LAB 2. CONSTANT ACCELERATION

Supplies

Drop: clamping support, tape timer, ticker tape, hanging weight, catch pad

Ramp: computer with Capstone installed; Science Workshop 750 interface; USB to interface cable; interface power supply; PASCO Motion sensor II with cable; dynamics cart; grooved aluminum track; books, boxes, or blocks to elevate one end of the track.

Box station: Motion sensor apparatus from the ramp activity; level surface (floor or table top); cardboard box or other sliding object

Activities

Activity 1: Drop

What to do

In this activity, you will drop a weight hanging from a length of paper tape so that it falls freely and draws the tape between a metal plate and a circle of carbon paper on the timer. The Pasco Tape Timer strikes the metal plate at a frequency of 40 hertz, making a mark on the paper at regular intervals of 1/40 sec.

1. Set a book or pad under the tape timer to catch the falling weight.
2. Cut a piece of paper tape long enough to reach from the timer to the floor, with about 50 cm excess.
3. Thread one end of the tape through the slots on the timer, from top to bottom. Make sure that the tape runs between the metal bar and the circle of carbon paper.
4. Fold over the lower end of the paper and hook the weight through both layers. (This keeps the paper from tearing.)
5. Hold the rest of the tape above the timer so that the mass hangs just below the bottom of the timer. Turn on the timer to 40 Hz. Let it run for a few seconds to get up to speed.
6. Drop the tape, allowing the weight to fall freely.
7. Turn off the timer. Remove the tape from the timer and fasten it to the table with masking tape.
8. Repeat this procedure for a second trial.
9. Complete Table 1 by following these steps for each trial.
10. Choose a starting point a few centimeters past the first group of dots and mark that dot as Position 0. (The first several dots are unreliable—do you see why?) Measure the *total* distance from Position 0 to each successive dot for up to 15 dots. (The last few dots on the tape are also unreliable—again, do you see why?) Record these values in Table 1.
11. In the next column of the table, calculate the distance Δd between successive dots by subtracting the position of the previous dot. If you wish, you may use a spreadsheet.
12. In the final column, calculate the average speed of the falling mass in each interval between successive dots using the relation $v = \Delta d/\Delta t$. Since the timer was set on 40 Hz, it was making

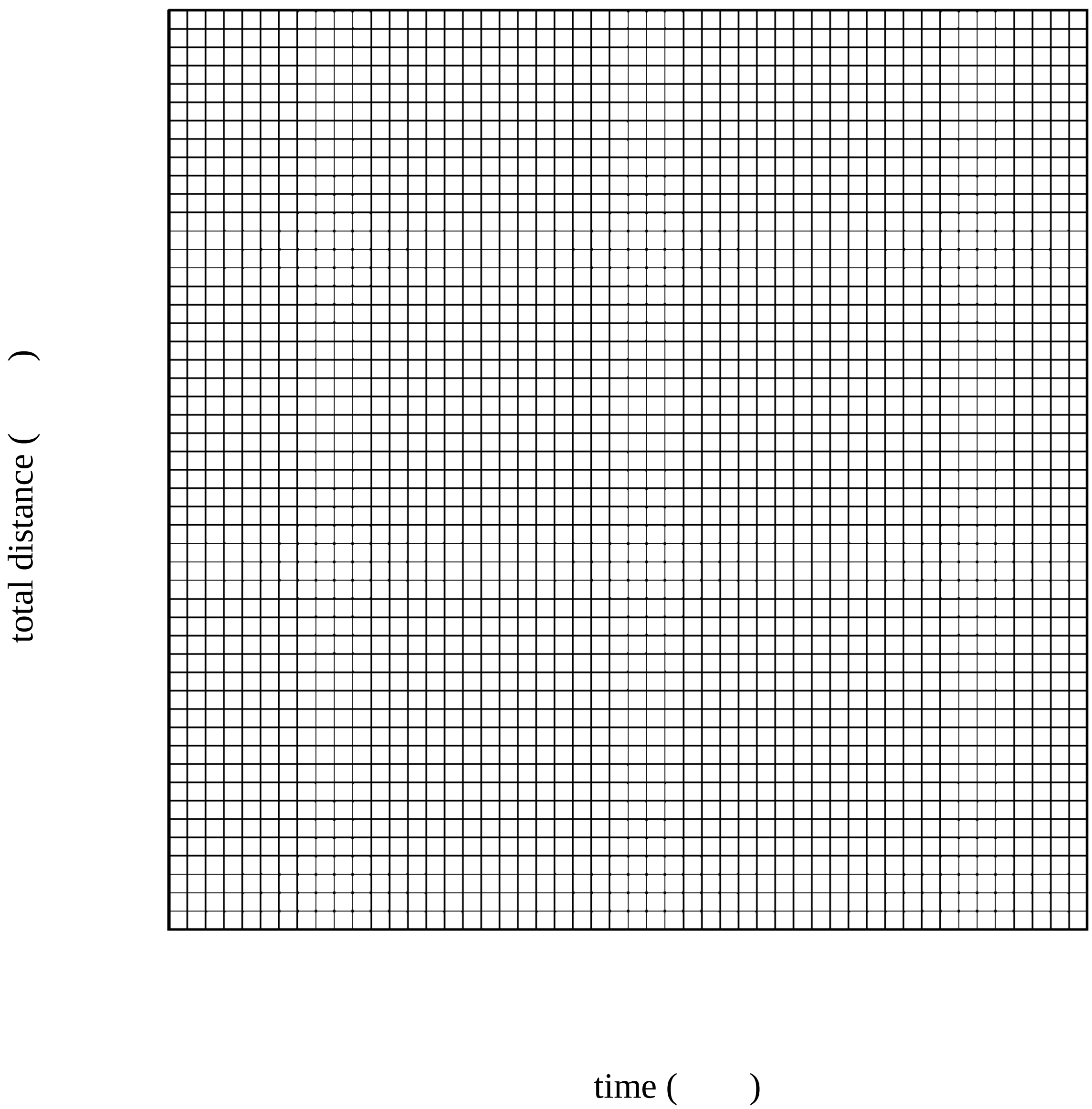
40 dots per second, so the time between successive dots is 1/40 s or 0.025 s. Numerically, this means you should multiply the number in the Δd column by 40. Do *not* divide d or Δd by the number in the "Time" column.

