Chapter 11.1-11.2 Motion/Acceleration

Observing Motion

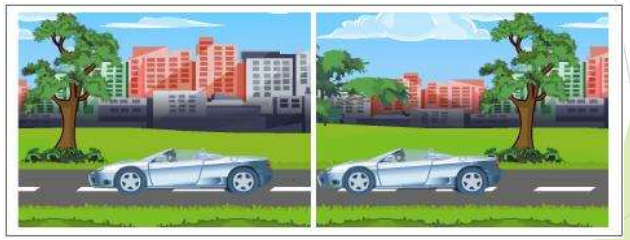
- **Motion**- an object's change in position relative to a reference point.

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

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.

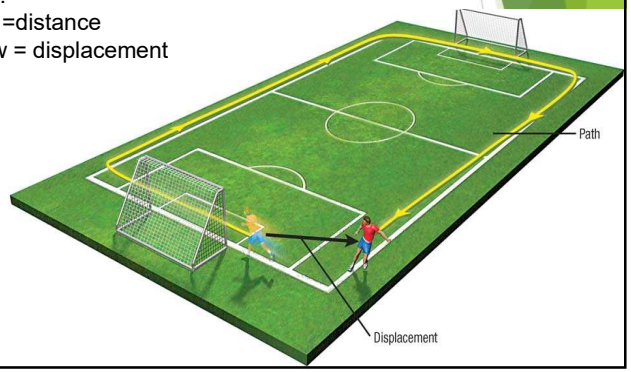


What objects in this picture can be used as frame of reference?

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

Speed

- To describe motion you discuss speed
- Speed is the distance an object travels per unit of time
- Constant speed-A moving object that doesn't change it's speed.
- 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).

$$S = d/t$$

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

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?

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

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

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

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

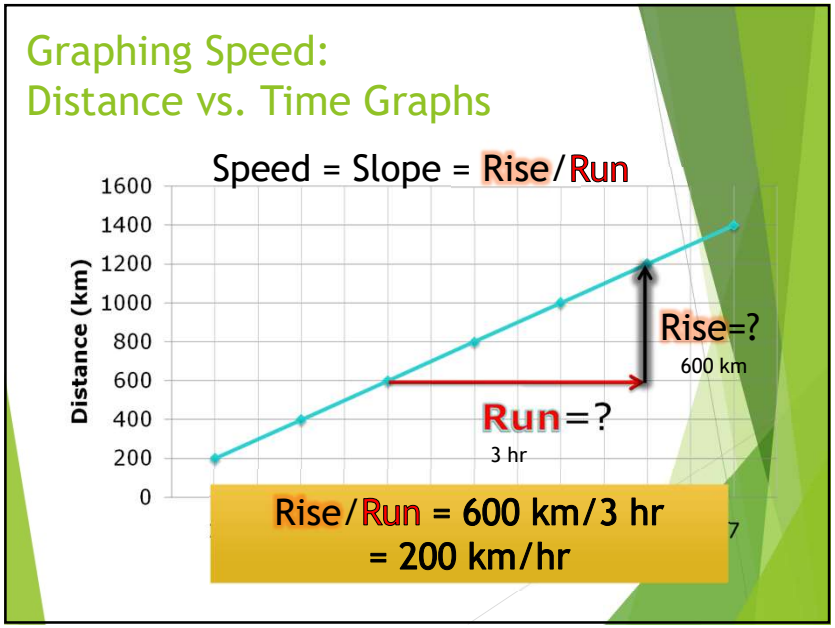
$$d = (80\text{km/hr}) \times 6\ \text{hrs} \qquad d = 480\ \text{km}$$

Velocity

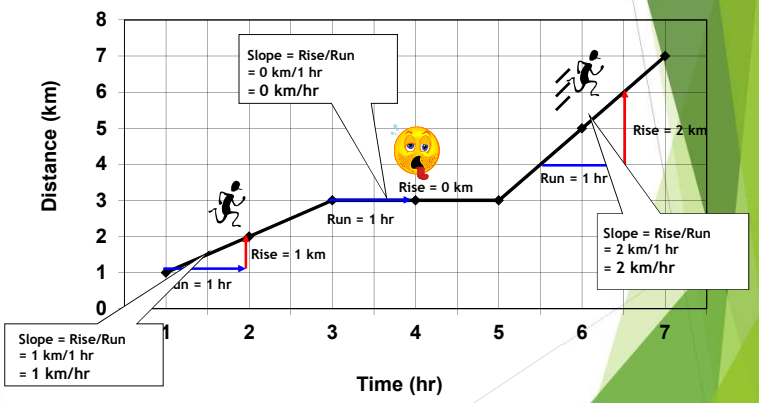
- **Velocity** – the SPEED and DIRECTION of an object.
  - It is more precise for describing motion
  - Example:
    - An airplane moving North at 500 mph
    - A missile moving towards you at 200 m/s
- People often use the word speed when they mean velocity
  - Speed tells how fast an object moves
  - Velocity tells both speed and direction

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

Graphing Speed: Distance vs. Time Graphs



Different Slopes



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

Calculating Acceleration

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

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

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

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

Practice Problem:

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

$$\text{Acceleration} = \frac{\text{Final Speed} - \text{Initial Speed}}{\text{Time}}$$

$$= \frac{40\text{m/s} - 20\text{ m/s}}{2\text{s}}$$

$$= \frac{20\text{ m/s}}{2\text{s}}$$

$$= 10\text{m/s}^2$$

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 = ?

