

7.2 - Motion

Describing Motion

Frame of Reference: A coordinate system used to identify an object's position.

Reference Point: A place or object that is used for comparison to determine if an object is in motion.

Example: The bird is on a tree limb 2 meters to the left of the building. (Note that the building is the frame of reference and is essentially 0 m in this scenario) One could say that the building is 2 meters to the right of the bird. (Note that in this scenario, the bird has changed to become the 0 m point or the reference point)

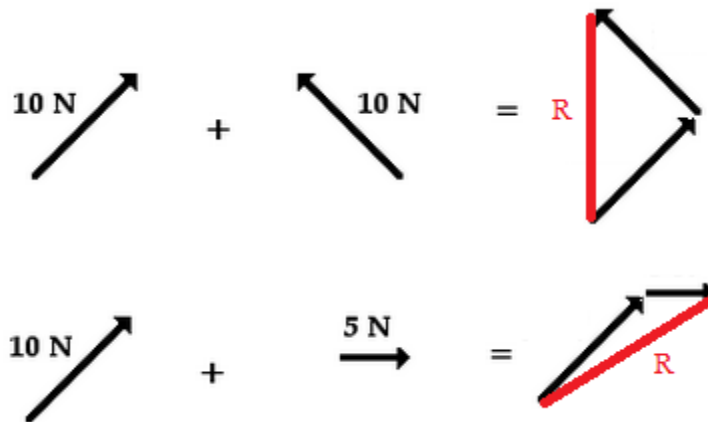
Vector Measurements

- **Scalars** are quantities that are fully described by a magnitude (number) alone.
- **Vectors** are quantities that are fully described by both a magnitude and a direction.

A vector arrow shows both a magnitude (number) and a direction which means the size of the arrow indicates the magnitude of number of the vector. One can add vectors by either assigning a + or - to the value (indicating direction) or adding the vectors "head to tail."

Example:

$$\begin{aligned} \vec{5} + \vec{5} &= \vec{10} \\ \vec{5} + \overleftarrow{5} &= 0 \\ \vec{5} + \vec{10} &= \vec{15} \\ \vec{5} + \overleftarrow{10} &= \overleftarrow{5} \end{aligned}$$



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Types of Scalar Quantities

Distance: How far an object has traveled total from its initial position. Measured in meters (m).

Example: A person walked 10 meters north and 5 meters south. The person's distance is 15 m. (Note that there is no direction needed)

Average Speed: The rate at which an object's distance traveled changes. Measured in meters per second (m/s).

$$\text{average speed} = \bar{v} = \frac{\text{distance}}{\text{time}} = \frac{d}{t}$$

Example: A deer walks 1300 m north and then 500 m south. What is the deer's average speed if the entire trip took 600 seconds? $v = (1300 \text{ m} + 500 \text{ m}) / 600 \text{ sec} = 3 \text{ m/s}$

Speed: The magnitude of number of velocity. Measured in meters per second (m/s).

Types of Vector Quantities

Position: An object's location at any given point in time. Measured in meters (m).

Example: Student A is standing at a position of 0 m. Student B is standing at a position of +3 m.

Displacement: How far an object is from its starting position. Measured in meters (m).

$$\text{displacement } (d) = \text{position final} - \text{position initial} = x_f - x_0$$

Example: A person walked 10 meters north and 5 meters south. The person's displacement is 5 meters north. $d = +10 \text{ m} + -5 \text{ m} = +5 \text{ m}$ (Note that positive and negative indicate direction)

Average Velocity: The rate at which an object's displacement, or position, changes. Measured in meters per second (m/s).

$$\text{average velocity} = \bar{v} = \frac{\Delta \text{displacement}}{\Delta \text{time}} = \frac{x - x_0}{t}$$

Note: Δ means change

Example: A deer walks 1300 m north and then 500 m south. What is the deer's average velocity if the entire trip took 600 seconds? $v = (+1300 \text{ m} + -500 \text{ m}) / 600 \text{ sec} = 1.33 \text{ m/s}$

Acceleration: The rate at which velocity changes. Measured in meters per second per second (m/s^2).

$$\text{acceleration} = a = \frac{\Delta \text{velocity}}{\Delta \text{time}} = \frac{v - v_0}{t}$$

Example: A car accelerated from 10 m/s to 20 m/s over 5 seconds. What was the car's acceleration? $a = (20 \text{ m/s} - 10 \text{ m/s}) / 5 \text{ sec} = 2 \text{ m/s}^2$

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Equations

Constant Velocity or Speed Equation:

$$v = \frac{d}{t} \text{ or } d = vt$$

Constant Acceleration Equations


$$v = v_0 + at$$


$$d = v_0t + \frac{1}{2}at^2$$

$$v^2 = v_0^2 + 2ad$$


Ticker Tape Diagrams

Constant Velocity or Speed

Fast: 

