the X-ray films expense is kept by entries in the stock book and whenever film packets are taken out of stores.
19. Learns new techniques and technologies as required by the professional bodies.
20. To exhibit keen interest, initiative & drive in the overall development of the Department and 'Leadership Qualities' for others to follow.
21. He / She is expected to be confident and to perform all the duties diligently with utmost sincerity and honesty.
22. 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.

Eligibility for admission:

Selection procedure

- Candidate should have passed 10 + 2 with science(PCB)
- Minimum percentage of marks: 55% aggregate.
- Separate entrance exam should be incorporated for these student who wants to purse allied and healthcare course,
  OR
- Direct entry for the student who has appeared and cleared national level entrance exam such as CPMT, JEE, etc. on basis of ranks and limited seats would be offered to such students.

Provision of Lateral Entry:

- There should a provision for lateral entry for the students who has successfully completed DMRIT and would like to pursue BMRIT can directly enter into the second year or 3rd semester.

Duration of the course

Duration of the course is of 2.5 years or 5 semesters (inclusive of six months of internship) with 1000 hours of Theory & 1160 hours of Practical Classes and 720 hours dedicated for internship.

Total number of hours – 2880

Medium of instruction:

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

Attendance:

A candidate has to secure minimum 80% attendance in overall with at least-

1. 75% attendance in theoretical
2. 80% in Skills training (practical) for qualifying to appear for the final examination.

No relaxation, whatsoever, will be permissible to this rule under any ground including indisposition etc.

Assessment:

Assessments should be completed by the academic staff, based on the compilation of the student's theoretical &clinical performance throughout the training programme. To achieve this, all assessment forms and feedback should be included and evaluated. Student must **attain at least 50%** marks in each Theory, Internal assessment and Practical independently / separately for each individual subject.

Model Curriculum Outline

First Semester– Foundation Course

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
DRTT-001	Introduction to Healthcare Delivery System in India	60	0	60
DRTT-002	Basic computers and information Science	10	40	50
DRTT-003	Communication and soft skills	20	10	30
DRTT-004	Medical Terminology and Record keeping (including anatomical terms)	40	0	40
DRTT-005	Medical Law and Ethics	40	0	40
DRTT-006	Introduction to Quality and Patient safety (including Basic emergency care and life support skills, Infection prevention and control, Biomedical waste management, Disaster management and Antibiotic resistance)	40	60	100
DRTT-007	Professionalism and values	20	0	20
DRTT-008	Research Methodology and Biostatistics	40	20	60
DRTT-009	Principals of Management	40	0	40
DRTT-010	Community orientation and clinical visit (including related practical to course 001)*	0	100	100
TOTAL		310	230	540

Teaching resources (tutors) should be made available at every institute for basic subjects such as – Biology and English for students who wish to undertake the extra classes for the same.

Second Semester

S No.	Subjects	Hours		
		Theory	Practical	Total
DRMIT- 011	Human Anatomy and Physiology Part -I	40	60	100
DRMIT- 012	Basics Physics including Radiological Physics	40	60	100
DRMIT-013	Conventional Radiological Equipment	60	60	120
DRMIT-014	Radiographic and Image Processing Techniques	70	60	130
DRMIT-015	English & Communication skills	50	0	50
	DRMIT Directed Clinical Education – part I (studentship)		40	40
	TOTAL	260	280	540

Third Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
DRMIT- 016	Human Anatomy, Physiology including Pathology Part 2	50	40	90
DRMIT- 017	Clinical Radiography- Positioning Part 1	70	70	140
DMRIT- 018	Modern Radiological & Imaging Equipment including Physics	50	30	80
DRMIT-019	Contrast & Special Radiography Procedures	60	80	140
	DRMIT Directed Clinical Education – part II (studentship)			90
TOTAL		230	220	540

Fourth Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
DRMIT-021	Physics of Newer Imaging Modalities	50	70	120
DRMIT-022	Clinical Radiography Positioning Part 2	50	70	120
DRMIT-023	Newer Modalities-Imaging Techniques including Patient Care	50	70	120
DRMIT-024	Quality Control in Radiology and Radiation Safety	50	30	80
	DRMIT Directed Clinical Education – part III (studentship)			100
	TOTAL	200	240	540

Fifth Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
	RMIT Internship		720	720

First Semester- Foundation course

Introduction to National Healthcare System

The course provides the students a basic insight into the main features of Indian health care delivery system and how it compares with the other systems of the world. Topics to be covered under the subject are as follows:

1. Introduction to healthcare delivery system
    a. Healthcare delivery system in India at primary, secondary and tertiary care
    b. Community participation in healthcare delivery system
    c. Health system in developed countries.
    d. Private Sector
    e. National Health Mission
    f. National Health Policy
    g. Issues in Health Care Delivery System in India
2. National Health Programme- Background objectives, action plan, targets, operations, achievements and constraints in various National Heath Programme.
3. Introduction to AYUSH system of medicine
    a. Introduction to Ayurveda.
    b. Yoga and Naturopathy
    c. Unani
    d. Siddha
    e. Homeopathy
    f. Need for integration of various system of medicine
4. Health scenario of India- past, present and future
5. Demography & Vital Statistics-
    a. Demography – its concept
    b. Vital events of life & its impact on demography
    c. Significance and recording of vital statistics
    d. Census & its impact on health policy
6. Epidemiology
    a. Principles of Epidemiology
    b. Natural History of disease
    c. Methods of Epidemiological studies

d. Epidemiology of communicable & non-communicable diseases, disease transmission, host defense immunizing agents, cold chain, immunization, disease monitoring and surveillance.

Medical terminologies and record keeping

This course introduces the elements of medical terminology. Emphasis is placed on building familiarity with medical words through knowledge of roots, prefixes, and suffixes. Topics include: origin, word building, abbreviations and symbols, terminology related to the human anatomy, reading medical orders and reports, and terminology specific to the student's field of study. Spelling is critical and will be counted when grading tests.[25]Topics to be covered under the subject are as follows:

1. Derivation of medical terms.
2. Define word roots, prefixes, and suffixes.
3. Conventions for combined morphemes and the formation of plurals.
4. Basic medical terms.
5. Form medical terms utilizing roots, suffixes, prefixes, and combining roots.
6. Interpret basic medical abbreviations/symbols.
7. Utilize diagnostic, surgical, and procedural terms and abbreviations related to the integumentary system, musculoskeletal system, respiratory system, cardiovascular system, nervous system, and endocrine system.
8. Interpret medical orders/reports.
9. Data entry and management on electronic health record system.

Basic computers and information science

The students will be able to appreciate the role of computer technology. The course has focus on computer organization, computer operating system and software, and MS windows, Word processing, Excel data worksheet and PowerPoint presentation. Topics to be covered under the subject are as follows:

1. Introduction to computer: Introduction, characteristics of computer, block diagram of computer, generations of computer, computer languages.
2. Input output devices: Input devices(keyboard, point and draw devices, data scanning devices, digitizer, electronic card reader, voice recognition devices, vision-input devices), output devices(monitors, pointers, plotters, screen image projector, voice response systems).
3. Processor and memory: The Central Processing Unit (CPU), main memory.
4. Storage Devices: Sequential and direct access devices, magnetic tape, magnetic disk, optical disk, mass storage devices.
5. Introduction of windows: History, features, desktop, taskbar, icons on the desktop, operation with folder, creating shortcuts, operation with windows (opening, closing, moving, resizing, minimizing and maximizing, etc.).
6. Introduction to MS-Word: introduction, components of a word window, creating, opening and inserting files, editing a document file, page setting and formatting the text, saving the document, spell checking, printing the document file, creating and editing of table, mail merge.
7. Introduction to Excel: introduction, about worksheet, entering information, saving workbooks and formatting, printing the worksheet, creating graphs.
8. Introduction to power-point: introduction, creating and manipulating presentation, views, formatting and enhancing text, slide with graphs.
9. Introduction of Operating System: introduction, operating system concepts, types of operating system.
10. Computer networks: introduction, types of network (LAN, MAN, WAN, Internet, Intranet), network topologies (star, ring, bus, mesh, tree, hybrid), components of network.
11. Internet and its Applications: definition, brief history, basic services (E-Mail, File Transfer Protocol, telnet, the World Wide Web (WWW)), www browsers, use of the internet.
12. Application of Computers in clinical settings.

Practical on fundamentals of computers -

1. Learning to use MS office: MS word, MS PowerPoint, MS Excel.
2. To install different software.
3. Data entry efficiency

Medical law and ethics

Legal and ethical considerations are firmly believed to be an integral part of medical practice in planning patient care. Advances in medical sciences, growing sophistication of the modern society's legal framework, increasing awareness of human rights and changing moral principles of the community at large, now result in frequent occurrences of healthcare professionals being caught in dilemmas over aspects arising from daily practice.[26]

Medical ethics has developed into a well based discipline which acts as a "bridge" between theoretical bioethics and the bedside. The goal is "to improve the quality of patient care by identifying, analyzing, and attempting to resolve the ethical problems that arise in practice".[26] Doctors are bound by, not just moral obligations, but also by laws and official regulations that form the legal framework to regulate medical practice. Hence, it is now a universal consensus that legal and ethical considerations are inherent and inseparable parts of good medical practice across the whole spectrum. Few of the important and relevant topics that need to focus on are as follows:

1. Medical ethics - Definition - Goal - Scope
2. Introduction to Code of conduct
3. Basic principles of medical ethics – Confidentiality
4. Malpractice and negligence - Rational and irrational drug therapy
5. Autonomy and informed consent - Right of patients
6. Care of the terminally ill- Euthanasia
7. Organ transplantation
8. Medico legal aspects of medical records – Medico legal case and type- Records and document related to MLC - ownership of medical records - Confidentiality Privilege communication - Release of medical information - Unauthorized disclosure - retention of medical records - other various aspects.
9. Professional Indemnity insurance policy
10. Development of standardized protocol to avoid near miss or sentinel events
11. Obtaining an informed consent.

Communication and soft skills

Major topics to be covered under Communication course[27] –

1. Basic Language Skills: Grammar and Usage.
2. Business Communication Skills. With focus on speaking - Conversations, discussions, dialogues, short presentations, pronunciation.
3. Teaching the different methods of writing like letters, E-mails, report, case study, collecting the patient data etc. Basic compositions, journals, with a focus on paragraph form and organization.
4. Basic concepts & principles of good communication
5. Special characteristics of health communication
6. Types & process of communication
7. Barriers of communication & how to overcome

Introduction to Quality and patient safety

1. Quality assurance and management - The objective of the course is to help students understand the basic concepts of quality in health Care and develop skills to implement sustainable quality assurance program in the health system.
    a. Concepts of Quality of Care
    b. Quality Improvement Approaches
    c. Standards and Norms

d. Quality Improvement Tools
e. Introduction to NABH guidelines

2. Basics of emergency care and life support skills - Basic life support (BLS) is the foundation for saving lives following cardiac arrest. Fundamental aspects of BLS include immediate recognition of sudden cardiac arrest (SCA) and activation of the emergency response system, early cardiopulmonary resuscitation (CPR), and rapid defibrillation with an automated external defibrillator (AED). Initial recognition and response to heart attack and stroke are also considered part of BLS. The student is also expected to learn about basic emergency care including first aid and triage. Topics to be covered under the subject are as follows:
    a. Vital signs and primary assessment
    b. Basic emergency care – first aid and triage
    c. Ventilations including use of bag-valve-masks (BVMs)
    d. Choking, rescue breathing methods
    e. One- and Two-rescuer CPR
    f. Using an AED (Automated external defibrillator).
    g. Managing an emergency including moving a patient

    At the end of this topic, focus should be to teach the students to perform the maneuvers in simulation lab and to test their skills with focus on airways management and chest compressions. At the end of the foundation course, each student should be able to perform and execute/operate on the above mentioned modalities.

3. Bio medical waste management and environment safety- The aim of this section will be to help prevent harm to workers, property, the environment and the general public. Topics to be covered under the subject are as follows:
    a. Definition of Biomedical Waste
    b. Waste minimization
    c. BMW – Segregation, collection, transportation, treatment and disposal (including color coding)
    d. Liquid BMW, Radioactive waste, Metals / Chemicals / Drug waste
    e. BMW Management & methods of disinfection
    f. Modern technology for handling BMW
    g. Use of Personal protective equipment (PPE)
    h. Monitoring & controlling of cross infection (Protective devices)

4. Infection prevention and control - The objective of this section will be to provide a broad understanding of the core subject areas of infection prevention and control and to equip AHPs with the fundamental skills required to reduce the incidence of hospital acquired infections and improve health outcomes. Concepts taught should include –
    a. Evidence-based infection control principles and practices [such as sterilization, disinfection, effective hand hygiene and use of Personal protective equipment (PPE)],
    b. Prevention & control of common healthcare associated infections,
    c. Components of an effective infection control program, and
    d. Guidelines (NABH and JCI) for Hospital Infection Control

5. Antibiotic Resistance-
    a. History of Antibiotics
    b. How Resistance Happens and Spreads
    c. Types of resistance- Intrinsic, Acquired, Passive
    d. Trends in Drug Resistance
    e. Actions to Fight Resistance
    f. Bacterial persistence
    g. Antibiotic sensitivity

h. Consequences of antibiotic resistance
i. Antimicrobial Stewardship- Barriers and opportunities, Tools and models in hospitals

6. Disaster preparedness and management- The objective of this section will be to provide knowledge on the principles of on-site disaster management. Concepts to be taught should include-
    a. Fundamentals of emergency management,
    b. Psychological impact management,
    c. Resource management,
    d. Preparedness and risk reduction,
    e. Key response functions (including public health, logistics and governance, recovery, rehabilitation and reconstruction), information management, incident command and institutional mechanisms.

Professionalism and Values

The module on professionalism will deliver the concept of what it means to be a professional and how a specialized profession is different from a usual vocation. It also explains how relevant is professionalism in terms of healthcare system and how it affects the overall patient environment.

1. Professional values- Integrity, Objectivity, Professional competence and due care, Confidentiality
2. Personal values- ethical or moral values
3. Attitude and behavior- professional behavior, treating people equally
4. Code of conduct , professional accountability and responsibility, misconduct
5. Differences between professions and importance of team efforts
6. Cultural issues in the healthcare environment

Research Methodology and Biostatistics

The objective of this module is to help the students understand the basic principles of research and methods applied to draw inferences from the research findings.

1. Introduction to research methods
2. Identifying research problem
3. Ethical issues in research
4. Research design
5. Basic Concepts of Biostatistics
6. Types of Data
7. Research tools and Data collection methods
8. Sampling methods
9. Developing a research proposal

Principals of Management

The course is intended to provide a knowledge about the basic principles of Management.

1. Introduction to management
2. Strategic Management
3. Foundations of Planning
4. Planning Tools and Techniques
5. Decision Making, conflict and stress management
6. Managing Change and Innovation
7. Understanding Groups and Teams
8. Leadership
9. Time Management
10. Cost and efficiency

Community orientation and clinical visit

The objective of this particular section of the foundation course is to sensitize potential learners with essential knowledge; this will lay a sound foundation for their learning across the under-graduate program and across their career. Innovative teaching methods should be used to ensure the attention of a student and make them more receptive such as group activities, interactive fora, role plays, and clinical bed-side demonstrations. [28]

1. The community orientation and clinical visit will include visit to the entire chain of healthcare delivery system -Sub center, PHC, CHC, SDH, DH and Medical College, private hospitals, dispensaries and clinics.
2. The student will also be briefed regarding governance at village level including interaction and group discussion with village panchayat and front line health workers.
3. Clinical visit to their respective professional department within the hospital.

Second Semester

Human Anatomy and Physiology

Anatomy is a key component of all education programmes for MRITs and should have a strong focus on organ position, orientation and relationships. The topics provide the student with an understanding of the structure and relationships of the systems and organs of the body which is essential in patient preparation and positioning. The radiographic anatomy component will enable MRITs to evaluate images prior to reporting by the radiologist.

Similarly *Physiology* provides the students with knowledge of the function of systems and organs and their relationships and underpins the understanding of how various imaging modalities are to be selected depending upon the clinical history.

1. Introduction to the body as a whole
2. The cells, tissues of the body
3. The cell: Structure, multiplication.
4. Tissue: Types, structure, characteristics, functions
5. Epithelium:
6. Simple : Squamous, Cuboidal, columnar, cilliated
7. Compound: Stratified, transitional
8. Connective: Areolar, adipose, fibrous, elastic, Cartilage, blood and bone
9. Muscle: Striated (Voluntary), Smooth (Involuntary, Cardiac)
10. Nervous tissue
11. Fibrous tissue
12. Cell regeneration
13. Membranes: Mucous, Serous, Synovial
14. Osteology (including whole skeleton, bones and joints)
15. Development of bone (osteogenesis) : Cells involved
16. Types and functions of bone, Types of joints and various movements.
17. AXIAL Skelton:
    a. Skull: Cranium, face, air sinuses
    b. Vertebral column: regions, movements and characteristics
    c. Sternum
    d. Ribs
18. Appendicular skeleton: Bones involving -Shoulder girdle and Upper limb, Pelvic girdle and lower limb, healing of bones: cellular activity, Factors that delay healing, Diseases of bones and joints.
19. The Respiratory System:
    a. Organs: Position and structure
    b. Nose and nasal cavities
    c. Functions: respiratory, Olfactory
    d. Pharynx
    e. Larynx: Functions - respiratory, vocal

f. Trachea, Bronchi, lungs: lobes, lobules, pleura

20. Respiratory functions: External and internal respiration, common terms relating to disease and conditions of the system.

Practicals

1. Study of Human Skeleton parts with skeletal models.
2. Study with charts and models of all organ systems mentioned above.
3. Microscopic slides examination of elementary human tissues, cells.

Basic physics including Radiological Physics

1. Basic Physics: Sound -The nature and propagation of sound wave (the characteristics of sound, wave theory), speed of sound in a material medium, intensity of sound, the decibel, Interference of sound waves, beats, diffraction, Doppler's effect
2. 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, Heat radiation.
3. Applied mathematics: Proportion: Direct proportion and inverse proportion, inverse square law with relevant examples, graphical representation of parameters that obey linear and exponential law: example of linear and semilog plotting.
4. Electricity and Magnetism: A.C. and D.C. power supply with examples, single phase and poly phase power supply, switches, fuses, circuit breakers, earthing etc. main voltage drop: causes and remedy, cables; low tension, high tension. DC circuit, Ohm's law, resistivity, series and parallel combination, EMF, Krichoff's law, heating effect of current, Ammeter, voltmeter, Galvanometer. Magnets and magnetic field, force on an electric current in a magnetic field, force on electric charge moving in a magnetic field, magnetic field due to straight wire ; force between two parallel wires, Ampere's law, electromagnet and solenoids
5. Rectification and Transformers: Thermionic emission; - variation of anode current with anode voltage and filament temperature; principle of rectification, wave form of half wave and full wave current/voltage wave form; Rectifiers: Introduction, energy bands in solids, the semiconductor, p-type and n-type semiconductors, density of charge carriers and conductivity, p-n junction, p-n junction diode, p-n junction diode as rectifier (half- wave and full-wave rectifier), rectifiers relative merits and demerits; silicon, germanium diodes. Principles of transformer, Electromagnetic induction, transformer design, efficiency of transformer, source of power loss
6. Electromagnetic radiation: Electromagnetic radiation spectrum, common properties of electromagnetic radiation; relationship between energy, frequency, wavelength and velocity e.g. X-rays and gamma rays. Properties of X-rays and gamma rays; General properties of X-rays, velocity, frequency etc., photographic effect, photochemical effect – discolouration of salts, heating effect, biological effect; ionization of gases e.g. air.
7. Interaction of radiation with matter: Transmission through matter, law of exponential attenuation, half value layer, attenuation coefficients; interaction of radiation with matter, classical scattering, Compton scatter, photo electric absorption, pair production; practical aspects of radiation absorption and transmission through body tissues.
8. Measurement of X-rays: Unit of quantity of radiation exposure - definition and application of 'roentgen', unit of quantity of radiation dose - definition and application of 'rad', 'gray' and 'rem'; principle and application of ionizations chamber and ionization reader unit, film and densitometer, thermo luminescent dosimeter (TLD). X. Quality and quantity of X-rays: Specification and explanation of electron volt (eV), kilovolt (kV) and half value layer (H.V.L) as an index of penetration of the radiation.
9. Basic radiation protection: Historical development, dose equivalent limit, international recommendations and current code of practice for the protection of radiation workers and the public against ionizing radiation arising from medical and dental use; protective materials, lead - impregnated substances; building materials, lead equivalents of protective, personal monitoring; film badge, pocket dosimeter TLD badges and their uses and relative merits.

Practicals

Study with charts, models & power point presentations Atomic structure, X-ray tubes, X-ray circuits involving students to present and discuss

Conventional Radiological Equipment

1. 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; 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.
2. 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.
3. 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.
4. Interlocking circuits: Relays: description and working, use of relays in diagnostic machines for over load protection, circuit diagram; simplified circuit and block diagrams illustrating sequence of events from mains supply to controlled emission of x-rays.
5. Control of scattered radiation: Beam limiting devices: cones, diaphragms, light beam collimator, beam centering device, methods to verify beam centering and field alignment; 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.
6. 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 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.
7. Care and Maintenance of X-ray equipment;
8. 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.

Radiographic and Image Processing Techniques

1. The photographic process: Introduction, visible light, images produced by radiation, light sensitive photographic materials.
2. Image characteristic: Real and mental images, reflected, transmitted and emitted light images Photographic emulsions. The photographic latent image. Positive process
3. Film materials in X-ray departments, history, structure of an x- ray film, single and double emulsion films, types of films, cross over effect.
4. Spectral sensitivity of film material, graininess of film material, speed and contrast of photographic materials.
5. Sensitometry: Photographic density, characteristic curves, features of the characteristic curve.
6. Variation in the characteristic curve with the development. Comparison of emulsions by their characteristic curves. Information from the characteristic curve. The storage of film materials and radiograph; Storage of unprocessed films, storing of radiographs - expiry date, shelf life, storage condition, stock control.

7. Intensifying screens and cassettes. Luminescence: fluorescence and phosphorescence. Construction of an intensifying screen.
8. The fluorescent materials, types of intensifying screens, intensification factor. The influence of KV, scattered radiation. Detail, sharpness and speed, size of the crystals, reciprocity failure, and quantum mottle.
9. Cassette design, care of cassettes, types of cassettes, and mounting of intensifying screens, loading and unloading of cassettes.
10. Care of intensifying screens, tests to check screen film contact and light leakage.
11. Film processing: Development. The nature of development-manual or automatic. The PH scale.
12. The constitution of developing solutions both in manual and automatic processing and properties of developing chemicals.
13. The development time, factors in the use of a developer, developer activity.
14. Film processing: Fixing and role of a fixing solution. Constitution of the fixing solutions and properties of the constituents.
15. Fixer used in automatic processors. Factors affecting the use of the fixer.
16. Regeneration of fixing solution. Silver recovery from waste fixer or from scrap film and its various methods.
17. Rinsing, washing and drying. Objects of rinsing and washing, methods employed. Methods of drying films.
18. Preparation of solutions and making stock solution.
19. Processing equipment: Materials for processing equipment, processors for manual operation, hangers, control of chemicals temperature by heating and thermostat, immersion heaters as well as cooling methods.
20. Maintenance of automatic processors and common faults.
21. Dark Room: Layout and planning. Dark room construction - Nature of floor, walls, ceiling and radiation protection.
22. Type of entry, door design. Dark room illuminations - white light and safe lighting
23. Dark room equipment and its layout. Location of pass through boxes or cassette hatches.
24. Systems for daylight film handling. Daylight systems using cassettes and without cassettes.
25. The radiographic image: Components in image quality-density, contrast and detail.
26. Unsharpness in the radiographic image. Various factors contributing towards unsharpness - geometric, photographic; motional, mottle, graininess, distortion.
27. The presentation of the radiograph. Identification markers and orientation.
28. Documentary preparation.
29. Viewing accessories: Viewing boxes, magnifiers, viewing conditions.
30. Light images and their recording. The laser imager, CRT cameras, Video- imagers, dry silver imaging.
31. Photo fluorography: cine cameras, cine fluorography, cine film, serial cameras, processing of cine films, flurographic films.
32. Cameras for photo flurography. Sensitometric response of fluorography film.
33. Some special imaging processes, Xero-radiography its meaning, technique and applications.
34. Copying radiograph. Its techniques and applications.
35. Subtraction: its techniques applied to radiography as well as its applications.
36. Common film faults due to manufacturing as well as due to chemical processing.
37. Management of the quality of the Radiographic images and image quality control.

