GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester - V

Course Title: Medical Imaging Techniques
(Course Code: 4350301)

Diploma programme in which this course is offered	Semester in which offered
Biomedical Engineering	5th Semester

1. RATIONALE

There has been tremendous development in imaging field during last few years. Few decades back we only had an X-ray machine to image human body. Today, we have highly sophisticated equipment like CT scan, Ultrasound Scanner, MRI, Endoscope, etc. that have completely changed the scenario of medical imaging. Hence it is essential that the students acquire skills to maintain these latest imaging systems for which this course is designed.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in students so that they are able to acquire following competency:

- **Maintain different types of medical imaging instruments.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

a) Interpret the working of various elements of X-Ray equipment and their specification.
b) Select relevant X-Ray imaging modality for specific applications.
c) Differentiate between various generations of CT scan machines.
d) Identify different types of ultrasound scans.
e) Interpret the functioning of MRI machine.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	4	5	30	70	25	25	150

(*):Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *-Practical;* ***C*** *– Credit,* ***CA*** *- Continuous Assessment;* ***ESE*** *-End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) that are the sub-components of the COs. *Some of the* ***PrOs*** *marked* ***'*'*** *are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	To Observe X-ray machine components and controls.	1	4
2	To adjust exposure factors (kvp, mas) based on body part and patient size.	1	2
3	To Study of the radiation dose and safety aspects of X- ray.	1	2
4	To adjust collimators to restrict the X-ray beam to the area of interest.	2	2
5	To Observe CT scanner components and user interface.	3	4
6	To Demonstrate the administration of contrast agents for contrast-enhanced CT.	3	2
7	To Understand about biological affect and safety aspects of computed tomography.	3	2
8	To Analyze CT scans in group discussions, interpreting findings.	3	2
9	To Observe fluoroscopy system components and controls.	2	2
10	To adjust the image intensifier and understanding its role for image enhancement.	2	2
11	To Study about the Principle of Magnetic Resonance Imaging.	5	4
12	To Study about the different types of magnets used MRI machine.	5	2
13	To Study about different types of coil arrangement in MRI.	5	2
14	To Understand the transducer, console, and imaging setting in Ultrasound	4	2
15	To Demonstrate different modes and probes of ultrasound imaging.	4	2
16	To Demonstrate the performance of different ultrasonic probes (sector and electronic).	4	2
17	To Practice Scanning techniques for different anatomical regions.	4	2
18	To Observe angiography machine components, controls, and safety features.	2	4
19	To Observe mammography machine components, controls, and compression systems.	2	4
20	To Analyze X-ray, CT, MRI, and ultrasound images (To Observe images of X-ray, CT, MRI, and ultrasound scan)	All	2
21	To Understand the environmental impact of imaging equipment and practices.	All	2
22	To Develop eco-friendly practices and waste reduction during	All	4

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	usage of medical imaging techniques/instrumentation/equipment.		
	Total		**56**

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills(more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

a) X-Ray Machine
b) Ultrasound Machine
c) CT Scan Machine (External Facility)
d) MRI Machine (External Facility)
e) Cathode Ray Oscilloscope

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical appliances.
c) Practice environmental friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency

Unit	Unit Outcomes (UOs)	Topics and Sub-topic
Unit – I X-ray technique	1a. Define X-rays. Enlist various properties of X-rays. 1b. Define Roentgen (R), Radiation absorbed dose (Rad). 1c. Describe white and characteristic radiation. 1d. Compare stationary and rotating X-ray tubes. 1e. Explain construction of X-ray machine. 1f. Define various X-ray tube ratings. 1g. Explain construction and need of beam restrictors and grids.	1.1 Introduction to X-rays: Definition, Properties, Measurement units 1.2 Generations of X-rays: White and Characteristics radiation 1.3 X-ray Generators: Types of X-ray tubes. Stationary and Rotating 1.4 X-RAY machine: Technical specifications and block diagram, 1.5 X-ray tube ratings, 1.6 Beam restrictors and collimators.
Unit– II Digital radiographic techniques	2a. Differentiate Conventional and Digital Radiographic techniques. 2b. Explain the layout of Catheterization laboratory in brief. 2c. Explain basic components of fluoroscopy. 2d. Describe angiography procedure. 2e. Explain step by step procedure used to perform angioplasty. 2f Explain step by step procedure to perform mammography.	2.1 Digital Vs. Conventional X-ray Radiography 2.2 Catheterization laboratory: 2.2.1 Layout of Cath lab 2.3.1 Fluoroscopy: Performance parameters and image reproduction 2.4. Angioplasty and Angiography: Step by step procedure 2.5 Mammography: basic technique.
Unit– III Computed Tomography technique	3a. Explain the Principle of CT-Scan. 3b. Define CT number. 3c. Explain various Generations of CT-Scan 3d. Compare X-ray and Computed Tomography.	3.1 Computed tomography: Basic Principle of CT 3.2 CT number 3.3 Generations of CT-Scanner 3.4 X-ray Vs CT Scan
Unit – IV Ultrasound Imaging technique	4a. Explain various properties of ultrasound. 4b. Explain the working principle of Ultrasound transducers. 4c. Draw and explain the basic block diagram of pulse-echo system. 4d. Differentiate various modes of ultrasound imaging. 4e. Describe the Biological effects of Ultrasound.	4.1 Introduction, properties of ultrasound & its limitations, Ultrasound transducer. 4.2 Pulse-echo technique 4.3 Ultrasound imaging: - A-Mode, B-Mode, M-Mode 4.4 Biologic effects of Ultrasound.
Unit – V Advanced Imaging Techniques and Radiation Safety	5a. Explain basic principle of MRI Machine. 5b.Describe the types of Magnets used in MRI 5c. Radiation safety and hazards 5d. Radioactive waste management	5.1 Magnetic Resonance Imaging (MRI): Basic working principle of MRI, Block diagram, Parts of NMR machine. 5.2 Magnets and Coils of MRI machine 5.3 Biological effect of Ionizing radiation on human health. 5.4 Prevention of Radiation hazards and safe practices. 5.5 Methods of Radioactive waste

