Chapter 11.1-11.2 Motion

Observing Motion

- **Motion**- an object's change in position relative to a reference point.

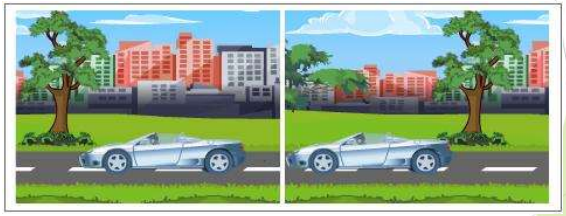
Frame of Reference

- **Frame of reference-** a system for specifying the precise location of objects in space and time.
  - Object that you assume is fixed in place

What do you use as a frame of reference?

Reference Frame

- The perception of motion depends on the observer's frame of reference
- Objects is in motion when object changes position with respect to a frame of reference.

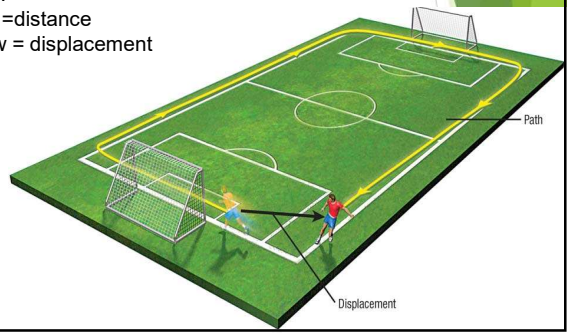


What objects in this picture can be used as frame of reference?

Displacement

- Displacement- the change in position of an object.
  - Always includes direction
  - Shorter than distance traveled

- In the diagram:
  - yellow line =distance
  - black arrow = displacement



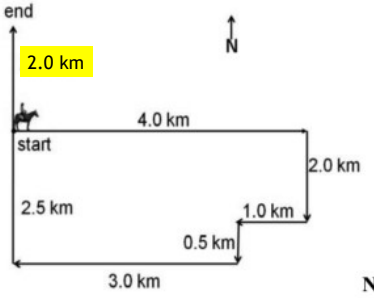
Video

Displacement vs Distance

For each set, create a scenario in which an object moves with the following displacement, distance, and move requirements. Your scenario may be written or drawn. Have your partner check your scenario.

Scenario #1	Scenario #2
• Distance = 150 meters • Displacement = 25 meters • Minimum of two moves	• Distance = 200 meters • Displacement = 150 meters • Minimum of three moves
Scenario #3	**Scenario #4**
• Distance = 280 meters • Displacement = 0 meters • Minimum of three moves • Two moves are in the same direction	• Distance = 525 meters • Displacement = 10 meters • Minimum of four moves • Two moves are in the same direction • Two moves are in opposite directions

Displacement



Note: The figure is not drawn to scale

1. A guy rides his horse for a couple of hours. When he is finished what is his total displacement?

Displacement vs Distance

Two soccer players, X and Y, are kicking a ball back and forth to each other.

The table below shows the distance and direction the ball moves after each of four kicks.

Kick	Player	Distance and Direction
1	X	5 m right
2	Y	4 m left
3	X	6 m right
4	Y	5 m left

1. What is the balls displacement?

5m + 6m to the right= 11 m to the right
4 m + 5 m to left = 9 m to the left

11m - 9m = 2 m

2. What is the balls total distance traveled? 5m + 4m + 6m + 5m = 20 m

Speed

- To describe motion you discuss speed
- Speed is the distance an object travels per unit of time

1. Constant speed-A moving object that doesn't change it's speed.

2. Average speed-total distance traveled per total time it took.
   - Speed is usually NOT CONSTANT

Constant speed or average speed?
1. Track Race
2. Walking with a friend
3. Hiking up and down a hill

Calculating Speed

- To calculate its speed you divide the distance it travels by the time it travels
- **Speed (S)** = distance traveled (d) / the amount of time it took (t).

