

# GUJARAT TECHNOLOGICAL UNIVERSITY

## BIO MEDICAL ENGINEERING (31)

### BIODYNAMICS

**SUBJECT CODE: 2733104**

**SEMESTER: III**

**Type of course:** Major Elective

**Prerequisite:** Basic knowledge of knowledge of human biology or biomechanics

**Rationale:** This course will introduce you to the anatomical, physiological and biomechanical principles needed to understand how everyday movements such as walking, running and jumping are possible. The roles of the skeleton and various skeletal tissues will be examined, along with the interaction of the body with its environment, to uncover the secrets of human movement and help explain why sometimes we get injured. This course and lab examines the biomechanical principles that relate to the human body and performance. Concepts on mechanical factors on human movement from a disability, rehabilitative, and sports perspective will also be discussed.

### Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	PA (V)		PA (M)			
					ESE	OEP	PA	RP		
3	2#	2	5	70	30	20	10	10	10	150

### Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	<b>Introduction to Human Body Structure and Motion</b> <i>Human Body Structure:</i> Skeletal Tree, Bone, Cartilage, and Ligaments, Joints of the Human Body, Physical Properties of Skeletal Muscle, Muscle Groups and Movement, <i>Particles in Motion:</i> Conservation of Linear Momentum, Center of Mass and Its Motion, Multiplication of Vectors, Moment of a Force, Moment of Momentum About a Stationary Point, Moment of Momentum About the Center of Mass	10	18
2	<b>Bodies in Planar Motion and Statics</b> Planar Motion of a Slender Rod , Angular Velocity, Angular Acceleration, Angular Momentum , Conservation of Angular Momentum , Applications to Human Body Dynamics , Instantaneous Center of Rotation Equations of Static Equilibrium, Contact Forces in Static Equilibrium, Structural Stability and Redundancy, Structures and Internal Forces , Distributed Forces	10	22
3	<b>Internal Forces and the Human Body</b> Complexity of the Musculoskeletal System, Muscle Force in Motion, Examples from Weight Lifting, Arm and Joint Angle, Multiple Muscle Involvement in Flexion of the Elbow, Biarticular Muscles, Physical Stress, Musculoskeletal Tissues, Limb-Lengthening	10	20

4	<b>Impulse and Momentum and Energy Transfers</b> Principle of Impulse and Momentum, Angular Impulse and Angular Momentum, Elasticity of Collision: Coefficient of Restitution, Initial Motion Kinetic Energy, Potential Energy, Conservation of Mechanical Energy, Multibody Systems, Applications to Human Body Dynamics	10	20
5	<b>Three-Dimensional Motion</b> Time Derivatives of Vectors, Angular Velocity and Angular Acceleration, Conservation of Angular Momentum, Dancing Holding on to a Pole, Rolling of an Abdominal Wheel on a Horizontal Plane, Biomechanics of Twisting Somersaults, Throwing and Hitting Motions	8	20

### Reference Books:

1. Roger Bartlett, Introduction to Sports Biomechanics: Analysing Human Movement Patterns, Second Edition, Taylor & Francis, 2007.
2. Knudson Duane, Fundamental of Biomechanics, Second Edition, Springer, 2007.
3. Aydın Tözeren, Human Body Dynamics: Classical Mechanics and Human Movement, Springer-Verlag New York, Inc. 2000.
4. David A. Winter, Biomechanics and Motor Control of Human Movement, John Wiley & Sons; 4th Edition, 2009.
5. Joseph Hamill, Biomechanical Basis of Human Movement, Lippincott Williams and Wilkins, 1995.

### Course Outcome:

By the end of this course students will be expected to learn:

1. How anatomy affects movement patterns in the human body
2. How the body interacts with its environment and how this affects locomotion
3. The physical laws that govern how the human body moves
4. Identify the characteristics of human tissues important for locomotion
5. Explain human movements, such as walking, running and jumping in terms of biomechanics
6. Understand basic laws of physics as applied to human movements
7. Understand and apply concepts and terminology within the area of biomechanics
8. Describe how biomechanical factors influence motion in sport and exercise
9. Demonstrate an understanding of statics, kinematics and kinetics in human movement
10. Evaluate movement and estimate force on human structures during exercise and sports
11. Demonstrate an understanding of how changes of movement patterns and techniques will influence the load on human tissues during movement

And students will be expected to have gained and/or developed the following skills:

1. Evaluation of human movement patterns using biomechanical principles
2. Reading and evaluating a research paper
3. Carried out group practical exercises in order to understand a biomechanical concept

**List of Experiments:** An experimental study should be used in conjunction with a theoretical approach, such as the use of deterministic models or some other way of identifying key factors in the movement or more advanced movement modelling techniques, such as computer simulation modelling or the use of artificial neural networks within the scope of this course.

Suggested Experimentation areas are;

1. Qualitative and quantitative analysis of range of motion
2. Functional anatomy
3. Muscle actions and the stretch-shortening cycle (ssc)
4. Velocity in sprinting
5. Accuracy of throwing speed measurements
6. Impulse–momentum: force–time principle
7. Angular kinetics of exercise
8. Calculating center of gravity using angular kinetics
9. Magnus effect in basketball pitching
10. Qualitative analysis of walking gait

**Design based Problems (DP)/Open Ended Problem:** Student has to search and select (i) research paper from reputed conference or journal, or (ii) mini project, related to real life application and has to implement the same using any tool/platform under the guidance of course instructor.

**Major Equipment:** Digital Video recording techniques, advanced modelling and simulation software.

**List of Open Source Software/learning website:** Students may visit the online research and publication and ongoing project information from following research centers from the respective websites.

1. Department of Orthopaedic Surgery, Wake Forest University
2. Department of Physical Therapy, Winston-Salem State University
3. VT-WFU School of Biomedical Engineering
4. Department of Applied Mechanics, Indian Institute of Technology Madras

**Review Presentation (RP):** The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.