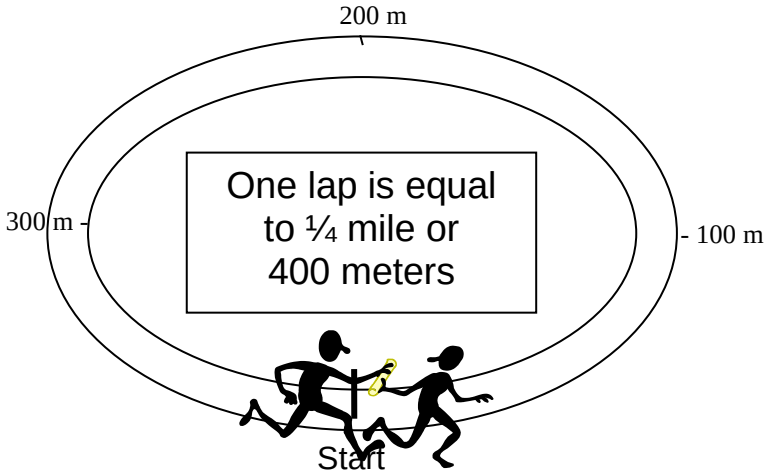
SWBAT: Classify Vector and Scalar quantities and generate examples of each

# Measuring Motion

AIM: What are the two main families of measurements used in Physics?

Below is a typical High School Track. One lap is equal to ¼ mile or 400 meters. Determine the distance and displacement of a runner when they complete the following number of laps.





| # of Laps | Distance (m) | Displacement (m) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 4.5 | | |

Based on the above exercise, define each of the following variables:

Distance:

Displacement:

Q.1. Under what conditions will the values for distance and displacement be the same? What track events follow these conditions?

SWBAT: Classify Vector and Scalar quantities and generate examples of each


Q.2. What does the odometer in your car measure, distance or displacement? Explain,

Positive Displacement:

Negative Displacement:

When physicists measure quantities they classify them into two distinct families. Look at the measurements below and determine the common properties within each family.

Common Properties of Family I

Common Properties of Family II

| Family I | Family II |
|---|---|
| 10 m | 30 Newtons, East |
| $15^{o}F$ | 15 m, Left |
| 30 seconds | 50 mph, Northwest |
| 12 mph | 32 mph, west |

Name of Family I

Name of Family II

SWBAT: Classify Vector and Scalar quantities and generate examples of each

Examples of Scalars:

Examples of Vectors:

Q.3. What does a speedometer measure, speed or velocity? Explain.


---

Q.4. A hiker walks 10.0 kilometers west and then 14 kilometers south. Make a rough sketch showing his displacements.

a) What total distance did he travel?

b) Would his displacement be more, less or the same as the distance traveled? Explain.

Q.5. A girl leaves a history classroom and walks 100.0 meters north to a drinking fountain. Then she turns and walks 30.0 meters south to an art classroom. What is the girl's total displacement from the history classroom to the art classroom?

(1) 70. m south
(2) 70. m north
(3) 40. m south
(4) 40. m north

Sketch:

---

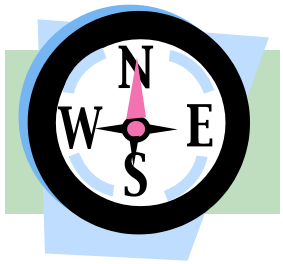
Conclusions:

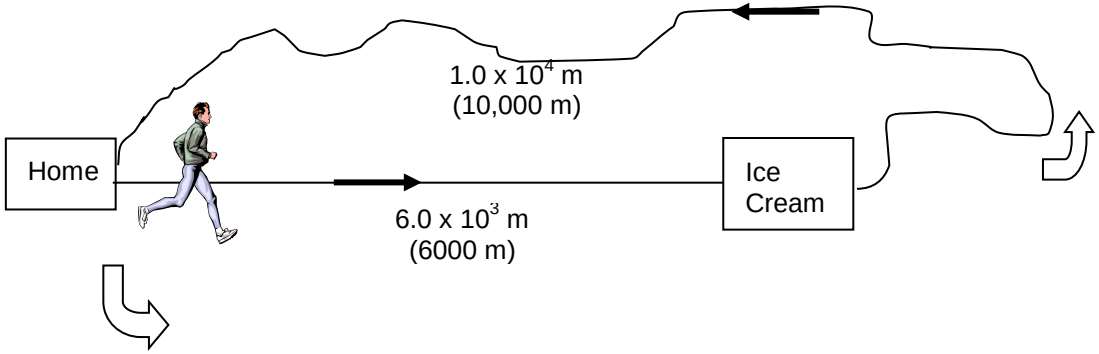
SWBAT: Differentiate speed and velocity, develop a formula for each and make calculations of each

## Change in Position

AIM: What is the difference between speed and velocity?

One morning I decided to run from home to my favorite ice cream shop. To save time I ran along a straight line (through a couple of backyards, a golf course and one person's living room). After eating the ice cream, I ran home along a different route (as shown below). You are to fill in the missing pieces of data and calculate the average speed for each route. Then try to determine how average velocity was determined.




| Direction | Distance (m) | Displacement (m) | Time (Sec) | Average Speed (Unit ) | Average Velocity (Unit ) |
|---|---|---|---|---|---|
| Home to Ice Cream Shop | | | $1.8 \times 10^3$ s (1800 s) | | 3.3 |
| Ice Cream Shop to Home | | | $3.4 \times 10^3$ s (3400 s) | | 1.8 |
| Round Trip | | | $5.2 \times 10^3$ s (5200 s ) | | 0.00 |

Q.1. How did you calculate speed? What are the units (MKS)?

Q.2. How was velocity calculated? Explain.