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

Units for speed

- Depends, but will always be a distance unit / a time unit
  - Cars: mi/h
  - Jets: km/h
  - Snails: cm/s
  - Falling objects: m/s

Calculating speed Problems

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

- If I travel 100 kilometer in one hour then I have a speed of… **100 km/h**
- If I travel 1 meter in 1 second then I have a speed of…. **1 m/s**
- If a runner travels 100 meters in 10 seconds what was his average speed? **10 m/s**

Calculating Speed

- Speed = $\frac{\text{Distance}}{\text{Time}}$

You have to rearrange the formula

Formulas for the other pieces

- Distance = speed x time
- Time = $\frac{\text{Distance}}{\text{Speed}}$

Practice Problems

1. A car race is 500 km long. It takes the winner 2.5 hours to complete it. How fast was he going?

   $S = \frac{500\text{km}}{2.5\text{hours}}$ S=200 km/hour

2. It is 320 km to Las Vegas. If you average 80 km/hr, how long will it take you to get there?

   $t = \frac{320\text{km}}{80\ \text{km/hr}}$ t= 4 hours

3. You are going on a trip. You average 80 km/hr for 6 hours. How far did you go?

   d= (80km/hr) x 6 hrs d= 480 km

Think about it!!!!!!!!!

Explain why knowing the velocity of an airplane is more important to a traveler than knowing only the airplane's speed.

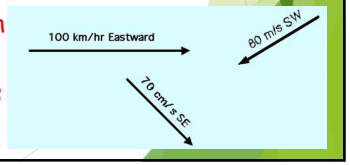
Velocity

Formula: Velocity = Distance with a direction/Time

or

Velocity= Displacement/Time

- **Velocity** – The distance an object travels in a certain period of time in a specific direction.
  - May be + or –
  - It is more precise for describing motion
  - Example:
    - An airplane moving North at 500 mph
    - A missile moving towards you at 200 m/s



Velocity

- People often use the word speed when they mean velocity
  - Speed tells how fast an object moves
  - Velocity tells both speed and direction

Speed= 40 km/hr
Velocity= 40 km/hr west

- <u>Velocity can change in two ways</u>
  - Change speed
  - Change directions

Velocity

How would the cheetahs velocity change?

Practice Problems:

1. Young male cheetah covered 100 meters east in 7.19 seconds in a timed run. What is his velocity?

V=
D=
T=

V= d/t V= 100m/7.19 s **13.9 m/s east**

2. It took 3.5 hours for a train to ravel the distance between two cities at a velocity of 120 km/hr. How many kilometers lie between the two cities?

V=
D=
T=

D= v x t D= 120km/hr x 3.5 hr

420 km

1. What is the speed of a skater who travels a distance of 210 m in a time of 10 seconds?

2. What is the speed in m/s of a skater who travels a distance of 210 m in a time of 30 seconds?

3. How far can a person run in 10 minutes at a speed of 260 m/min?

4. How far can a person run in .25 hr at a speed of 240 m/hr?

5. A bus traveled at a constant speed of 80 km/h. How long did it take the bus to travel 40 km?

6. A bus traveled at a constant speed of 80 km/h. How long did it take the bus to travel 400km?

7. Metal stakes are sometimes placed in glaciers to help measure a glacier's movement. For several days in 1936, Alaska's Black Rapids glacier surged as swiftly as 89 m per day down the valley. Find the glacier's velocity in meters per second (be sure to include the direction of motion).

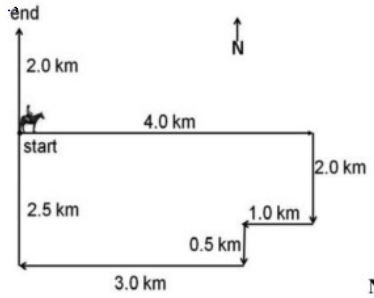
8. Find the velocity in meters per second of a swimmer who swims exactly 110 m toward the shore in 72 s.

