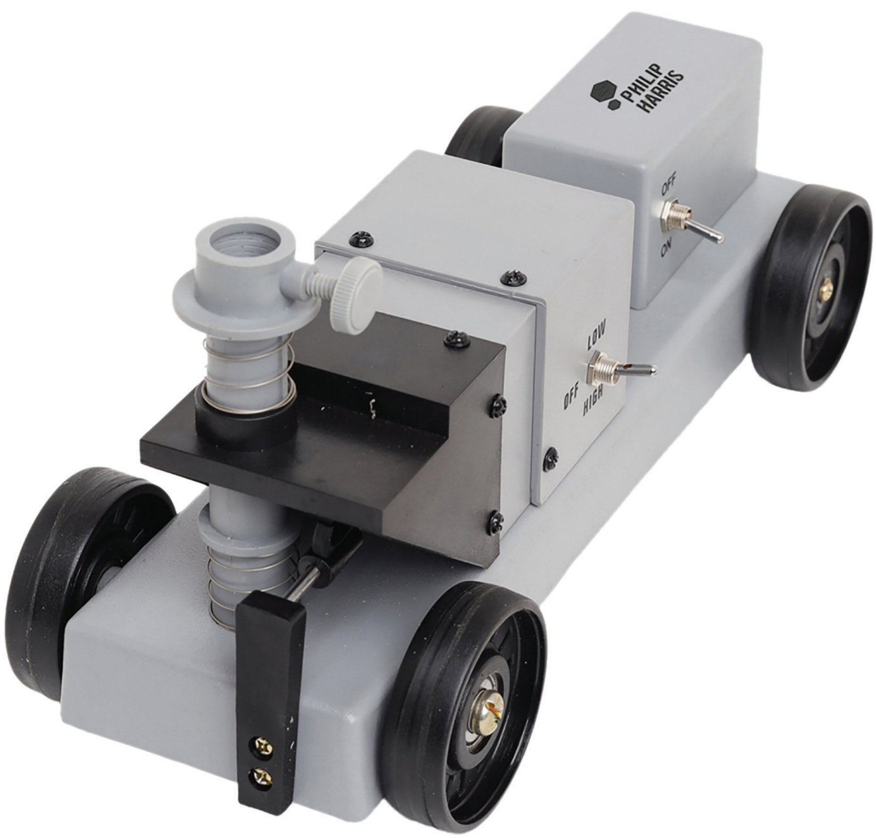
Foundation Physics



Constant Motion Cart

Constant Motion Cart

KIT CONTENTS

ITEM	QUANTITY	DESCRIPTION
1	1	Constant Motion Cart
2	1	Hex Wrench
3	1	Instructions (this booklet): Teacher's Guide: pages 2 - 8 Student Guide (reproducible): pages 9 - 15

Additional Materials Needed:
Roll(s) of adding machine paper
Pencil or marker
Stopwatch
Meter stick

OVERVIEW / SUGGESTIONS FOR USE

The Constant Motion Cart allows students to investigate the idea of constant velocity and acceleration, using hands on activities. When in motion, the Constant Motion Cart reciprocating arm dots a piece of paper with a marker at regular intervals. Varying speeds and acceleration will make different patterns, which allows students to analyze the car's motion.

CLASS TIME REQUIRED

(2) 40-minute periods

YEAR GROUP

Grades 9 - 11

NATIONAL CURRICULUM STANDARD

Content Standard	Grades 8 - 12
B: Physics	• Conservation of energy and increase in disorder • Interactions of Energy and Matter

TEACHER PREPARATION (PRIOR TO CLASS)

- Read through the student activities and make copies of pages S1- S15.

- Place a roll or two of adding machine paper in a central area accessible to all students. If you have more than one Constant Motion Cart, distribute them to the various lab stations.

SUGGESTED ACTIVITIES

Activity 1: Introduction to Velocity and Acceleration - KS4
Students make observations on the difference between a car moving at a constant velocity and a car that is accelerating.

Activity 2: Constant Velocity - KS4
The Constant Motion Cart travels at two different constant speeds. Students will investigate the dot pattern associated with the different constant speeds.

Activity 3: Positive Acceleration - Higher KS4
After allowing the Constant Motion Cart to roll freely down an incline, students investigate the pattern created by an accelerating object.

Activity 4: Negative Acceleration - Higher KS4
Students push the Constant Motion Cart up an incline, and then investigate the negative acceleration pattern.

TEACHER ANSWER GUIDE

The following answers are based on actual trials using the 'Foundations of Physics' and Constant Motion Cart. Note, however, that these are not the only possible answers.

ACTIVITY 1: INTRODUCTION TO VELOCITY AND ACCELERATION

Questions

1. Look at the two paper strips marked "constant speed". Describe any similarities or differences in the placement and pattern of the dots.

   Both constant velocity strips will have dots that are equally spaced; however, the distance between the dots will be different for each strip. The "high speed" strip will have a larger distance between the dots.

2. The marker motor moved at the same speed for all of the experiments. Explain why the dot pattern for the two constant velocity (low speed and high speed) paper strips are different from each other.

   During the same amount of elapsed time, the car travels faster on the "high speed" setting than it does on the "low speed" setting. This makes the distance between the dots on the high speed strip greater than the distance between the dots on the low speed strip, even though the elapsed time between each dot is the same.

3. Look at the two paper strips that were placed on the incline (rolling down, and rolling up). Describe and explain the reasons for any similarities or differences in the placement and pattern of the dots on these strips.

   On the incline, the car was either speeding up (traveling down the incline) or slowing down (traveling up the incline). Since the speed was constantly changing, the distance between the dots also changed. They become closer together going up the incline and farther apart going down the incline.

4. Explain how you can determine if the Constant Motion Cart was accelerating or moving at a constant speed based solely on the dot pattern it leaves behind.

