UCONN
UNIVERSITY OF CONNECTICUT

Introduction to Biomechanics Part I

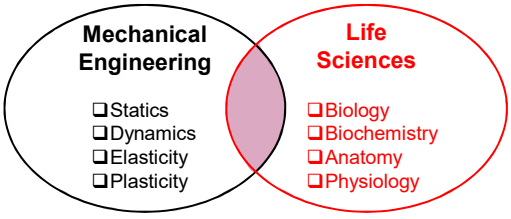
ENGR 1166 Biomedical Engineering

What is “biomechanics”?

- It applies principles from classical mechanics to the study of living systems

What is “biomechanics”?

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



Biomechanics

Mechanics

Biomechanics

Mechanics

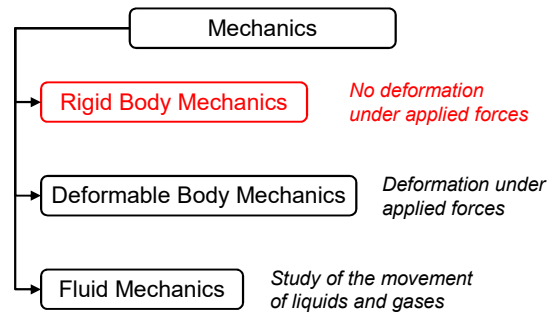
The study of the behavior of physical bodies when subjected to forces or displacements

