Speed and Velocity

Reference Point Examples

Reference Point Scenarios

Suppose you are in a train, and you cannot tell if you are stopped or moving. Outside the window, another train is slowly moving forward. What could be happening?

- Your train is stopped, and the other train is moving slowly forward…
- The other train is stopped, and your train is moving slowly backwards…
- Both trains are moving forward, with the other train moving a little faster…
- Your train is moving very slowly backward, and the other train is moving slowly forward…

Could you be sure as to which is actually happening??

An object is in motion if it changes position relative to a reference point.

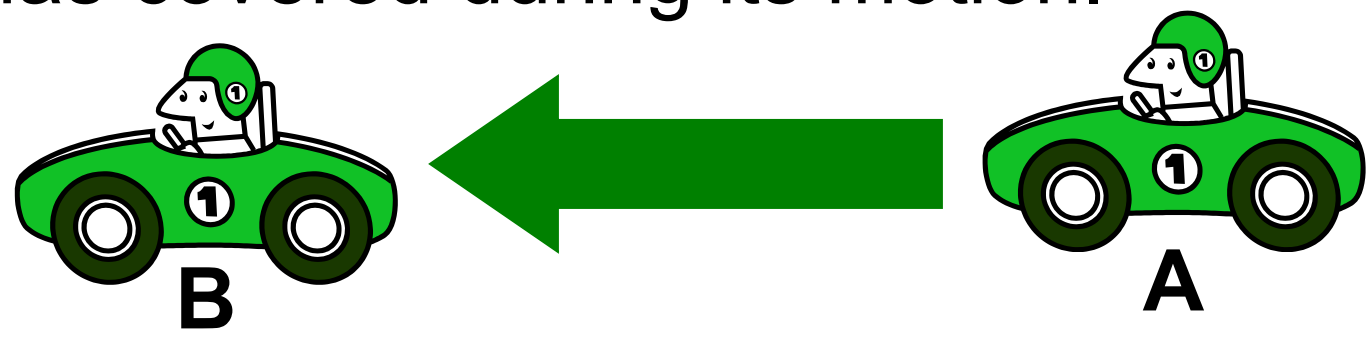
- Objects that we call stationary—such as a tree, a sign, or a building—make good reference points.

The passenger can use a tree as a reference point to decide if the train is moving. A tree makes a good reference point because it is stationary from the passenger's point of view.

Distance

When an object moves, it goes from point A to point B – that is the DISTANCE it traveled. (SI unit is the meter)

Distance is how much ground an object has covered during its motion.



Displacement

Knowing how far something moves is not sufficient. You must also know in what direction the object moved.

Displacement is how far our of place the object is; it is the object's overall change in position.

Speed

- It is a rate!
- What does that mean?
- A change over time. What is the change?
- Change in position, in other words, distance.
- Standard unit: meters per second (m/s)

Calculation

- Average speed – rate for the duration of an entire trip
- This can be calculated…ready for the equation?
- $v = d/t$
- v – velocity
- d – distance
- t – time
- What units do we use?
- Try the practice problems.

Speed

Calculating Speed: If you know the **distance** an object travels in a certain amount of time, you can calculate the **speed** of the object.

What is instantaneous speed?

Instantaneous speed is the velocity of an object at a certain time.

Speed = Distance/time

Average speed = Total distance/Total time

2.1

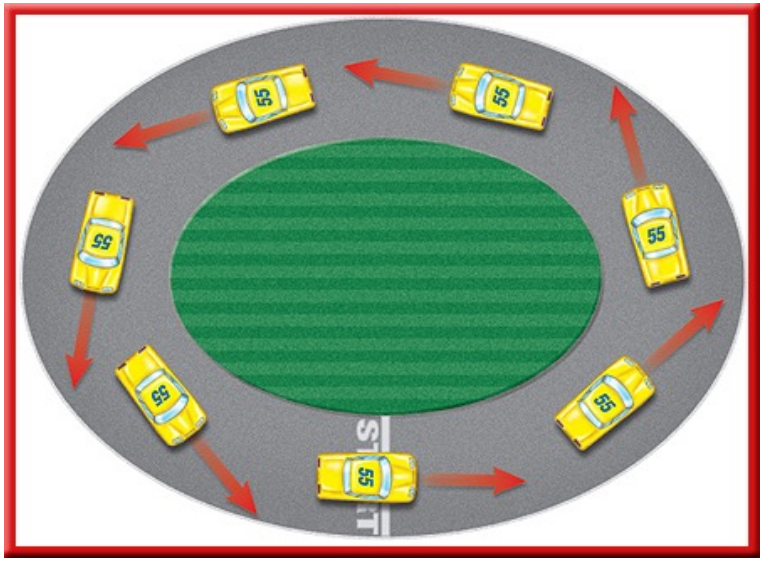
Velocity

- Speed describes only how fast something is moving.
- To determine direction you need to know the velocity.
- **Velocity** includes the speed of an object and the direction of its motion.

Velocity

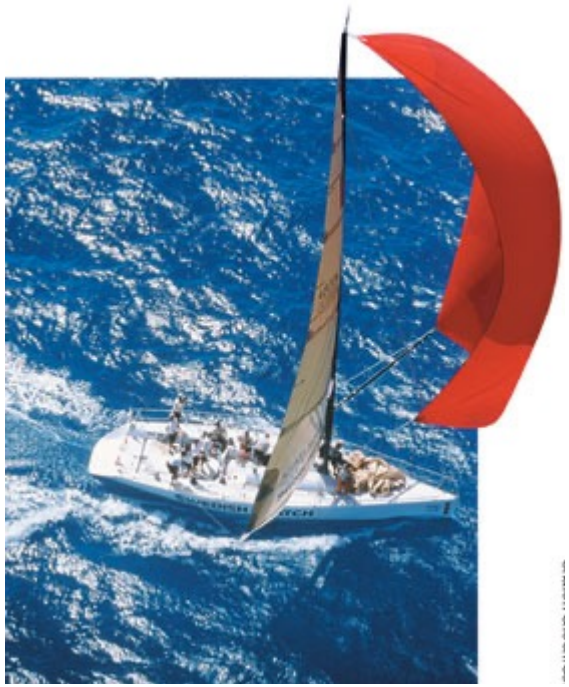
Because velocity depends on **direction** as well as **speed**, the velocity of an object can change even if the speed of the object remains constant.