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

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 = ?

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

4. Mai's car accelerates at an average rate of 2.6 m/s^2. How long will it take her car to speed up from 24.6 m/s to 26.8 m/s?

$V_f = 26.8$ m/s
$V_i = 24.6$ m/s
Time= ?
a= 2.6 m/s^2

$t = \frac{\Delta V}{a}$ $t = \frac{26.8\text{ m/s} - 24.6\text{ m/s}}{2.6\text{ m/s}^2}$ $t = 0.85$ 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
Time= 5.0 s
a= ?

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

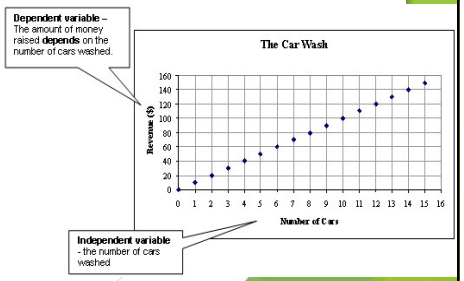
6. A cyclist travels at a constant velocity of 4.5 m/s westward and then speeds up with a steady acceleration of 2.3 m/s^2. Calculate the cyclist's speed after accelerating for 5.0s.

$V_f = V_i + at$ $V_f = 4.5\ m/s + (2.3\ m/s^2 \times 5.0\ s)$ $V_f = 16\ m/s$

Graphing Acceleration

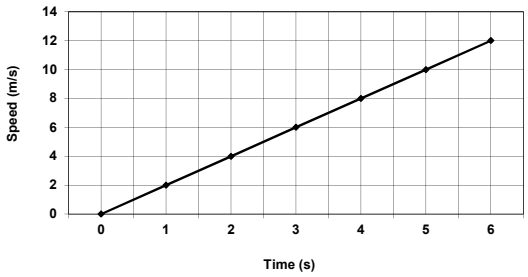
- Can use 2 kinds of graphs
  - Speed vs. time
  - Distance vs. time

- Dependent variable= y-axis
- Independent variable=x-axis



Graphing Acceleration: Speed vs. Time Graphs

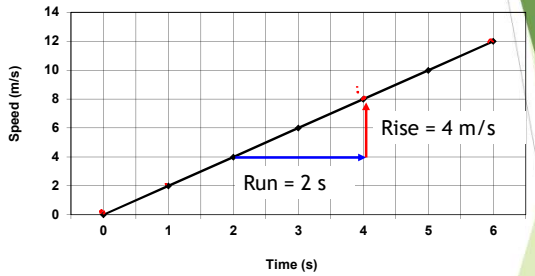
Dependent variable



Independent Variable

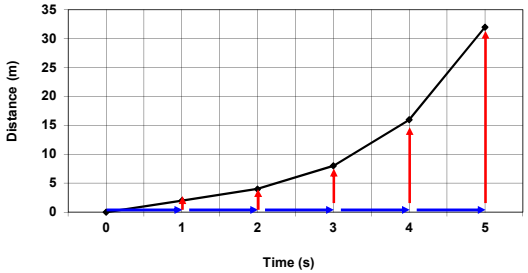
1) Speed is increasing with time = accelerating
2) Line is straight = acceleration is constant

Graphing Acceleration: Speed vs. Time Graphs



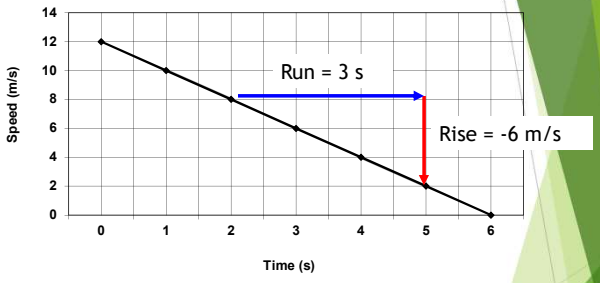
1) In Speed vs. Time graphs:
Acceleration = Rise/Run
Find the acceleration
= 4 m/s ÷ 2 s = **2 m/s^2**

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.

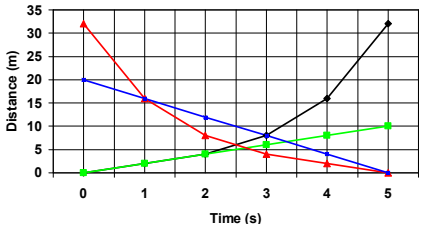
Question



Above is a graph 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)?
2) What is this car's acceleration?