Practicals:

1. Test to check the x-ray films and screen contact in the cassette
2. Test to check light leakage in the cassette.
3. To prepare a characteristic curve of a radiographic film
4. To check the effect of safe light on exposed as well as unexposed x-ray film

English and Communication skills:

1. Ability to speak and write proper English
2. Ability to read and understand English
3. Ability to understand and practice medical terminology
4. Letter writing
5. Note making

6. Essay writing
7. Report writing, etc.

DMRIT Directed Clinical Education – part I (studentship)

Students will observe the basic operations of the radiology equipments while interacting with the multidisciplinary team members involved in providing optimal care to the patients. The student will be introduced to various terminology, equipment, and techniques used for treatment.

Third Semester

Human Anatomy, Physiology including Pathology- Part 2

Review of Types of cells, tissues, bones and joints. Introduction to system and cavities of the body.

1. Heart and blood vessels (Circulatory system):
    a. Blood vessels: arteries, veins, capillaries, sinusoids, structure and functions
    b. Heart: Position, structure and functions
    c. Circulation of blood: pulmonary, systemic, portal, main blood vessels, their origins and distribution. Diseases of blood vessels and heart and conditions of the system
2. The Lymphatic system:
    a. The parts of the lymphatic system.
    b. Lymph channels: Capillaries, vessels, ducts structure and functions
    c. Lymph nodes: position, structure and functions
    d. Lymphatic tissues: tonsils, adenoids, intestinal nodules
    e. Spleen: position, structure and functions, diseases and conditions of the system.
3. The digestive system:
    a. Elementary tract structure:
    b. Mouth, pharynx, salivary glands, oesophagus, stomach, liver, gall bladder, small intestine, large intestine: Position, structure and functions of these organs.
    c. Digestion and absorption, Metabolism of carbohydrates. Proteins and fats. Diseases and conditions of the system.
4. The Urinary System
    a. Parts of urinary system
    b. Position, structure and functions
    c. Kidneys, ureters, urinary bladder and urethra
    d. Formation and composition of urine
    e. Water and electrolyte balance
    f. Diseases and conditions of the system
5. The Reproductive System:
    a. Female reproductive system:
        - External genitalia: positions and structures and functions.
        - Perineum.
        - Internal organs: positions and structures.
        - Vagina, uterus, uterine tubes, ovaries.
        - Menstrual cycle stages, hormone control, ovulation.
        - Breasts (Mammary glands)
        - Changes: puberty, in pregnancy, during lactation.

    b. Male reproductive system:
        - Scrotum, testis, epididymis: positions.
        - Spermatogenesis,
        - Spermatic Cords, seminal vesicles,
        - ejaculatory ducts: position, structure & functions
        - Prostate gland : position
        - Functions of male reproductive system, puberty

- Diseases of female and male reproductive system.

6. The Endocrine system:
    a. Endocrine glands:
    b. Pituitary and hypothalamus: Position & structure
    c. Thyroid gland, parathyroid glands
    d. Adrenal (supra renal) glands
    e. Pancreas: Position, types of cells
    f. Hormones: secretion, function and control, pineal gland
    g. Common terms and diseases related to the system
7. The organs of sense:
    a. Hearing and the ear:
    b. External, middle and inner ear
    c. Physiology of hearing and diseases of ear.
    d. Sight and the eye: position, structure, sclera, cornea, choroid, ciliary body.
    e. Iris, lens, retina, optic nerves
    f. Physiology of sight and diseases of the eye.
8. Sense of smell
    a. Olfactory nerves, origins, distribution
    b. Physiology of smell
    c. Sense of taste : tongue
9. The nervous system
    a. Neurons: Structure, types and properties
    b. Central nervous system: neurons, neuralgia meninges.
    c. Ventricles of brain, CSF
    d. Brain, spinal cord: structures, functions, peripheral nervous system.
    e. Spinal and cranial nerves: origin distribution and functions.
    f. Automatic nervous system
    g. Sympathetic and para sympathetic: origin distribution and function.
    h. Common diseases of the system.
10. The Skin
    a. Structure of skin
    b. Epidermis, dermis
    c. Functions of skin
    d. Hypothermia
    e. Wound healing: primary and secondary diseases of skin
11. Cross-sectional anatomy related to Ultrasound, CT and MRI techniques.

Pathology

1. General Pathology Adaptations, Cell Injury and Repair: Hyperplasia, atrophy, metaplasia, necrosis and apoptosis - Differences between apoptosis and necrosis.
2. Acute and Chronic inflammation : Five cardinal signs of inflammation- Outcomes of acute inflammation- Chronic inflammation-Granulomatous inflammation-Acute phase proteins
3. Tissue repair, regeneration and hemodynamic disorders : Cutaneous wound healing-Pathologic aspects of repair-Hyperaemia and congestion-Thrombosis and Virchow triad-Embolism-Infarction-Shock ; Bronchial asthma, COPD - Tumors
4. Diseases of immune system : Hypersensitivity reaction-Type I, II, III, and IV hypersensitivity reactions
5. Neoplasia: Definition of neoplasia. Differences between benign and malignant tumors ; Metastasis ; Carcinogenesis – Causes ; Carcinoma of oral cavity – Causes; Etiology of Carcinoma cervix – type of virus implicated, high risk sero-types, Screening investigations; Breast carcinoma – Risk factors
6. Systemic Pathology
    a. RBC and Bleeding disorders: Anaemia – Definition and classification, Haemolytic anaemia, Iron deficiency anemia, Thrombocytopenia, Coagulation disorders – Terminology, Uses of Bleeding Time, PT and a PTT
    b. WBC disorders: Leukocytosis, Leukemia – acute and chronic, Causes of splenomegaly

c. Disease of the GIT: Peptic ulcer – causes; Carcinoma stomach – causes; Intestinal obstruction – causes; acute appendicitis – causes; Colonic carcinoma - causes
d. Diseases of Liver, Biliary tract and Pancreas: Jaundice – classification based on pathophysiology; Cirrhosis – Definition and causes; Hepatitis – Types of viral hepatitis and transmission; Portal hypertension – Symptoms; Hepatic failure
e. Endocrine System: Diagnostic criteria of diabetes mellitus, Major subtypes of diabetes mellitus, Differences between type I and Type II diabetes mellitus, Complications of diabetes mellitus

8. Systemic Path emphasis I
    a. Blood vessels: Atherosclerosis – Risk factors; American Heart association classification (1995) of Human atherosclerosis ; Hypertension – diagnostic criterion, types and causes ; Varicose veins; Thrombophlebitis and Phlebothrombosis
    b. The Heart: Heart failure; congenital heart diseases causing left to right shunt and vice versa; Myocardial infarction – causes, laboratory changes and complications; Cor-pulmonale; Rheumatic fever
    c. Diseases of the Lung: Chronic obstructive pulmonary disease; Asthma – pathogenesis; Pneumonia – lobar and bronchopneumonia; Lung carcinoma – Incidence and Causes
9. Systemic Path emphasis II
    a. The Kidney and Lower urinary tract: Acute Renal failure – definition and causes of Pre-renal, renal and post-renal ARF ; Chronic renal failure – definition and causes; Acute nephritic syndrome – definition and causes; Nephrotic syndrome – definition and causes; Acute tubular necrosis – definition and causes; Urolithiasis – types of stones
10. Systemic Path emphasis III Female genital tract: Endometriosis – Definition; Adenomyosis – Definition; Leiomyoma Male genital tract: Carcinoma penis – causes; Testicular tumors – Classification terminology; Prostatic Hyperplasia – Causes, symptoms and PSA screening
11. Systemic Path emphasis IV Nervous system : Intracerebral, Subarachnoid and Subdural haemorrhage, Meningitis and Encephalitis – Bacterial and viral causes and CSF findings; Epilepsy – Causes; Acute brain failure – Coma; Epilepsy – Classification terminology; CNS tumors – Classification terminology

Clinical Radiography-Positioning

Skeletal system:

1. Upper limb: Technique for hand, fingers, thumb, wrist joint carpal bones, forearm, elbow joint, radio ulnar joints and humerus supplementary techniques for the above. E.g. Carpal tunnel view, ulnar groove, head of the radius, supracondylar projections.
2. Lower limb: Technique for foot, toes, great toe, tarsal bones, calcaneum, ankle joint, lower leg, knee, patella & femur.
3. Supplementary techniques: Stress view for torn ligaments,
    a. Subtalar joint and talo calcaneal joint.
    b. Inter condylar projection of the knee.
    c. Tibial tubercle.
    d. Length measurement technique.
4. Shoulder girdle and thorax: Technique for shoulder joint, scapular, clavicle, acromio clavicular joints, sternum, ribs, sterno-clavicular joint. Supplementary projections and techniques
    a. Recurrent dislocation of shoulder.
    b. Traumatic dislocation of shoulder.
    c. Cervical ribs.
5. Vertebral column: Technique for atlanto-occipital joint, cervical spine, cervico thoracic spine, thoracic spine, thoraco- lumber spine, lumbo sacral spine, sacrum and coccyx. Supplementary techniques to demonstrate:
    a. Scoliosis.
    b. Kyphosis
    c. Spondylolisthesis

d. Disc lesion
e. Union of spinal graft.

Adaptation of techniques to demonstrate specific pathologies.

6. Pelvic girdle and hip region: Technique for whole pelvis. Ilium, ischium, pubic bones, sacro iliac joint, symphysis pubis, hip joint, acetabulum neck of femur, greater and lesser trochanter.

   Supplementary techniques-

   a. Congenital dislocation of hips
   b. Epiphysis of femur:
   c. Lateral projections for hip joints to show femoral head and neck relationship.
7. Skeletal survey: Skeletal survey for metabolic bone disease, metastases, hormonal disorder, renal disorders.
8. Skull: Basic projections for cranium, facial bones, nasal bones and mandible.
   Technique for
   a. Petrous temporal for mastoids. Internal auditory canal. - Accessory nasal sinuses.
   b. Tempero - mandibular joint. - Orbits and optic foramen. - Zygomatic arches.
   c. Styloid process. - Pituitary fossa. - Jugular foramen.

Dental Radiography:

Technique for intra oral full mouth, occlusal projections, extra oral projections including orthopantomography, Supplementary techniques.

Upper respiratory system:

Technique for post nasal airways, larynx, trachea, thoracic inlet - Valsalva manoeuvre. - Phonation.

Lungs and Mediastinum:

Technique for routine projections:

Projections: Antero-posterior, obliques, lordotic, apical projection, use of penetrated postero-anterior projection. - Expiration technique. - Technique for pleural fluid levels and adhesions.

Abdominal viscera:

For plain film examination, Projection for acute abdomen patients. Technique to demonstrate:

1. Foreign bodies
2. Imperforate anus.

Radiography using mobile X-ray equipment:

Radiography in the ward: Radiography in the specialized unit, such as:

1. Intensive care unit
2. Coronary care
3. Neonatal unit. - Radiography in the operating theatre.

Practicals

Radiographic positioning of all parts of the body.

Modern Radiological & Imaging Equipment including Physics

1. Special equipment: Portable and mobile x-ray units, dental x-ray machine, skull table mammographic device - Technical aspects of Mammography; Generator, x-ray tubes; Accessories; Resolution; Quality control; Application and role in medicine. , digital radiographic equipment, digital subtraction techniques. Tomography: Body section radiography, basic principle and equipment, multi section tomography, various types of tomographic movements, Dual energy x-ray absorptionometry (DEXA), stats can.

2. Computed radiography: its principle, physics & equipment. Digital Radiography. 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.
3. Vascular Imaging Equipment: Introduction, historical developments, Principle, scanned projection radiography, digital subtraction angiography, applications and definition of terms.
4. Picture archiving and communication system (PACS)

Practicals
Demonstration of basic procedures in all modern modalities.

Contrast and Special Radiography Procedures

1. Gastrointestinal Tract: Fluoroscopy, general considerations, responsibility of radiographers. Barium swallow, pharynx and oesophagus- Barium meal and follow through - Hypotonic duodenography - Small bowel enema.- Barium Enema routine projections for colon and rectum, colonic activators; double contrast studies; colostomy. Special techniques for specific disease to be examined. - Water soluble contrast media - e.g. gastrograffin studies.
2. Salivary glands: Routine technique, procedure - sialography.
3. Biliary system:
    a. Plain film radiography. - Intravenous cholangiography.- Percutaneous cholangiography.
    b. Endoscopic retrograde cholangio-pancreatography (ERCP). - Operative cholangiography.
    c. Post-Operative Choangiography (T - tube Cholangiography).
4. Urinary system: Intravenous urography- Retrograde pyelography.- Antegrade pyelography.- Cystography and micturating cystouresthrography.- Urethrography (ascending) - Renal puncture.
5. Female reproductive system: Hysterosalpingography.
6. Mammography: Mammography: Basic views, special views, wire localization. - Ductography.
7. Respiratory system: Bronchography: Awareness.
8. Central Nervous System: Myelography. - Cerebral studies. - Ventriculography.
9. Arthrography: Shoulder, Hip, Knee, Elbow
10. Venography Peripheral venography- Cerebral venography- Inferior and superior venocavography - Relevant visceral phlebography.
11. Sinusography: Routine technique and procedure.
12. Tomography: General principles. Estimation, selection of depth of layer. - Layer thickness required for different examination. - Spacing of layers. - Types and advantages of various movements. - Choice of tomographic movement- exposure factor. - Sequential, horizontal and multi section tomography. - Application of tomography to specific regions.
13. Macroradiography: General principles - Requirement - Equipment - Technique
14. 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.
15. High kV Radiography: General principles- Relation to patient dose- Change in radiographic contrast. - Scatter elimination; beam collimation; grid ratio - Speed and type of grid movement- Radiographic factor; application and uses.
16. Localization of foreign bodies: General location principles- Ingested; inhaled; inserted; embedded foreign bodies - Foreign bodies in eye- Preparation of the area to be investigated- Appropriate projection for all - Techniques to locate non-opaque foreign body.

Practicals
Positioning and imaging of all kinds of contrast & special radiographic procedures

DMRIT Directed Clinical Education – part II (studentship)

Students will gain additional skills in diagnostic procedures, interaction with patients and professional personnel. Students apply knowledge from previous clinical learning experience under the supervision of a radiologist or senior technologist. Students are tested on intermediate clinical radiological skills.

Fourth Semester

Physics of the Newer Imaging Modalities

1. Mammography System: History - Imaging requirements- Mammography system - construction/types accessories tube, compression, grids, AEC etc. - nature of X-Ray beam suitable accessories for immobilization, film processing - image quality - image recording devices interventional procedures – accessories-biopsy equipment attachments - radiation dose- mammo tomogram-Sonomammography-future developments.
2. Computed tomography
    a. Computerized tomography - basic principles, advantages and limitations. X-ray tubes & detectors, data acquisition, generations, image reconstruction.
    b. X-ray tube - construction working and limitations – generations - methods of cooling the anode - anode rating chart - speed of anode rotation, angle of anode inclination - Focus - anode heel effect - Effect of variation of anode voltage and filament temperature - inherent filter and added filter – bow tie filter - effect on quality of the spectrum.
    c. Collimator designs - Pencil beam - Fan beam - Cone beam CT - Z-axis collimation- detector design – construction and working - Gas filled detectors – solid state detectors – flat panel detectors.
    d. Principles of tomography - advantages and limitations – generations – spiral CT – slip ring technology - Multislice CT – dual source CT - pitch – rotation time.
    e. Basic principles of image reconstruction: back projection, analytical an iterative methods – MPR – MIP – volume rendering – surface shaded display (SSD) – bone reconstruction.
    f. CT artefacts: motion artefacts, streak artefacts, ring artefacts, partial volume artefacts etc. causes and remedy.
    g. Dose and Dosimetry, CT Dose Index (CTDI, etc.), Multiple Scan Average Dose (MSAD), Dose Length Product (DLP), Dose Profile, Effective Dose, Phantom Measurement Methods, Dose for Different Application Protocols, Technique Optimization
    h. Technical Assessment and Equipment Purchase Recommendations.
3. Ultrasonography
    a. Basic physics, ultrasound waves, velocity, acoustic impedance, sound intensity, decibels, Longitudinal Waves, Transverse Waves, Sound Wave Properties, Wavelength, Frequency, Period and Velocity, Density and Pressure Changes in Materials, Dependence of Sound Speed on Medium and Properties, Decibel Scale, Interaction of ultrasound with matter, attenuation, reflection, refraction, absorption.
    b. Transducers; principle design and types, Electronics, Matching Layers, Image acquisition and display; A-mode, M-mode, B-mode, Linear and Curvilinear Arrays, Phased Arrays, Annular Arrays, The Near Field, The Far Field, Focused Transducers, Side and Grating Lobes.
    c. Image Data Acquisition: Signal Acquisition, Pre-amplification and Analog to Digital Conversion, Time Gain Compensation, Logarithmic Compression, Demodulation and Envelope Detection, Rejection, Processed Signal
    d. Image quality and artefacts. Reverberation, lateral and axial resolution, time gain compensation.
    e. Doppler - Doppler Theory, Doppler-Frequency Shift, Reflector Velocity Dependence, Doppler Angle Dependence, Spectral Analysis, Continuous Wave (CW) Doppler, Pulsed Doppler, Pulse Transmission and Range Gating, Aliasing, Duplex Scanning, Color Flow Imaging, Power Doppler.
    f. Ultrasound bio effects and safety.

4. Magnetic resonance imaging (MRI)

a. Basic concepts - Atomic structure – Hydrogen as imaging medium – magnetism – precession – resonance – Electromagnetic radiation – NMR - basic concepts of MRI – Faraday's cage.
b. Basic MR Image formation - RF Excitation – Relaxation (T1 and T2) – Computation and display - Free induction decay - k-space – RF wave form designs.
c. Introduction to MR coils - Volume coils - Gradient coils - Slice selection - phase encoding - frequency encoding
d. Magnetic field – Eddy currents – Shimming – Secondary magnets – Superconductive magnets - force on an electric current in a magnetic field, force on electric charge moving in a magnetic field, magnetic field due to straight wire ; force between two parallel wires, Ampere's law, electromagnet and solenoids. Induced EMF, Faraday's Law, Lenz's law, EMF induced in a moving conductor, changing magnetic flux produces electric field, Transformer, Inductance, Energy stored in a magnetic field, resonance in A.C circuit.
e. Introduction to pulse sequencing - Spin echo sequence – T1w image – T2W image- Proton density - Gradient echo sequence – Inversion recovery
f. ARTIFACTS - Cause of artifacts - Image quality, image contrast, signal to noise ratio, resolution, artefacts, MR contrast agents, Advanced MR techniques, flow effects, MR angiography echo planner imaging, magnetization transfer, fat suppression, MR spectroscopy, functional imaging, Magnetic resonance hazards and safety, Recent development.
g. MR safety – instrumentation and biological effects

Practicals
Demonstration of Physics principles in CT, Ultrasound and MR consoles

Clinical Radiography Positioning Part 2

1. Mammography: The Mammography as a clinical diagnostic tool- immobilization and identification techniques positioning techniques for various projections - exposure factors- Conventional & Digital studies- quality and advantage- diagnosis and screening- Characteristics of benign and malignant lesions – patient care – female attendant - interventional procedures - recent advances in mammography techniques -mammotomogram & Sonomammography procedures- advantages & limitations.

2. Ultrasonography/ Doppler studies: Techniques of sonography-selection- Preparations - instructions and positioning of patient for TAS, TVS, TRUS, neck USG and extremities- patient care and maintenance protocols clinical applications display methods –quality image reproducible extend - assurance to patients.

3. CT scan studies acquisition/ protocols /techniques: CT of head and neck – thorax – abdomen – pelvis – musculo skeletal system – spine – PNS Anatomy – clinical indications and contraindications – patient preparation – technique –contrast media-types, dose, injection technique; timing, sequence - image display – patient care – utilization of available techniques & image processing facilities to guide the clinician-CT anatomy and pathology of different organ systems.

4. MRI Scanners: Methods of MRI imaging methods – Head and Neck, Thorax, Abdomen, Musculoskeletal System imaging - Clinical indications and contraindications- types of common sequences effects of sequence on imaging - Protocols for various studies- slice section- patient preparation-positioning of the patient -patient care-calibration - paramagnetic agents and dose, additional techniques and recent advances in MRI -image acquisition-modification of procedures in an unconscious or un co-operative patient -plain studies- contrast studies -special procedures- reconstructions- 3D images- MRS blood flow imaging, diffusion/perfusion scans - strength and limitations of MRI- role of radiographer.

5. Angiography and Cine Studies /DSA: Conventional / DSA studies- Abdominal, visceral, peripheral, cerebral and cardiac angiography - arterial/venous anatomy, physiology-clinical indications and contraindications -patient preparation-positioning of the patient -patient care-contrast media - types of contrast -dosage - accessories catheters, guide wires- pressure injection- control of radiographic

and fluoroscopic equipment - exposure factors for serial programmes-programming-injection protocols- outline on each radiological procedure- radiographer's role- patient management before - during and after the procedure - venography- interventional angiography in hepatobiliary, GIT, urology and vascular system- coils/stents etc.- indications and contraindications - role of radiographer-radiation safety.

