

GUJARAT TECHNOLOGICAL UNIVERSITY

BIO-MEDICAL ENGINEERING (03)

BIOMECHANICS

SUBJECT CODE: 2160308

B.E. 6th SEMESTER

Type of course: Core

Prerequisite: Human anatomy and physiology, Mechanics of solids, Physics, Higher Engineering Mathematics.

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 C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		PA (V)		PA (I)		
PA	ALA	ESE		OEP						
3	2	0	5	70	20	10	30	0	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, Equilibrium of coplanar forces, Newton's laws of motion, Work and energy, Moment of inertia.	6	13
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.	6	13
3	Biofluid Mechanics: Introduction, viscosity and capillary viscometer, Rheological properties of blood, laminar flow, Couette flow and Hagen-poiseuille equation, turbulent flow.	5	11
4	Hard Tissues: Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models – anisotropy.	4	9
5	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	5	11

6	Cardiovascular Mechanics: Cardiovascular system, artificial heart valves, biological and mechanical valves development, testing of valves, Blood Flow Models, Blood Vessel Mechanics, Heart Valve Dynamics, Prosthetic Valve Dynamics.	4	9
7	Respiratory Mechanics: Mechanism of air flow, respiratory cycle, lung ventilation model, methods of determining pressure, flow rate and volume; spirometry.	4	9
8.	Applied Biomechanics: Engineering approaches to standing, sitting and lying, Biomechanics of gait, application of gait and locomotion analysis, Fluid mechanics and energetics: Forms of energy and energy transfer.	5	11
9.	Biomechanics of Implants: Design of orthopaedic implant, specifications for a prosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.	6	13

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%	0

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. Y C Fung, Biomechanics: Mechanical Properties of Living Tissues, springer, 2nd edition, 1993.
2. N. Ozkaya and M. Nordin, Fundamentals of Biomechanics-Equilibrium, Motion and Deformation, springer-verlag, 2nd edition 1999
3. Duane knudson, Fundamental of biomechanics, springer, 2nd edition 2007
4. D. J. Schneck and J. D. Bronzino, Biomechanics- Principles and Applications, CRC Press, 2nd Edition, 2000
5. Joseph D, Bronzino, "The Biomedical Engineering Handbook", CRC Press, 3rd edition, 2006.
6. Roger Bartlett, Introduction to Sports Biomechanics 1997, Roger Bartlett, Taylor & Francis Group
7. Mow, Van C.; Huiskes, Rik, Basic Orthopaedic Biomechanics and Mechano-Biology, 3rd Edition, 2005, Lippincott Williams & Wilkins
8. Hiroshi Wada, Biomechanics at Micro and Nano scale Levels, volume 1, 2005, World Scientific Publishing Co. Pt. Ltd.

Course Outcome:

After learning the course the students should be able to:

1. Build on a basic understanding of mechanics (from pre-requisites) to develop a more in-depth level of understanding that will enable engineering analysis of selected biomechanical systems.
2. Be able to translate the understanding of anatomical and physiological function into an engineering model based on analysis of a biological system whose function is based on a differential equation.

3. Develop skill in applying a high-level engineering analysis of mechanical aspects of biological system.
4. Be able to apply engineering principles in designing mechanical devices for biological problems.

List of Tutorials: (Outlines)

1. To study the profile of blood flow in different blood vessels.
2. To study the behavior of muscle spindle in isotonic and isometric loading conditions.
3. To study the gait performance and analysis of joint movement for normal human walking.
4. To find the joint angles movement for upper and lower limbs.
5. To study and energy requirements for walking and running and to understand the relation of bio heat and biomass transfer.
6. To study the mechanics of cardiovascular system

Active Learning Assignments: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding of theory and practical work. The faculty will assign topics from which students can grasp knowledge about current scenario of the Diagnostic Instrumentation. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.