MALLAREDDY VISHWAVIDYAPEETH

SCHOOL OF ALLIED HEALTHCARE SCIENCES AND TECHNOLOGY

Suraram X Roads, Jeedimetla, Hyderabad-500055
www.mallareddyvishwavidyapeeth.com

PROGRAM

MASTERS IN MEDICAL RADIOLOGY& IMAGING TECHNOLOGY[MMRIT]

COURSE STRUCTURE

2026

Master in Medical Radiology and Imaging Technology

Introduction:

Learning Objectives:

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

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

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

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

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

Criteria for pass:

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

Attendance and appearance for Exam:

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

Overview

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

Distribution of Credits:

L – Lectures- 1 hour: 1 credit

T – Tutorial- 1 hour: 1 credit P

– Practical- 2 hours: 1 credit

Clinical (Studentship)- 3 hours: 1 credit

MALLAREDDY VISWAVIDHYAPEETH
(DEMEED TO BE UNIVERSITY)

COURSE
[Masters in Medical Radiology & Imaging Technology]

1st YEAR I SEMESTER

S.NO	SUBJECT CODE	SUBJECT	L	T	P	C	Examination Scheme									Grand TOTAL
							Theory					Practical				
							Exam Duration Hours	CIE Max Marks	ESE Max Marks	Total Max marks	Total Min Marks	CIE Max Marks	ESE Max Marks	Total Max Marks	Total Min marks	TOTAL
1.	MMRIT01	Radiological and Medical Physics	2	1	6	6	2.5	30	70	100	-	-	-	-	-	100
2.	MMRIT02	Clinical Special Radiography Positioning	2	1	6	6	2.5	30	70	100	30	30	70#	100	50	200
3.	MMRIT03	Biostatistics and Research Methodology	3	-	-	3	2.5	30	70	100	-	-	-	-	-	100
4.	---	MMRIT Radiology Clinical Education – part I (studentship)*	-	-	15	5	-	-	-	-	30	30	70	100	-	100
TOTAL			7	2	27	20	-	-	-	300	-	-	-	100		500

1st YEAR II SEMESTER

S.NO	SUBJECT CODE	SUBJECT	L	T	P	C	Examination Scheme									Grand TOTAL
							Theory					Practical				
							Exam Duration Hours	CIE Max Marks	ESE Max Marks	Total Max marks	Total Min Marks	CIE Max Marks	ESE Max Marks	Total Max Marks	Total Min marks	TOTAL
1.	MMRIT04	Modern Radiological Imaging – Equipment and Physics	2	1	4	5	2.5	30	70	100	50	-	-	-	-	100
2.	MMRIT05	Modern Imaging and Special Radiological Procedures	2	1	4	5	2.5	30	70	100	50	30	70#	100	50	200
3.	MMRIT06	Contrast Media and Interventional Radiology	2	1	4	5	2.5	30	70	100	50	30	70#	100	50	200
4.	---	Radiology Clinical Education – Part II (Studentship)*	-		15	5	-	-	-	-	-	30	70	100	50	100
Total			7	2	27	20	-	-	-	300	-	-	-	200	-	600

2nd YEAR (III- SEMESTER) Electives of CT Technology

S.NO	SUBJECT CODE	SUBJECT	L	T	P	C	Examination Scheme									Grand TOTAL
							Theory					Practical				
							Exam Duration Hours	CIE Max Marks	ESE Max Marks	Total Max marks	Total Min Marks	CIE Max Marks	ESE Max Marks	Total Max Marks	Total Min marks	TOTAL
1.	MMRIT07	Principles of CT Imaging Technology	2	1	4	5	2.5	30	70	100	50	-	-	-	-	100
2.	MMRIT08	CT Imaging Procedures and Scanning Protocols	3	1	4	6	2.5	30	70	100	50	30	70#	100	50	200
3.	MMRIT09	Basic and Cross-Sectional Anatomy in CT Imaging	-	2	4	4	-	-	-	-	-	30	70#	100	50	100
4.	---	Radiology Clinical Education - part III (studentship)*	-	-	15	5	-	-	-	-	-	30	70	100	50	100
		TOTAL	5	4	27	20	-	-	-	-	-	-	-	200	-	500