Table 1. Falling mass

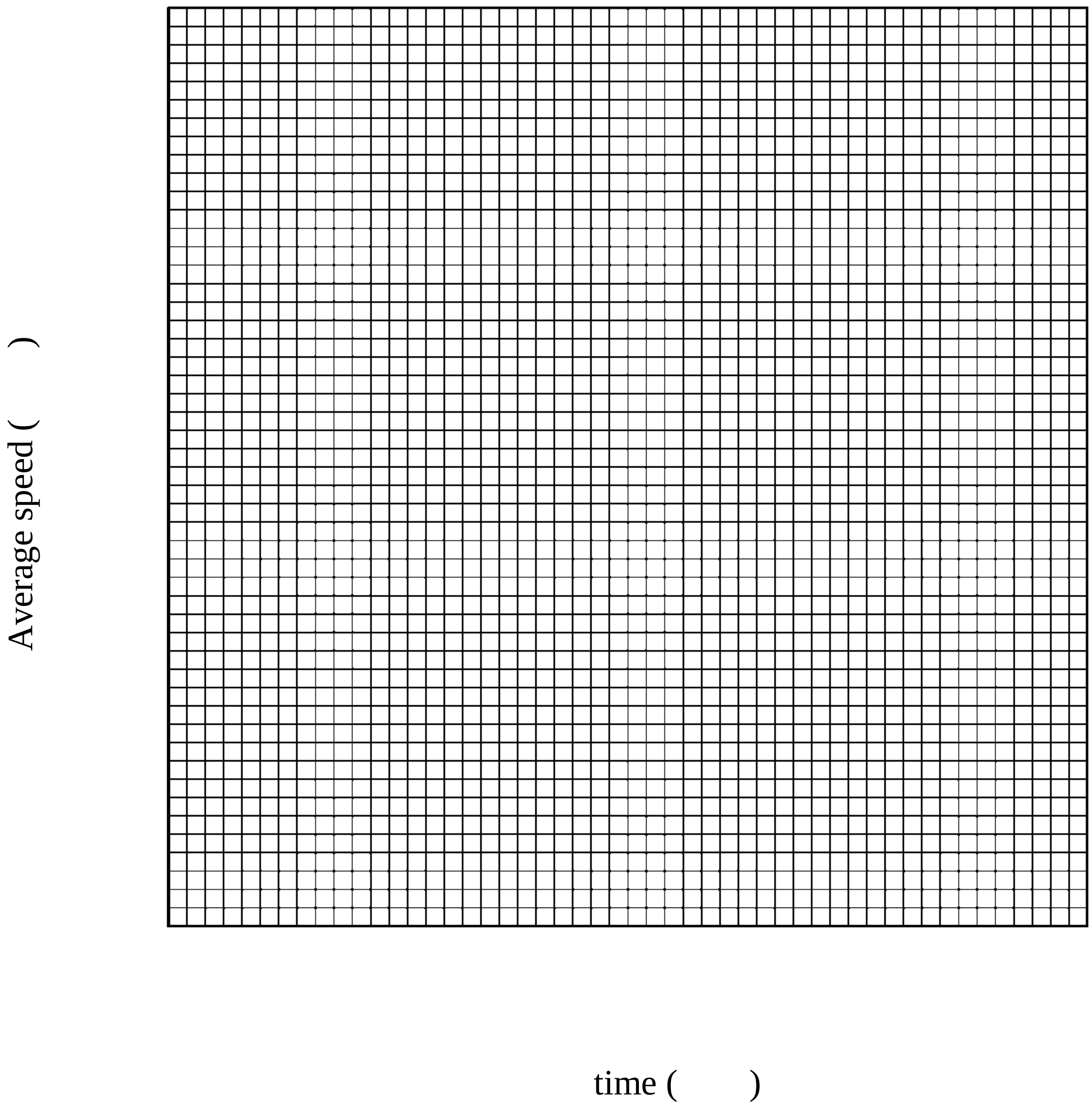
Dot	Time t (s)	Trial 1			Trial 2		
		Total Distance d (cm)	Change in Distance Δd (cm)	Average Speed v (cm/s)	Total Distance d (cm)	Change in Distance Δd (cm)	Average Speed v (cm/s)
0	0	0	—	—	0	—	—
1	0.025						
2	0.050						
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