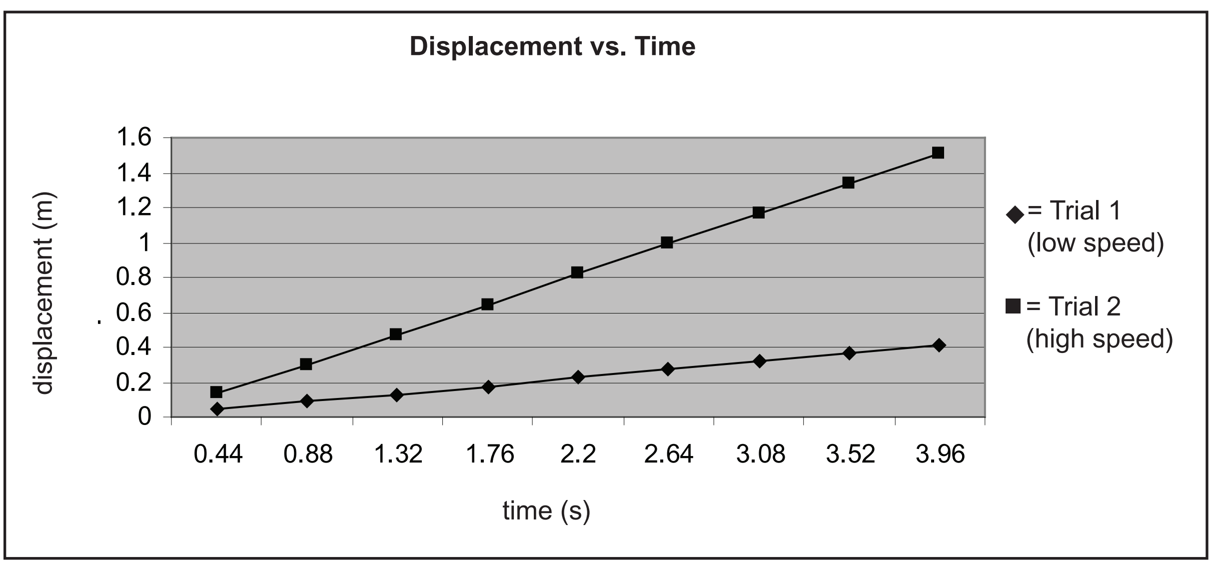
   A Constant Motion Cart moving at a constant speed will leave a pattern of equally spaced dots. A car that is accelerating (either positively or negatively) will have dots that are either coming closer together (slowing down) or farther apart (speeding up).

ACTIVITY 2: CONSTANT VELOCITY

Data Table 1: Constant Velocities Time: *0.44 sec*				
Dot #	Time (s)	Distance between dots (m)	Displacement from the starting point (m)	Velocity (m/s)
Trial 1 - LOW SPEED SETTING				
1	*0*	–	*0*	–
2	*0.44*	*0.045*	*0.045*	*0.10*
3	*0.88*	*0.045*	*0.09*	*0.10*
4	*1.32*	*0.040*	*0.13*	*0.09*
5	*1.76*	*0.045*	*0.175*	*0.10*
6	*2.20*	*0.050*	*0.225*	*0.11*
7	*2.64*	*0.045*	*0.27*	*0.10*
8	*3.08*	*0.045*	*0.315*	*0.10*
9	*3.52*	*0.050*	*0.365*	*0.11*
10	*3.96*	*0.045*	*0.41*	*0.10*
Trial 2 - HIGH SPEED SETTING				
1	*0*	–	*0*	–
2	*0.44*	*0.133*	*0.133*	*0.30*
3	*0.88*	*0.165*	*0.298*	*0.38*
4	*1.32*	*0.165*	*0.463*	*0.38*
5	*1.76*	*0.180*	*0.643*	*0.41*
6	*2.20*	*0.180*	*0.823*	*0.41*
7	*2.64*	*0.175*	*0.998*	*0.40*
8	*3.08*	*0.170*	*1.168*	*0.39*
9	*3.52*	*0.170*	*1.338*	*0.39*
10	*3.96*	*0.170*	*1.508*	*0.39*

Questions

1. On the graph below, plot displacement versus time for Trials 1 (low speed) and 2 (high speed).



ACTIVITY 2: CONSTANT VELOCITY (CONTINUED)

2. What do the slopes of the lines represent? What can you tell about the motion of the car based on the shape and/or direction of the slope?

   The slope represents the velocity of each car. A relatively straight line represents a car moving at a constant velocity.

3. For either one of the trials, describe the pattern you observed in the physical separation of the dots. Did this pattern also occur in the other trial?

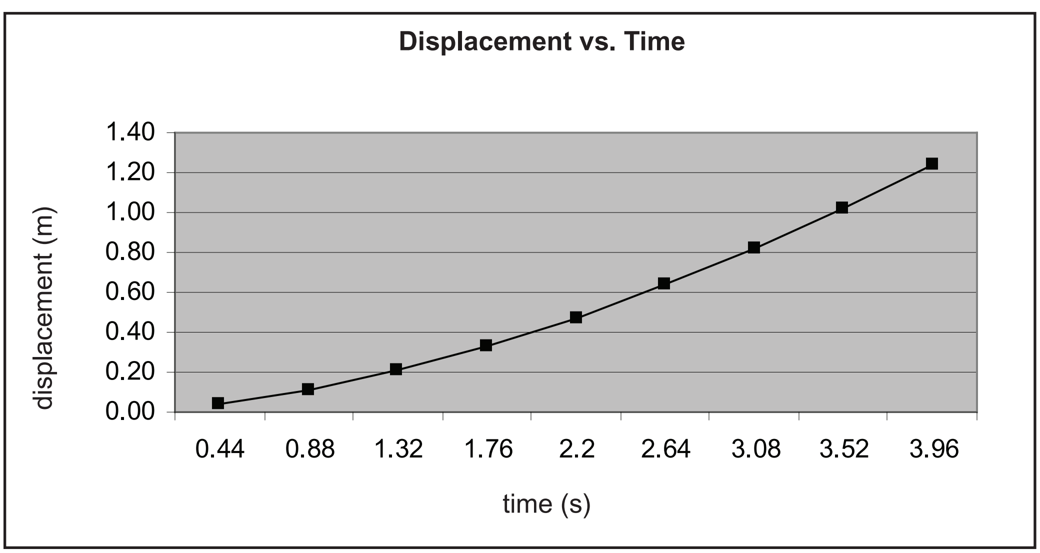
   Overall the dots were spaced relatively evenly from one another in each trial. However, the distance between the dots was smaller in the low speed trial and greater in the high speed trial.

