Experiment
1

Graph Matching

One of the most effective methods of describing motion is to plot graphs of distance, velocity, and acceleration *vs*. time. From such a graphical representation, it is possible to determine in what direction an object is going, how fast it is moving, how far it traveled, and whether it is speeding up or slowing down. In this experiment, you will use a Motion Detector to determine this information by plotting a real time graph of *your* motion as you move across the classroom.

You will be working in groups. It is very important that each member of the group take turns using the motion detector, and that all members share their insights and participate in the discussions.

Make as many predictions as possible as you work through this lab. When you correct your predictions use a different color pencil and make sure you and your partners understand the corrected graphs.

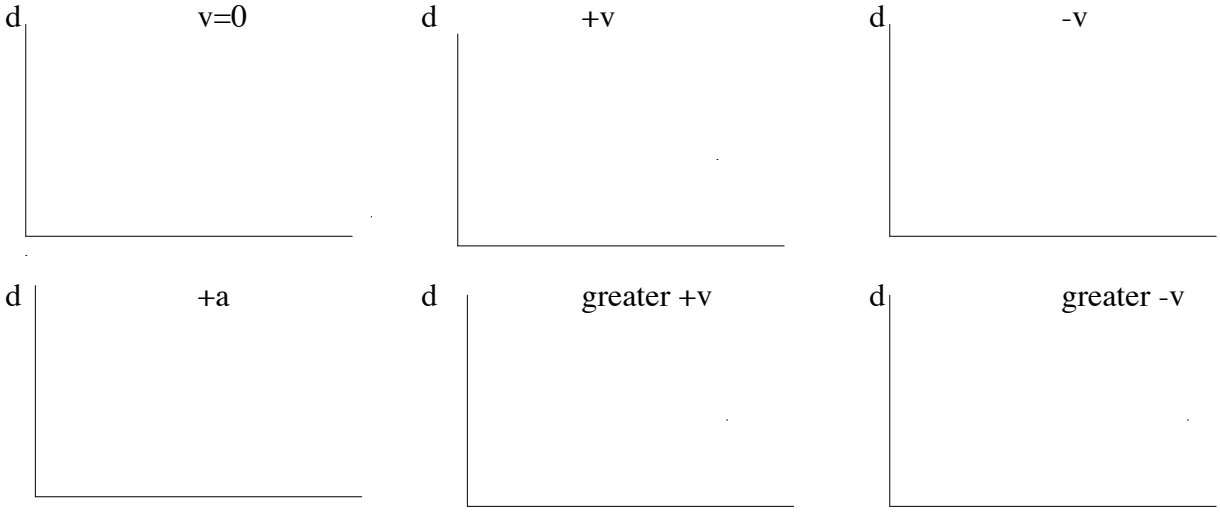
OBJECTIVES/PURPOSE:

To learn:
- how to relate the motion of an object in one dimension to graphs plotting *position (d)* , *velocity (v)*, and *acceleration* (*a*) vs *time(t)*.
- how to read, draw, and analyze such graphs
- how to relate these graphs to each other for a particular motion