9. A baseball is pitched with a speed of 35 m/s. How long does it take the ball to travel 18.4 m from the pitcher's mound to home plate?

10. Find the velocity in meters per second of a baseball thrown 38 m from third base to first base in 1.7 s.

Velocity= Distance/Time

It took the rider 3 hours to check on his entire land.



Velocity= ?
Time= 3 hrs
Distance= 15 km

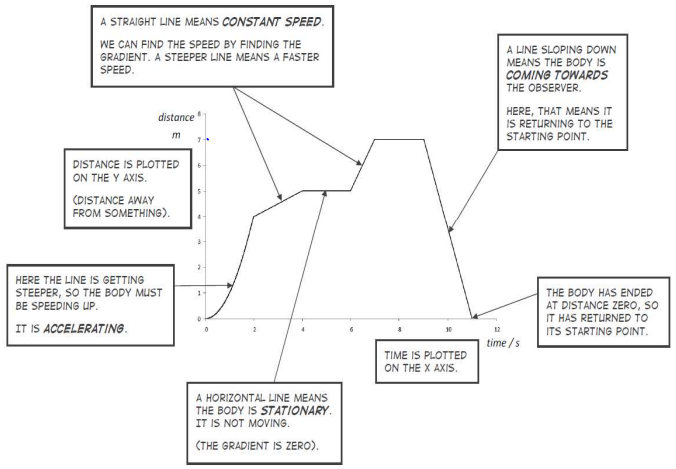
Note: The figure is not drawn to scale

What is his velocity?

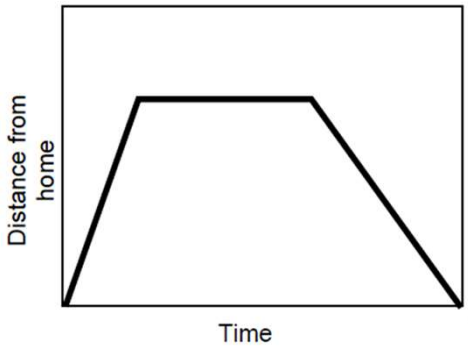
What is the difference between speed and velocity?

Both describe how fast motion is happening. Velocity gives a direction (+/-) as well.

THE ANATOMY OF A DISTANCE-TIME GRAPH



Write a brief story to go along with this distance-time graph.

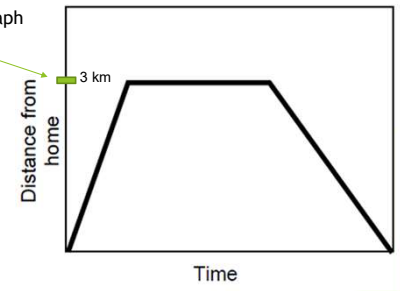


What is the total distance traveled by the object in this graph? 6km

What is the object's displacement? 0

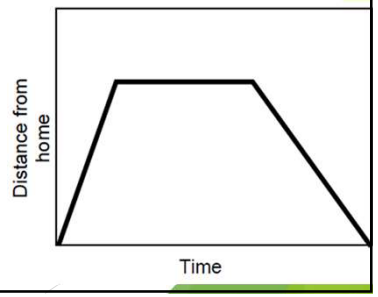
What is the frame of reference? Home

Add the 3km to your graph



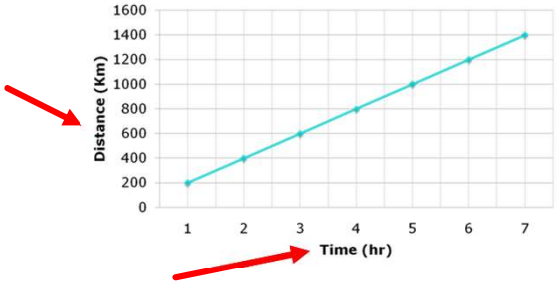
Question

- What does the slope of a distance vs. time graph show you about the motion of an object?
- It tells you the SPEED



How does this graph display speed?

