Biomechanics

Third Stage/ Biomaterials Engineering and prosthesis Branch

Presented By

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Lecture Two

Dr. Alaa Abed

Kinetic Analysis

Basic Concepts Related to Kinetics

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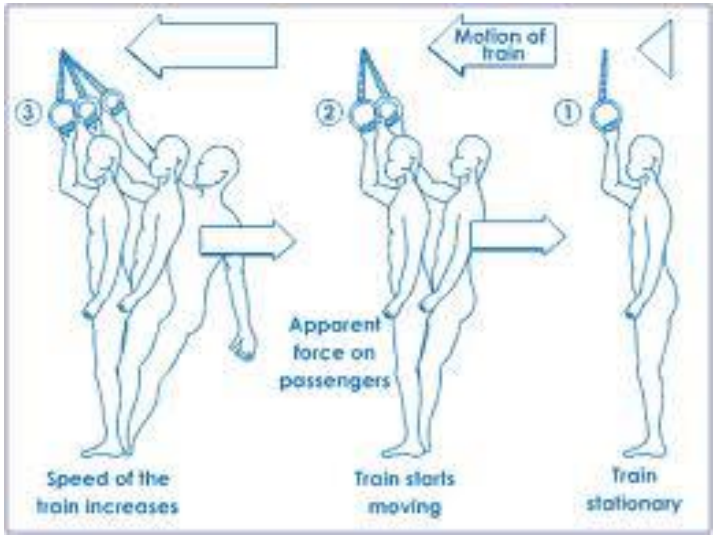
Inertia:

- tendency to resist change in state of motion
- proportional to mass
- has no units!



Mass:

- quantity of matter composing a body
- represented by m
- units are kg or slug

center of gravity:

- point around which a body's weight is equally balanced in all directions.
- point that serves as an index of total body motion.
- point at which the weight vector acts same as the center of mass.

Basic Concepts Related to Kinetics

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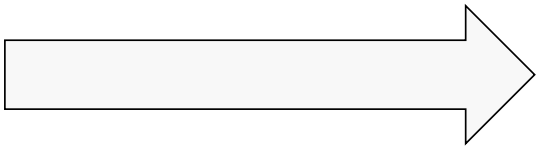
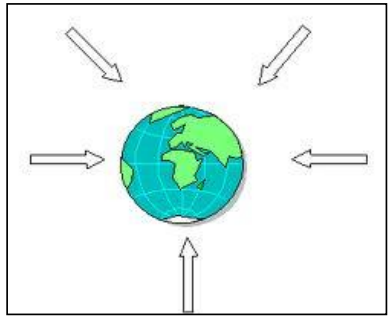
Force:



- a push or a pull
- characterized by magnitude, direction, and point of application
- F = ma
- unit is the Newton (N) in metric system
- Units of force are units of mass multiplied by units of acceleration, e.g.,
  - 1 N = 1 kg · 9.8 m/s^2
  - 1 lb = 1 slug · 32 ft/s^2
  - Slug is much larger

Weight:



- attractive force that the earth exerts on a body
- wt. = mg (product of mass and the acceleration of gravity: -9.81 m/s^2 or -32.2 ft/s^2)

Basic Concepts Related to Kinetics

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Pressure:

- force per unit of area over which the force acts
- commonly used to describe force distribution within a fluid (e.g. blood pressure, water pressure, air pressure but not barometric)
- Units of pressure are units of force divided by units of area, e.g.,

$P = F/A$

Lb/in^2 (psi)

Pascal = N/m^2

Impulse:

- the product of force and the time during which the force acts (Ft)
- units are Ns

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Volume:

- space occupied by a body
- has three dimensions (width, height, and depth)
- units are m^3 and cm^3 and liters (=1000 cm^3) or ft^3 and in^3

Density:

- mass per unit of volume
- represented with the small Greek letter rho: ρ
- units are kg/m^3 or kg/l or g/cc

specific weight:

- weight per unit of volume
- represented with the Greek letter gamma: γ
- units are N/m^3

Basic Concepts Related to Kinetics

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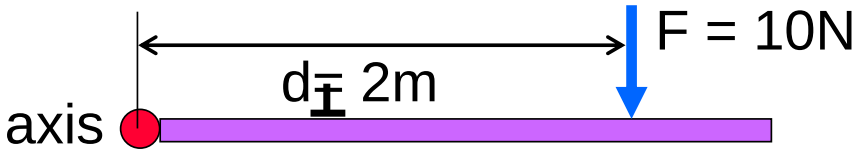
a torque:

