GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: CRITICAL CARE INSTRUMENTATION
(Course Code: 4350302)

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

1. RATIONALE

Critical care instrumentation is a multidisciplinary field concerned with patients who have sustained, or are at risk of sustaining life threatening, single or multiple organ system failure due to disease or injury. Critical care medicine seeks to provide for the needs of these patients through immediate and continuous observation and intervention so as to restore health and prevent complications. Hence this course provides knowledge and underlying functional concepts of the different critical equipment used in NICU, ICCU, and ICU. Biomedical Engineers will be able to apply their knowledge in reducing the environmental consequences of an intensive care unit in major areas. This course emphasizes the importance of critical care instruments in ensuring patient safety and enhancing the efficiency of healthcare delivery.

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 following competency:

- **Maintain different critical care instruments used in hospitals.**

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 outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

(a) Illustrate various biomedical critical care instruments.
(b) Interpret operations of patient monitoring system
(c) Demonstrate the operations of cardiac care instruments
(d) Maintain the operations of life support equipment.
(e) Illustrate the operations of telemetry and green cardiac care

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'.*

Sr No	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Identify various instruments and their application used in critical care units in hospitals.	1	02
2	Identify the Standardized Emergency Color code used for hospitals	1	02
3	Experiment measurement of various parameters of Bedside monitor	2	02
4	Demonstrate various parameters measurement on central monitor	2	02
5	Plot the characteristic of normal sinus rhythm, bradycardia, tachycardia, arrhythmia, Ventricular fibrillation etc. heart disease	3	02
6	Plot the Charging and discharging characteristics of capacitor waveform for DC defibrillator	3	02
7	Demonstrate the working of an external defibrillator	3	02
8	Test the charging, discharging and energy control in dc defibrillators with instant and synchronous mode	3	02
9	Demonstrate the working of an asynchronous type external pacemaker	3	02
10	Demonstrate the working of an synchronous type external pacemaker	3	02
11	To study Ventricular Fibrillation (Chaotic Ventricular depolarization) & Corrected Ventricular Fibrillation (Pacemaker Action).	3	02
12	Demonstrate Normal Sinus Rhythm (Lead II), Bradycardia (Slower Heart Rate < 60), Corrected Bradycardia wave (Pacemaker Action).	3	02
13	Identify the various electrodes used in the defibrillator and pacemaker	3	02
14	Plot characteristic of temperature control in neonatal incubator and test the annunciating system.	4	02
15	Illustrate different terminology related to ventilators.	4	02
16	Operate the ventilator in different modes.	4	02
17	Demonstrate the operation of Bipap machine	4	02
18	Demonstrate the operation of Anesthesia Machine	4	02
19	Demonstrate the working of nebulizer	4	02
20	Illustrate the operation of a heart lung machine.	4	02
21	Illustrate the operation of Intra Aortic Balloon Pump (IABP).	4	02
22	Demonstrate the transmission and reception of biological signal using a telemetry system	5	02
23	Explain the flowchart of environmental impact of an intensive care unit showing four major areas.	5	02
	Total		**Hrs**

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	30
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

1. Patient monitor
2. Bedside Monitor
3. Defibrillator
4. Pacemaker Simulator Scientech-2361
5. BiPap machine
6. Nebulizer
7. Baby Incubator
8. ECG telemetry system
9. Ventilator
10. Heart lung machine
11. IABP
12. Anesthesia machine

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

Unit	Unit Outcomes (UOs)	Topics and Sub-topic
Unit – I Introduction to critical care	1.a Define critical care instrumentation 1.b Enlist different critical care instruments used in hospital 1.c Give importance to different critical care instruments used in hospitals. 1.d Define MICU,ICCU,SICU,PICU, NICU,TICU. 1.e Illustrate standardized emergency color codes used in hospital their purpose	1.1 Introduction to critical care instrumentation with enlisting and the importance of different equipment used in critical units of the hospital. 1.2 Critical units: basic concepts of MICU, NICU, ICCU , PICU, SICU, TICU 1.3 Standardized Emergency Color code used for hospitals
Unit– II Patient Monitoring System	2.a Classify various patient monitoring systems 2.b Elucidate block diagram of bedside monitor 2.c Elucidate block diagram of central monitor.	2.1 Concepts of patient monitoring system classifications-bedside and central monitoring system 2.2 Bedside monitor 2.3 Central monitor
Unit– III Cardiac Care Instruments	3.a Define ventricular fibrillation and cardiac arrhythmia 3.b.Explain working principle of DC defibrillator 3.c Enumerate types of defibrillator 3.d. Explain AED 3.e.State detailed classification of pacemaker 3.f.Explain External continuous/ fixed rate pacemaker 3.g Explain block diagram of R wave triggered implantable pacemaker 3.h Explain block diagram of R wave blocked implantable pacemaker 3.i. Explain block diagram of Atrial triggered pacemaker 3.j Classify various electrodes of pacemakers. 3.k Compare defibrillator and pacemaker.	3.1 Defibrillator-ventricular fibrillation. 3.1.1 DC defibrillator, defibrillator electrodes, types of defibrillator based on mode of application i.e. AED and implantable defibrillators 3.2 Pacemaker- Cardiac arrhythmia, Need of pacemaker 3.2.1 Classification of pacemaker: external and implantable 3.2.2 External pacemaker: Continuous Pacemaker (Fixed rate) 3.2.3 Implantable Pacemaker: Fixed rate, R wave Triggered (Ventricular synchronous demand), R wave blocked(ventricular inhibited), Atrial triggered pacemaker 3.3. Electrodes of pacemaker : unipolar and bipolar 3.4 Comparison of the defibrillator and pacemaker.
Unit – IV Life Supporting Instrument	4.a Explain artificial ventilation 4.b Enlist different types of ventilator 4.c. explain positive pressure ventilator	4.1 Ventilators- mechanism of respiration, artificial ventilation, types of ventilator