The speed of this car might be constant, but its velocity is not constant because the direction of motion is always changing.



Velocity

Velocity is a description of an object's **speed** and **direction**.



As the sailboat's direction changes, its velocity also changes, even if its speed stays the same. If the sailboat slows down at the same time that it changes direction, how will its velocity be changed?

Speed v. Velocity

1. How are speed and velocity similar?

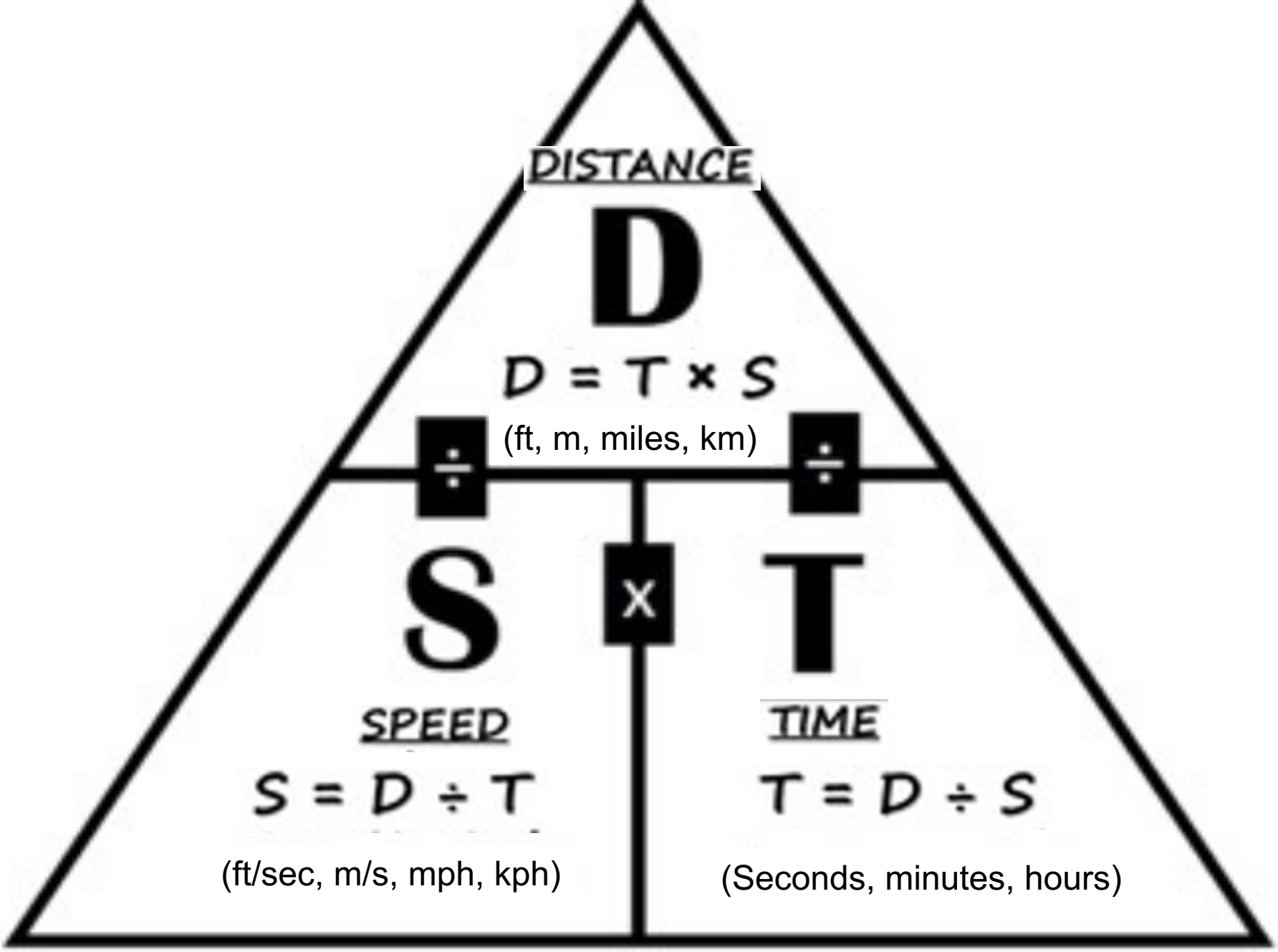
They both measure how **fast** something is moving

2. How are speed and velocity different?

Velocity includes the **direction** of motion and speed does not (the car is moving 5mph East)

3. Is velocity more like distance or displacement? Why?

Displacement, because it includes direction.


