



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code: 3723110

Semester – II

Subject Name: Design of Medical implants and artificial organs

Type of course: Core Biomedical Engineering

Prerequisite: Human Anatomy and Physiology, Mechanics of solids, Biomaterial and implants, CAD, Mathematics, Biomechanics.

Rationale: The human body has all the characteristics of a wonderful machine, but it is much more than a machine. The movement of the body generates forces in various work situations and also internally at various joints, muscles, and ligaments. It is essential to figure out the forces' moments, pressure, and so forth, which are usually dealt with in biomechanics. The viscoelastic properties of the tissue, unlike many engineering materials. This subject aims to understand substitution of diseased organs and body parts with artificial organs and bio-implants. Design methodologies and characterization of various biomaterials are discussed. As well rapid prototyping emphasizing on 3D printing technology.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Overview of Human System and Its Artificial Replacement: Human Body's Superficial Anatomy, Body Size, Type, and Proportion, A Brief Outline of the Organization of the Human System, Major Organ Systems, Brief Idea of Artificial Organs.	4
2	Mechanical Properties of Biological Materials, Basics of Design Process: Adoptive and Adaptive Design, Introduction to Machine Design, Principle of Science or Mechanism to Be Used, Safety of Products: Material and Design Safety aspects, Manufacturability, Standardization, Customization.	7
3	Dental Implants: Their Design and Manufacture, Types of Implants in Use, Surface Characteristics, Loading Conditions, Clinical and Biomechanical Considerations for Fixed Tooth Replacement. The Eye and Its Artificial Replacement: Ophthalmic Disorders, Types-Classification and Manufacturing of Contact Lenses, Complications associated with contact lenses, Bionic Eye.	8



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4	Orthopedic Implants: The Design of a Bone Fracture-Fixation Device, Upper Limb Joints (Finger, Wrist, Elbow and Shoulder) and Its Artificial Replacement, Lower Limb Joints (Hip, Knee and Ankle) and Its Artificial Replacement.	8
5	The Lung and Its Transplantation and Artificial Replacement, Design of the Total Artificial Heart, The Design of Heart Valves, Skin and the Design of Artificial Skin.	7
6	Rapid prototyping of Biomaterials & Implants: Introduction, definition of RP systems, Basic Process, Conventional RP systems and classification. Design of various artificial implants in CAD, their Design, testing and characterization.	8

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	10	10	15	15	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Design of Artificial Human Joints & Organs, Subrata Pal, Springer, 2014, ISBN 978-1-4614-6254-5, ISBN 978-1-4614-6255-2 (eBook).
2. Rapid prototyping of biomaterials-Principles and applications, Roger Narayan, Woodhead Publishing Limited, 2014, ISBN 978-0-85709-599-2 (print), ISBN 978-0-85709-721-7 (online)
3. Bio-Materials and Prototyping Applications in Medicine, Paulo Bartolo, Bopaya Bidanda, Springer Science, ISBN: 978-0-387-47682-7 e-ISBN: 978-0-387-47683-4.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand human system and possibilities for artificial replacement of human organs and body parts.	10
CO-2	To understand design, safety and Manufacturing process with characterization of biomaterials.	10



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CO-3	To design dental and ophthalmic implants with all design criteria and technical considerations.	20
CO-4	To design orthopaedic implants with all design criteria and technical considerations with integration of Fundamentals of Biomechanics.	25
CO-5	To design artificial lungs, heart, heart valves and skin with all design criteria and technical considerations with integration of Fundamentals of Biomechanics.	25
CO-6	To understand rapid prototyping technology for various artificial organs and implants.	10

List of Experiments:

1. To study various artificial organs and medical implants.
2. To study mechanical properties of Biological materials.
3. To study surface characteristics and loading conditions for dental implants.
4. To study rapid prototyping devices/systems for Biomaterials.
5. To design Artificial Total Knee Replacement in CAD.
6. To design Artificial Total Hip Replacement in CAD.
7. To design Artificial Heart Valves in CAD.
8. To design various Bone Fracture-Fixation Device in CAD.
9. To design Artificial wrist joint in CAD.
10. To design various dental implants in CAD.

Major Equipment: 3D Printer, 3D Bio-printer, Fatigue testing machine for dental implants and orthopedic implants.

List of Open Source Software/learning website: AutoCAD, Ansys, CFD- Computational Fluid Dynamics software, 3D Systems. Free CAD, Solid works, CATIA, CREO, Opens CAD, Med Web Software, ComSol.