2nd YEAR (IV -SEMESTER) Electives Of CT Technology

S.NO	SUBJECT CODE	SUBJECT	L	T	P	C	Examination Scheme									Grand TOTAL
							Theory					Practical				
							Exam Duration Hours	CIE Max Marks	ESE Max Marks	Total Max marks	Total Min Marks	CIE Max Marks	ESE Max Marks	Total Max Marks	Total Min marks	TOTAL
1.	MMRIT-10	Advancements in CT Technology	2	1	4	5	2.5	30	70	100	50	-	-	-	-	**100**
2.	MMRIT-11	Quality Assurance, Radiation Protection and Patient care in CT Imaging	2	1	4	5	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT-12	Basic Pathology and Image Interpretation in CT Imaging	-	-	6	3	-	-	-	-	-	30	70#	100	50	**100**
4.	MMRIT-13	Dissertation-1	-	-	-	2	-	-	-	-	-	30	70#	100	50	**100**
5.	------	Radiology Clinical Education - part IV (studentship)*	-	-	15	5	-	-	-	-	-	30	70	100	50	**100**
TOTAL			4	2	29	20	-	-	-	200	-	-	-	300	-	500

2nd YEAR (III -SEMESTER) Electives of MRI Technology

S.NO	SUBJECT CODE	SUBJECT	L	T	P	C	Examination Scheme									Grand TOTAL
							Theory					Practical				
							Exam Duration Hours	CIE Max Marks	ESE Max Marks	Total Max marks	Total Min Marks	CIE Max Marks	ESE Max Marks	Total Max Marks	Total Min marks	TOTAL
1.	MMRIT-14	Principles of MR imaging Technology	2	1	4	5	2.5	30	70	100	50	-	-	-	-	**100**
2.	MMRIT-15	MR Imaging Protocols and Scanning Techniques	3	1	4	6	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT-16	Basic and Cross Sectional Anatomy in MR Imaging	-	2	6	4	-	-	-	-		30	70#	100	50	**100**
4.	--------	Radiology Clinical Education - part V (studentship)*	-	-	-	5	-	-	-	-	-	30	70	100	50	**100**
TOTAL			5	4	15	20	-	-	200	-	-	-	-	200	-	500

2nd YEAR (IV -SEMESTER)Electives of MRI Technology

S.NO	SUBJECT CODE	SUBJECT	L	T	P	C	Examination Scheme									Grand TOTAL
							Theory					Practical				
							Exam Duration Hours	CIE Max Marks	ESE Max Marks	Total Max marks	Total Min Marks	CIE Max Marks	ESE Max Marks	Total Max Marks	Total Min marks	TOTAL
1.	MMRIT-17	Advancements in MR imaging Techology	2	1	4	5	2.5	30	70	100	50	-	-	-	-	**100**
2.	MMRIT-18	Planning, Safety and Patient care in MR Imaging	2	1	4	5	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT-19	Basics Pathology and Image Interpretation in MR Imaging	-	-	6	3	-	-	-	-	-	30	70#	100	50	**100**
4.	MMRIT-20	Dissertation	-	-	-	2	-	-	-	-	-	30	70#	100	50	**100**
5.		MRMMRIT Radiology Clinical Education - part IV (studentship)*	-	-	15	5	-	-	-	-	--	30	70	100	50	**100**
TOTAL			4	2	29	20	-	-	-	200	-	-	-	300	-	600

2nd YEAR (III -SEMESTER) Electives of Breast Imaging Technology

S.NO	SUBJECT CODE	SUBJECT	L	T	P	C	Examination Scheme									Grand TOTAL
							Theory					Practical				
							Exam Duration Hours	CIE Max Marks	ESE Max Marks	Total Max marks	Total Min Marks	CIE Max Marks	ESE Max Marks	Total Max Marks	Total Min marks	TOTAL
1.	MMRIT-21	Principles of Breast Imaging Technology	2	1	4	5	2.5	30	70	100	50	-	-	100	50	**100**
2.	MMRIT-22	Breast Imaging Procedures and scanning protocols	3	1	4	6	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT-23	Basics and Cross sectional anatomy of Breast	-	2	4	4	-	-	-	-	-	30	70#	100	50	**100**
4.		MMRIT Radiology Clinical Education - part III (studentship)*	-	-	15	5	-	-	-	-	-	30	70	100	50	**100**
TOTAL			5	4	27	20	-	-	-	200	-	-	-	300	-	600

