GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2022)
Semester – IV

Course Title: Biomedical Instrumentation
(Course Code: 4341705)

Diploma programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	4th Semester

1. RATIONALE

There is a growing use of biomedical instruments in health care every day. Today's hospitals use advanced, complex, and precise instruments. Biomedical Instrumentation is also a branch of instrumentation hence diploma instrumentation engineers should be familiar with biomedical instrumentation fundamentals and how various biomedical instruments work. Thus, this course aims to develop some basic skills in understanding, operating, and testing various biomedical instruments.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire the following competency:

- **Operate and test biomedical 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 different learning outcomes in the cognitive, psychomotor, and affective domains to demonstrate the following course outcomes.

1. Understand various bio-signals / Potentials.
2. Operate different biomedical recorders used in Hospitals.
3. Explain construction and working of various medical imaging equipment and operate them.
4. Explain construction and working of surgical and therapeutic instruments and operate them.
5. Explain construction and working of medical laboratory instruments and operate them.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	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

Following practical outcomes (PrOs) are the subcomponents of the Course Outcomes (Cos).

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Measure blood pressure using a sphygmomanometer.	I	2
2	Measure respiration rate using respiration rate-meter.	I	2
3	Measure body temperature using analog and digital thermometer.	I	2
4	Identify ECG, EMG and EEG electrodes.	II	2
5	Demonstrate the performance of the ECG machine.	II	4
6	Demonstrate the performance of the EEG machine.	II	4
7	Demonstrate the performance of the EMG machine.	II	4
8	Demonstrate the performance of an X-ray machine.	III	2
7	Demonstrate the performance of Computed Tomography (CT scan) Machine.	III	4
8	Identify the parts of the MRI Machine.	III	2
9	Identify the parts of the PET scanner Machine.	III	2
10	Demonstrate operation of cardiac pacemaker	IV	2
11	Maintain different electrodes for Electro-surgery machine (cautery).	IV	2
12	Demonstrate various cutting modes of Electro-surgery machines.	IV	4
13	Identify various parts of Haemodialysis machines.	IV	2
14	Demonstrate operation Haemodialysis machine.	IV	4
15	Demonstrate operation of Muscle Stimulators.	IV	2
16	Demonstrate operation of Ventilator.	IV	2
17	Demonstrate operation of Blood Cell Counter.	V	4

18	Demonstrate operation of Auto analyzer.	V	2
19	Demonstrate operation of Pulse Oximeter	V	2

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.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Lab Record	05
2	Discuss the Bio-medical basics	10
3	lab setup for practicals	15
4	Practical performance	30
5	Result Interpretation	20
6	Viva Performance	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to the user in uniformity of practical's in all institutions across the state.

- Heart rate monitor cum ECG trainer
- 12 lead ECG simulator
- Respiration-rate monitor
- Electro-myograph trainer
- Phono-cardiograph trainer
- Blood pressure measurement trainer
- Sphygmomanometer
- Bio-Electrodes for (ECG/EEG/EMG)
- Ultrasound probes
- Ultrasound machine trainer
- Electrocautery machine
- Muscle simulator
- cardiac pacemaker
- Ventilator
- Electronic/ electrical assorted tool kit
- Pulse Oximeter

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 course competency.

a) Work as a leader/ team member.
b) Follow safety practices while using biomedical instruments.

The ADOs are best developed through 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

The major underpinning theory is given below based on the higher-level UOs of *Revised Bloom's taxonomy* formulated for developing COs and competency. If required, more such UOs could be included by the course teacher to focus on the attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit-I Fundamentals of Medical Instruments	1a. List the Sources of biomedical signals. 1b. Explain the generation of bio-potential in the human body. 1c. Explain the generalized block diagram of the medical instrumentation system. 1d. List the different types of medical transducers used in medical instruments for Body temperature, Blood pressure, and respiration rate. 1e. Explain the working of the indirect blood pressure measurement instrument (sphygmo -manometer). 1f. Classify medical instruments based on different principles with Application Viz - (diagnostic, therapeutic, Imaging, analytical) , Physiological parameter and biopotential, Biological system,	1.1 Fundamentals of medical instrumentation. a. Sources of biomedical signals b. Generalized medical instrumentation block diagram. c. Medical transducers: Body temperature, Blood pressure, respiration rate 1.2 Classification of Medical instruments based on: a. Application - (diagnostic, therapeutic, Imaging, analytical) b. Physiological parameter and biopotential c. Biological system d. Different departments

	Different departments in the hospital.	in the hospital
Unit-II Biomedical Recorders	2a. Explain the working principle of Electrocardiograph with a block diagram. 2b. Explain the relating cardiac activity of the heart with a labeled ECG waveform. 2c. Explain ECG electrodes with diagrams. 2d. Explain bipolar and unipolar leads used for ECG measurements. 2e. Write working on a phono-cardiograph. 2f. Explain the working principle of Electro-encephalograph. 2g. Explain EEG electrodes with diagrams. 2h. Draw block diagrams and describe the working principle of EMG. 2i. Explain EMG electrodes with diagrams. 2j. Explain bio- feedback instrumentation with block diagrams.	2.1 Cardiograph Machine: a. ECG block diagram b. Bipolar and unipolar leads c. Phono-cardiograph d. ECG electrodes 2.2 Electro- encephalograph (EEG). a. EEG block diagram b. EEG electrodes c. EEG readout device d. 10-20 electrode placement system. 2.3 Electro-myograph (EMG) machine. a. EMG block diagram b. EMG electrodes 2.4 Biofeedback Instrumentation
Unit-III Medical Imaging Equipments	3a. List the characteristics of x-ray. 3b. Explain the generation of an X-ray. 3c. Describe the working of an X-ray machine with a block diagram. 3d. Describe the working of a CT scan machine with a block diagram. 3e. List properties of ultrasound and its applications in medical instrumentation. 3f. Describe the working of an echo-cardio graph machine	3.1 X-ray machine a. characteristics of x-ray b. generation of an X-ray 3.2 CT-Scan machine 3.3 Echo-cardiograph a. Properties of ultrasound b. Applications of Ultrasound 3.4 Magnetic Resonance Imaging (MRI) 3.5 Positron Emission Tomography (PET)