Newer Modalities- Imaging Techniques including Patient Care

1. Preparation of patients for general radiological procedures: Departmental instructions to out-patients or ward staff; use of aperients, enemas and colonic irrigations, flatulence and flatus; causes and methods of relief; principles of catheterisation and intubations, pre medication; its uses and methods; anaesthetized patients, nursing care before and after special x-ray examination (for example in neurological, vascular and respiratory conditions); diabetic patients special attention to food; hazards of trauma.
2. Radiological contrast agents: General principles Opaque agents and gases. Relationship of x-ray transmission to density and atomic number of the elements of contrast medium. Types of Barium sulphate solutions, concentration and its particular uses. Additional modifications activators, non-flocculating suspension, flavouring agents, food mixes for children.
3. Iodine preparation: Organic iodine compounds, water - soluble group; ingested group, agents for mechanical filling. Significance of iodine content, proprietary preparations, iodised oil, Application of various systems of human body, Volume, contra-indications, methods of administration and route. Sensitivity test, side effects and management, elimination from the body. Gases: Air, Oxygen and carbon-di-oxide application and dangers.
4. Ionic and Non-ionic contrast media: Application to various system of the human body; Method of administration; route, elimination from the body, common reactions, treatment for minor reactions and major reactions.
5. Contrast media:
   For any four contrast media used in the x-ray department (inclusive of those applicable to CT & MRI), the following details should be taught to students:
   a. Chemical composition of the agent chemical structure-formula.
   b. Description of the drug.
   c. Indications
   d. Routes
   e. Dosage in children, adult and Nursing mothers.
   f. Double contrast
   g. Clinical pharmacology - the route of the administered drug and relative concentration in critical organs
   h. Contraindication
   i. Precaution
   j. Adverse reactions and management.
6. Emergencies in the x-ray department and management: External defibrillation, direct cardiac massage, internal defibrillation, defibrillation by drugs, cardiogenic shock, cerebral oedema, complications; cardiac arrest, respiratory arrest. GI Bleed, local anaesthetics; reactions, treatment. Emergency Equipment: Alarm system, oxygen cylinder, face mask, resuscitation set and their use.
7. Special procedures in diagnostic Radiology:

   (General preparation trolley setting, care of patient and safety measures)

   a. Gastrointestinal tract: Barium meal, Barium swallow, Small bowel enema, Barium enema.
   b. Renal tract: Intravenous urography, retrograde pyelography, micturating cystourethrography.
   c. Biliary system: Plain film radiography, Intravenous cholangiography, percutaneous cholangiography, Endoscopic retrograde cholangio-pancreatography. (ERCP), Operative cholangiography, Post-Operative cholangiography (T - tube Cholangiography)
   d. Gynaecology: Hysterosalpingography.
   e. Cardio vascular system: Angiography, including all commonly covered areas
   f. Central nervous system: Myelography.
   g. Other: Sialography
   h. Ultrasound + Guided procedures.
   i. CT guided procedures

j. MRI guided procedures
k. Fluoro- guided procedure

DMRIT – 021 Quality Control in Radiology & Radiation Safety (AERB GUIDELINES)

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

1. Quality assurance activities: Equipment selection phase; Equipment installation and acceptance phase; Operational phase; Preventive maintenance.
2. Quality assurance programme tests: General principles and preventive maintenance for routine, daily, weekly, monthly, quarterly, annually – machine calibration. Basic concepts of quality assurance – LASER printer - Light beam alignment; X-ray out-put and beam quality check; KVp check; Focal spot size and angle measurement; Timer check; mAs test; Grid alignment test; High and low contrast resolutions; Mechanical and electrical checks; Cassette leak check; Proper screen-film contact test; Safe light test; Radiation proof test; Field alignment test for fluoroscopic device; Resolution test; Phantom measurements - CT, US and MRI.
3. Quality assurance of film and image recording devices: Sensitometry; Characteristic curve; Film latitude; Film contrast; Film speed Resolution; Distortion; Artifacts of films and image recording. Monitor calibration. SMPTE pattern
4. Maintenance and care of equipment: Safe operation of equipment; Routine cleaning of equipment and instruments; Cassette, screen maintenance; Maintenance of automatic processor and manual processing units; Routine maintenance of equipments; Record keeping and log book maintenance; Reject analysis and objectives of reject analysis programme.

Radiation protection

1. Somatic and genetic radiation effects.
   The effective dose equivalent limits of occupational radiation exposure.
   Basis for occupational exposure limits. Concept of negligible individual risk level. Ionizing radiation from natural and man- made source and their approximate dose equivalent contribution. Legal and ethical radiation protection responsibilities of radiation workers.
2. Units detection and measurement:
   Units of radiation for exposure, absorbed dose, dose equivalent, and radio- activity
   Quality factor to determine the dose equivalent. Theory and operation of the following radiation detection devices. Ion -Chambers. Proportional counter. Thermo-luminescent dosimeters (TLD).Appropriate application and limitation of each radiation detection device.
3. Surveys and regulations. Radiation protection survey. Need for survey.
   Performance standards for beam directing, beam defining and limiting devices in radiation protection equipment survey of the following a Radiographic equipment. Fluoroscopic equipment. CT and special equipment. Controlled and non-controlled areas and acceptable exposure levels. State and local regulations governing radiation protection practice.
4. Personal monitoring and occupational exposures: personal monitoring for Radiation workers
   Monitoring devices, Body badges and ring badges. Thermo-luminescent dosimeters. Pocket ionization chambers. Applications, advantages and limitations of each device, Values for dose equivalent limits for occupational radiation exposures. Structures critical for potential life effect for whole body irradiation. Age proportion formula for the determination of a maximum accumulated dose equivalent.

5. Patient Protection:
   Relationship of beam limiting devices with radiation protection of patients, Added and inherent filtration in terms of the effect on patient dose, Purpose and importance of patient shielding, Patient shielding devices and radiographic procedures shielding to the radiographic procedures, Protection of women at child- bearing age, The relationship of exposure factors to patient dosage, Film screen combinations for radiographic procedures for optimum diagnostic image with the minimum radiation exposure to patient, Methods to avoid repeat radiographs, Importance of clear, concise, instruction (effective communication skills) as a method of radiation protection, Effects of immobilization techniques to eliminate voluntary motions, Minimum source to table distance for

fixed and mobile fluoroscopes, Safety factors for patients during radiographic procedures using mobile machines.

6. Practical Radiation Protection:
   Barrier materials and their use in specific x-ray installation, Primary and secondary barriers, Factors influencing the design of X-ray installation, Use ; Work Load ; Occupancy ; Distance ;Material, Time, distance and shielding to keep the radiation exposure to a minimum, Calculations of exposure with varying time, distance and shielding; relationship between half -value layer and -shielding design
7. AERB specifications – radiation safety (lead glass equivalence, lead lined doors) - room size - type approval – registrations & licenses - selection of exposure parameter for various protocols – diagnostic reference levels.

Practicals

Quality assurance and Radiation safety survey in diagnostic X-ray installations.

DMRIT Directed Clinical Education – part III (studentship)

Students will improve their skills in clinical procedures. Progressive interaction with patients and professional personnel are monitored as students practice in radio diagnosis unit in a supervised setting. Additional areas include problem solving, identifying machine components and basic side effect management. Students will demonstrate competence in beginning and intermediate procedures.

Fifth Semester - Internship

The course provides students the opportunity to continue to develop confidence and increased skill in simulation and treatment delivery. Students will demonstrate competence in beginning, intermediate, and advanced procedures in both areas. Students will participate in advanced and specialized treatment procedures. Students will learn both conventional and modern radiographic and imaging techniques. The student will complete the clinical training by practicing all the skills learned in classroom and clinical instruction.

Skills based outcomes and monitorable indicators for Junior Medical Radiology and Imaging Technologist

Competency statements

1. Position patient safely for examination and adapt standard techniques depending on medical/surgical conditions associated with disability, illness or trauma.
2. Perform a range of radiographic examinations on patient to produce high quality images.
3. Should be able to perform radiographic procedures and assist in other radiological procedures apart from care and maintenance of equipments, Interpretation of the requisition forms. These tasks will be performed under the supervision of a qualified Medical Radiology and Imaging Technologist (MRIT).
4. Assist radiologists and senior staff in complex radiological examinations.
5. Ensure that the X-ray films/reports of the patients are sent to the delivery desk as soon as the radiologist has written the report.
6. Understands and observes health and safety precautions and instruction for self and others protection.
7. Communicates relevant information to other members and completes accurate documentation
8. Demonstrates ability to correctly position the patient
9. Demonstrates ability to carry out the daily organization of the imaging unit.
10. Demonstrates knowledge of accurate position and ability to immobilize all patients as per instructions
11. Practices accurate diagnosis documentation
12. Demonstrates ability to interpret, apply and disseminate information as a member of the radio imaging team
13. Demonstrates professional behavior
14. Demonstrates a sensitive and caring attitude towards the patient
15. Demonstrate empathy and humane approach towards communities and exhibit interpersonal behavior in accordance with the societal norms and expectations.
16. Demonstrate sufficient understanding of basic science related to the technology and be able to integrate such knowledge in his/her work.
17. To integrate the academic environment with the clinical setting.
18. Manage information to enable effective, timely, accurate, and cost-effective reporting of related information
19. Have knowledge of Research design/practice sufficient to evaluate published studies as an informed consumer

S. no.	Learning outcomes	Knowledge/comprehension	Applications / synthesis /evaluation	Hours
1	Follow radiological diagnostic needs of patients and assist the use of X-ray, CT scan, angiography, fluoroscopy, ultra sound and MRI to produce images of organs and body parts.	Determining x-ray, CT scan or MRI scan needs of patient	Analyze the prescription of the patient and decide on the best position to take the recommended scan	200
		Know the protocols used in the department	Interpret and understand all planning techniques for the clinical site/s	
2	Be able to transfer all relevant information and complete accurate documentation	Recognize the importance of accurate transfer of information to allow for accurate diagnostic plan according to the prescription	Construct the most appropriate device for the individual patient within the context of the protocol	200
		Know what should be included	Apply the necessary precautions	
		Know to whom or where the documentation and	Implement correct QC, storage and handling	

S. no.	Learning outcomes	Knowledge/comprehension	Applications / synthesis /evaluation	Hours
		information should be sent	procedures for imaging devices	
3	Process radiographic images	Understand internal procedures and policies with respect to radiological equipment and scans	Perform X-ray film / image processing techniques (including dark room techniques)	200
		Be familiar with the techniques and equipment used	Explain the principles of radiographic imaging	
		Know the protocols used in the department		
4	Prepare the patient and the room for the procedure	Be familiar with the techniques and equipment used	Prepare the patient for treatment according to departmental protocols	100
		Set up the X-ray machine, MRI machine or CT scan machine for the procedure	Prepare the diagnostic equipment safely and accurately	
5	Be able to carry out the daily organization of the treatment unit	Recognize the importance of team interactions	Participate in the organization of the daily work schedule to maximize efficiency	50
		Explain the principles of effective communication		
6	Be able to interpret, apply and disseminate information as a member of the radio imaging team	Define and explain the data that must be disseminated	Identify the appropriate personnel to whom specific information should be disseminated	50
			Communicate the correct, relevant and appropriate information	
7	Be able to demonstrate professional behavior	Explain the legal and ethical guidelines related to the profession	Practice in accordance with legislation regulations and ethical guidelines	100
		Be aware of your own competency levels	Promote collaborative practice	
		Identify the elements that reflect professional appearance and manner		
8	Be able to demonstrate a sensitive and caring attitude to patients	Explain the components of good communication	Self-awareness of their own personality traits	50
		Be aware of the patient' gender, age, cultural background, educational level and social situation	Analyze how the differences in personality influence approach	
	Total			950

4.2 B.Sc. in Medical Radiology and Imaging Technology (B.Sc. MRIT)

BSc. in Medical Radiology and Imaging Technology

Introduction:

Learning Objectives:

The Aim of B.Sc. in Medical Radiology and Imaging Technology program is to provide highest and Atomic Energy Regulatory Board (AERB) accredited educational process through formal didactic and state-of-the-art clinical experiences that will render qualified, patient focused, compassionate, critical thinkers Medical Radiology and Imaging Technologist for the community who are engaged in lifelong learning. The graduates of the program are prepared to apply for the Level I Radiation Safety Officer (RSO) as per AERB norms.

The objectives of the program are to:

1. Provide the profession and community with trained qualified technologist
2. Provide education a comprehensive program that promotes problem solving, critical thinking and communication skills in the clinical environment
3. Students will demonstrate quality patient care skills including professionalism and ethical behaviors as specified in the code of ethics
4. Graduate students with specific skills necessary to be competent entry level

Expectation from the future graduate in the providing patient care.

1. Should be able to undertake Mammography, CT scan and MRI procedures independently.
2. Assist in specialised radiological procedures.
3. Able to do the image processing.
4. Should be able to handle all radiological and imaging equipment independently.
5. Should ensure radiation protection and quality assurance
6. Undertake care and maintenance of all radiological and imaging equipment
7. Able to evaluate images for technical quality
8. Able to identify and manage emergency situations.
9. Able to receive and document verbal, written and electronic orders in the patient's medical record.
10. Should have computer skills.
11. Should be able to provide empathetic professional patient care.
12. Able to demonstrate professional growth, sense of professionalism and desire to learn
13. Able to demonstrate the core values of caring, integrity and discovery.
14. To exhibit keen interest, initiative & drive in the overall development of the Department and 'Leadership Qualities' for others to follow.
15. He / She is expected to be confident and to perform all the duties diligently with utmost sincerity and honesty.
16. 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.

Eligibility for admission:

Selection procedure:

1. He/she has passed the Higher Secondary (10+2) or equivalent examination recognized by any Indian University or a duly constituted Board with pass marks in Physics, Chemistry, Biology

   OR

   Diploma in Medical Radiology and Imaging Technology after completing 12th class/ 10 +2 of CBSE or equivalent with minimum aggregate of 50% marks in physics chemistry and biology provided the candidate has passed in each subject separately.

2. Candidates who have studied abroad and have passed the equivalent qualification as determined by the Association of Indian Universities will form the guideline to determine the eligibility and must have passed in the subjects: Physics, Chemistry, Biology and English up to 12th Standard level.
3. Candidates who have passed the Senior Secondary school Examination of National Open School with a minimum of 5 subjects with any of the following group subjects.
    a. English, Physics, Chemistry, Botany, Zoology
    b. English, Physics, Chemistry, Biology and any other language
4. He/she has attained the age of 17 years as on - (current year) & maximum age limit is 30 years.
5. He/she has to furnish at the time of submission of application form, a certificate of Physical fitness from a registered medical practitioner and two references from persons other than relatives testifying to satisfactory general character.
6. Admission to B.Sc. Medical Radiology and Imaging Technology course shall be made on the basis of eligibility and an entrance test to be conducted for the purpose. No candidate will be admitted on any ground unless he/she has appeared in the admission test and interview.
    a. Entrance test, to be conducted by the university as per the syllabus under 10 +2 scheme of CBSE, subject-wise distribution of questions will be as 30% in Physics, 30% in biology, 30% in Chemistry, 5% in English (Language & Comprehension) and 5% in General Awareness about health related methods.
    b. Successful candidates on the basis of written Test will be called for the interview & shall have face an interview board. The interview board will include the Head of the Department of medical imaging (Chairman of the Board) along with the Principal / chief faculty as well as Chief of MRIT apart from other nominees, whose recommendations shall be final for the selection of the students..
    c. During subsequent counseling (s) the seat will be allotted as per the merit of the candidate depending on the availability of seats on that particular day.
    d. Candidate who fails to attend the Medical Examination on the notified date(s) will forfeit the claim for admission and placement in the waiting list except permitted by the competent authority under special circumstances.
    e. The name of the student(s) who remain(s) absent from classes for more than 15 days at a stretch after joining the said course will be struck off from the college rolls without giving any notice.

Provision of Lateral Entry:

Lateral entry to second year for allied and healthcare science courses for candidates who have passed diploma program from the Government Boards and recognized by State/Central University, fulfilling the conditions specified and these students are eligible to take admission on lateral entry system only if the same subject have been studied at diploma level.

There may be need of deliberation on the inclusion of a few bridging courses are advisable for those having less qualified subjects.

Duration of the course

Duration of the course: 4 years or 8 semesters. (1060 hours of Theory & 2120 hours of Practical Classes) and 1440 hours of internship

Total hours - 4620

Medium of instruction:

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

Attendance:

A candidate has to secure minimum 80% attendance in overall with at least-

1. 75% attendance in theoretical
2. 80% in Skills training (practical) for qualifying to appear for the final examination.

No relaxation, whatsoever, will be permissible to this rule under any ground including indisposition etc.

Assessment:

Assessments should be completed by the academic staff, based on the compilation of the student's theoretical &clinical performance throughout the training programme. To achieve this, all assessment forms and feedback should be included and evaluated. Student must **attain at least 50%** marks in each Theory, Internal assessment and Practical independently / separately for each individual subject.

Model Curriculum Outline

First Semester– Foundation Course

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
BMRIT-001	Introduction to Healthcare Delivery System in India	60	20	80
BMRIT-002	Basic computers and information Science	10	20	30
BMRIT-003	Communication and soft skills	20	20	40
BMRIT-004	Medical Terminology and record keeping (including anatomical terms)	40	10	50
BMRIT-005	Medical Law and Ethics	40	0	40
BMRIT-006	Introduction to Quality and patient safety (including Basic emergency care and life support skills, Infection prevention and control, Biomedical waste management, Disaster management and Antibiotic resistance)	40	0	40
BMRIT-007	Professionalism and values	20	80	100
BMRIT-008	Research Methodology and Biostatistics	40	40	80
BMRIT-009	Principals of Management	40	0	40
BMRIT-010	Community orientation and clinical visit (including related practical to course 001)*	0	0	20
TOTAL		**310**	**190**	**540**

Teaching resources (tutors) should be made available at every institute for basic subjects such as – Biology and English for students who wish to undertake the extra classes for the same.

Second Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
BMRIT -011	Human Anatomy and Physiology Part 1	40	70	110
BMRIT -012	Basics Physics including Radiological Physics	40	70	110
BMRIT -013	Conventional Radiography and equipment	30	50	80
BMRIT -014	Radiographic and Image processing Techniques	40	60	100
BMRIT-015	English & Communication skills	40		40
	BMRIT Directed Clinical Education – part I (studentship)			100
TOTAL		**190**	**250**	**540**

Third Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
BMRIT -016	Human Anatomy and Physiology including Pathology Part-2	40	70	110
BMRIT -017	Clinical Radiography- Positioning Part 1	30	60	90
BMRIT-018	Modern Radiological &Imaging Equipment including Physics	30	60	90

BMRIT-019	Contrast & Special Radiography procedures	50	80	130
	BMRIT Directed Clinical Education – part II (studentship)			120
TOTAL		**150**	**270**	**540**

Fourth Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
BMRIT-020	Physics of Newer Imaging Modalities	40	70	110
BMRIT-021	Clinical Radiography Positioning Part 2	40	60	100
BMRIT-022	Newer Modalities Imaging Techniques including patient care	40	60	100
BMRIT-023	Quality Control in Radiology and Radiation Safety	40	50	90
	BMRIT Directed Clinical Education – part III (studentship)			140
TOTAL		**160**	**240**	**540**

Fifth Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
BMRIT-024	Cross sectional anatomy and Physiology	40	50	90
BMRIT-025	Physics of Advanced Imaging Technology	40	60	100
BMRIT-026	Radiographic Techniques of Advanced Imaging Technology	40	60	100
BMRIT-027	Regulatory Requirements in Diagnostic Radiology & Imaging, Act and rules, regulations for JCI, NABH, NABHR.	40	50	90
	BMRIT Directed Clinical Education – part IV (studentship)			160
TOTAL		**160**	**220**	**540**

Sixth Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
BMRIT-028	Quality Assurance & Radiation Safety (AERB Guidelines) in Diagnostic Radiology Part 2	30	60	90
BMRIT-029	Research methodology	30	50	80
BMRIT-030	Hospital Practice & Care of Patients	30	60	90
BMRIT-031	Seminars, Journal club & Group Discussions	40	60	100
	BRIT Directed Clinical Education – part V (studentship)			180
	TOTAL	**130**	**230**	**540**

Seventh and Eighth Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
	MRIT Internship		1440	1440

INTERNSHIP – minimum 1440 hours (calculated based on 8 hours per day, if 180 working days in a year)

Students have to undertake the rotational postings during which students have to work under supervision of an experienced staff in the following areas:

	Postings	Duration
1	Conventional radiography	2months
2	Radiographic special procedures including diagnostic and Therapeutic Interventional Procedures	2 months
3	CR, DR and PACS	2 month
4	Nuclear Medicine	1 month
5	Ultrasonography	1 month
6	Doppler Imaging	1 month
7	Computed Tomography	2 months
8	Magnetic Resonance Imaging	2 months

First Semester- Foundation course

Introduction to National Healthcare System

The course provides the students a basic insight into the main features of Indian health care delivery system and how it compares with the other systems of the world. Topics to be covered under the subject are as follows:

1. Introduction to healthcare delivery system
    a. Healthcare delivery system in India at primary, secondary and tertiary care
    b. Community participation in healthcare delivery system
    c. Health system in developed countries.
    d. Private Sector
    e. National Health Mission
    f. National Health Policy
    g. Issues in Health Care Delivery System in India
2. National Health Programme- Background objectives, action plan, targets, operations, achievements and constraints in various National Heath Programme.
3. Introduction to AYUSH system of medicine
    a. Introduction to Ayurveda.
    b. Yoga and Naturopathy
    c. Unani
    d. Siddha
    e. Homeopathy
    f. Need for integration of various system of medicine
4. Health scenario of India- past, present and future
5. Demography & Vital Statistics-
    e. Demography – its concept
    f. Vital events of life & its impact on demography
    g. Significance and recording of vital statistics
    h. Census & its impact on health policy
6. Epidemiology
    i. Principles of Epidemiology
    j. Natural History of disease
    k. Methods of Epidemiological studies

l. Epidemiology of communicable & non-communicable diseases, disease transmission, host defense immunizing agents, cold chain, immunization, disease monitoring and surveillance.

Medical terminologies and record keeping

This course introduces the elements of medical terminology. Emphasis is placed on building familiarity with medical words through knowledge of roots, prefixes, and suffixes. Topics include: origin, word building, abbreviations and symbols, terminology related to the human anatomy, reading medical orders and reports, and terminology specific to the student's field of study. Spelling is critical and will be counted when grading tests.[25] Topics to be covered under the subject are as follows:

1. Derivation of medical terms.
2. Define word roots, prefixes, and suffixes.
3. Conventions for combined morphemes and the formation of plurals.
4. Basic medical terms.
5. Form medical terms utilizing roots, suffixes, prefixes, and combining roots.
6. Interpret basic medical abbreviations/symbols.
7. Utilize diagnostic, surgical, and procedural terms and abbreviations related to the integumentary system, musculoskeletal system, respiratory system, cardiovascular system, nervous system, and endocrine system.
8. Interpret medical orders/reports.
9. Data entry and management on electronic health record system.

Basic computers and information science

The students will be able to appreciate the role of computer technology. The course has focus on computer organization, computer operating system and software, and MS windows, Word processing, Excel data worksheet and PowerPoint presentation. Topics to be covered under the subject are as follows:

1. Introduction to computer: Introduction, characteristics of computer, block diagram of computer, generations of computer, computer languages.
2. Input output devices: Input devices(keyboard, point and draw devices, data scanning devices, digitizer, electronic card reader, voice recognition devices, vision-input devices), output devices(monitors, pointers, plotters, screen image projector, voice response systems).
3. Processor and memory: The Central Processing Unit (CPU), main memory.
4. Storage Devices: Sequential and direct access devices, magnetic tape, magnetic disk, optical disk, mass storage devices.
5. Introduction of windows: History, features, desktop, taskbar, icons on the desktop, operation with folder, creating shortcuts, operation with windows (opening, closing, moving, resizing, minimizing and maximizing, etc.).
6. Introduction to MS-Word: introduction, components of a word window, creating, opening and inserting files, editing a document file, page setting and formatting the text, saving the document, spell checking, printing the document file, creating and editing of table, mail merge.
7. Introduction to Excel: introduction, about worksheet, entering information, saving workbooks and formatting, printing the worksheet, creating graphs.
8. Introduction to power-point: introduction, creating and manipulating presentation, views, formatting and enhancing text, slide with graphs.

9. Introduction of Operating System: introduction, operating system concepts, types of operating system.
10. Computer networks: introduction, types of network (LAN, MAN, WAN, Internet, Intranet), network topologies (star, ring, bus, mesh, tree, hybrid), components of network.
11. Internet and its Applications: definition, brief history, basic services (E-Mail, File Transfer Protocol, telnet, the World Wide Web (WWW)), www browsers, use of the internet.
12. Application of Computers in clinical settings.

