Describing Motion with Position-Time Graphs

Read from **Lesson 3** of the **1-D Kinematics** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/1DKin/U1L3a.html
http://www.physicsclassroom.com/Class/1DKin/U1L3b.html
http://www.physicsclassroom.com/Class/1DKin/U1L3c.html

MOP Connection: Kinematic Graphing: sublevels 1-4 (and some of sublevels 9-11)

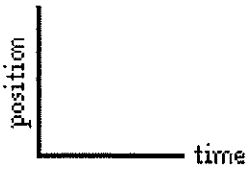
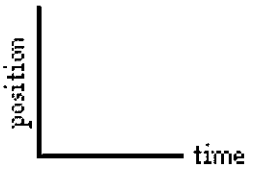
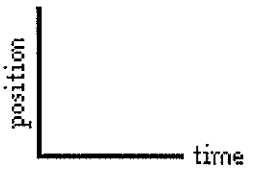
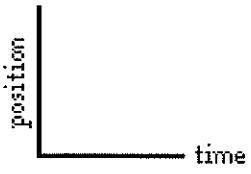
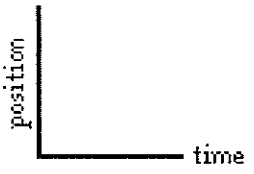
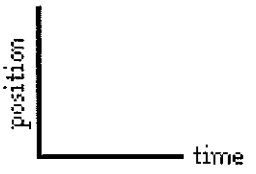
Motion can be described using words, diagrams, numerical information, equations, and graphs. Describing motion with graphs involves representing how a quantity such as the object's position can change with respect to the time. The key to using position-time graphs is knowing that the slope of a position-time graph reveals information about the object's velocity. By *detecting* the slope, one can infer about an object's velocity. "As the slope goes, so goes the velocity."

Review:

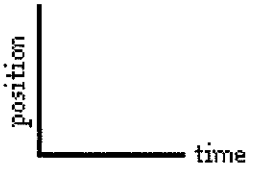
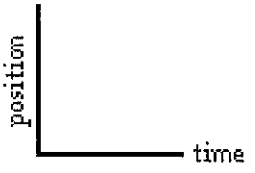
1. Categorize the following motions as being either examples of + or - acceleration.
   a. Moving in the + direction and speeding up (getting faster) _____
   b. Moving in the + direction and slowing down (getting slower) _____
   c. Moving in the - direction and speeding up (getting faster) _____
   d. Moving in the - direction and slowing down (getting slower) _____

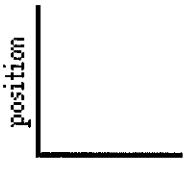
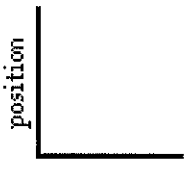
Interpreting Position-Graphs

2. On the graphs below, draw two lines/curves to represent the given verbal descriptions; label the lines/curves as A or B.

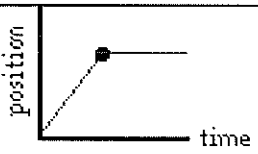
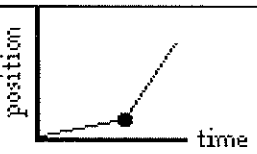
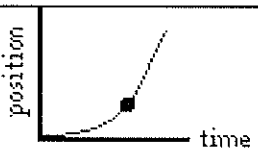
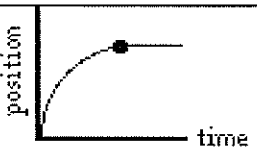
A Remaining at rest B Moving 	A Moving slow B Moving fast 	A Moving in + direction B Moving in - direction 
A Moving at constant speed B Accelerating 	A Move in + dirn; speed up B Move in + dirn; slow dn 	A Move in - dirn; speed up B Move in - dirn; slow dn 

