Name Period Date

Acceleration

Driving Questions

What does it mean to decelerate?

What does it mean to accelerate?

Background

Acceleration is the rate at which the velocity of an object changes.

$$\text{acceleration} = \frac{\text{velocity}_{\text{final}} - \text{velocity}_{\text{initial}}}{\Delta\text{time}}$$

Because velocity is the speed and direction of an object's motion, acceleration can mean speeding up, slowing down, or changing direction.

A car can have a positive acceleration when it is speeding up and a negative acceleration when it is slowing down depending on its direction of travel.

When a car is speeding up, its acceleration is in the same direction of its velocity: both acceleration and velocity are positive or negative. When a car is slowing down, its acceleration is in the opposite direction of its velocity: velocity and acceleration have opposite signs.

Constant acceleration means that an object's velocity is changing at a uniform rate.

For example, when you throw a ball into the air, it experiences a velocity change of 9.8 m/s every one second. Because the acceleration's direction is pointing towards the Earth, the ball will decelerate (slow down) when moving up and accelerate (speed up) when falling down.

Materials and Equipment

For each student or group:

- Data collection system
- Dynamics track
- Dynamics cart
- Rod stand
- Motion sensor
- Dynamics track pivot clamp
- Dynamics track end stop

Safety

Follow all standard laboratory procedures.

Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

Repeat the data collection procedure this time pushing the cart up the incline away from the motion sensor.	Determine the acceleration of each trial from the slope of the graphed data.	Release the cart from the elevated end of the track to produce a velocity time graph.	Assemble the inclined track with the end stop at one end and the motion sensor at the opposite end.

Procedure

After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.

Note: When you see the symbol "�" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Set Up

1. ☐ Start a new experiment on the data collection system. �(1.2)

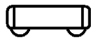
2. ☐ Connect a motion sensor to the data collection system. �(2.1)

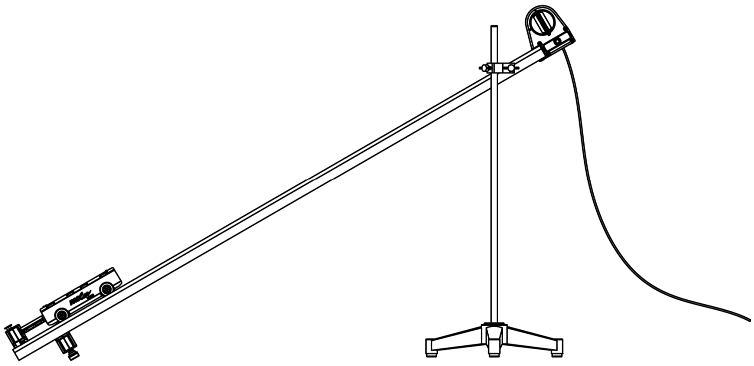
3. ☐ Display Velocity on the y-axis of a graph with Time on the x-axis. �(7.1.1)

4. ☐ When a car's acceleration is negative but its velocity is positive, what is the car doing?

____

____

5. ☐ Ensure that your sampling rate is set to at least 20 samples per second. If your motion sensor has a selector switch, ensure that it is in the cart setting. �(5.1) 



6. ☐ Attach the end stop to the lower end of the dynamics track.

7. ☐ Mount the track to your rod stand using the pivot clamp, slightly inclining the track at one end.

8. ☐ Attach the motion sensor to the elevated end of the track with the face of the sensor pointed down the length of the track.

Collect Data

9. ☐ Set the cart at the top of the inclined end of the track, holding it just over 15 cm from the motion sensor.

10. ☐ Start data collection, and release the cart allowing it to roll down the track. �(6.2)

11. ☐ Catch the cart at the bottom of the inclined track just before it hits the end stop, and stop data collection. �(6.2)

12. ☐ Set the cart at the bottom of the inclined end of the track.

13. ☐ Start data collection, and give the cart a quick push with your hand up the track. �(6.2)

14. ☐ Allow the cart to roll back down the track, and catch the cart at the bottom of the inclined track just before it hits the end stop, and stop data collection. �(6.2)

Analyze Data

15. ☐ Sketch both runs of data in Velocity versus Time Graph in the Data Analysis section.