Practical on fundamentals of computers -

1. Learning to use MS office: MS word, MS PowerPoint, MS Excel.
2. To install different software.
3. Data entry efficiency

Medical law and ethics

Legal and ethical considerations are firmly believed to be an integral part of medical practice in planning patient care. Advances in medical sciences, growing sophistication of the modern society's legal framework, increasing awareness of human rights and changing moral principles of the community at large, now result in frequent occurrences of healthcare professionals being caught in dilemmas over aspects arising from daily practice.[26]

Medical ethics has developed into a well based discipline which acts as a "bridge" between theoretical bioethics and the bedside. The goal is "to improve the quality of patient care by identifying, analyzing, and attempting to resolve the ethical problems that arise in practice".[26] Doctors are bound by, not just moral obligations, but also by laws and official regulations that form the legal framework to regulate medical practice. Hence, it is now a universal consensus that legal and ethical considerations are inherent and inseparable parts of good medical practice across the whole spectrum. Few of the important and relevant topics that need to focus on are as follows:

1. Medical ethics - Definition - Goal - Scope
2. Introduction to Code of conduct
3. Basic principles of medical ethics – Confidentiality
4. Malpractice and negligence - Rational and irrational drug therapy
5. Autonomy and informed consent - Right of patients
6. Care of the terminally ill- Euthanasia
7. Organ transplantation
8. Medico legal aspects of medical records – Medico legal case and type- Records and document related to MLC - ownership of medical records - Confidentiality Privilege communication - Release of medical information - Unauthorized disclosure - retention of medical records - other various aspects.
9. Professional Indemnity insurance policy
10. Development of standardized protocol to avoid near miss or sentinel events
11. Obtaining an informed consent.

Communication and soft skills

Major topics to be covered under Communication course[27] –

1. Basic Language Skills: Grammar and Usage.
2. Business Communication Skills. With focus on speaking - Conversations, discussions, dialogues, short presentations, pronunciation.

3. Teaching the different methods of writing like letters, E-mails, report, case study, collecting the patient data etc. Basic compositions, journals, with a focus on paragraph form and organization.
4. Basic concepts & principles of good communication
5. Special characteristics of health communication
6. Types & process of communication
7. Barriers of communication & how to overcome

Introduction to Quality and patient safety

1. Quality assurance and management - The objective of the course is to help students understand the basic concepts of quality in health Care and develop skills to implement sustainable quality assurance program in the health system.
    a. Concepts of Quality of Care
    b. Quality Improvement Approaches
    c. Standards and Norms
    d. Quality Improvement Tools
    e. Introduction to NABH guidelines

2. Basics of emergency care and life support skills - Basic life support (BLS) is the foundation for saving lives following cardiac arrest. Fundamental aspects of BLS include immediate recognition of sudden cardiac arrest (SCA) and activation of the emergency response system, early cardiopulmonary resuscitation (CPR), and rapid defibrillation with an automated external defibrillator (AED). Initial recognition and response to heart attack and stroke are also considered part of BLS. The student is also expected to learn about basic emergency care including first aid and triage. Topics to be covered under the subject are as follows:
    a. Vital signs and primary assessment
    b. Basic emergency care – first aid and triage
    c. Ventilations including use of bag-valve-masks (BVMs)
    d. Choking, rescue breathing methods
    e. One- and Two-rescuer CPR
    f. Using an AED (Automated external defibrillator).
    g. Managing an emergency including moving a patient

    At the end of this topic, focus should be to teach the students to perform the maneuvers in simulation lab and to test their skills with focus on airways management and chest compressions. At the end of the foundation course, each student should be able to perform and execute/operate on the above mentioned modalities.

3. Bio medical waste management and environment safety- The aim of this section will be to help prevent harm to workers, property, the environment and the general public. Topics to be covered under the subject are as follows:
    a. Definition of Biomedical Waste
    b. Waste minimization
    c. BMW – Segregation, collection, transportation, treatment and disposal (including color coding)
    d. Liquid BMW, Radioactive waste, Metals / Chemicals / Drug waste
    e. BMW Management & methods of disinfection
    f. Modern technology for handling BMW

g. Use of Personal protective equipment (PPE)
h. Monitoring & controlling of cross infection (Protective devices)

4. Infection prevention and control - The objective of this section will be to provide a broad understanding of the core subject areas of infection prevention and control and to equip AHPs with the fundamental skills required to reduce the incidence of hospital acquired infections and improve health outcomes. Concepts taught should include –
    a. Evidence-based infection control principles and practices [such as sterilization, disinfection, effective hand hygiene and use of Personal protective equipment (PPE)],
    b. Prevention & control of common healthcare associated infections,
    c. Components of an effective infection control program, and
    d. Guidelines (NABH and JCI) for Hospital Infection Control

5. Antibiotic Resistance-
    a. History of Antibiotics
    b. How Resistance Happens and Spreads
    c. Types of resistance- Intrinsic, Acquired, Passive
    d. Trends in Drug Resistance
    e. Actions to Fight Resistance
    f. Bacterial persistence
    g. Antibiotic sensitivity
    h. Consequences of antibiotic resistance
    i. Antimicrobial Stewardship- Barriers and opportunities, Tools and models in hospitals

6. Disaster preparedness and management- The objective of this section will be to provide knowledge on the principles of on-site disaster management. Concepts to be taught should include-
    a. Fundamentals of emergency management,
    b. Psychological impact management,
    c. Resource management,
    d. Preparedness and risk reduction,
    e. Key response functions (including public health, logistics and governance, recovery, rehabilitation and reconstruction), information management, incident command and institutional mechanisms.

Professionalism and values

The module on professionalism will deliver the concept of what it means to be a professional and how a specialized profession is different from a usual vocation. It also explains how relevant is professionalism in terms of healthcare system and how it affects the overall patient environment.

1. Professional values- Integrity, Objectivity, Professional competence and due care, Confidentiality
2. Personal values- ethical or moral values
3. Attitude and behavior- professional behavior, treating people equally
4. Code of conduct , professional accountability and responsibility, misconduct
5. Differences between professions and importance of team efforts
6. Cultural issues in the healthcare environment

Research Methodology and Biostatistics

The objective of this module is to help the students understand the basic principles of research and methods applied to draw inferences from the research findings.

1. Introduction to research methods
2. Identifying research problem
3. Ethical issues in research
4. Research design
5. Basic Concepts of Biostatistics
6. Types of Data
7. Research tools and Data collection methods
8. Sampling methods
9. Developing a research proposal

Principals of Management

The course is intended to provide a knowledge about the basic principles of Management.

1. Introduction to management
2. Strategic Management
3. Foundations of Planning
4. Planning Tools and Techniques
5. Decision Making, conflict and stress management
6. Managing Change and Innovation
7. Understanding Groups and Teams
8. Leadership
9. Time Management
10. Cost and efficiency

Community orientation and clinical visit

The objective of this particular section of the foundation course is to sensitize potential learners with essential knowledge; this will lay a sound foundation for their learning across the under-graduate program and across their career. Innovative teaching methods should be used to ensure the attention of a student and make them more receptive such as group activities, interactive fora, role plays, and clinical bed-side demonstrations. [28]

1. The community orientation and clinical visit will include visit to the entire chain of healthcare delivery system -Sub centre, PHC, CHC, SDH, DH and Medical College, private hospitals, dispensaries and clinics.
2. The student will also be briefed regarding governance at village level including interaction and group discussion with village panchayat and front line health workers.
3. Clinical visit to their respective professional department within the hospital.

Second Semester

Human Anatomy and Physiology Part –I

Anatomy is a key component of all education programmes for MRITs and should have a strong focus on organ position, orientation and relationships. The topics provide the student with an understanding of the structure and relationships of the systems and organs of the body which is essential in patient preparation and positioning. The radiographic anatomy component will enable MRITs to evaluate images prior to reporting by the radiologist.

Similarly Physiology provides the students with knowledge of the function of systems and organs and their relationships and underpins the understanding of how various imaging modalities are to be selected depending upon the clinical history.

1. Introduction to the body as a whole
2. The cells, tissues of the body
3. The cell: Structure, multiplication.
4. Tissue: Types, structure, characteristics, functions
5. Epithelium:
6. Simple : Squamous, Cuboidal, columnar, ciliated
7. Compound: Stratified, transitional
8. Connective: Areolar, adipose, fibrous, elastic, Cartilage, blood and bone
9. Muscle: Striated (Voluntary), Smooth (Involuntary, Cardiac)
10. Nervous tissue
11. Fibrous tissue
12. Cell regeneration
13. Membranes: Mucous, Serous, Synovial
14. Osteology (including whole Skelton, bones and joints)
15. Development of bone (ostogenesis) : Cells involved
16. Types and functions of bone, Types of joints and various movements.
17. AXIAL Skelton: Skull : Cranium, face, air sinuses, Vertebral column: regions, movements and characteristics, Sternum, Ribs
18. Appendicular Skelton: Bones involving -Shoulder girdle and Upper limb, Pelvic girdle and lower limb, healing of bones: cellular activity, Factors that delay healing, Diseases of bones and joints.
19. The Respiratory System: Organs: Position and structure, Nose and nasal cavities, Functions: respiratory, Olfactory, Pharynx, and Larynx: Functions - respiratory, vocal, Trachea, Bronchi, lungs: lobes, lobules, pleura, and respiratory functions: External and internal respiration, common terms relating to disease and conditions of the system.

Practicals

1. Study of Human Skeleton parts with skeletal models.
2. Study with charts and models of all organ systems mentioned above.
3. Microscopic slides examination of elementary human tissues, cells.

Basic Physics including Radiological Physics

Basic physics

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.
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.

3. **Electromagnetic waves**: Introduction, Maxwell's equation, electromagnetic waves, energy density and intensity, momentum, electromagnetic spectrum and radiation in Atmosphere.

4. Sound.

a. The nature and propagation of sound wave (the characteristics of sound, wave theory), speed of sound in a material medium, intensity of sound, the decibel, Interference of sound waves, beats, diffraction.

b. Doppler's effect, Ultrasonic wave, production of ultrasonic waves (piezo-electric effect) in ultrasonography.

c. Use of principle of Doppler's effect in Diagnostic Radiology (e.g. Echo, blood flow measurement).

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, Heat radiation, perfect black body, Stefan law, application in Diagnostic Radiology (Heat dissipation in both stationary and rotating X-ray tubes).

4. Electronics.

a. Semiconductors; Conduction in crystals, Energy bands. Intrinsic and Extrinsic semiconductors n-type and p-type semiconductors, majority and minority carriers.

b. 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.

c. 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.

5. Basic Radiological Physics

a. X-rays: Discovery of x-rays-X-ray production and properties: Bremsstrahlung radiations-Characteristics X-Rays, factors affecting X-ray emission spectra, X-ray quality and quantity, HVL measurements, heel effect, soft and hard X-Rays, added and inherent filtration, reflection and transmission targets.

b. Interaction of ionizing radiation with matter-Types of interactions of X-and gamma radiation, Photoelectric & Compton, Pair production, annihilation radiation.

c. 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.

d. Exponential attenuation (linear/mass attenuation coefficients), Half Value Thickness (HVT), Tenth Value Thickness (TVT), dependence on energy and atomic number.

e. Radiation intensity and exposure, photon flux and energy flux density.

f. LET, range of energy relationship for alpha, beta particles with X-Rays.

g. 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.

h. 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.

i. Heat dissipation methods, tube rating, heat units, operating conditions and maintenance and Q.A procedures.

j. 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.

k. 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.

l. Physical quantity, its unit and measurement: Fundamental and derived quantity, SI unit, various physical/radiation quantity used in Diagnostic Radiology and its unit (for example, KVp, mA, mAS, Heat unit (HU.

m. Radiation quantities and units: Radiation intensity-exposure, roentgen, its limitations-kerma and absorbed dose-electronic equilibrium-rad, gray, conversion factor for roentgen to rad-quality factor-dose equivalent-rem, Sievert. Quality factor, dose equivalent, relationship between absorbed dose and equivalent dose.

n. Radiation detection and measurements: Principle of radiation detection-Basic principles of ionization chambers, proportional counters, G.M counters and scintillation detectors. Measuring system: free ionization chamber-thimble ion chamber-condenser chamber-secondary standard dosimeter-film dosimeter-chemical dosimeter-Thermo Luminescent Dosimeter-Pocket dosimeter.

Conventional Radiological Equipment

1. 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; 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.
2. 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.
3. 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.

4. Interlocking circuits: Relays: description and working, use of relays in diagnostic machines for over load protection, circuit diagram; simplified circuit and block diagrams illustrating sequence of events from mains supply to controlled emission of x-rays.
5. Control of scattered radiation: Beam limiting devices: cones, diaphragms, light beam collimator, beam centering device, methods to verify beam centering and field alignment; 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.
6. 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 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.

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.

Radiographic and Image Processing Techniques

1. Appreciation and application of all the factors listed below will enable the student/technologist to produce X-ray films of good quality and diagnostic value. The lectures to be linked with practical demonstration to illustrate the importance of all that goes to make up correct exposure conditions.
2. Radiographic Film: Structure of film emulsion-film characteristics (speed, base + fog, gamma, latitude)-effect of grain size on film response to exposure, interpretation of characteristics curve-Grain technology-Gelatin-Basic film types-Film formats and packing-Direct exposure duplitised films-Single coated emulsions-Films for specialized use-manufacturing process. Structure, properties of different parts, handling, film wrappings. Handling of exposed and unexposed films. Types, applications, advantages/limitations of different types, safe light requirements.
3. Sensitometer: Photographic density-characteristic curve-information from the characteristic curve-speed Vs definition. Storage of X-ray film.
4. Control of scattered radiation: Methods of minimizing formation of scatter radiation, effectiveness of grids-grid ratio-preventing scattered radiation, use of cones, diaphragm light beam devices and effectiveness of collimation in reducing effects of scatter. Effects of scatter radiation on radiograph image quality, patient dose and occupational exposure.
5. Intensifying screens: Structure and functions, common phosphors used-types, screen mounting, care and maintenance of film screen contact. Intensifying factor-speed and detail-

crossover effect-resolution-mottle-reciprocity-screen asymmetry-cleaning. New phosphor technology-influence of kilo voltage. Photo-stimulable phosphor Imaging.

6. Cassettes: Structure and function-Types-single, gridded, film holder-Design features and consideration with loading/unloading-Care and maintenance (cleaning).
7. Photochemistry: Principles: Acidity, alkalinity, pH, the processing cycle, development, developer solution. Fixing, fixer solution, washing, drying replenishment, checking and adjusting-latent image formation--nature of development-constitution of developer-development time-factors in the use of developer. Fixers-constitution of fixing solution-factors affecting the fixer-replenishment of fixer-silver conservation-Drying-developer and fixer for automatic film processor-rinsing-washing and drying. Replenishment rates in manual and automatic processing-Silver recovery-Auto and manual chemicals.
8. Processing: manual processing-care of processing equipment-automatic processor-manual VS automatic processing-principles and typical equipment Microprocessor controlled-Cine processing-Daylight systems-Processing faults-maintenance.
9. Automatic Film Processor.
    a. Functions of various components.
    b. Film roller transport-transport time, film feed system.
    c. Importance and relation to temp, fixed and variable time cycles.
    d. Care and maintenance (cleaning routine and methods of cleaning).
10. Radiographic image-components of image quality-unsharpness in radiographic image-contrast of the radiographic image-distinctness of the radiographic image-size, shape and spatial relationships.
11. Factors affecting Image Quality: Meaning of radiographic image contrast, density, resolution, sharpness, magnification and distortion of image, noise and blur. Radiographic illuminators and viewing conditions, visual acuity and resolution.
12. Presentation of radiographs-opaque letters and markers-Identification of dental films-preparation of stereo radiographs-viewing conditions.
13. Monitor images-Characteristics of the video image-television camera-imaging camera. Laser-light and laser-laser imaging-laser imagers-imaging plates-Dry cameras.

Processing room: location of the dark room-dark room illumination-equipment and layout-X-ray viewing room-Day light processing-Daylight handling-daylight systems with cassettes-without cassettes.

Dark Room

1. The processing area.
2. Dark room design, construction, illumination, entrance safe lighting-types.
3. Room storage, shelving of films.
4. Cleaning and maintenance.

Dark Room Planning:

1. For A Small Hospital, for A Large Hospital Location of Dark Room and construction of Dark Room.
2. Ventilation, Wall Protection Entrance to Dark Room - Single Door, Double Door, Labyrinth.

Dark Room:

1. Instruction to Staff, Dry Bench, Drawer, Cupboard.
2. Loading and Unloading Cassettes.
3. Hangers, Types of Hangers and Storage of Hangers
4. Wet Bench Cleanliness, Control of Dust, Dark Room Sink

5. Hatches and Drier
6. Safe Lights, Direct and Indirect, Uses, Factors Affecting Safelight Performance, Safelight Tests.
7. Viewing Room, Film Dispensing

BMRIT – 013 English and Communication skills:

1. Ability to speak and write proper English
2. Ability to read and understand English
3. Ability to understand and practice medical terminology
4. Letter writing
5. Note making
6. Essay writing
7. Report writing, etc.

BMRIT Directed Clinical Education – part I (studentship)

Students will gain additional skills in clinical procedures, interaction with patients and professional personnel. Students apply knowledge from previous clinical learning experience under the supervision of a radiologist or senior technologist Students are tested on intermediate clinical radiological skills.

Third Semester

Human Anatomy and Physiology including Pathology Part- 2

Review of types of cells, tissues, bones and joints. Introduction to system and cavities of the body.

1. Heart and blood vessels (Circulatory system):
    a. Blood vessels: arteries, veins, capillaries, sinusoids, structure and functions
    b. Heart: Position, structure and functions
    c. Circulation of blood: pulmonary, systemic, portal, main blood vessels, their origins and distribution. Diseases of blood vessels and heart and conditions of the system
2. The Lymphatic system:
    a. The parts of the lymphatic system.
    b. Lymph channels: Capillaries, vessels, ducts structure and functions
    c. Lymph nodes: position, structure and functions
    d. Lymphatic tissues: tonsils, adenoids, intestinal nodules
    e. Spleen: position, structure and functions, diseases and conditions of the system.
3. The digestive system:
    a. Elementary tract structure:
    b. Mouth, pharynx, salivary glands, oesophagus, stomach, liver, gall bladder, small intestine, large intestine: Position, structure and functions of these organs.
    c. Digestion and absorption, Metabolism of carbohydrates. Proteins and fats. Diseases and conditions of the system.
4. The Urinary System
    a. Parts of urinary system
    b. Position, structure and functions
    c. Kidneys, ureters, urinary bladder and urethra
    d. Formation and composition of urine
    e. Water and electrolyte balance
    f. Diseases and conditions of the system
5. The reproductive system:
    a. Female reproductive system:
        - External genitalia: positions and structures and functions.

- Perineum.
- Internal organs: positions and structures.
- Vagina, uterus, uterine tubes, ovaries.
- Menstrual cycle" stages, hormone control, ovulation.
- Breasts (Mammary glands)
- Changes: puberty, in pregnancy, during lactation.

b. Male reproductive system:
- Scrotum, testis, epididymis: positions.
- Spermatogenesis,
- Spermatic Cords, seminal vesicles,
- Ejaculatory ducts: position, structure & functions
- Prostate gland: position
- Functions of male reproductive system, puberty
- Diseases of female and male reproductive system.

6. The Endocrine system:
   a. Endocrine glands:
   b. Pituitary and hypothalamus: Position & structure
   c. Thyroid gland, parathyroid glands
   d. Adrenal (supra renal) glands
   e. Pancreases: Position, types of cells
   f. Hormones: secretion, function and control, pineal gland
   g. Common terms and diseases related to the system
7. The organs of sense:
   a. Hearing and the ear:
   b. External, middle and inner ear
   c. Physiology of hearing and diseases of ear.
   d. Sight and the eye: position, structure, sclera, cornea, choroid, ciliary body.
   e. Iris, lens, retina, optic nerves
   f. Physiology of sight and diseases of the eye.
8. Sense of smell
   a. Olfactory nerves, origins, distribution
   b. Physiology of smell
   c. Sense of taste : tongue
9. The nervous system
   a. Neurons: Structure, types and properties
   b. Central nervous system: neurons, neuralgia meninges.
   c. Ventricles of brain, CSF
   d. Brain, spinal cord: structures, functions, peripheral nervous system.
   e. Spinal and cranial nerves: origin distribution and functions.
   f. Automatic nervous system
   g. Sympathetic and para sympathetic: origin distribution and function.
   h. Common diseases of the system.
10. The Skin
    a. Structure of skin
    b. Epidermis, dermis
    c. Functions of skin
    d. Hypothermia
    e. Wound healing: primary and secondary diseases of skin
11. Cross-sectional anatomy related to Ultrasound, CT and MRI techniques.