2nd YEAR (IV -SEMESTER) Electives of Breast Imaging Technology

S.NO	SUBJECT CODE	SUBJECT	L	T	P	C	Examination Scheme									Grand TOTAL
							Theory					Practical				
							Exam Duration Hours	CIE Max Marks	ESE Max Marks	Total Max marks	Total Min Marks	CIE Max Marks	ESE Max Marks	Total Max Marks	Total Min marks	TOTAL
1.	MMRIT-24	Advancements in Breast Imaging Technology	2	1	4	5	2.5	30	70	100	50	-	-	-	-	**100**
2.	MMRIT-25	Quality Assurance, Radiation Protection and Patient care in Breast Imaging	2	1	4	5	2.5	30	70	100	50	30	70#	100	50	**200**
3.	MMRIT-26	Basics Pathology and Image Interpretation in Breast Imaging	-	-	6	3	-	-	-	-	-	30	70#	100	50	**100**
4.	MMRIT-27	Dissertation	-	-	-	2	-	-	-	-	-	30	70#	100	50	**100**
5.		MMRIT Radiology Clinical Education - part IV (studentship)*	-	-	15	5	-	-	-	-	-	30	70	100	50	**100**
TOTAL			4	2	29	20	-	-	-	200	-	-	-	300	-	600

Subject: Radiological and Medical Physics

Subject Code: MMRIT01

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

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

THEORY COMPONENTS

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

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

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

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: Clinical Special Radiography Positioning

Subject Code: MMRIT02

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

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

THEORY COMPONENTS

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

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

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

12.	Soft Tissue Radiography	10

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

SUGGESTED LEARNING RESOURCES

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

Subject: Biostatistics and Research Methodology

Subject Code: MMRIT03

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

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

THEORY COMPONENTS

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

Unit	Topic and contents	Hours	Marks
1.	Introduction: Meaning, Definition, Characteristics of Statistics; Importance of the Study of Statistics. Branches of Statistics; Descriptive and Inferential Statistics; Variables and Their Types. Measurement Scales.	**6**	**10**
2.	Tabulation of Data: RawData, the Array, Frequency Distribution. Basic Principles of Graphical Representation; Types of Diagrams - Histograms, Frequency Polygons, Smooth Frequency Polygon, Commutative Frequency Curve, O give; Normal ProbabilityCurve.	**6**	**10**
3.	Measure of Central Tendency: Need For Measures of Central Tendency; Definition and Calculation of Mean; Ungrouped and Grouped Meaning, Interpretation and Calculation of Median	**6**	**15**
	Ungrouped and Grouped; Meaning and Calculation of Mode; Comparison of the Mean, and Mode; Guidelines for the Use of Various Measures of Central Tendency.		
4.	Measure of Variability: Need For Measure of Dispersion. The Range, the Average Deviation, The Variance and Standard Deviation; Calculation of Variance and Standard Deviation, Ungrouped and Grouped.	**6**	**15**
5.	Probability and Standard Distributions: Meaning of Probability of Standard Distribution, The Binominal Distribution. The Normal Distribution; Divergence from Normality - Skewness,Kurtosis	**6**	**10**

6.	Sampling Techniques: Need For Sampling - Criteria for Good Samples. Application of Sampling in Community, Procedures of Sampling and Sampling Designs Errors. Sampling Variation and Tests of Significance.	**6**	**10**
Total		**54**	**70**

SUGGESTED LEARNING RESOURCES

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

MMRIT Radiological Clinical Education- part I (studentship): 16 hrs/week
The course may offer hands-on training or practical sessions, allowing participants to enhance their skills in teaching and research.