16. ☐ Use your data collection system to apply a linear fit to each run, and record the slope in Table 1 in the Data Analysis section. �(9.6)

17. ☐ Save your data as instructed by your teacher. �(11.1)

Data Analysis

Velocity versus Time

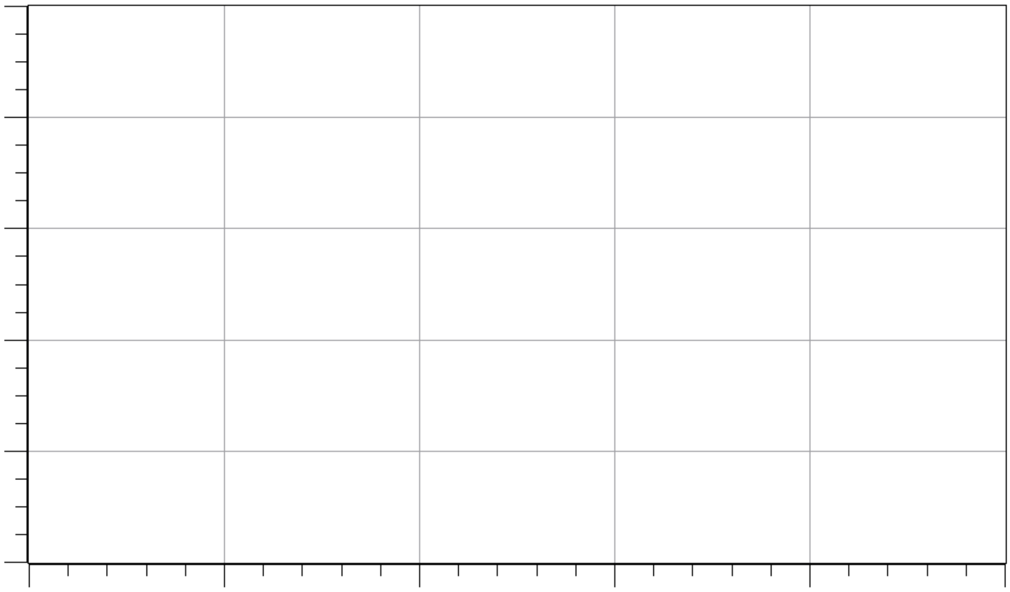


Table 1: Slope of Velocity versus Time

Run	**Slope**
Run 1	
Run 2	

Analysis Questions

1. During the period when the cart was in motion, are the Velocity versus Time graphs straight lines? Refer to the previous page if necessary. How is the acceleration of the cart changing if your Velocity versus Time graphs are straight lines?

2. Although the paths of the cart in both trials were different, the slopes of the Velocity versus Time graphs for each trial are the same (during the period in which the cart was in motion). Why is this the case? Justify your answer.

3. Looking at the Velocity versus Time graph, what would a negative slope tell you about the cart's acceleration? What would a positive slope tell you?

4. What was causing the cart to accelerate after releasing it from rest at the top of the track? Was that acceleration constant?

5. Describe the motion of an object that has a Velocity versus Time graph that is a horizontal straight line (a slope of zero).

Synthesis Questions

Use available resources to help you answer the following questions.

1. **The term "acceleration" is used in our everyday lives and language, but is often used in a non-physical context. Now that you have developed a physical definition of "acceleration," give an example of where the physical definition matches the "everyday" definition. Give an example where they are different.**

2. **Modern aircraft carriers use a steam powered catapult system to launch jets from a very short range. These catapults can provide a constant acceleration to bring jets up to speed in only 2 seconds. If each jet requires a minimum take-off speed of 82.3 m/s, how much acceleration must the catapult supply so the jet can take off?**

3. **How many different devices in a car help to accelerate the vehicle? What are they?**

Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. **If the acceleration due to gravity is –9.8 m/s^2, which of the following choices would best describe the acceleration of a 0.5 kg frictionless block sliding down the track used in our experiment?**

- **A.** 3.5 m/s^2 down the ramp
- **B.** 3.5 m/s^2 up the ramp
- **C.** 0 m/s^2
- **D.** Indefinable

2. A cart with an initial velocity of zero and a final velocity of 12 m/s after 2 s will have an acceleration of?

- **A.** 4 m/s^2
- **B.** 6 m/s^2
- **C.** 8 m/s^2
- **D.** 12 m/s^2

3. A race car starting from rest accelerates uniformly at a rate of 5 m/s^2. What is the car's speed after it has traveled for 5 s?

- **A.** 5 m/s
- **B.** 10 m/s
- **C.** 20 m/s
- **D.** 25 m/s

Key Term Challenge

Fill in the blanks from the list of randomly ordered words in the Key Term Challenge Word Bank.

1. ____________ is defined as the change in velocity over time. If an object is sitting still or moving at a constant ____________, it has an acceleration of zero. If an object has a constant, non-____________, acceleration, the velocity of the object is ____________ changing at the same rate. In common usage, an object with a positive velocity and a negative acceleration is said to be ____________, and an object with a positive velocity and a positive acceleration is said to be accelerating.

Key Term Challenge Word Bank

Paragraph 1

Acceleration

Continuously

Decelerating

Newtonian

Position

Velocity

Zero