Pathology

1. General Pathology Adaptations, Cell Injury and Repair: Hyperplasia, atrophy, metaplasia, necrosis and apoptosis - Differences between apoptosis and necrosis.
2. Acute and Chronic inflammation : Five cardinal signs of inflammation- Outcomes of acute inflammation- Chronic inflammation-Granulomatous inflammation-Acute phase proteins
3. Tissue repair, regeneration and hemodynamic disorders : Cutaneous wound healing-Pathologic aspects of repair-Hyperaemia and congestion-Thrombosis and Virchow triad-Embolism-Infarction-Shock ; Bronchial asthma, COPD - Tumors
4. Diseases of immune system : Hypersensitivity reaction-Type I, II, III, and IV hypersensitivity reactions
5. Neoplasia: Definition of neoplasia. Differences between benign and malignant tumors ; Metastasis ; Carcinogenesis – Causes ; Carcinoma of oral cavity – Causes; Etiology of Carcinoma cervix – type of virus implicated, high risk sero-types, Screening investigations; Breast carcinoma – Risk factors
6. Systemic Pathology
7. RBC and Bleeding disorders: Anaemia – Definition and classification, Haemolytic anaemia, Iron deficiency anemia, Thrombocytopenia, Coagulation disorders – Terminology, Uses of Bleeding Time, PT and a PTT
8. WBC disorders: Leukocytosis, Leukemia – acute and chronic, Causes of splenomegaly
9. Disease of the GIT: Peptic ulcer – causes; Carcinoma stomach – causes; Intestinal obstruction – causes; acute appendicitis – causes; Colonic carcinoma - causes
10. Diseases of Liver, Biliary tract and Pancreas: Jaundice – classification based on pathophysiology; Cirrhosis – Definition and causes; Hepatitis – Types of viral hepatitis and transmission; Portal hypertension – Symptoms; Hepatic failure
11. Endocrine System: Diagnostic criteria of diabetes mellitus, Major subtypes of diabetes mellitus, Differences between type I and Type II diabetes mellitus, Complications of diabetes mellitus
12. Systemic Path emphasis I
13. Blood vessels: Atherosclerosis – Risk factors; American Heart association classification (1995) of Human atherosclerosis ; Hypertension – diagnostic criterion, types and causes ; Varicose veins; Thrombophlebitis and Phlebothrombosis
14. The Heart: Heart failure; congenital heart diseases causing left to right shunt and vice versa; Myocardial infarction – causes, laboratory changes and complications; Cor-pulmonale; Rheumatic fever
15. Diseases of the Lung: Chronic obstructive pulmonary disease; Asthma – pathogenesis; Pneumonia – lobar and bronchopneumonia; Lung carcinoma – Incidence and Causes
16. Systemic Path emphasis II
17. The Kidney and Lower urinary tract: Acute Renal failure – definition and causes of Pre-renal, renal and post-renal ARF ; Chronic renal failure – definition and causes; Acute nephritic syndrome – definition and causes; Nephrotic syndrome – definition and causes; Acute tubular necrosis – definition and causes; Urolithiasis – types of stones
18. Systemic Path emphasis III Female genital tract : Endometriosis – Definition ; Adenomyosis – Definition; Leiomyoma Male genital tract : Carcinoma penis – causes; Testicular tumors – Classification terminology; Prostatic Hyperplasia – Causes, symptoms and PSA screening
19. Systemic Path emphasis IV Nervous system : Intracerebral, Subarachnoid and Subdural haemorrhage, Meningitis and Encephalitis – Bacterial and viral causes and CSF findings;

Epilepsy – Causes; Acute brain failure – Coma; Epilepsy – Classification terminology; CNS tumors – Classification terminology

Clinical Radiography-Positioning Part 1

1. Skeletal system:
   a) Upper limb: Technique for hand, fingers, thumb, wrist joint carpal bones, forearm, elbow joint, radio ulnar joints and humerus supplementary techniques for the above. E.g. Carpal tunnel view, ulnar groove, head of the radius, supracondylar projections.
   b) Lower limb: Technique for foot, toes, great toe, tarsal bones, calcaneum, ankle joint, lower leg, knee, patella & femur. Supplementary techniques: Stress view for torn ligaments,
      - Subtalar joint and talo calcaneal joint.
      - Inter condylar projection of the knee.
      - Tibial tubercle.
      - Length measurement technique.
   c) Shoulder girdle and thorax: Technique for shoulder joint, scapular, clavicle, acromio clavicular joints, sternum, ribs, sterno-clavicular joint. Supplementary projections and techniques
      - Recurrent dislocation of shoulder.
      - Traumatic dislocation of shoulder.
      - Cervical ribs.
   d) Vertebral column: Technique for atlanto-occipital joint, cervical spine, cervico thoracic spine, thoracic spine, thoraco- lumber spine, lumbo sacral spine, sacrum and coccyx. Supplementary techniques to demonstrate:
      - Scoliosis
      - Kyphosis
      - Spondylolisthesis
      - disc lesion
      - Union of spinal graft.
   e) Pelvic girdle and hip region: Technique for whole pelvis. Ilium, ischium, pubic bones, sacro iliac joint, symphysis pubis, hip joint, acetabulum neck of femur, greater and lesser trochanter. Supplementary techniques-
      - Congenital dislocation of hips
      - Epiphysis of femur
      - Lateral projections for hip joints to show femoral head and neck relationship.
   f) Skeletal survey: Skeletal survey for metabolic bone disease, metastases, hormonal disorder, renal disorders.
   g) Skull: Basic projections for cranium, facial bones, nasal bones and mandible. Technique for
      - Petrous temporal for mastoids. Internal auditory canal. - Accessory nasal sinuses.
      - Tempero - mandibular joint. - Orbits and optic foramen.- Zygomatic arches.
      - Styloid process. - Pituitary fossa. - Jugular foramen.

2. Dental Radiography- Technique for intra oral full mouth.- Occlusal projections.- Extra oral projections including orthopantomography.- Supplementary techniques.
3. Upper respiratory system- Technique for post nasal airways, larynx, trachea, thoracic inlet, Valsalva manoeuvre. - Phonation.

4. Lungs and Mediastinum: Technique for routine projections- Supplementary projections: Antero-posterior, obliques, lordotic, apical projection, use of penetrated postero-anterior projection. - Expiration technique. - Technique for pleural fluid levels and adhesions.
5. Abdominal viscera- Technique for plain film examination. - Projection for acute abdomen patients. - Technique to demonstrate: Foreign bodies, Imperforate anus.
6. Radiography using mobile X-ray equipment- Radiography in the ward: Radiography in the specialized unit, such as: Intensive care unit, Coronary care, Neonatal unit.- Radiography in the operating theatre.

Practicals
Radiographic positioning of all parts of the body.

Modern Radiological Equipment including Physics

1. Special radiological equipment: Portable and mobile x-ray units, dental x-ray machine, skull table mammographic device - Technical aspects of Mammography; High Tension Generators, x-ray tubes-their types and advancements; Accessories; Resolution; Quality control; Application and role in medicine. , digital radiography equipment, digital subtraction techniques. Tomography: Body section radiography, basic principle and equipment, multi section tomography, various types of tomographic movements, Tomosynthesis, Stich radiography, Dual energy x-ray absorptionometry (DEXA) scan.
2. Computed radiography: its principle, physics & equipment. Digital Radiography. 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.
3. Vascular Imaging Equipment: Introduction, historical developments, Principle, scanned projection radiography, digital subtraction angiography, applications and definition of terms,
4. Picture archiving and communication system (PACS)

Practicals
Demonstration of basic procedures in all modern modalities.

Contrast & Special Radiography Procedures

For each of the examination the points listed below should be included:

1. Review the anatomy of the area.
2. State the clinical indication for the examination.
3. State contra indication if any for the examination.
4. Describe the preparation of the patient including the pre medication if appropriate.
5. Specify the type and quantity of contrast agent used.
6. Describe the method of introduction of the contrast agent.
7. Describe the series of projections taken during the examination.
8. Indicate the timings of the radiographs in relation to the administration of contrast agent.
9. Outline the practical problems and the way in which they may be overcome.
10. Explain the choice of exposure factor.
11. Detail the measures that should be taken for radiation protection.
12. Explain the after care of the patient.

Special radiographic procedures
1. Responsibility of Radiographer during Radiological Procedures.
2. Preparation of Patient for Different Procedures.
3. Contrast Media - Positive and Negative, Ionic & Non – Ionic

4. Adverse Reactions To Contrast Media and Patient Management
5. Emergency Drugs in the Radiology Department
6. Emergency Equipments In the Radiology Department
7. Aseptic technique
8. Indications, contraindications, basic techniques and relationship to other techniques of the following special procedures
    a. **Gastrointestinal Tract:**
        - Fluoroscopy, general considerations, responsibility of radiographers
        - Barium swallow, pharynx and oesophagus
        - Barium meal and follow through
        - Hypotonic duodenography
        - Small bowel enema
        - Barium Enema routine projections for colon and rectum, colonic activators; double contrast studies; colostomy. Special techniques for specific disease to be examined
        - Water soluble contrast media - eg. gastrograffin studies
    b. **Salivary glands:** Routine technique, procedure – sialography
    c. Biliary system:
        - Plain film radiography
        - Intravenous cholangiography
        - Percutaneous cholangiography
        - Endoscopic retrograde cholangio-pancreatography (ERCP)
        - Operative cholangiography
        - Post-Operative cholangiography (T - tube Cholangiography)
    d. Urinary system:
        - Intravenous urography
        - Retrograde pyelography
        - Antegrade pyelography
        - Cystography and micturating cystouresthrography
        - Urethrography (ascending)
        - Renal puncture
    e. Female reproductive system: Hysterosalpingography.
    f. Mammography:
        - Mammography: Basic views, special views, wire localization.
        - Ductography.
    g. Respiratory system: Bronchography: Awareness.
    h. Sinusography: Routine technique and procedure.
    i. Tomography:
        - General principles.
        - Estimation, selection of depth of layer.
        - Layer thickness required for different examination.
        - Spacing of layers.
        - Types and advantages of various movements.
        - Choice of tomographic movement- exposure factor.
        - Sequential, horizontal and multi section tomography.
        - Application of tomography to specific regions.

j. Macroradiography:

- General principles.
- Requirement.
- Equipment.
- Technique.

k. 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.

l. High kV Radiography:

- General principles
- Relation to patient dose
- Change in radiographic contrast.
- Scatter elimination; beam collimation; grid ratio.
- Speed and type of grid movement.
- Radiographic factor; application and uses.

m. Localization of foreign bodies:

- General location principles.
- Ingested; inhaled; inserted; embedded foreign bodies.
- Foreign bodies in eye.
- Preparation of the area to be investigated.
- Appropriate projection for all
- Techniques to locate non-opaque foreign body.

BMRIT Directed Clinical Education – part II (studentship)

Students will gain additional skills in clinical procedures, interaction with patients and professional personnel. Students apply knowledge from previous clinical learning experience under the supervision of a senior technologist. Students are tested on intermediate clinical radio diagnosis skills.

Fourth Semester

Physics of Newer Imaging Modalities

1. Computed Tomography its principle, various generations and advancements
2. Magnetic Resonance Imaging- its principle, advancements and applications.
3. Ultrasonography, Color Doppler- its principle, advancements and applications.
4. Digital Radiography and Digital subtraction angiography equipment- principle, advancements and applications.
5. Fusion Imaging including PET-CT, PET- MRI.
6. Digital Mammography, DEXA equipment- principle, advancements and applications.
7. Tele radiology HIS,RIS and PACS,
8. Image processing in digital radiography systems: Post processing techniques in console using CR, DR and flat panel fluoroscopy systems

Clinical Radiography Positioning Part- 2

1. Radiography technique comprising of the complete

2. Radiography of Skull and Radiography of cranial bones; including special techniques for sella turcica, orbits, opticforamina, superior orbital fissure and inferior orbital fissure etc.
3. Facial bones; Paranasal sinuses, Temporal bone and Mastoids.
4. Dental Radiography: Radiography of teeth-intra oral, extra oral and occlusal view.
5. Abdomen: Preparation of patient. General abdominal radiography and positioning for fluid and air levels. Plain film examination. Radiography of female abdomen to look for pregnancy. Radiography in case of acute abdomen.
6. Macroradiography: Principle, advantage, technique and applications.
7. Stereography - Procedure - presentation, for viewing, stereoscopes, stereometry.
8. High KV techniques principle and its applications.
9. Soft tissue Radiography including Mammography - its techniques, equipment, advancements and applications.
10. Localization of foreign bodies. Various techniques
11. Ward /mobile radiography - electrical supply, radiation protection, equipment and instructions to be followed for portable/ward radiography.
12. Operation theatre techniques: 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.
13. Trauma radiography/Emergency radiography
14. Neonatal and Paediatric Radiography,
15. Tomography and Tomosynthesis
16. Dual energy X-ray absorptiometry
17. Forensic Radiography

Newer Imaging Techniques including Patient Care

1. Interventional Radiography:
   Basic angiography and DSA:
   a. History , technique, patient care
   b. Percutaneous catherisation, catheterization sites, Asepsis
   c. Guidewire, catheters, pressure injectors, accessories
   d. Use of digital substraction- single plane and bi-plane
   All forms of diagnostic procedures including angiography, angioplasty, bilary examination, renal evaluation and drainage procedure.
2. Central Nervous System:
   a. Myelography
   b. Cerebral studies
   c. Ventriculography
3. Arthrography: Shoulder, Hip, Knee, Elbow
4. Angiography:
   a. Carotid Angiography (4 Vessel angiography)
   b. Thoracic and Arch Aortography
   c. Selective studies: Renal, SMA, Coeliac axis
   d. Vertebral angiography
   e. Femoral arteriography
   f. Angiocardiography
5. Venography:
   a. Peripheral venography
   b. Cerebral venography

c. Inferior and superior venocavography
d. Relevant visceral phlebography

6. Cardiac catheterization procedures: PTCA, BMV, CAG, Pacemaker, Electrophyiology,

Microbiology

1. Introduction and morphology - Introduction of microbiology, Classification of microorganisms, size, shape and structure of bacteria. Use of microscope in the study of bacteria.
2. Growth and nutrition -nutrition, culture media, types of medium with example and uses of culture media in diagnostic bacteriology, antimicrobial sensitivity test
3. Sterilization and disinfection - principles and use of equipments of sterilization namely hot air oven, autoclave and serum inspissator, pasteurization, anti-septic and disinfectants.
4. Introduction to immunology, bacteriology, parasitology, mycology

Patient care in Medical Imaging Department

Patient management is based on team work, it is essential that the student should appreciate the technologist's role and that the importance of co-operation with wards and other departments. The students should be attached to wards or the accident and emergency department for a definite training period.

1. Hospital procedure: Hospital staffing and organization; records relating to patients and departmental statistics; professional attitude of the technologist to patients and other members of the staff; medico- legal aspects; accidents in the departments, appointments, organization; minimizing waiting time; out-patient and follow-up clinics; stock-taking and stock keeping.
2. Care of the patient : FIRST contact with patients in the department; management of chair and stretcher patients and aids for this, management of the unconscious patient; elementary hygiene; personal cleanliness; hygiene in relation to patients (for example clean linen and receptacles , nursing care; temperature pulse and respiration; essential care of the patient who has a tracheostomy; essential care of the patient who has a colostomy; bedpans and urinals; simple application of a sterile dressing.
3. First aid: Aims and objectives of first aid; wounds and bleeding, dressing and bandages; pressure and splints, supports etc. Shock; insensibility; asphyxia; convulsions; resuscitation, use of suction apparatus, drug reactions; prophylactic measures; administration of oxygen; electric shock; burns; scalds; hemorrhage; pressure points; compression band. Fractures; splints, bandaging; dressing, foreign bodies; poisons.
4. Infection: Bacteria, their nature and appearance; spread of infections; auto-infection or cross-infection; the inflammatory process; local tissue reaction, general body reaction; ulceration; asepsis and antisepsis. Universal precautions, hospital acquired infections- HIV, Hepatitis B, C, and MRSA etc.
5. Principles of asepsis: Sterilization - methods of sterilization; use of central sterile supply department; care of identification of instruments, surgical dressings in common use, including filamented swabs, elementary operating theatre procedure; setting of trays and trolleys in the radio imaging department (for study by radio imaging students only)
6. Departmental procedures: Department staffing and organisations; records relating to patients and departmental statistics; professional attitudes of the technologist to patients and

other members of the staff, medico-legal aspects accidents in the department; appointments; organisations; minimizing waiting time; out-patient and follow-up clinics; stock taking and stock keeping.

7. Drugs in the department: Storage: classification; labelling and checking, regulations regarding dangerous and other drugs; units of measurement, special drugs, anti-depressive, anti-hypertensive etc.

Quality Control in Radiology and Radiation Safety

1. Objectives of quality Control: Improve the quality of imaging thereby increasing the diagnostic value; to reduce the radiation exposure; Reduction of film wastage and repeat examination; to maintain the various diagnostic and imaging units at their optimal performance.
2. Quality assurance activities: Equipment selection phase; Equipment installation and acceptance phase; Operational phase; Preventive maintenance.
3. Quality assurance programme at the radiological faculty level: Responsibility; Purchase; Specifications; Acceptance; Routine testing; Evaluation of results of routine testing; Quality assurance practical exercise in the X ray generator and tube; Image receptors from processing; Radiographic equipment; Fluoroscopic equipment; Mammographic equipment; Conventional tomography; Computed tomography; Film processing, manual and automatic; Consideration for storage of film and chemicals; Faults tracing; Accuracy of imaging- image distortion for digital imaging devices. LASER printer calibration
4. Quality assurance programme tests: General principles and preventive maintenance for routine, daily, weekly, monthly, quarterly, annually – machine calibration. Basic concepts of quality assurance – LASER printer - Light beam alignment; X-ray out-put and beam quality check; KVp check; Focal spot size and angle measurement; Timer check; mAs test; Grid alignment test; High and low contrast resolutions; Mechanical and electrical checks; Cassette leak check; Proper screen-film contact test; Safe light test; Radiation proof test; Field alignment test for fluoroscopic device; Resolution test; Phantom measurements - CT, US and MRI.
5. Quality assurance of film and image recording devices: Sensitometry; Characteristic curve; Film latitude; Film contrast; Film speed Resolution; Distortion; Artifacts of films and image recording. Monitor calibration. SMPTE pattern
6. Maintenance and care of equipment: Safe operation of equipment; Routine cleaning of equipment and instruments; Cassette, screen maintenance; Maintenance of automatic processor and manual processing units; Routine maintenance of equipments; Record keeping and log book maintenance; Reject analysis and objectives of reject analysis programme.
7. Care and maintenance of diagnostic equipment: General principles and preventive maintenance for routine - daily, Weekly, monthly, quarterly, annually: care in use, special care of mobile equipment.

Radiation safety in diagnostic Radiology

1. Radiation Quantities and Units: Radiation- Radioactivity- Sources of radiation - natural radioactive sources -cosmic rays terrestrial radiation - - man made radiation sources. Units of radiation - Quality factor - Flux- Fluence-Kerma- Exposure- Absorbed dose- Equivalent

Dose- Weighting Factors-Effective Dose - Occupational Exposure Limits - Dose limits to public.

2. Biological Effects of radiation: Ionization, excitation and free radical formation, hydrolysis of water, action of radiation on cell-Chromosomal aberration and its application for the biological dosimetry- Effects of whole body and acute irradiation, dose fractionation, effects of ionizing radiation on each of major organ system including fetus -Somatic effects and hereditary effects- stochastic and deterministic effects-Acute exposure and chronic exposure-LD50 - factors affecting radio sensitivity. Biological effects of non-ionizing radiation like ultrasound, lasers, IR, UV and magnetic fields.
3. Radiation detection and Measurements: Ionization of gases- Fluorescence and Phosphorescence -Effects on photographic emulsion. Ionization Chambers – proportional counters- G.M counters- scintillation detectors – liquid semiconductor detectors – Gamma ray spectrometer. Measuring systems – free air ionization chamber – thimble ion chamber – condenser chamber – Secondary standard dosimeters – film dosimeter – chemical dosimeter- Thermoluminescent Dosimeter. -Pocket dosimeter-Radiation survey meter- wide range survey meter -zone monitor-contamination monitor -their principle function and uses. Advantages & disadvantages of various detectors & its appropriateness of different detectors for different type of radiation measurement. Dose and Dosimetry, CT Dose Index (CTDI, etc.), Multiple Scan Average Dose (MSAD), Dose Length Product (DLP), Dose Profile, Effective Dose, Phantom Measurement Methods, Dose for Different Application Protocols, Technique Optimization. Dose area product in fluoroscopy and angiography systems, AGD in mammography.
4. Radiation protection: Radiation protection of self and patient- Principles of radiation protection, time - distance and shielding, shielding - calculation and radiation survey – ALARA- personnel dosimeters (TLD and film batches) - occupational exposure.
5. Radiation Hazard evaluation and control: Philosophy of Radiation protection, effects of time, Distance & Shielding. Calculation of Work load, weekly calculated dose to radiation worker & General public Good work practice in Diagnostic Radiology. Planning consideration for radiology, including Use factor, occupancy factors, and different shielding material.

BMRIT Directed Clinical Education – part III (studentship)

Students will gain additional skills in clinical procedures, interaction with patients and professional personnel. Students apply knowledge from previous clinical learning experience under the supervision of a senior technologist. Students are tested on intermediate clinical radio diagnosis skills.

Fifth Semester

Cross Sectional Anatomy and Physiology

Radiology has been developing dramatically during the past few years. With enhancements in magnetic resonance imaging (MRI) and computed tomography (CT), the role of the radiologic technologist has also been changing.

Skills in cross-sectional anatomy are important to help the technologist in MRI and CT to identify the anatomy being imaged and to communicate effectively with the radiologist and physicians.

At the completion of this, candidates will be able to:

1. Identify cross-sectional anatomy in the sagittal, coronal and axial planes on CT and MR images.
2. Describe anatomical structural relationships.
3. Recognize normal anatomy and build a personal resource system for future study.
4. Locate and identify pertinent cerebral, upper thorax, mid-thorax, and abdominal anatomy.
5. On CT and MR images, identify anatomical structures of the body and of the head.
6. Distinguish between arterial and venous anatomy of the entire body's vascular system.
7. Classify the various sections of anatomical regions and their associated parts.

The students will be given a thorough understanding of:

1. Introduction to Sectional Anatomy & Terminology- Sectional planes, Anatomical relationships/terminology
2. Anatomy of the upper thorax- Surface anatomy relationships, Bony structures and muscles, Blood vessels.
3. Divisions of the mid-thorax, heart and great vessels- Lungs, heart and great vessels, Esophagus
4. CT/MRI Images of the Thorax - Normal and pathologic
5. Anatomy of the Abdomen- Major organs and their accessories, Abdominal blood vessels
6. CT/MR Images of Abdomen - Normal and pathologic
7. Anatomy of the Pelvis- Bony structures and associated muscles, Digestive and urinary systems
8. Reproductive Organs
9. CT/MR Images of the Male/Female Pelvis- Normal and pathologic
10. Neuro Anatomy- Scan planes
11. Brain - Cerebral hemispheres, Sinuses, Ventricles, Brainstem and associated parts, Arterial/venous systems, Basal ganglia, Cranial nerves
12. Spine- Vertebra and disc, Spinal cord and meninges
13. Neck- Arterial/venous systems, Muscles, Glands and pharynx

Physics of Advanced Imaging Technology

1. Basic Computed Tomography- Basic principles of CT, generations of CT, CT instrumentation, image formation in CT, CT image reconstruction, Hounsfield unit, CT image quality, CT image display
2. Advanced Computed Tomography
   Helical CT scan: Slip ring technology, advantages, multi detector array helical CT, cone – beam geometry, reconstruction of helical CT images, CT artifact, CT angiography, CT fluoroscopy, HRCT, post processing techniques: MPR, MIP, Min IP, 3D rendering: SSD and VR, CT Dose, patient preparation, Imaging techniques and protocols for various parts of body, CT contrast enhanced protocols – CT angiography – (Aortogram, selective angiogram head, neck and peripheral) image documentation and Filing, maintenance of equipment and accessories.
3. Advanced technique & instrumentation of MRI
   a. Basic Principles: Spin – precession – relaxation time – pulse cycle – T1 weighted image – T2 weighted image – proton density image.
   b. Pulse sequence : Spin echo pulse sequence – turbo spin echo pulse sequence - Gradient echo sequence – Turbo gradient echo pulse sequence - Inversion recovery sequence – STIR sequence – SPIR sequence – FLAIR sequence – Echo planar imaging – Advanced pulse sequences.
   c. MR Instrumentation: Types of magnets – RF transmitter – RF receiver – Gradient coils – shim coils – RF shielding – computers.
   d. Image formation: 2D Fourier transformation method – K-space representation – 3D Fourier imaging – MIP.
   e. MR contrast media – MR angiography – TOF & PCA – MR Spectroscopy – functional MRI

4. Ultrasonography
    a. Basic Acoustics, Ultrasound terminologies: acoustic pressure, power, intensity, impedance, speed, frequency, dB notation: relative acoustic pressure and relative acoustic intensity.
    b. Interaction of US with matter: reflection, transmission, scattering, refraction and absorption, attenuation and attenuation coefficients, US machine controls, US focusing.
    c. Production of ultrasound: Piezoelectricity, Medical ultrasound transducer: Principle, construction and working, characteristics of US beam.
    d. Ultrasound display modes: A, B, M
    e. Real-time ultrasound: Line density and frame rate, Real-time ultrasound transducers: mechanical and electronic arrays, ultrasound artifacts, ultrasound recording devices, and Distance, area & volume measurements.
    f. Techniques for imaging different anatomic areas, ultrasound artifacts, biological effects and safety.
    g. Doppler Ultrasound- Patient preparation for Doppler, Doppler artifacts, vascular sonography,

Radiographic Techniques in Advanced Imaging Technology

1. Ultrasonography/ Doppler studies: Techniques of sonography-selection- Preparations - instructions and positioning of patient for TAS, TVS, TRUS, neck USG and extremities- patient care and maintenance protocols clinical applications display methods –quality image reproducible extend – biopsy procedures, assurance to patients.2. CT scan studies acquisition/ protocols /techniques: CT of head and neck – thorax – abdomen – pelvis – musculo skeletal system – spine – PNS. Anatomy – clinical indications and contraindications – patient preparation – technique – contrast media-types, dose, injection technique; timing, sequence - image display – patient care – utilization of available techniques & image processing facilities to guide the clinician- CT anatomy and pathology of different organ systems.
2. MRI Scanners: Methods of MRI imaging methods – Head and Neck ,Thorax, Abdomen, Musculoskeletal System imaging - Clinical indications and contraindications- types of common sequences effects of sequence on imaging - Protocols for various studies- slice section- patient preparation-positioning of the patient -patient care-calibration - paramagnetic agents and dose, additional techniques and recent advances in MRI - image acquisition-modification of procedures in an unconscious or un co-operative patient - plain studies- contrast studies -special procedures- reconstructions- 3D images- MRS blood flow imaging, diffusion/perfusion scans - strength and limitations of MRI- role of radiographer.