Second Semester

Subject: Modern Radiological Imaging - Equipment and Physics

Subject Code: MMRIT04

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

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

THEORY COMPONENTS

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

Unit	**Topic and contents**	**Hours**	**Marks**
1.	Modern x-ray tube: its principle, physics & equipment	5	5
2.	Digital Radiography: its principle, physics & equipment. Flat panel digital fluoroscopy and radiography system, Direct and indirect digital radiography and fluoroscopy systems. Digital radiography and Computed radiography its advantages, disadvantages and applications. Digital Portable and mobile x-ray units	5	**5**
3.	Dual energy x-ray absorptionometry (DEXA) scan: its principle, physics & equipment	5	5
4.	Computed radiography: its principle, physics & equipment.	5	5
5.	Mammography and Tomosynthesis: its principle, physics & equipment	5	5
6.	Modern dental equipments. Cone beam dental CT	5	5
7.	Bone mineral density test: its principle, physics & equipment	5	5
8.	Picture archiving and communication system (PACS), RIS, HIS and Teleradiology	5	5
9.	Computed Tomography	7	5

10.	Magnetic Resonance Imaging	5	5
11.	Ultrasound Imaging	5	5
12.	Hybrid Imaging	5	5
13.	Smart Simulator/virtual imaging	5	5
14.	Artificial Intelligence in Modern Radiological Imaging	**5**	**5**
Total		**72**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

Sr. No		**Hours**
1.	Modern x-ray tube: its principle, physics & equipment	5
2.	Digital Radiography	5
3.	Dual energy x-ray absorptionometry (DEXA) scan: its principle, physics & equipment	2
4.	Computed radiography	3
5.	Mammography and Tomosynthesis: its principle, physics & equipment	5
6.	Modern dental equipments. Cone beam dental CT	3
7.	Bone mineraldensitytest: its principle, physics & equipment	2
8.	Picture archiving and communication system (PACS), RIS, HIS and Teleradiology	5
9.	Computed Tomography	5
10.	Magnetic Resonance Imaging	5
11.	Ultrasound Imaging	5
12.	Hybrid Imaging	5

13.	Smart Simulator/virtualimaging AI Imaging	4
Total		**54**

SUGGESTED LEARNING RESOURCES

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

Subject: Contrast Media and Interventional Radiology

Subject Code: MMRIT05

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

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

THEORY COMPONENTS

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: Modern Imaging and Special Radiological Procedures

Subject Code: MMRIT06

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

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

THEORY COMPONENTS

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Third Semester

Subject: Principles of CT Imaging Technology

Subject code: MMRIT07

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

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

THEORY COMPONENTS

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: CT Imaging Procedures and Scanning Protocols

Subject code: MMRIT08

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

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

THEORY COMPONENTS

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

Sr. No		Hours
7.	Miscallaneous	12
	Total	72

SUGGESTED LEARNING RESOURCES

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

Subject: Basic and Cross Sectional Anatomy in CT Imaging

Subject code: MMRIT09

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

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

PRACTICAL COMPONENTS

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

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

SUGGESTED LEARNING RESOURCES

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

Fourth Semester

Subject: Advancements in CT Technology

Subject code: MMRIT10

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

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

THEORY COMPONENTS

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

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

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

Subject code: MMRIT11

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

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

THEORY COMPONENTS

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: Basic Pathology and Image Interpretation in CT Imaging

Subject code: MMRIT13

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

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

PRACTICAL COMPONENTS

The following topics/subtopics should be thought and assessed in oder to attain the identified competency

Unit	Topic and content	Hours	Marks
1.	Basic pathologies and general interpretations of Head, Face&Neck	15	10
2.	Basic pathologies and general interpretations of Vascular imaging	5	5
3.	Basic pathologies and general interpretations of Spine	15	10
4.	Basic pathologies and general interpretations of Brachial plexus,Chest, Heart and great vessels	10	5
5.	Basic pathologies and general interpretations of Breast	5	5
6.	Basic pathologies and general interpretations of Kidney, Pancreas, Liver and biliary system	13	5
7.	Basic pathologies and general interpretations of Abdomen and Pelvis	10	5
8.	Basic pathologies and general interpretations of Upper limb	10	5
9.	Basic pathologies and general interpretations of Lower Limb	10	5
10.	Basic pathologies and general interpretations of Peripheral vascular system	5	5
11.	Basic pathologies and general interpretations of Pediatric imaging	10	10
	Total	**108**	**70**