- the rotary effect of a force
- the angular equivalent of force
- also known as moment of force

For example:



$T = Fd^{\perp}$ (the product of force and the perpendicular distance from the force's line of action to the axis of rotation)

$T = Fd_{\perp}$

$T = (10N)(2m)$

$T = 20\ Nm$

Common Units for Kinetic Quantities

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Quantity	Symbol	Metric Unit	English Unit
Mass	**m**	**kg**	**slug**
Force	**F**	**N**	**lb**
Pressure	**P**	**Pa**	**psi**
Volume (solids)	**V**	**m^3**	**ft^3**
(liquids)		**liter**	**gallon**
Density	ρ	**kg/m^3**	**lb/ft^3**
Specific weight	γ	**N/m^3**	**lb/ft^3**
Torque	**T**	N·m	ft·lb
Impulse	**J**	N·s	ft·s

Mechanical Loads

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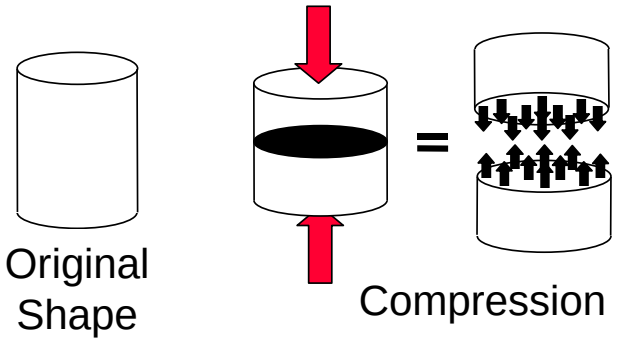
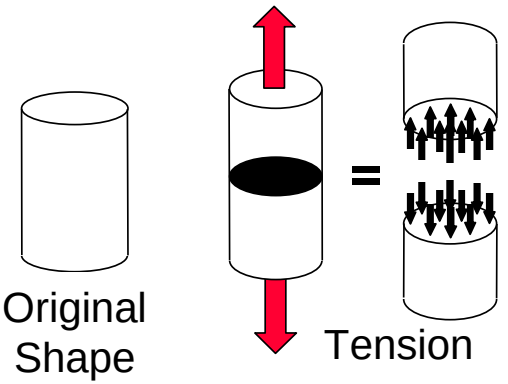
* compression



(pressing or squeezing force directed axially through a body)

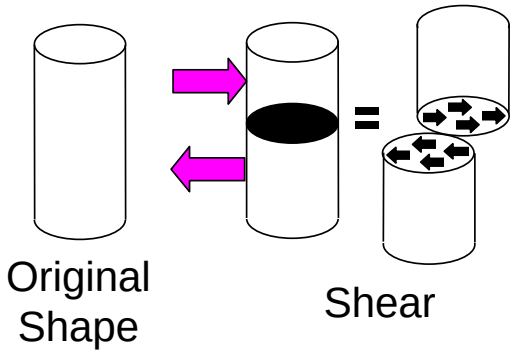
* tension



(pulling or stretching force directed axially through a body)

*shear

(force directed parallel to a surface)



Mechanical Loads

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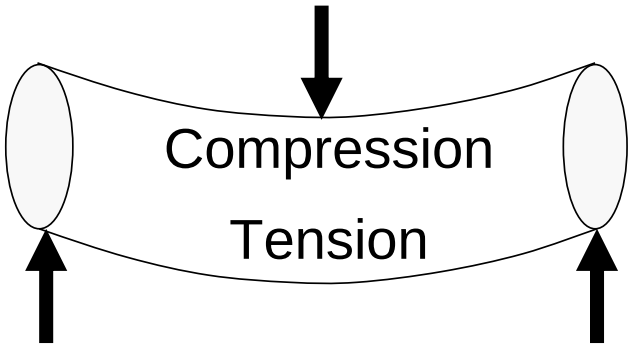
Stress:

- force per unit of area over which the force acts
- commonly used to describe force distribution within a body
- units are N/m^2