The object is moving at a constant speed.

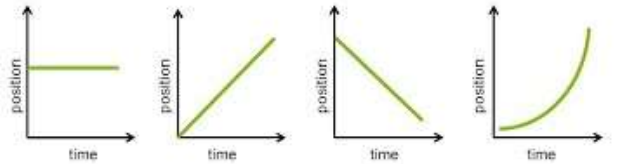


- How do you know?

The line is moving up at a constant slope

Distance vs Time Graph Motion

Slope of distance-Time graph = velocity over that interval of time



Slope is zero
∴velocity is zero
(object at rest)

Slope is positive
∴velocity is constant, positive

Slope is negative
∴velocity is constant, negative

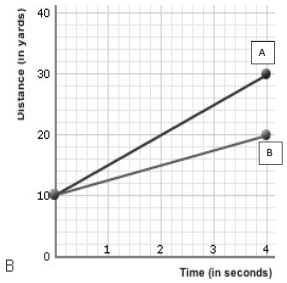
Slope is curve
∴velocity is **not** constant
(object accelerating)

The steeper the slope, the higher the speed (value of velocity)

Distance vs. Time Graphs

Slope = $\frac{y_2 - y_1}{x_2 - x_1}$ = $\frac{\text{change in distance}}{\text{change in time}}$

Use the slope equation to calculate the slope of each graph.



A= Slope = $\frac{30\text{yrd} - 10\text{ yrd}}{4\text{ s} - 0\text{s}}$

Slope = $\frac{20\text{ yrd}}{4\text{s}}$

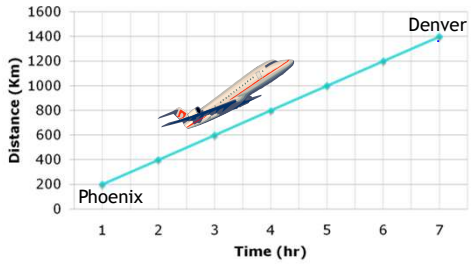
Slope= 5 yrd/s

B= Slope = $\frac{20\text{yrd} - 10\text{ yrd}}{4\text{ s} - 0\text{s}}$

Slope = $\frac{10\text{ yrd}}{4\text{s}}$

Slope= 2.5 yrd/s

Distance vs. Time Graphs



Slope = $\frac{y_2 - y_1}{x_2 - x_1}$ = $\frac{\text{change in distance}}{\text{change in time}}$

What is the slope for this graph?

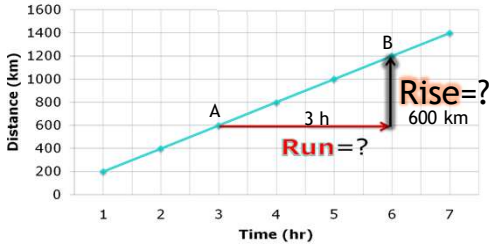
A= Slope = $\frac{1400\text{ km} - 200\text{ km}}{7\text{ hr} - 1\text{hr}}$

Slope = $\frac{1200\text{ km}}{6\text{ hr}}$

Slope= 200 km/hr

Distance vs. Time Graphs

Speed = Slope = Rise/Run



What is the slope for this graph?

A= Slope = $\frac{1200 \text{ km} - 600 \text{ km}}{6 \text{ hr} - 3 \text{hr}}$

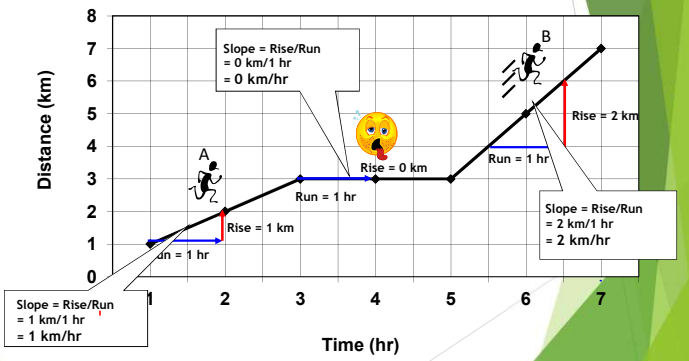
Slope = $\frac{y_2 - y_1}{x_2 - x_1}$ = $\frac{\text{change in distance}}{\text{change in time}}$