**Official Formula:**

**V =**

SWBAT: Differentiate speed and velocity, develop a formula for each and make calculations of each

Q.3. Define: Average Speed: Instantaneous Speed:

Q.4. What do the following devices measure, instantaneous speed or average speed? Explain.

Police Radar Speedometer MapQuest Speed of a Marathon Runner

---

Q.5. Two bike riders travel on a straight road with an average velocity of 24 km/hr heading west. What is there displacement after two hours?

Given Needed Relation Solution

---

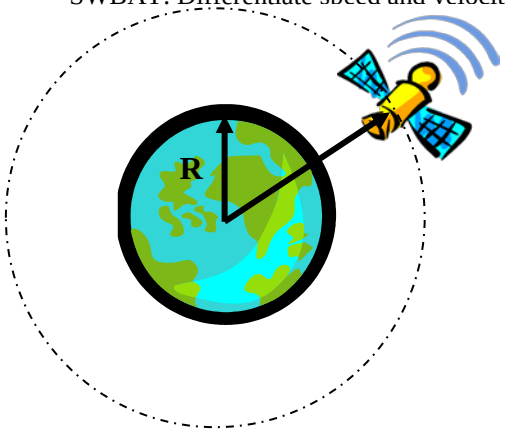
Q.6. When we go see my son at SUNY Binghamton it is a distance of 200 miles. It takes us usually 4 hours to get there.

a) What is our average speed?

Given Needed Relation Solution

b) How would our instantaneous speed compare to the average speed?

SWBAT: Differentiate speed and velocity, develop a formula for each and make calculations of each




The average speed of a satellite orbiting the Earth is 3.20 x$10^4$ km/hr (32000 km/hr). The satellite orbits above the center of the Earth at 6.8 x $10^3$ km (6,800 km).

a) What is the shape of the satellites orbit? What is the 'math' that describes this shape?

b) Determine the length of one orbit.

c) Determine the time for one complete orbit (revolution).

| Given | Needed | Relation | Solution |
|---|---|---|---|

d) What would be the satellite's average velocity for one complete orbit? Explain.

---

Q.6. A baseball player runs 27.4 meters from the batter's box to first base, overruns first base by 3.0 meters, and then returns to first base. Compared to the total distance traveled by the player, the magnitude of the player's total displacement from the batter's box is

(1) 3.0 m shorter
(2) 6.0 m shorter
(3) 3.0 m longer
(4) 6.0 m longer

---

Conclusions:

SWBAT: Describe relative motion and predict the apparent motion of objects based on the observer

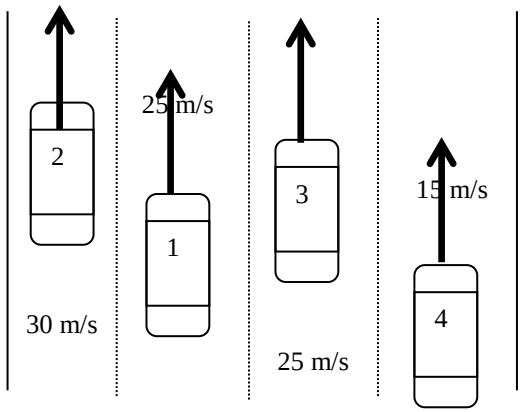
# Relative Motion

AIM: What does it mean when someone says “Motion is relative?”

You are a passenger in a car traveling on the Long Island Expressway. You are observing the other cars moving around you. You are in Car #1 traveling at 25 m/s as shown to the right.

For Cars #2, #3, and #4, state the direction the car will appear to be moving with respect to your car. Also determine the relative speed of the car.

Car #2 (30 m/s): Car #3 (25 m/s): Car #4 (15 m/s):




You are now magically transported into Car #4. For Cars #1, #2, and #3, state the direction the car will appear to be moving with respect to your car.

Car #1 (25 m/s): Car #2 (30 m/s): Car #3 (25 m/s):

We then ditch you on the side of the road. Again, determine the speeds of the cars

Car #1 (25 m/s): Car #2 (30 m/s): Car #3 (25 m/s): Car #4 (15 m/s)

---

Q.1. Based upon the above exercise, construct a summary statement about determining the motion of objects.

Q.2. How is this observed when riding in a train?

---

Conclusions:

SWBAT: Construct, interpret, predict the motion of an object based upon graphical data

## Graphing Motion

The data table below shows the motion of a rocket traveling in a straight line. Using this data, construct a position versus time graph in the space provided to the right. Be sure to follow all of the proper steps.

Independent and Dependent Variables:

| Time (s) | Position (m) |
|---|---|
| 0 | 0 |
| 1 | 250 |
| 2 | 500 |
| 3 | 750 |
| 4 | 1000 |
| 5 | 1250 |
| 6 | 1500 |

Draw a best fit line or curve:

Describe the motion of the object:

Predict the position of the object at 1.5 seconds. At 8 seconds.

## Slopes of Distance (or Position) versus Time Graphs

Slope:

Q.1. Determine the average speed from t = 0 to t = 3 using the slope method.

Slope =

SWBAT: Construct, interpret, predict the motion of an object based upon graphical data

Q.2. Determine the average speed from t = 3 to t = 6 using the slope method.

