5. Introduction to Force

Driving Questions

What is a force?

Background

A *contact force* is a physical push or pull. Contact forces are all around us. When you kick a ball, when you pull on a rope, or when you push someone on a swing, you are exerting or experiencing contact forces. *Non-contact forces*, or *action-at-a-distance forces*, are forces that can influence an object without touching it. The most prevalent example of this in everyday life is gravity.

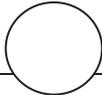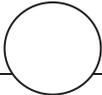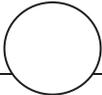## Materials and Equipment

For each student or group:
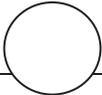
♦ Data collection system
♦ Force sensor
♦ Objects (textbook, ball, carts, etc)
♦ Short rod
♦ String, 1 m

♦ Rod stand
♦ Masses (at least three different values)
♦ Balance (1 per classroom, optional)
♦ Right angle clamp

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.

◯	◯	◯	◯
Connect the force sensor to your data collection system.	Record the value of the slope of the best-fit line.	Once the reading has stabilized, record the value for force in your data table.	Find the best-fit line using the linear curve fit tool for Force versus Mass.

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.

Part 1 – Pushing

Set Up

1. □ Start a new experiment on the data collection system. ❖(1.2)

2. □ Connect the force sensor to the data collection system. ❖(2.1)

3. □ Attach the rubber bumper to the force sensor.

4. □ With the force sensor flat on the surface that you will be pushing and pulling across, press the "zero" button.

5. □ Select three objects from the pool of objects available to you, and record your selected items in Table 1 in the Data Analysis section.

6. □ Which item do you think will require the greatest force to move, and which item will require the least? Explain.

_____

_____

7. □ Display Force on the y-axis of a graph with Time on the x-axis. ❖(7.1.1)

Collect Data

8. □ Start data collection. ❖(6.2)

9. □ Use the force sensor to push an object about 20 cm.

10. □ Stop data collection. ❖(6.2)

Analyze Data

11. ☐ Describe the relationship between the contact of the force sensor and the object, the force plot, and the motion that resulted from the applied force.

_____

_____

12. ☐ Find the maximum force applied by the sensor to the object on the Force versus Time graph. ◆(9.4)

13. ☐ Record the value in the Table 1 in the Data Analysis section.

14. ☐ Repeat data collection for each object.

Part 2 – Pulling

Set Up

15. ☐ Remove the rubber bumper from the force sensor, and replace it with the hook.

16. ☐ Set up your objects to be pulled the same 20 cm distance. Use the string if necessary.

17. ☐ Which item do you think will require the greatest force to move, and which item will require the least? Explain.

_____

_____

Collect Data

18. ☐ Start data collection. ◆(6.2)

19. ☐ Use the force sensor to push an object about 20 cm.

20. ☐ Stop data collection. ◆(6.2)

Analyze Data

21. ☐ Describe the relationship between the contact of the force sensor and the object, the force plot, and the motion that resulted from the applied force.

_____

_____

22. ☐ Find the maximum force applied by the sensor to the object on the Force versus Time graph. ◆(9.4)

23. ☐ Record the value in the Table 1 in the Data Analysis section.

24. ☐ Repeat data collection for each object.

25. ☐ Save your experiment. ◆(11.1)

Part 3 – What is a Newton?

Set Up

26. ☐ Connect your force sensor to the rod stand using the short rod and the right angle clamp.

27. ☐ Push the "zero" button on the force sensor.

28. ☐ Set up your data collection system to manually collect a force value for each mass value in a table, where mass is the user entered data in units of kg. ◆(5.2.1)

Collect Data

29. ☐ Hang a mass from the force sensor.
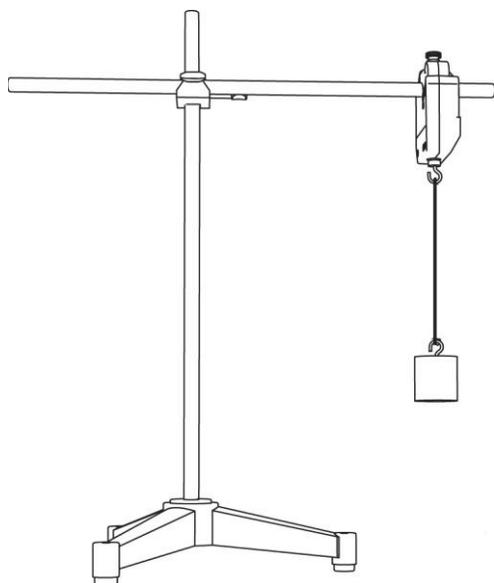
30. ☐ Start a manually entered data set with the first mass, collect a force value for each value of user-entered mass (switching masses between each value you keep), and stop collecting data when you have a force value for each mass. ◆(6.3)

31. ☐ Copy your values of force and mass to Table 2 in the Data Analysis section. ◆(9.6)

32. ☐ What two forces are acting on the mass? What kind of forces are they? Sketch them on the setup diagram above.