Slope = $\frac{600 \text{ km}}{3 \text{ hr}}$

Slope= 200 km/hr

Different Slopes

Speed = Slope = Rise/Run

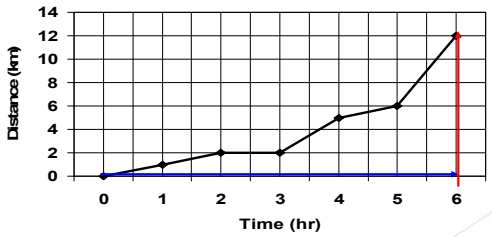


How do you figure out average speed?

- Use very 1st point and Last point on the graph.

Average Speed = Total distance/Total time

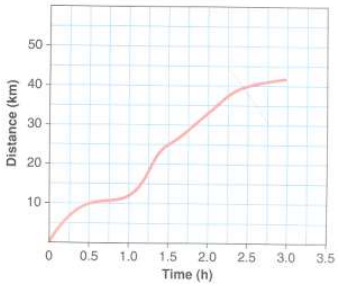
Average Speed= 12 km/6 hr= **2 km/hr**



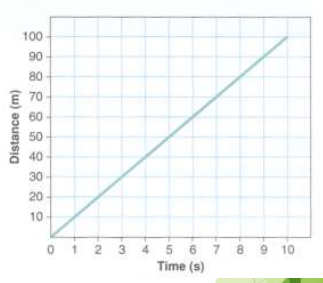
Rise = 12 km

Run = 6 hr

- Why are these graphs different?
- How was the motion different?



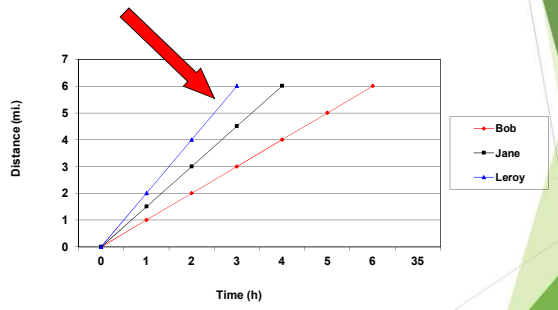
Average speed



Constant Speed

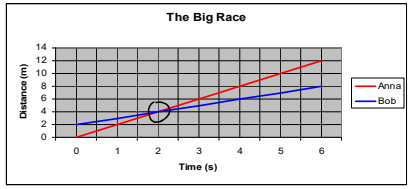
Question

- Below is a distance vs. time graph for 3 runners. Who is the fastest?



Leroy is the fastest. He completed the race in 3 hours

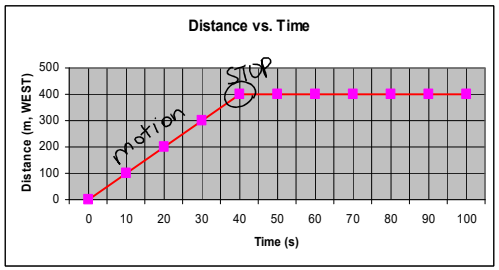
Interpreting Position-Time Graphs



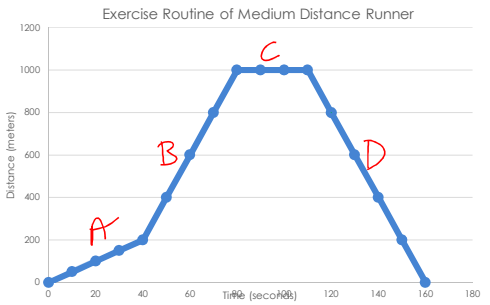
1. Who has the greater velocity? Anna
2. Who starts ahead of the starting line? Bob
3. What happens at 2 seconds? Anna passes Bob

35

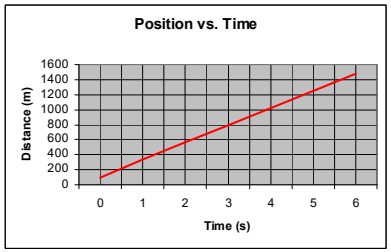
Describe what is happening in this graph.



