

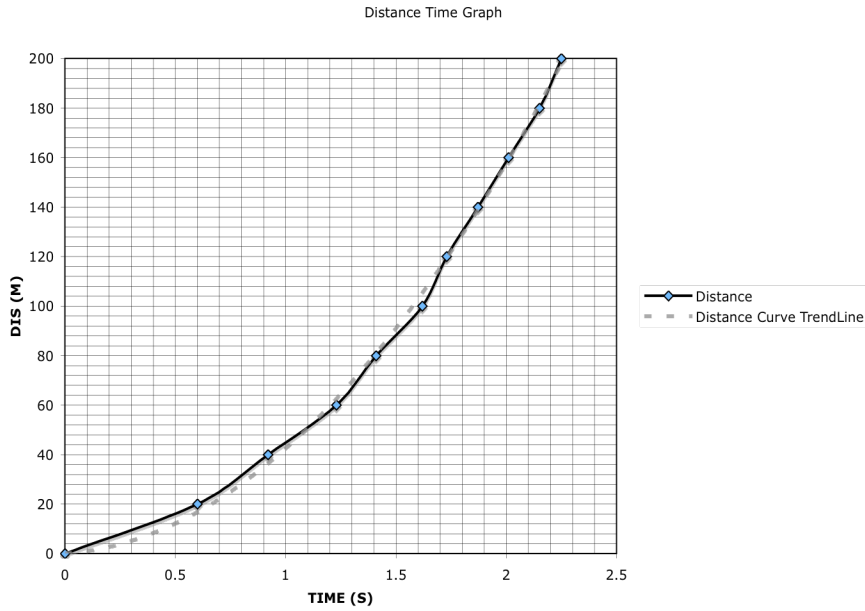
## *ROLLING DOWN A LONG RAMP SAMPLE ANSWERS*

This experiment requires several people to work together to analyze the motion of a ball moving down a long ramp. Your goals are to observe, measure, and analyze  
A c c e l e r a t i o n !

Gather down a long ramp with your partners. Several students should have timers at be stationed at equal distances (every .1 m, every .2 m or every .3 meters??) along the ramp. At the start signal the ball is released and each person starts the timer. The timer is stopped when the ball passes each person's position. OR do several trials with different distances each time. Make sure you get as accurate measurements as possible. Your distance time chart should have at least 10 data points.

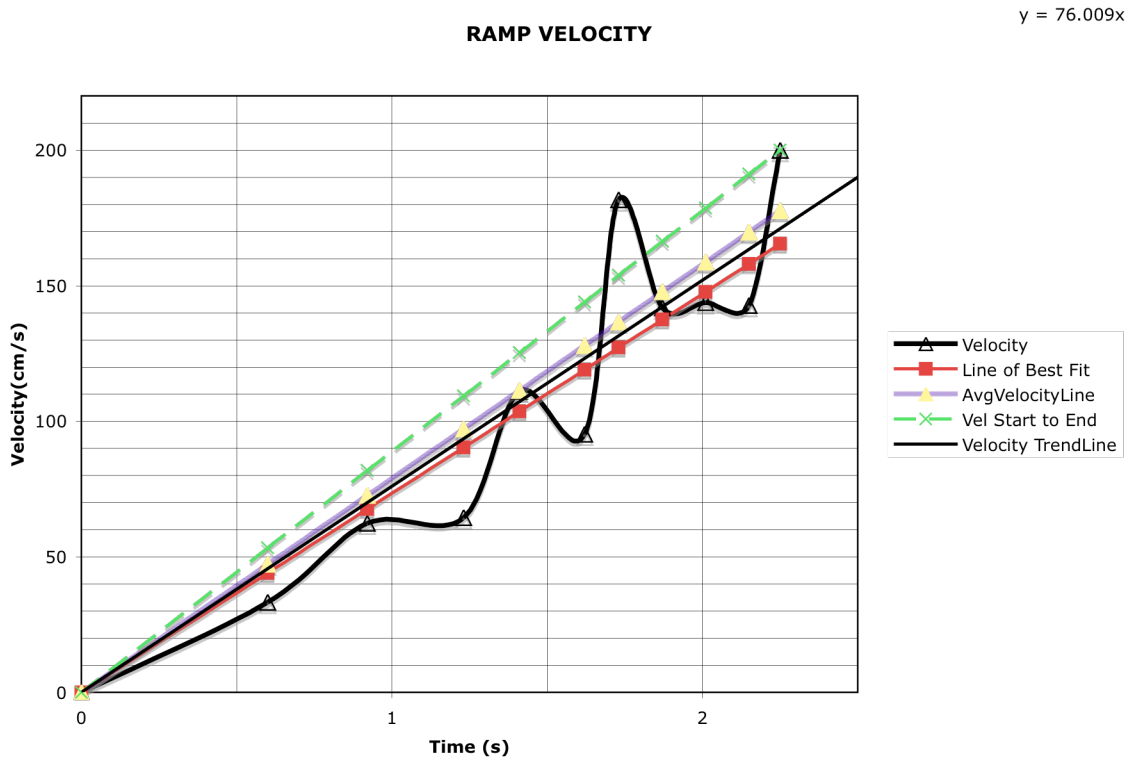
DIST(cm)	TIME(S)	VEL (cm/s) $\Delta D/\Delta T$
0	0	0
20	0.6	33.33333333
40	0.92	62.5
60	1.23	64.51612903
80	1.41	111.1111111
100	1.62	95.23809524
120	1.73	181.8181818
140	1.871	141.8439716
160	2.01	143.8848921
180	2.15	142.8571429
200	2.25	200

