

**Problem**

If there is no friction, what will be the shapes of the position-time and the velocity-time graphs for a car that coasts from rest down a hill of uniform slope?

**Description of Data Collection**

A teacher obtained permission from the police for four students to do a kinematics experiment. The method consisted of coasting a car down a steep hill on a quiet paved road. One student drove the car. A second student called out the time at 5.0 s intervals. A third student threw a small sandbag down onto the pavement and a fourth student recorded the speed registered by the speedometer. The students then measured the position of the car at 5.0 s intervals by the sand marks on the pavement. Their data are recorded in the table.

Time $t$ (s)	Position $\vec{d}$ (m[from start])	Velocity $\vec{v}$ (km/h[downhill])
0.0	0.0	0.0
5.0	6.3	9.0
10.0	25.0	19.0
15.0	56.0	26.0
20.0	100.0	36.0
25.0	156.0	45.0

**Instructions**

- Use LoggerPro - available in the "Phys Ed & Science" folder - to answer the following questions.
- Refer to the LoggerPro instruction sheet (2<sup>nd</sup> page) for help using the program.
- When plotting your data be sure to:
  - use point protectors (ie circles around data) to represent any measurement errors
  - replace the "connect-the-dot" line with a line of "best fit"
  - use proper graphing techniques (labels, title, ...)
- Be sure to express your answers to the accuracy/precision indicated and don't forget the units!
- When answering the discussion questions, be sure to use complete sentences.

**Questions**

- Plot a position-time ( $\vec{d}-t$ ) graph of the car's motion. Be sure to hand in a copy of your graph.
- From the position-time graph determine:
  - the time when the car was 40 m from the start. (1 dec. pl.)
  - the position of the car at a time of 17s. (2 sig. dig)
  - the change in position of the car between  $t = 6.0$  s and  $t = 12$  s. (2 sig. dig)
  - the slope of the graph at  $t = 5.0$  s and  $t = 20$  s. (2 sig. dig.)
- Plot a velocity-time ( $\vec{v}-t$ ) graph of the car's motion. Be sure to hand in a copy of your graph.
- From the velocity-time graph determine:
  - the time when the car had a velocity of 15 km/h. (1 dec. pl.)
  - the velocity of the car at a time of 18 s. (2 sig. dig)
  - the change in velocity of the car between  $t = 6.0$  s and  $t = 17$  s. (2 sig. dig)
- Determine the slope of the velocity-time graph in (km/h)/s and convert this to (m/s)/s, or  $m/s^2$ . (2 sig. dig)
- Determine the area under the velocity-time graph in (km/h)s and convert this to m. (3 sig. dig)

**Discussion**

- Describe the position-time graph. What relationship (linear/non-linear) exists between position & time?
- What kind of motion (uniform/non-uniform) was the car undergoing? How could you tell by looking at the position-time graph?
- Describe the velocity-time graph. What does the shape of the graph indicate about the motion?
- What does the slope of a velocity-time graph represent? What does the slope of a line joining two points on a velocity-time graph represent?
- What does the area under a velocity-time graph represent? How does the area under the graph compare to the position at  $t = 25$  s? How should it compare?

## INSTRUCTIONS FOR USING LOGGER PRO

### Question #1

- ① Double click "X" in the DataSet - under Name put "Time", under Short Name put "t" & under Units put "s".
- ② Open the "Options" menu & change the Displayed Precision to "1".
- ③ Do something similar for "Position".
- ④ Enter your data (time & position) & when finished press "Autoscale" (A button at the top). (If for some reason the graph origins were not {0,0} right-click the mouse on the graph, choose "Autoscale" and then "Autoscale from 0".)
- ⑤ Right-click the mouse on the graph & choose "Graph Options" from the menu. Enter an appropriate title for the graph (Position vs Time - Car Coasting Down a Hill) and be sure to turn on the "Point Protectors" and turn off the "Connect Points". Press "Done" when finished.
- ⑥ Choose the "Curve Fit" button at the top. Choose "Linear" & then "Try Fit". If the line goes through your all your data points or very close to them, this is a good fit. If not, try "Quadratic". Press "OK" when finished. An "Equation" box will be created. You can move this around the screen so it doesn't obscure your graph but do NOT delete it - deleting the box deletes the line of best fit.
- ⑦ To print your graph choose "File" & then "Print Graph". Click on the "Print Footer" box, type your name in the box presented and then click "Ok".

### Question #2abc

- ① In order to determine accurate time and position data you need to use another feature of LoggerPro. Under "Analyze" turn on the "Interpolate" feature. This now allows you to drag the cursor along the graph and determine the time and position at any location.

### Question #2d

- ① In order to determine the slope of the graph at various locations you need to use yet another feature of LoggerPro. Under "Analyze" turn on the "Tangent" feature. This now allows you to drag the cursor along the graph and determine the slope of the graph at any location.

### Question #3

- ① Double click "X" in the DataSet - under Name put "Time", under Short Name put "t" & under Units put "s".
- ② Open the "Options" menu & change the Displayed Precision to "1".
- ③ Do something similar for "Velocity".
- ④ Enter your data (time & velocity) & when finished press the "Autoscale" Button at the top.
- ⑤ Right-click the mouse on the graph & choose "Graph Options" from the menu. Enter an appropriate title for the graph (Velocity vs Time - Car Coasting Down a Hill) and be sure to turn on the "Point Protectors" and turn off the "Connect Points". Press "Done" when finished.
- ⑥ Choose the "Curve Fit" button at the top. Choose "Linear" & then "Try Fit". If the line goes through your all your data points or very close to them, this is a good fit. If not, try "Quadratic". Press "OK" when finished. An "Equation" box will be created. You can move it around like before but you will need to refer to it later so do NOT delete it.

### Question #4abc

- ① In order to determine accurate time and velocity data you need to use the "Interpolate" feature again.

### Question #5

- ① In order to determine the slope of the velocity-time graph one only needs to look at the "Equation" box that was produced when the line of best-fit was created. You should have obtained a "Linear" fit so that a straight line was created. The equation  $y = mx + b$  contains the information you seek (i.e. "m").
- ② Whether you are converting from m/s to km/h or (m/s)/s to (km/h)/s you use the same conversion factor that was discussed in class.

### Question #6

- ① In order to determine the area under the graph you need to use yet another feature of LoggerPro. Under "Analyze" turn on the "Integral" feature. This will determine the area under the whole graph. If you only want the area under a select data set, left-click the mouse and drag the cursor to select a portion of the graph/data. Then choose "Integral".



LOGGERPRO IS AVAILABLE TO YOU FOR **FREE** FROM THE LIBRARY  
JUST SIGN IT OUT & INSTALL IT AT HOME!

