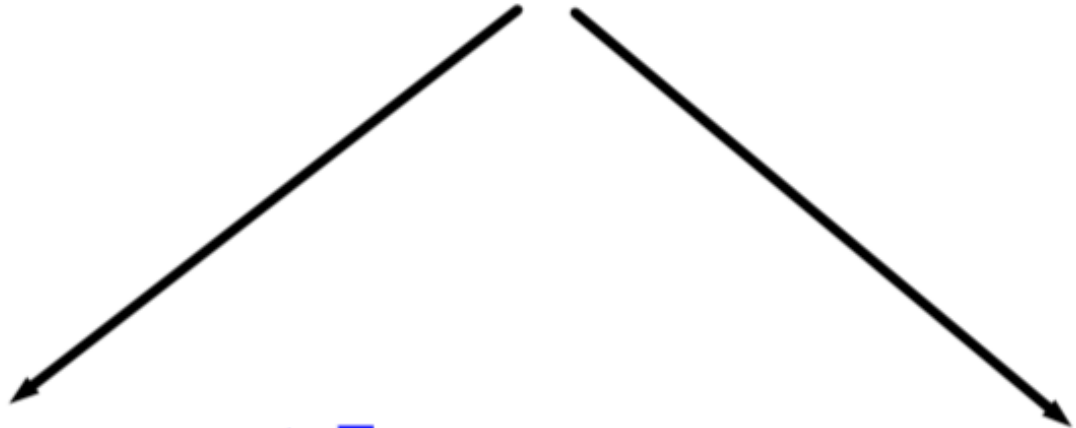
Unit 1: Kinematics

Mechanics



Kinematics

Dynamics

The study of *how* objects move.

Motion

- **Motion**: Change in position.
- **Frame of reference**: Something not moving with respect to an observer that can be used to detect motion.

Scalars

- **Scalars** are measurements that are independent of direction.
  - Time
  - Mass
  - Distance
  - Speed

Vectors

- **Vectors** are measurements that require a direction (it is relative to a coordinate system within a frame of reference). Variables that are vectors are symbolized in bold or with an arrow above them. For example, $\vec{F}$ and $\vec{a}$.
- Position
- Displacement
- Velocity
- Acceleration
- Force

Distance

- Length of the route between two points.

DIRECTION

- Described in relative terms: up, down, left, right, forward, etc.
- Cardinal directions: east, west, north and south.
- For calculations it can be positive or negative.

POSITION & DISPLACEMENT

- Position: Distance and direction from a reference point at a given time.
- Displacement: Change in position.

The moving man

You try:

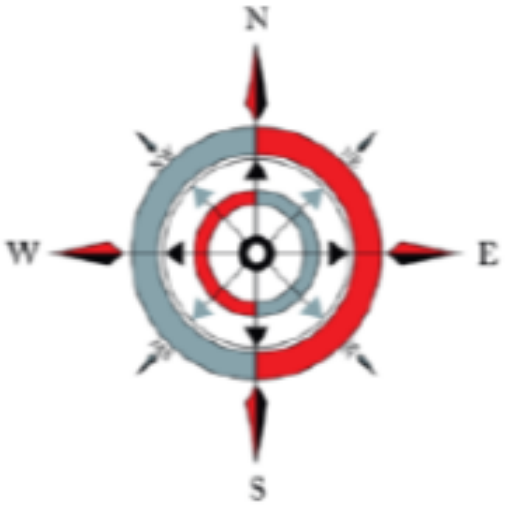
- Calculate this person's distance traveled and final position.
  - 5 m [N]
  - 15 m [N]
  - 40 m [S]
  - 10 m [N]
  - 25 m [S]

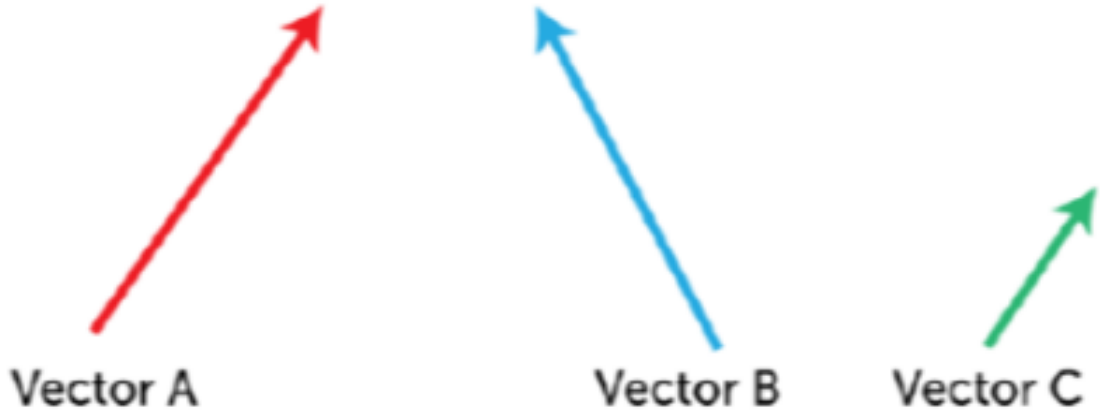
Speed

- Scalar (no direction)
- Average Speed: Total distance traveled per unit time.
  - $v_{sp} = \frac{distance}{time}$
  - The path taken matters. This is what we feel.
- Instantaneous Speed: Speed at an instant in time (speedometer of a car).

Velocity

- Vector
- Speed with direction.





Average velocity

- $\vec{v}_{avg} = \frac{change\ in\ position}{time} = \frac{\vec{d}}{t}$, where $\vec{d} = \vec{d}_f - \vec{d}_o$
- The answer to such a problem communicates how fast and in what direction to travel to reach a destination in a specific amount of time.
- If an object changes its speed or direction, the velocity changes.