Slope =

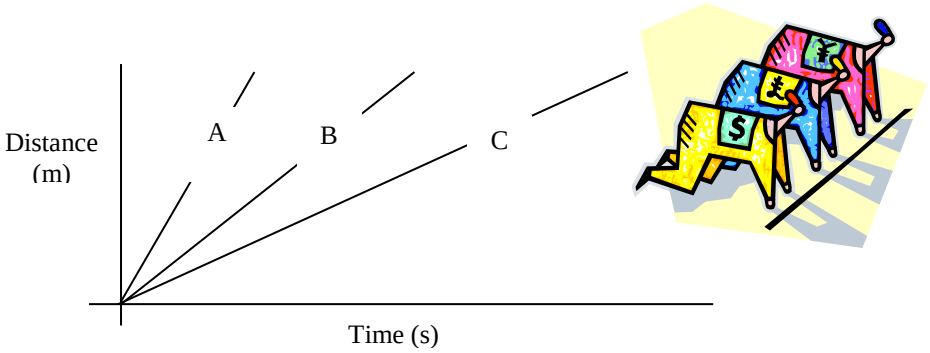
---

Q.3. What is true about the slope of the line from your graph? What does this indicate about the rocket's speed?

Q.4. Would the velocity of the rocket be greater, equal to, or smaller than the rocket's speed? Explain.

---

Q.3. The motion of three runners is recorded and their data is plotted on the graph below. Using this graph determine which runner is moving with the greatest speed. Explain.



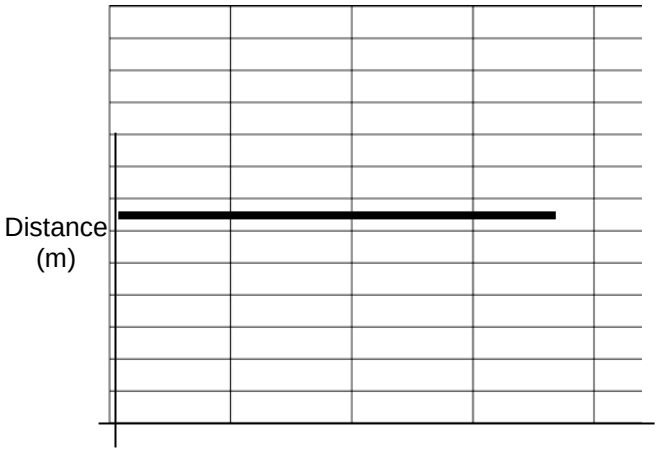

Relationship between slope and speed/velocity?

Conclusions:

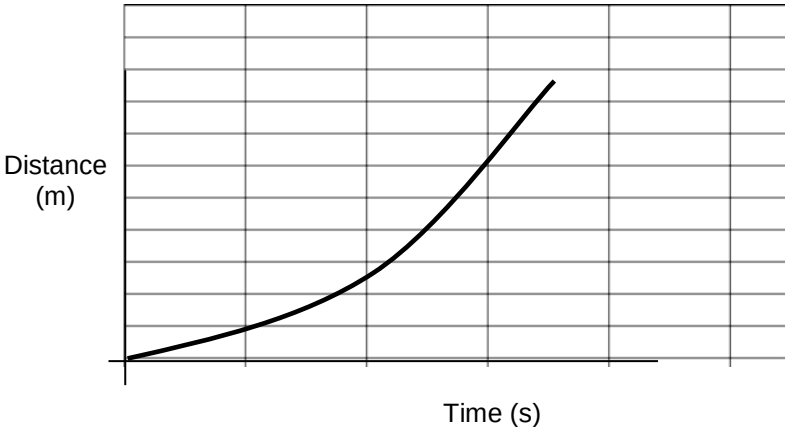
SWBAT: Construct, interpret, predict the motion of an object based upon graphical data

## Other Distance Versus Time Graphs

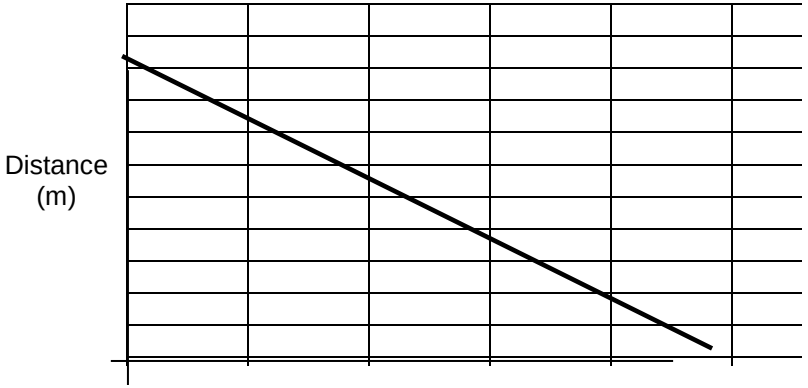
For each graph below, determine the motion of the object. Include a description of the slope of the line/curve for each graph.




(A)




(B)



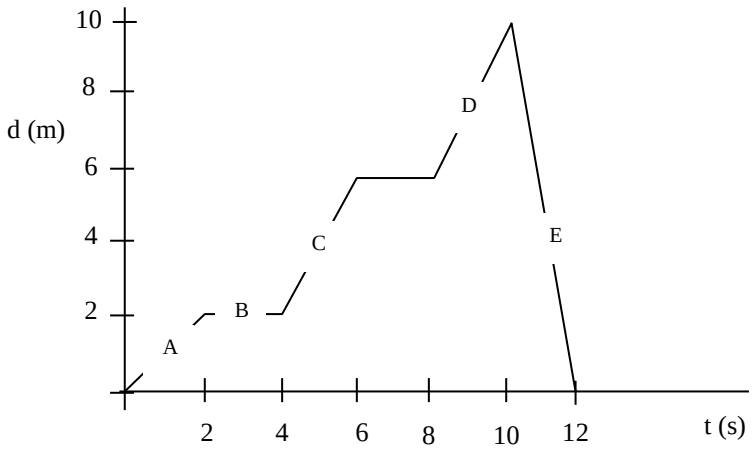

(C)

Conclusions:

SWBAT: Construct, interpret, predict the motion of an object based upon graphical data

## Analysis of Motion

Using the slope method, determine the velocity of the object during each time interval (assume the object is moving along a straight line).