Regulatory Requirements in Diagnostic Radiology

1. Regulatory Bodies & regulatory Requirements: International Commission on Radiation Protection (ICRP) / National Regularity body (AERB - Atomic Energy Regulatory Board) - Responsibilities, organization, Safety Standard, Codes and Guides, Responsibilities of licenses, registrants & employers and Enforcement of Regulatory requirements.
2. Role of Radiographer in Planning, QA & Radiation Protection: Role of technologist in radiology department - Personnel and area monitoring., Setting up of a new X-Ray unit, staff requirement, AERB specifications for site planning and mandatory guidelines – Planning of X-ray rooms, dark rooms – Inspection of X-Ray installations - Registration of X-Ray equipment installation- Certification -Evaluation of workload versus radiation factors – Occupational exposure and protection Tools/devices. ICRP, NRPB, NCRP and WHO guidelines for radiation protection, pregnancy and radiation protection. NABH guidelines, AERB guidelines, PNDT Act and guidelines

BMRIT Directed Clinical Education – part IV (studentship)

Students will gain additional skills in clinical procedures, interaction with patients and professional personnel. Students apply knowledge from previous clinical learning experience under the supervision of a senior technologist. Students are tested on intermediate clinical radio diagnosis skills.

Sixth Semester

Quality Control in Radiology and Radiation Safety Part 2

Quality Assurance and quality control of Modern Radiological and Imaging Equipment which includes Digital Radiography, Computed Radiography, CT scan, MRI Scan, Ultrasonography and PACS related. Image artifacts their different types, causes and remedies, Newer Radiation safety protocols and recent advances in radiation safety including AERB guidelines.

Research Methodology

1. **Accessing research literature:**
   Use of databases and other sources

2. **Understanding research design:**
   Qualitative and quantitative methodologies - their differences and potential integration. Evaluating research and its potential for informing practice. Developing research questions and devising methods for their investigation. Ethical issues in research

3. **Analysis:**
   Analysis of qualitative and quantitative data. Utilisation of appropriate software to assist in the retrieval of information and data analysis

4. **Clinical audit:**
   Distinctiveness of research and audit processes and their function

5. **Research Skills and Management**:
   The role of evidence based practice within health and welfare

Hospital Practice and Care of Patient

Hospital staffing and administration, records, professional, ethics, co-operation with other staff and departments, Departmental organisations. Handling of the patients, seriously ill and traumatized patients, visually impaired, speech and hearing impaired, mentally impaired, drug addicts and non-English speaking patients. Understanding patient needs - patient dignity of inpatient and out patients. Interaction with the patient's relatives and visitors. Methods of effective communication - verbal skills, body language, professional appearance, visual contact etc. Elementary personal and departmental hygiene, dealing with receptacles, bed pans and urinal etc. General preliminaries to the exam. Moving chair and stretcher, patient. Unconscious patient, general comfort and reassurance for the patient. Vital signs and oxygen - patient's Haemeatasis status.
Body temp, respiratory rate, pulse, blood pressure, oxygen therapy, oxygen devices,
Chest tubes and lines. First aid - shock, electrical shock, haemorrhage, burns, Asphyxia, fractures, loss of consciousness. Emergency treatment to the collapsed patient. Artificial respiration and resuscitation. Preparation of patient for general and special radiological examinations. Supervision of patients undergoing special examination. Administration of drugs and contrast media. Aseptic and sterile procedures. Handling of infections patients in the department or in the ward. Regulation

of dangerous drugs. Trolley set up for special x-ray examinations, Radiation hazardous and protective measures.

Seminars, Journal Clubs and Group Discussions

Each student will be assigned topics for presentations as seminars, will explore recent innovations in MRIT for presenting topics during journal clubs and shall be holding group discussions along with in the presence of MRIT faculty.

BMRIT Directed Clinical Education – part IV (studentship)

Students will gain additional skills in clinical procedures, interaction with patients and professional personnel. Students apply knowledge from previous clinical learning experience under the supervision of a senior technologist. Students are tested on intermediate clinical radio diagnosis skills

Skills based outcomes and monitorable indicators for Medical Radiology and Imaging Technologist

Competency statements

1. Should be able to undertake Mammography, CT scan and MRI procedures independently.
2. Assist in specialised radiological procedures.
3. Able to do the image processing.
4. Should be able to handle all radiological and imaging equipment independently.
5. Should ensure radiation protection and quality assurance
6. Undertake care and maintenance of all radiological and imaging equipment
7. Able to evaluate images for technical quality
8. Able to identify and manage emergency situations.
9. Able to receive and document verbal, written and electronic orders in the patient's medical record.
10. Implements health and safety procedures
11. Demonstrates ability to interpret, apply and disseminate information as a member of the medical imaging team
12. Ensures radiation protection legislation is adhered to
13. Demonstrates knowledge and skills to carry out the daily/weekly Quality Control (QC) checks
14. Participates in research activities

S. no.	Learning outcomes	Knowledge/comprehension	Applications / synthesis /evaluation	Hours
1	Be able to interpret and evaluate a	Identify the area for treatment.	Determining x-ray, CT scan or MRI scan needs of patient	200

S. no.	Learning outcomes	Knowledge/comprehension	Applications / synthesis /evaluation	Hours
	prescription	Quantify the practical problems associated with machine and accessory equipment limitations	Understand and interpret instructions and requirements documented by the physician in the patient's prescription	
2	Operate and oversee operation of radiologic equipment	Selecting and performing basic views (projections) and conventional contrast studies using appropriate radiographic parameters and equipment	Reliably perform all non-contrast plain Radiography, conventional contrast studies and non-contrast plain radiography in special situations	200
		Carrying out routine procedures for troubleshooting and maintenance of imaging and processing systems	Control and manipulate parameters associated with exposure and processing to produce a required image of desirable quality	
			Apply quality control procedures for all radiologic equipment	
3	Be able to transfer all relevant information and complete accurate documentation	Recognize the importance of accurate transfer of information to allow for accurate treatment set-up according to the treatment plan and prescription	Construct the most appropriate device for the individual patient within the context of the protocol	100
		Know what should be included	Apply the necessary precautions in production	
		Know to whom or where the documentation and information should be sent	Implement correct QC, storage and handling procedures for shielding devices	
		Be aware of the legal issues relating to documentation		
4	Be able to prepare the diagnostic machinery	Know the shielding devices/methods available	Construct the most appropriate device for the individual patient within the context of the protocol	100
		Know how to use these devices	Apply the necessary precautions in production	
		Recognize the associated health and safety issues	Implement correct QC, storage and handling procedures for immobilization devices	

S. no.	Learning outcomes	Knowledge/comprehension	Applications / synthesis /evaluation	Hours
5	Be able to carry out the daily organization of the treatment unit	Recognize the importance of team interactions	Participate in the organization of the daily work schedule to maximize efficiency	50
		Explain the principles of effective communication	Inform the patient about the procedure	
		Review the individual patient requirements		
6	Be able to accurately and consistently set-up and produce a good quality radiological image	Able to interpret the set-up information	Interpret the diagnostic plan and set-up the patient accordingly	200
		Apply knowledge of radiographic imaging to the production of radiographs and the assessment of image quality	Carrying out quality control tests on images obtained	
7	Be able to prepare and position the patient for the procedure	Be familiar with the treatment plan	Explain the anatomic and physiological basis of the procedure to be undertaken	200
		Identify preparatory procedures	Identify and explain the possible side effects to each patient	
			Check all preparatory procedures have been completed	
		Be familiar with the diagnostic plans for all patients on the treatment unit	Identify the patient in accordance with recognized procedures and consistent with the department protocol	
		Recognize the signs and symptoms associated with treatment in different sites	Analyze the information and integrate to define the optimal patient position	
		Discuss the importance of patient identification and how it should be carried out	Interpret the diagnostic plan and use the equipment accordingly	
8	Be able to complete accurate treatment documentation	Recognize the importance of accurate documentation	Complete the treatment documentation accurately	50
		Know what should be included	Ensure all legal requirements have been met	
		Be aware of the legal issues relating to treatment documentation		
		List support groups that might benefit patients		

S. no.	Learning outcomes	Knowledge/comprehension	Applications / synthesis /evaluation	Hours
9	Advise patient on appropriate nutrition, sexual function, rest, skin care, nausea and other symptoms	Explain the impact of nutritional status on patient tolerance of treatment	Assess the patient's nutritional status	50
10	Monitor and assure quality	Monitor treatment process/outcomes	Identify needs and expectations of patient/health care professionals	50
		Identify problems in treatment process/outcomes	Solve treatment process/outcome problems	
		Know what patient care is relevant for the procedure	Evaluate potential solutions thoroughly	
11	Be able to carry out the necessary data transfer checks	Define and explain the data that must be transferred	Check and verify all parameters	50
			Confirm approval and signatures	
12	Be able to process radiographic images	Apply knowledge of radiographic imaging to the production of radiographs and the assessment of image quality	Perform X-ray film / image processing techniques (including dark room techniques)	50
		Control and manipulate parameters associated with exposure and processing to produce a required image of desirable quality	Acquire an appropriate image as per instructions	
13	Recognise contrast induced adverse reactions	Promptly recognize and assess the reactions	Know the correct medications and other treatment options	50
		Taking precautionary measures to avoid the reactions	Recognise the contraindications of allergic reactions	
14	Be able to carry out corrective actions as per instructions	Recognize the critical structures on the verification images	Make corrections in accordance with the protocol	50
		Identify the correct imaging protocol	Record any corrections	
15	Be able to implement health and safety procedures	Explain the health and safety issues for patients and staff	Assess the safety features to ensure they are in place and adhered to	50

S. no.	Learning outcomes	Knowledge/comprehension	Applications / synthesis /evaluation	Hours
16	Be able to interpret, apply and disseminate information as a member of the medical imaging team	Define and explain the data that must be disseminated	Identify the appropriate personnel to whom specific information should be disseminated	50
			Communicate the correct, relevant and appropriate information	
17	Be able to demonstrate professional behaviour	Explain the legal and ethical guidelines related to the profession	Practice in accordance with legislation regulations and ethical guidelines	100
		Be aware of your own competency levels	Promote collaborative practice	
		Identify the elements that reflect professional appearance and manner		
18	Be able to demonstrate a sensitive and caring attitude to patients	Explain the components of good communication	Self-awareness of their own personality traits	50
		Describe the main personality types	Analyze how the differences in personality influence approach	
		Be aware of the patient' gender, age, cultural background, educational level and social situation		
19	Be able to ensure radiation protection legislation is adhered to	Describe the radiation hazards and how they are managed	Routinely inspect the area to ensure that radiation protection measures are in place and functional	50
		Explain the legislation relating to radiation protection		
20	Be able to carry out the daily/weekly Quality Control (QC) checks	Explain Quality Management System (QMS), Quality Assurance (QA) and Quality Control (QC	Perform the daily/weekly/monthly QC procedures	50
21	Be able to review the literature	Define search terms for specific treatment sites	Identify the appropriate literature in the area of interest	30
22	Be able to suggest implementation of research findings	Identify relevant sources of Research	Evaluate research with respect to current departmental practice	10
23	Be able to suggest/ initiate topics for medical imaging	Identify literature to support research proposal	Review the literature in the area	10
		Define the necessary steps in	Formulate a research question	

S. no.	Learning outcomes	Knowledge/comprehension	Applications / synthesis /evaluation	Hours
	research	preparing and carrying out research		

Total Hours- 1800

4.3 M.Sc. in Medical Radiology and Imaging Technology (M.Sc. MRIT)

MSc. in Medical Radiology and Imaging Technology

Introduction:

Learning Objectives:
The M.Sc. in Medical Radiology & Imaging Technology is specifically aimed at those pursuing a professional career in Imaging Science technology. It is designed to provide specialized training in the scientific principles of modern imaging science and in the application of these principles in the field of radio diagnosis. It is designed as a higher degree course suitable for gradates having experience in the technology of imaging science. The objective of the programme is to train students in to qualified, patient focused, compassionate, critical thinkers Diagnostic Radiographer / Technologist for the community who are engaged in lifelong learning.

Upto successful completion of the M.Sc. course, students will have developed a broad knowledge of the principles, technology, instrumentation, recent developments and proper handling of the modern radiological equipments and proper execution of the various radiological procedures and be able to embark Upto a successful career in their chosen direction of Imaging Science research.

Expectation from the future graduate in the providing patient care

Perform a range of radiographic examinations on patient 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 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 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 precautions and instruction for self and others protection. He/she should wear dosimeter during duty hours.
15. Attends all in service education required as per hospital policy.
16. Providing education. Educating and monitoring students and other health care providers.
17. Orientation and teaching students and new employees.
18. To supervise and allocate responsibilities to level 4 and level 5.
19. Learns new technologies and technologies as required by the professional bodies.
20. Impart appropriate training to the students and other staff.
21. Should have management and research skills.

22. To exhibit keen interest, initiative & drive in the overall development of the Department and 'Leadership Qualities' for others to follow.
23. He / She is expected to be confident and to perform all the duties diligently with utmost sincerity and honesty.
24. 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.

Eligibility for admission:

B.Sc. in Medical Radiology& Imaging Technology/B.Sc. Medical Technology Radio diagnosis and Imaging/ B.Sc. Radiological Technology/B.Sc. in Radiography/B.Sc. Medical Technology (X-ray) with a minimum 60% marks in B.Sc.

The selection of the candidates for admission to the course is made on merit on the basis of combined entrance examination conducted by the institute on All India basis. The admission notice is released in all leading English Newspaper. Only those candidates will be eligible who score minimum 50% marks in the entrance test for General Category candidates and 45% of for those belonging to SC/ST category.

OR

Selection of the students by the Entrance examination conducted by the State itself or the Institute, followed by personal interview or counseling by the Interview Board constituted by the institution according to the norms.

OR

A candidate with Bachelor degree in any science discipline with a minimum of 60% marks in the BSc. Exam or diploma holders in Medical Radiology and Imaging Technology with such (3-5) years of professional experience may be considered as the eligible candidates for the MSc. Program.

Duration of the course

Duration of the course: 4 semesters or 2 Years (590 hours of Theory & 750 hours of Practical Classes) and 850 hours of Resident Postings.
Total hours – 2180

Medium of instruction:

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

Attendance:

A candidate will be permitted to appear for the University Examination for any semester if he / she secure not less than 75% of attendance in the number of instructional days/ practical at industry during the calendar year, failing which he / she should complete the number of days/hours and undergo the next semester/final examination conducted by the university.

Assessment:

The examination to the first/second year shall be open to a student who:

Has remained on the rolls of the course concerned for full on academic year preceding the examination and having attendant not less than 75% of the full course of lectures and practical separately held for the purpose in each year. The lectures/practical will be conducted up to the last day when the classes break up for the appearing in the examination. Student must **attain at least 50%** marks in each Theory, Internal assessment and Practical independently / separately for each

individual subject. The practical and viva voice examination will be held at the end of each years. The candidate will be examined on the subject matter prescribed for that year.

Model Curriculum Outline

First Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
MMRIT-001	Management &Planning of a Radiology & Imaging department including national & international guidelines.	60	60	120
MMRIT-002	Modern Imaging Techniques including Fusion and hybrid imaging technologies	60	120	180
MMRIT-003	Advanced Physics of Radiology & Imaging	60	60	120
	Residency – I			120
TOTAL		180	240	540

Second Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
MMRIT-004	Radiation Safety and Protection- AERB guidelines	60	60	120
MMRIT-005	Modern Radiological and Imaging Equipment	60	60	120
MMRIT-006	Radiological and Imaging Procedures	60	100	160
	Residency – II			140
TOTAL		180	220	540

Third Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
MMRIT-007	Quality Assurance and Quality Control in Diagnostic Radiology and Imaging	40	70	110
MMRIT-008	Newer Imaging Modalities	40	60	100
MMRIT-009	Intervention Radiological Techniques and Care of Patient	60	100	160
	Residency - III			180
TOTAL		140	210	550

Fourth Semester

Sl. No.	Course Titles	Hours		
		Theory	Practical	Total
MMRIT-010	Newer Developments in Advanced Imaging Technology such as maxillo-facial imaging, dental radiology and other advanced modalities	60	60	120
MMRIT-011	Seminars, Journal Club and Group Discussions	20	60	80
	Residency –IV Dissertation	40	300	240
TOTAL		**120**	**420**	**540**

Management and Planning of radiology department with compliance to national & international guidelines

1. Planning consideration for radiology, including Use factor, occupancy factors, and different shielding materials Protection for primary radiation, work load, use factor, occupancy factor, protection from scatter radiation and leakage radiation, X-Ray/Fluoroscopy/Mammography/Intervention/DSA/CT room design, structural shielding, protective devices.
2. Regulatory Bodies & regulatory Requirements: International Commission on Radiation Protection (ICRP) / National Regularity body (AERB - Atomic Energy Regulatory Board) - Responsibilities, organization, Safety Standard, Codes and Guides, Responsibilities of licenses, registrants & employers and Enforcement of Regulatory requirements. (ICRP, NRPB, NCRP and WHO guidelines for radiation protection, pregnancy and radiation protection).
3. Surveys and regulations. Radiation protection survey: Need for survey. - Performance standards for beam directing, beam defining and limiting devices in radiation protection equipment survey of the following. a. Radiographic equipment b. Fluoroscopic equipment c. CT and special equipment. Controlled and non-controlled areas and acceptable exposure levels. State and local regulations governing radiation protection practice.
4. Personal monitoring and occupational exposures: Personal monitoring for Radiation workers. Monitoring devices. Body badges and ring badges. Thermo-luminescent dosimeters, Pocket ionization chambers. Applications, advantages and limitations of each device, Values for dose equivalent limits for occupational radiation exposures.
5. NABH guidelines, AERB guidelines and code, Basic safety standard, PNDT Act and guidelines.
6. Procedural safety
7. Achievable safety through compliance on the regulations in India and recommendations of ICRT, IAEA.
8. Role of Radiographer in Planning & Radiation Protection: Role of technologist in radiology department - Personnel and area monitoring., Setting up of a new X-Ray unit, staff requirement, AERB specifications for site planning and mandatory guidelines – Planning of X-ray/CT rooms, Inspection of X-Ray installations - Registration of X-Ray equipment installation- Certification -Evaluation of workload versus radiation factors – Occupational exposure and protection Tools/devices.
9. Introduction to Management of a Radiology Department
    a. Strategic Management
    b. Decision Making, conflict and stress management
    c. Managing Change and Innovation
    d. Understanding Groups and Teams
    e. Leadership
    f. Time Management
    g. Cost and efficiency

Modern Imaging Techniques including Fusion and hybrid imaging technologies

1. Interventional Radiography: Basic angiography and DSA:
    a. History , technique, patient care
    b. Percutaneous catherisation, catheterization sites, Asepsis
    c. Guidewire, catheters, pressure injectors, accessories
    d. Use of digital substraction- single plane and bi-plane

All forms of diagnostic procedures including angiography, angioplasty, bilary examination, renal evaluation and drainage procedure.

2. Central Nervous System:
    a. Myelography.
    b. Cerebral studies.
    c. Ventriculography
3. Arthrography: Shoulder, Hip, Knee, Elbow
4. Angiography:
    a. Carotid Angiography (4 Vessel angiography).
    b. Thoracic and Arch Aortography.
    c. Selective studies: Renal, SMA, Coeliac axis.
    d. Vertebral angiography.
    e. Femoral arteriography.
    f. Angiocardiography.
5. Venography:
    a. Peripheral venography.
    b. Cerebral venography.
    c. Inferior and superior venocavography.
    d. Relevant visceral phlebography.
6. Cardiac catheterization procedures: PTCA, BMV, CAG, Pacemaker, Electrophyiology
7. Ultrasonography/ Doppler studies: Techniques of sonography-selection- Preparations - instructions and positioning of patient for TAS, TVS, TRUS, neck USG and extremities- patient care and maintenance protocols clinical applications display methods –quality image reproducible extend – biopsy procedures, assurance to patients.
8. CT scan studies acquisition/ protocols /techniques: CT of head and neck – thorax – abdomen – pelvis – musculo skeletal system – spine – PNS. Anatomy – clinical indications and contraindications – patient preparation – technique – contrast media-types, dose, injection technique; timing, sequence - image display – patient care – utilization of available techniques & image processing facilities to guide the clinician- CT anatomy and pathology of different organ systems.
9. MRI imaging – Head and Neck ,Thorax, Abdomen, Musculoskeletal System imaging - Clinical indications and contraindications- types of common sequences effects of sequence on imaging - Protocols for various studies- slice section- patient preparation-positioning of the patient -patient care-calibration - paramagnetic agents and dose, additional techniques and recent advances in MRI - image acquisition-modification of procedures in an unconscious or un co-operative patient - plain studies- contrast studies -special procedures- reconstructions- 3D images- MRS blood flow imaging, diffusion/perfusion scans - strength and limitations of MRI- role of radiographer.
10. Techniques of Fusion and hybrid Imaging Technology including PET CT,PET MRI, PET Ultrasound, MRI, CT, Fluoroscopy, Hybrid Imaging as well as Advanced Interventional suite.

Advanced Physics of Radiology & Imaging

1. Physics of Imaging including conventional radiography, computed radiography and flat panel DR imaging.
2. Computed Tomography- Basic principles of CT, generations of CT, CT instrumentation, image formation in CT, CT image reconstruction, Hounsfield unit, CT image quality, CT-image display.

3. Advanced Computed Tomography -Helical CT scan: Slip ring technology, advantages, multi detector array helical CT, cone – beam geometry, reconstruction of helical CT images, CT artifact, CT angiography, CT fluoroscopy, HRCT, post processing techniques: MPR, MIP, Min IP, 3D rendering: SSD and VR, CT Dose Index.
4. MRI- Basic Principles: Spin – precession – relaxation time – pulse cycle – T1 weighted image – T2 weighted image – proton density image.
    a. Pulse sequence : Spin echo pulse sequence – turbo spin echo pulse sequence - Gradient echo sequence – Turbo gradient echo pulse sequence - Inversion recovery sequence – STIR sequence – SPIR sequence – FLAIR sequence – Echo planar imaging – Advanced pulse sequences
    b. MR Instrumentation: Types of magnets – RF transmitter – RF receiver – Gradient coils – shim coils – RF shielding – computers.
    c. Image formation: 2D Fourier transformation method – K-space representation – 3D Fourier imaging – MIP.
    d. MR Spectroscopy – functional MRI
5. Ultrasonography

    Basic Acoustics, Ultrasound terminologies: acoustic pressure, power, intensity, impedance, speed, frequency, dB notation: relative acoustic pressure and relative acoustic intensity.
    Interaction of US with matter: reflection, transmission, scattering, refraction and absorption, attenuation and attenuation coefficients, US machine controls, US focusing.
    Production of ultrasound: Piezoelectricity, Medical ultrasound transducer: Principle, construction and working, characteristics of US beam.
    Ultrasound display modes: A, B, M
    Real-time ultrasound: Line density and frame rate, Real-time ultrasound transducers: mechanical and electronic arrays, ultrasound artifacts, ultrasound recording devices, and Distance, area & volume measurements.
    Doppler Ultrasound, Doppler artifacts, vascular sonography

Residency part – I

In the residency the professional is expected to work and contribute in the medical imaging unit.