ACTIVITY 3: POSITIVE ACCELERATION

Data Table 2: Positive Acceleration Time: *0.44 sec*					
Dot #	Time (s)	Distance between dots (m)	Displacement from the starting point (m)	Velocity (m/s)	Acceleration (m/s^2)
1	*0*	–	*0*	–	–
2	*0.44*	*0.04*	*0.04*	*0.10*	–
3	*0.88*	*0.07*	*0.11*	*0.13*	*0.07*
4	*1.32*	*0.10*	*0.21*	*0.16*	*0.08*
5	*1.76*	*0.13*	*0.34*	*0.19*	*0.07*
6	*2.20*	*0.14*	*0.48*	*0.22*	*0.06*
7	*2.64*	*0.16*	*0.64*	*0.24*	*0.06*
8	*3.08*	*0.18*	*0.82*	*0.27*	*0.06*
9	*3.52*	*0.20*	*1.03*	*0.29*	*0.05*
10	*3.96*	*0.21*	*1.24*	*0.31*	*0.05*

Questions

1. On the graph below, plot displacement versus time.

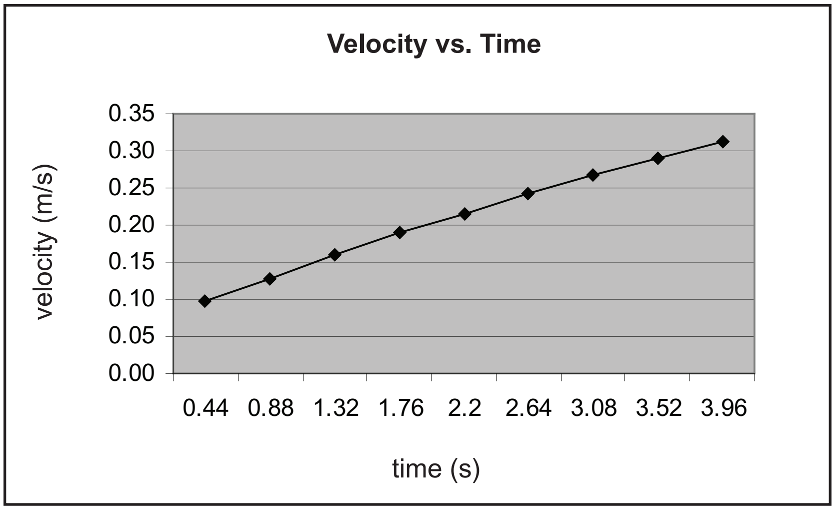


ACTIVITY 3: POSITIVE ACCELERATION (CONTINUED)

2. What does the slope of the line on the displacement versus time graph represent? Describe the shape and/or direction of the slope. What can you tell about the motion of the car based on this shape?

   The slope of the graph represents the velocity of the car. The upward slant indicates a positive velocity; however, the line is slightly curved, indicating that the velocity is not constant.

3. On the graph below, plot velocity versus time.



4. What does the slope of the line on the velocity versus time graph represent? Describe the shape and/or direction of the slope. What can you tell about the motion of the car based on this shape?

   The slope of the graph represents the acceleration of the car. Since the line is relatively straight, it represents a constant acceleration.

5. How does the pattern of dots compare to that of the dots from Activity 2? Look at your data for this activity. In terms of velocity, explain how and why the distance between the dots changed.

   Unlike in Activity 2, the dots in this activity are not equally spaced. The distance between the dots keeps getting larger because the velocity of the car is increasing; the car is travelling a greater distance between each dot, even though the time between each dot remains the same.

6. Look at your data for this activity.

   What trend do you see for the <u>velocity</u> of the car as it travels down the incline?

   The velocity increases as the car travels down the incline.

   What trend do you see for the <u>acceleration</u> of the car as it travels down the incline?

   The overall acceleration remains relatively constant as the car travels down the incline.

7. Describe what would happen to the velocity and acceleration of the car if you lifted the table up higher, increasing the incline.

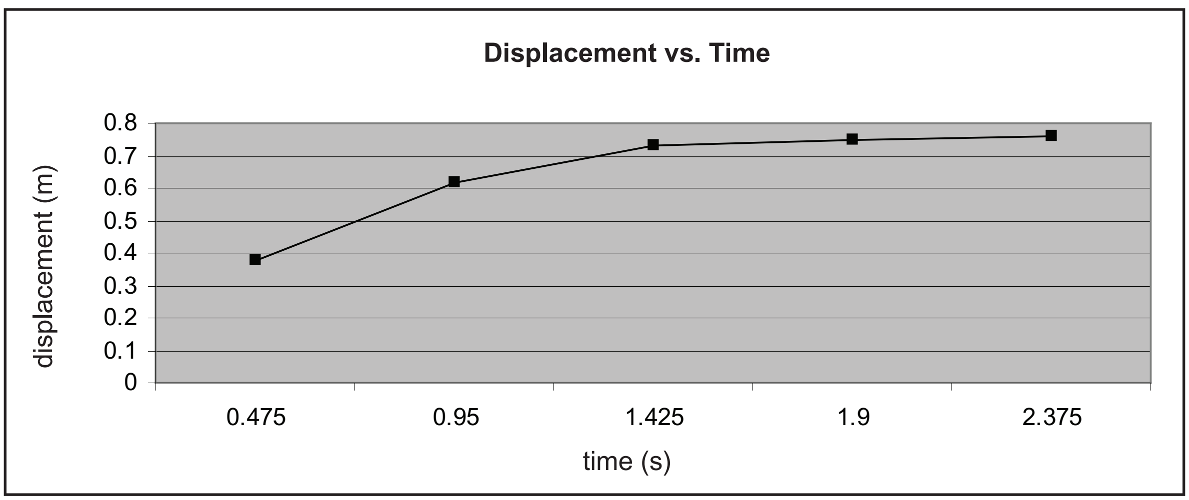
   A steeper incline will yield a larger gap between each pair of dots, representing increasing velocity The acceleration would be also be greater, but still constant throughout the duration of the car's motion.