Time Interval:

A –

B –

C –

D –

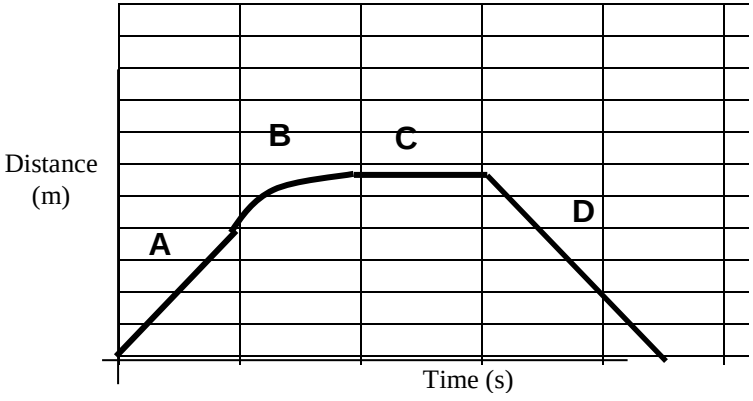
E –

Q.1. Using the graph above, determine the following:

a) The total distance covered by the object:

b) The total displacement of the object:

Q.2. Desribe the object's motion at the intervals indicated.



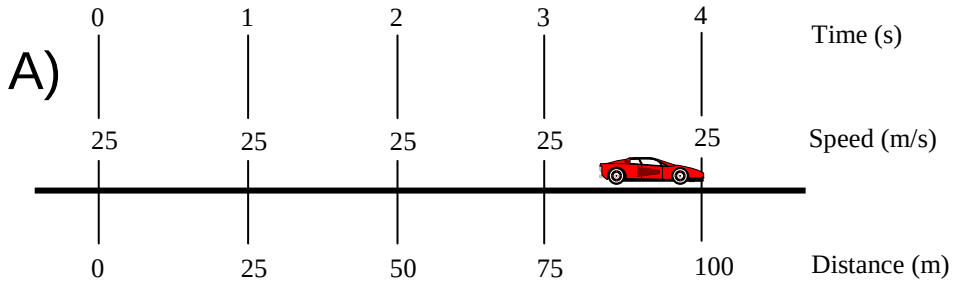

| Interval | Motion |
|---|---|
| A | |
| B | |
| C | |
| D | |

Conclusions:

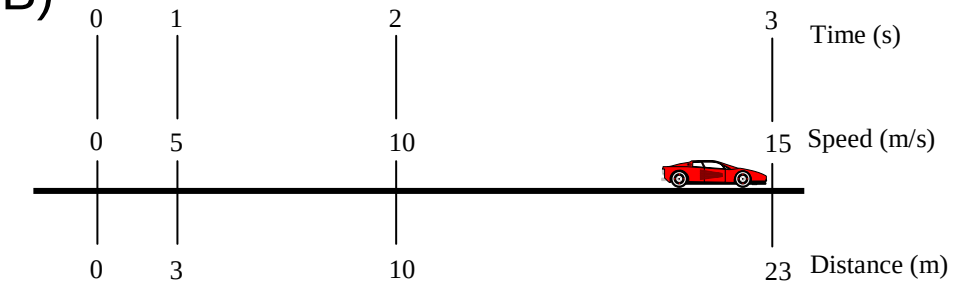
SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

## Changes in Velocity

A)




B)




C)

| Time (s) | Distance (m) | Speed (m/s) |
|---|---|---|
| 0 | 0 | 0 |
| 1 | 5 | 10 |
| 2 | 20 | 20 |
| 3 | 45 | 30 |
| 4 | 80 | 40 |

Describe the motion of each object in terms of distance and speed.

A –

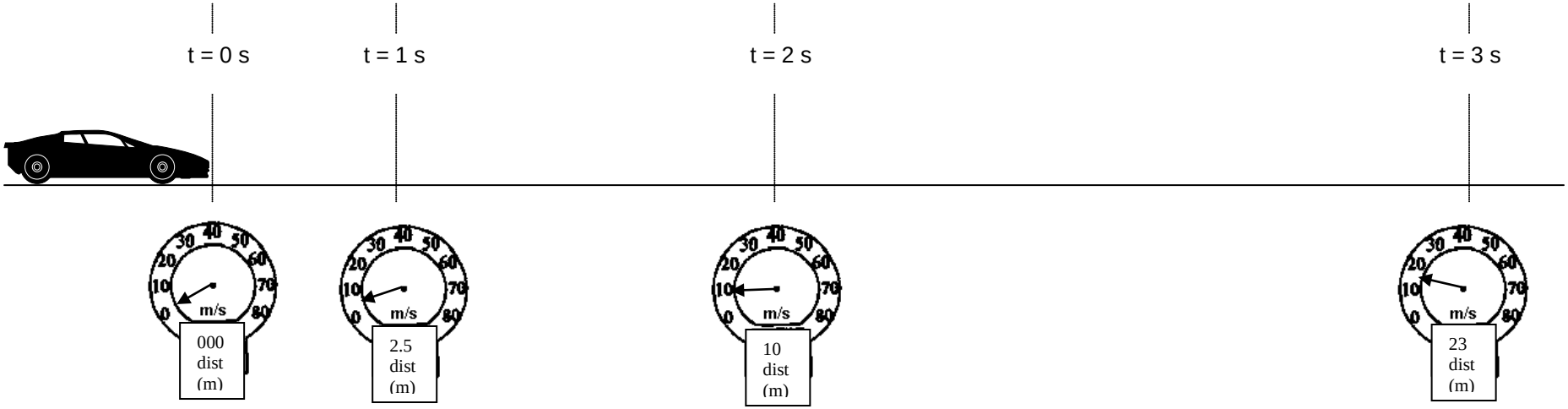
B –

C –

Q.1 Would speed and velocity be the same or different in each of the examples above? Explain.