3. For each type of accelerated motion, construct the appropriate shape of a position-time graph.

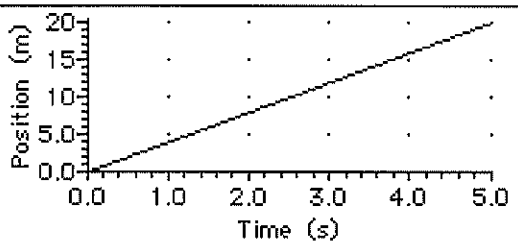
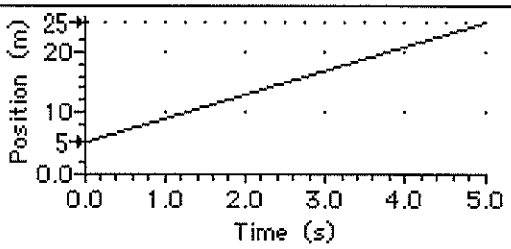
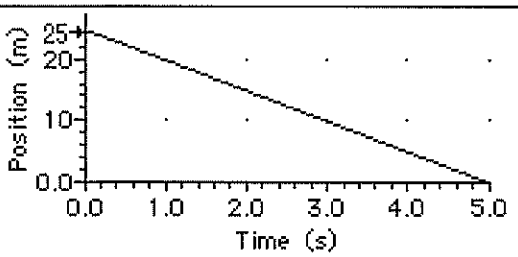
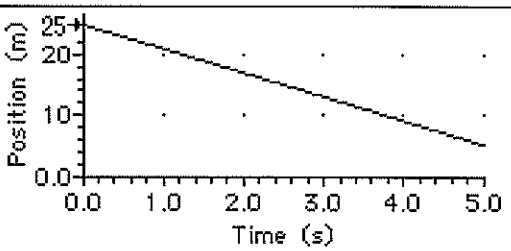
Moving with a + velocity and a + acceleration 	Moving with a + velocity and a - acceleration 

Moving with a - velocity and a + acceleration	Moving with a - velocity and a - acceleration
	

4. Use your understanding of the meaning of slope and shape of position-time graphs to describe the motion depicted by each of the following graphs.

 Verbal Description:	 Verbal Description:
 Verbal Description:	 Verbal Description:

5. Use the position-time graphs below to determine the velocity. **PSYW**

 **PSYW:**	 **PSYW:**
 **PSYW:**	 **PSYW:**

Describing Motion with Velocity-Time Graphs

Read from **Lesson 4** of the **1-D Kinematics** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/1DKin/U1L4a.html
http://www.physicsclassroom.com/Class/1DKin/U1L4b.html
http://www.physicsclassroom.com/Class/1DKin/U1L4c.html
http://www.physicsclassroom.com/Class/1DKin/U1L4d.html

MOP Connection: Kinematic Graphing: sublevels 5-8 (and some of sublevels 9-11)

Motion can be described using words, diagrams, numerical information, equations, and graphs. Describing motion with graphs involves representing how a quantity such as the object's velocity = changes with respect to the time. The key to using velocity-time graphs is knowing that the slope of a velocity-time graph represents the object's acceleration and the area represents the displacement.

Review:

1. Categorize the following motions as being either examples of + or - acceleration.
   a. Moving in the + direction and speeding up (getting faster) _____
   b. Moving in the + direction and slowing down (getting slower) _____
   c. Moving in the - direction and speeding up (getting faster) _____
   d. Moving in the - direction and slowing down (getting slower) _____

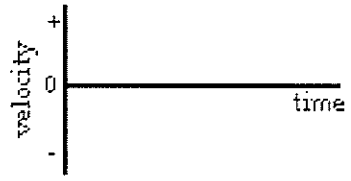
Interpreting Velocity-Graphs

2. On the graphs below, draw two lines/curves to represent the given verbal descriptions; label the lines/curves as A or B.

A Moving at constant speed in - direction
B Moving at constant speed in + direction

A Moving in + direction and speeding up
B Moving in - direction and speeding up

A Moving in + direction and slowing down
B Moving in - direction and slowing down