SUGGESTED LEARNING RESOURCES

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

Third Semester

Subject: Principles of MR Imaging Technology

Subject Code: MMRIT14

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

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

THEORY COMPONENTS

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: MR Imaging Procedures and Scanning Protocols

Subject Code: MMRIT15

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

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

THEORY COMPONENTS

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

Unit	Topic and contents	Hours	Marks
1.	**MRI Brain:** Routine, stroke, epilepsy, MS, tumour protocols, MR Angiography (COW), MR Venography, CSF Flow analysis.	**10**	**14**
2.	**MRI Face:** Orbit, Cochlea, OSA, Pituitary, Neck, Brachial Plexus, Sialography, Dacrocystography	**7**	**10**
3.	**MRI Upper limb protocols:** Shoulder, elbow, wrist, hand. MR Upper limb angiography/venography. Shoulder Arthrography.	**9**	**10**
4.	**MRI Lower limb Protocols:** Pelvis- bony, male and female, hip joint, knee, ankle, foot. MR Cartigram. Lower Limb Angiography/Venography.	**9**	**10**
5.	**MRI Spine:** Cervical, Thoracic, Lumbo-sacral, Flexion-Extension, Whole spine screening.Composing. MR Cisternography, Myelography.	**9**	**12**
6.	**MRI Thorax-Abdomen:** Cardiac MR, routine Abdomen, MRCP, Fetal MRI, Fistulography, MR Prostate, MR Placenta, MR Urography, Enteroclysis. Respiratory and ECG Gating techniques	**5**	**7**
7.	**All special MRI procedures** including MRCP, perfusion scan, ASL, FMRI, Cardiac MRI etc. Pediatric scan: Kitten MRI	**5**	**7**
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: Basic and Cross-Sectional Anatomy in MR Imaging

Subject Code: MMRIT16

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

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

PRACTICAL COMPONENTS

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

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

SUGGESTED LEARNING RESOURCES

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

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

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

Fourth Semester

Subject: Advancements in MR Imaging Technology

Subject Code: MMRIT17

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

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

THEORY COMPONENTS

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: Planning, Safety and Patient care in MR Imaging

Subject Code: MMRIT18

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

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

THEORY COMPONENTS

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

Unit	Topic and contents	Hours	Marks
1.	**Bioeffects of MRI:** Bio-effects of static and gradient magnetic fields, Acoustic noise, Bio-effects of radiofrequency power deposition and induced heating during MRI, SAR, Claustrophobia, anxiety and emotional distress in the MR	**14**	**16**
2.	**MRI facility design:** Site selection, MRI safety zones, Scanner room layout. Shielding techniques, Faraday Cage.	**10**	**14**
3.	**Implants:** Materials used as implants and prosthesis,cardiac devices, Patient monitoring in the MRI environment, Managing Acute situations, Screening, History, Metal Detection.	**10**	**14**
4.	**MRI Contrast Safety:** Identification and management of acute reactions related to gadolinium based contrast agents, Contrast safety in pregnancy and lactation, nephrogenic systemic fibrosis, Extravasation.	**10**	**16**
5.	**Miscallaneous Safety aspects:** Quenching, Ambient temperature, cryogen levels,Safety issues for interventional MR Systems, MRI safety guidelines, policies and procedures.	**10**	**10**
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: Basics Pathology and Image Interpretation in MR Imaging