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

A car starts from rest and moves in the direction shown. Data on the car's velocity and position are given.




Describe the motion of the car:

---

Acceleration:

Factors: Relation: Formula: Units:

Vector/Scalar:

---

Q.2. Determine the acceleration of the car above.

Given: Needed: Relation: Solution:

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

Q.3. A car's velocity increases from 4 m/s to 36 m/s in 4.0 seconds. What is the car's average acceleration?

Given: Needed: Relation: Solution:

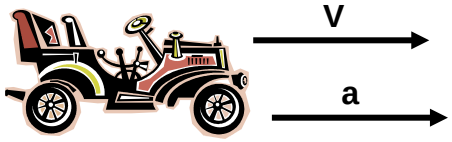
---

Q.4. A boat accelerates from rest at a rate of 2.0 m/s/s. Fill in the data table below showing the velocity and acceleration of the boat for the first 5 seconds of travel.

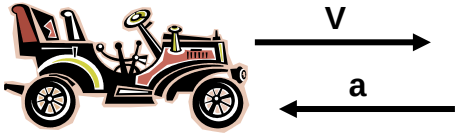
| Time (s) | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Velocity (m/s) | | | | | | |
| Acceleration ($m/s^2$) | | | | | | |

---

The diagram below shows the vectors of velocity and acceleration for a moving object. Based upon this information, construct a statement that describes the conditions for 'speeding up' and 'slowing down'.




Speeding Up



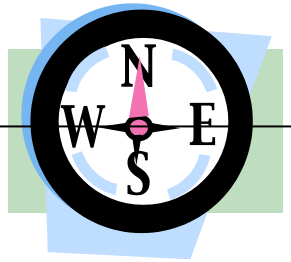

Slowing Down

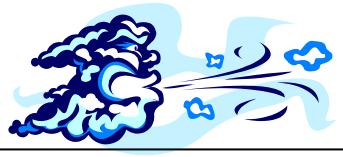
Statement:

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

Q.4. A tractor drives west at 15 m/s into a hurricane which is blowing east. The strong wind slows the tractor down at a rate of 5 m/s/s. Fill in the data table below showing the velocity and acceleration of the tractor for the first 5 seconds of travel.

| Time(s) | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Velocity (m/s) | | | | | | |
| Acceleration ($m/s^2$) | | | | | | |



Q.5. You do a good deed by picking up a blind hitchhiker and driving them home. The hitchhiker notices along the way that you accelerated the car in three different ways. What are they and how did the hitchhiker know it? What are the three instruments in your car that control each of these types of acceleration?

1) 2) 3)

Q.6. A car rounds a curve at a constant speed of 15 m/s. Is the car accelerating? Explain why or why not.

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

Q.8. If you are in a car that is accelerating, is your speed changing? Explain.

If you are in a car that is accelerating, is your velocity changing? Explain.

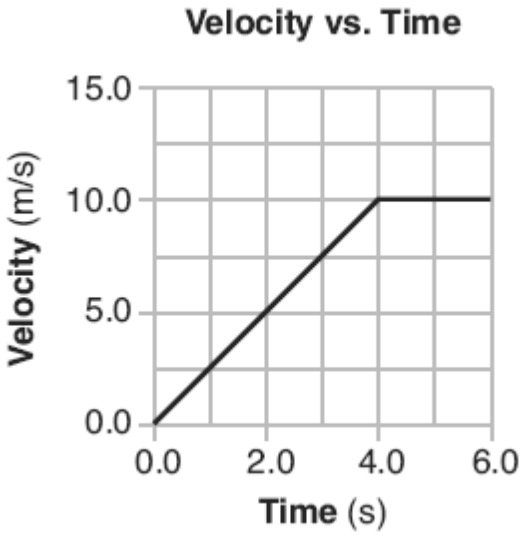
---

Q.9. A graph is constructed of a car, starting from rest and uniformly accelerating in a straight line.

What is the acceleration of the car at *t* = 2.0 seconds?

At t = 3.0 seconds

At t = 5.0 seconds

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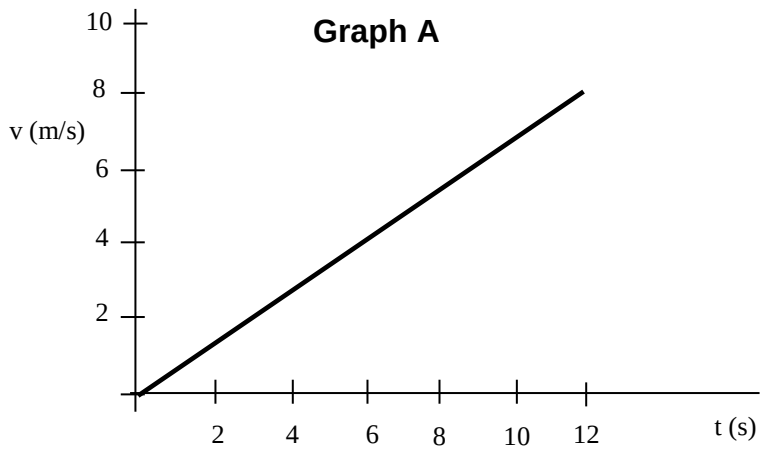
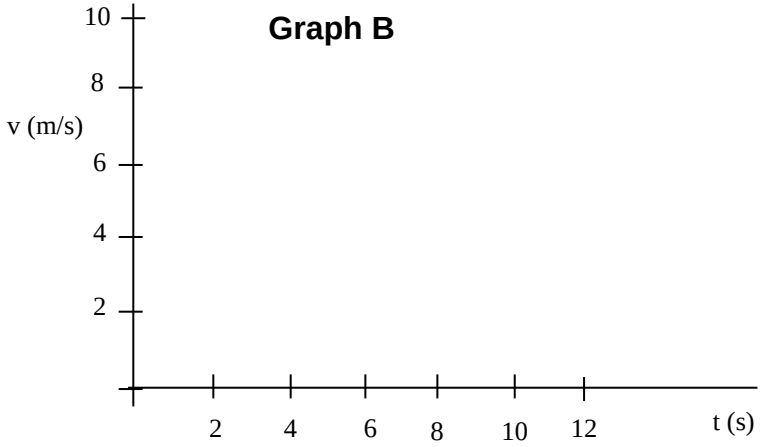
Conclusions:

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

## Velocity Versus Time Graphs and Acceleration

Describe the motion of each object:




Description:

Description:

## Slopes of Velocity versus Time graphs

Slope =

Units =

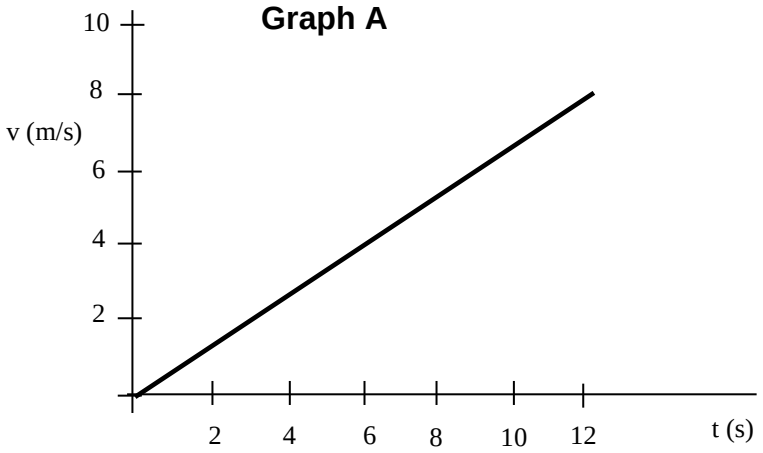
Determine the acceleration in each of the given graphs.

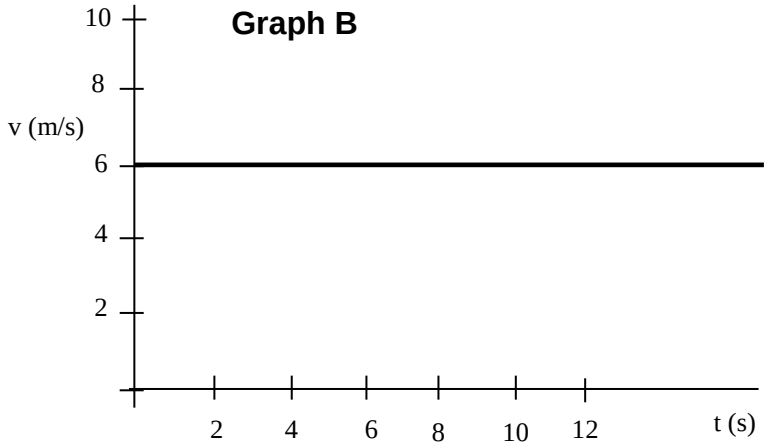
Graph A:

Graph B:

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

## Area Under the Curve of Velocity versus Time graphs



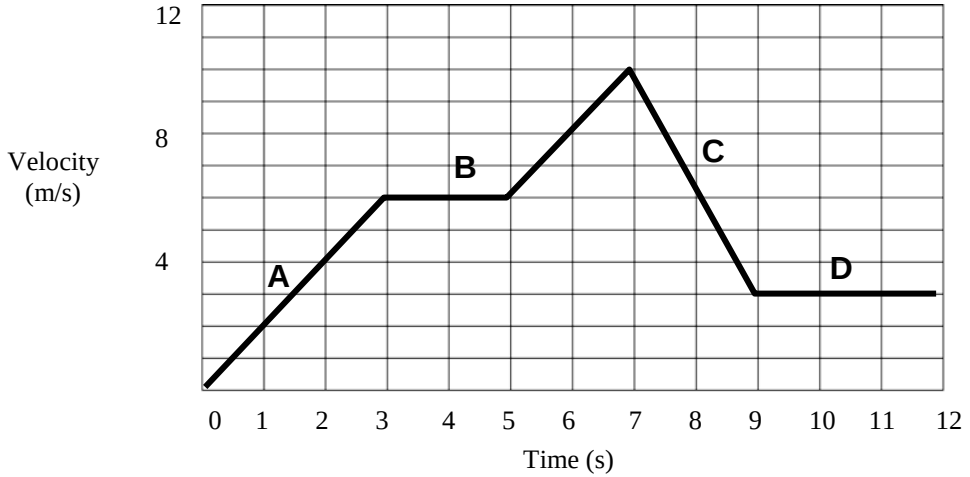




Determine the area under the curve for the first 12 seconds of motion:

Graph A: Graph B: What are the units for the area?

---

Q.1. Determine the acceleration and the distance traveled for each segment shown below.




Conclusions:

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

# Plotting Acceleration

Using the data tables below, construct the appropriate graphs:

| Time (s) | Dist (m) |
|---|---|
| 0 | 0 |
| 1 | 5 |
| 2 | 20 |
| 3 | 45 |
| 4 | 80 |

| Time (s) | velocity (m/s) |
|---|---|
| 0 | 0 |
| 1 | 10 |
| 2 | 20 |
| 3 | 30 |
| 4 | 40 |

Q.1. Describe the shape of the distance vs. time graph. Decide what the shape means.

