

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester-V

Course Title: Robotics in Biomedical

(Course Code:4354104)

Diploma programme in which this course is offered	Semester in which offered
Automation and Robotics	5

1. RATIONALE

The field of biomedical engineering is witnessing a paradigm shift towards robotic applications due to their precision, efficiency, and ability to perform complex tasks with minimal human intervention. Robotics in Biomedical Engineering represents a crucial intersection of technological innovation and healthcare advancement. In the rapidly evolving landscape of healthcare, the integration of robotic technologies has become indispensable for diagnostics, treatment, and rehabilitation. By incorporating Robotics in Biomedical into the curriculum, the students will be equipped with practical skills that align with current and future industry needs.

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:

- Simulate real-life medical scenarios with robotic techniques

- **3. COURSE OUTCOMES (COs)**

After completing this course the students would be able to:

1. List various types of diagnostic and therapeutic biomedical equipment.
2. Summarize the applications of robotics in biomedical engineering
3. Explain the concept of robotic surgery
4. Enlist various robotic applications for rehabilitative and assistive therapy
5. Identify the operational and ethical challenges associated with robotic applications in medicine

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)				Total Credits (L+T+P/2)		Examination Scheme			
						Theory Marks		Practical 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:

The following practical outcomes (PrOs) that are the subcomponents of the COs. *These PrOs need to be attained to achieve the COs.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Identify and describe the sources of biomedical signals	1	2
2	Identify different types of medical transducers (e.g., body temperature, blood pressure, respiration rate).	1	2
3	Demonstrate the correct placement and measurement techniques for each physiological parameter using appropriate transducers.	1	2
4	Categorize medical instruments based on their application and biological system.	1	2
5	To understand the role of sensors and feedback in enhancing the capabilities of medical robots.	1	2
6	To understand the basic movements and applications of robotic arms in surgical procedures.	2	2
7	To explore the ethical implications and safety protocols associated with the use of medical robots.	2	2
8	Prepare a list of companies/ industries that manufactures or research in medical robotics.	2	2
9	To understand the basics of robotic arm control and precision.	3	2

10	To simulate real-life surgical scenarios using robotic surgery techniques.	3	2
11	To explore the role of sensors and feedback in robotic surgery	3	2
12	To understand the principles of image-guided robotic surgery.	3	2
13	To develop a computer-based simulation of a gait training robot	4	2
14	Program a basic simulation of an upper-limb rehabilitation robot using software	4	4
15	Design and build a miniature model or simulation of a gait training robot using affordable materials like LEGO Mindstorms or 3D-printed components.	4	4
16	Explore the concept of degree-of-freedom augmentation in assistive robotics and its implications	4	2
17	Create a process flow diagram simulation of hospital logistics, focusing on patient flow, bed management, and resource allocation.	5	2
18	Design and prototype a simplified drug management system for a pharmacy using basic electronics components (e.g., sensors, microcontrollers).	5	4
19	Develop simulations of patient transfer and care scenarios using role-playing or scenario-based exercises.	5	4
20	Simulate a high-throughput lab automation workflow for handling and processing samples.	5	4
	Total Hrs.		50

6. 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.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
1	Biomedical Signals Simulator trainer kits : ECG,EEG, EMG and various Physiological transducers	1 to 5
2	Robotic surgery educational kits	6 to 12
3	Microcontrollers, servo motors and supporting components like LEGO Mindstorms or 3D-printed components	6 to 16
4	Simulation tools for robotics	13 to 20
5	Hospital management softwares	17 to 20

8. UNDERPINNING THEORY:

Unit	Unit Outcomes (UOs)	Topics and Sub-topic
Unit – I Introduction to Biomedical Engineering	1a) List the Sources of biomedical signals. 1b) Explain generation of bio-potential in human body. 1c) Draw and explain generalized block diagram of medical instrumentation system. 1d) Describe the features of the ECG/ EEG/ EMG/Defibrillator electrodes drawing schematic diagram. 1e). Explain the different types of medical transducers used in medical instruments for Body temperature, Blood pressure, and respiration rate. 1f) Explain the working of the indirect blood pressure measurement instrument (sphygmo-manometer). 1g) Classify medical instruments based on different principles with Application Viz - (diagnostic, therapeutic, Imaging, analytical) , Physiological parameter and biopotential , Biological system , Different departments in the hospital.	1.1 Fundamentals of medical instrumentation. <ul style="list-style-type: none"> ● Sources of biomedical signals ● Generalized medical instrumentation block diagram. ● Medical electrodes - ECG,EEG,EMG , Defibrillator . ● Medical transducers: Body temperature, Blood pressure, respiration rate 1.2 Classification of Medical instruments based on: <ul style="list-style-type: none"> ● Application - (diagnostic, therapeutic, Imaging, analytical) ● Physiological parameter and biopotential Biological system Different departments in the hospital