ACTIVITY 4: NEGATIVE ACCELERATION

Data Table 3: Negative Acceleration Time: *0.475 sec*					
Dot	Time (s)	Distance between dots (m)	Displacement from the starting point (m)	Velocity (m/s)	Acceleration (m/s^2)
1	0	—	0	—	—
2	*0.475*	*0.375*	*0.375*	*0.79*	—
3	*0.95*	*0.24*	*0.615*	*0.65*	*– 0.299*
4	*1.425*	*0.1175*	*0.7325*	*0.51*	*– 0.281*
5	*1.9*	*0.0175*	*0.75*	*0.39*	*– 0.251*
6	*2.375*	*0.375*	*0.7575*	*0.32*	*– 0.160*
7					
8					
9					
10					

Questions

1. On the graph below, plot displacement versus time.

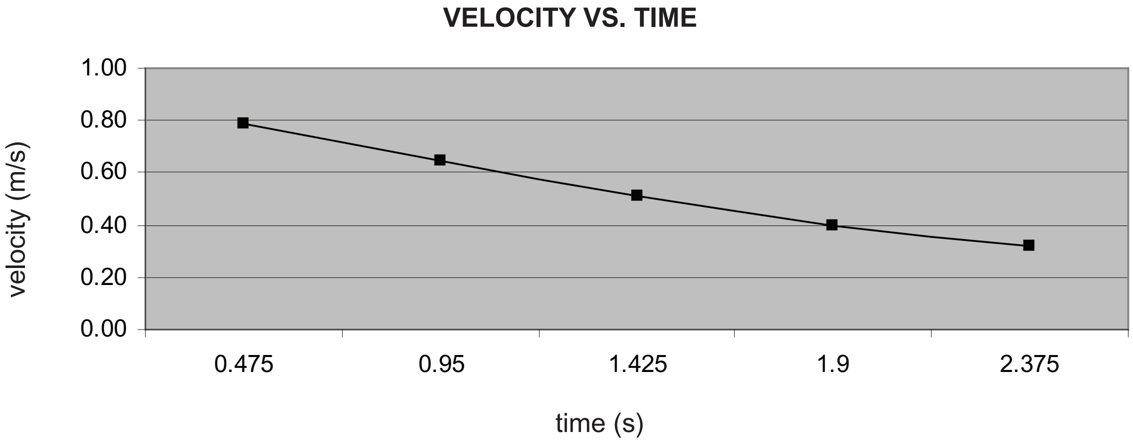


2. What does the slope of the line on the displacement versus time graph represent? Describe the shape and/or direction of the slope. What can you tell about the motion of the car based on this shape?

   The slope of the graph represents the velocity of the car. The slant indicates it is a positive velocity; however, the slight curve of the line indicates that the velocity is not constant.

ACTIVITY 4: NEGATIVE ACCELERATION (CONTINUED))

3. On the graph below, plot velocity versus time.



4. What does the slope of the line on the velocity versus time graph represent? Describe the shape and/or direction of the slope. What can you tell about the motion of the car based on this shape?

   The slope of the graph represents the acceleration of the car. Since the line is relatively straight and slopes downwards, it represents a constant negative acceleration.

5. This activity is very similar to Activity 3. Explain what is different about the changes in distance between the dots and the velocities.

   The distance between the dots in this activity gradually decreased, since the car was moving more slowly each time it made a dot on the paper.

6. Explain why the sign (negative or positive) for the acceleration is different than in Activity 3. What does this value represent?

   Since the final velocity is less than the initial velocity, the difference yields a negative value. The negative acceleration indicates that the car is slowing down.

Constant Motion Cart **Student Guide**

BACKGROUND

Consider the motion of things in your everyday life. Creatures crawl, fly, run, and swim. Human beings walk and run and have devised machines—such as bicycles, cars, and planes—that carry us much faster. Even the Earth on which we live is in constant motion. The motion of any object is described in terms of its velocity and acceleration.

Velocity (v) is defined as the change in position (Δx) of an object over a period of time (Δt). The total change in position, which marks the distance and the direction of an object from a reference point, is called displacement. Velocity describes an object's speed and its direction. The equation for calculating velocity in meters per second (m/s) is:

$$v = \frac{\text{displacement}}{\text{time}} = \frac{\Delta x}{\Delta t}$$

To calculate Δx, subtract the final position from the initial position, measured in meters. Similarly, calculate Δt by subtracting the final time from the initial time. (The initial time is usually zero seconds.)

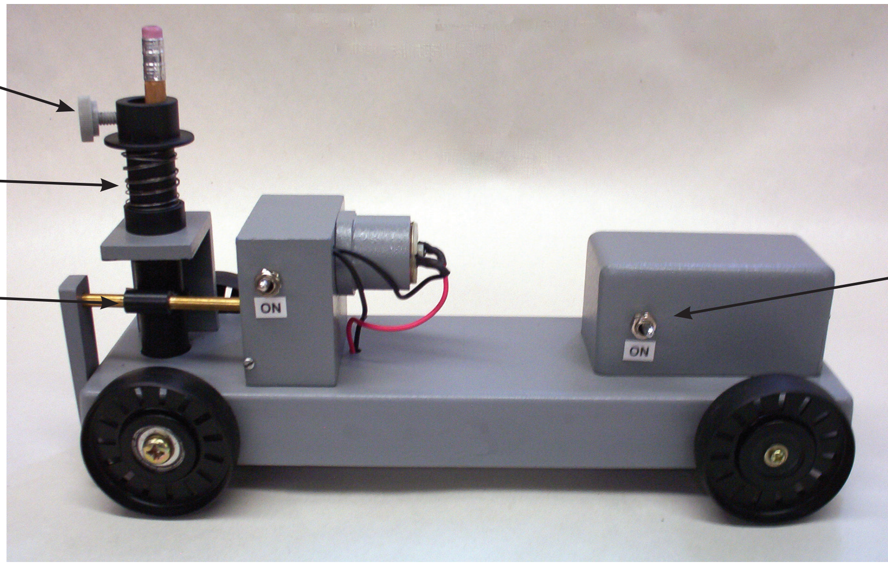
Acceleration (a) is the change in velocity over time. The equation for calculating acceleration is:

$$a = \frac{\text{change in velocity}}{\text{time}} = \frac{\Delta v}{\Delta t}$$

