GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Bio Medical Engineering
Subject Code : ME02031011
Subject Name : Design of Medical implants and artificial organs

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	PCC

Prerequisite:	Human Anatomy and Physiology, Biomechanics, Biomaterial and implants, CAD.
Rationale:	The movement of the body generates forces in various work situations and also internally at various joints, muscles, and ligaments. Any abnormality due to aging, accidental loss, diseased condition etc demand a necessary medical solution like replacement of that body parts/organs. Now a days, the development of patient-specific implants is a reality. This subject aims to understand the mechanical properties of human body tissues, selection of biomaterials, design of implants, mechanical testing as well rapid prototyping emphasizing on 3D printing technology.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	To understand human system and possibilities for artificial replacement of human organs and body parts.	R/U
02	To understand design, safety and Manufacturing process with characterization of biomaterials.	R/U
03	To design dental and ophthalmic implants with all design criteria and technical considerations.	A/N/C
04	To design orthopedic implants with all design criteria and technical considerations with integration of fundamentals of Biomechanics.	A/N/C
05	To understand and apply for design artificial lungs, heart, heart valves and skin.	U
06	To understand rapid prototyping technology for various artificial organs and implants.	U

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
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	10
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	16
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	18
4.	**Orthopedic:** Fracture fixation: Clinical reasons and Functional requirements of fracture fixation devices, Fracture fixation designs. Clinical reasons, Functional requirements, design, Materials used and Design concerns in spinal implants, knee replacements, Hip implant and Its Artificial Replacement. Engineering challenges and design constraints of orthopedic implants	9	20
5.	The Lung, Its transplantation and Artificial replacement, Design of the Total Artificial Heart, The Design of Heart Valves, Skin and the Design of Artificial Skin.	7	18
6.	**Rapid prototyping in biomedical engineering:** Introduction, definition of RP systems, Material properties of structural biomaterials, Rapid prototyping – a novel manufacturing approach, Patient-Specific Implants design. Design of various artificial implants in CAD, their Design, testing and characterization. **The Medical Device Market and Ethical Issues of Implants,** **The Manufacturing, Testing, and Sterilization of Implants**	7	18
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
10	25	30	15	10	10

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) 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. Biointegration of medical implant materials, Chandra P. Sharma, Woodhead Publishing Limited, 2010, ISBN 978-1-84569-509-5 (book), ISBN 978-1-84569-980-2 (e-book).
4. Mechanics of Biomaterials: Fundamental Principles for Implant Design, Lisa A. Pruitt & Ayyana M. Chakravartula, CAMBRIDGE UNIVERSITY PRESS, 2011, ISBN 978-0-521-76221-2
5. 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.

(b) Open source software and website:

- Solid works, Blender, Fusion 360, AutoCAD, Ansys, 3DSystems. Free CAD, CATIA, OpenSCAD, ComSol etc software
- NPTEL MOOC Course – Related to Subject

Suggested Course Practical List:

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 design Artificial Knee joint in CAD.
5. To design Artificial Hip joint and perform simulation of its mechanical testing.
6. To design Artificial Heart Valves in CAD.
7. To design various Bone Fracture-Fixation Device in CAD.
8. To design Artificial wrist joint in CAD.
9. To design various dental implants and perform simulation of its mechanical testing.
10. To design bioimplants for the given specific dimension (Patient specific design)

Note: Faculty can add more laboratory practical's related to the content of the syllabus.

Major Equipment:

orthopedic implants, 3D Printer and Mechanical testing machine for implants.

Suggested Activities for Students: Individual or in a group, students have to do literature survey on any medical implant. Student has to design an implant, choose appropriate material and perform mechanical testing on it.

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