<p>Unit– II</p> <p>Basics of Medical Robotics</p>	<p>2a.Explain the characteristics of Medical Robotics</p> <p>2b. Enlist the advantages of using a robot in Medical Procedure</p> <p>2c. Describe the state of the art of robotics in Medical Procedures</p>	<p>2.1. Requirements for Medical Robotics</p> <ul style="list-style-type: none"> ● Safety ● Sterility ● Constraints of Surgical Theater <p>2.2. Head and Neck surgery</p> <p>2.3 Neurosurgery</p> <p>2.4. Orthopedic surgery</p> <p>2.5 Laparoscopic surgery</p> <p>2.6. Interventional Radiology</p> <p>2.7 Other treatments</p>
<p>Unit– III</p> <p>Robotic Surgery and Surgical Robots</p>	<p>3a. List various surgical robots.</p> <p>3b. Explain the clinical needs for surgical robots.</p> <p>3c Explain Robotic Neurosurgery and Orthopedics.</p> <p>3d. Explain Robotic laparoscopy and Endoluminal Intervention</p> <p>3e Describe the basics of Superhuman Dexterity and Human–Robot Cooperation</p> <p>3f. Explain Vision and Sensing in Robotic Surgery</p> <p>3g. Explain Image-Guided Robotic Surgery</p> <p>3h. List various technologies for Robotic Surgery</p> <p>3i. State advantages and limitations of various Robotic Surgery</p>	<p>3.1 Surgical Robots and Clinical Needs</p> <ul style="list-style-type: none"> ● The Da Vinci Systems ● Neurosurgery and Orthopedics ● Robotic Laparoscopy and Endoluminal Intervention <p>3.2 Superhuman Dexterity and Human–Robot Cooperation</p> <p>3.3 Vision and Sensing in Robotic Surgery</p> <p>3.4 Image-Guided Robotic Surgery</p> <p>3.5 Technologies for Robotic Surgery</p>
<p>Unit – IV</p> <p>Rehabilitation and Assistive robotics</p>	<p>4a. Explain how upper-limb rehabilitation robots contribute to the recovery process compared to traditional therapies</p> <p>4b. State the role of robotics in personalized rehabilitation programs for individuals with upper-limb impairments.</p> <p>4c. State the importance of Rehabilitation robots.</p> <p>4d. Discuss the advantages and limitations of using robots for gait training over conventional physical therapy methods.</p> <p>4e. Describe the functions and capabilities of assistive robots designed for ADL support.</p> <p>4f. Discuss the concept of degree-of-freedom augmentation in assistive robotics and its implications for enhancing human movement.</p> <p>4g. Explain how sensory</p>	<p>4.1 Robots for Therapeutic Training</p> <ul style="list-style-type: none"> ● Upper-Limb Rehabilitation Robots ● Rehabilitation Robot for Gait Training <p>4.2 Robots for Personal Assistance</p> <ul style="list-style-type: none"> ● Assistive Robots for Activities of Daily Living (ADL) ● Assistive Robots for Human Movement Augmentation ● Degree-of-Freedom Augmentation <p>4.3 Prostheses</p> <p>4.4 Human–Robot Interaction</p> <ul style="list-style-type: none"> ● Multimodal Interfaces for HRI ● HRI for Robot Control

	<p>feedback systems in prostheses contribute to improving user experience and functionality</p> <p>4h. Explain the importance of multimodal interfaces in enhancing human-robot interaction (HRI).</p> <p>4i. Describe the principles of human-robot interaction as they apply to robot control interfaces.</p>	
<p>Unit – V</p> <p>Hospital Automation Robotics and Emerging Challenges</p>	<p>5a. State the importance of Hospital Automation</p> <p>5b Explain robots for hospital logistics.</p> <p>5c. Explain robots for Patient Transfer and care.</p> <p>5d. Explain robots for High-Throughput Lab Automation.</p> <p>5e. State the operational and ethical challenges associated with surgical robotics, rehabilitation and assistive robotics and hospital automation robotics.</p>	<p>5.1 Importance of Hospital Automation</p> <p>5.2 Robots for Hospital Logistics</p> <p>5.3 Robots for Pharmacy and Drug Management</p> <p>5.4 Robots for Patient Transfer and Care</p> <p>5.5 Robots for High-Throughput Lab Automation</p> <p>5.6 Operational and ethical challenges</p> <ul style="list-style-type: none"> ● Challenges of Surgical Robotics ● Challenges of Rehabilitation and Assistive Robotics ● Challenges of Hospital Automation Robotics

9.SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A	Total Marks
1	Introduction to Biomedical Engineering	6	6	4	0	10
2	Basics of Medical Robotics	8	4	4	2	10
3	Robotic Surgery and Surgical Robots	8	6	8	4	18
4	Rehabilitation and Assistive robotics	10	4	6	4	14
5	Hospital Automation Robotics and Emerging Challenges	10	6	8	4	18
Total		42	26	30	14	70

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 conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidence for their (student's) portfolio which will be useful for their placement interviews:

1. Construct a basic robotic arm using various available kits and controller.
2. Use virtual reality (VR) or simulation software to practice basic surgical tasks using robotic arms.
3. Develop a prototype for a medical robot that can assist in a specific healthcare task (e.g., drug delivery, patient monitoring).
4. Develop a prototype for an automated inventory management system using robotics.
5. Research and present case studies of successful robotic applications in biomedical engineering (e.g., Da Vinci Surgical System).
6. Participate in hands-on sessions using robotic surgery simulators available in labs or through virtual platforms.
7. Hold a debate or discussion on topics like ethics, privacy, and legal implications of using robots in healthcare.

11.SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Following Sample strategies teacher can use to accelerate the attainment of the various outcomes in this course:

1. Engage students in scenarios that simulate real-world challenges biomedical engineers face, promoting empathy and ethical decision-making.
2. Facilitate debates or discussions on ethical dilemmas in medical robotics, encouraging students to express and defend their viewpoints.
3. Analyze case studies of successful and unsuccessful implementations of medical robotics, promoting critical analysis and understanding of technical challenges.
4. Have students assemble and disassemble robotic components, reinforcing their understanding of mechanical systems and troubleshooting techniques.
5. Arrange visits to hospitals or surgical centers where students can observe robotic surgeries, encouraging reflection on the impact of technology on patient care.
6. Assign projects where students interview individuals who use assistive robotics, fostering empathy and understanding of user needs in designing rehabilitation technologies.
7. Organize workshops where students brainstorm innovative uses of robotics in hospital automation while considering societal impacts.
- 8.

12.SUGGESTED PROJECT LIST

1. Program a robotic arm to perform a simple task, such as picking up and placing objects.
2. Use simulation software to simulate a robotic surgery scenario.
3. Prepare a comparison chart of various robotic medical technologies.

4. Conduct a literature review on recent advancements in robotics applied to biomedical engineering, focusing on one emerging technology (e.g., nanorobotics for drug delivery).
5. Survey about the feedback from the patients receiving robotic surgery.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication
1	Handbook of Biomedical Instrumentation	R.S. Khandpur	Tata McGraw Hill, New Delhi
2	Medical Robotics - History, Challenges and Future Directions	Yao Guo Giulio Dagnino Guang-Zhong Yang	Springer
3	Medical Robotics	Jocelyne Troccaz	John Wiley & Sons
4	Medical Robotics	Achim Schweikard Floris Ernst	Springer

14. SOFTWARE/LEARNING WEBSITES

<https://www.coursera.org/courses?query=robotics>

<https://www.coursera.org/courses?query=biomedical%20engineering>

<https://simsurgery.com/>

<https://rovislab.com/ros.html>

<https://unity.com/>

<https://www.virtamed.com/en/products-and-solutions/simulators/arthros>

15. PO-COMPETENCY-CO MAPPING:

Semester V	Robotics in Biomedical (Course Code:)						
	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
<i>Competency</i>	● Simulate real-life medical scenarios with robotic techniques						
CO1 List various types of diagnostic and therapeutic biomedical	2	1	-	1	1	-	2

equipment.	Biomedical					Course Code:4354104	
CO2 Summarize the applications of robotics in biomedical engineering	3	1	-	-	1	1	2
CO3 Explain the concept of robotic surgery	3	2	1	2	2	2	2
CO4 Enlist various robotic applications for rehabilitative and assistive therapy	3	2	1	2	1	1	2
CO5 Identify the operational and ethical challenges associated with robotic applications in medicine	2	2	-	1	3	2	3

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

16.COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
1	Viral D. Parmar Lecturer in Biomedical Engineering	Government Polytechnic Ahmedabad	8511562348	vdparmar@gpahmedabad.ac.in
2	Dr. Darshna M. Joshi Lecturer in Instrumentation and Control Engineering	Government Polytechnic Ahmedabad	9824549854	dmjoshi@gpahmedabad.ac.in