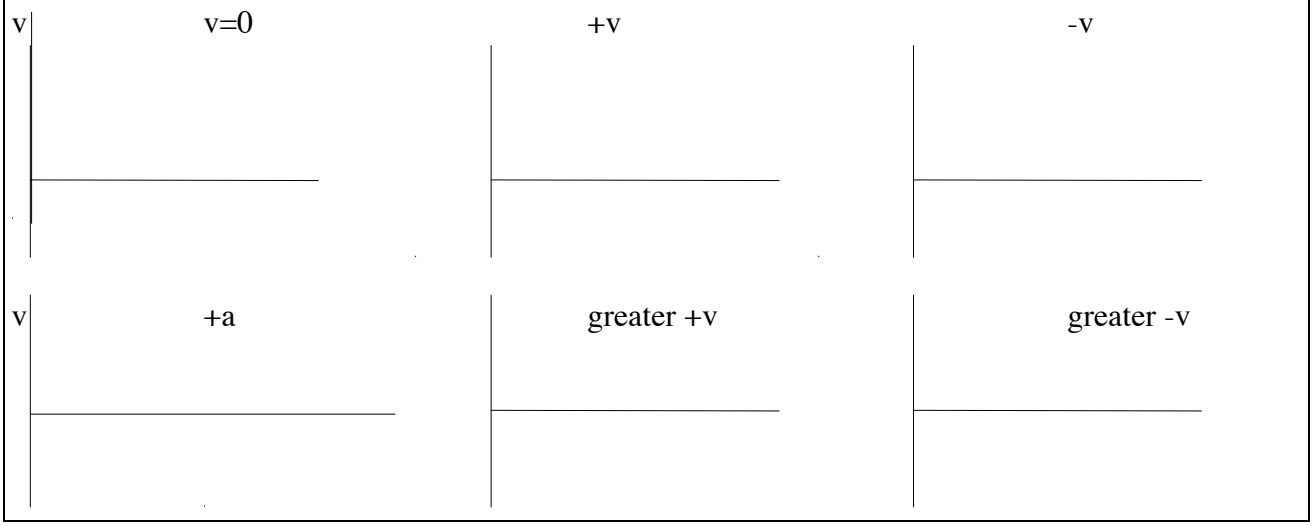
PRE-LAB PREPARATION/PRELIMINARY QUESTIONS

1. Use a coordinate system with the origin at far left and positive distances increasing to the right. Sketch the distance *vs*. time graph for each of the following situations:

-an object at rest (v=0)
-an object moving in the positive direction with a constant speed (+v)
-an object moving in the negative direction with a constant speed (-v)
-an object that is accelerating in the positive direction, starting from rest (+a)
-an object moving in the positive direction with a constant speed *greater* than above
-an object moving in the negative direction with a constant speed *greater* than above



2. Sketch the velocity *vs*. time graph for each of the situations described question 1 above.



MATERIALS

Power Macintosh or Windows PC
Universal Lab Interface
Logger *Pro*
Vernier Motion Detector
meter stick & masking tape
color pencil (to correct graphs)

PROCEDURE

Part l Setting up the computer &Preliminary Experiments

A. Connect the Motion Detector to PORT 2 of the Universal Lab Interface(ULI), and turn on the ULI switch in the back.

1. Turn on the computer by pressing the space bar.

2. Click on the Logger *Pro* logo.

3. Place the Motion Detector so that it points toward an open space at least 4 m long. Use short strips of masking tape on the floor to mark the 1 m, 2 m, 3 m, and 4 m distances from the Motion Detector.

4. Prepare the computer for data collection by opening "Exp 01A" from the *Physics with Computers* experiment files of Logger *Pro*. These files can be reached by clicking OPEN inside

the FILE menu . One graph will appear on the screen. The vertical axis has distance scaled from 0 to 5 meters. The horizontal axis has time scaled from 0 to 10 seconds. These scales are easily changed by clicking on the numbers and changing to another value.

B. *Do a practice run*. Using Logger *Pro*, produce a graph of your motion when you walk away from the detector with constant velocity. To do this, stand about 1 m from the Motion Detector and have your lab partner click ⊠. Walk slowly away from the Motion Detector when you hear it begin to click. Be aware that the motion will not pick up objects closer than 0.5 m.

1. Try to match the shape of the distance *vs*. time graphs that you sketched in the *Preliminary Questions* section on page 1 by walking in front of the Motion Detector.