Describe the routine of this runner



Use the Graph to Calculate Velocity



V=
d=
t=

V=?
d=1500 m
t=6 s

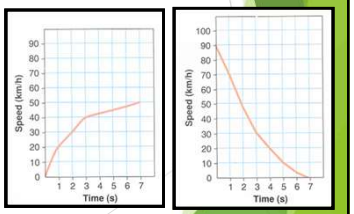
V= d/t

V= 1500m /6s

V= 250 m/s

Acceleration

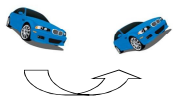
- Any change in velocity is acceleration, even if the speed of the object remains the same.
- **Acceleration** - the rate at which velocity changes
  - Can be an:
    - Increase in speed
    - Decrease in speed
    - Change in direction



Types of acceleration

- Increasing speed
  - Example: Car speeds up at green light

- Decreasing speed
  - Example: Car slows down at stop light
- Changing Direction
  - Example: Car turns right(can be at **constant speed)**



Question

- How can a car be accelerating if its speed is a constant 65 km/h?
- If it is changing direction

Calculating Acceleration

- If an object is moving in a straight line
  - You can calculate acceleration, by substrate the difference between final speed and initial speed. Then divide by time
- Units of acceleration: m/s^2

$$\text{Acceleration} = \frac{\text{Final Speed}(V_f) - \text{Initial Speed}(V_i)}{\text{Time}}$$

$$a = \frac{(V_f)-(V_i)}{\text{Time}}$$

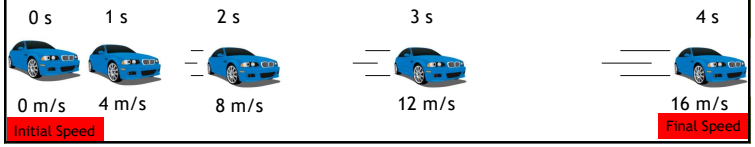
$$a = \frac{\Delta v}{t}$$

Calculating Acceleration

- Lets practice

$$\text{Acceleration} = \frac{\text{Final Speed}(V_f) - \text{Initial Speed}(V_i)}{\text{Time}}$$

$a = \frac{\Delta v}{t}$ $a = \frac{16\ m/s - 0\ m/s}{4s}$ $a = \frac{16\ m/s}{4s}$ $a = 4\ m/s^2$



Practice Problem:

1. A skydiver accelerates from 20 m/s to 40 m/s in 2 seconds. What is the skydiver's average acceleration?

Givens	Unknown	Equation (rearranged to solve for unknown)	Setup	Solve (include the correct unit with your answer)
$V_f = 40$ m/s $V_i = 20$ m/s t= 2 sec	a= ?	$a = \frac{(V_f) - (V_i)}{\text{time}}$	$a = \frac{40m/s - 20\ m/s}{2s}$ $a = \frac{20\ m/s}{2s}$	$a = 10 m/s^2$

Acceleration Practice Problems

2. Natalie accelerates her skateboard along a straight path from o m/s to 4.0 m/s in 2.5 s. Find her average acceleration.

Final speed (V_f)= 4.0 m/s
Initial speed (V_i) = 0 m/s
Time=2.5s
a = ?

$a = \frac{4.0\ m/s - 0\ m/s}{2.5\ s}$ $a = 1.6\ m/s^2$

3. A turtle swimming in a straight line toward shore has a speed of 0.50 m/s. After 4.0s, its speed is 0.80 m/s. What is the turtle's average acceleration?

