GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: REHABILITATION ENGINEERING
(Course Code: 4360301)

Diploma programme in which this course is offered	Semester in which offered
Biomedical Engineering	6th Semester

1. RATIONALE

Rehabilitation Engineering is a specialized field that applies engineering principles and techniques to enhance the lives and independence of individuals with disabilities. This interdisciplinary area of study involves the design, development, and implementation of assistive technologies and devices tailored to meet the specific needs of people with physical, cognitive, sensory, or communication impairments. Therefore, this course tries to build knowledge and skills to the students and make them capable to maintain and operate different types of sensory/motor rehabilitation systems.

2. COMPETENCY

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

I. Understand rehabilitation concepts, rehabilitation engineering principles, and innovative rehabilitation technologies.
II. Design and implement customized solutions for individuals with diverse rehabilitation needs.

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:

1. Select the appropriate rehabilitation concept for various disabilities.
2. Compare the different methods of orthopedic prosthetics and orthotics for rehabilitation.
3. Comprehend the construction of manual and powered wheelchair and compare them.
4. Select proper sensory augmentation and substitution devices for specific disabilities.
5. Demonstrate the knowledge of proper handling of Orthotic and Prosthetic Waste

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	Introduction to Rehabilitaion Engineering.	1	2
2	Demonstrate the use of various devices for activities of daily living.	1	2
3	Explore different sensory rehabilitation techniques for various impairments.	1	2
4	Explore different motor rehabilitation techniques for various impairments.	1	2
5	Study the various applications of computers in rehabilitation engineering.	2	2
6	Understand the features and capabilities of intelligent prosthetic knees. also evaluate the impact of intelligent prosthetic knee on the quality of lifeof an amputee.	2	2
7	Investigate various prosthetic hand designs and technologies and discuss the challenges and advancements in prosthetic hand design.	2	2
8	Explore the principles and applications of FES in rehabilitation. also assess its effectiveness in improving functional outcomes.	2	2
9	Understand the concept and principles of Hybrid Assistive Systems and identify its components.	2	2
10	Classify wheelchairs based on various criteria (manual, power, pediatric, etc.) and compare the features and benefits of different wheelchairs.	3	2
11	Explore different materials used in wheelchair construction. and evaluate the advantages and disadvantages of various materials.	3	2
12	Demonstrate the assembly of different wheelchair frame types and discuss the impact of frame design on mobility and functionality.	3	2
13	Explore the types of wheels and casters used in wheelchairs and also evaluate the performance and suitability of different wheel configurations.	3	4
14	Demonstrate the features of a power wheelchair and discuss advantages of power wheelchairs over manual alternatives	3	2
15	Explore visual augmentation devices and technologies.	4	2
16	Understand the principles and components of the OPTACON system.	4	2
17	Explore the design and functionality of LASER canes.	4	2
18	Understand the surgical and technical aspects of cochlear implants.	4	2
19	Identify common materials used in orthotics and prosthetics and discuss their characteristics.	5	2
20	Understand the environmental impact of orthotic and prosthetic waste.	5	2
	Total		**42 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	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) Manual Wheelchair
b) Power Wheelchair
c) 3D Printers
d) Computer-Aided Design (CAD) Software
e) Wheelchair Design and Testing Tools
f) FES System
g) Ultrasonic Blind Detector
h) Laser Cane
i) Braille System
j) Active Above Knee Prosthesis
k) Orthotic Knee Joint
l) Prosthetic Hand
m) Prosthetic Leg

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 Introduction to rehabilitation engineering	1.a Describe the rehabilitation engineering. 1.b Define/explain rehabilitation concepts. 1.c Explain engineering concepts in sensory rehabilitation. 1.d Describe engineering concepts in motor rehabilitation.	1.1 Rehabilitation concepts 1.1.1 Define: a. Rehabilitation Engineering b. Rehabilitation Medicine c. Rehabilitation Technology d. Rehabilitation Science e. Activities Of Daily Living (ADL) f. Disability g. Impairment h. Handicap i. Residual Function j. Residual Capacity k. Orthosis l. Prosthesis 1.2 Engineering concepts in sensory rehabilitation 1.3 Engineering concepts in motor rehabilitation 1.4 Future of engineering in Rehabilitation
Unit – II Orthopedic Prosthetics & Orthotics in Rehabilitation and Active Prosthesis	2.a Describe computer applications in rehabilitation engineering. 2.b Describe an intelligent prosthetic knee. 2.c Describe Hierarchically Controlled Prosthetic Hand. 2.d Elaborate orthotic knee joint. 2.e Explain functional electrical stimulation and restoration of hand functions as well as restoration of standing and walking using FES systems. 2.f Describe hybrid assistive system in brief. 2.g Describe the salient features of the myoelectric hand. 2.h Explain active prosthesis. 2.i Describe externally controlled transfemoral prosthesis 2.j Describe Powered Hand and Arm Prostheses	2.1 Computer-Aided Engineering in Customized Component Design. 2.2 Examples of Innovative Component Design: 2.2.1 An Intelligent Prosthetic Knee 2.2.2 A Hierarchically Controlled Prosthetic Hand 2.2.3 A Self-Aligning Orthotic Knee Joint 2.3 Externally powered and controlled orthoses and prosthesis: 2.3.1 FES system and its principle of working 2.3.2 Restoration of hand functions 2.3.3 Restoration of standing and walking 2.3.4 HAS-hybrid assistive system for walking 2.4 Active Prostheses: 2.4.1 Externally Controlled Transfemoral Prosthesis 2.4.2 Powered Hand and Arm Prostheses