	with a block diagram. 3g. Describe the working of an MRI machine with a block diagram. 3h. Describe the working of a PET Scanner machine with a block diagram.	
Unit-IV Surgical & Therapeutic Instruments	4a. Describe the working of an implantable Pacemaker with a diagram. 4b. Describe the working of an electro-surgery machine with a block diagram and the safety precautions to be taken. 4c. List the electrodes used with an electrosurgery machine. 4d. List and explain dialyzer with diagrams. 4e. Describe working of a Haemodialysis machine with block diagram. 4f. Describe working of a Muscle Stimulator machine with a block diagram. 4g. List various terms related to respiratory system. 4h. Describe working of Ventilators with a neat diagram.	4.1 Cardiac Pacemaker: a. Need for cardiac pacemaker b. Implantable Pacemakers 4.2 Electro-surgery machine (cautery machine) 4.3 Haemodialysis machine: a. Function of natural and artificial kidney b. Dialyzer: Hollow fibre dialyzer c. Haemodialysis machine 4.4 Electrotherapy: a. Current waveforms employed in electrotherapy b. Muscle stimulator machine 4.5 Ventilator machine a. Artificial ventilation b. Classification of ventilators.
Unit-V Medical Laboratory Instruments&waste management	5a. List the pathological (clinical) test Instruments for medical diagnosis. 5b. Draw the block diagram and describe the working of a blood cell counter. 5c. Explain oximetry and describe in-vivo, in-vitro, and pulse oximetry with the necessary diagram. 5d. Draw the block diagram and describe the working of an	5.1 Types of tests a Blood cell b Biochemistry 5.2 Blood Cell Counter a. Flow cytometry b. Coulter Counter 5.3 Basics of Oximetry a. In-vivo oximetry b. In-vitro oximetry c. Pulse oximetry 5.4 Auto analyzer 5.5 Bio-medical Waste

	auto analyzer. 5e. Write steps to manage biomedical waste at hospitals.	a. Medical waste types b. Medical waste management

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Fundamentals of Medical Instruments**	**8**	5	5	2	**12**
II	**Biomedical Recorders**	**9**	4	7	3	**14**
III	**Medical Imaging Equipments**	**8**	5	8	3	**16**
IV	**Surgical & Therapeutic Instruments**	**10**	5	10	3	**18**
V	**Medical Laboratory Instruments & waste management**	**7**	3	5	2	**10**
	Total	**42**	**22**	**35**	**13**	**70**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a) Present a seminar on technical topics covered in the syllabus.
b) Debate on merits and demerits of various biomedical instruments.
c) Prepare a poster/ chart on anyone advanced topic related of course.
d) Collect the extracurricular information related to the course from the internet and share it with other students.
e) Institutes should arrange hospital visits for students.

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) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.

e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.

f) Helping the students to understand the concepts of the world wide web (WWW) and the Internet.

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:

a) Prepare presentations on relevant topics.
b) Prepare a chart/model on a relevant topic.

13. SUGGESTED LEARNING RESOURCES

Sr. 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	Introduction to biomedical equipment technology	Carr Joseph J., Brown J.M.	Pearson education, New Delhi
3	Medical instrumentation application & design	John G. Webster, Editor	John Wiley and Sons, New Delhi
4	Biomedical instrumentation measurements.	Lesli P Cromwell, Fred J. Weibell, Erich A. Pfeiffer	PHI Learning, New Delhi

14. SOFTWARE/ LEARNING WEBSITES

- http://phet.colorado.edu/en/simulations/category/biology

15. PO-COMPETENCY-CO MAPPING

Semester IV	BIOMEDICAL INSTRUMENTATION (Course Code: 4341705)						
	POs						
Competency & Course Outcomes	**PO 1 Basic & Discipline specific knowledge**	**PO 2 Problem Analysis**	**PO 3 Design/ develop-ment of solutions**	**PO 4 Engineering Tools, Experimen-tation& Testing**	**PO 5 Engineering practices for society, sustainability & environment**	**PO 6 Project Manage-ment**	**PO 7 Life-long learning**
Competency	**Operate and test biomedical instruments**						
Course Outcomes CO 1) Understand various bio-signals / Potentials.	2	1	-	1	2	-	3
CO 2) Operate different biomedical recorders used in Hospitals.	2	2	-	2	2	-	2
CO 3) Explain construction and working of various medical imaging equipment and operate them.	2	2	-	2	2	-	2
CO 4) Explain construction and working of surgical and therapeutic instruments and operate them.	2	2	-	2	2	-	2
CO 5) Explain construction and working of medical laboratory instruments and operate them.	2	2	-	2	2	-	2

*Legend: '**3'** for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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