$V_f = 0.80$ m/s
$V_i = 0.50$ m/s
Time= 4.0 s
a = ?

$a = \frac{0.80\ m/s - 0.50\ m/s}{4.0\ s}$ $a = 0.075\ m/s^2$

4. Haley's car accelerates at an average rate of 1.2 m/s^2. How long will it take her car to speed up from 14.3 m/s to 19.6 m/s?

$V_f = 19.6$ m/s
$V_i = 14.3$ m/s
Time= ?
a= 1.2 m/s^2

$t = \frac{\Delta V}{a}$ $t = \frac{19.6\ m/s - 14.3\ m/s}{1.2\ m/s^2}$ $t = 4.42$ s

Acceleration Practice Problems

5. Tom is driving down I-75. He notices a police officer and slows down from 81 m/s to 62 m/s in 5.0 s. Calculate his acceleration.

V_f = 62 m/s
V_i = 81 m/s
T= 5.0 s
a= ?

$a = \frac{62\ m/s - 81\ m/s}{5.0\ s}$ $a = \frac{-19\ m/s}{5.0\ s}$ $a = -3.8\ m/s^2$

6. A car travels at a constant velocity of 15.1 m/s westward and then speeds up with a steady acceleration of 6.2 m/s^2. Calculate the car's speed after accelerating for 8.0 s.

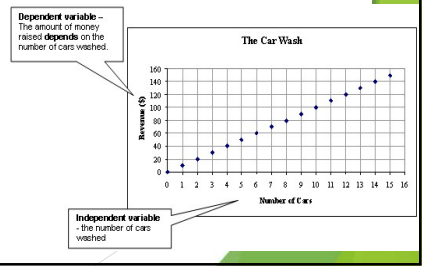
V_f = ?
V_i = 15.1m/s
T= 8.0 s
a= 6.2 m/s^2

$V_f = V_i + at$ $V_f = 15.1\ m/s + (6.2\ m/s^2 \times 5.0\ s)$

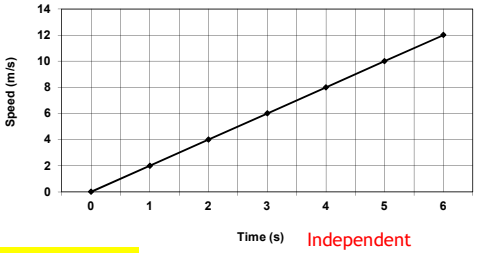
$V_f = 16\ m/s$

Graphing Acceleration

- Can use 2 kinds of graphs
  - Speed vs. time
  - Distance vs. time
- Dependent variable= y-axis
- Independent variable=x-axis



Graphing Acceleration: Speed vs. Time Graphs



Dependent variable

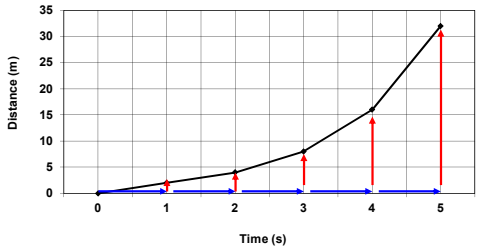
Independent Variable

How is the object moving?

1) Speed is increasing with time = accelerating
2) Line is straight = acceleration is constant

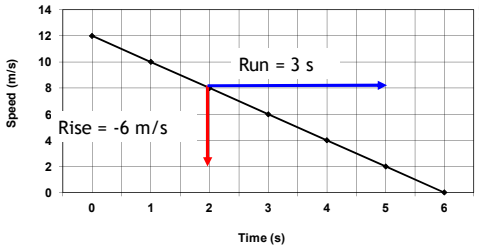
* The object is increasing speed, but at a constant rate.

Graphing Acceleration: **Distance** vs. Time Graphs



1) **On Distance vs. Time graphs a curved line means the object is accelerating.**
2) Curved line also means your speed is increasing. Remember slope = speed.

