Introduction to Biomechanics
Part I
ENGR 1166 Biomedical Engineering

What is “biomechanics”?

- It applies principles from classical mechanics to the study of living systems
- It combines Engineering and Life Sciences
Biomechanics

Mechanics

The study of the behavior of physical bodies when subjected to forces or displacements

Rigid Body Mechanics
No deformation under applied forces

Deformable Body Mechanics
Deformation under applied forces

Fluid Mechanics
Study of the movement of liquids and gases
Biomechanics

Mechanics

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Biomechanics

Mechanics

- Rigid Body Mechanics: No deformation under applied forces
- Statics
- Dynamics

Biomechanics

Mechanics

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Study of the bodies in equilibrium
Study of the bodies in motion
Biomechanics

Mechanics

- Rigid Body Mechanics
  - Statics
    - Study of the bodies in equilibrium
  - Dynamics
    - Kinematics
    - Kinetics

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- Fluid Mechanics
  - Study of the movement of liquids and gases
The study of the behavior of physical bodies when subjected to forces or displacements.

**Force**

An interaction that tends to change the motion of an object with mass.
Mechanics

The study of the behavior of physical bodies when subjected to forces or displacements

- **Force** is an interaction that tends to change the motion of an object with mass.

\[ F = (d, F) \]

- **Mass** is a property of matter causing resistance to changes in motion.
**Biomechanics: key concepts**

**Mechanics**

The study of the behavior of physical bodies when subjected to forces or displacements

- **Force** ≡ An interaction that tends to change the motion of an object with mass
- **Mass** ≡ Property of matter causing resistance to changes in motion
- **Matter** ≡ Substance that occupies space
- **Body** ≡ Collection of matter bounded by a closed space. A body is **rigid** if it does not deform under forces

**Newton's laws of motion**

- **First Law**
  A body at rest will remain at rest; a body in motion will move in a straight line with constant velocity (no change in speed or direction) unless a net external force acts upon it
  \[ \sum F_i = 0 \]
Newton’s laws of motion

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  \[ \sum F_i = 0 \]

- **Second Law**
  A change in net force produces an acceleration in the direction of the applied force with a magnitude in proportion to the force (mass)
  \[ \sum F_i = ma \]

- **Third Law**
  When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body
Newton's laws of motion

Third Law
When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body.

\[ \vec{F}_{1\rightarrow 2} = -\vec{F}_{2\rightarrow 1} \]
Newton's law of universal gravitation

Any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

\[ F_1 = F_2 = G \frac{M \cdot m}{r^2} \]

On earth: \( M \), \( r \) are constant.
The conditions of equilibrium or motion of a rigid body will remain unchanged if a force acting at a given point of the rigid body is replaced by a force of the same amplitude, direction, and line of action, but acting at a different point.
Newton's laws are applied to objects which are idealized as **single point masses**, i.e., the size and shape of the object's own body can be neglected.

This assumption holds when the object is **small** compared to the distances involved in its analysis, or the deformation and rotation of the body are of no importance.