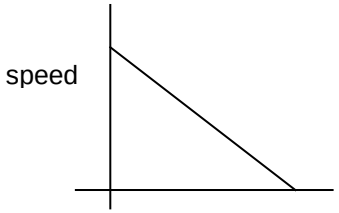
Q.2. Describe the shape of the velocity vs. time graph. Decide what the shape means.

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

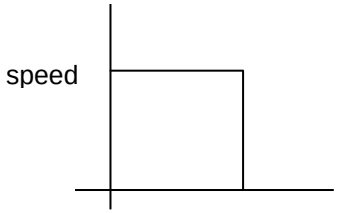
## Analyzing Motion Graphs

For each of the objects below, identify the graph that best represents what the object is doing.

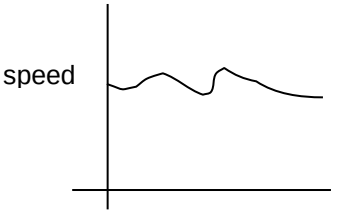
1. A school bus pulls up to your stop and picks you up.




(a)

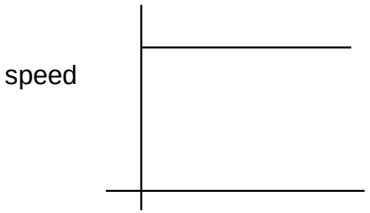



(b)

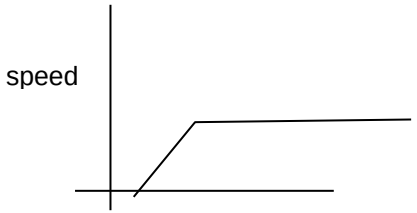



(c)

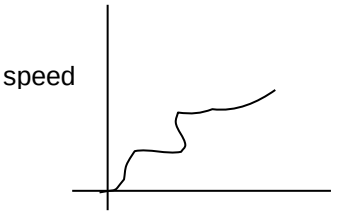
2. A sprinter runs the 100-m dash.




(a)

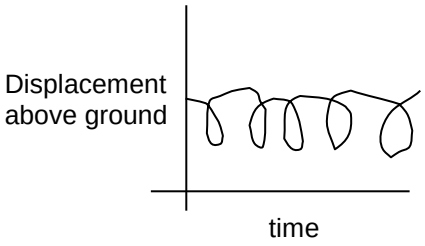



(b)

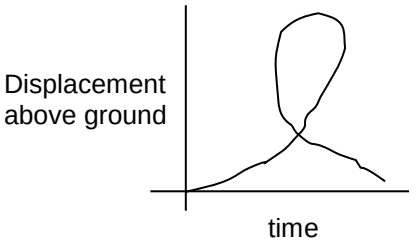



(c)

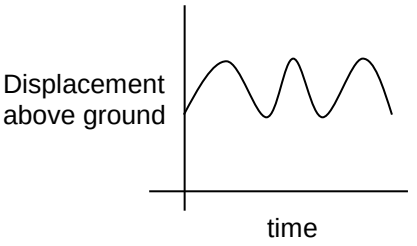
3. A man rides a Ferris wheel.




(a)




(b)



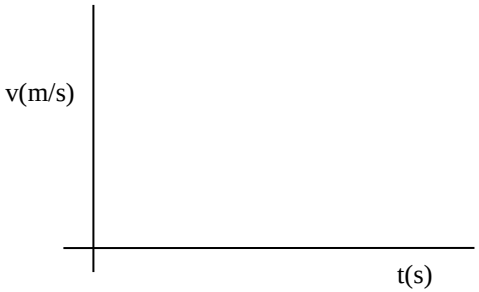

(c)

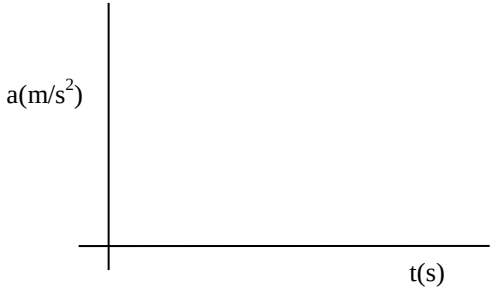
Conclusions:

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

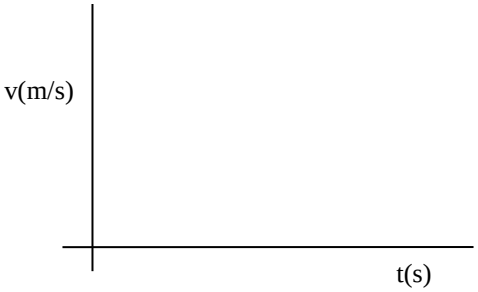
# Motion Graphing

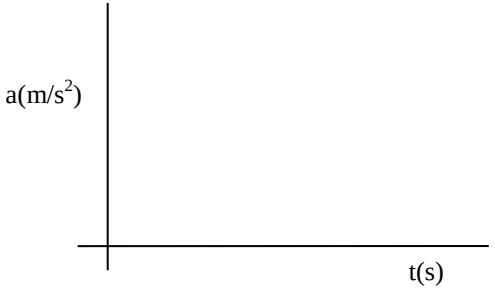
## Constant Distance

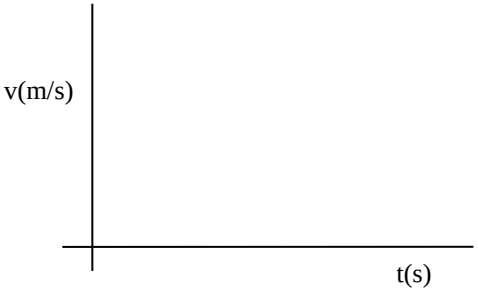



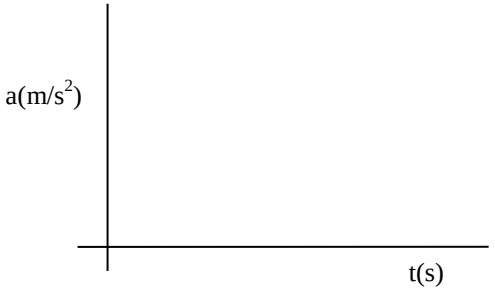

## Constant Velocity


## Constant Acceleration

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

## Displacement and Acceleration

Equations that have acceleration in them:

i) ii) iii)

$v_f$ = a = t = $v_i$ = d =

Q.1. A car starts from rest and accelerates at a rate of 2.0 $m/s^2$ for 10.0 seconds. How far did the car travel during that time?