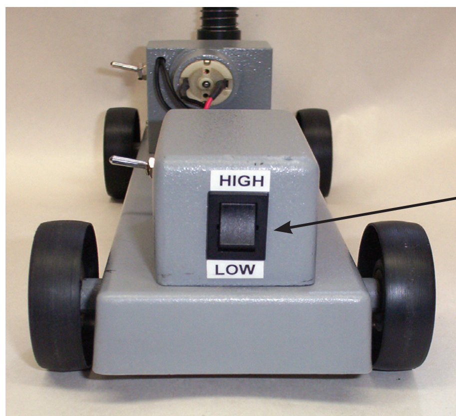
where a is in m/s^2 and Δv is the final velocity minus the initial velocity ($v_f - v_i$). The order of the equation for calculating Δv is very important. If the final velocity is greater than the initial velocity, the result will be a positive value. If the final velocity is less than the initial velocity, the result will be a negative value. In either case, make sure you always subtract the initial velocity from the final velocity, to obtain not only the change in velocity but also to determine whether the acceleration is positive or negative.

In this lab, you will use the Constant Motion Cart to explore velocity and acceleration. The Constant Motion Cart is set up to push down on a marker at regular intervals; this marker makes contact with a strip of adding machine paper and leaves a small dot. When the Constant Motion Cart is stationary, the marker only hits in one spot. As the car moves slowly at a constant speed, the marks can be individually seen along the strip of paper, but they are close together. When the Constant Motion Cart speeds up, the distance between the markings on the paper increases because the car is traveling faster each second. The time interval between each mark, however, remains the same. As the Constant Motion Cart slows down, the distance between the markings gradually decreases.

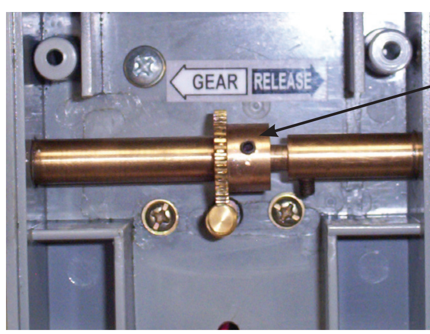
Parts of the Constant Motion Cart



Side view



Front view



Use the hex wrench to loosen the gear.
Move it to the left to engage the drive motor.
Move it to the right to allow the cart to roll freely.

Bottom view

Measuring the time interval between each dot

You will be measuring the velocity and acceleration of the Constant Motion Cart based on the distance between the dots. Begin each activity by measuring the time required for the marker to move up and down. The time between cycles of the marker may change eventually due to the diminishing battery power. Holding the Constant Motion Cart off the table, measure the time required for the marker to move up and down 10 times. Then divide this number by 10. This will give you the time interval between each dot.

Adjusting the marker/pencil height

The most technically challenging part of the Constant Motion Cart is setting up the marker (or pencil) properly. If the marker is positioned too high in the holder, it will not leave a mark on the paper. If the marker is too low in the holder, it will push into the paper and lift the car up, possibly breaking the marker. You may need to experiment a bit to get the marker properly positioned, so that it leaves a mark on the paper but does not lift up the car. Once you have achieved this, fasten the marker in place by gently setting the holding screw. Do not overtighten the holding screw, or you will strip the screw.

General tips for performing the experiments

If you run out of tape while doing an experiment you can either repeat it using more tape or use the data points that are available. If time is an issue, you can shorten the experiments by running the car for a shorter distance or using a shorter length of paper, and then just using the data points available. In these instances, however, realize that there will be blank cells in your data tables.

ACTIVITY 1: INTRODUCTION TO VELOCITY AND ACCELERATION

Equipment needed
Constant Motion Cart
Marker (or pencil)
Roll of adding machine paper
Meter stick

Procedure

A. Constant Speed

1. Place a scrap piece of paper under the car and insert a marker in the vertical tube.
2. Adjust and set the marker height (see instructions, above).
3. Cut a 2-m long piece of adding machine paper and place it on the floor. If needed, use a few small pieces of tape to hold the adding machine paper in place.
4. Set the Constant Motion Cart 20 cm from one end of the tape. Make sure the speed is set to “Low” and the gear is engaged with the motor. (See the parts of the Constant Motion Cart on the previous page)
5. Simultaneously, turn on the marker motor and the motor to drive the car. Release the car so it drives straight along the length of the paper strip and makes a series of clearly visible marks along the strip of paper.
    - If the car strays off the paper or if there are no marks visible on the strip of paper, make any needed adjustments (height of marker, alignment of car, etc.) flip the paper strip over, and repeat step 5. If you do flip the paper strip over, make sure to mark the wrong side as “incorrect” or “do not use”.

6. Once you have a strip with a good set of marks to work with, label this strip “Slow constant speed” and set the strip aside.
7. Repeat steps 1 - 6 with the speed of the car set to “High”. Once you have a strip with a good set of marks to work with, label this strip “High constant speed” and set the strip aside.
8. You will use both of the strips you set aside when you complete the question section later in this activity.

B. Acceleration

In Part A of this activity you set up the car on a flat surface, in order to investigate constant speed. In this part of the activity, you will set up the car on a ramp or inclined surface, in order to investigate acceleration.

