

## Lab 2: Graphical Analysis of Motion

## Physics 112

In this lab you will be using graphs to determine the speed of an object moving with uniform motion and instantaneous speeds and the acceleration of a falling object.

**Equipment:** sparktimer, tickertape, tape, ruler, motion cart, 200 g mass.

You should bring: looseleaf, graph paper, calculator, ruler, pencil

### Part I: Uniform Motion

Get a piece of tickertape about 1 m long and feed it through the spark timer, then tape it to the motion cart. Set the sparktimer to 1/10 s. This will form a pair of dots on the tape every 1/10 s. Hold the sparktimer tightly to the lab bench. Turn on the timer and push the motion cart *moderately* to obtain your data.

Using the tickertape, ignore the first few pair of dots (which will be unevenly spaced until the cart has reached its constant speed). When the dots appear evenly spaced, mark the first dot as  $t=0$ . This will be your reference point. Measure the distance from the reference point to the next dot and record it in a table similar to the one below – this is the distance for 0.1 s. Repeat these measurements (**always** from your reference point,  $t=0$ ) up to  $t=1.0$  s. Record your data in a table similar to Table 2.1.

**Table 2.1:** Uniform Motion

Time(s)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Distance(m)	0										

Plot a graph of distance vs. time (distance on the y-axis). Label the graph appropriately (with a title)!

1. What pattern does your graph appear to indicate? What does this tell you about the relationship between distance and time?

Draw a best-fit line through the points and determine the slope.

2. Using the slope of the graph, find the speed of the cart.

### Part II: Accelerated Motion

Feed another piece of tickertape through the spark timer and then tape the end to the 200 g mass. Place the sparktimer near the corner of the lab bench. **Set the sparktimer to 1/60 s.** Turn the timer on and drop the mass to the floor. Use this tape to obtain your data.

Analyse the dots as before (but don't look for the dots to be equally spaced). Start measuring when the dots are a "comfortable" distance apart (about 0.2 cm). Label this as  $t=0$ . Measure the distances between the dots and your reference point as before, and record it in a similar table to Table 2.1 (called Table 2.2). Keep measuring until you get a decrease in distance between two successive dots. (This would indicate that the mass has hit the floor!) You should have at least 18 sets of dots *after*  $t=0$ .

Plot a graph of distance vs. time. With the aid of a thin ruler or flexicurve, draw a curve through the points.

3. Using the tangent line method, calculate the speed at 0.1 s and 0.3 s. Show your slope points and calculations.

### Part III: Accelerated Motion - Straight Line Graph

We can rearrange the equation  $d = v_i t + \frac{1}{2} a t^2$  by dividing by  $t$  to get

$$\frac{d}{t} = v_i + \frac{1}{2} a t.$$

If we plot a graph of  $\frac{d}{t}$  against  $t$  we should get a straight line.

4. What would the slope of this graph represent?
5. What would the y-intercept represent?

Using the data from your table in part II, create a table similar to the following one. Do not use  $t=0$  as a point ( $0/0$  is undefined).

**Table 2.3:** Data for straight line graph of accelerated motion

Times	Distance (m)	d/t (m/s)
1/60		
2/60		
3/60		
⋮		

Note that  $d/t$  is **not** the instantaneous speed of the mass (that you calculated from the tangent line in part II) but rather the **average speed** up to time  $t$ .

Plot  $d/t$  vs.  $t$  and draw the best fit line.

6. What is the slope and y-intercept of your line?
7. Why is the y-intercept not zero?
8. What is the acceleration of the mass? How does this compare with what you expect (% difference)?

Percent difference can be calculated in three different ways depending upon the circumstances. It is a means of comparing two values – either two experimental values, or an experimental value with a theoretical or predicted value. % differences should be rounded to 1 significant figure if less than one percent or to the nearest percent

Case 1: An experimental value and a theoretical or predicted value

$$\% \text{ difference} = \frac{|\text{theoretical or predicted value} - \text{experimental value}|}{\text{theoretical or predicted value}} \times 100\%$$

Case 2: An experimental value with a better experimental value

$$\% \text{ difference} = \frac{|\text{value 1} - \text{value 2}|}{\text{better value}} \times 100\%$$

Case 3: Two experimental values with no reason to believe one is better than the other

$$\% \text{ difference} = \frac{|\text{value 1} - \text{value 2}|}{\text{smaller value}} \times 100\%$$

9. Using the equation  $v_f = v_i + at$  find the instantaneous velocities at 0.1 s and 0.3 s respectively. Compare these values with those from question 3.