Second Semester

Radiation Safety and Protection

Radiation safety in diagnostic Radiology

1. Introduction to Radiation protection-Need for protection, Aim of radiation protection.
2. Limits for radiation exposure: Concept of ALARA, maximum permissible dose, exposure in pregnancy, children. Occupational Exposure Limits - Dose limits to public
3. Radiation Protection in: Radiography, Fluoroscopy, Mammography, Mobile Radiography, CT scan, DSA and Interventional Radiology.
4. Radiation measuring instruments: survey meters, area monitor, personnel dosimeters, film badge, thermo luminescent dosimeter, pocket dosimeter.
5. Radiation Quantities and Units: Radiation, Radioactivity, Sources of radiation - natural radioactive sources, cosmic rays, terrestrial radiation, manmade radiation sources. Kerma, Exposure, Absorbed dose, Equivalent Dose, Weighting Factors, Effective Dose
6. Biological Effects of radiation: Direct & Indirect actions of radiation ,concept of detriment ,Deterministic & stochastic effect of radiation ,somatic and genetic effects, dose relationship , effects of antenatal exposure Ionization, excitation and free radical

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

7. Radiation detection and Measurements: Ionization of gases, Fluorescence and Phosphorescence, Effects on photographic emulsion. Ionization Chambers, proportional counters, G.M counters, scintillation detectors, liquid semiconductor detectors, Gamma ray spectrometer. Measuring systems: free air ionization chamber, thimble ion chamber, condenser chamber, Secondary standard dosimeters, film dosimeter, chemical dosimeter- thermo luminescent Dosimeter, Pocket dosimeter, Radiation survey meter- wide range survey meter, zone monitor, contamination monitor -their principle function and uses. Advantages & disadvantages of various detectors & appropriateness of different detectors for different type of radiation measurement.
8. Dose and Dosimetry, CT Dose Index (CTDI, etc.), Multiple Scan Average Dose (MSAD), Dose Length Product (DLP), Dose Profile, Effective Dose, Phantom Measurement Methods, Dose for Different Application Protocols, Technique Optimization. Dose area product in fluoroscopy and angiography systems, AGD in mammography.
9. Radiation protection, Hazard evaluation and control:: Philosophy of Radiation protection Radiation protection of self and patient and General Public, Principles of radiation protection, time - distance and shielding, shielding - calculation and radiation survey, Calculation of Work load, weekly calculated dose to radiation worker & General public Good work practice in Diagnostic Radiology.
10. Planning consideration for radiology, including Use factor, occupancy factors, and different shielding materials Protection for primary radiation, work load, use factor, occupancy factor, protection from scatter radiation and leakage radiation, X-Ray/Fluoroscopy/Mammography/Intervention/DSA/CT room design, structural shielding, protective devices.
11. Regulatory Bodies & regulatory Requirements: International Commission on Radiation Protection (ICRP) / National Regularity body (AERB - Atomic Energy Regulatory Board) - Responsibilities, organization, Safety Standard, Codes and Guides, Responsibilities of licenses, registrants & employers and Enforcement of Regulatory requirements. (ICRP, NRPB, NCRP and WHO guidelines for radiation protection, pregnancy and radiation protection).
12. NABH guidelines, AERB guidelines, PNDT Act and guidelines.
13. Procedural safety
14. Achievable safety through compliance on the regulations in India and recommendations of ICRT, IAEA.

Newer Radiation safety protocols and recent advances in radiation safety.

Role of Radiographer in Planning & Radiation Protection: Role of technologist in radiology department - Personnel and area monitoring., Setting up of a new X-Ray unit, staff requirement, AERB specifications for site planning and mandatory guidelines – Planning of X-ray/CT rooms, Inspection of X-Ray installations - Registration of X-Ray equipment

installation- Certification -Evaluation of workload versus radiation factors – Occupational exposure and protection Tools/devices.

Modern Radiological and Imaging Equipment

1. High Frequency X-Ray Generators and their types and applications.
2. Modern x-ray tubes-their types and advancements.
3. Special radiological equipment: Computed radiography: its principle, physics & equipment. Digital Radiography, Direct and indirect digital radiography Digital Fluoroscopy , Digital Mammography; including cones compression devices Stereotactic Biopsy system including Prone Table Biopsy system.
4. Image Receptors: Flat Panel Detectors, Image Processing Workstation and Imaging Cameras.
5. Tomography: Body section radiography, basic principle and equipment, multi section tomography, various types of topographic movements,
6. Tomosynthesis, Stitch radiography
7. Dual energy x-ray absorptionometry (DEXA) scan.
8. Vascular Imaging Equipment: Introduction, historical developments DSA Equipment-Principle, applications and definition of terms, Single Plane, Biplane, Hybrid DSA Lab-digital subtraction techniques.
9. Scatter radiation its formation and control: beam centering devices, collimators, cone diaphragms and grids.
10. Fluoroscopy and IITV systems including cine radiography with various recording devices.
11. Computed Tomography -Principle, data acquisition concepts, image reconstruction, instrumentations, image manipulation Historical developments - Various generations, spiral/helical, single slice/multislice CT, Electron beam CT, mobile CT, Advances in volume scanning, continuous, sub-second scanning. Real time CT fluoroscopy, interventional guidance tool, 3D CT, CT angiography. Virtual reality imaging, including image quality and quality control in CT Scanners.
12. Ultrasonography: :Basic principle of U.S., various types of transducers, mechanism of image formation, various advancements including Doppler, Elastography, HIFU,ABVS and image artifacts.
13. MRI: Basic principle of MRI, complete imaging equipment and various requirements, T1 and T2 Relaxation behaviors of tissues, T1, T2 and proton density images, spatial localization of images. Types of imaging sequences (spin echo, fast spin echo, flash, inversion recovery, gradient echo etc. MR spectroscopy, principle and techniques, Contrast Agents in MRI, Image quality, Image artifacts and its compensators, NMR hazard and safety. Advances in MRI.
14. Radionuclide scanning including rectilinear scanner, gamma camera, PET, SPECT, their principles, working, applications and advancements.
15. Care and maintenance of radiological equipments

Radiological and Imaging Procedures

1. Special Radiographic/Radiological procedures

2. Selection of Fluoroscopy Equipment, general considerations, responsibility of radiographers. Patient Preparation, Indications Contraindications Technique Post Care and Preparation of Drug Trolley/Tray, Radiation Safety. Contrast Media - Positive and Negative, Ionic & Non – Ionic, Adverse Reactions To Contrast Media and Patient Management, Emergency Drugs in the Radiology Department ,Aseptic technique for the following procedures.
3. Gastrointestinal Tract: Barium swallow, pharynx and oesophagus. Barium meal and follow through. Hypotonic duodenography. Small bowel enema. Barium Enema routine projections for colon and rectum, colonic activators; double contrast studies; colostomy. Special techniques for specific disease to be examined. Including water soluble contrast media - e.g. gastrograffin studies. Including CT, US and MRI Special Imaging Techniques.
4. Salivary glands: Routine technique, procedure - sialography.
5. Biliary system: Plain film radiography. Intravenous cholangiography. Percutaneous cholangiography, Endoscopic retrograde cholangio- pancreatography (ERCP). Operative cholangiography, Post-Operative cholangiography (T-tube Cholangiography). Including CT, US and MRI Special Imaging Techniques.
6. Urinary system: Intravenous urography, retrograde pyelography. Antegrade pyelography. Cystography and micturating cystouresthrography. Urethrography (ascending) renal puncture. Including CT, US and MRI Special Imaging Techniques.
7. Reproductive system: All the Techniques relating to Male and Female reproductive system including Hysterosalpingography.
8. Breast Imaging: Mammography: Basic views, special views, wire localization. Ductography, Tomosynthesis, ABVS, Various Biopsy Techniques including Prone Table Biopsy, CT, US and MRI Special Imaging Techniques
9. Respiratory system: - Bronchography: Including CT, US and MRI Special Imaging Techniques.
10. Sinography: Routine technique and procedure.
11. Central Nervous System: Myelography. Cerebral studies. Ventriculography etc. including CT, US and MRI Special Imaging Techniques.
12. Arthrography: Shoulder, Hip, Knee, Elbow joints etc. including CT, US and MRI Special Imaging Techniques.
13. Angiographic Studies: Carotid Angiography (4 Vessel angiography). Thoracic and Arch Aortography. Selective studies: Renal, SMA, Coeliac axis. Vertebral angiography. Femoral arteriography. Angiocardiography, Peripheral angiography
14. Venography: Peripheral venography. Cerebral venography. Inferior and superior venocavography. Relevant visceral phlebography.
15. Microbiology: Introduction and morphology - Introduction of microbiology, Classification of microorganisms, size, shape and structure of bacteria. Use of microscope in the study of bacteria. Growth and nutrition -nutrition, culture media, types of medium with example and uses of culture media in diagnostic bacteriology, antimicrobial sensitivity test Sterilization and disinfection - principles and use of equipments of sterilization namely hot air oven, autoclave and serum inspissator, pasteurization, anti-septic and disinfectants. Introduction to immunology, bacteriology, parasitology, mycology

Residency part – II

In the residency the professional is expected to work and contribute in the medical imaging unit.

Third Semester

Quality Assurance and Quality Control in Diagnostic Radiology and Imaging

1. Objectives of Quality Control: Improve the quality of imaging thereby increasing the diagnostic value; to reduce the radiation exposure; Reduction of film wastage and repeat examination; to maintain the various diagnostic and imaging units at their optimal performance.
2. Quality Assurance activities: Equipment selection phase; Equipment installation and acceptance phase; Operational phase; Preventive maintenance.
3. Quality assurance programme in the radiological faculty level: Responsibility; Purchase; Specifications; Acceptance; Routine testing; Evaluation of results of routine testing; Quality assurance practical exercise in the X ray generator and tube; Image receptors from processing; Radiographic equipment; Fluoroscopic equipment; Mammographic equipment; Conventional tomography; Computed tomography; Film processing, manual and automatic; Consideration for storage of film and chemicals; Faults tracing; Accuracy of imaging- image distortion for digital imaging devices. LASER printer calibration
4. Quality assurance programme tests: General principles and preventive maintenance for routine, daily, weekly, monthly, quarterly, annually – machine calibration. Basic concepts of quality assurance – LASER printer - Light beam alignment; X-ray out-put and beam quality check; KVp check; Focal spot size and angle measurement; Timer check; mAs test; Grid alignment test; High and low contrast resolutions; Mechanical and electrical checks; Cassette leak check; Proper screen-film contact test; Safe light test; Radiation proof test; Field alignment test for fluoroscopic device; Resolution test; Phantom measurements - CT, US and MRI.
5. Quality assurance of film and image recording devices: Sensitometry; Characteristic curve; Film latitude; Film contrast; Film speed Resolution; Distortion; Artifacts of films and image recording. Monitor calibration. SMPTE pattern.
6. Maintenance and care of equipment: Safe operation of equipment; Routine cleaning of equipment and instruments; Cassette, screen maintenance; Maintenance of automatic processor and manual processing units; Routine maintenance of equipments; Record keeping and log book maintenance; Reject analysis and objectives of reject analysis programme.
7. Care and maintenance of diagnostic equipment: General principles and preventive maintenance for routine - daily, Weekly, monthly, quarterly, annually: care in use, special care of mobile equipment.
8. Quality Assurance and quality control of Modern Radiological and Imaging Equipment which includes Digital Radiography, Computed Radiography, CT scan, MRI Scan, Ultrasonography and PACS related. Image artifacts their different types, causes and remedies

Newer Imaging Modalities

1. Basic Computed Tomography- Basic principles of CT, generations of CT, CT instrumentation, image formation in CT, CT image reconstruction, Hounsfield unit, CT image quality, CT image display
2. Advanced Computed Tomography - Helical CT scan: Slip ring technology, advantages, multi detector array helical CT, cone – beam geometry, reconstruction of helical CT images, CT artifact, CT angiography, CT fluoroscopy, HRCT, post processing techniques: MPR, MIP, Min IP, 3D rendering: SSD and VR, CT Dose, patient preparation, Imaging techniques and protocols for various parts of body, CT contrast enhanced protocols – CT angiography – (Aortogram, selective angiogram head, neck and peripheral) image documentation and Filing, maintenance of equipment and accessories.
3. Advanced technique & instrumentation of MRI
4. Basic Principle: Spin – precession – relaxation time – pulse cycle – T1 weighted image – T2 weighted image – proton density image.
5. Pulse sequence : Spin echo pulse sequence – turbo spin echo pulse sequence - Gradient echo sequence – Turbo gradient echo pulse sequence - Inversion recovery sequence – STIR sequence – SPIR sequence – FLAIR sequence – Echo planar imaging – Advanced pulse sequences.
6. MR Instrumentation: Types of magnets – RF transmitter – RF receiver – Gradient coils – shim coils – RF shielding – computers.
7. Image formation: 2D Fourier transformation method – K-space representation – 3D Fourier imaging – MIP.
8. MR contrast media – MR angiography – TOF & PCA – MR Spectroscopy – functional MRI Ultrasonography
   Basic Acoustics, Ultrasound terminologies: acoustic pressure, power, intensity, impedance, speed, frequency, dB notation: relative acoustic pressure and relative acoustic intensity.
   Interaction of US with matter: reflection, transmission, scattering, refraction and absorption, attenuation and attenuation coefficients, US machine controls, US focusing.
9. Production of ultrasound: Piezoelectricity, Medical ultrasound transducer: Principle, construction and working, characteristics of US beam.
10. Ultrasound display modes: A, B, M
11. Real-time ultrasound: Line density and frame rate, Real-time ultrasound transducers: mechanical and electronic arrays, ultrasound artifacts, ultrasound recording devices, and Distance, area & volume measurements.
12. Techniques for imaging different anatomic areas, ultrasound artifacts, biological effects and safety.
13. Doppler Ultrasound- Patient preparation for Doppler, Doppler artifacts, vascular sonography,
14. Elastography, HIFU, ABVS etc.
15. Fusion Imaging -PET CT & PET MRI

Intervention Radiological Techniques and Care of Patient

1. Basic Angiography and DSA:
   History , technique, patient care, Percutaneous catherisation, catheterization sites, Asepsis ,Guide wire, catheters, pressure injectors, accessories, Use of digital substraction- single plane and bi-plane.
   All forms of diagnostic procedures including angiography, angioplasty, biliary examination, renal evaluation and drainage procedure and aspiration cytology under flouro, CT, US, MRI guidance.
2. Central Nervous System: Myelography. Cerebral studies, Ventriculography.
3. Arthrography: Shoulder, Hip, Knee, Elbow

4. Angiography: Carotid Angiography (4 Vessel angiography).Thoracic and Arch Aortography. Vertebral angiography, femoral arteriography. Selective studies: Renal, SMA, Coeliac axis. Angiocardiography.
5. Venography: Peripheral venography, Cerebral venography, Inferior and superior venocavography. Relevant visceral phlebography.
6. Cardiac catheterization procedures: PTCA, BMV, CAG, Pacemaker.
7. Microbiology Introduction and morphology - Introduction of microbiology, Classification of microorganisms, size, shape and structure of bacteria. Use of microscope in the study of bacteria. Growth and nutrition -nutrition, culture media, types of medium with example and uses of culture media in diagnostic bacteriology, antimicrobial sensitivity test. Sterilization and disinfection - principles and use of equipments of sterilization namely hot air oven, autoclave and serum inspissator, pasteurization, anti-septic and disinfectants.

Care of Patient in Interventional Radiology

1. Introduction to patient care: responsibilities of healthcare facility-responsibilities of the imaging technologist.
2. General patient care, patient transfer technique-restraint techniques-aspects of patient comfort-specific patient conditions-security of patient property-obtaining vital signs-laying up a sterile trolley-assisting in IV injection.
3. Surgical Asepsis: The Environment and Surgical Asepsis, Methods of Sterilization, Disinfection, Opening Sterile Packs, Changing Dressing.
4. Nursing procedure in radiology- general abdominal preparation, clothing of the patient-giving an enema-handling the emergencies in radiology- first aid in the X-ray department
5. Patient care during investigation: GI tract, biliary tract, respiratory tract, Gynecology, cardiovascular lymphatic system, CNS etc.
6. Infection control: definitions- isolation techniques-infection sources-transmission modes-procedures-psychological considerations – sterilization & sterile techniques.
7. Patient education: communication – patient communication problems – explanation of examinations-radiation safety/protection – interacting with terminally ill patient.
8. Medical Emergencies: Shock, Pulmonary Embolus, Diabetic Emergencies, Respiratory Failure, Cardiac Failure, Airway Obstruction, Stroke, Fainting, Seizures.
9. Drug Administration: System of Drug Administration, Medication Error and Documentation, Equipment for Drug Administration, Methods of Drug Administration, Care of patient with Intravenous Infusions

Residency part –III

In the residency the professional is expected to work and contribute in the medical imaging unit.

Fourth Semester

Newer Developments in Advanced Imaging Technology and Biostatics.

1. In addition to existing Radiological and Imaging Modalities -Newer Developments in Digital Imaging CT,MRI,US and any other modality.
2. Newer Radiological and Imaging Equipment: including Computed radiography: Digital Radiography, Digital Fluoroscopy, Digital Mammography and DSA - Introduction to Newer Technology innovations, software and its applications.

3. Computed Tomography Introduction to Newer Developments/ Newer Technology innovations, software and its applications.
4. MRI Introduction to Newer Developments/Newer Technology innovations, software and its applications.
5. Advanced Ultrasonography Newer Developments/Newer, Technology innovations, software and its applications. Elastography, HIFU, ABVS etc.
6. Maxillo-facial imaging, dental radiology including RGV, OPG, CBCT and other advanced modalities
7. Tele-radiology, HIS, RIS, PACS, Imaging processing and archiving.

Biostatistics & Basic Research Methodology

1. What is statistics – importance of statistics in behaviors sciences- descriptive statistics and inferential statistics-usefulness of qualification in behavioral sciences – scales of measurements- nominal, ordinal, interval and ratio scales.
2. Data collection – classification of data-class intervals – continuous and discrete measurements-drawing frequency polygon-histogram-cumulative frequency curve-ogives-drawing inference from graph.
3. Measures of central tendency- need-types: mean, median, mode – working out these measures with illustrations. Measures of variability – need- types range, quartile deviation, average deviation, standard deviation, variance-interpretation.
4. Normal distribution-general properties of normal distribution-theory of probability-illustration of normal distribution-area under the normal probability curve. Variants from the normal distribution-skewness-quantitative measurements of skewness-kurtosis-measurements of kurtosis-factors contributing for non-normal distribution
5. Correlation-historical contribution-meaning of correlation-types: rank correlation, regression analysis.
6. Tests of significance- need for-significance of the mean-sampling error-significance of differences between means-interpretation of probability levels-small samples-large samples-inferential statistics-parametric and non-parametric methods-elements of multivariate analysis

Seminars, Journal Clubs and Group Discussions

Each student will be assigned topics for presentations as seminars, will explore recent innovations in MRIT for presenting topics during journal clubs and shall be holding group discussions along with other students in the presence of MRIT faculty. This will also include visits to other Institutions, Factories or Industries in the field of MRIT.

Dissertation.

Each candidate will have to carry out of a dissertation on the related subject. The dissertation will be guided by one or two members of the faculty or medical Physicists of the department. The dissertation will be evaluated by the External/Internal Examiners at the time of viva voice examination of the candidate during the second year and 10& weightage will be given to the candidate for the dissertation at the time of clinical/practical and viva voice examination of second year. The candidate will be asked to make presentation before the External/Internal Examiner.

The final dissertation duly approved by the External/Internal examiners will be submitted to the Dean's office with the result. The dean's office will send the dissertation to the library for record.

Skills based outcomes and monitorable indicators for Senior Medical Radiology and Imaging Technologist (Sr. MRIT)

Competency statements

1. Demonstrate knowledge to interpret and evaluate a prescription
2. Communicates relevant information to other members and completes accurate documentation
3. Demonstrates knowledge of accurate position and ability to position all patients as per instructions
4. Recognise contrast induced adverse reactions
5. Collate and communicate health information
6. Operate and oversee operation of radiologic equipment
7. Maintain a safe, healthy and secure environment
8. Demonstrates ability to carry out the daily organization of the medical imaging unit
9. Demonstrates ability to interpret, apply and disseminate information as a member of the radiotherapy team
10. Demonstrates professional behavior
11. Demonstrates a sensitive and caring attitude towards the patient
12. Demonstrates ability to prepare the patient for the procedures.
13. Demonstrates ability to carry out the necessary data transfer checks
14. Demonstrate the ability to process and produce good quality radiographic mages.
15. Demonstrates ability to carry out treatment verification
16. Demonstrates ability to carry out corrective actions as per instructions
17. Demonstrates knowledge to check the dosage
18. Implements health and safety procedures
19. Demonstrates ability to interpret, apply and disseminate information as a member of the radiotherapy team
20. Ensures radiation protection legislation is adhered to
21. Demonstrates knowledge and skills to carry out the daily/weekly Quality Control (QC) checks
22. Participates in research activities

Fundamental Competencies	Applies fundamental competencies in the performance of tasks assigned.
Safe Work Practices	Conducts professional practice according to established protocols, safety guidelines and existing legislation.
Communication and Interactions	Interacts in a professional and competent manner, using effective listening, verbal and written communication in dealing with laboratory colleagues, patients, clients and other health professionals.
Film Processing	Perform X-ray film / image processing techniques (including dark room techniques)
Quality Assurance	Follows quality assurance policies and procedures and participants in quality assurance initiatives.
Communication	Collate and Communicate Health Information within and between the departments. Make decisions on information to be communicated based on needs of the individual and various regulations and guidelines

Professionalism	Meets the legal and ethical requirements of practice and protect the patient's right to an established standard of care. Professional responsibility encompasses scope of practice, accountability, and professional development.
Practical Skills	Able to Operate and oversee operation of radiologic equipment, To be able to process radiographic images and prepare and document reports, Recognise contrast induced adverse reactions Collate and communicate health information Ensure availability of medical and diagnostic supplies Maintain a safe, healthy and secure environment Making sure that the radiation safety guidelines are followed Making sure that biomedical waste disposal protocols are followed Making sure that the infection control policies and procedures are followed Monitor and assure quality.

Chapter 5
Job description

Chapter 5: Job Description for all levels (Proposed)

Level 4

1. The post of JMRIT with DMRIT qualification shall be available in PHC, Civil hospital only.
2. Should be able to perform radiographic procedures and assist in other radiological procedures apart from care and maintenance of equipments, Interpret the requisition form,
3. These tasks will be performed under the supervision of a qualified Medical Radiology and Imaging Technologist (MRIT) or medical specialists.
4. To enter report on Radiology Info. System (RIS), answering telephone requests from medical and nursing staff, providing results from the Radiology IT system and relaying routine information where appropriate.
5. Maintaining stock levels of some in-use consumables which will require a lifting, carrying and issuing from the store.
6. To undertake training and competency assessment in relevant tasks
7. Assist in the training of new staff in the Reception area and acclimatize them in their place of posting.
8. To refer to a senior member of staff when a matter is beyond their level of competence
9. To participate in audit
10. To participate in annual staff performance reviews
11. Must enjoy interacting with others and be team players. They must also be polite and be able to calm and placate upset individuals. They should be able to remain standing for long periods of time and must have strength to transfer and position patients for scans. They should have the capacity to visualize two and three-dimensional spatial relationships.