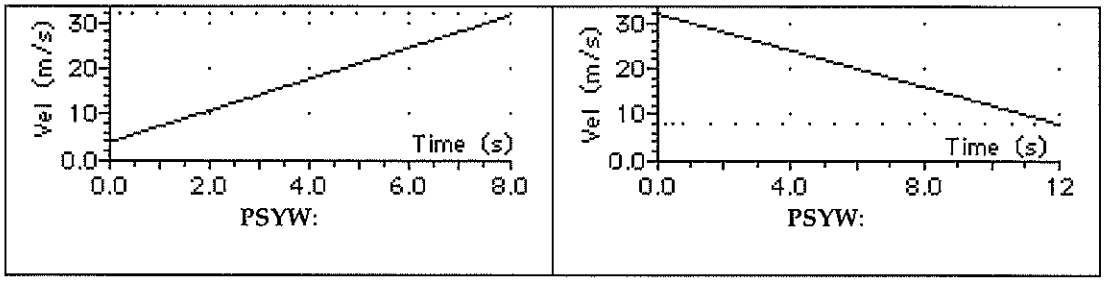


A Moving with + velocity and - accel'n
B Moving with + velocity and + accel'n

A Moving with - velocity and - accel'n
B Moving with - velocity and + accel'n

A Moving in + dir'n, first fast, then slow
B Moving in - dir'n, first fast, then slow

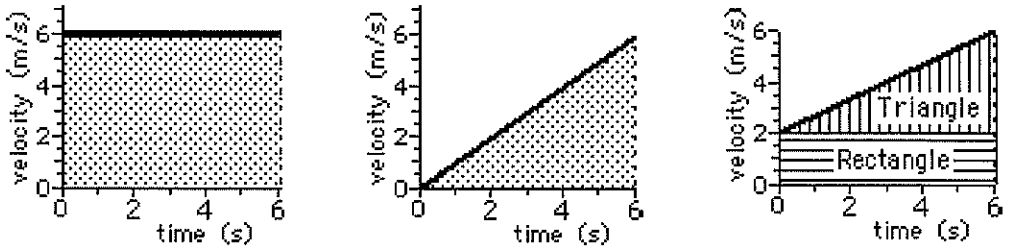
3. Use the velocity-time graphs below to determine the acceleration. **PSYW**



4. The area under the line of a velocity-time graph can be calculated using simple rectangle and triangle equations. The graphs below are examples:

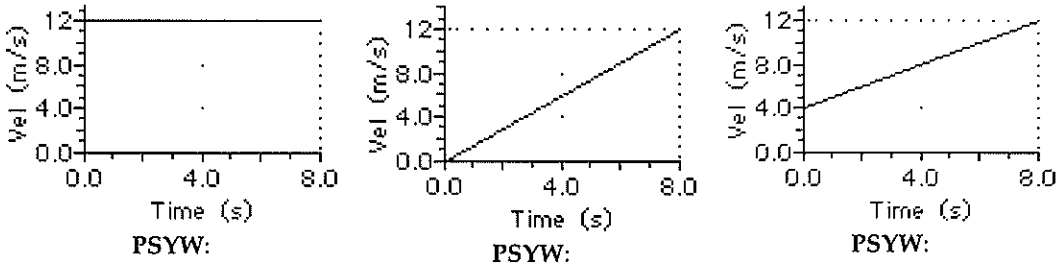
If the area under the line forms a ...

... **rectangle**, then use	... **triangle**, then use	... **trapezoid**, then make it into a rectangle + triangle and add the two areas.
area = base*height	area = 0.5 * base*height	

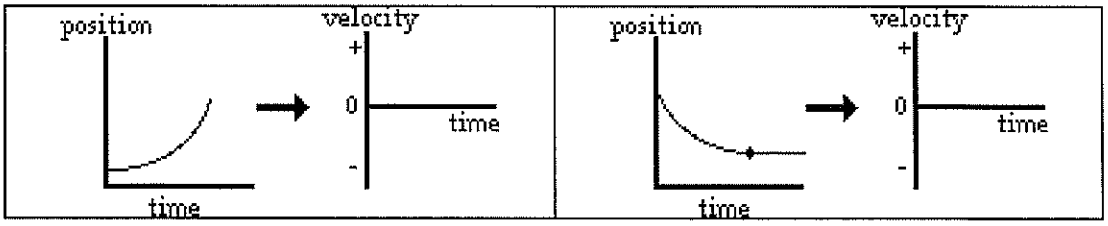


A = (6 m/s)*(6 s) = **36 m**	A = 0.5 * (6 m/s)*(6 s) = **18 m**	$A_{total} = A_{rectangle} + A_{triangle}$ A_{total} = (2m/s)*(6 s) + 0.5 * (4 m/s) * (6 s) = **24 m**

Find the displacement of the objects represented by the following velocity-time graphs.