DISTANCE
D
D = T × S
(ft, m, miles, km)
÷
÷
S
X
T
SPEED
S = D ÷ T
(ft/sec, m/s, mph, kph)
TIME
T = D ÷ S
(Seconds, minutes, hours)

Practice

- If a runner runs 100 meters in 50 seconds, what is his speed in meters per second?
- How far could this runner run in 25 seconds?

$$S = D \div T$$

Speed = 100 meters / 50 seconds

Speed = 2 meters / second

$$D = T \times S$$

Distance = (25 seconds) x (2 meters / second)

Distance = 50 meters

Position-Time and Velocity-Time Graphs

Questions for Consideration

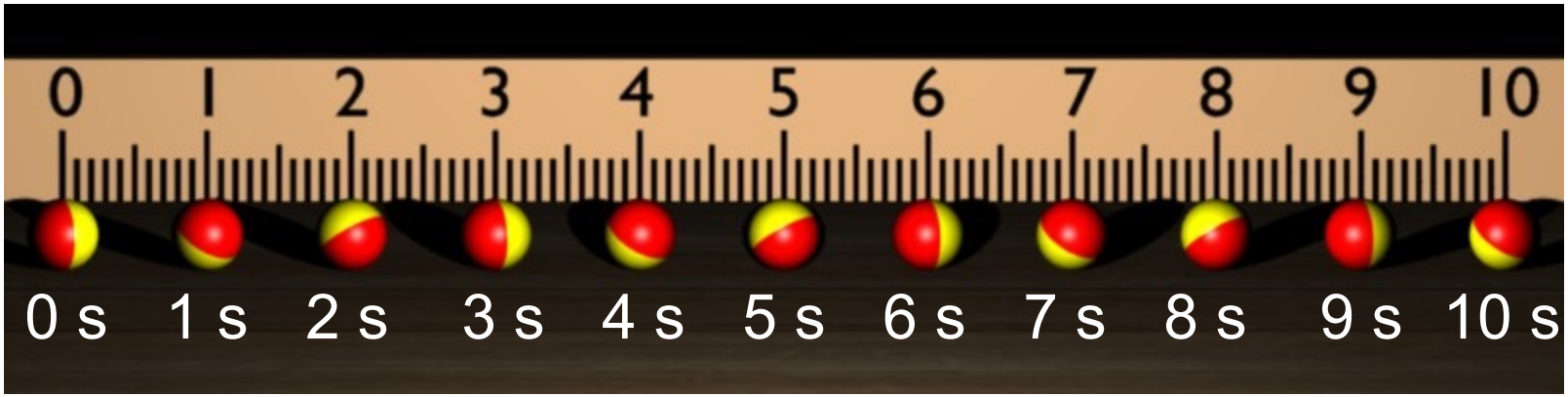
- What is a position-time graph?
- What is a velocity-time graph?
- How do features on one graph translate into features on the other?

Distance-Time Graphs

- Show an object's position as a function of time.
  - x-axis: time
  - y-axis: distance

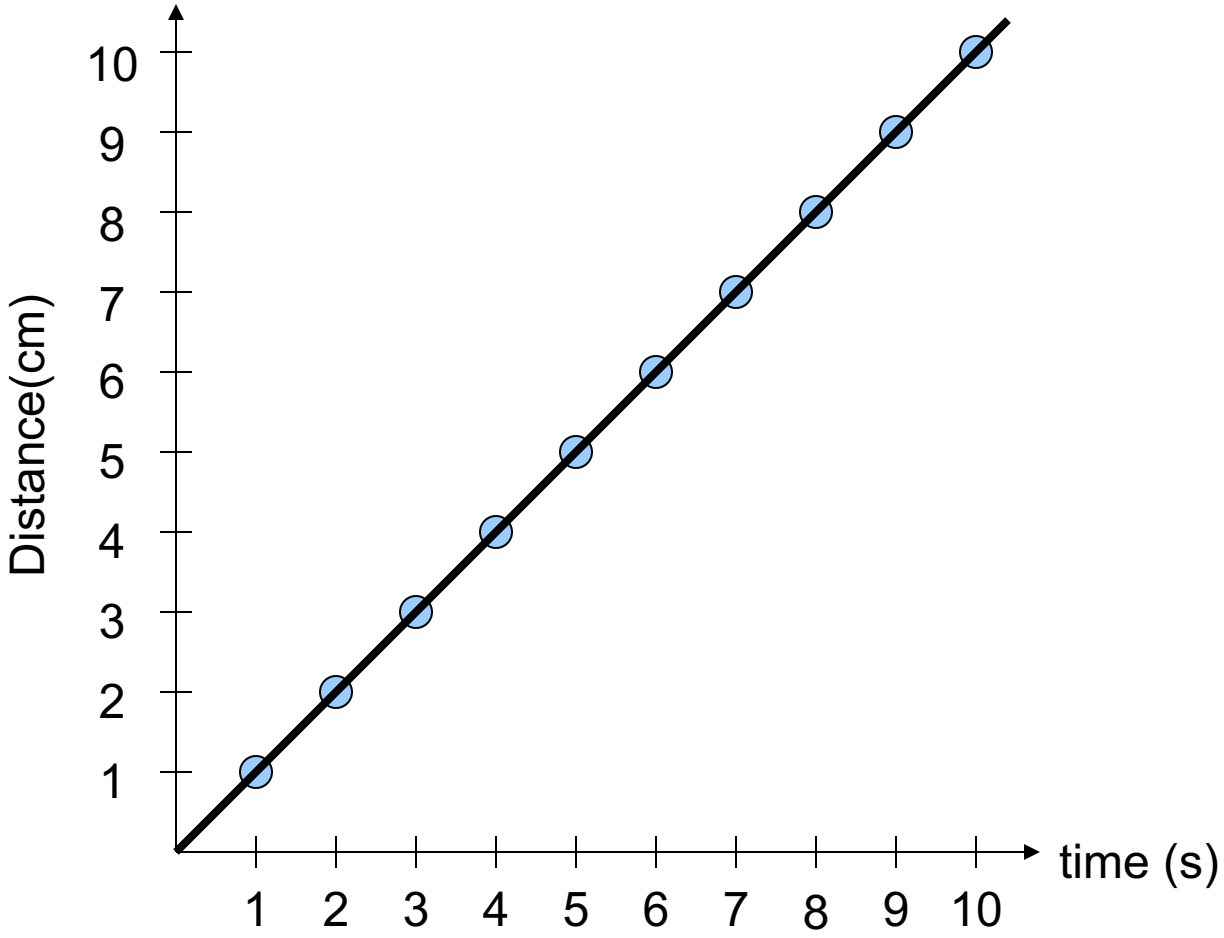
Distance-Time Graphs

- Imagine a ball rolling along a table, illuminated by a strobe light every second.