1) The car is slowing down
2) Acceleration = rise/run = -6m/s ÷3s = **-2 m/s²**

Question:



The **black and red lines** represent a objects that are accelerating. Black is going a greater distance each second, so it must be speeding up. Red is going less each second, so must be slowing down

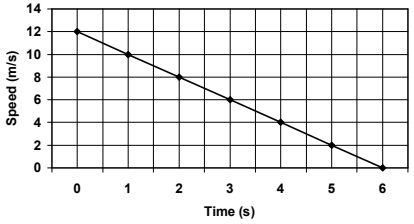
Remember: in distance vs. time graphs:

curved line = accelerating, flat line = constant speed

1) **Which line represents an object that is accelerating?**

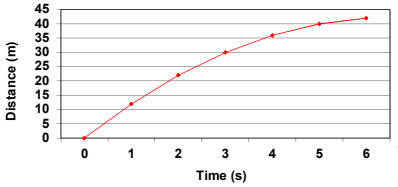
The black and green lines

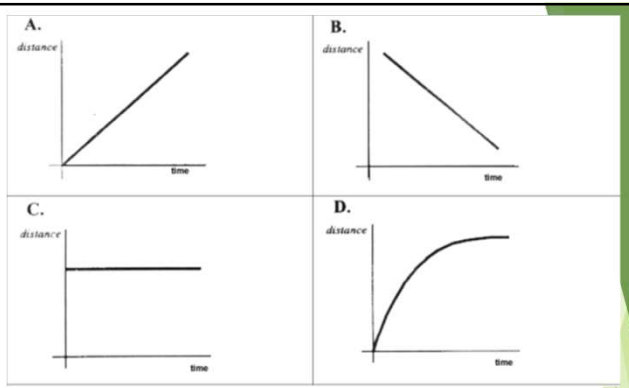
Question: Hard one (Draw)



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

1)What would a distance vs. time graph for this look like? It looks like the graph below.

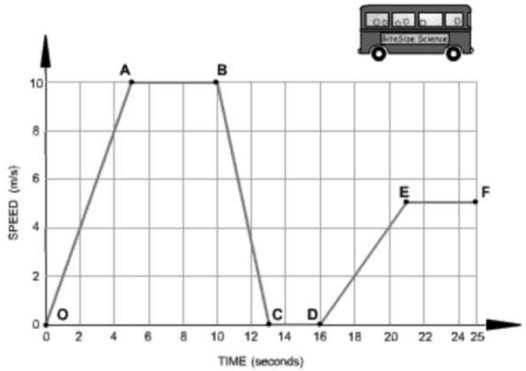




Use the graphs above to help match the following statements with the descriptions provided underneath them. State why

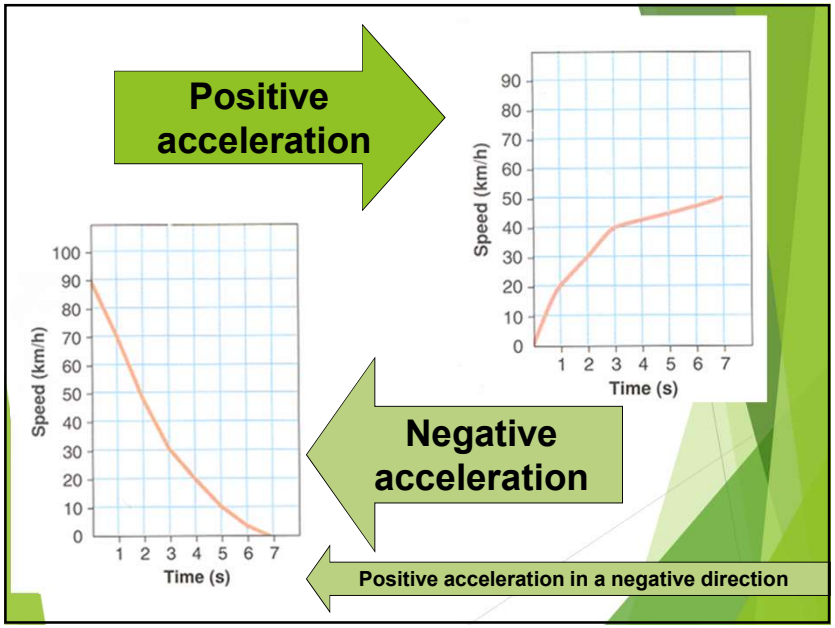
Graph A matches description __2__
Graph B matches description __4__
Graph C matches description __1__
Graph D matches description __3__

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


Positive acceleration
Speed (km/h)
Time (s)
Negative acceleration
Speed (km/h)
Time (s)
Positive acceleration in a negative direction