5. For the following pos-time graphs, determine the corresponding shape of the vel-time graph.



Describing Motion Graphically

Study **Lessons 3 and 4** of the **1-D Kinematics** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/1DKin/1DKinTOC.html

MOP Connection: Kinematic Graphing: sublevels 1-11 (emphasis on sublevels 9-11)

1. The slope of the line on a position vs. time graph reveals information about an object's velocity. The magnitude (numerical value) of the slope is equal to the object's speed and the direction of the slope (upward/+ or downward/-) is the same as the direction of the velocity vector. Apply this understanding to answer the following questions.

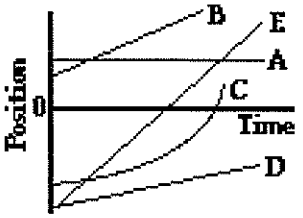
   a. A horizontal line means _____.

   b. A straight diagonal line means _____.

   c. A curved line means _____.

   d. A gradually sloped line means _____.

   e. A steeply sloped line means _____.



2. The motion of several objects is depicted on the position vs. time graph. Answer the following questions. Each question may have less than one, one, or more than one answer.

   _____ a. Which object(s) is(are) at rest?

   _____ b. Which object(s) is(are) accelerating?

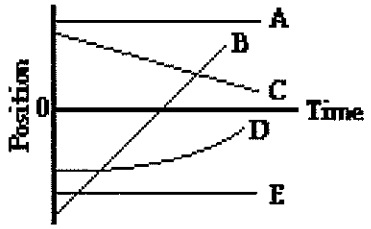
   _____ c. Which object(s) is(are) not moving?

   _____ d. Which object(s) change(s) its direction?

   _____ e. Which object is traveling fastest?

   _____ f. Which moving object is traveling slowest?

   _____ g. Which object(s) is(are) moving in the same direction as object B?



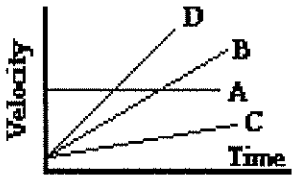
3. The slope of the line on a velocity vs. time graph reveals information about an object's acceleration. Furthermore, the area under the line is equal to the object's displacement. Apply this understanding to answer the following questions.

   a. A horizontal line means _____.

   b. A straight diagonal line means _____.

   c. A gradually sloped line means _____.

   d. A steeply sloped line means _____.



4. The motion of several objects is depicted by a velocity vs. time graph. Answer the following questions. Each question may have less than one, one, or more than one answer.

   _____ a. Which object(s) is(are) at rest?

   _____ b. Which object(s) is(are) accelerating?

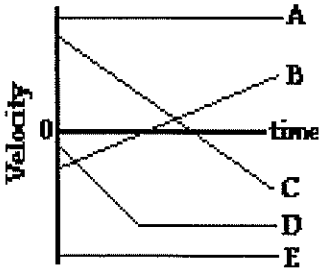
   _____ c. Which object(s) is(are) not moving?

   _____ d. Which object(s) change(s) its direction?

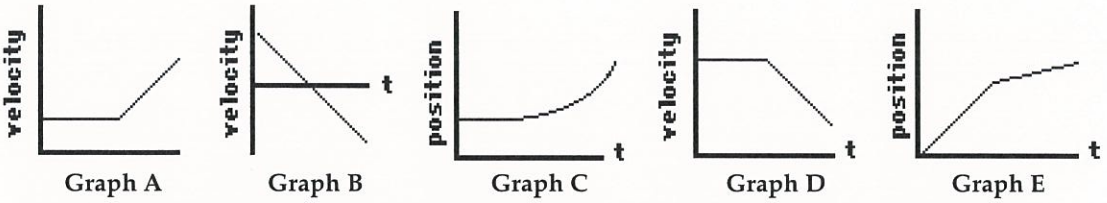
   _____ e. Which accelerating object has the smallest acceleration?

   _____ f. Which object has the greatest acceleration?

   _____ g. Which object(s) is(are) moving in the same direction as object E?



5. The graphs below depict the motion of several different objects. Note that the graphs include both position vs. time and velocity vs. time graphs.