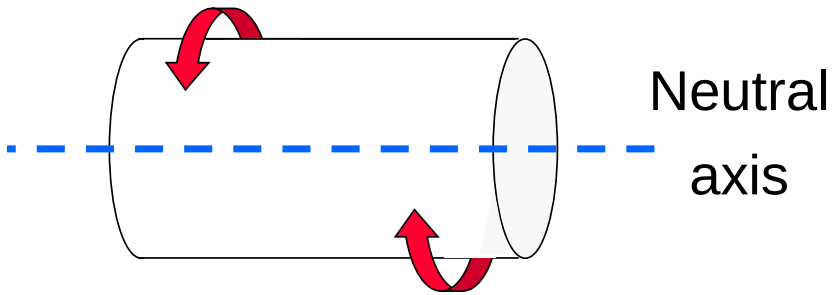
Bending:

(asymmetric loading that produces tension on one side of a body's longitudinal axis and compression on the other side)



Torsion:

(load producing twisting of a body around its longitudinal axis)



Effects of Loading

Deformation:(change in shape)

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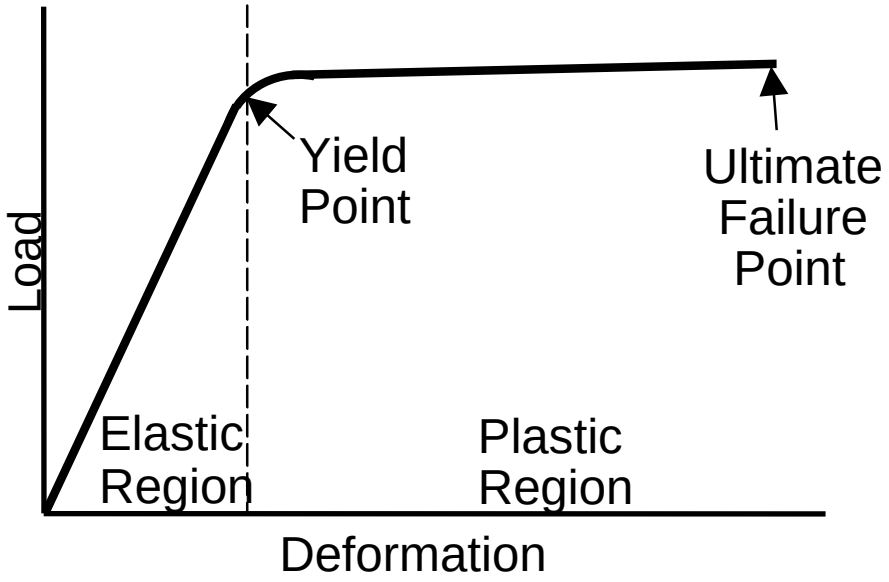

Effects of Loading

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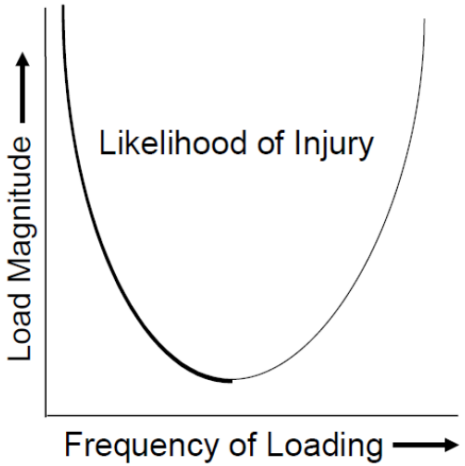
- **repetitive**: repeated application of a subacute load that is usually of relatively low magnitude. For example, each time a foot hits the pavement during running, a force of approximately two to three times body weight is sustained. Although a single force of this magnitude is not likely to result in a fracture of healthy bone, numerous repetitions of such a force may cause a fracture of an otherwise healthy bone somewhere in the lower extremity.
- **acute**: application of a single force of sufficient magnitude to cause injury to a biological tissue. For example, The force produced by a fall, a rugby tackle, or an automobile accident may be sufficient to fracture a bone.

Repetitive vs. acute loading



Tools for Measuring Kinetic Quantities

- **Electromyography (EMG)**
  - To study neuromuscular function.
- **Dynamography**
  - Force and pressure platforms interfaced with computer measure ground reaction forces.
  - Primarily employed in gait research, starts, takeoffs, landings, baseball & golf swings, and balance

The End of Lecture