1. Using the hex wrench, loosen the drive gear on the under side of the Constant Motion Cart. Push it over to the side of the axle so it is not in contact with the drive motor. Tighten the gear so it stays in place. This will allow the car to roll freely.
2. Set up a table, or some other apparatus, at an incline. Tape a 2-m practice strip of paper along the incline. Practice releasing the car down the incline. You want the incline large enough to overcome any friction in the cart but not so large that the car moves too fast. Your goal is to get about eight dots marked along the paper strip. Make sure there is someone to catch the cart at the bottom of the incline.
3. Once you have the set up correct, tape a clean 2-m strip of paper along the incline. Place the car at the top of the incline, turn on the marker motor and release the car, as you did in the previous activity.
4. Once you have a good set of dots along the strip of paper, label the paper as “Rolling down incline” and set it aside.
5. Now you will repeat the experiment but this time the car will be starting at the bottom of the incline an travel up the incline. To do this, you will give the car enough of an initial push so that it travels all the way up the incline without any additional assistance. (In other words, give it a hard push, and then let go!) Practice rolling the car up the incline. You want the car to roll up to the top of the incline without falling off and to keep the paper strip centered on the incline, under the car.
6. Again, tape a clean 2-m strip of paper along the incline. Once you are ready, turn on the marker motor and push the car up the incline.
7. Once you have a good set of dots along the strip of paper, label the paper as “Rolling up incline” and set it aside.
8. Complete the questions for this activity, as directed by your teacher.

Questions

1. Look at the two paper strips marked “constant speed”. Describe any similarities or differences in the placement and pattern of the dots.

2. The marker motor moved at the same speed for all of the experiments. Explain why the dot pattern for the two constant velocity (low speed and high speed) paper strips are different from each other.

3. Look at the two paper strips that were placed on the incline (rolling down, and rolling up). Describe and explain the reasons for any similarities or differences in the placement and pattern of the dots on these strips.

4. Explain how you can determine if the Constant Motion Cart was accelerating or moving at a constant speed based solely on the dot pattern it leaves behind.

ACTIVITY 2: CONSTANT VELOCITY

Equipment needed
Constant Motion Cart
Marker
Roll of adding machine paper
Stopwatch
Meter stick

Procedure

1. Place the marker in the Constant Motion Cart and calculate the time interval between each dot, as described in the background. (Note: At this point, you do not actually record any dots; you simply calculate how long it takes the arm of the marker to go up and down.) Record this time in the space at the top of **Data Table 1**.
2. In **Data Table 1** the Time column will be incremental amounts based on what you find in step 1. For example, if the time between dots is .4 seconds, then the time for dot 1 would be 0.4 seconds, the time for dot 2 would be 0.8 seconds, the time for dot 3 would be 1.2 seconds, and so on. Record your time intervals in **Data Table 1**.
3. Place a 2-m strip of adding machine paper on a flat surface. Set the Constant Motion Cart 20 cm in front of the paper strip. This will allow the car to come up to the motor speed before making any marks on the paper.
4. Turn the power of the car to the low speed setting, turn on the motor engaging the marker and the drive wheel, and let the car go until at least 10 dots have been drawn on the paper. Dot 1 will be considered the starting point.
5. After you have at least 10 dots on the strip, catch the Constant Motion Cart, turn off both motors, and set the car off to the side.
6. Using a metric ruler, measure the distance between the dots #1 and #2. In the row for dot #2 in **Data Table 1**, record this distance (in m) twice: once in the column for “Distance between dots” and once in the column for “Displacement from the starting point.”
7. Measure the distance between dots # 2 and #3. Record in **Data Table 1**, in the row for Dot #3, and the “Distance between dots” column.
8. Measure the distance between dot #1 (starting point) and dot #3. Record in **Data Table 1**, in the row for Dot #3, and the “Displacement from the starting point” column.
9. Repeat this process of measuring and recording the distance between adjacent dots and the displacement from the starting point until you reach the tenth dot.
10. Calculate and record the velocity of the car between each set of dots, using the formula:

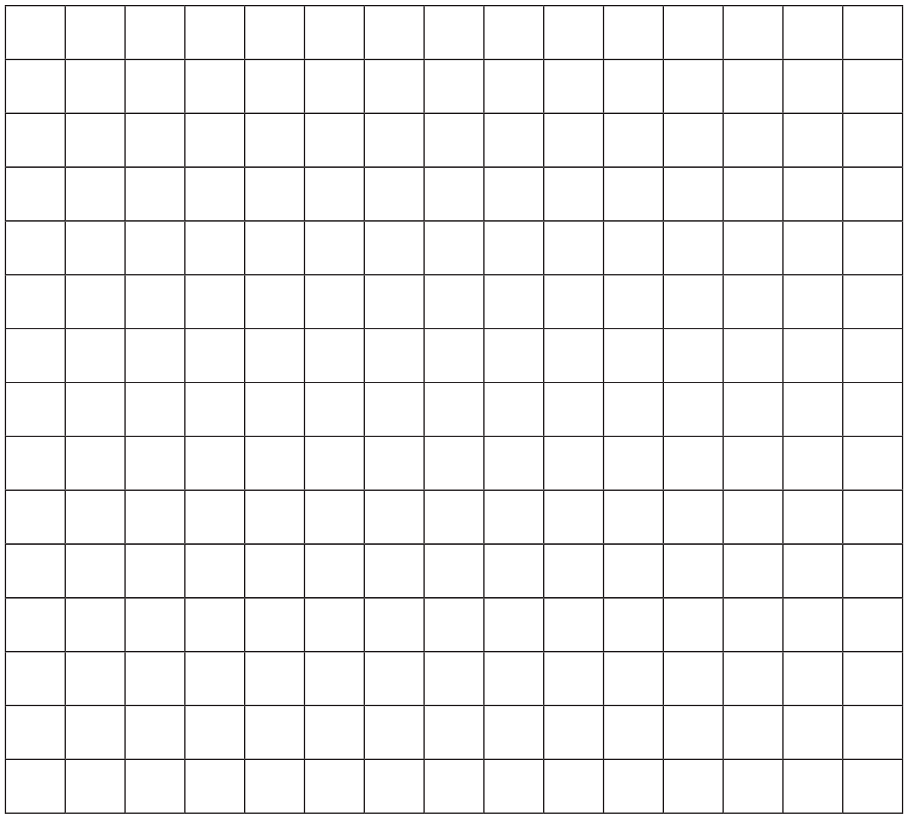
$$v = \frac{\text{displacement from starting point}}{\text{time}}$$