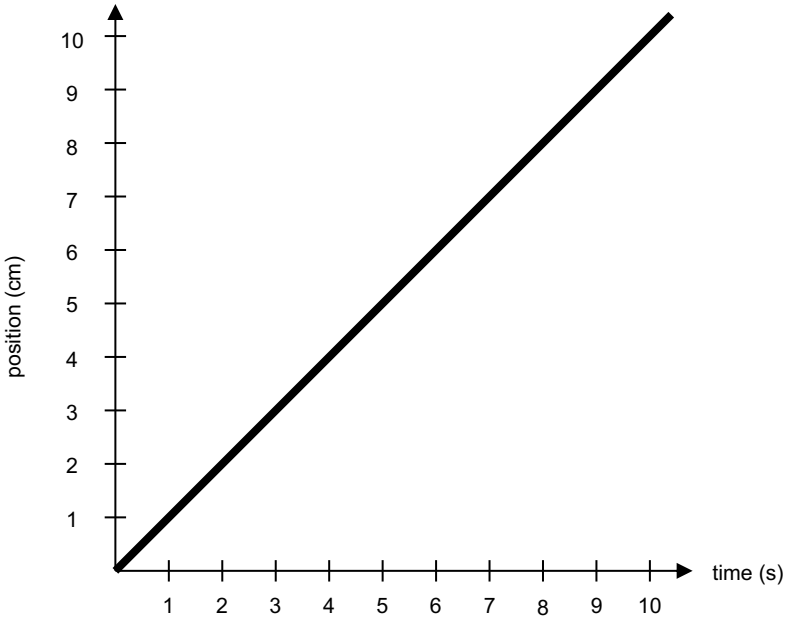
- You can plot the ball's position as a function of time.

Distance-Time Graphs



Distance-Time Graphs

- What are the characteristics of this graph?
  - Straight line, upward slope
- What kind of motion created this graph?
  - Constant speed

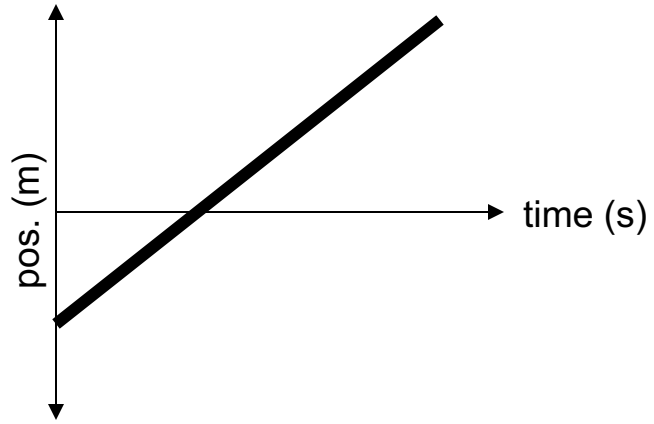


Distance-Time Graphs

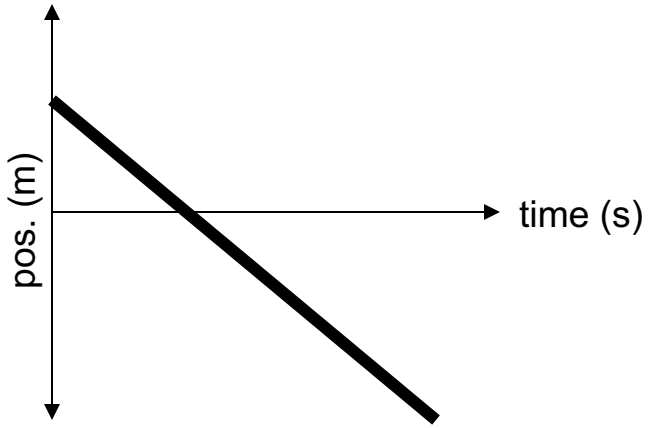
- Each type of motion has a characteristic shape on a D-T graph.
  - Constant speed
  - Zero speed (at rest)
  - Accelerating (speeding up)
  - Decelerating (slowing down)

Distance-Time Graphs

- Constant speed is represented by a straight segment on the D-T graph.



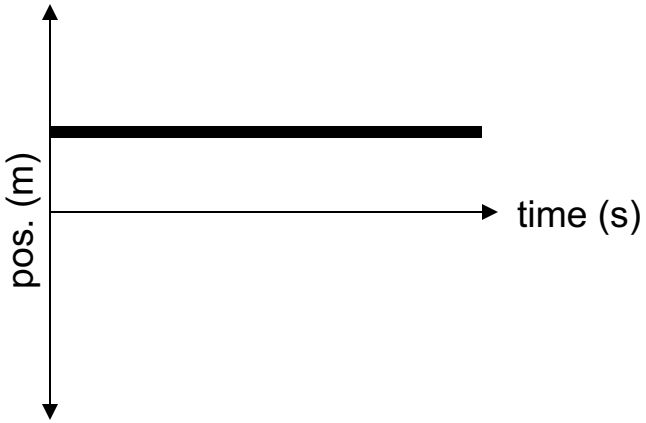
Constant speed in positive direction.



Constant speed in negative direction.