Biomechanics

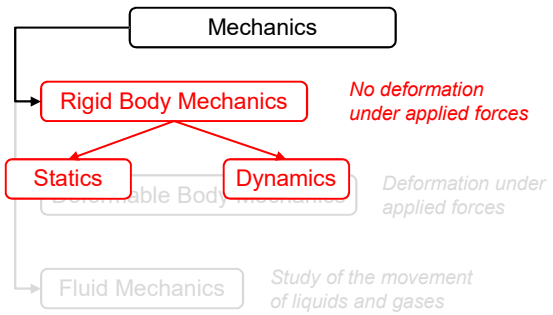
Mechanics

- 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*

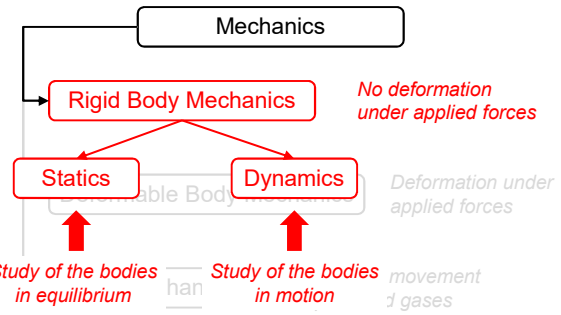
Biomechanics



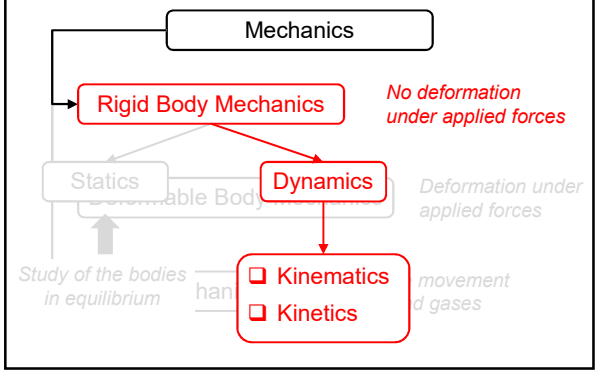
Biomechanics



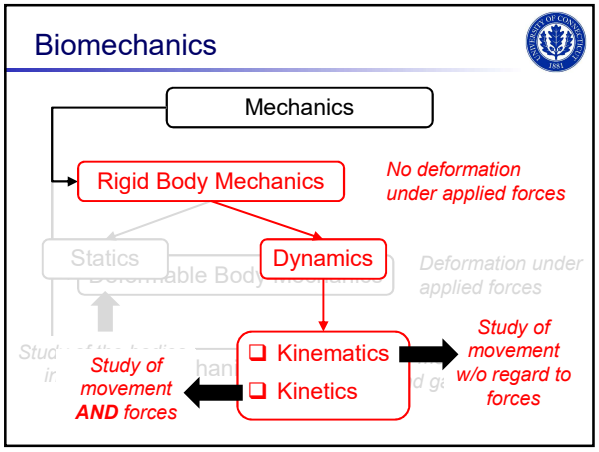
Biomechanics



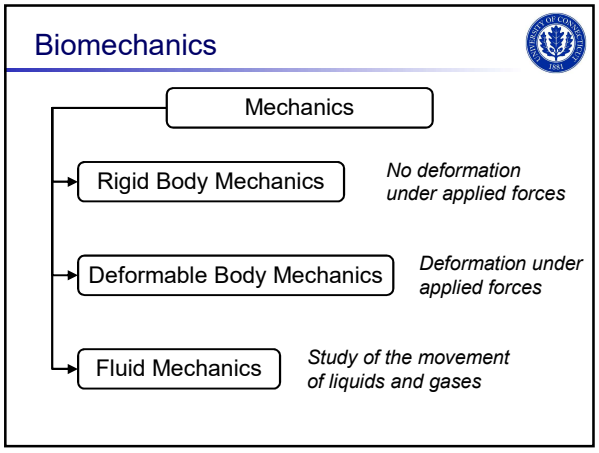
Biomechanics



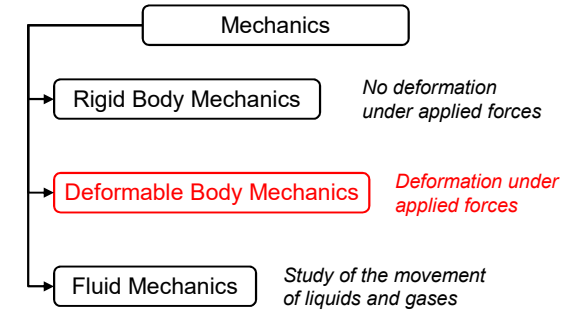
Biomechanics



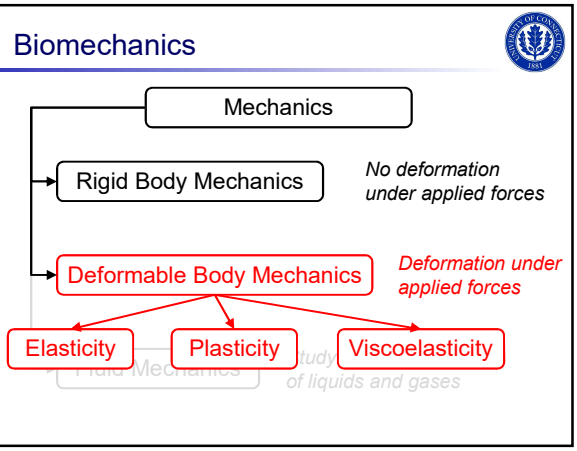
Biomechanics



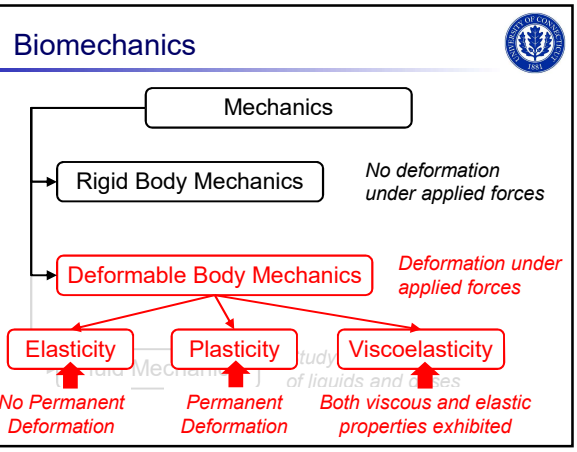
Biomechanics



Biomechanics



Biomechanics



Biomechanics: key concepts

Mechanics

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

Biomechanics: key concepts

Mechanics

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

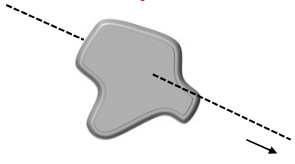
❑Force $\stackrel{\text{def}}{=}$ *An interaction that tends to change the motion of an object with mass*

Biomechanics: key concepts

Mechanics

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

❑Force $\stackrel{\text{def}}{=}$ *An interaction that tends to change the motion of an object with mass*

