Objectives

1. Define mechanics & biomechanics
2. Define kinematics, kinetics, statics, & dynamics
3. Metric & U.S. systems
4. Scalars & vectors
Mechanics

• Deals with force, matter, space & time.
• Answers questions in reference to forces and motion
  – What’s happening?
  – Why?
Biomechanics

- Mechanics of living things, especially humans.
- Interdisciplinary physical and natural sciences.
Statics and Dynamics
(Biomechanics includes statics & dynamics)

**STATICS**

\[ \Sigma F = 0 \]

» (i.e., the sum of the forces equals zero)
» All forces acting on a body are balanced
» The body is in equilibrium

**DYNAMICS:**

\[ \Sigma F \neq 0 \]

» (i.e., the sum of the forces DOES NOT equals zero)
» Deals with unbalanced forces
» Causes object to change speed or direction
» Possibly turning force(s) exist (i.e., unbalanced torques)
» Principles of mass and acceleration are included; *and some times work and energy principles*
Kinetics and Kinematics

• Wikipedia: “In physics, kinetics is one of the branches of dynamics, concerned with what motions of bodies are produced under the action of particular forces. Not to be confused with kinematics, the study of what forces are implied by selected motions.”
Units of Measurement

U.S. system:
- Inches, feet, pounds, gallons, second

Metric system:
- Meter, kilogram, newton, liter, second
Units of Measurement

Length:
• Metric; all units differ by a multiple of 10.
• US; based on the foot, inches, yards, & miles.

Area or Volume:
• Metric: Area; square centimeters of meters
  – Volume; cubic centimeter, liter, or meters
• US: Area; square inches or feet
  – Volume; cubic inches or feet, quarts or gallons
Units of Measurement

Mass: quantity of matter a body contains.
Weight: product of mass & gravity.
Force: a measure of mass and acceleration.
  – Metric: newton (N) is the unit of force
  – US: pound (lb) is the basic unit of force
Time: basic unit in both systems in the second.
Scalar & Vector Quantities

Scalar:

– Described by magnitude (size or amount)
  • Ex. Speed of 8 km/hr

Vector:

– Described by magnitude and direction
  • Ex. Velocity of 8 km/hr heading northwest
VECTOR ANALYSIS

- Vector is represented by an arrow
Resolution of Vectors

- Any vector may be broken down into two component vectors acting at a right angles to each other.
- The arrow in this figure may represent the velocity the shot was put.
Resolution of Vectors

- What is the vertical velocity (A)?
- What is the horizontal velocity (B)?
- A & B are components of resultant (R)
Location of Vectors in Space

• Position of a point (P) can be located using
  – Rectangular coordinates
  – Polar coordinates
• Horizontal line is the x axis.
• Vertical line is the y axis.
Location of Vectors in Space

- **Rectangular coordinates** for point P are represented by two numbers (13,5).
  - 1\textsuperscript{st} - number of x units
  - 2\textsuperscript{nd} - number of y units
Location of Vectors in Space

- **Polar coordinates** for point P describes the line R and the angle it makes with the x axis. It is given as: \((r, \theta)\)
  - Distance \((r)\) of point P from origin
  - Angle \((\theta)\)
Location of Vectors in Space

Rectangular

P
(x, y)

R
(13, 5)

Polar

P
(r, θ)
Location of Vectors in Space

- Degrees are measured in a counterclockwise direction.
Trigonometric Resolution of Vectors

• EXAMPLE: A jumper leaves the ground with an initial velocity of 9.6 m/s at an angle of 18°

Find:
• Horizontal velocity ($V_x$)
• Vertical velocity ($V_y$)
Trigometric Relationships

- For a Right Triangle (i.e. one angle is 90 degrees), with a hypotenuse ("H") and two other sides:
  - the “opposite side” ("O") with respect to an angle (e.g., THETA)
  - and an “adjacent side” ("A") with respect to the same angle:

\[
\begin{align*}
\text{SIN(THETA)} &= \frac{O}{H} \\
\text{COS(THETA)} &= \frac{A}{H} \\
\text{TAN(THETA)} &= \frac{O}{A}
\end{align*}
\]
Trigonometric Resolution of Vectors

Given: \( R = 9.6 \text{ m/s} \)
\[ \theta = 18^\circ \]

To find Value \( V_y \):

\[
\sin \theta = \frac{O}{H} = \frac{V_y}{R}
\]

\[ V_y = \sin 18^\circ \times 9.6 \text{m/s} \]
\[ = 0.3090 \times 9.6 \text{m/s} \]
\[ = 2.97 \text{ m/s} \]
Trigonometric Resolution of Vectors

Given: \( R = 9.6 \text{ m/s} \)
\( \theta = 18^\circ \)

To find Value \( V_x \):

\[
\cos \theta = \frac{A}{H} = \frac{V_x}{R}
\]

\( V_x = \cos 18^\circ \times 9.6\text{m/s} \)
\( = .9511 \times 9.6\text{m/s} \)
\( = 9.13 \text{ m/s} \)
Trigonometric Combination of Vectors

• Example
  – If a baseball is thrown with a vertical velocity of 15 m/s and a horizontal velocity of 26 m/s.
  – What is the velocity of throw & angle of release?
Trigonometric Combination of Vectors

Given:

\( V_y = 15 \text{ m/s} \)
\( V_x = 26 \text{ m/s} \)

Find: \( R \) and \( \theta \)

Solution:

\[
R^2 = V_y^2 + V_x^2
\]
\[
R^2 = (15 \text{ m/s})^2 + (26 \text{ m/s})^2 = 9
\]

\[
R = \sqrt{901} \text{ m}^2/\text{s}^2
\]
\[
R = 30 \text{ m/s}
\]
Trigonometric Combination of Vectors

Solution:

\[ \theta = \arctan \frac{V_y}{V_x} \]
\[ \theta = \arctan \frac{15 \text{ m/s}}{26 \text{ m/s}} \]
\[ \theta = 30^\circ \]

Velocity = 30 m/s
Angle = 30°
Trigonometric Combination of Vectors

• If more than two vectors are involved and they are not at right angles to each other, Resultant obtained by determining x and y components for each vector, then summing to obtain x and y components for the resultant.

• Example: Muscle J of 1000 N at 10°, and Muscle K of 800 N at 40°.
Muscle J

\[ R = (1000\text{N}, 10^\circ) \]
\[ y = R \sin \theta \]
\[ y = 1000\text{N} \times (0.1736) \]
\[ y = 173.6 \text{ N (vertical)} \]

\[ x = R \cos \theta \]
\[ x = 1000\text{N} \times (0.9848) \]
\[ x = 984.8 \text{ N (horizontal)} \]
Muscle K

\[ R = (800\text{N}, 40^\circ) \]
\[ y = R \sin \theta \]
\[ y = 800\text{N} \times (0.6428) \]
\[ y = 514.2 \text{ N} \text{ (vertical)} \]
\[ x = R \cos \theta \]
\[ x = 800\text{N} \times (0.7660) \]
\[ x = 612.8 \text{ N} \text{ (horizontal)} \]

**Sum the x and y components**
Trigonometric Combination of Vectors

Given:
\[ \Sigma F_y = 687.8 \text{ N} \]
\[ \Sigma F_x = 1597.6 \text{ N} \]

Find:
\[ \theta \text{ and } r \]
Trigonometric Combination of Vectors

Solution:

\[ \theta = \arctan \frac{\sum F_y}{\sum F_x} \]
\[ \theta = \arctan \frac{687.8N}{1597.6N} \]
\[ \theta = 23.3^\circ \]
\[ R^2 = \sum F_y^2 + \sum F_x^2 \]
\[ R^2 = (687.8N)^2 + (1597.6N)^2 \]
\[ R^2 = 3025395N^2 \]
\[ R = 1739N \]