Distance-Time Graphs

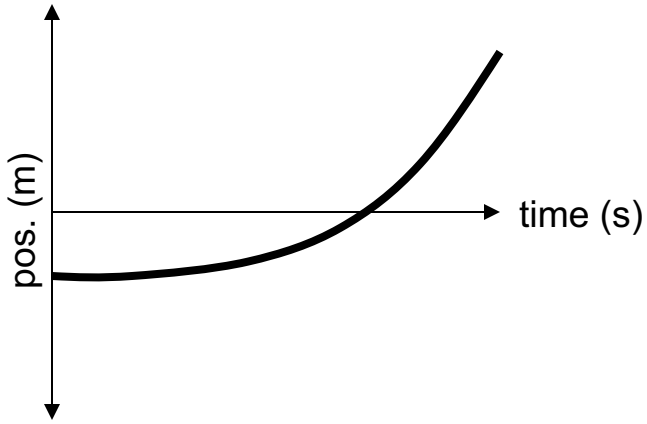
- Constant speed is represented by a straight segment on the D-T graph.



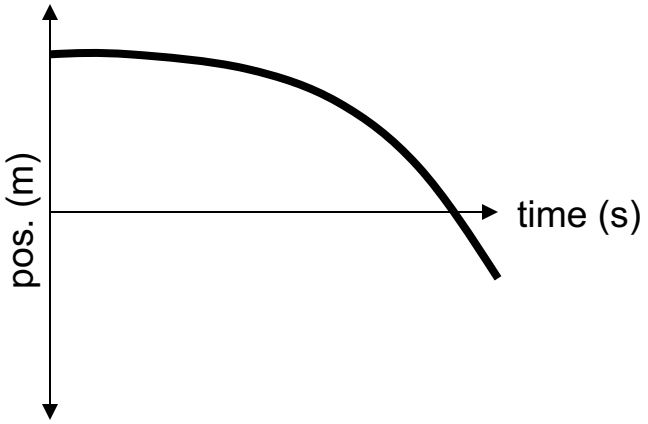
A horizontal segment means the object is at rest.

Distance-Time Graphs

- Curved segments on the D-T graph mean the object's speed is changing.



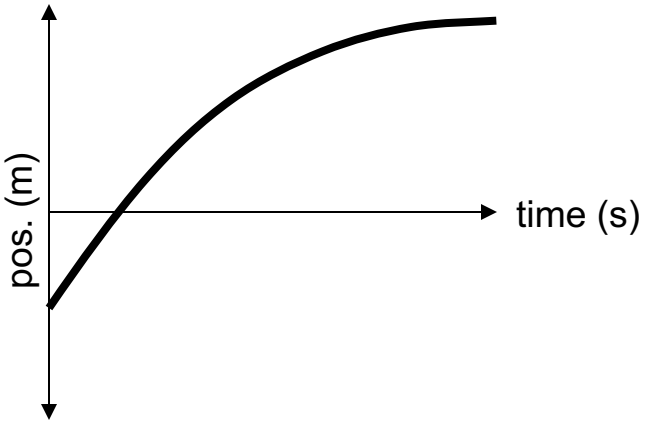
Speeding up in positive direction.



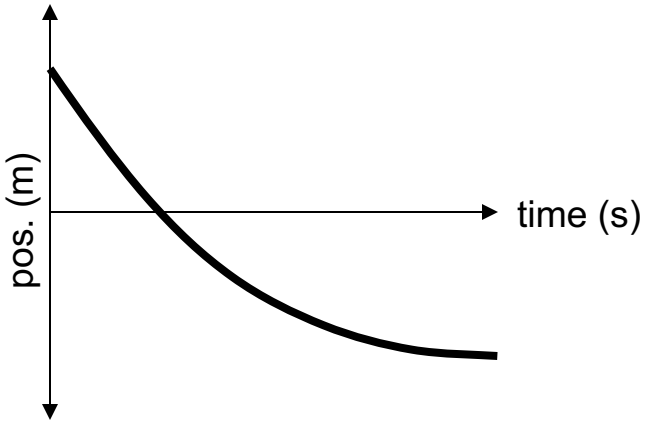
Speeding up in negative direction.

Distance-Time Graphs

- Curved segments on the D-T graph mean the object's speed is changing.



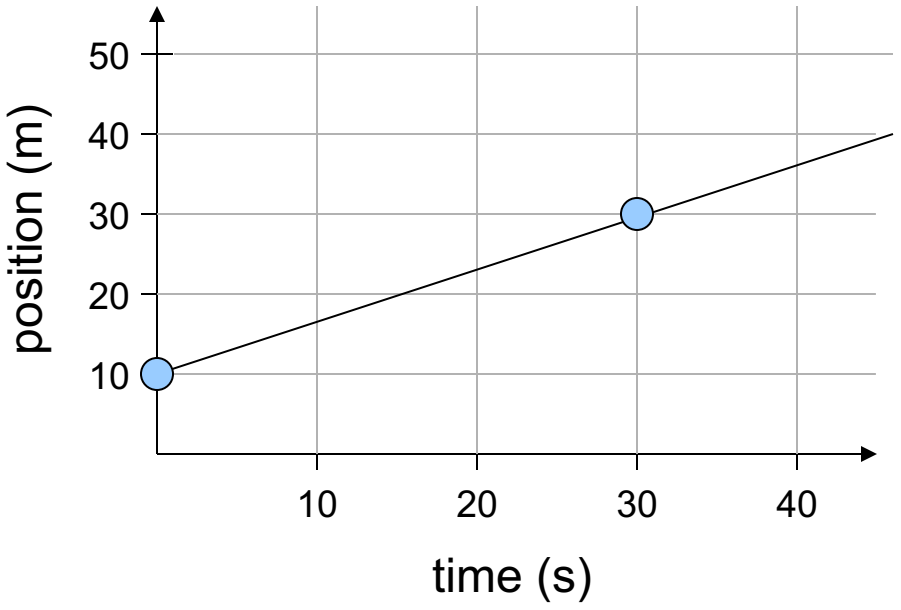
Traveling in positive direction, but slowing down.