Make an accurate distance time graph of the trip.



Calculate the average instantaneous velocity at each point (Change in distance divided by change in time).

Make an accurate velocity time graph of the trip.



## QUESTIONS

1) Did the ball travel half way down the ramp in half the total time of the trip? Support your answer with specific evidence.

*NO.... halfway down the ramp was 100 cm, the time there was 1.62 sec., over 2/3 the time.*

*Half of the time was at 1.125 sec, the ball was at about 50 cm, only a quarter of the trip distance..*

2) Consider your graph of this motion and compare it to graphs you have previously drawn which depicted uniform (constant) speed. How is it similar or different?

*The distance time graph shows a curve, not a straight diagonal line.*

3) Did the ball in this experiment travel the same amount of distance during each second? Discuss...

*The ball kept increasing the distance it traveled in each second.*

4) What is the average speed of the ball during its entire trip as it rolled down the ramp. Use the definition of average speed (total distance divided by total time).

*The average speed was the total distance of 200cm/ total time of 2.25 s = 88.89 m/s*

5) If the beginning speed was zero, and you know the average speed, how would you use these two pieces of information to find the approximate speed at the END of the ramp?

*Since  $V_{avg} = (V_i + V_f)/2$  or the middle of the starting and ending speeds...*

*Then  $V_f = 2(V_{avg}) - V_i = 2 * 88.89 = 177.78$  m/s*

6) If you know the speed at the end of the ramp from #5, and the ball started from rest.. calculate the average acceleration ( change in speed/change in time) of the ball.

*$Accel = (V_f - V_i)/T = (177.78)/(2.25) = 79.01$  m/s<sup>2</sup>*

7) Given certain conditions (starting speed of zero, and constant acceleration) acceleration can be calculated in another manner.  $A = 2 D / T^2$

Use this to calculate the acceleration, and compare it to the answer from # 6.

*$A = 2 (200)/(2.25^2) = 79.01$ , it is the same!*

8) Using your velocity time graph, find acceleration by finding the slope of a best fit line. Which method for finding acceleration is most useful?

*The slope of our velocity best fit trend lines is about 73 or 76 m/s<sup>2</sup>*

## *HALF THE TRIP*

What do we mean by “half of a trip” when an object is accelerating? Do we mean half the time? Do we mean half the distance?

Release a ball from the top of a ramp. Time the trip along the full length many times to obtain an accurate value.

DIST of ramp: 200 cm                      Time for full trip 2.25 sec

Mark the exact middle of the ramp. Use a timer to determine the amount of time it takes the ball to travel the first half of the ramp only.

DIST of half ramp 100 cm                      Time for half ramp trip 1.62 sec

WITHOUT taking ANY additional measurements calculate the following: When the ball was released from the top of the ramp, how long did it take the ball to roll down the SECOND HALF of the ramp??

$T_{total} = 2.25 \text{ sec}$ ,  $T_{first \text{ half}} = 1.62 \text{ sec}$ ,  $T_{second \text{ half}} = 2.25 - 1.62 = 0.63 \text{ sec}$

Why is it a different time from the first half? DISCUSS FULLY!!!!

*It is different because it takes a longer time to go down the first half, then less time as it speeds up on the second half.*

WITHOUT MEASURING.... Using only the definitions of average speed, acceleration.... Find the distance the ball moves during the first half of the total TIME of the trip. Show your work and explain fully!

*Total time is 2.25 seconds, total distance is 200 cm... Average Velocity on the whole trip is  $200/2.25$  or  $88.89 \text{ m/s}$ ... which is what the velocity is at half time (1.125 sec)*

*The acceleration on the ramp is  $A = (2D/T^2) = 79 \text{ m/s}^2$*

*Distance in half the time  $D = 1/2 AT^2$  or  $D = 1/2 * 79 * (1.125)^2 = 50 \text{ meters}$*

*Or  $D \text{ at half} = (0 + 88.89)/2 * 1.125 = 50 \text{ meters}$*