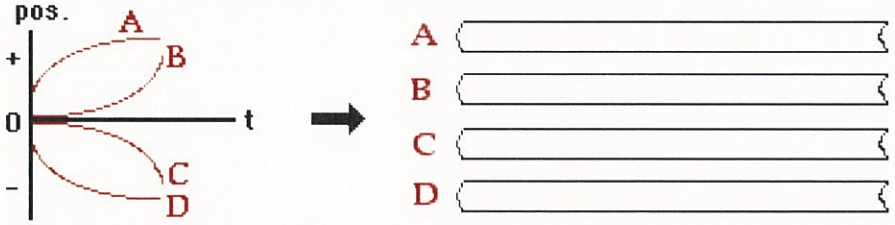


Graph A Graph B Graph C Graph D Graph E

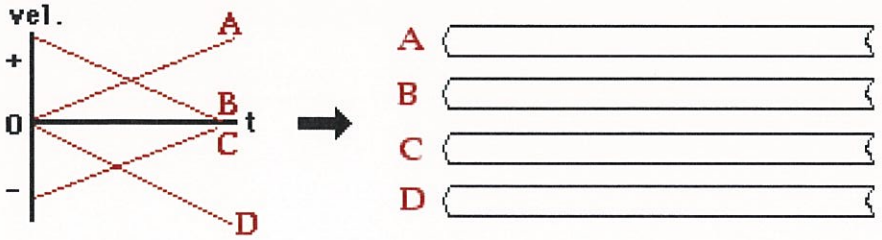
The motion of these objects could also be described using words. Analyze the graphs and match them with the verbal descriptions given below by filling in the blanks.

Verbal Description	Graph
a. The object is moving fast with a constant velocity and then moves slow with a constant velocity.	_____
b. The object is moving in one direction with a constant rate of acceleration (slowing down), changes directions, and continues in the opposite direction with a constant rate of acceleration (speeding up).	_____
c. The object moves with a constant velocity and then slows down.	_____
d. The object moves with a constant velocity and then speeds up.	_____
e. The object maintains a rest position for several seconds and then accelerates.	_____

6. Consider the position-time graphs for objects A, B, C and D. On the *ticker tapes* to the right of the graphs, construct a dot diagram for each object. Since the objects could be moving right or left, put an arrow on each *ticker tape* to indicate the direction of motion.

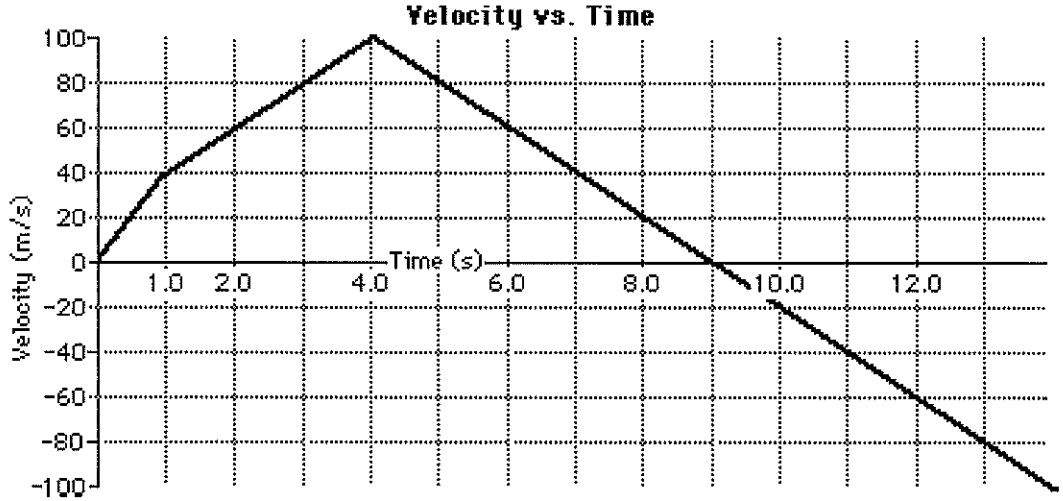


7. Consider the velocity-time graphs for objects A, B, C and D. On the *ticker tapes* to the right of the graphs, construct a dot diagram for each object. Since the objects could be moving right or left, put an arrow on each *ticker tape* to indicate the direction of motion.



Interpreting Velocity-Time Graphs

The motion of a two-stage rocket is portrayed by the following velocity-time graph.



Several students analyze the graph and make the following statements. Indicate whether the statements are correct or incorrect. Justify your answers by referring to specific features about the graph.