Traveling in negative direction, but slowing down.

Distance-Time Graphs

- The slope of a D-T graph is equal to the object's velocity in that segment.



$$\text{slope} = \frac{\text{change in y}}{\text{change in x}}$$

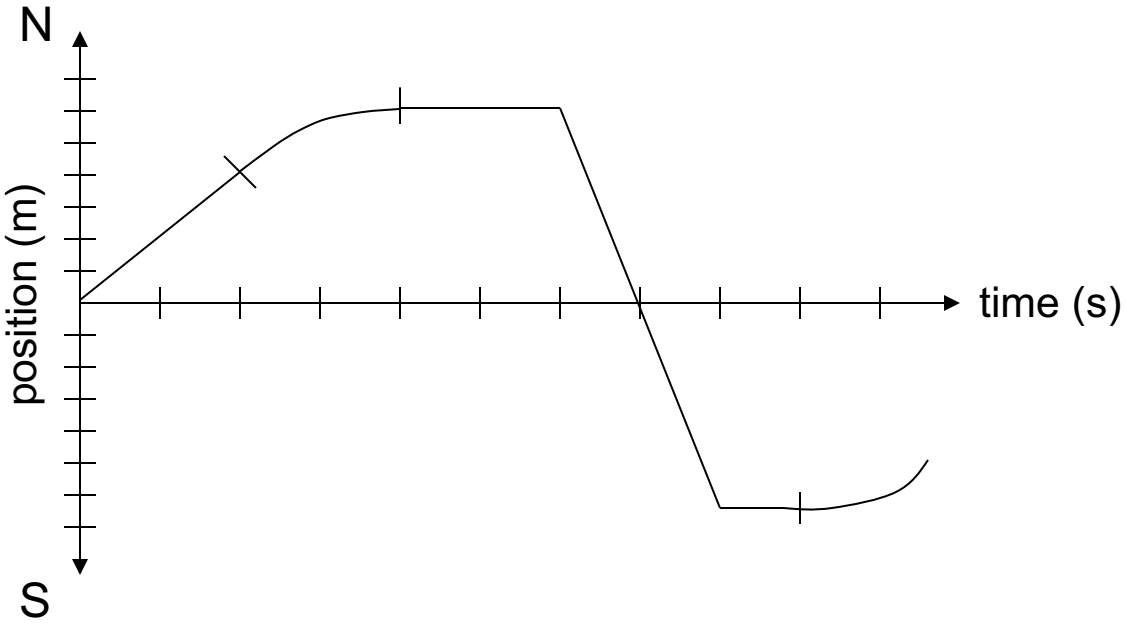
$$\text{slope} = \frac{(30\text{ m} - 10\text{ m})}{(30\text{ s} - 0\text{ s})}$$

$$\text{slope} = \frac{(20\text{ m})}{(30\text{ s})}$$

$$\text{slope} = 0.67\text{ m/s}$$

Distance-Time Graphs

- The following D-T graph corresponds to an object moving back and forth along a straight path. Can you describe its movement based on the graph?

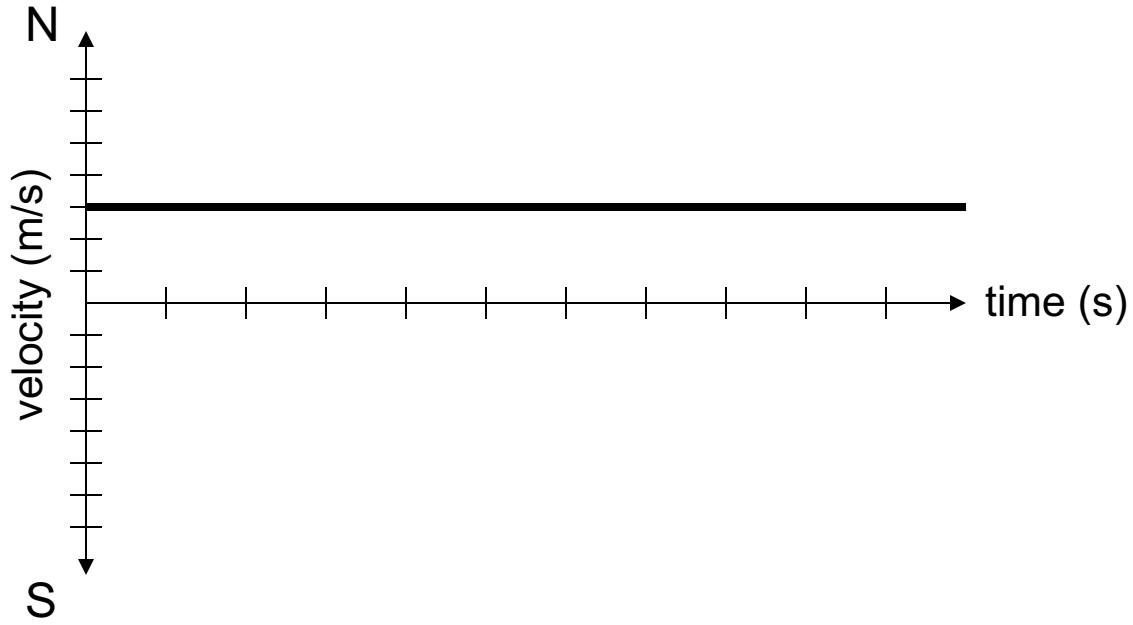


Velocity-Time Graphs

- A velocity-time (V-T) graph shows an object's velocity as a function of time.
  - A horizontal line = constant velocity.
  - A straight sloped line = constant acceleration.
    - Acceleration = change in velocity over time.
  - Positive slope = positive acceleration.
    - Not necessarily speeding up!
  - Negative slope = negative acceleration.
    - Not necessarily slowing down!

Velocity-Time Graphs

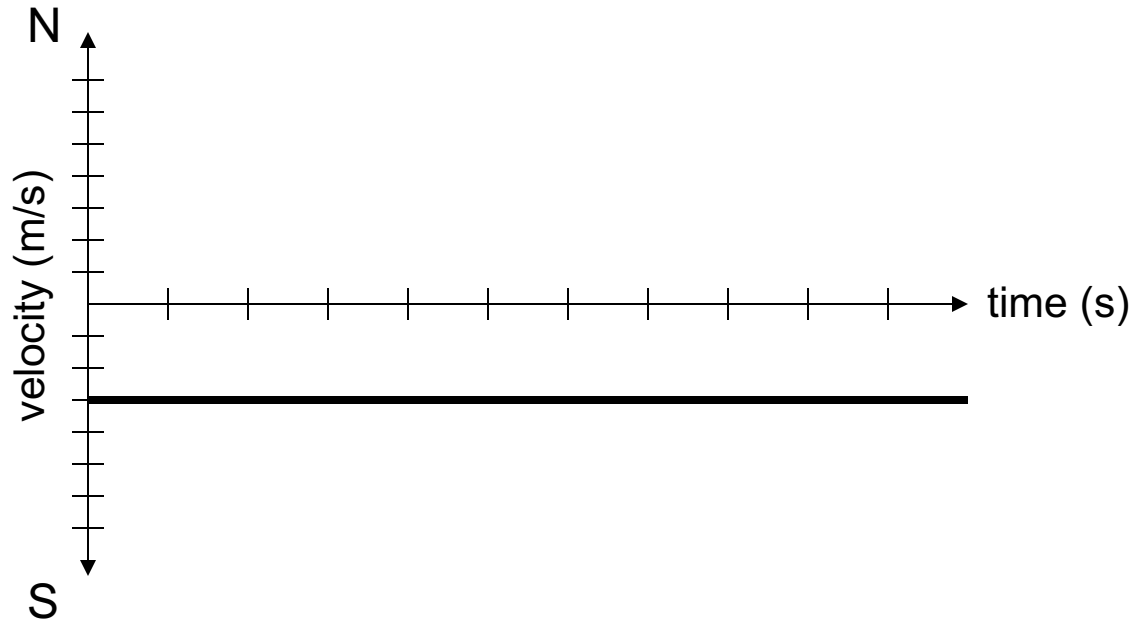
- A horizontal line on the V-T graph means constant velocity.



Object is moving at a constant velocity North.

Velocity-Time Graphs

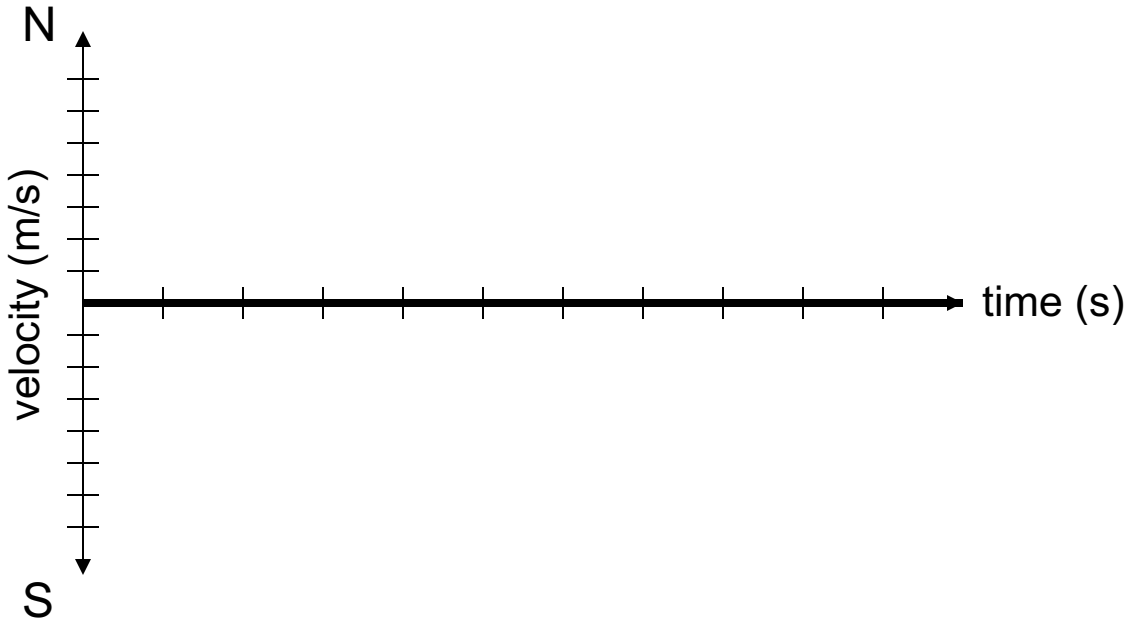
- A horizontal line on the V-T graph means constant velocity.



Object is moving at a constant velocity South.

Velocity-Time Graphs

- If an object isn't moving, its velocity is zero.



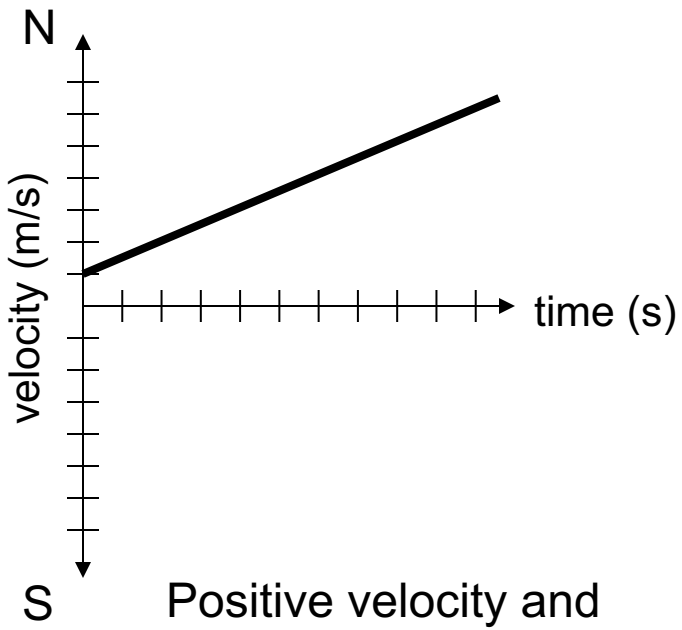
Object is at rest

Velocity-Time Graphs

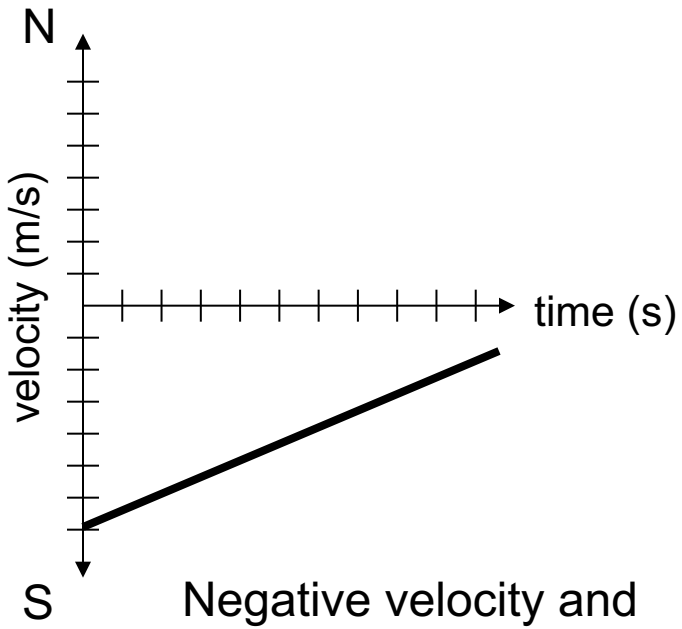
- If the V-T line has a positive slope, the object is undergoing acceleration in positive direction.
  - If v is positive also, object is speeding up.
  - If v is negative, object is slowing down.

Velocity-Time Graphs

- V-T graph has positive slope.



Positive velocity and positive acceleration: object is speeding up!



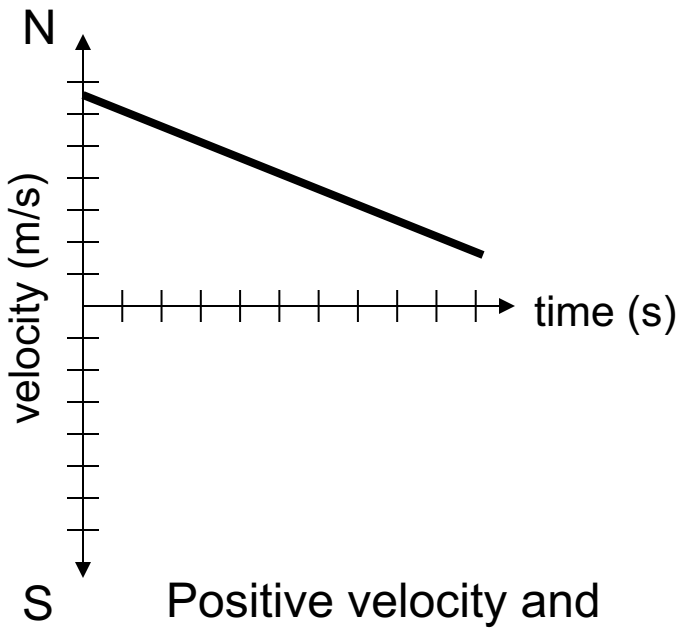
Negative velocity and positive acceleration: object is slowing down.

Velocity-Time Graphs

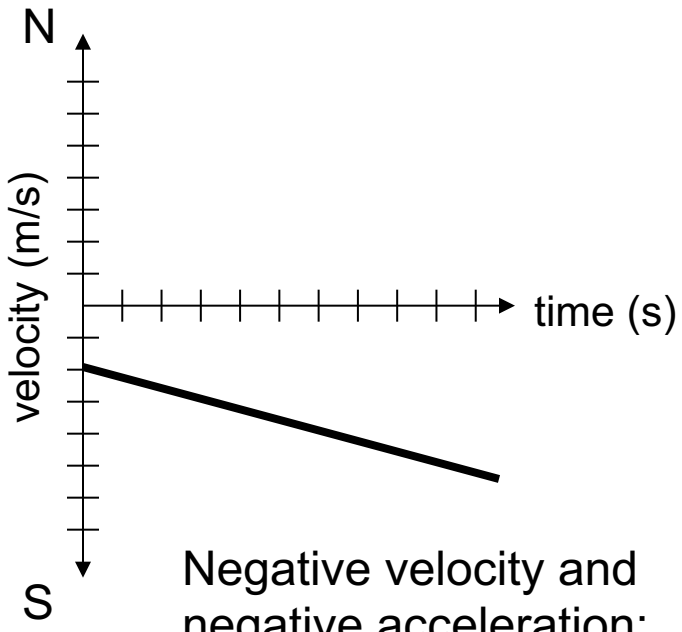
- If the V-T line has a negative slope, the object is undergoing acceleration in the negative direction.
  - If v is positive, the object is slowing down.
  - If v is negative also, the object is speeding up.

Velocity-Time Graphs

- V-T graph has negative slope.



Positive velocity and negative acceleration: object is slowing down,



Negative velocity and negative acceleration: object is speeding up! (in negative direction)