_____

_____

_____

33. ☐ What is the net force on the mass?

_____

_____

Analyze Data

34. ☐ Display Force on the *y*-axis of a graph with Time on the *x*-axis. ❖(7.1.1)

35. ☐ Change the *x*-axis from Time to Mass. ❖(7.1.9)

36. ☐ Find the slope of the best-fit line to the data using the linear fit tool. ❖(9.6)

37. ☐ Save your experiment ❖(11.1)

38. ☐ Sketch your plot of Force versus Mass in the Data Analysis section, and annotate it with the slope from your best-fit line.
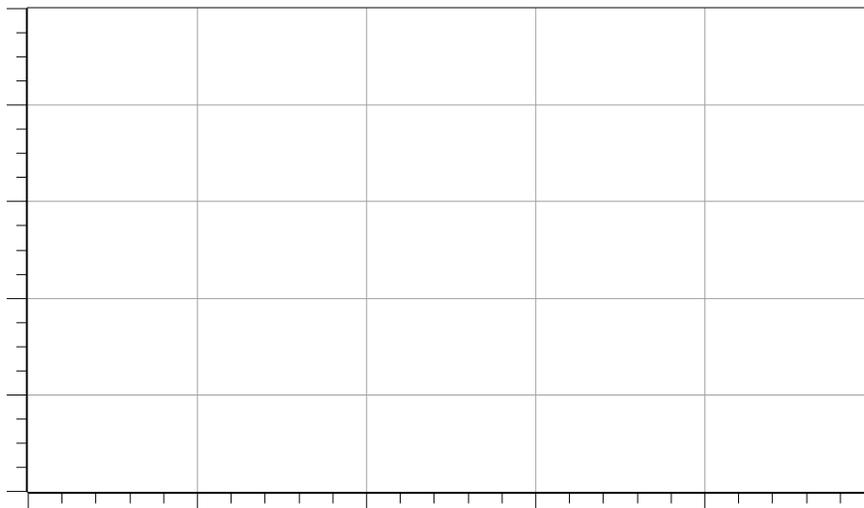
Data Analysis

Table 1: Objects and Forces

Object	Maximum Push Force	Maximum Pull Force

Table 2: Mass and Force

Mass (kg)	Force (N)

Force versus Mass

Analysis Questions

1. **What is the slope of the best-fit line?**

_____

_____

2. **Does the value of the slope of the line represent a physical quantity? What are the units of this quantity?**

_____

_____

_____

3. Given that the force divided by the mass yields a physical quantity with its own units, what units make up a newton?

Synthesis Questions

Use available resources to help you answer the following questions.

1. If a car has a mass of 1,000 kg that is evenly distributed to its four tires, how much force does each tire apply to the road?

_____

_____

2. If you push a book across a table, what are the forces on the book? Draw the forces on the diagram below.

_____

_____

_____
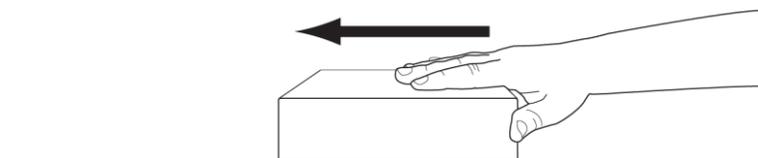
Multiple Choice Questions

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

1. If an object is pushed north with 15 N of force, and friction between the object and the ground pulls back in the opposite direction at 2 N, what is the Net Force on the object?

    A. 17 N north

    B. 17 N south

    C. 13 N north

    D. 13 N south

2. If a boat on a river is pushed West with 4 N of force by the wind, and pulled South by the current with a force of 3 N, what is the Net Force on the object?

    A. 5 N 37 degrees south of west

    B. 7 N south

    C. 5 N 37 ° west of south

    D. 1 N west

3. A book sitting on a table experiences a force due to gravity of 20 N when a student pushes down on the book with a force of 90 N. What is the magnitude of the net force on the book ?

    A. 110 N

    B. 70 N

    C. 1800 N

    D. 0 N

Key Term Challenge

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

1. When two _____ of equal _____ but opposite direction are applied to the same object, they _____, and the Net Force is zero. If a force is applied to an object that is greater than any opposing forces, the _____ is not zero, and the object moves. Because forces are _____ with both direction and magnitude, we represent them as arrows with lengths proportional to their magnitude in free body _____.

Key Term Challenge Word Bank

Paragraph 1

Balance

Charts

Diagrams

Forces

Magnitude

Net force

Scalar

Vectors