Chapter 10:
Terminology and Measurement in Biomechanics

KINESIOLOGY

Scientific Basis of Human Motion, 11th edition

Hamilton, Weimar & Luttgens

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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:

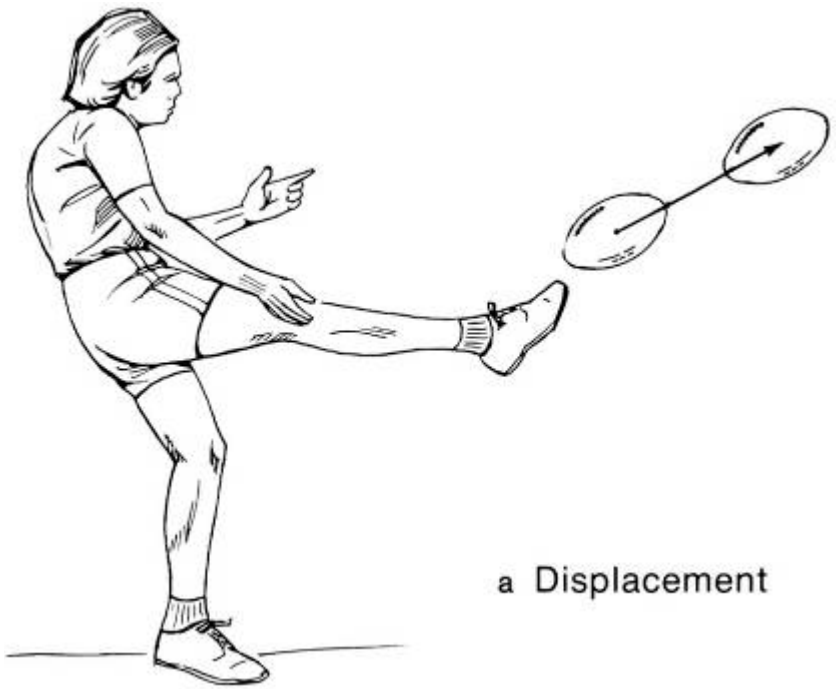
- Described by magnitude (size or amount)
  - Ex. Speed of 8 km/hr

Vector:

- Described by magnitude and direction
  - Ex. Velocity of 8 km/hr heading northwest