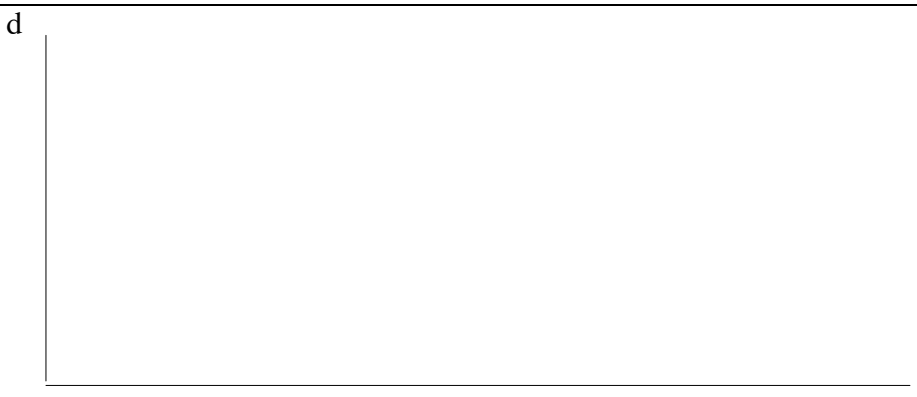
2. Correct your preliminary sketches using a different color pencil. Make sure you understand why these graphs look the way they do.

3. What kind of steps work best in generating a smooth graph? What could you do to make yourself a better target for the motion detector?

Note that your real-life motion is never as smooth as the graphs you see in books. Those graphs are idealized simplifications of real motions.

Part II Distance from the origin (Position) *vs*. Time Graph Matching

A. *Sketch* a prediction for the position vs time graph of a person who stands 1 m from the detector for 2 s, then moves slowly and steadily away from the detector for 4 s, then stops for 2 s, and finally continues to move steadily away from the detector but about twice as fast as before. This will be graph 1A.

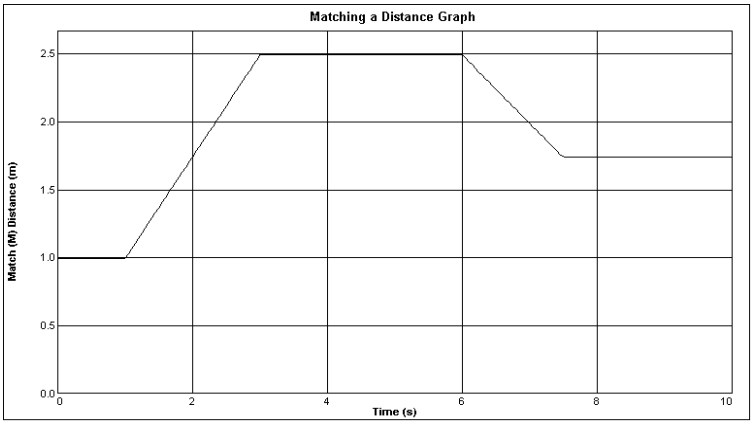


Graph 1A

1. *Verify* your prediction by recreating the motion above in front of the motion detector. Repeat until you are satisfied you have a good match.

2. Sketch the computer generated graph on top of your original prediction with a different color pencil.

B. Prepare the computer for data collection by opening "Exp 01B" from the *Physics with Computers* experiment files of Logger *Pro*. The distance *vs*. time graph shown will appear.



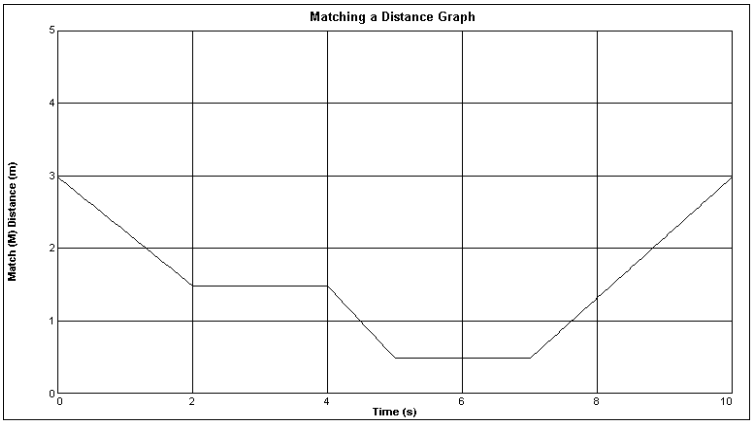
Graph 1B

1. Describe qualitatively how you would move to create this graph.

2. To test your prediction, stand at the starting position. Start data collection by clicking ☒. When you hear the Motion Detector begin to click, walk in such a way that the graph of your motion matches the target graph on the computer screen.