The graph is showing the speed of a car over time.

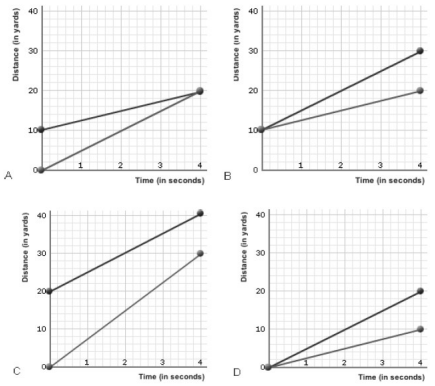


1) How is the speed of the car changing (speeding up, slowing down, or staying the same)? 1) The car is slowing down

2) What is this car's acceleration?

$a = \frac{(V_f) - (V_i)}{time}$ $a = \frac{-6\ m/s}{3s}$ **$a = -2\ m/s^2$**

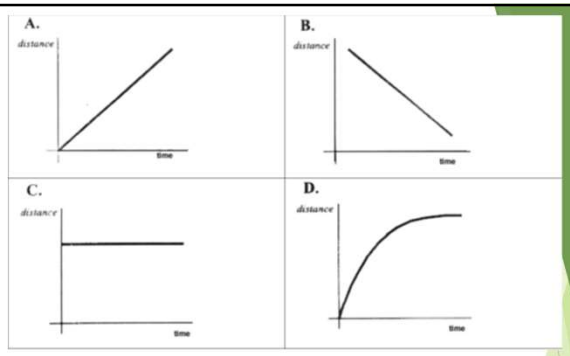
Examine the following Distance vs Time Graphs.



1. Which of the graphs shows that one of runners started 10 yards further ahead of the other? Explain

2. In which of the following graphs below are both runners moving at the same speed? Explain

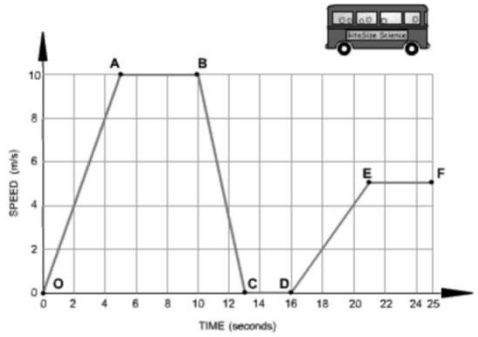
3. In which of the following graphs below are both runners moving at the same speed? Explain



Use the graphs above to help match the following statements with the descriptions provided underneath them. State why

Graph A matches description 2
Graph B matches description 4
Graph C matches description 1
Graph D matches description 3

Descriptions:
1. The car is stopped.
2. The car is traveling at a constant speed.
3. The speed of the car is decreasing.
4. The car is coming back.



Choose the correct words from the following list to describe the motion during each segment of the journey to fill in the blanks.

- accelerating: O to A D to E
- decelerating: B to C
- constant speed: E to F A to B
- at rest: C to D

Motion Concepts

Susan ran around the track four times for a distance of 1 mile in 6 minutes. Note: She started and stopped at the same point. Someone yelled, "Way to hustle, Susan! That's great speed. But, your displacement is zero!"

A group of friends meet at the front entrance of the mall. They spend the next 2 hours walking around the mall. One of the friends' wrist monitors says they walked a distance of 4.2 miles. When they return to the front entrance of the mall, their displacement is zero.

**** What is the difference between distance and displacement?**

Motion Concepts

	Speed	Velocity
Susan (1 mile in 6 min)	0.167 mile/minute	0 mile/minute around the track
David	55 mph	55 mph North
Jaguar	70 mph	70 mph toward his prey
Elephant	25 mph	25 mph out of the jungle
Space-X Rocket	7.9 km/s	7.9 km/s away from Earth

**** What is the difference between speed and velocity?**