Analysis

1. Make a plot of total distance vs. time from your measurements in Table 1. Plot both sets of data on the same graph, using a different plot symbol and color for them. Scale your graph to use at least half of each axis. Include a legend on your graph to tell which is which. Enter the units in the axis labels. Title your graph.



2. Make a graph of the velocity vs. time from your measurements in Table 1. Plot both sets of data on the same graph, using a different plot symbol and color for each. Include a legend with your graph to tell which is which. Enter the units in the axis labels. Scale your graph to use at least half of each axis. Title your graph.



3. Using a ruler, draw a straight line that best approximates the trend of the points from Trial 1. Draw another line for the Trial 2 points. Determine the slope of each line.
4. What do the slopes represent physically?

5. Do straight lines reasonably approximate the data? What does that mean?

Activity 2: Ramp

What to do

Use the motion sensor apparatus to make velocity measurements of the dynamics cart rolling down the ramp.

1. Place the motion detector at the top of the ramp, facing down.
2. Elevate the track by placing books or boxes under one end. Measure and record the height of the support and the length of the ramp (hypotenuse) from base to support. Don't neglect the units!
3. Place the cart at the top of the ramp.
4. Start data collection.
5. Release the cart, allowing it to roll down the ramp.
6. Catch the cart before it reaches the end of the ramp. Do not allow it to collide with anything or to crash to the floor.
7. In Capstone, plot the graph of velocity vs. time. Select the linear portion of the graph and find its slope using the Capstone software. (If there is no linear region, something is wrong. See me.) The slope is the average acceleration of the cart for that run. Record it in Table 2. Don't neglect the units.
8. Repeat steps 3–7 twice more, for three runs per incline angle.
9. Repeat steps 2–8 for at least four ramp angles.