3. If you were not successful, repeat the process until your motion closely matches the graph on the screen. Sketch your best effort on top of the given graph with a different color pencil.

C. Prepare the computer for data collection by opening "Exp 01C" from the *Physics with Computers* experiment files of Logger *Pro* and repeat Steps 1-3 above, using a new target graph.



Graph 1C

1->3. Describe how you would walk to produce this target graph. Then test your prediction and finally sketch your best effort on top of the given graph.

D. Answer the following questions: THESE ARE IMPORTANT CONCEPTS, MAKE SURE YOU UNDERSTAND THEM!

1. Explain the significance of the slope on a distance *vs*. time graph. Include a discussion of positive and negative slope.

2. What type of motion is occurring when the slope of a distance *vs*. time graph is zero?..when it is constant?

3. What type of motion is occurring when the slope of a distance *vs*. time graph is changing? Test your answer to this question using the Motion Detector.

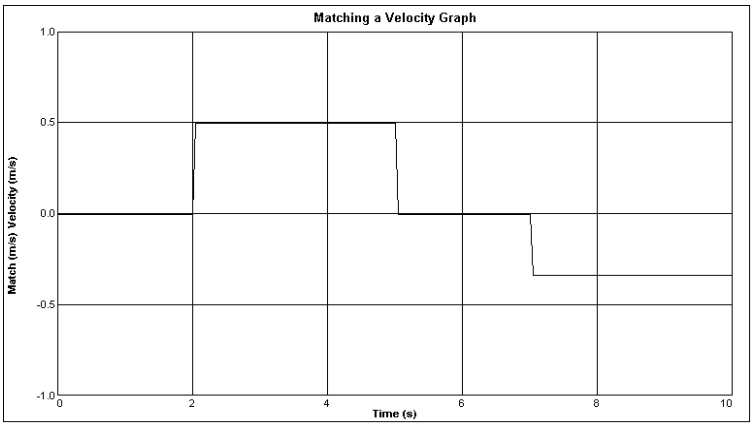
4. Is it possible to have a vertical line in the position vs time graph? Explain your answer.

Part III Velocity *vs*. Time Graph Matching

A. To create velocity graphs, go back and reopen file "Exp01a". Click on the Distance axes. When the dialogue box appears check the **Velocity** box, uncheck the **Distance** box, then check OK.

1. Try to match the shape of the velocity*'s*. time graphs that you sketched in the *Preliminary Question 2* (p.2) by walking in front of the Motion Detector.
2. Go back to the velocity graphs you produced in the PreLab section. Correct your preliminary sketches using a different color pencil. Make sure you understand why these graphs look the way they do.

B. Prepare the computer for data collection by opening "Exp 01D" from the *Physics with Computers* experiment files of Logger *Pro*. You will see the following velocity *vs*. time graph.



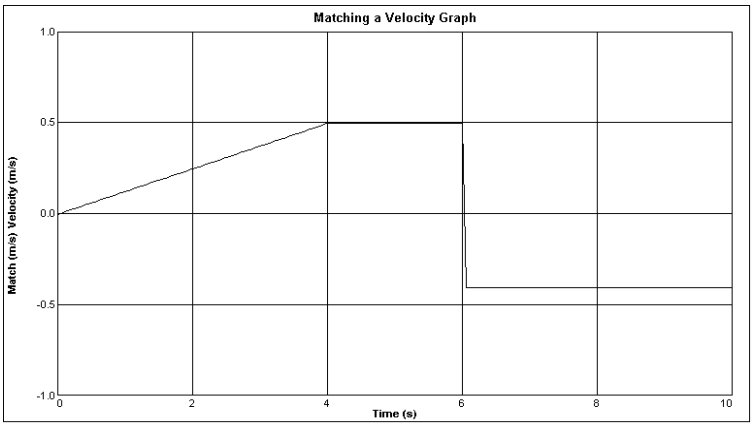
Graph 1D

1. Describe how you would walk to produce this target graph.

2. To test your prediction, choose a starting position and stand at that point. Start Logger *Pro* by clicking ☒. When you hear the Motion Detector begin to click, walk in such a way that the graph of your motion matches the target graph on the screen. It will be more difficult to match the velocity graph than it was for the distance graph.

3. Sketch your best effort on top of the given graph with a different color pencil.

C. Prepare the computer for data collection by opening "Exp 01E" from the *Physics with Computers* experiment files of Logger *Pro*. Repeat Steps 1-3 above to match this graph.



Graph 1E

1->3. Describe how you would walk to produce this target graph. Then test your prediction and finally sketch your best effort on top of the given graph.

D. Answer the following questions: THESE ARE IMPORTANT CONCEPTS, MAKE SURE YOU UNDERSTAND THEM!

1. Consider the area (or areas) between the *time* axes and the *graph lines* of the velocity graph. This is commonly referred to as the "area under a velocity *vs*. time graph" or the "integral of the velocity function" (refer to the text if you need help with this concept). What does it represent? Explain your reasoning.

2. What type of motion is occurring when the slope of a velocity *vs*. time graph is zero?

3. What type of motion is occurring when the slope of a velocity *vs*. time graph is not zero and positive?...not zero and negative?

4. Is it possible to have a vertical line in the velocity vs time graph? Explain your answer.

RELATING POSITION AND VELOCITY GRAPHS

A. Study the position graphs 1A, 1B, and 1C in part II. Sketch the velocity *vs*. time graphs that match each one. Remember that the *slope* of the distance vs time graphs represents the *average velocity* (distance traveled/time elapsed) of an object during any particular interval of time.

Match for 1A	Match for 1B	Match for 1C
v		

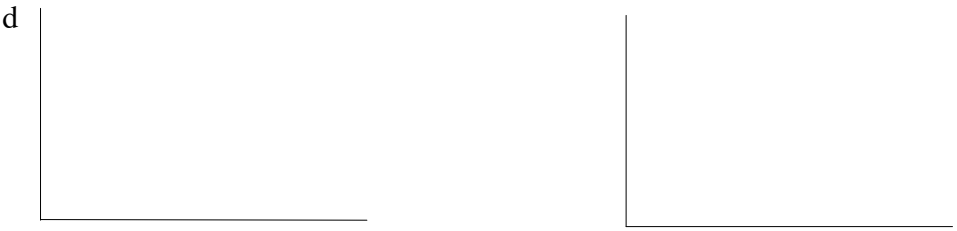
1. Obtain approximate numerical values of the *average velocities* during each time interval in the position vs time graphs (1A, B, and C in part II) by calculating the best slope value for each interval. Show your work below. Return to the sketches drawn jsut above and *scale* the axes properly to reflect the velocities that you have just calculated.

Slope values for 1A Slope values 2A Slope values 3A

2. To check your predictions of velocity *vs*. time graphs for position graphs 1B & 1C, click on the **Distance** axes. When the dialogue box appear, check the **VelMatch** box under the "Run 1" column. Click ⊠ to see the velocity graph. Pressing *control A* rescales the graphs properly for you. Make corrections to your predictions.

B. Study the velocity graphs (1D and 1E in part III). Sketch distance *vs*. time graph that match each of these graphs. Remember that the *area* under the graph represents the *distance traveled* during any particular interval of time.

Match for 1D Match for 1E



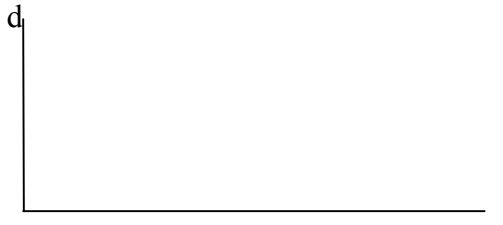
1. Obtain approximate numerical values of the distances traveled during each time interval in the velocity vs time graphs (graphs 1D and 1E in part III) by estimating the value of the area under the graph at each interval using rectangle and triangle area formulas. . Show your work here. Return to the sketches above and *scale* the axes properly to reflect the distances that you have just calculated.

Area values for 1D: Area values for 1E:

2. To check your predictions of position *vs*. time graphs for velocity graphs 1D & 1E, click on the **Velocity** axes. When the dialogue box appear, check the **DistMatch** box under the "Run 1" column. Click ⊠ to see the position graph. Pressing *control A* rescales the graphs properly for you. Make corrections to your predictions.

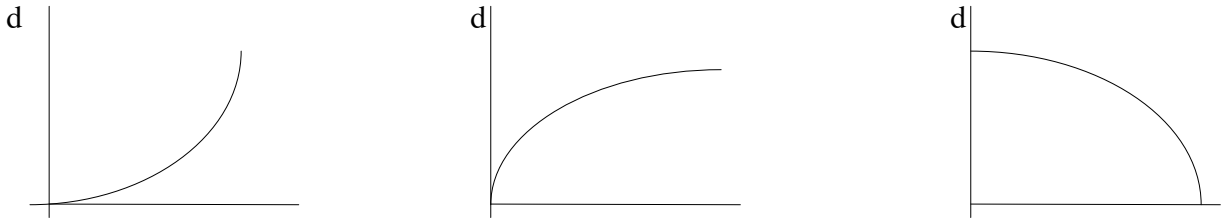
EXTENSIONS

1. Create a graph-matching challenge. Sketch a distance *vs*. time graph on a piece of paper and challenge another student in the class to match your graph. Have the other student challenge you in the same way.

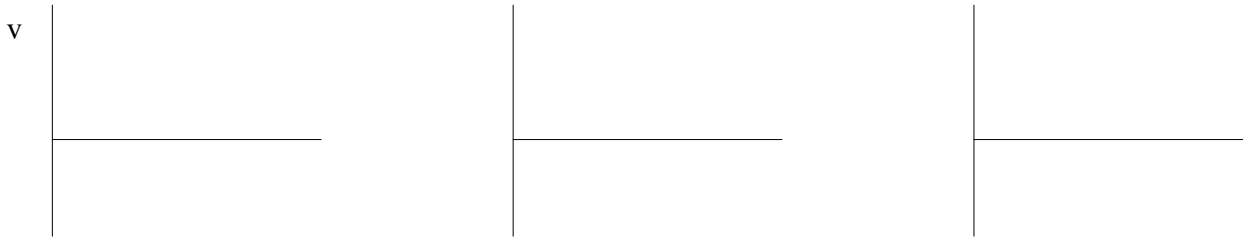


2. Create a velocity *vs*. time challenge in a similar manner.

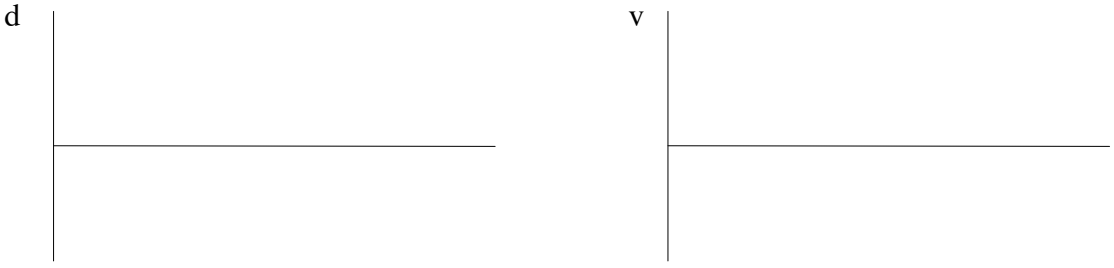
3. Describe how you would move to make the curves below appear in a position vs time graph. Note whether you need to move in the positive or negative direction and whether you have to speed up or slow down. If you have access to a motion detector, try to make these graphs:



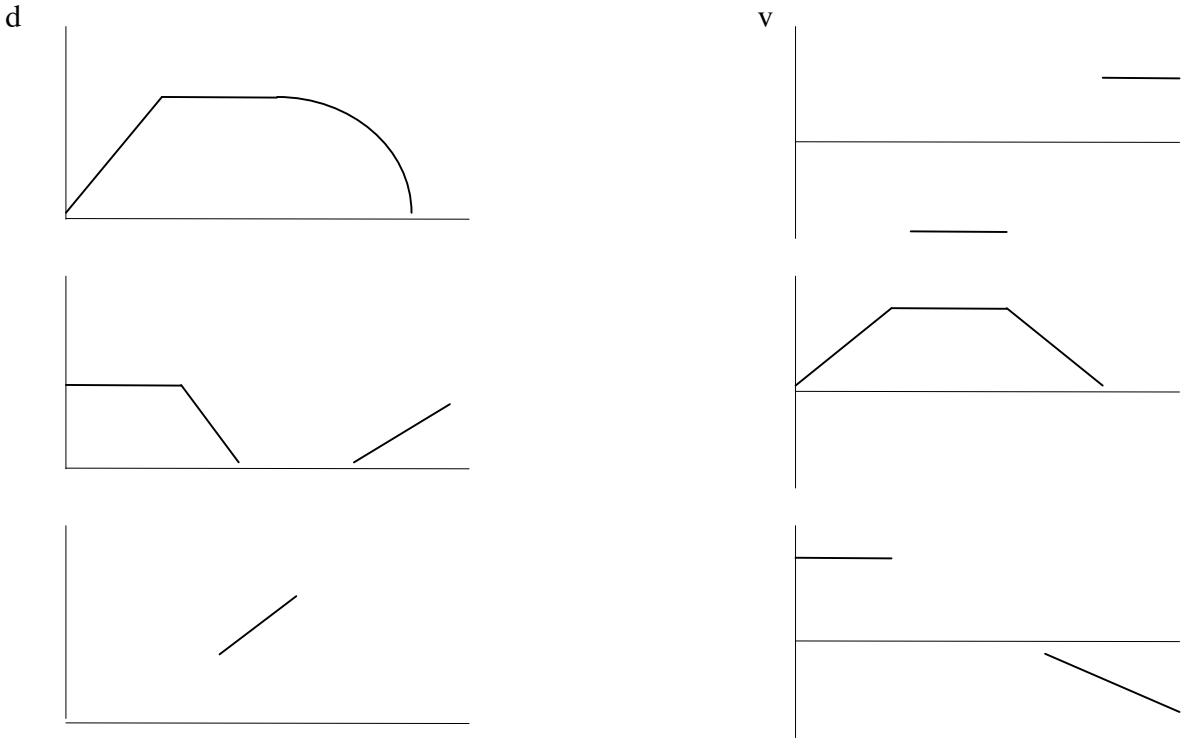
4. Predict the velocity graphs for each of the curved graphs above. If you have access to a motion detector, check your predictions and make corrections. Check the area under the graphs



5. What would a position graph look like if you were behind the detector (- positions) and moved slowly away from the detector and then quickly back toward it? Sketch velocity graphs describing this motion and show that the slope and area concepts are still valid in this case.



6. Match the position graphs on the left to the appropriate velocity graph on the right. Describe the motion represented by each pair.



7. For each graph given below, sketch the companion position or velocity graph. In each case, describe the motion represented by each pair.