VECTOR ANALYSIS

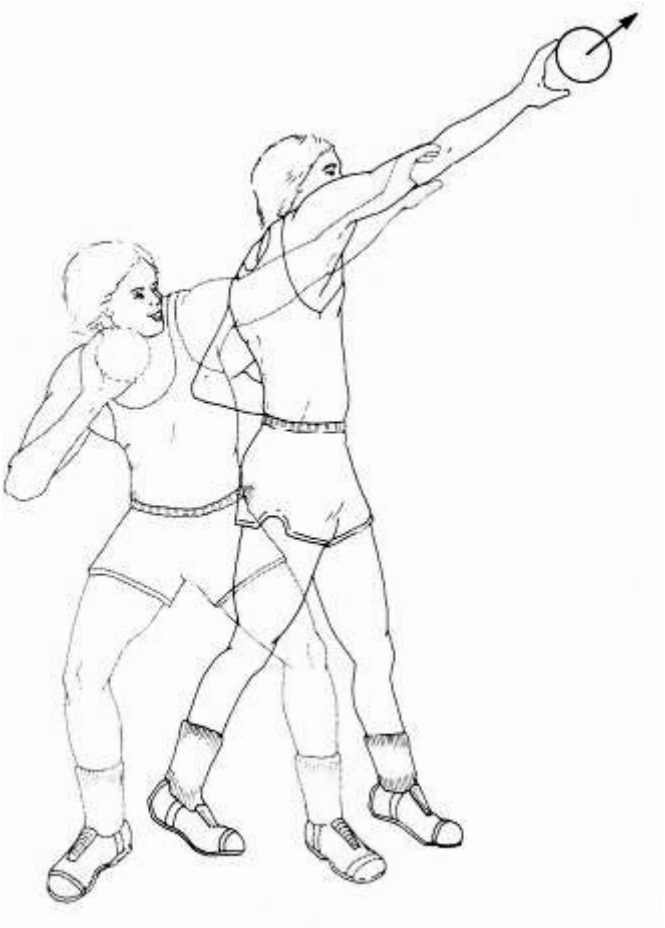
- Vector is represented by an arrow



a Displacement

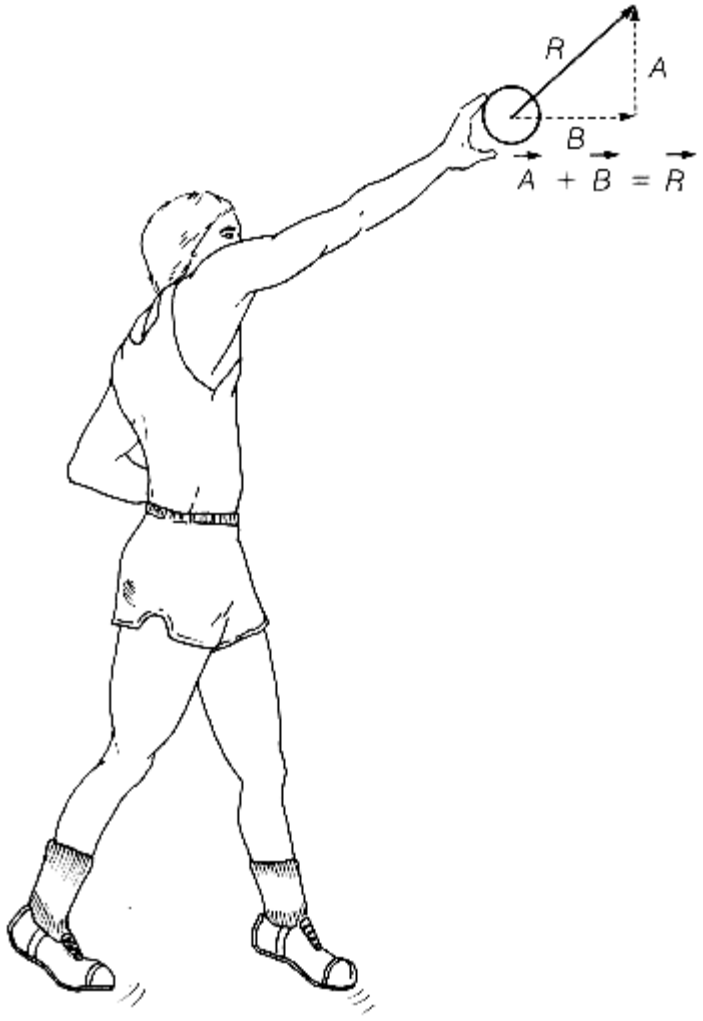
Resolution of Vectors

- 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.



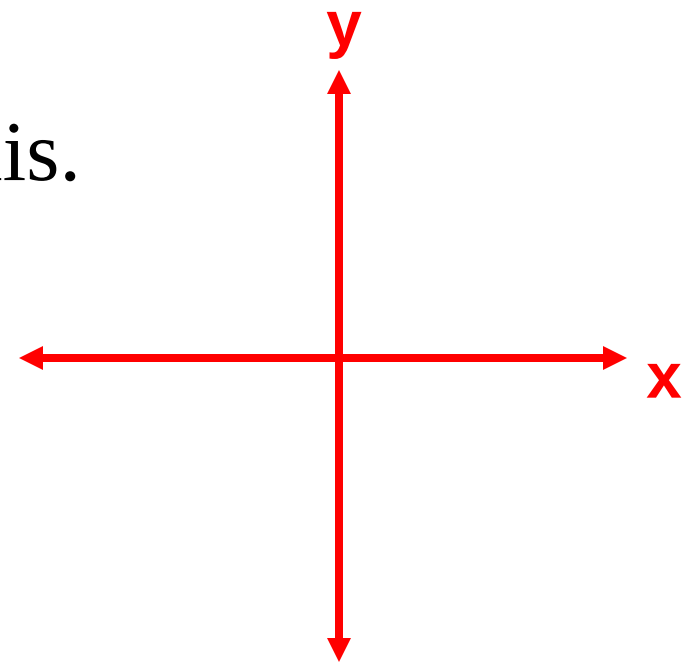
Resolution of Vectors

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



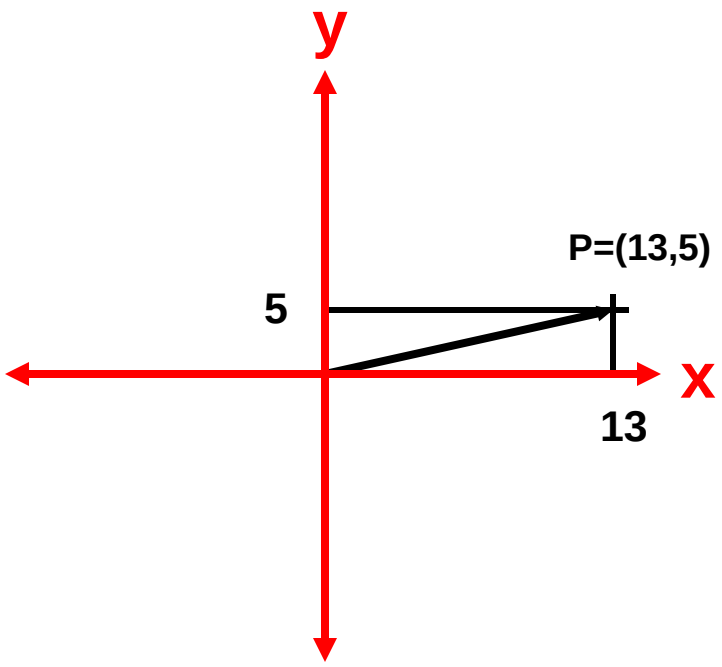
Location of Vectors in Space

- 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.



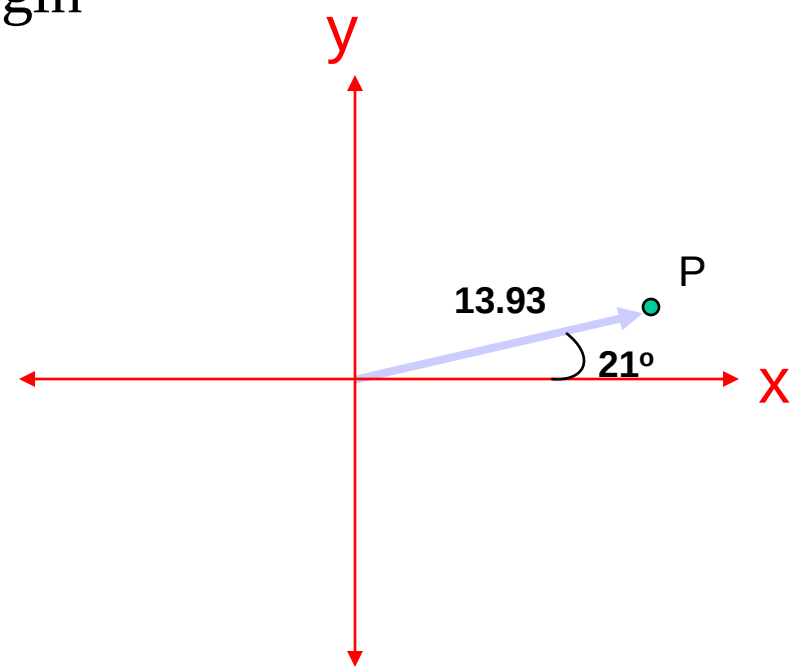
Location of Vectors in Space

- Rectangular coordinates for point P are represented by two numbers (13,5).
  - 1st - number of x units
  - 2nd - number of y units

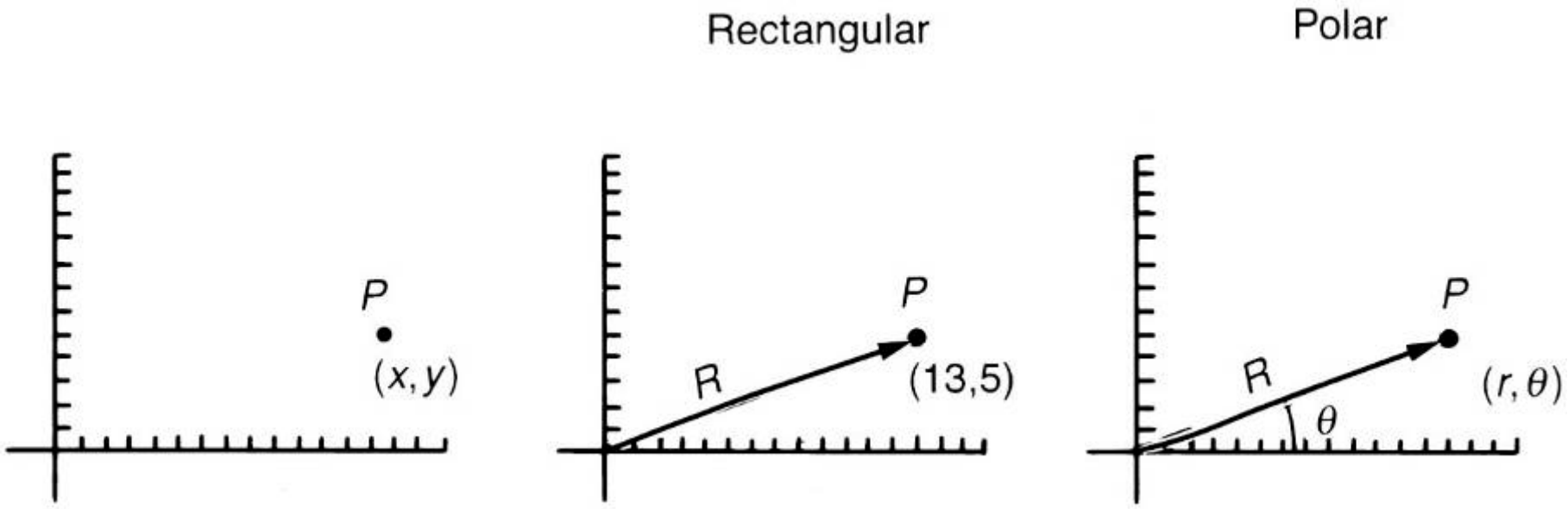


Location of Vectors in Space

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

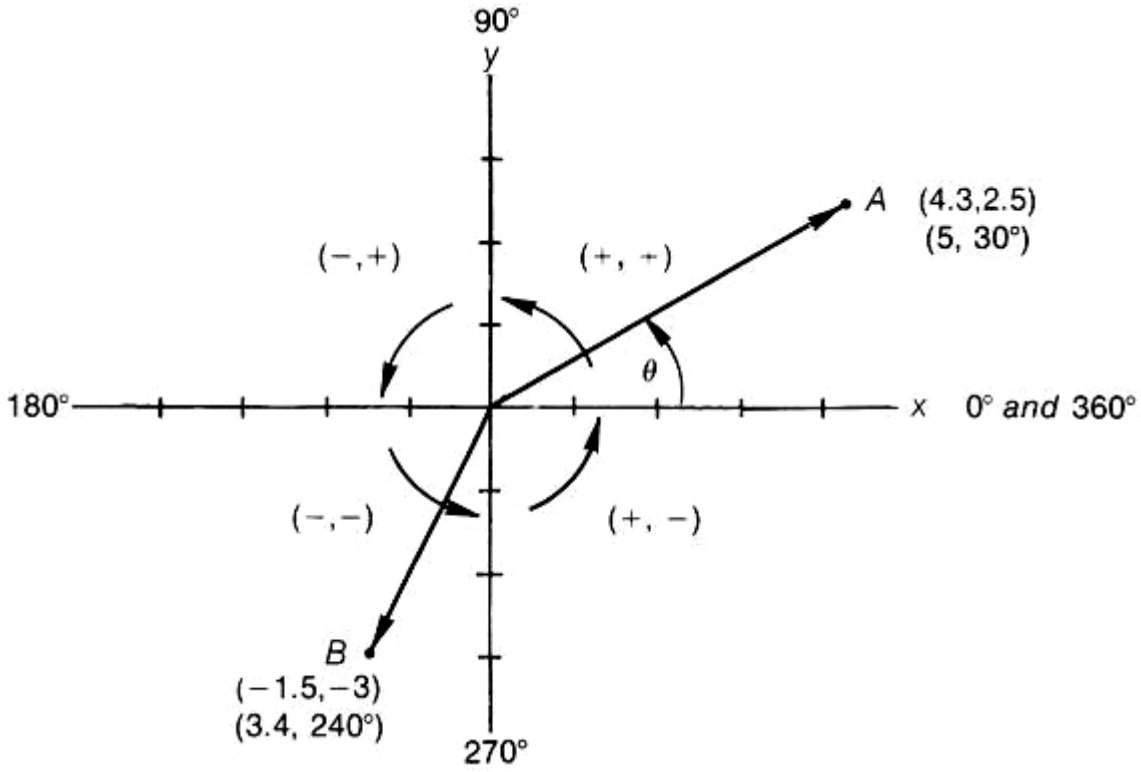


Location of Vectors in Space



Location of Vectors in Space

- Degrees are measured in a counterclockwise direction.