11. Repeat steps 1 – 10; this time though, when you reach step 4, turn the power of the car to the high speed setting.

Data Table 1: Constant Velocities Time: ___________sec				
Dot #	Time (s)	Distance between dots (m)	Displacement from the starting point (m)	Velocity (m/s)
Trial 1 - LOW SPEED SETTING				
1	0	–	0	–
2				
3				
4				
5				
6				
7				
8				
9				
10				
Trial 2 - HIGH SPEED SETTING				
1	0	–	0	–
2				
3				
4				
5				
6				
7				
8				
9				
10				

Questions

1. On the graph below, plot displacement versus time for Trials 1 (low speed) and 2 (high speed).



2. What do the slopes of the lines represent? What can you tell about the motion of the car based on the shape and/or direction of the slope?

3. For either one of the trials, describe the pattern you observed in the physical separation of the dots. Did this pattern also occur in the other trial?

ACTIVITY 3: POSITIVE ACCELERATION

Equipment needed
Constant Motion Cart
Marker
Roll of adding machine paper
Stopwatch
Meter stick

Procedure

1. Place the marker in the Constant Motion Cart and calculate the time interval between each dot, as described in the background. (Note: At this point, you do not actually record any dots; you simply calculate how long it takes the arm of the marker to go up and down.) Record this time in the space at the top of **Data Table 2**.
2. In **Data Table 2** the Time column will be incremental amounts based on what you find in step 1. For example, if the time between dots is .4 seconds, then the time for dot 1 would be 0.4 seconds, the time for dot 2 would be 0.8 seconds, the time for dot 3 would be 1.2 seconds, and so on. Record your time intervals in **Data Table 2**.
3. Tape a 2-m paper strip onto a table. Place the Record this time in the space at the top of at one end of the table, with the marker toward the back, at the end of the table. **Make sure that the motor that powers the car is disengaged.**
4. Turn the marker motor on. Do not turn on the drive motor. Slowly lift the end of the table so that the Constant Motion Cart rolls down the incline. Your goal is to get 10 dots on the paper. Have a partner ready at the other end of the table to ensure the Constant Motion Cart does not roll off the table! At the end of this step, turn the marker motor off.
5. Using a metric ruler, measure the distance between the dots #1 and #2. In the row for dot #2 in **Data Table 2**, record this distance (in m) twice: once in the column for “Distance between dots” and once in the column for “Displacement from the starting point.”
6. Measure the distance between dots # 2 and #3. Record in **Data Table 2**, in the row for Dot #3, and the “Distance between dots” column.
7. Measure the distance between dot #1 (starting point) and dot #3. Record in **Data Table 2**, in the row for Dot #3, and the “Displacement from the starting point” column.
8. Repeat this process of measuring and recording the distance between adjacent dots and the displacement from the starting point until you reach the tenth dot.
9. Calculate and record the velocity of the car between each set of dots, using the formula:

$$v = \frac{\text{displacement from starting point}}{\text{time}}$$

10. Calculate and record the acceleration of the car between each set of dots, using the formula:

$$a = \frac{\Delta v}{\Delta t}$$

NOTE: The first acceleration you can calculate is between the second and third dot. In this case, define Δv as the velocity recorded in the dot #3 row minus the velocity recorded in the dot #2 row. In this case, this should yield a positive value.

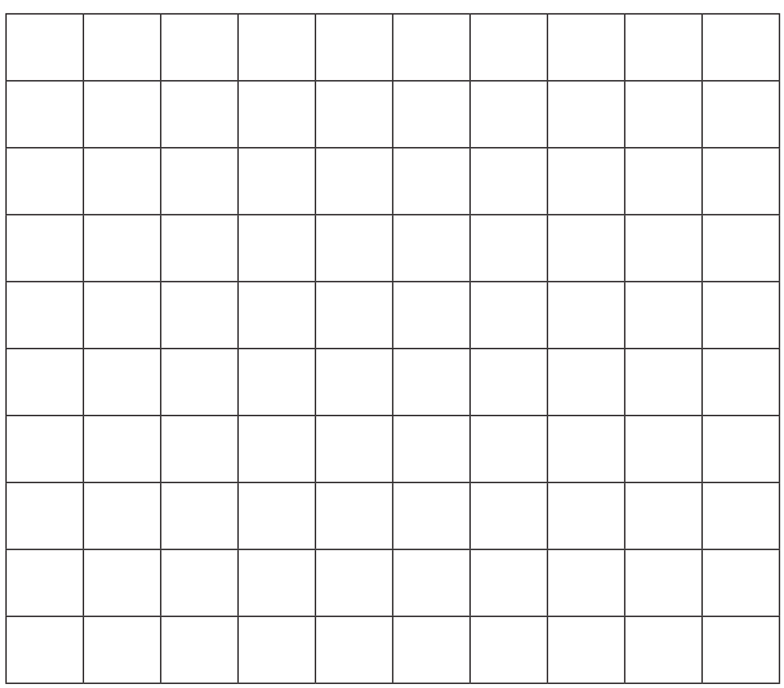
Data Table 2: Positive Acceleration

Time: ___________s

Dot #	Time (s)	Distance between dots (m)	Displacement from the starting point (m)	Velocity (m/s)	Acceleration (m/s^2)
1		–	0	–	–
2					–
3					
4					
5					
6					
7					
8					
9					
10					