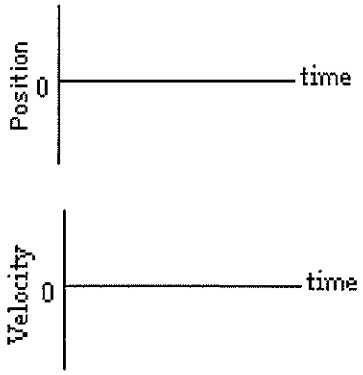
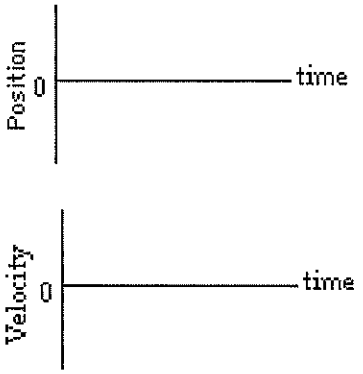
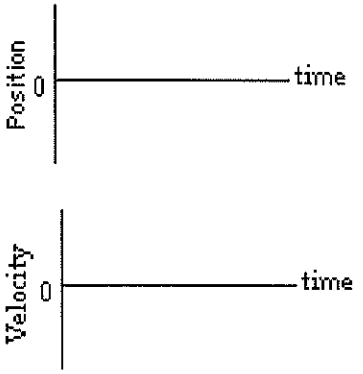
Student Statement	Correct? Yes or No
1. After 4 seconds, the rocket is moving in the negative direction (i.e., down). Justification: _____	_____
2. The rocket is traveling with a greater speed during the time interval from 0 to 1 second than the time interval from 1 to 4 seconds. Justification: _____	_____
3. The rocket changes its direction after the fourth second. Justification: _____	_____
4. During the time interval from 4 to 9 seconds, the rocket is moving in the positive direction (up) and slowing down. Justification: _____	_____
5. At nine seconds, the rocket has returned to its initial starting position. Justification: _____	_____

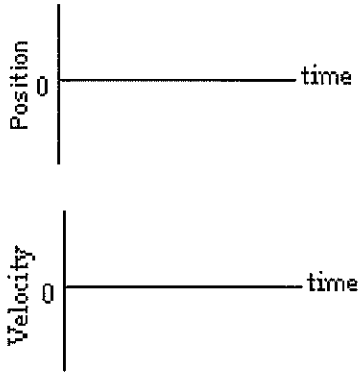
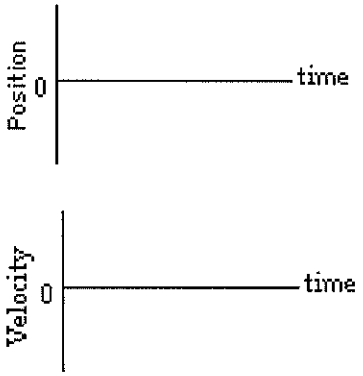
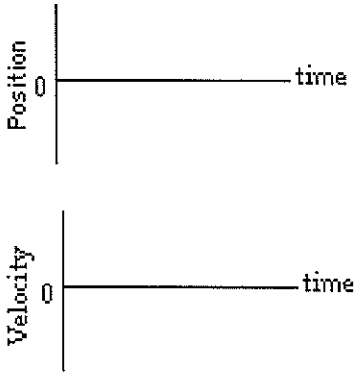
Graphing Summary

Study **Lessons 3 and 4** of the **1-D Kinematics** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/1DKin/1KinTOC.html

MOP Connection: Kinematic Graphing: sublevels 1-11 (emphasis on sublevels 9-11)

Constant Velocity Object moves in + Direction Velocity Dir'n: + or -	**Constant Velocity** Object moves in - Direction Velocity Dir'n: + or -	**Constant + Acceleration** Object moves in + Direction Velocity Dir'n: + or - Speeding up or Slowing Down?
		