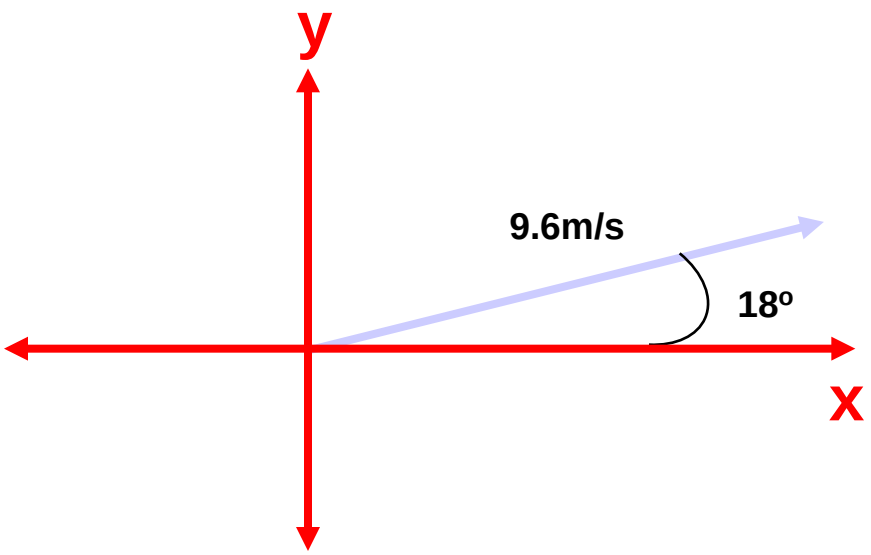


Trigonometric Resolution of Vectors

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

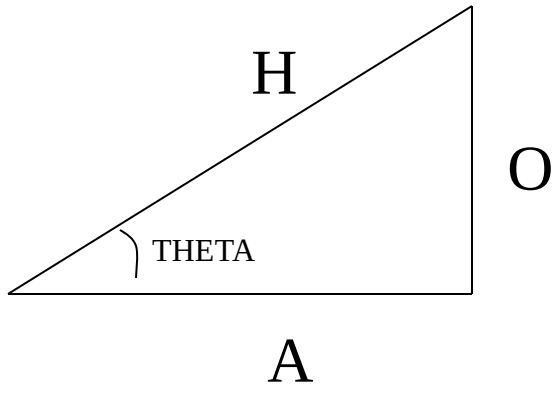
Find:

- 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:



SIN(THETA) = O/H

COS(THETA) = A/H

TAN(THETA) = O/A

Trigonometric Resolution of Vectors

Given: R = 9.6 m/s

$\theta = 18^{\circ}$

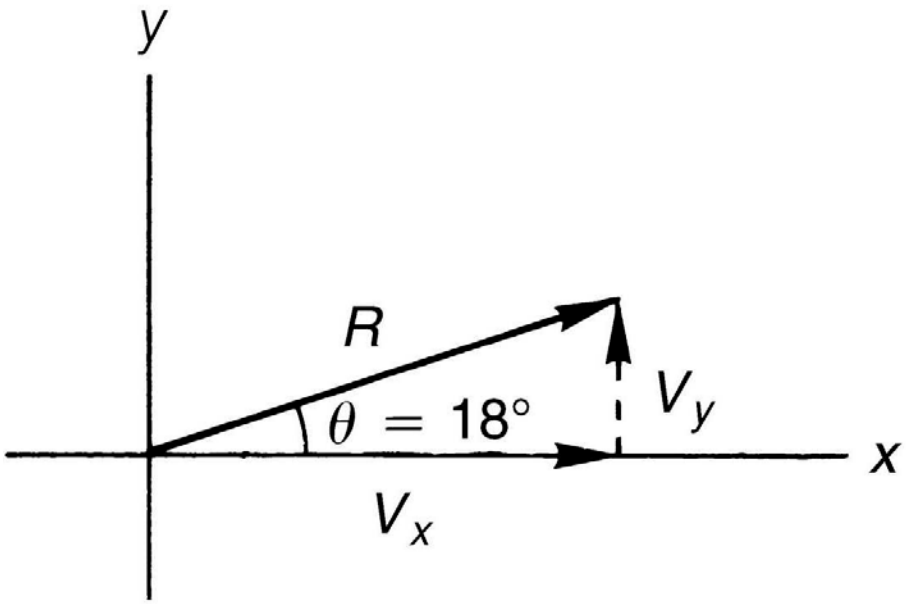
To find Value V_y:

$$\sin\theta = \frac{O}{H} = \frac{V_y}{R}$$

$V_y = \sin 18^{\circ} \times 9.6 \text{m/s}$

$= .3090 \times 9.6 \text{m/s}$

$= 2.97 \text{ m/s}$



Trigonometric Resolution of Vectors

Given: R = 9.6 m/s

$\theta = 18^\circ$

To find Value V_x:

$$\cos\theta = \frac{A}{H} = \frac{V_x}{R}$$

$V_x = \cos 18^\circ \times 9.6\text{m/s}$

$= .9511 \times 9.6\text{m/s}$

$= 9.13\ \text{m/s}$

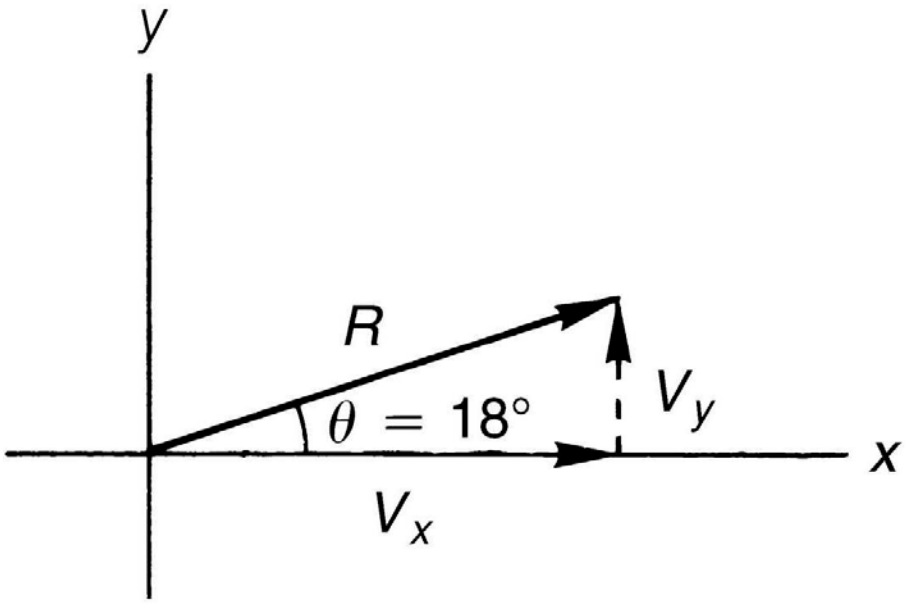


Fig 10.11

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?

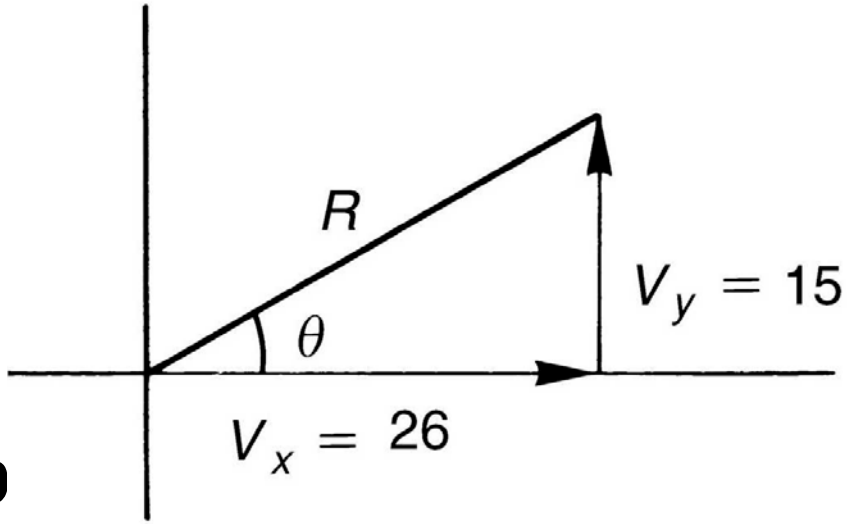
Trigonometric Combination of Vectors

Given:

V_y = 15 m/s

V_x = 26 m/s

Find: R and θ



Solution:

$$R^2 = V_y^2 + V_x^2$$

$$R^2 = (15\ m/s)^2 + (26\ m/s)^2 = 9$$

$$R = \sqrt{901\ m^2/s^2}$$

$$R = 30\ m/s$$

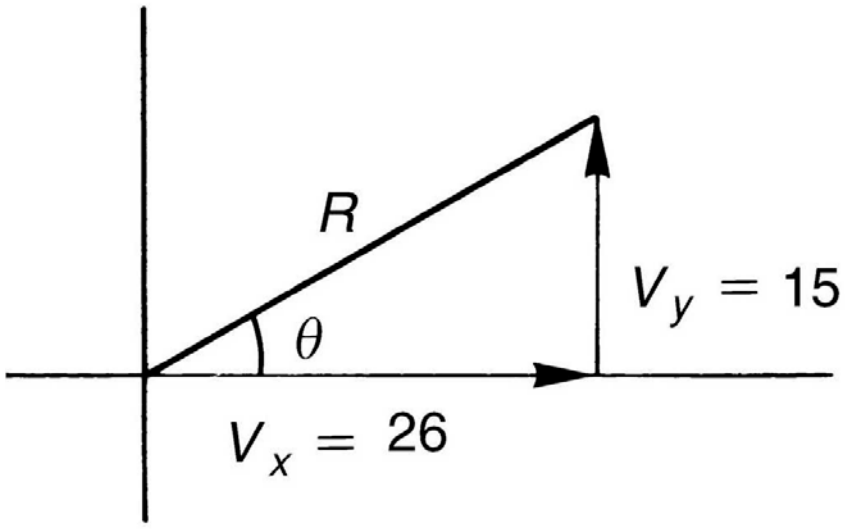
Trigonometric Combination of Vectors

Solution:

$$\theta = \arctan \frac{V_y}{V_x}$$

$$\theta = \arctan \frac{15\,{}^{m}\!/_{s}}{26\,{}^{m}\!/_{s}}$$

$$\theta = 30^{o}$$



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°.

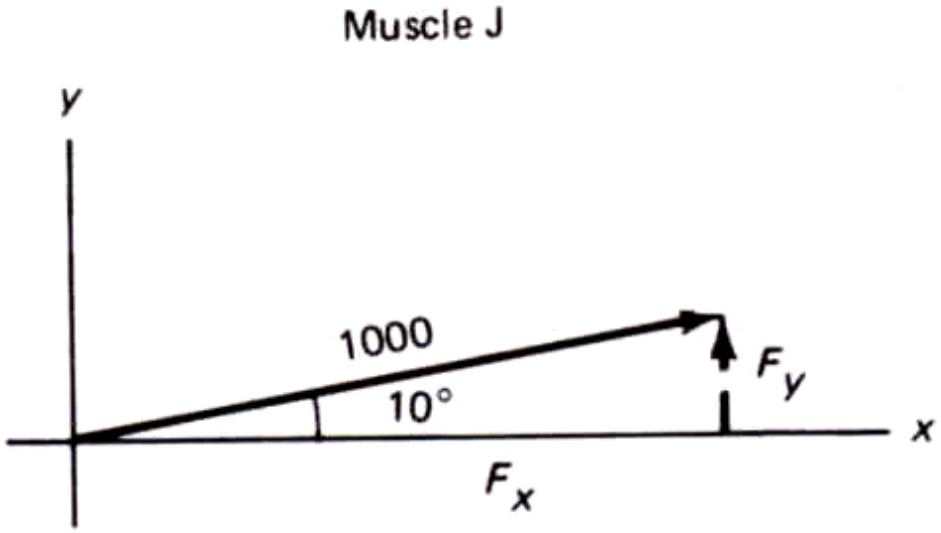
Muscle J

R = (1000N, 10°)

y = R sin θ

y = 1000N x (0.1736)

y = 173.6 N (vertical)



x = R cos θ

x = 1000N x (0.9848)

x = 984.8 N (horizontal)

Muscle K

R = (800N, 40°)

y = R sin θ

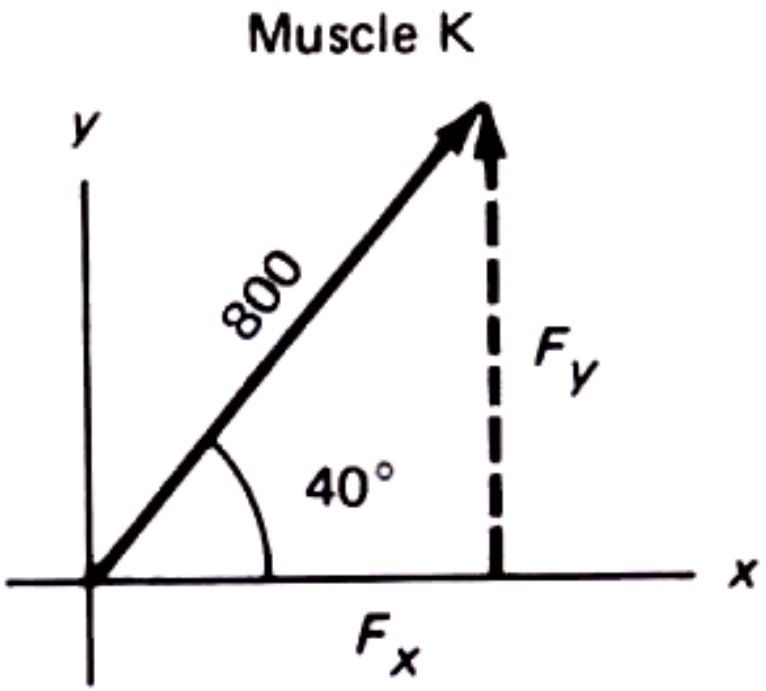
y = 800N x (0.6428)

y = 514.2 N (vertical)

x = R cos θ

x = 800N x (0.7660)

x = 612.8 N (horizontal)



Sum the x and y components

Trigonometric Combination of Vectors

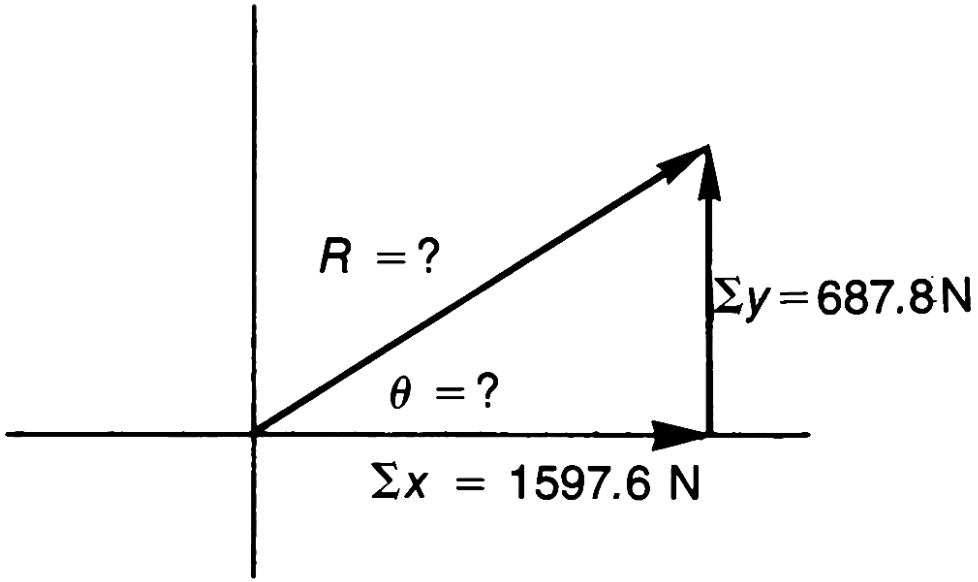
Given:

$\sum Fy = 687.8$ N

$\sum Fx = 1597.6$N

Find:

θ and r



Trigonometric Combination of Vectors

Solution:

$$\theta = \arctan \frac{\sum F_y}{\sum F_x}$$

$$\theta = \arctan \frac{687.8N}{1597.6N}$$

$$\theta = 23.3^o$$

$$R^2 = \sum F_y^2 + \sum F_x^2$$

$$R^2 = (687.8N)^2 + (1597.6N)^2$$

$$R^2 = 3025395N^2$$

$$R = 1739N$$