Average velocity

- The average velocity of an object averages out changes in direction. The path taken does not matter.
- Allows for the analysis of an object's position at a certain time; or the object's change in position during a time interval.
- Can be zero.

Instantaneous velocity

- The speed and direction of an object at in instant in time.
- The speedometer of a car AND the direction it is traveling at a moment in time.

Example Problem #1

- A person drives the following in 3.5 hours:
  - 25 km [E]
  - 40 km [W]
  - 30 km [W]
  - 60 km [E]

1. Calculate the total distance traveled.
2. Calculate the final position.
3. Calculate the average speed.
4. Calculate the average velocity.

Position & Velocity problems

1. Fred averages 92 km/h [E] and drives for 4.1 hours.
   a) Calculate the final position in that time.

   b) Calculate the length of time necessary for Fred to drive 1375km assuming no change in average velocity.

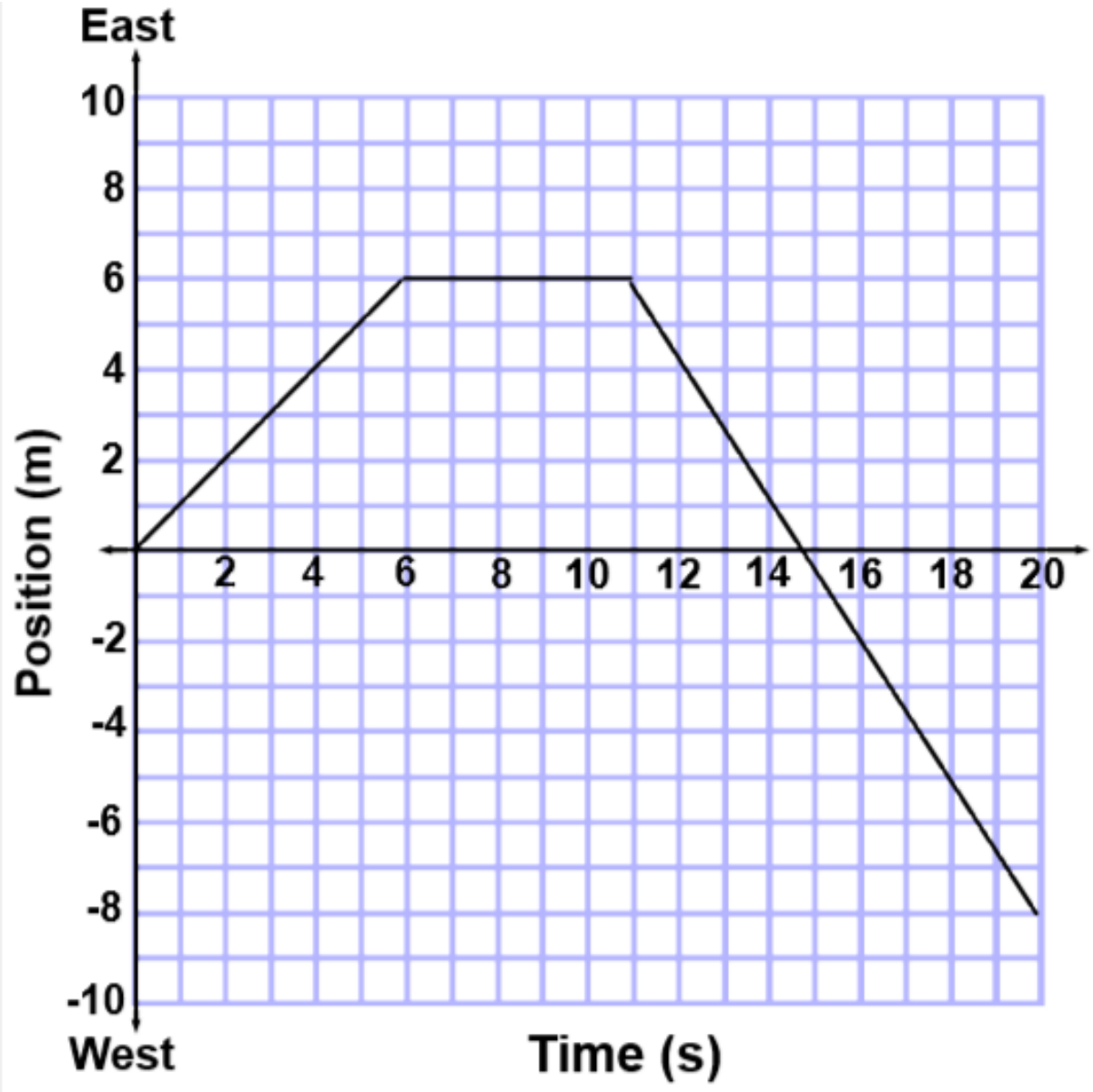
Graphical analysis of position & time

- Review Frame of reference and coordinate system.
- Analyze how position can change with time.
- Learn how to find key points on the graph.
- Develop knowledge about how the graph relates to speed and velocity.

Position-Time Graphs: Key Concepts

- Position: Read from the graph.
- Distance: Sum up all the motions.
- Average Speed: Distance/Time
- Instantaneous Speed: Slope of the line at that time; positive value only.
- Average Velocity: Position/Time
- Instantaneous Velocity: Slope of the line at that time; positive or negative.

Analyzing position-time graphs



- What was the object's position at the 4, 10 and 18 s marks?
- Calculate the distance traveled during the first 14 seconds.
- Calculate the average speed during the first 14 seconds.
- Calculate the average velocity during the first 14 seconds.
- Calculate the instantaneous velocity at the 16 s mark.
- Calculate the object's total distance traveled and final position.
- Calculate the object's average speed and velocity for the full 20s.