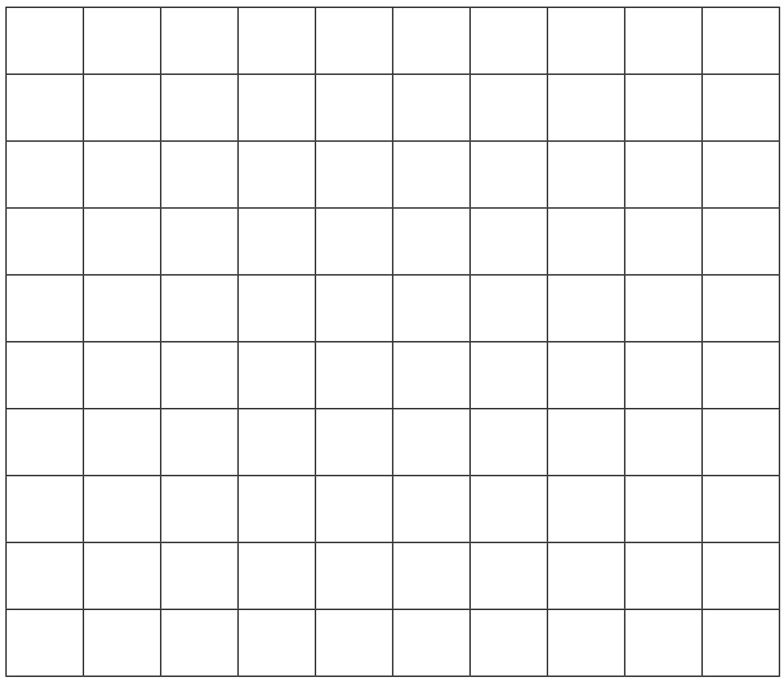
Questions

1. On the graph below, plot displacement versus time.



2. What does the slope of the line on the displacement versus time graph represent? Describe the shape and/or direction of the slope. What can you tell about the motion of the car based on this shape?

3. On the graph below, plot velocity versus time.



4. What does the slope of the line on the velocity versus time graph represent? Describe the shape and/or direction of the slope. What can you tell about the motion of the car based on this shape?

5. How does the pattern of dots compare to that of the dots from Activity 2? Look at your data for this activity. In terms of velocity, explain how and why the distance between the dots changed.

ACTIVITY 3: POSITIVE ACCELERATION (continued)

6. Look at your data for this activity.

   What trend do you see for the <u>velocity</u> of the car as it travels down the incline?

   What trend do you see for the <u>acceleration</u> of the car as it travels down the incline?

7. Describe what would happen to the velocity and acceleration of the car if you lifted the table up higher, increasing the incline.

ACTIVITY 4: NEGATIVE ACCELERATION

Equipment needed
Constant Motion Cart
Marker
Roll of adding machine paper
Stopwatch

Procedure

1. Place the marker in the Constant Motion Cart and calculate the time interval between each dot, as described in the background. (Note: At this point, you do not actually record any dots; you simply calculate how long it takes the arm of the marker to go up and down.) Record this time in the space at the top of **Data Table 3**.
2. In **Data Table 3** the Time column will be incremental amounts based on what you find in step 1. For example, if the time between dots is .4 seconds, then the time for dot 1 would be 0.4 seconds, the time for dot 2 would be 0.8 seconds, the time for dot 3 would be 1.2 seconds, and so on. Record your time intervals in **Data Table 3.**
3. Tape a 2-m paper strip onto a table.
4. Lift or carefully prop up one end of the table. Place the Constant Motion Cart at the low end of the table, with the marker toward the back, at the end of the table. **Make sure that the motor that powers the car is disengaged.**
5. Turn the marker motor on. Do not turn on the drive motor. Have a partner give the Constant Motion Cart a good initial push, so that the car travels up the incline. Your goal is to get at least 5 dots on the paper. Have a partner ready at the other end of the table to remove the car once it stops moving forward. At the end of this step, turn the marker motor off.
6. Using a metric ruler, measure the distance between the dots #1 and #2. In the row for dot #2 in **Data Table 3**, record this distance (in m) twice: once in the column for "Distance between dots" and once in the column for "Displacement from the starting point."
7. Measure the distance between dots # 2 and #3. Record in **Data Table 3**, in the row for Dot #3, and the "Distance between dots" column.
8. Measure the distance between dot #1 (starting point) and dot #3. Record in **Data Table 3**, in the row for Dot #3, and the "Displacement from the starting point" column.
9. Repeat this process of measuring and recording the distance between adjacent dots and the displacement from the starting point until you reach the final dot.
10. Calculate and record the velocity of the car between each set of dots, using the formula:

$$v = \frac{\text{displacement from starting point}}{\text{time}}$$

11. Calculate and record the acceleration of the car between each set of dots, using the formula:

$$a = \frac{\Delta v}{\Delta t}$$

NOTE: The first acceleration you can calculate is between the second and third dot. In this case, define Δv as the velocity recorded in the dot #3 row minus the velocity recorded in the dot #2 row. In this case, this should yield a negative value.

ACTIVITY 4: NEGATIVE ACCELERATION (continued)

Data Table 3: Negative Acceleration Time: ___________s					
Dot	Time	Distance between dots (m)	Distance from the starting point (m)	Velocity (m/s)	Acceleration (m/s^2)
1		-	0	-	-
2					-
3					
4					
5					
6					
7					
8					
9					
10					

Questions

1. On the graph below, plot displacement versus time.

2. What does the slope of the line on the displacement versus time graph represent? Describe the shape and/or direction of the slope. What can you tell about the motion of the car based on this shape?

3. On the graph below, plot velocity versus time.

4. What does the slope of the line on the velocity versus time graph represent? Describe the shape and/or direction of the slope. What can you tell about the motion of the car based on this shape?

5. This activity is very similar to Activity 3. Explain what is different about the changes in distance between the dots and the velocities.

6. Explain why the sign (negative or positive) for the acceleration is different than in Activity 3. What does this value represent?

0345 120 4521

techsupport@philipharris.co.uk

www.philipharris.co.uk

Philip Harris Education
2 Gregory Street, Hyde, Cheshire SK14 4TH