Level 5

In addition to level 4 must be able to perform:

1. Mammography, CT scan and MRI independently
2. Assist in specialized radiological procedures.
3. Image processing, Computer skills
4. Independent handling of all radiological and imaging equipment
5. Ensure radiation protection and quality assurance
6. Care and maintenance of all radiological and imaging equipment
7. Evaluating images for technical quality
8. Ensuring proper identification,
9. Identifying and managing emergency situations.
10. Receiving and documenting verbal, written and electronic orders in the patient's medical record.

Level 6

In addition to level 5

1. Verifying informed consent, assuming responsibility for patient needs during procedures, preparing patients for 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. Identifying and managing emergency situations.
5. Providing education. Educating and monitoring students and other health care providers.
6. Performing ongoing quality assurance activities.
7. Performing diagnostic radiographic and non-interpretive fluoroscopic procedures.
8. Orientation and teaching students and new employees.
9. Research and development of new techniques and procedures as assigned.

10. Follows established safety practices including biohazards, exposure control plan
11. 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.
12. Attends all in service education required as per hospital policy.
13. Demonstrates respect and regard for the dignity of all patients, families, visitors and fellow employees to ensure a professional, responsible and courteous environment.
14. To supervise and allocate responsibilities to level 4 and level 5.

Level 7

In addition to level 6 responsibilities, level 7 will perform as under

1. Employ professional judgment to adapt imaging procedures to improve diagnostic quality
2. Determines the need for and selects supplies, accessory equipment, shielding and immobilization devices.
3. Determines the course of action for an emergency or problem situation. Determines that all procedural requirements are in place to achieve a quality diagnostic.
4. Reviews lab reports prior to administering medication and beginning specialized radiologic procedures.
5. Determines type and dose of contrast agent to be administered, based on the patient's age, weight and medical/physical status.
6. Verifies that exposure indicator data for digital radiographic systems has not been altered or modified and is included in the Digital Imaging Communications in Medicine (DICOM) header and on images printed
7. Analyzes digital images to determine utilization of appropriate imaging parameters.
8. To ensure implementation of internal quality control and quality assurance programmes.
9. To perform all such duties to ensure continued enhancement in the quality of patient care through efficient Health care delivery system.
10. To assist the ASSOCIATE PROFESSORS / PROFESSORS / HEADS OF THE DEPARTMENT in Complete management of a Full-time Unit in such a way that there is no "Medical Negligence" in patient care service as a result of breach / violation / infringement of any Act / Code of professional ethics which brings disgrace to the reputation of the Institute / Hospital.
11. It is binding to attend to Emergency calls as and when required even beyond duty hours.
12. To provide the Radiology records as and when required by the Administration.
13. To suggest / recommend use of certain managerial tools / techniques / skills to upgrade the quality of patient care services.
14. To ensure implementation of quality control and quality assurance procedures as per requirements including calibration of instrument.

Level 8

In addition to supervisory responsibilities of at level 7, will perform as under:

1. Procurement and Purchase of Equipment, prescribing Technical Specifications ,
2. Supervision of subordinates with specialized role in advanced Radiological & Imaging Modalities.
3. Incorporating new design and ideas,
4. Conflict management,
5. Handling of Medical Legal cases and coordinate with the hospital administration
6. Participation in CPD, National Conferences / International Conference and Publications etc.
7. Ensures orientation and training of students/ new recruits.
8. Participation in Research and development.
9. To perform all such duties to ensure continued enhancement in the quality of patient care through efficient Health care delivery system.
10. In Complete management of a Full-time Unit in such a way that there is no "Negligence" in patient care service as a result of breach / violation / infringement of any Act / Code of professional ethics which brings disgrace to the reputation of the Institute / Hospital.
11. It is binding to attend to Emergency calls as and when required even beyond duty hours.
12. To provide the radiology records as and when required by the Administration.

13. To suggest / recommend use of certain managerial tools / techniques / skills to upgrade the quality of patient care services.
14. To ensure implementation of quality control and quality assurance procedures as per requirements including calibration of instrument.
15. Supervise the Work of Assistant Professors, Students
16. To assist the head of the department perform all such duties to ensure continued enhancement in the quality of performance of teaching as well as non-teaching staff of the Department.
17. Planning, proposing, processing the proposals, procuring & to supervise maintenance of equipment & instruments.
18. To work on various Hospital/Institute Committees like Local Tender Committee, Radiation safety committee Hospital Infection Control Committee, Grievance Committee, Sexual Harassment Committee etc.
19. To exercise authority in Administrative control of the Department :
    a) To maintain 'Personal Files' of all teaching as well as non-teaching staff of the Dept.
    b) To recommend or refuse any kind of Leave (Casual Leave/Special Leave/Earned Leave to any staff member of the Dept. as per rules in that regard.
20. To maintain Muster Roll of teaching as well as non-teaching staff of the Department; to conduct periodic audit of the timings of arrival / departure of the staff; to mark any Sanctioned Leave or Absence Without Leave (AWL) – which is Unauthorised Absence – of the employee as the case may be and to report to the Competent Leave-sanctioning Authority i.e. Dean, any irregularity in attendance or punctuality in respect of a defaulting employee.
21. To serve a memorandum to the undisciplined employee giving him / her a chance to improve.
22. To write annual 'Confidential Report' (Performance Appraisal / Work Audit) of the employees working in the Dept. as well as your own "Self-Appraisal / Assessment" as per the guiding principles in that regard; to inform the erring member about the adverse remarks, if any, immediately through a memorandum.
23. To organise / conduct / encourage "Core Competency Development Programmes" for Faculty Development; also training programmes for other non-teaching staff of the Dept.
24. Whenever ordered by the higher authorities , to conduct "Preliminary Inquiry" into a particular untoward incidence or in respect of a particular employee and to submit report in time as per the rules in that regard.

Level 9

1. In addition to level 8 responsibilities, level 9 (MRIT CTO) will perform as under:
2. Sorting of anomalies and Discrepancies if any in Breakdown of Equipment and Maintenance Contracts.
3. Ensures overall performance of Radiology and Imaging as per Good Radiological Practice.
4. Attend and organize various in-service Workshops and up gradation required from time to time.
5. To direct and allocate responsibilities to staff through level 8.
6. To undertake any task entrusted by AHP Board like working on "Inspection Committee" for Laboratories in other Institutes/Hospitals with the permission of the Principal/Dean /Director or any other competent authority.
7. Participation and to ensure Research and development i.e. Research Projects & their presentation at various National/ international Conferences and its publication and to participate in various "Research committees".
8. To undertake any other task entrusted by University/ Institute like working on "Local Inquiry Committee", "Ethics Committee", and "Staff Welfare-related Committees" and to enforce discipline among departmental staff.
9. To perform all such duties as at level 8 to ensure continued improvement in the quality of Medical Education & Research.
10. Teaching & training Undergraduate students including Interns/ Postgraduate students so as to achieve the Educational Objectives i.e. to develop their knowledge, skills & attitude.
11. To do periodic evaluation / assessment through examination/to conduct examination/to maintain attendance & academic (including Internship) record of individual Undergraduate & Postgraduate student for the minimum period as per Govt. rules.

12. To work on the College Council , Undergraduate & Postgraduate Academic Committees , Medical Education , Library Committee , to organize / participate in teaching programmes like Lectures / Tutorials/Group Discussions Demonstrations/ Practicals and other academic activities like Seminars / Symposia / Panel Discussions / Workshops / Guest Lectures / Conferences / Continuing Medical Education Programmes etc. and to maintain a Departmental Library for students as well as teaching staff.
13. To participate in conduct academic Examinations of other State Health Universities / National Board as an External Examiner with the permission / under the direction of the Dean availing the facility of Special leave.
14. To undertake any task entrusted by AHP Board like working on "Inspection Committee" for inspection of Colleges in other States with the permission of the Principal/Dean/Director.
15. To undertake any other task entrusted by University/ Institute like working on "Local Inquiry Committee" for inspection of Colleges.
16. To conduct Research Projects – clinical research, and contribute to medical knowledge by scientific paper publications in indexed journals & their presentation at various local / state / international Conferences.
17. To work on various Research-related Committees like Ethics Committee , Research Society of the institute
18. To work on various Students' Welfare-related Committees like "Anti-Ragging Committee" and to enforce discipline among medical students.
19. To perform all such duties to ensure continued enhancement in the quality of patient care through efficient Health care delivery system.
20. In Complete management of a Full-time Unit in such a way that there is no "Negligence" in patient care service as a result of breach / violation / infringement of any Act / Code of professional ethics which brings disgrace to the reputation of the Institute / Hospital.
21. It is binding to attend to Emergency calls as and when required even beyond duty hours.
22. To provide the radiology records as and when required by the Administration.
23. To suggest / recommend use of certain managerial tools / techniques / skills to upgrade the quality of patient care services.
24. To ensure implementation of quality control and quality assurance procedures as per requirements including calibration of instrument.
25. Supervise the Work of Assistant , Associate Professors, Students
26. To assist the head of the department perform all such duties to ensure continued enhancement in the quality of performance of teaching as well as non-teaching staff of the Department.
27. Planning, proposing, processing the proposals, procuring & to supervise maintenance of equipment & instruments.
28. To work on various Hospital/Institute Committees like Local Tender Committee, Hospital Infection Control Committee, Grievance Committee, Sexual Harassment Committee etc.
29. To exercise authority in Administrative control of the Department :
30. To maintain 'Personal Files' of all teaching as well as non-teaching staff of the Dept.
31. To recommend or refuse any kind of Leave (Casual Leave/Special Leave/Earned Leave to any staff member of the Dept. as per rules in that regard.
32. To maintain Muster Roll of teaching as well as non-teaching staff of the Department; to conduct periodic audit of the timings of arrival / departure of the staff; to mark any Sanctioned Leave or Absence Without Leave (AWL) – which is Unauthorized Absence – of the employee as the case may be and to report to the Competent Leave-sanctioning Authority i.e. Dean, any irregularity in attendance or punctuality in respect of a defaulting employee.
33. To serve a memorandum to the undisciplined employee giving him / her a chance to improve.
34. To write annual 'Confidential Report' (Performance Appraisal /Work Audit) of the employees working in the Dept. as well as your own "Self-Appraisal / Assessment" as per the guiding principles in that regard; to inform the erring member about the adverse remarks, if any, immediately through a memorandum.
35. To organize / conduct / encourage "Core Competency Development Programmes" for Faculty Development; also training programmes for other non-teaching staff of the Dept.
36. Whenever ordered by the higher authorities , to conduct "Preliminary Inquiry" into a particular untoward incidence or in respect of a particular employee and to submit report in time as per the rules in that regard.

Level 10

1. Overall operation and administration
   Take responsibility for overall operation and administration of radiology unit, including employment of personnel competent to perform test procedures, record and report test results, promptly, accurately and proficiently.
2. Definition/retention of others' duties
   If desired, delegate / Specify / reapportion, in writing responsibilities, authorities and duties of each consultant and person engaged in any phase of testing.
3. Licensure and accreditation
   Assure compliance with applicable regulations.
4. Personnel Management & Authorization
   Identify which examinations and procedures each individual is authorized to perform.
5. Training & Competency Assessment
   Ensure all personnel have appropriate education, experience and training for type & complexity of services, in order to perform testing reliably and report accurate results.
6. Supervision
   Ensure on-site supervision of high complexity testing. Identify supervision required for specimen processing, test performance or result reporting. Identify supervisory or director review required prior to reporting patient test results.
7. Adequate and Appropriate Staffing
   Employ sufficient/appropriate personnel with education, training, and experience to provide consultation, supervise and perform tests, and report test results.
8. Monitoring Competency
   Ensure policies and procedures for monitoring individuals to assure competency and to assure identification of needs for remedial training or continuing education.
9. Facilities & Safety
   Ensure physical and environmental conditions are appropriate and provide a safe environment in which employees are protected from physical, chemical, and biological hazards.
10. Quality Management System
    Ensure that all the services of the imaging department are as per Quality Management system which includes: Quality control, Quality assurance, Quality improvement, proficiency testing etc. etc.
11. Interaction with others
    Relate and function effectively with accrediting regulatory agencies, administrative officials, medical community, medical device industry, and patient population.
12. Strategic Planning
    Perform planning for setting goals and developing and allocating resources appropriate to Institute/hospital/Diagnostic laboratory environment i.e. Operational Management + Financial Management +
13. Administration and Management
    Provide effective and efficient administration, including budget planning and control with responsible financial management. Define, implement, and monitor standards of performance in cost-effectiveness of lab services.
14. Research and Development
    Plan and direct research and development appropriate to the facility.
15. Education
    Ensure proper planning and implementation of teaching system for Medical Radiology and imaging Technology students/staff, and participate in educational programs of the institution.

Allied and Healthcare Professions

Allied and healthcare professionals 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.

The wide variation in the understanding of the concept of allied and healthcare professional, better known as 'paramedic', the nomenclature, and functions has led to the poor image of allied and healthcare sciences in India. The use of the word paramedic itself limits the activities of AHPs in the system. Hence, it is imperative to adequately compensate these professionals based on their qualifications and specialties. Despite a huge demand for services from this sector, allied and healthcare sciences is highly fragmented. As per the report 'From Paramedics to Allied Health Sciences', in total 138 courses of varied levels were identified during the process. Although it is estimated that there may be many more courses which are yet to be identified.

Considering the lack of regulatory mechanism following 15 core professional groups (accounting for around 44 professions) has been enlisted below **(The list is illustrative of the allied and healthcare professions. In future there may be addition or removal of certain professions based on the state of their regulation and standardization)**. **It also needs a mention that most of these professions are not restricted to the professional groups under which they have been categorized, their role may extend to other professional services too. Similarly, the categorization is an indicative categorization, however this may evolve over time based on deeper understanding of the roles and responsibilities of each professional group**:

1. **Healthcare Professions**
    1. Optometry
    2. Physiotherapy
    3. Occupational Therapy
    4. Nutrition Sciences
    5. Physician Associate and Assistants

2. **Allied Health Professions**
    6. Cardiology, Vascular and Pulmonary Technology
    7. Medical Laboratory Sciences
    8. Medical Radiology and Imaging Technology
    9. Neurosciences Technology
    10. Non- direct and Administrative services
    11. Primary Care and Community services
    12. Radiation Therapy
    13. Renal Technology
    14. Surgical and Anesthesia related Technology
    15. Trauma Care Services

The above mentioned groups account for over 44 job profiles in the allied and healthcare space, which are as follows-

A. Healthcare Professions

1. Optometry

    a. Optometrist
2. Physiotherapy
    a. Physiotherapist
3. Occupational Therapy
    a. Occupational Therapist
4. Nutrition Sciences
    a. Nutritionist
    b. Dietitian
5. Physician Associate and Assistants
    a. Physician Associates and Assistants

B. Allied Health Professions

6. Surgical and anesthesia related technology
    a. Anesthesia Assistants and Technologist
    b. OT Technologist
    c. Endoscopy Technologist
7. Medical Laboratory Sciences
    a. Cyto-Technologist
    b. Dermatology/STD /Leprosy Lab Technologist
    c. Forensic Technologist
    d. Hemato-Technologist
    e. Histopath-Technologist
    f. Phlebotomist
    g. Medical and Clinical Lab Technologist
8. Medical Radiology and Imaging Technology
    a. Radiographer
    b. Radiologic /Imaging Technologist
    c. Diagnostic Medical Sonographer
9. Renal Technology
    a. Urology Technologist
    b. Dialysis Therapy Technologist
10. Radiation Therapy
    a. Radiotherapy Technologist
    b. Medical Dosimetrist
    c. Nuclear Medicine Technologist
11. Trauma Care Services
    a. Emergency Medical Technologist (paramedic)
    b. Critical Care/ICU Technologist
12. Neurosciences Technology
    a. EEG/END Technologist
    b. EMG Technologist
    c. Neuro Lab Technologist
    d. Sleep Lab Technologist
13. Cardiology, Vascular and Pulmonary Technology
    a. Cardiovascular Technologist
    b. ECG Technologist
    c. ECHO Technologist

d. Perfusionist
e. Pulmonary Function (PFT) Technologist
f. Respiratory Therapist

14. Non- direct and Administrative Services
    a. Biomedical Engineers and Technologist
    b. Medical Assistant
    c. Medical Secretaries
    d. Medical Transcriptionist
    e. Health Information Management Technologist
15. Primary Care and community services
    a. Blood Bank Technologist
    b. Counselor- Integrated Behavioral Health Counselors, Palliative counselors etc.
    c. Sanitary Health Inspectors

REFERENCES:

[1] Narayan, K Kar, S Gupta, N. From 'Paramedics' to 'Allied Health Professionals': Landscaping the Journey and Way Forward. Public Health Foundation of India: New Delhi, India, 2012.
[2] Allied Health Professions Federation. AHPs involvement in health and social care 2011. Available from: http://www.ahpf.org.uk/files/ahpf_gov_briefing_v7_09-05-11.pdf.
[3] Narayan. K. How many doctors it takes to fix India's healthcare glitches? Deccan Herald [Internet]. 2014. Available from: http://www.deccanherald.com/content/381371/how-many-doctors-takes-fix.html.
[4] Introduction to clerkship 1999. Available from: https://umanitoba.ca/faculties/medicine/media/missiion_goals_object_class_2011.pdf.

[5] Standards of practice for ACT Allied Health Professionals 2005. Available from: http://health.act.gov.au/c/health?a=dlpubpoldoc&document=863.
[6] Pamela Mitchell et al. Core principles and values of effective team based healthcare2012. Available from: https://www.nationalahec.org/pdfs/VSRT-Team-Based-Care-Principles-values.pdf.
[7] Professionalism in nursing, midwifery and the allied health professions in Scotland. Scottish Government, 2012 978-1-78045-925-7.
[8] Nursing & Midwifery Council .Standards for competence for registered nurses. Available from: http://www.nmc-uk.org/Documents/Standards/Standards%20for%20competence.pdf.
[9] Social Accountability- A vision for Canadian medical schools Available from: https://www.afmc.ca/fmec/pdf/sa_vision_canadian_medical_schools_en.pdf.
[10] University of Manitoba. Faculty of medicine teaching handbook2004. Available from: umanitoba.ca/faculties/medicine/media/teaching_handbook04.doc.
[11] Medical Council of India. Vision 2015. Published March 2011. Available from: http://www.mciindia.org/tools/announcement/MCI_booklet.pdf.
[12] Sherwin J. Competency-Based Medical Education Takes Shape2011. Available from: https://www.aamc.org/newsroom/reporter/april11/184286/competency-based_medical_education.html.
[13] Bushway D, Everhart D. Investing in Quality Competency-Based Education2014. Available from: http://www.educause.edu/ero/article/investing-quality-competency-based-education.
[14] Brookfield, S. D. Self-Directed Learning In: YMCA George Williams College ICE301 Lifelong learning Unit 1 Approaching lifelong learning. London: YMCA George Williams College; 1994.
[15] Ramnarayan K, Hande S. Thoughts on Self-Directed Learning in Medical Schools: Making Students More Responsible 2005. Available from: http://education.jhu.edu/PD/newhorizons/lifelonglearning/higher-education/medical-schools/.
[16] Harvey, B. J., Rothman, A. I., Frecker, R.C. Effect of an undergraduate medical curriculum on students' self-directed learning. Academic Medicine. 2003; 78(12): 1259-65.
[17] Credit-Based-Grading-System for Assessment of Students. Available from: http://www.presiuniv.ac.in/web/exam_assessment.php.
[18] Manual on semester based, credit and grading system Mumbai: University of Mumbai 2011. Available from: http://www.mu.ac.in/1__Manual_SCGS_Arts_09-06-2011.pdf.
[19] Vertical Integration2015. Available from: http://www.mcw.edu/Medical-School/Curriculum/Traditional-Curriculum/Vertical-Integration.htm.
[20] Baker D, Day R, Salas E. Teamwork as an essential component of high reliability organisations. Health Services Research. 2006; 41(4):1576-98.
[21] Srinivas, D.K. Adkoli, B.V. Faculty Development in Medical Education in India: The Need of the Day. Al Ameen J Med Sci (2009)2 (1):6-13. Available at: http://www.alameenmedical.org/ajms/ArticlePDFs/AJMS3.6-13.pdf
[22] The Royal Australian and New Zealand College of Radiologists®. http://www.insideradiology.com.au/
[23] Minimum standard requirements for the medical college for 100 admissions annually regulations, 1999 MCI
[24]Minimum standard requirements for the medical college for 100 admissions annually regulations, 1999 MCI
[28]Fremgen B, Frucht S. Medical Terminology: A Living Language: Pearson Education, Inc. Available from: http://www.ogeecheetech.edu/docs/d_Programs/AlliedHealth/Syllabi/ALHS1090.pdf.
[29]Kong-lung H. Law and ethics in medical practice: An Overview. 2003; 8. Available from: www.fmshk.org/article/746.pdf.

[30]Texas Intensive English Program2014. Available from: https://www.tiep.edu/intensive-programs/.
[31]Mittal R, Mahajan R, Mittal N. Foundation programme: A student's perspective. International Journal of Applied and Basic Medical Research. 2013; 3(1):52-4. Epub 10.4103/2229-516X.112241.
[32]Division of radiologic sciences, UNC school of medicines,

DETAILS OF INVOLVED/RESPONSIBLE OFFICERS AT THE MINISTRY OF HEALTH AND FAMILY WELFARE (MOHFW)

1. Mr Ali R.Rizvi, Joint Secretary (Human Resource)
2. Mr B. Sriramachandra Murthy, Director (Allied Health Section)
3. Mr Satish Kumar, Under Secretary (Allied Health Section)

National Initiative for Allied Health Sciences – Technical Support Unit (NIAHS – TSU)

1. Ms Kavita Narayan, *FACHE*, Director, NIAHS-TSU at MoHFW, GoI
2. Ms Shivangini Kar Dave , Project Lead Coordinator
3. Ms Natasha D'Lima, Program Coordinator
4. Ms Namita Gupta, Consultant
5. Mr Sutirtha Mazumder, Senior Research Assistant
6. Mr Ashish Arora, Senior Research Assistant (former)
7. Ms Tanu Sri Sahu, Senior Research Assistant
8. Mr Akhilendra Trivedi, Senior Research Assistant
9. Mr Vivek Bhatnagar, Senior Research Assistant
10. Mr Anirooddha Mukherjee, Research Assistant

For additional details or queries, please contact:

1. Mr Uttam Sengupta, SO (AHS),
   Room 442 – A,
   Nirman Bhavan, New Delhi 110001.
   Phone: 23063720, Email: ahssection@gmail.com

2. NIAHS TSU,
   Facilitation Centre, Near Gate No 5,
   Nirman Bhavan, New Delhi 110001.
   Phone: 011-23061751, Email: ahpsforindia@gmail.com

National Initiative for Allied Health Sciences – Technical Support Unit (NIAHS – TSU)
Facilitation Centre, Near Gate No. 5, Nirman Bhavan, New Delhi 110001.
Phone: 011-23061751, Email: ahpsforindia@gmail.com