Given: Needed: Relation: Solution:

Q.2. A bullet is accelerated at a rate of 400 $m/s^2$ for 0.05 seconds. If the bullet initially was at rest, how far did it travel while it was accelerating?

Given: Needed: Relation: Solution:

Q.3. Skid marks left from a stopped car are 27 meters long. If the car had a deceleration of 6 $m/s^2$ and stopped in 3.0 seconds, how fast was the car moving initially?

Given: Needed: Relation: Solution:

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## Assorted Motion Problems

Q.1. An elephant accelerates from 5 m/s to 10 m/s at a rate of 2.0 $m/s^2$. What is the elephant's final displacement?

Given: Needed: Relation: Solution:

Q.2. A jet stops in 525 m using a constant acceleration of -8.0 $m/s^2$. How fast was it moving initially?

Given: Needed: Relation: Solution:

Q.3. A racecar starts from rest and accelerates at a rate of 3.0 $m/s^2$ for 30 seconds. What was the displacement of the car after this time?

Given: Needed: Relation: Solution:

Q.4. Theoretically, a person wearing a seatbelt can withstand a deceleration of –300 $m/s^2$. A test dummy is placed in a sled and experiences this deceleration over a distance of 1.5m. How fast was the sled moving initially?

Given: Needed: Relation: Solution:

Conclusions:

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

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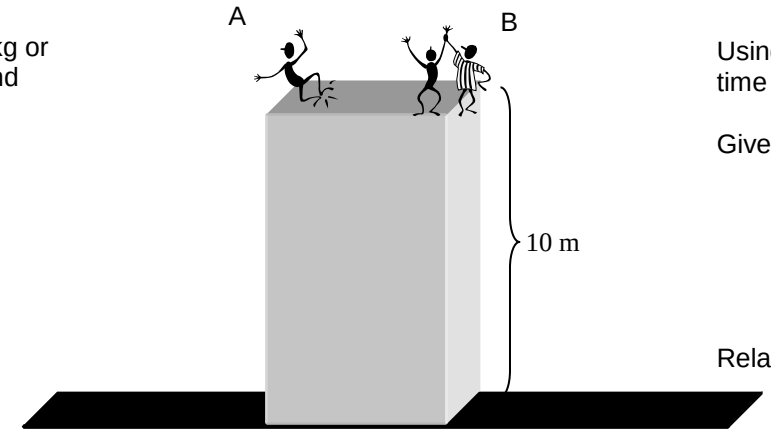
# Free-Fall and Gravity

Acceleration due to gravity on Earth:

Which group of people (A with a mass of 50 kg or B, with a mass of 100 kg) will reach the ground first? Explain.




Using the appropriate equation, determine the time to ground for A and B.

Given: Needed:

Relation: Solution:

From the above problem, develop a theory for falling bodies:

Support for Your Theory

| Demo 1 | Demo 2 | Demo 3 |
|---|---|---|
| Sketch:<br><br>Observations: | Sketch:<br><br>Observations: | Sketch:<br><br>Observations: |

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

Q.1. A diver jumps off a cliff (40 meters high). Determine the following:

a) time to ground

Given: Needed: Relation: Solution:

b) impact velocity

Given: Needed: Relation: Solution:

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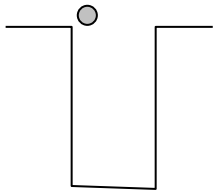
Q.2. A ball is dropped down a shaft and hits the bottom in 3.2 seconds. Determine the following:



a) Depth of the shaft

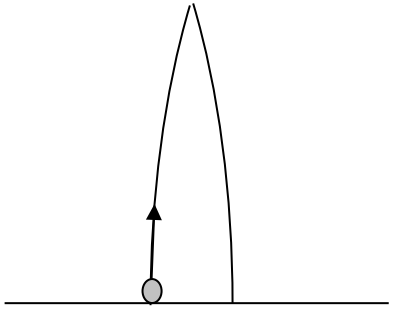
Given: Needed: Relation: Solution:

b) impact velocity

Given: Needed: Relation: Solution:

SWBAT: Contrast accelerated and non-accelerated motion, calculate acceleration, make predictions on displacement and velocity of an accelerating object

Q.3. A ball is thrown straight up in the air with an initial velocity of 30 m/s. Determine the following:



a) Time to the top

Given: Needed: Relation: Solution:

b) highest point reached

Given: Needed: Relation: Solution:

c) impact velocity

Given: Needed: Relation: Solution:

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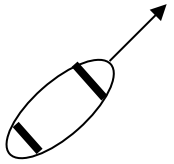
Q.4. A football is punted and remains airborne for 8 seconds. Determine the following:



a) Time to the top

Given: Needed: Relation: Solution:

b) highest point reached

Given: Needed: Relation: Solution:

c) vertical launching velocity

Given: Needed: Relation: Solution:

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Q.5. During the flight of the ball in question 4 and 5 what happens to the following quantities:

a) velocity

b) acceleration

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Conclusion: