GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160308
Semester – VI
Biomechanics

Type of course: Professional Elective Course -II

Prerequisite: Human anatomy and physiology.

Rationale: The purpose of this course is to acquaint each student with the knowledge of mechanics of biological system and enable them to and thereby enable them to understand its applications in developing mathematical models and mechanical aspects of designing implants and biological assistive devices.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	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	% Weightage
1	**Introduction of Mechanics**: Review of the principles of mechanics, Vector mechanics- Resultant forces of Coplaner & Noncoplaner and Concurrent & non-concurrent forces, parallel force in space, couple forces and moment, Equilibrium of forces and moments, Newton's laws of motion, pulley and lever, Moment of inertia, Statics and introduction to Dynamics (linear kinematics), and relevant numerical examples, work and power.	**8**	**18**
2	**Biomechanics of Joints**: Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle.	**7**	**18**
3	**Hard Tissues**: Bone structure & composition, mechanical properties of solids, cortical and cancellous bones, viscoelastic properties, Maxwell & Kelvin-Voight models – anisotropy. **Soft Tissues**: Structure and functions of Soft Tissues: Cartilage, Tendon, Ligament, and Muscle; Material Properties: Cartilage, Tendon, Ligament, and Muscle; Modeling of soft tissues: Cartilage, Tendon, Ligament, and Muscle, Hills's muscle model	**9**	**18**
4	**Biofluid Mechanics**: Introduction, intrinsic fluid properties, viscosity and viscometers, Couette flow and Hagen-poiseuille equation, Bernoulli equation, laminar flow, turbulent flow, flow development, Rheological properties of blood.	**11**	**26**

	Cardiovascular Mechanics: Cardiovascular system (Heart, systemic and coronary circulation), native heart valves, artificial heart valves, biological and mechanical valves development, testing of valves, Vascular Mechanics, Heart Valve Dynamics, Prosthetic Valve Dynamics.		
5	**Applied Biomechanics**: Engineering approaches to standing, sitting and lying, Biomechanics of gait and gait analysis. **Biomechanics of Implants**: Design of orthopedic implant, specifications for a prosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.	**10**	**20**
		45	**100%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15%	**30%**	**30%**	**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) R.C. Hibbeler, Engineering Mechanics: Statics and Dynamics, Pearson, 14th edition, 2016
2) N. Ozkaya and M. Nordin, Fundamentals of Biomechanics-Equilibrium, Motion and Deformation, springer-verlag, 2nd edition, 1999
3) K.B. Chandran, S.E. Rittgers, A.P. Yoganathan, Biofluid Mechanics: The Human Circulation, CRC Press, 2nd edition, 2012
4) Y.C. Fung, Biomechanics: Mechanical Properties of Living Tissues, springer, 2nd edition, 1993.
5) Duane knudson, Fundamental of biomechanics, springer, 2nd edition 2007
6) Subrata Pal, Design of Artificial Human Joints & Organs, Springer, 1st edition, 2014
7) M Nordin, V.H. Frankel, Basic Biomechanics of the Musculoskeletal System, LWW Wolters Kluwer, 4th edition, 2012
8) D.J. Schneck and J. D. Bronzino, Biomechanics- Principles and Applications, CRC Press, 2nd Edition, 2000
9) J.D. Bronzino, "The Biomedical Engineering Handbook", CRC Press, 3rd edition, 2006.
10) Roger Bartlett, Introduction to Sports Biomechanics 1997, Roger Bartlett, Taylor & Francis Group
11) Mow, Van C.; Huiskes, Rik, Basic Orthopaedic Biomechanics and Mechano-Biology, 3rd Edition,2005, Lippincott Williams & Wilkins

12) Hiroshi Wada, Biomechanics at Micro and Nano scale Levels, volume 1, 2005, World Scientific Publishing Co. Pt. Ltd.

Course Outcomes:
After learning this subject, students will be able to:

Sr. No.	CO Statement	Marks % weightage
CO-1	To study fundamentals of engineering mechanics.	18
CO-2	To study biomechanics of musculoskeletal joints.	18
CO-3	To study properties of hard and soft tissues.	18
CO-4	To study fundamentals of fluid mechanics and its applications to cardiovascular biomechanics.	26
CO-5	To apply the biomechanical principles to human movements and in implant design.	20

List of Tutorials:

Sr. No.	**Title**	**Duration (Hours)**
1.	To study vectors and calculate resultant vectors.	**2**
2.	To study types of forces and force systems.	**2**
3.	To study force and moment resolution.	**2**
4.	To study hard tissue and its properties.	**2**
5.	To study soft tissues and its properties.	**2**
6.	To study biomechanics of joints	**2**
7.	To study fluid and its basic equations.	**2**
8.	To study heart valves and its dynamics.	**2**
9.	To study GAIT cycle.	**2**
10.	To study orthopaedic implants.	**2**

Major Equipment: - GAIT analyzer, force plate system, goniometer.

List of Open Source Software/learning website:

https://nptel.ac.in/courses/112/106/112106286/
https://nptel.ac.in/courses/105/103/105103192/
https://nptel.ac.in/courses/103/106/103106158/
https://nptel.ac.in/courses/112/106/112106248/
https://nptel.ac.in/courses/103/103/103103133/
https://nptel.ac.in/courses/112/106/112106180/