Subject Code: MMRIT19

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

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

PRACTICAL COMPONENTS

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

Unit	Topic and content	Hours	Marks
1.	Basic pathologies and general interpretations of Head, Face&Neck	15	10
2.	Basic pathologies and general interpretations of Vascular imaging	5	5
3.	Basic pathologies and general interpretations of Spine	15	10
4.	Basic pathologies and general interpretations of Brachial plexus, Chest, Heart and great vessels	10	5
5.	Basic pathologies and general interpretations of Breast	5	5
6.	Basic pathologies and general interpretations of Kidney, Pancreas, Liver and biliary system	13	5
7.	Basic pathologies and general interpretations of Abdomen and Pelvis	10	5
8.	Basic pathologies and general interpretations of Upper limb	10	5
9.	Basic pathologies and general interpretations of Lower Limb	10	5
10.	Basic pathologies and general interpretations of Peripheral vascular system	5	5
11.	Basic pathologies and general interpretations of Pediatric imaging	10	10
	Total	**108**	**70**

SUGGESTED LEARNING RESOURCES

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

3.	Neurological Practice: An Indian Perspective	Wadia	

Third-Semester

Subject: Principle of Breast Imaging Technology

Subject Code: MMRIT21

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

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

THEORY COMPONENTS

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

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

SUGGESTED PRACTICALS/DEMONSTRATION

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

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

SUGGESTED LEARNING RESOURCES

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

Subject: Breast Imaging Procedures and Scanning Protocols

Subject Code: MMRIT22

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

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

THEORY COMPONENTS

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

Unit	Topic and contents	Hours	Marks
1.	**Sterile Techniques:** Spread of infection: Exogenous, Endogenous, Iatrogenic and Nosocomial**,** Preparation of local anesthetics, contrast media, Patient allergies and alternative options. Proper glove use, hand washing technique, Skin preparation Sterile tray preparation, Disposal of items.	**8**	**10**
2.	**Localization Modalities** Mammography localization: Stereotactic biopsy : Definition, Application & Technique Wire localization: Definition, Application&Technique Ultrasound Guidance: Definition, Application&Technique MR localization: Definition, Application, Technique.	**8**	**10**
3.	**Interventional Procedures:** Cyst aspirations, Fine-needle aspiration or biopsies, Core biopsy,Vacuum-assisted breast biopsy, Galactography, Specimen Imaging: Imaging Guidelines- Core Specimen and Surgical specimens.	**6**	**10**
4.	**Patient Positioning:** Foot Placement, Arm placement, Degree of obliquity- Size of breast, Lesion location, Patient comfort	**10**	**10**
5.	**Evaluation of Images** :Positioning , Compression, Exposure, Contrast, Sharpness, Noise, Artifacts, Motion, Labeling, Collimation	**6**	**10**

6.	**Patients requiring modification of positioning techniques :**Males, Transgender patients, Kyphotic patients, Large breasts, Small breasts, Encapsulated implants, Pectus excavatum, Pectus carinatum, Protruding abdomens, Pacemaker, Wheelchair, Infuse-port (Port-A-Cath), Physically disabled, Mentally disabled, Frozen shoulder, Barrel chest, Thick axilla, Irradiated breast, Reduction mammoplasty, Postsurgicalbreast, Loop recorder	**10**	**10**
7.	**Image Quality Problems and remedy**: Nipple not in profile, Skin folds or wrinkling, Difficulty compressing due to patient body habitus, Incorrect or uneven compression, Superimposition of extra anatomy, Drooping of breast, Motion, Artifact.	**6**	**10**
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

Subject: Basics and Cross Sectional anatomy of Breast

Subject Code: MMRIT23

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

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

THEORY COMPONENTS

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

Unit	Topic and contents	Hours	Marks
1.	**Definition of the Breast:** Male vs female**,** breast developmental stages: Fetal, Puberty, Menstruation, Pregnancy, Lactation, Menopause, Post menopause**,** Breast landmarks: Quadrants, Clock face references.	**20**	**14**
2.	Gross Anatomy of the Normal Breast, Nipple, Areola, Montgomery's glands, Morgagni's tubercles, Skin: Sebaceous glands, Sweat glands, Hair follicles, Axillarytail, Breast margins, Inframammary fold, Axilla, Internal Anatomy: Fascia, Layers, Retromammary(fat)space. Breast parenchymal components, Lobes and ducts, Cooper's ligaments, stroma, Lymphatic drainage, Breast Vasculature, Pectoralmuscle.	**40**	**25**
3.	**Histology of the breast:** Terminal ductal lobular unit**,** Extra lobular terminal duct, Intra-lobular terminal duct, Ductal sinus(acinus)**,** Cellular components: Epithelial cells, Myoepithelial cells, Basement membrane	**20**	**16**
4.	**Mammographic Appearance of Breast:** Density variations, BIRADS, Variances, Life cycle changes, lesions and characteristic features, lesion measurement.	**28**	**15**
Total		**108**	**70**