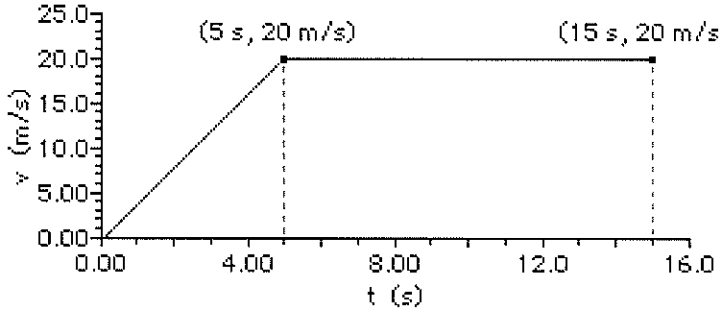
Constant + Acceleration Object moves in - Direction Velocity Dir'n: + or - Speeding up or Slowing Down?	**Constant - Acceleration** Object moves in - Direction Velocity Dir'n: + or - Speeding up or Slowing Down?	**Constant - Acceleration** Object moves in + Direction Velocity Dir'n: + or - Speeding up or Slowing Down?
		

Kinematic Graphing - Mathematical Analysis

Study **Lessons 3 and 4** of the **1-D Kinematics** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/1DKin/1KinTOC.html

1. Consider the following graph of a car in motion. Use the graph to answer the questions.



a. Describe the motion of the car during each of the two parts of its motion.

0-5 s: _____

5-15 s: _____

b. Construct a *dot diagram* for the car's motion.

c. Determine the acceleration of the car during each of the two parts of its motion.

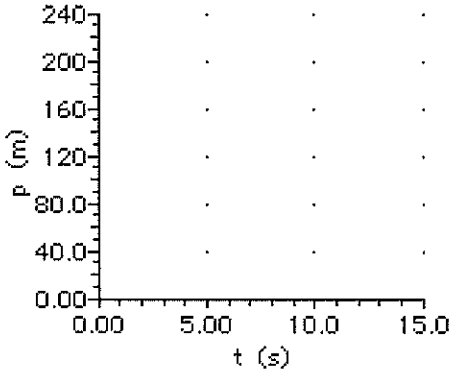
<u>0-5 s</u> <u>5-15 s</u>

d. Determine the displacement of the car during each of the two parts of its motion.

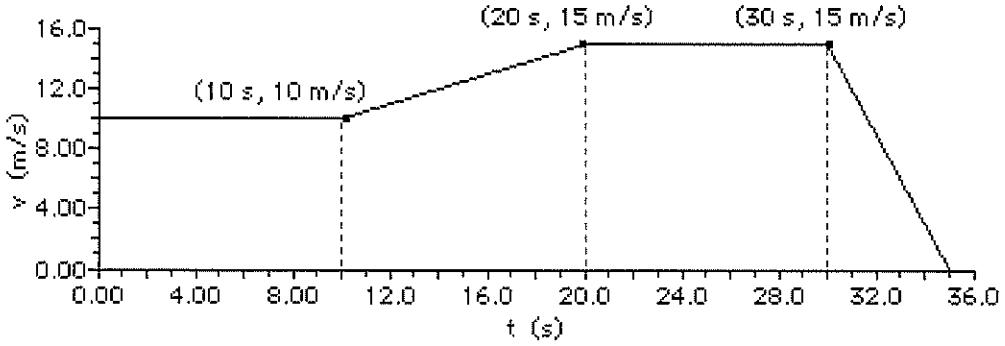
<u>0-5 s</u> <u>5-15 s</u>

e. Fill in the table and sketch position-time for this car's motion. Give particular attention to how you connect coordinate points on the graphs (curves vs. horizontals vs. diagonals).

Time (s)	Pos'n (m)
0	0
5	
10	
15	



2. Consider the following graph of a car in motion. Use the graph to answer the questions.



a. Describe the motion of the car during each of the four parts of its motion.

0-10 s: _____

10-20 s: _____

20-30 s: _____

30-35 s: _____

b. Construct a *dot diagram* for the car's motion.

c. Determine the acceleration of the car during each of the four parts of its motion. **PSYW**

<u>0-10 s</u> <u>10-20 s</u> <u>20-30 s</u> <u>30-35 s</u>

d. Determine the displacement of the car during each of the four parts of its motion. **PSYW**

<u>0-10 s</u> <u>10-20 s</u> <u>20-30 s</u> <u>30-35 s</u>

e. Fill in the table and sketch position-time for this car's motion. Give particular attention to how you connect coordinate points on the graphs (curves vs. horizontals vs. diagonals).

Time (s)	Pos'n (m)
0	0
5	
10	
15	
20	
25	
30	
35