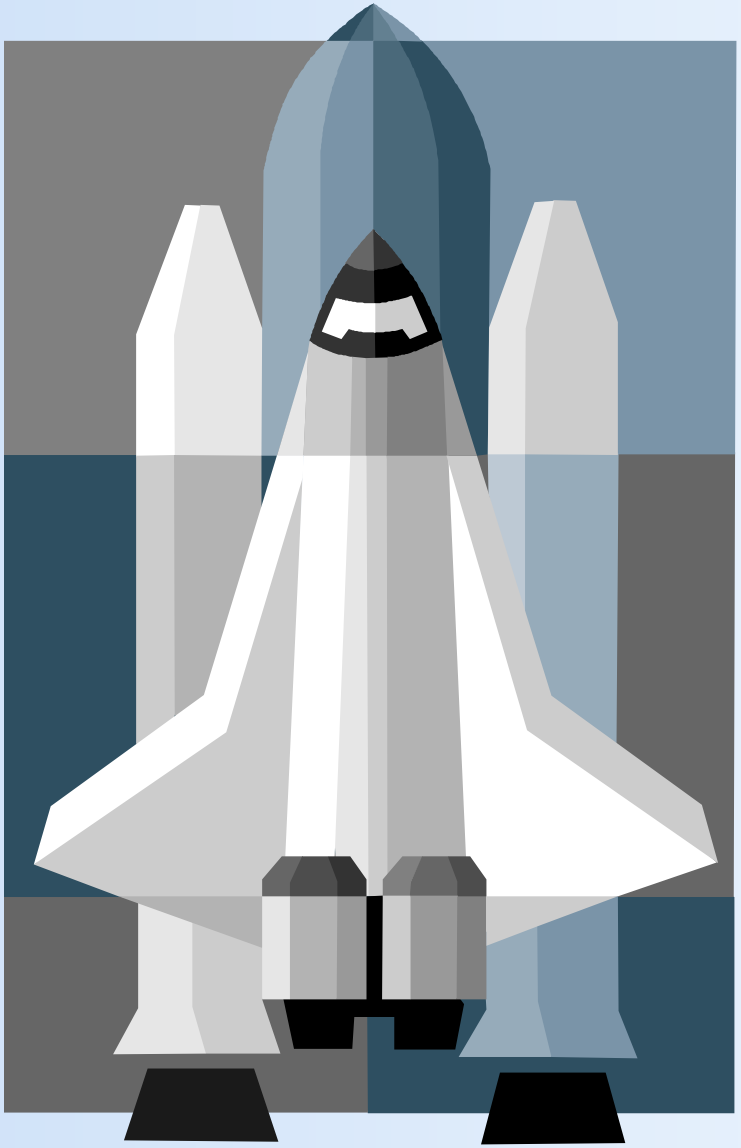
P. Sci.

Chapter 11

Motion

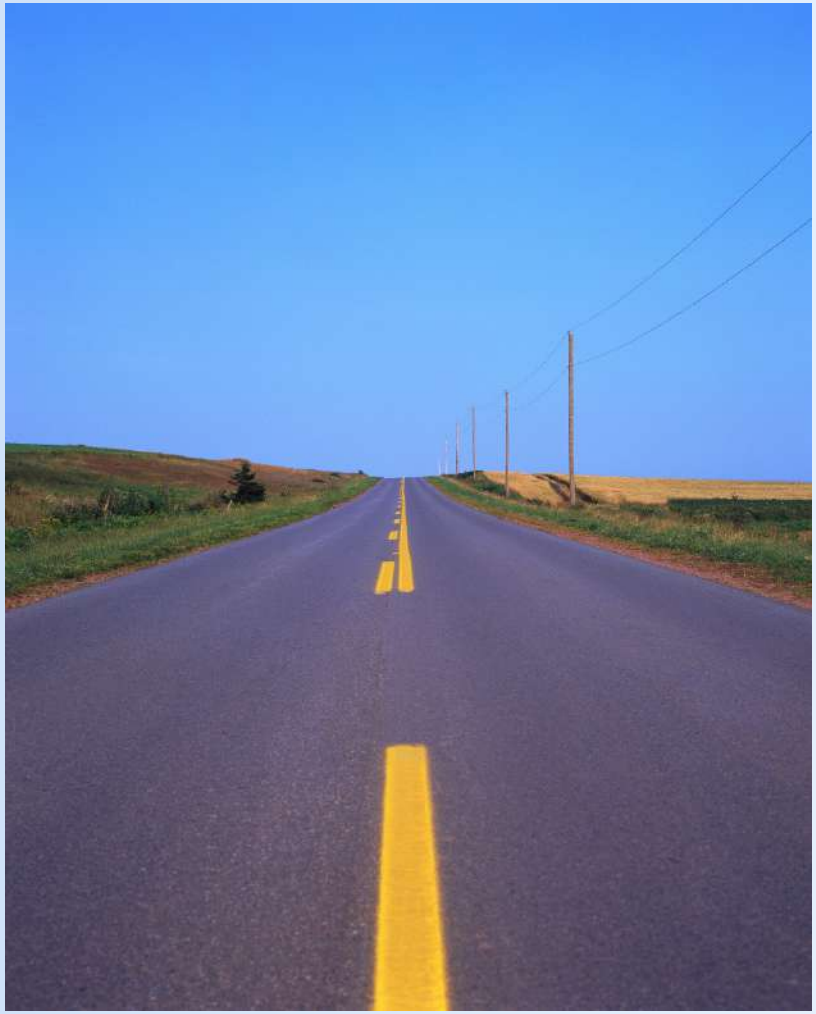


Motion

when something changes position

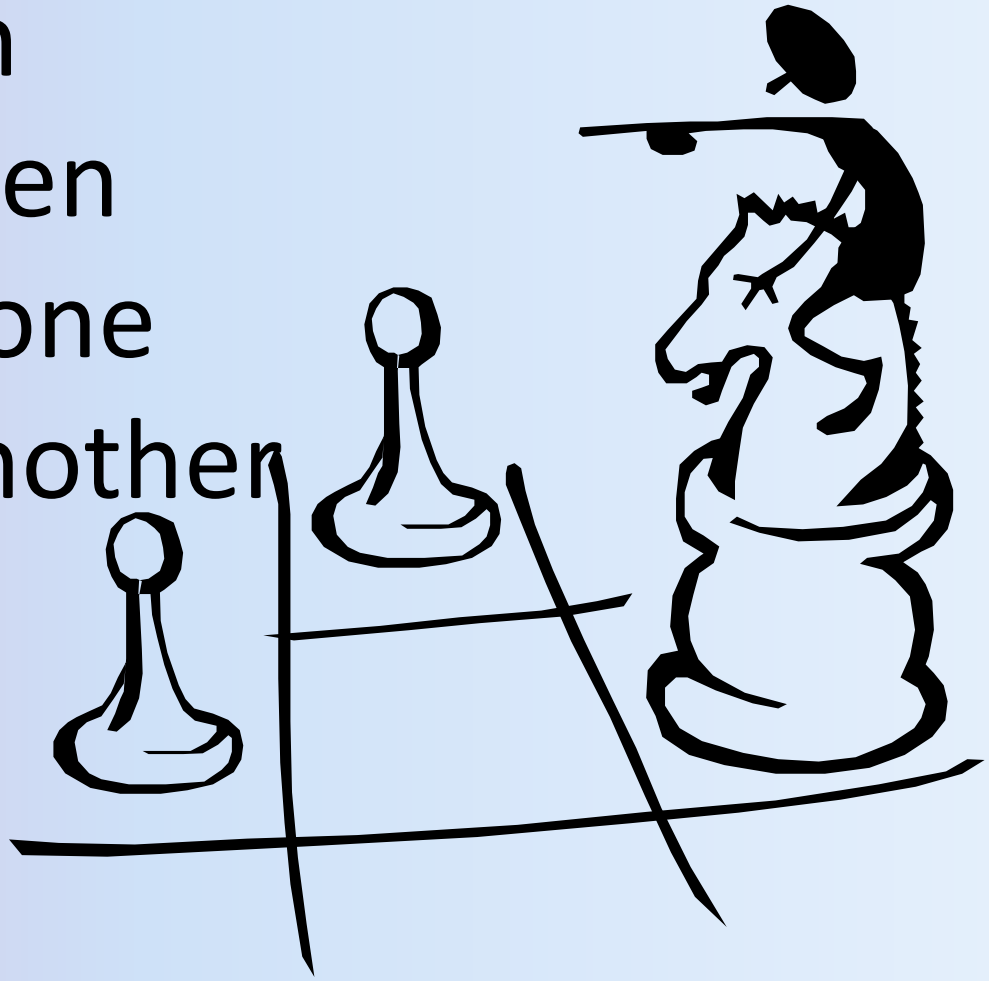
Distance

How far the object travels



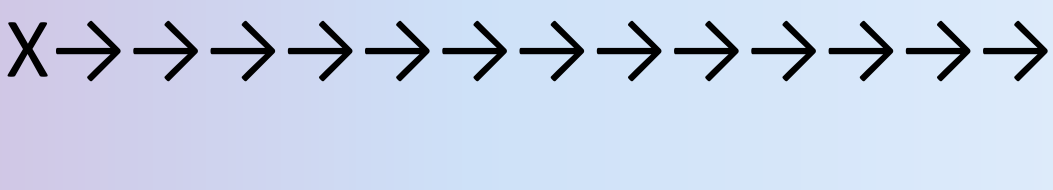
Displacement

the distance an object has been moved from one position to another



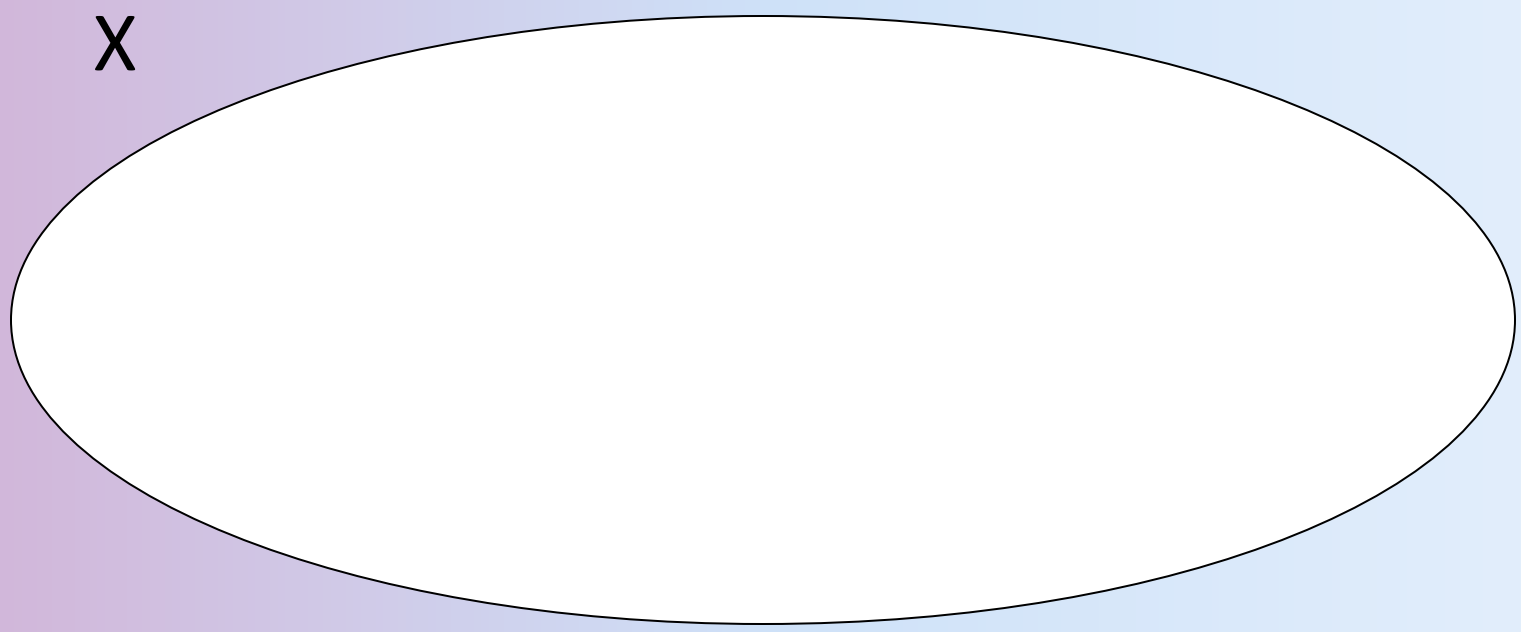
Example

one car travels from one town to another that is 20 km to the east.



20 km

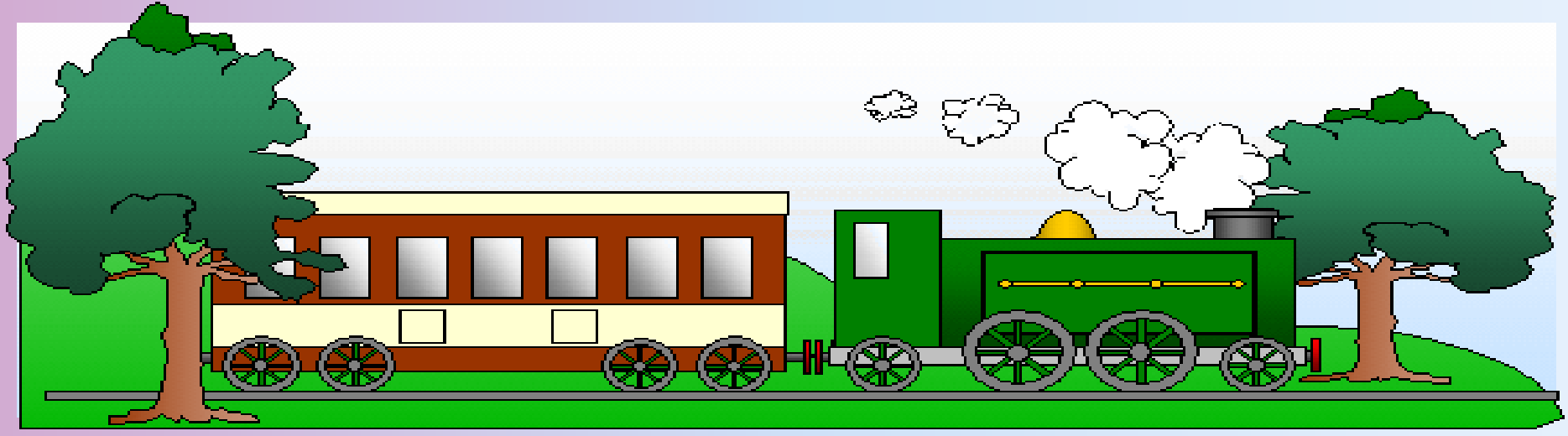
another car travels around a track for 20 km and ends up at the starting point.



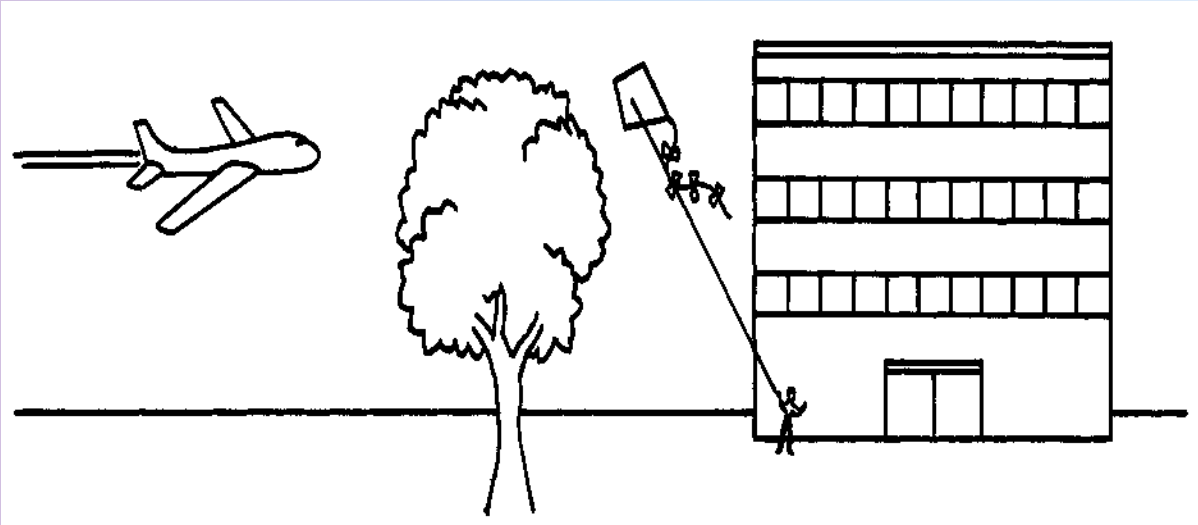
Both cars traveled a distance of 20 km but the first car's *displacement* is 20 km east while the second car's *displacement* is 0 km because it ended up where it started from.

Frame of reference

- To describe motion accurately and completely, a frame of reference is necessary.
- Frame of reference is a system of objects that are not moving with respect to one another.



- If you are standing beside the tree on the left what is moving?
- If you are on the train what is moving?
- If you are riding down the road on a buss is your friend moving beside you?
- Are the road signs moving?

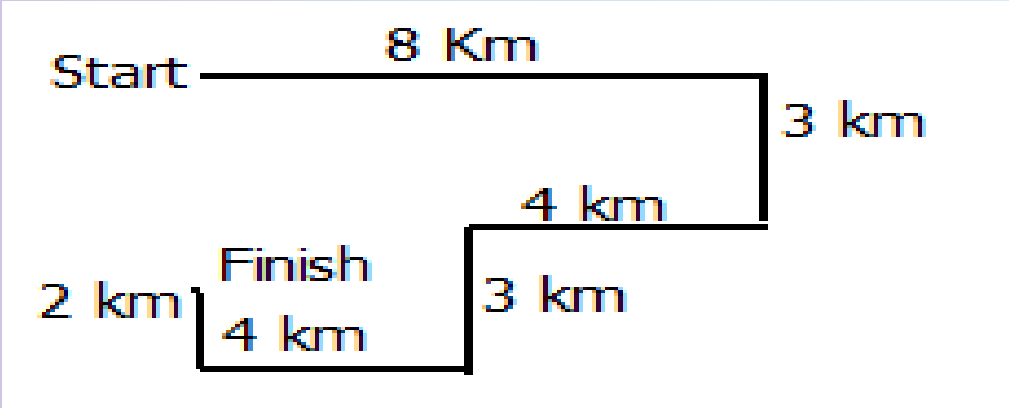


- If you are on the plane what is moving from your frame of reference?

- If you are beside the tree what is moving from your frame of reference?

Displacement vs. Distance

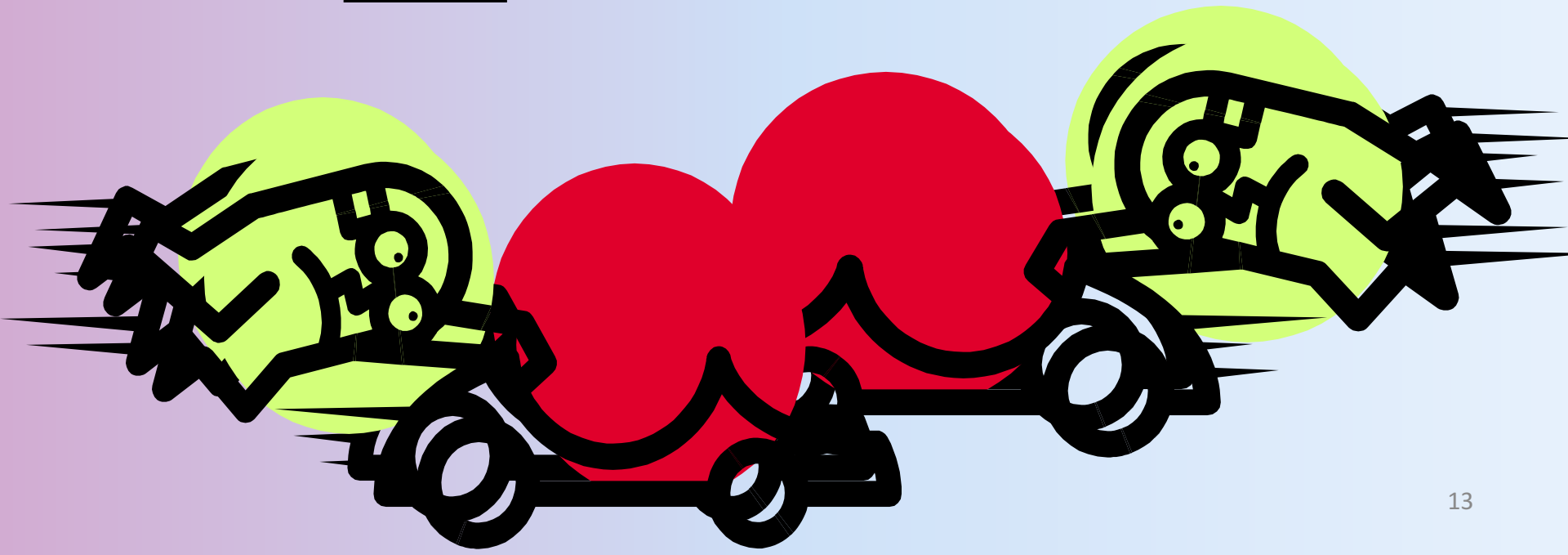
- Distance is the total length traveled
- Displacement is the distance measured directly from starting to stopping point.
  - What is the distance traveled on the path below?
  - What is the displacement?



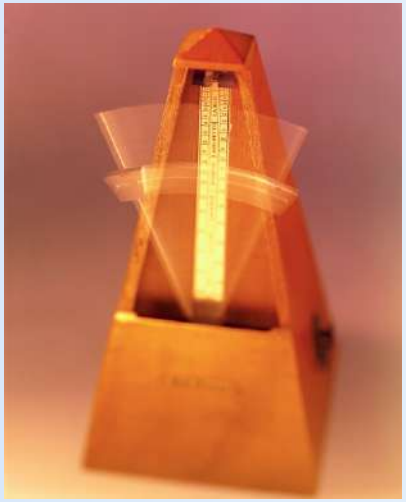
- A runner leaves his house and runs two blocks east, then three blocks south and finally 1 block west.
  - How far has the runner traveled?
  - What is his displacement?
- What is the distance traveled of a race car driver in the Indy 500?
- What is the displacement of a race car driver in the Indy 500?

Speed

How much time it takes for a change in position to occur or how fast something moves.



- Any change over time is called a rate.



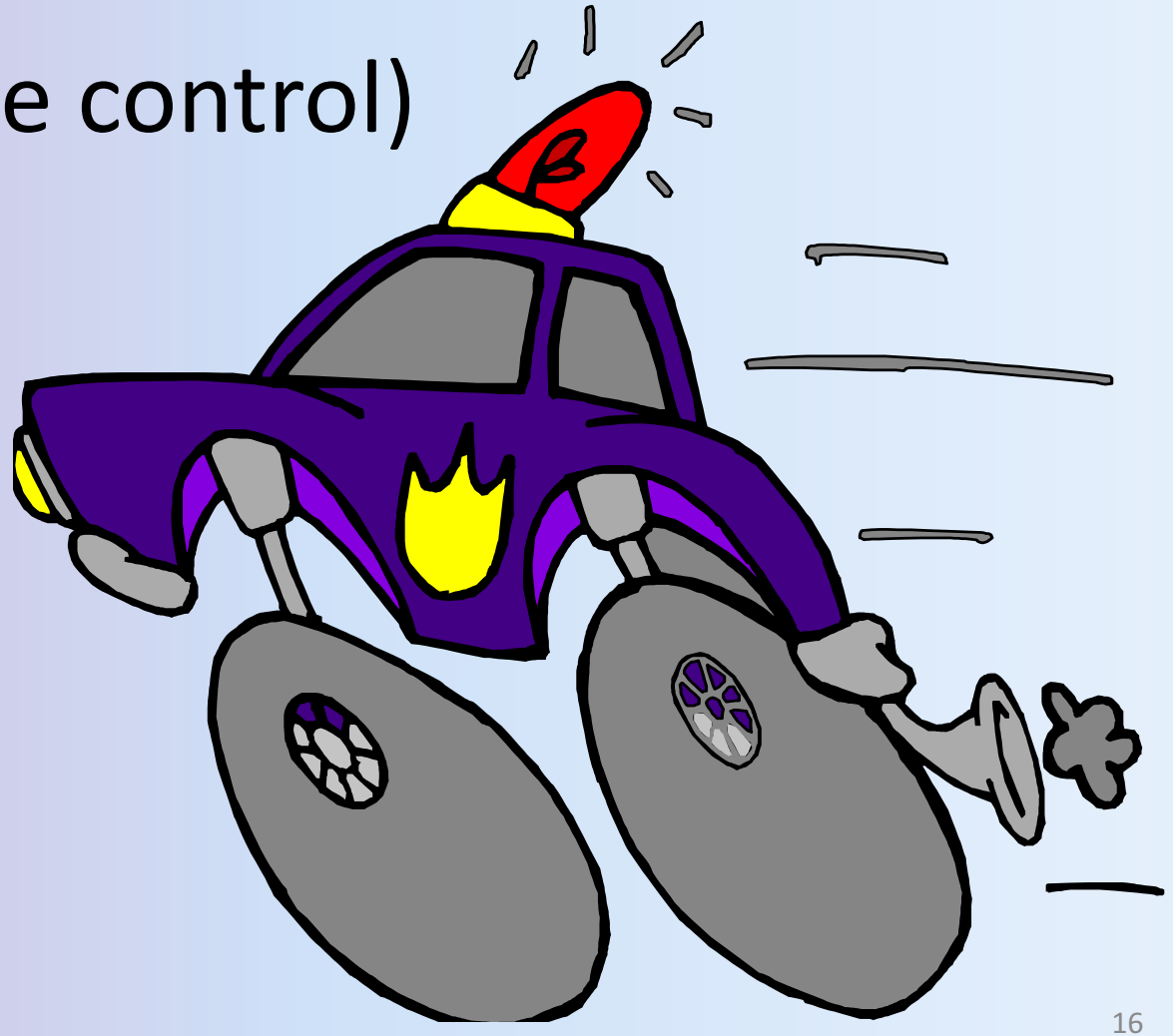
- Speed is the rate of change in position or the rate of motion.

Kinds of Speed

1. **Instantaneous**

   Speed – the rate of motion at any given instant. (speedometer)

2. Constant Speed – a speed that does not vary. (cruise control)

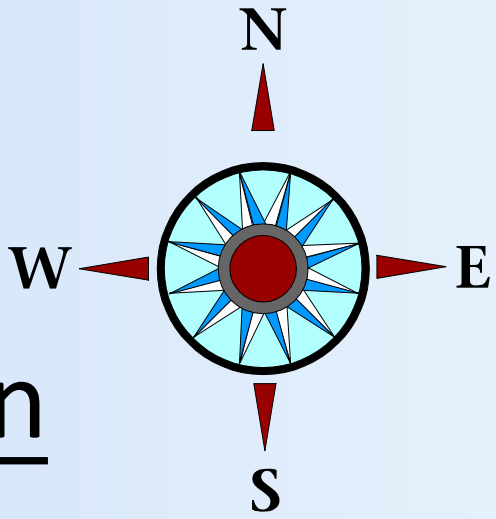


3. **Average Speed** – is the total distance traveled by total time of travel. (miles per hour)

Formula for speed:

$$s = \frac{d}{t}$$

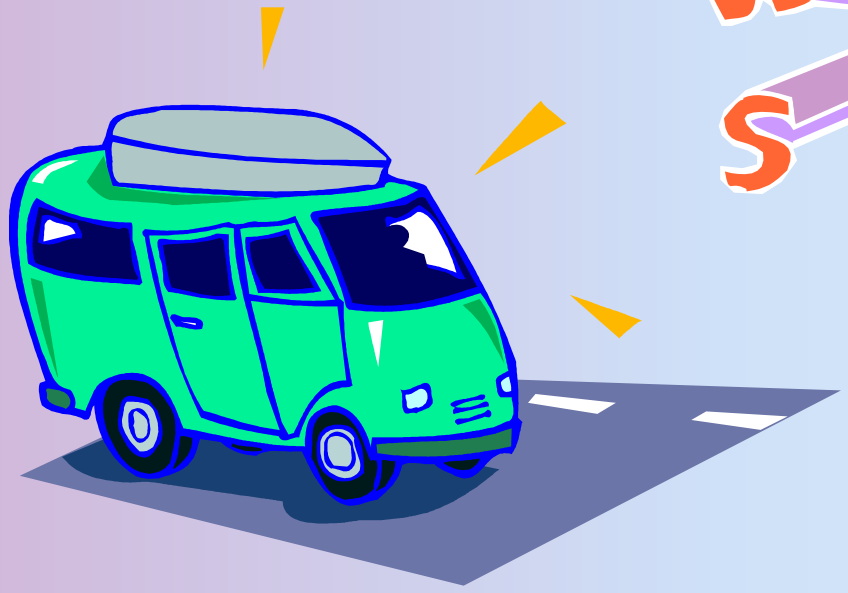
Velocity

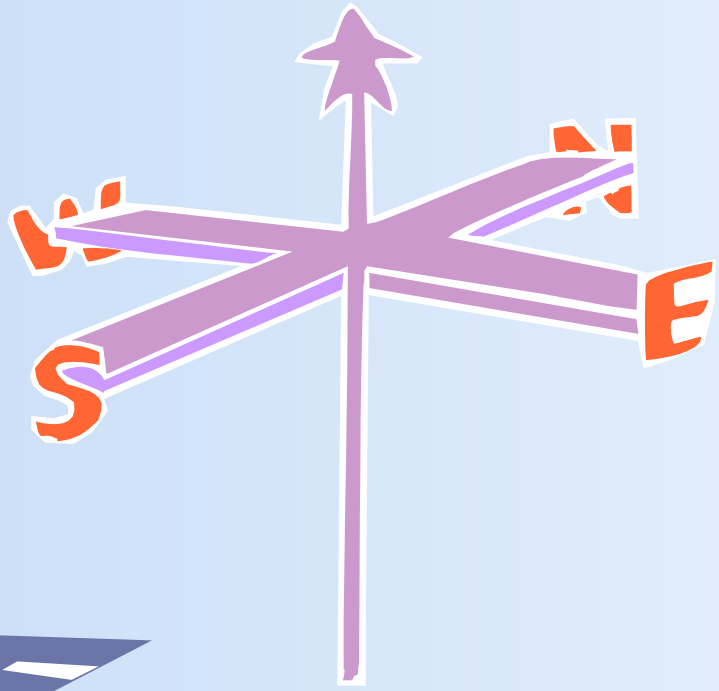


- is both speed and direction
- Like speed, velocity may change
- Unlike speed, the velocity can change while the speed stays constant (Because velocity includes both speed and direction, if either value changes, velocity will change)

Formula for velocity:

$$v = \frac{d}{t}$$ (in a certain direction)

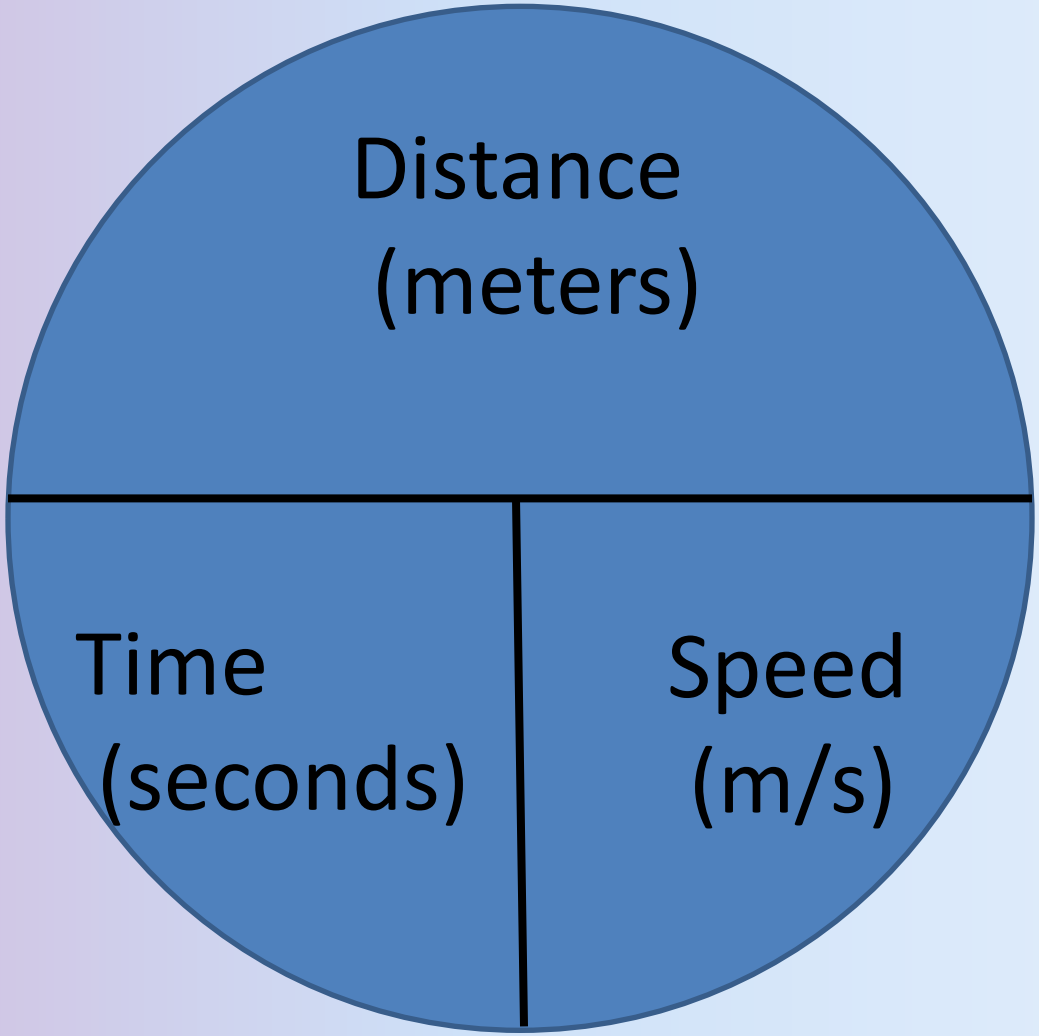




Terminal velocity

- the highest velocity that will be reached by a falling object.

Magic Circle with units



Velocity and speed

- Both are calculated by dividing distance by time.
  - Velocity = distance/time speed= distance/time
  - Velocity had a direction, speed does not.
  - UNITS of speed and velocity is meter/second or kilometer/hour

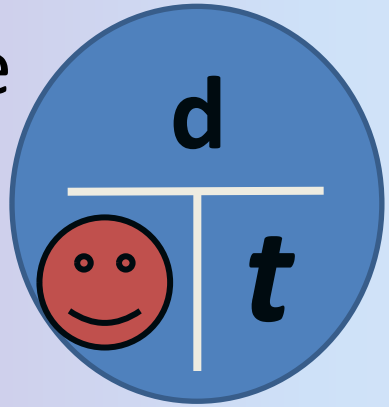
1. A runner ran 400 meters for 40 seconds. At what speed did he run?

Given:

400 m = distance

40 s = time

?? = speed



Solve

$$s = \frac{400m}{40s} =$$

S = 10 m/s

Velocity and Speed

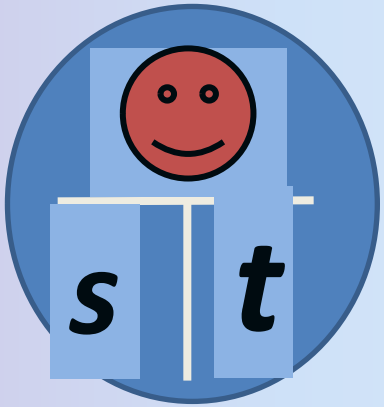
3. A runner traveling at 4.25 m/s will travel how far in 23 s?

Given:

4.25m/s = speed

23 s = time

?? = distance



Solve

$$d = 4.25\frac{m}{s} \times 23\ s =$$

d = 97.75 m

Velocity and Speed

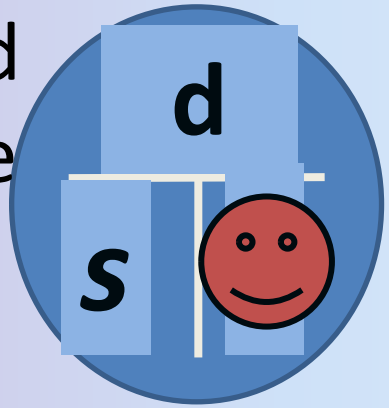
4. How long will it take a runner going 4.25 m/s to travel 50.0 meters?

Given:

4.25 m/s = speed

50.0m = distance

?? = time



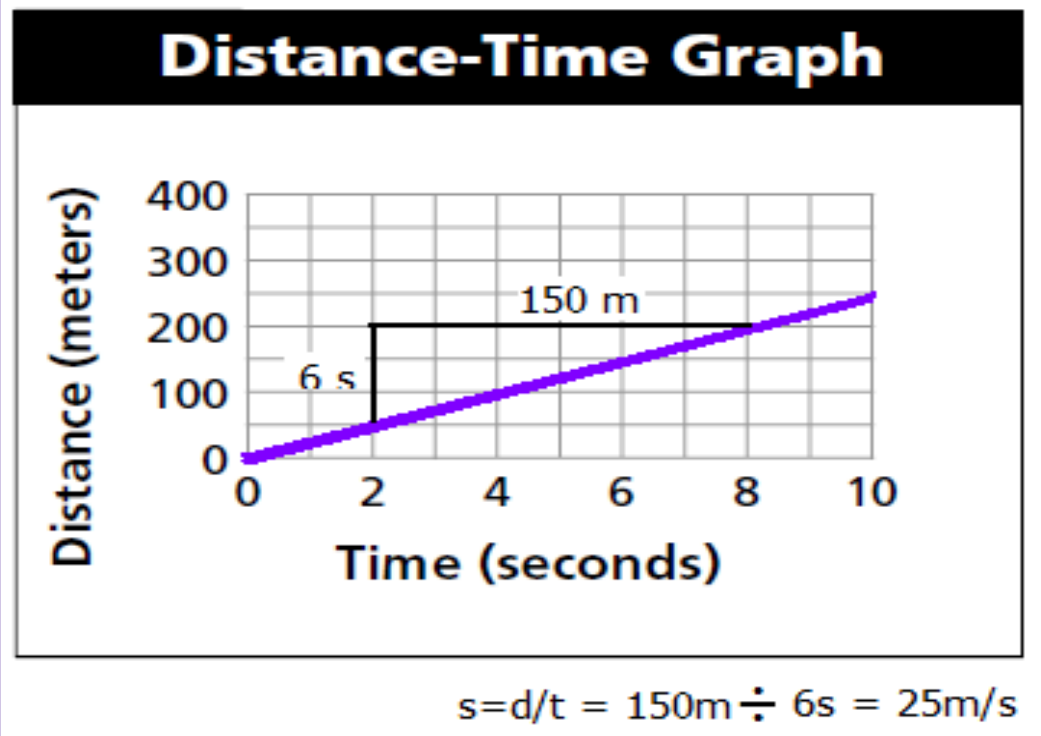
Solve

$$t = \frac{50.0\ m}{4.25\frac{m}{s}} =$$

t = 11.76 s

Graphing Speed

- A distance-time graph is a good way to describe motion
- **The slope of a line on a distance-time graphs is speed**

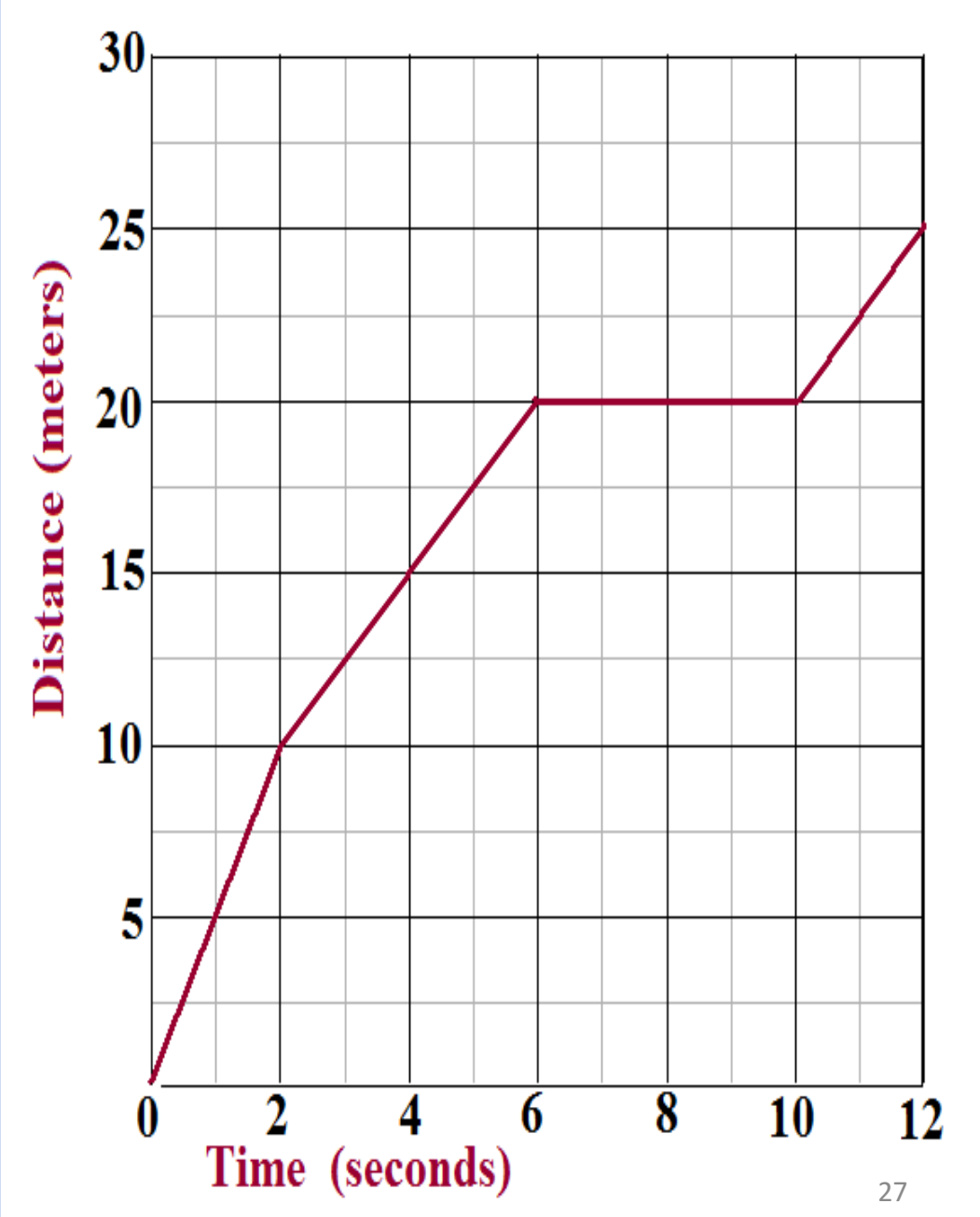


What is the objects average speed?

What is it's speed between 6s and 10 s?

When is it traveling the fastest?

When is it NOT moving?

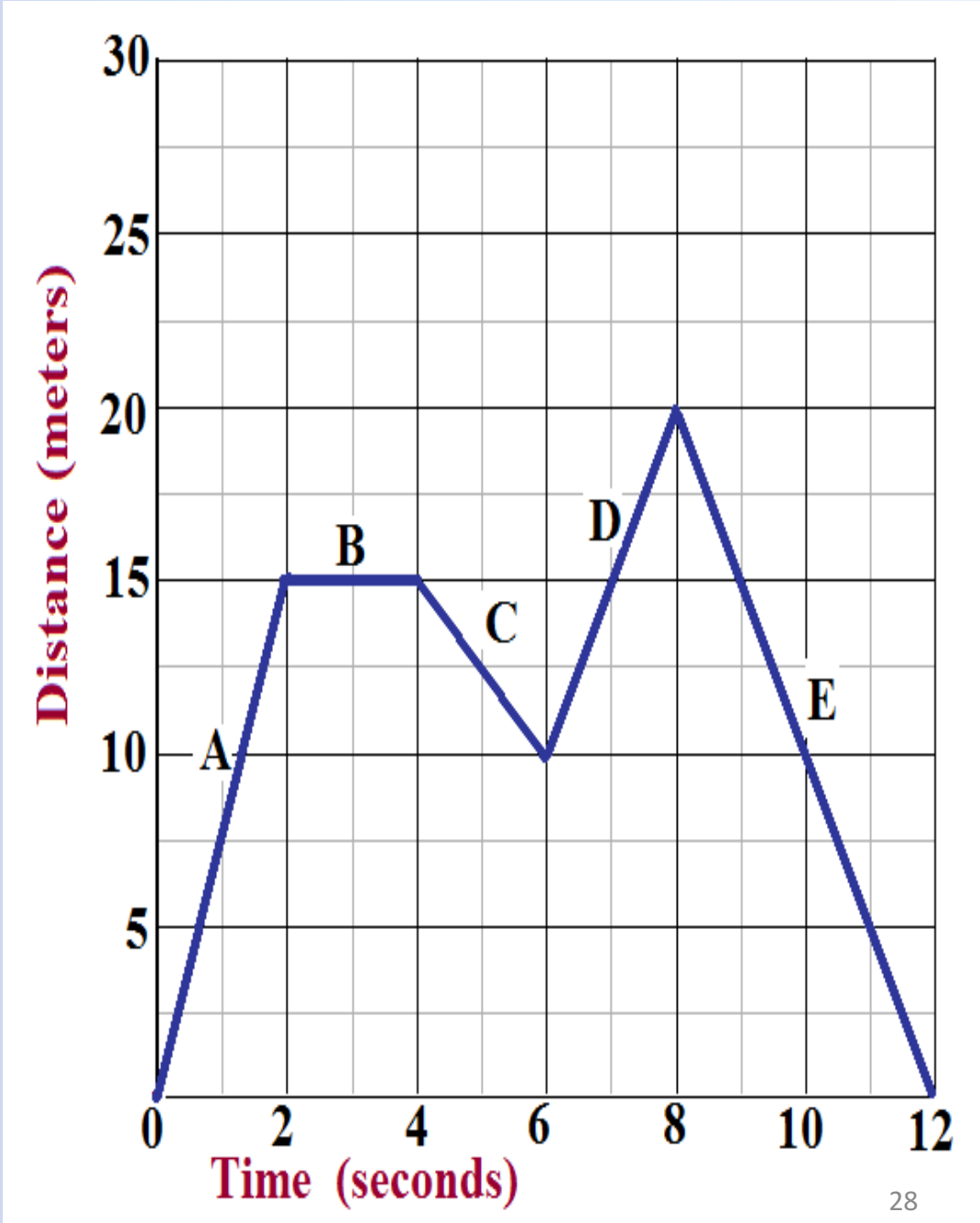


Where is the object standing still?

Where is the object traveling backwards?

Where is the object traveling at 5m/s?

What is speed at line E?



Acceleration

Acceleration

- the rate of change of velocity.
- Acceleration is both the rate of change in velocity and the direction of that change.
- So, even if an objects' speed remains constant acceleration occurs if the direction changes.

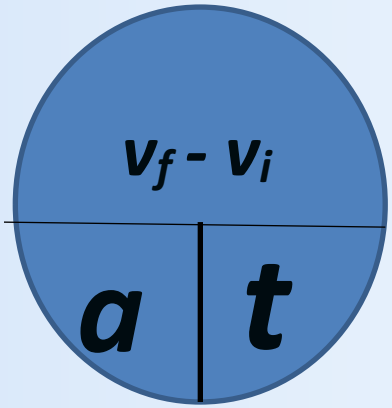
IF:

Acceleration (cont.)

- an object travels in a straight line acceleration is just the rate of change of speed.
- the acceleration is in the **same direction** as the velocity (change of direction) then the object speeds up.
- the acceleration is in the **opposite direction** from velocity then the object slows down.

To calculate average acceleration, divide the change in velocity by the time interval.

$$a = \frac{vf - vi}{t} = \frac{\Delta v}{t}$$



Where: a = average acceleration

vf = final velocity

vi = initial (starting) velocity

t = time

Δ = a greek symbol for delta (change) and it stands for "change in"

Δ v = change in velocity

Acceleration

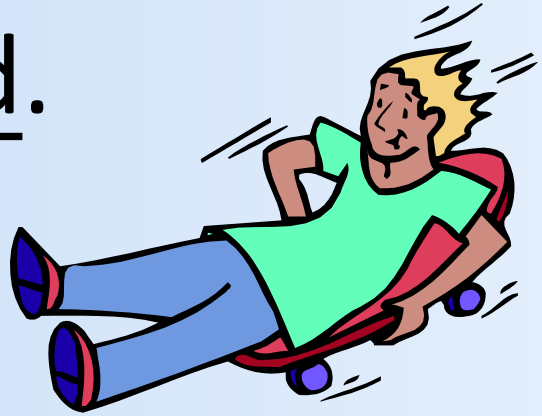
- The change in velocity over time.
- Or the change in speed or direction

- $$Acceleration = \frac{final\ velocity - inital\ velocity}{time}$$

Acceleration cont.

- If acceleration is **small** – speed change is <u>gradual</u>

- If acceleration is **large** – speed change is <u>rapid</u>.



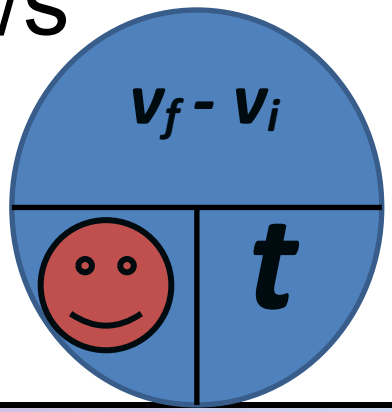
Acceleration cont.

- Positive acceleration = object is **speeding up**

- **Negative** acceleration = object is slowing down

D. Calculations

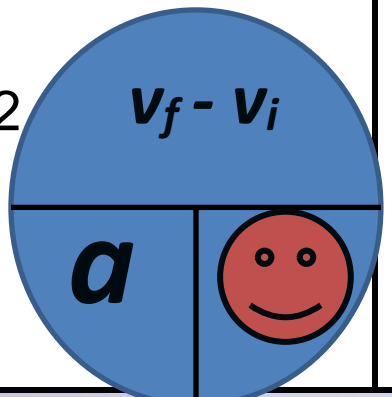
- A roller coaster starts down a hill at 10 m/s. Three seconds later, its speed is 32 m/s. What is the roller coaster's acceleration?

GIVEN:	WORK:
v_i = 10 m/s t = 3 s v_f = 32 m/s a = ? 	$a = (v_f - v_i) \div t$ a = (32m/s - 10m/s) ÷ (3s) a = 22 m/s ÷ 3 s **a = 7.3 m/s²**

D. Calculations

- How long will it take a car traveling 30 m/s to come to a stop if its acceleration is -3 m/s^2?

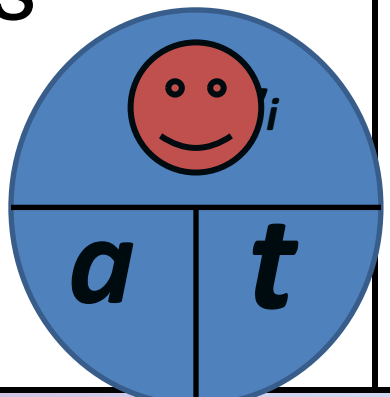
GIVEN:	WORK:
t = ? v_i = 30 m/s v_f = 0 m/s a = -3 m/s^2	$t = (v_f - v_i) \div a$ t = (0m/s-30m/s)÷(-3m/s^2) t = -30 m/s ÷ -3m/s^2 **t = 10 s**



D. Calculations

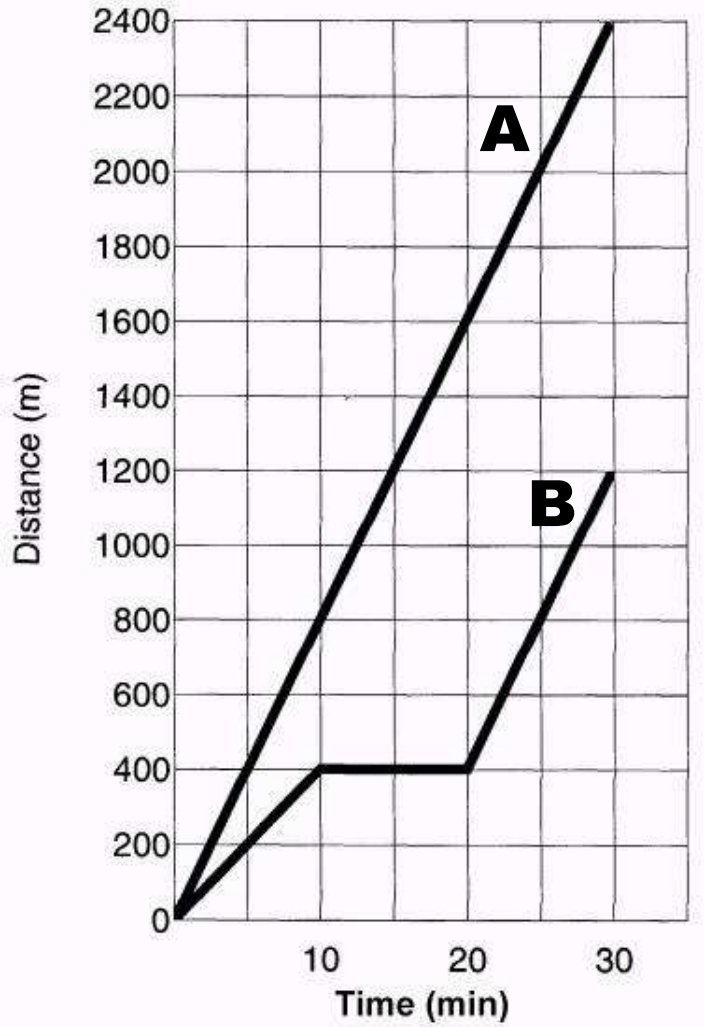
- What is the change in velocity if a truck acceleration is 25 m/s^2 over 4 seconds.

GIVEN:	WORK:
a = 25 m/s^2 t = 4 s Δv = ? m/s	Δv =4 s x 25 m/s^2 Δv = 100 m/s



E. Graphing Motion

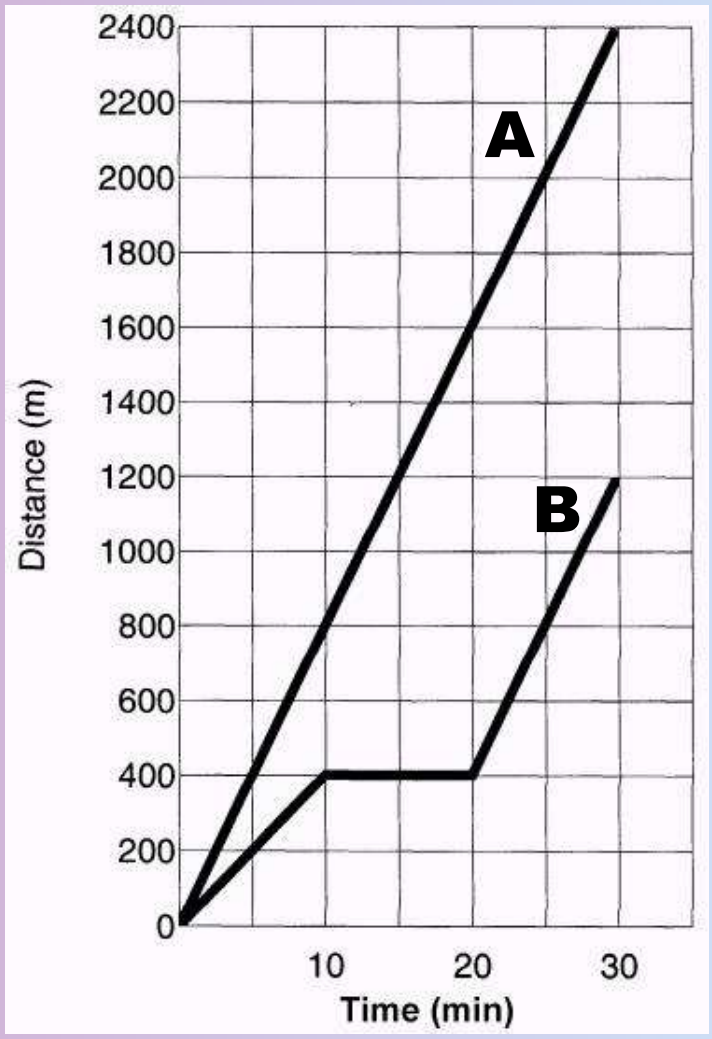
Distance-Time Graph



- slope = speed
- steeper slope = faster speed
- straight line = constant speed
- flat line = no motion

E. Graphing Motion

Distance-Time Graph



- Who started out faster?
  - A (steeper slope)
- Who had a constant speed?
  - A
- Describe B from 10-20 min.
  - B stopped moving
- Find their average speeds.
  - A = (2400m) ÷ (30min)
    A = 80 m/min
  - B = (1200m) ÷ (30min) B = 40 m/min

E. Graphing Motion

Distance-Time Graph

- Acceleration is indicated by a curve on a Distance-Time graph.

- Changing slope = changing velocity

E. Graphing Motion

Speed-Time Graph

- slope = acceleration
  - + = speeds up
  - - = slows down
- straight line = constant accel.
- flat line = no accel. (constant velocity)

E. Graphing Motion

Speed-Time Graph

Specify the time period when the object was...

- slowing down
  - 5 to 10 seconds
- speeding up
  - 0 to 3 seconds
- moving at a constant speed
  - 3 to 5 seconds
- not moving
  - 0 & 10 seconds