SUGGESTTED LEARNING RESOURCES

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

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

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

Fourth Semester

Subject: Advancements in Breast Imaging Technology

Subject Code: MMRIT24

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

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

THEORY COMPONENTS

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

Unit	Topic and contents	Hours	Marks
1.	**Computer-Aided Detection** Define, Proper protocol for use, Tool for mammography interpretation	**4**	**6**
2.	**Digital Breast Tomosynthesis (DBT):** Define, physical principle and components of DBT, Personnel training requirements (MQSA), Potential benefits, Types of images: Projection images &Reconstruction images.	**8**	**10**
3.	**Breast Imaging Biomarkers:** Breast Density assessment: Breast arterial calcification scoring, Cancermarkers, MRM.	**4**	**6**
4.	**Dual Energy Contrast-enhanced Mammography** Define, Theory, Potential benefits	**4**	**8**
5.	**Breast Elastography:** Ultrasound Imaging, Basic principle, types, advantages, image interpretation.	**4**	**6**
6.	**Nuclear Medicine Studies**: Define, basic principle, Potential benefits, Types: Scintimammography, Lympho-scintigraphy, Positron emission tomography.	**10**	**8**
7.	**3-D Ultrasound Imaging**: Concept, mechanism of action, advantages, indications.	**8**	**8**
8.	**Abbreviated Breast MRI:** Define, Theory, Potential benefits	**6**	**6**
9.	**Non-ionizing techniques:** CTML, Thermal Imaging, Breast Imaging with EIS**,** Breast Photo Imaging	**4**	**6**

10.	**Dedicated Breast CT:** Fundamental principle, dose estimation, indications, pros and cons, protective apparel.	**2**	**6**
Total		**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

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

SUGGESTED LEARNING RESOURCES

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

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

Subject Code: MMRIT25

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

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

THEORY COMPONENTS

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

Unit	Topic and contents	Hours	Marks
1.	**ALARA Principle:** Optimizing imaging techniques and using the lowest possible radiation dose are essential components of ALARA.	**10**	**12**
2.	**Appropriate Indications and contraindications.** **Technique Optimization:** Patient education, consent and preparation, history taking, exposure factors and compression settings based on the patient's breast size and density.	**10**	**14**
3.	**Mammographic Procedure:** Collimation and Field Size, Compression, Receptor Sensitivity (reduction of patient dose), Use of AEC, Patient Comfort.	**8**	**14**
4.	**Staff Education and Training:** Radiation safety protocols, Regular continuing education and training about latest techniques and guidelines. **Quality Assurance and Audits:** Implement quality assurance programs to monitor and assess radiation dose levels, image quality, and compliancewith radiationsafety protocols.	**8**	**16**

5.	**Patient Care in Interventional Mammographic procedures:** **Pre-procedural care:** Knowledge of informed consent, Use of 2 patient identifiers, Hard stop process, Vital signs, Explanation of procedure, Proper documentation **During procedure:** Patient awareness**,** Signs of vasovagal reaction and syncope**,** Signs of allergic reactions to anesthesia**,** Anxiety, patient compliance. **Post-procedural care:** Post-procedure imaging for clip placement**,** compression and wound dressing**,** instructions and medications prescribed, Follow-up.	**18**	**14**
	Total	**54**	**70**

SUGGESTED PRACTICALS/DEMONSTRATION

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

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

Subject: Basics Pathology and Image Interpretation in Breast Imaging

Subject Code: MMRIT26

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

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

PRACTICAL COMPONENTS

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

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

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

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

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

SUGGESTED LEARNING RESOURCES

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