Table 2. Rolling downhill

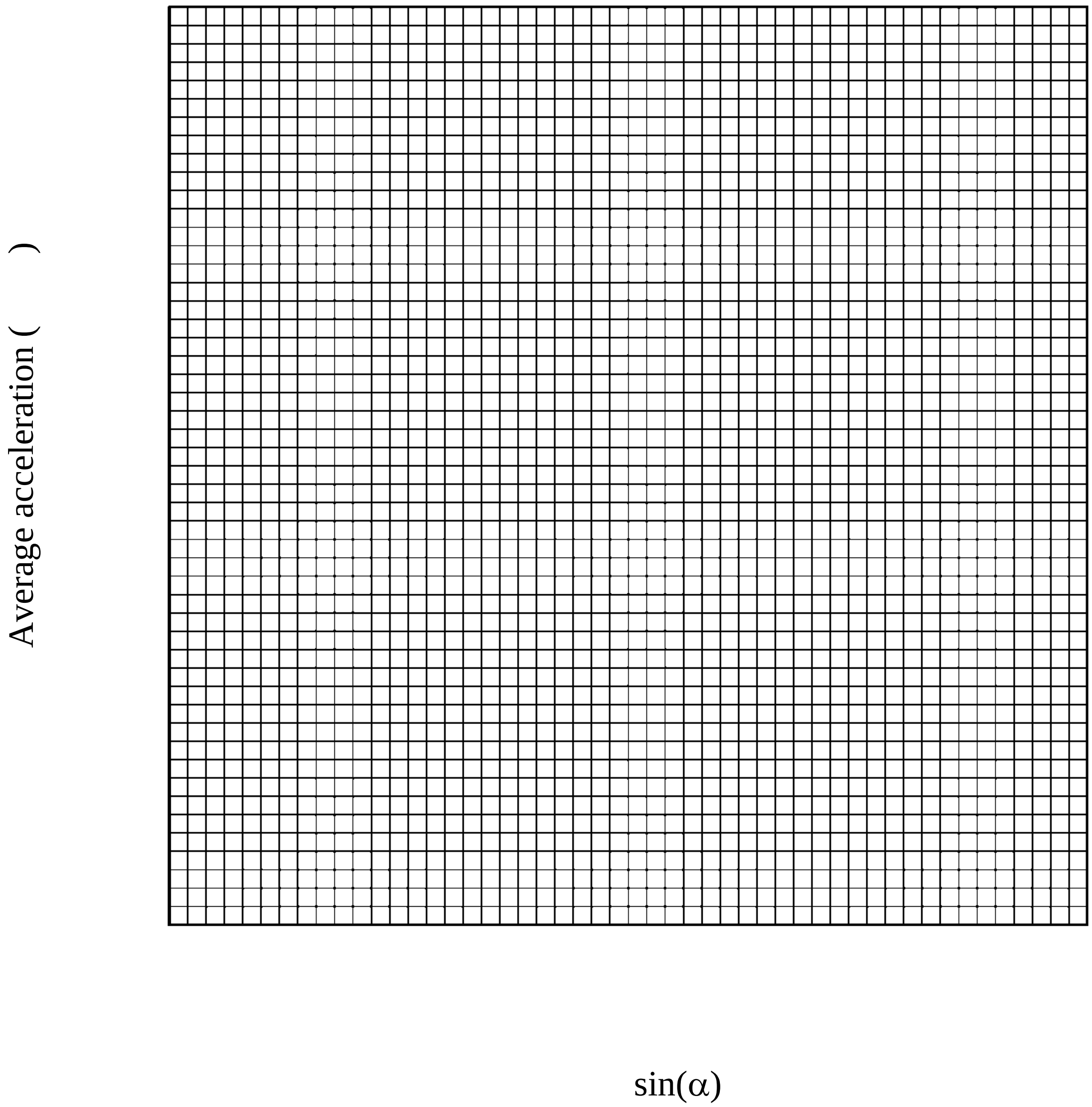
Length of hypotenuse s = _______________

Altitude h	Acceleration a			Average a	$\sin(\alpha)$
	1	2	3		

Data Processing

1. Average the accelerations from the three runs for each ramp angle. (They should be similar.) Record the averages in Table 2. Don't neglect the units.
2. Calculate the sine of each incline angle α of the ramp from the height h and hypotenuse s using the relation $\sin(\alpha) = h/s$. Record the sine in Table 2. Don't neglect the units.
3. Plot acceleration (vertical) vs. $\sin(\alpha)$ (horizontal). Scale your graph to use at least half of each axis. Title your graph.

4 .How does acceleration appear to vary with $\sin(\alpha)$?



Activity 3: Sliding box

1. Set up the motion detector to follow a box sliding along a bench top or the floor.
2. Start data collection.
3. Push the box toward the detector and let it slide to a stop before reaching the detector.
4. Create the position-time graph. If it is reasonably smooth, move to the next step. If the position-time graph is not smooth, repeat the run.
5. Create the velocity-time and acceleration-time graphs if you think they might help you understand the motion.
6. How would you describe the motion of the sliding box? When you have a good answer, call over the instructor. Explain your answer, using the evidence you have developed.