Unit– III Wheeled Mobility: Wheel Chair	3.a Describe features of a wheelchair. 3.b Explain the structure of the wheelchair. 3.c Compare the manual and power wheelchair in detail. 3.d Describe the parts of the powered wheelchair. 3.e Describe Four critical performance factors of Wheels. 3.f Describe the maintenance procedure of the power wheelchair.	3.1 Categories of Wheelchairs 3.2 Wheelchair Structure and Component Design 3.2.1 Materials 3.2.2 Frame Design 3.2.3 Wheels and Casters: ● Caster Flutter ● Caster Float ● Tracking ● Alignment 3.3 Power Wheelchair Electrical Systems 3.3.1 User Interface 3.3.2 Integrated Controls 3.3.3 Power System
Unit– IV Sensory Augmentation and Substitution	4.a Describe devices for visual augmentation. 4.b Describe the devices used for tactual vision substitution. 4.c Explain the devices used for auditory vision substitution. 4.d Describe devices used for auditory augmentation. 4.e Describe devices used for visual auditory substitution 4.f Describe devices used for tactual auditory substitution 4.g Explain tactual augmentation. 4.h Explain tactual substitution.	4.1 Visual System 4.1.1 Visual Augmentation ● Magnification ● Closed-Circuit Television (CCTV) Systems ● Phosphenes. 4.1.2 Tactual Vision Substitution ● Braille System ● Optacon 4.1.3 Auditory Vision Substitution ● Electronic Speech Synthesizers ● Optical Character Recognition (OCR) ● Laser Cane 4.2 Auditory system 4.2.1 Auditory augmentation ● Hearing Aids ● Cochlear Implant 4.2.2 Visual auditory substitution ● Lipreading ● Fingerspelling ● Closed caption ● Automatic speech-recognition 4.2.3 Tactual auditory substitution ● Tadoma ● Tactile Vocoders 4.3 Tactual system 4.3.1 Tactual augmentation 4.3.2 Tactual substitution
Unit– V Orthotic and Prosthetic Waste Mangement	5.a List of Material Used in Orthotics and Prosthetics 5.b Describe key strategies for managing orthotic and prosthetic waste	5.1 Materials used in orthotics and prosthetics 5.2 key strategies for managing orthotic and prosthetic waste

***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 rehabilitation engineering	8	6	6	2	14
2	Orthopedic Prosthetics & Orthotics in Rehabilitation and Active Prosthesis	11	8	8	2	18
3	Wheeled Mobility: Wheel Chair	11	6	8	2	16
4	Sensory Augmentation and Substitution	8	6	8	2	16
5	Orthotic and Prosthetic Waste Mangement	4	2	4	0	6
Total		**42**	28	34	8	**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) Visit to nearer Rehabilitation center
b) Visit nearer Hospital where orthotic and prosthetic center available
c) Prepare a chart of components currently used in Rehabilitation Engineering fields.
d) Prepare mini/micro project
e) Participate in a seminar/workshop for learning new trends and technology in Rehabilitation Engineering fields.
f) Prepare a poster for Orthotic and Prosthetic Waste Management

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/Rehabilitation center
d) Video films/animation films on working on different types of Rehabilitation engineering equipment.
e) Perform practical virtually on the various online website/software
f) Arrange expert lectures

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 and create Low Cost hearing Aid for the individuals with disabilities.
2. Design and create Low Cost Wheelchairs for the individuals with disabilities.
3. Design and create Low Cost Powered Wheelchairs for the individuals with disabilities.
4. Design and create a personalized assistive device tailored to the specific needs of an individual with a disability, such as a custom-made prosthetic limb, adaptive computer interface, or ergonomic tools.
5. Create a system that integrates smart home technology to enhance accessibility for individuals with mobility challenges. This could include voice-controlled devices, automated door openers, and smart lighting systems.
6. Develop a solution to improve accessibility in public transportation for individuals with disabilities.
7. Develop a smart mobility aid (e.g., a cane or walker) that incorporates navigation assistance to help individuals with visual impairments navigate unfamiliar environments.
8. Make a report on handling, recycling and disposal of orthotic and Prosthetic wastes in Rehabilitation Center and suggest some innovative strategies to overcome the problem if any.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Handbook of Biomedical Engineering, second edition –Volume II	Joseph D. Bronzino	Published in 2010 by CRC Press
2	An Introduction to Rehabilitation	Cooper Rory A.	Taylor and Francis, London, 2012
3	Textbook of Rehabilitation	Sunder S.	Jaypee,2012

14. SOFTWARE/LEARNING WEBSITES

- **Myoelectric Hand :**
  https://www.armdynamics.com/upper-limb-library/introduction-to-myoelectric-prostheses

- **WheelChair :**
  https://www.britannica.com/topic/wheelchair/Components
  https://www.physio-pedia.com/Types_of_Wheelchair

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 Define basic rehabilitation terminologies and select the appropriate rehabilitation concept for various disabilities.	1	3	1	-	3	-	-
CO-2 Compare the different methods of orthopedic prosthetics and orthotics for rehabilitation.	1	3	1	1	3	-	1
CO-3 Explain the construction of manual and powered wheelchair and compare them.	1	3	1	-	3	-	-
CO-4 Select proper sensory augmentation and substitution devices for specific disabilities.	1	3	1	-	3	-	-
CO-5 Demonstrate the knowledge of proper handling of Orthotic and Prosthetic Waste	-	1	-	-	3	1	1

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

17.

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
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