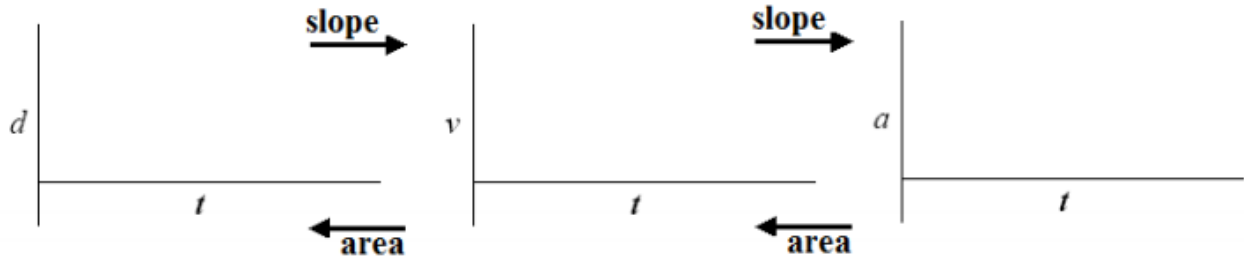
Slow: 

Constant Acceleration

Acceleration: 

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Motion Graphs



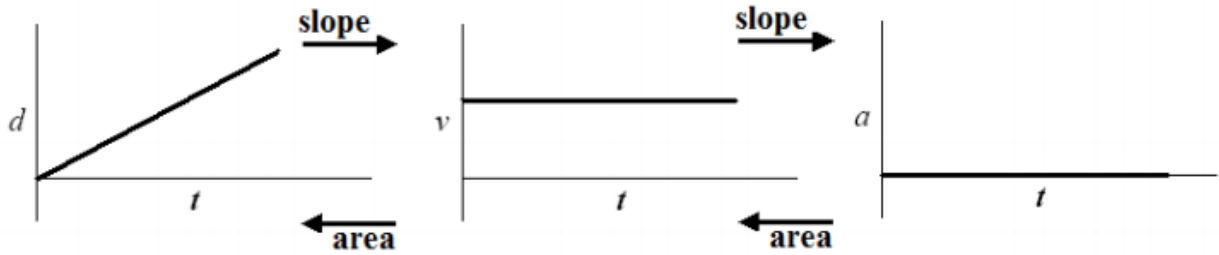
$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{y_2 - y_1}{x_2 - x_1}$$

Area of a rectangle = base x height

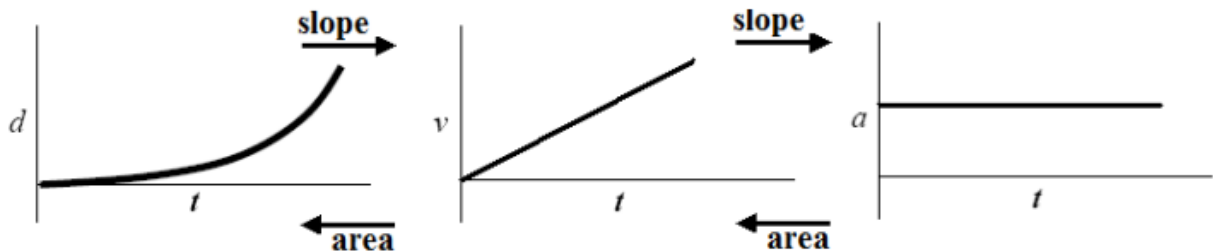
Area of a triangle = $\frac{1}{2}$ x base x height

Example:

Constant Positive Velocity



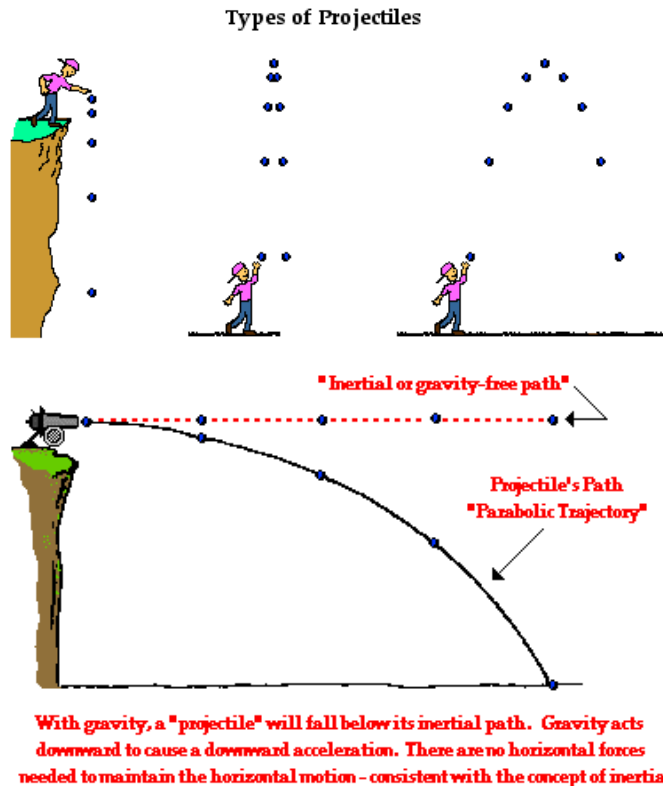
Constant Positive Acceleration



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Projectile Motion

A projectile is an object that only has the force of gravity acting upon it. If one drops a ball, throw a ball vertically upward, or launches a person out of a cannon, these are all examples of projectile motion. Once the object is projected it continues in motion by its own inertia and is influenced downward by the force of gravity.



Shown below, the horizontal velocity stays constant (20 m/s in the example). However the object accelerates in the vertical direction, making the magnitude of the velocity greater and greater (starting at 0 m/s). This gives the object the parabolic motion or projectile motion.