		disposal

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A	Total Marks
1	X-Ray Technique	10	10	4	2	16
2	Digital radiographic techniques	8	6	4	4	14
3	Computed Tomography technique	8	8	4	2	14
4	Ultrasound Imaging technique	8	8	4	2	14
5	Advanced Imaging Techniques and Radiation Safety	8	6	4	2	12
Total		**42**	38	20	12	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may varies lightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a) Visit to a nearby Imaging Centre.
b) Visit nearby Hospital where Medical Imaging facilities are available.
c) Prepare a chart of components currently used for Medical Imaging Equipment.
d) Prepare mini/micro project related to any one Imaging Modality.
e) Participate in a seminar/workshop for learning new trends and technology in Medical Imaging Techniques.
f) Prepare a poster for safety guidelines to be followed while operating/handling imaging equipment.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (MOOCs) may be used to teach various topics/ subtopics.
b) Guide student(s) in undertaking micro-projects.
c) Arrange to visit nearer Hospital/Imaging Centre.
d) Video films/animation films on working of different types of Medical Imaging Equipment.

e) Perform practical virtually on the various online website/software

f) Arrange expert lectures on advanced topics related to Medical Imaging.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, in the fifth and sixth semesters, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about 14-16 (fourteen to sixteen) student engagement hours during the course. The students ought to submit micro-project by the end of the semester to develop the industry oriented COs. A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1. Design a circuit for generating required current and voltage ratings for an X-Ray Machine.
2. Prepare model to demonstrate various types of X-Ray modalities.
3. Prepare model to demonstrate various generations of CT-Scan machine.
4. Prepare model to demonstrate various modes of transmission in Ultrasound
5. Prepare model to demonstrate various modes of display in Ultrasound
6. Prepare a chart depicting various advanced imaging modalities like MRI, PET and Nuclear Medicine.
7. Prepare a Report of Detailed Analysis of any one real Image of any (X-Ray, CT, MRI, Ultrasound) Imaging Technique.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Handbook of Biomedical Instrumentation	R.S. Khandpur	Tata McGraw Hill, New Delhi
2	Medical Electronics A.G. Patil Excel Books	Medical Electronics A.G. Patil Excel Books	Medical Electronics A.G. Patil Excel Books
3	Introduction to Physics of Diagnostic Radiology	Christen Sen's Thomas S. Curry Jamis E Dowdey Robert C.Murry	Lea and Febiger
4	Medical Electrical Equipment	Robert E. Molleoy	B.I. publication
5	Medical Instrumentation Application and Design	John G. Webster, Editor	A John Wiley and Sons, Inc., Publication
6	Fundamentals of Medical Imaging	Paul Suetens	Cambridge University Press
7	Introduction to Medical Imaging: Physics, Engineering and Clinical	Andrew Webb, Nadine Barrie Smith	Cambridge University Press

S. No.	Title of Book	Author	Publication with place, year and ISBN
	Applications		
8	Fundamentals Physics of Radiology	Meredith and Messey	A John Wright and Sons Ltd

14. SOFTWARE/LEARNING WEBSITES

- **X-Ray Imaging :**
  https://www.ncbi.nlm.nih.gov/books/NBK564423/
  https://www.aerb.gov.in/images/PDF/TrainingModule/3-MEDICAL-IMAGING-TECHNIQUES.pdf
- **CT Scan:**
  https://www.aerb.gov.in/images/PDF/TrainingModule/3-MEDICAL-IMAGING-TECHNIQUES.pdf
  https://www.nibib.nih.gov/science-education/science-topics/computed-tomography-ct
- **Ultrasound Imaging:**
  https://www.nibib.nih.gov/science-education/science-topics/ultrasound
  https://www.uscultrasound.com/what-is-ultrasound-and-how-does-it-work/
- **MRI:**
  https://www.nibib.nih.gov/science-education/science-topics/magnetic-resonance-imaging-mri
  https://www.hopkinsmedicine.org/health/treatment-tests-and-therapies/magnetic-resonance-imaging-mri

15. PO-COMPETENCY-CO MAPPING

Semester III	Pos						
Competency & Course Outcomes	**PO 1 Basic & Discipline specific knowledge**	**PO 2 Problem Analysis**	**PO 3 Design/ development of solutions**	**PO 4 Engineering Tools, Experimentation &Testing**	**PO 5 Engineering practices for society, sustainability & environment**	**PO 6 Project Management**	**PO 7 Life-long learning**
Competency							
CO-1: Interpret the working of various elements of X-Ray equipment and their	2	2	-	-	2	-	3

CO-2: Select relevant X-Ray imaging modality for specific applications.	3	-	1	3	-	2	2
CO-3: Differentiate between various generations of CT scan machines.	3	-	1	3	-	-	2
CO-4: Identify different types of ultrasound scans.	3	-	2	3	-	-	2
CO-5: Interpret the functioning of MRI machine.	3	-	2	3	2	3	3

Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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1	Mr. V. D. Parmar	Government Polytechnic Ahemdabad	8511562348	vdparmar@gpahmedabad.ac.in
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