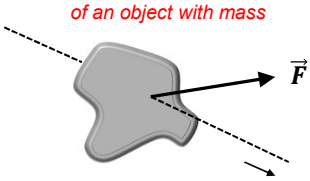


Biomechanics: key concepts

Mechanics

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

❑Force $\stackrel{\text{def}}{=}$ *An interaction that tends to change the motion of an object with mass*

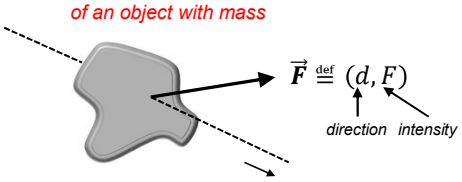


Biomechanics: key concepts

Mechanics

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

❑Force $\stackrel{\text{def}}{=}$ *An interaction that tends to change the motion of an object with mass*



Biomechanics: key concepts

Mechanics

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

❑Force $\stackrel{\text{def}}{=}$ *An interaction that tends to change the motion of an object with mass*

❑Mass $\stackrel{\text{def}}{=}$ *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 $\stackrel{\text{def}}{=}$ *An interaction that tends to change the motion of an object with mass*
- Mass $\stackrel{\text{def}}{=}$ *Property of matter causing resistance to changes in motion*
- Matter $\stackrel{\text{def}}{=}$ *Substance that occupies space*

Biomechanics: key concepts

Mechanics

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

- Force $\stackrel{\text{def}}{=}$ *An interaction that tends to change the motion of an object with mass*
- Mass $\stackrel{\text{def}}{=}$ *Property of matter causing resistance to changes in motion*
- Matter $\stackrel{\text{def}}{=}$ *Substance that occupies space*
- Body $\stackrel{\text{def}}{=}$ *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

$$\sum_i \vec{F}_i = \mathbf{0}$$

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

$$\sum_i \vec{F}_i = \mathbf{0}$$

- 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**)*

$$\sum_i \vec{F}_i = m\vec{a}$$

Newton's laws of motion

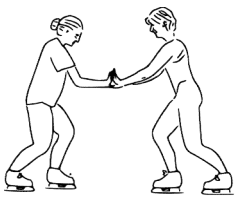
- Third Law

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

Newton's laws of motion

- Third Law

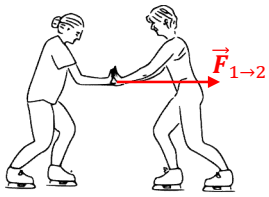
When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body



Newton's laws of motion

- Third Law

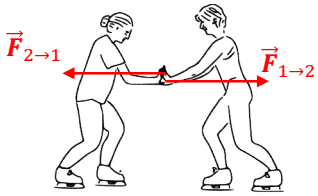
When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body



Newton's laws of motion

- Third Law

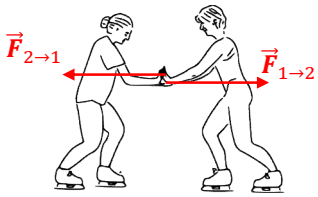
When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body



Newton's laws of motion

- Third Law

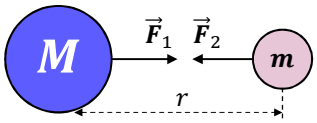
When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction on the first body



$$\vec{F}_{2\to1} = -\vec{F}_{1\to2}$$

Newton's law of universal gravitation

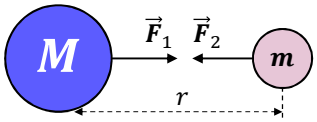
Any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them



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

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

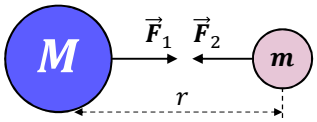


$$F_1 = F_2 = G\frac{M \cdot m}{r^2}$$

On earth: M = constant; $r \cong$ constant

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



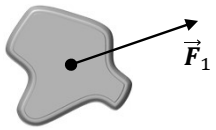
$$F_1 = F_2 = G\frac{M \cdot m}{r^2} = mg$$

g

On earth: M = constant; $r \cong$ constant

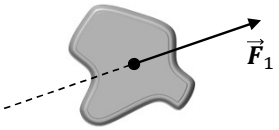
Principle of transmissibility

*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*



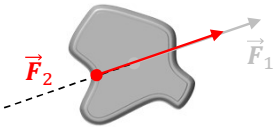
Principle of transmissibility

*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*



Principle of transmissibility

*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*



An important assumption…

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

An important assumption…

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