	4.d. Define Ventilator Terminology 4.e Classify modes of ventilation 4.f.Explain microprocessor based ventilator 4.g State principle of heart lung machine 4.h State principle of IABP. 4.i Elucidate principle of nebulizer 4.j. State the need of Anesthesia. 4.k. State various types of Anesthesia 4.k. Draw and explain the anesthesia machine in brief.	4.1.1 Ventilator Terminology: lung compliance, mean airway pressure, tidal volume, minute volume, conventional mechanical ventilation, positive end expiratory pressure(PEEP) , SIMV 4.1.2 Ventilator modes-such as spontaneous and mandatory ventilation 4.1.3 Microprocessor based ventilator 4.2 Heart lung machine, intra aortic balloon pump (IABP) and nebulizer 4.3 Anesthesia machine 4.3.1 Need of Anesthesia 4.3.2 Types of Anesthesia: local, Regional and general Anesthesia 4.3.3 Anesthesia machine: Gas supply and delivery, vapor delivery, patient breathing circuit
Unit – V Telemetry and Greening critical care units	5.a. Define telemetry. 5.b. Enlist types of telemetry system 5.c Draw and explain single channel telemetry system 5.d. Draw and explain Multi channel telemetry system 5.e. Draw and explain the flowchart of environmental impact of an intensive care unit showing four major areas.	5.1 Telemetry 5.1.1 Single channel telemetry: ECG telemetry 5.1.2 Multi channel telemetry 5.2 Reducing the environmental impact of an intensive care unit: fou focus areas: Consumption, waste, toxins and the personal footprint of staff

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.

***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	Introduction to critical care	4	6	4	0	10
2	Patient monitoring system	5	6	6	0	12
3	Cardiac Care instruments	14	6	8	4	18
4	Life support Instruments	14	6	8	4	18
5	Telemetry and Greening critical care units	5	6	4	2	12
Total		**42**	26	30	14	**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 vary slightly from the 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) Collect the images of various critical care instruments from the internet and attach their photographs in file/journal.
b) Survey the market and collect the specifications of different critical care instruments supplied by reputed companies and compare them with respect to their strengths and shortcomings.
c) Visit the ICU and OT of the hospital and list various equipment used in it along with their technical specifications.

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 a nearby Hospital.
d) Video films/animation films on working of different types of critical care instruments
e) Perform practical virtually on the various online website/software
f) Arrange expert lectures/ hands-on workshops of critical care specialist surgeons and biomedical engineers dealing with the critical care units.

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:

Following micro projects can be implemented using ESP32, ESP8266, Arduino, 8051 Microcontroller

1. Automatic patient heart beat and body temperature monitoring for remote doctors
2. Measurement of inhaled / exhaled respiratory system
3. Wireless fall sensor MPU 6050 with GPS location for monitoring the elderly
4. Patient fall detection using hip and abdomen sensor
5. IoT based wireless access to physiological data acquisition
6. Wireless data acquisition system for remote care of premature baby
7. Wireless ECG Telemetry system
8. Respiratory monitoring system with temperature and breath sensor
9. Noninvasive Human respiratory measurement
10. Wireless sensor network for healthcare services
11. ZigBee based patient monitoring system
12. Automatic medicine announcement system
13. Microcontroller based temperature control system for Baby incubator
14. IoT based Medical gas flow measurement
15. Medical gas leakage alarming system
16. Make a report on environmental physiotherapy specifically active transport use and physical exercise for healthy lifestyle

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 instrumentation Application and Design	John Webster	John Wiley and Sons, New Delhi
3	Introduction to Biomedical Equipment and technology	Carr and Brown	Pearson Education-Asia, New Delhi
4	Biomedical Instrumentation and Measurements	Leslie Cromwell, Fred J Weibell and Erich A. Pfeiffer	PHI Learning, New Delhi

14. SOFTWARE/LEARNING WEBSITES

- Greening critical care – PMC https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3219402/
- SKILLSET Online ECG Simulator https://www.skillstat.com/tools/ecg-simulator/#/-home
- Virtual Labs Abnormal ECG: http://bmsp-coep.vlabs.ac.in/exp/electrocardiogram-waveform/simulation/AbnormalECG/AbnormalECG.html

- Asynchronous Pacemaker Simulation: http://bmspcoep.vlabs.ac.in/exp/pacemaker/simulation/Pacemaker/PaceMaker.html
- Synchronous Pacemaker Simulation:
- http://bmsp-coep.vlabs.ac.in/exp/pacemaker/simulation/SyncPacemaker/index.html
- Videos for Practical Demonstration of Trainers Baby Incubator, ECG Telemetry, and BiPap Machine https://drive.google.com/drive/folders/1rElyXlpQa_-43vxihiw-wsmoR94m6WH-?usp=sharing
- www.coursera.org
- www.edx.org
- www.nptel.ac.in
- www.swayam.gov.in

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 Illustrate various biomedical critical care instruments.	3	2	-	-	2	-	3
CO-2 Interpret operations of patient monitoring system	3	2	3	3	2	1	2
CO-3 Demonstrate the operations of cardiac care instruments	3	2	3	3	1	1	2
CO-4 Maintain the operations of life support equipment.	3	3	3	3	1	2	2
CO-5 Illustrate the operations of telemetry and green cardiac care	3	2	3	-	3	2	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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