EARTH SCIENCE

When Push Comes to Shove

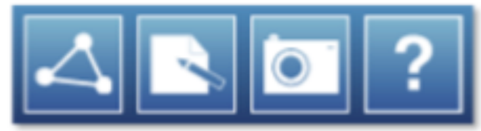
Space Exploration

Sally Ride Science

PASCO

012-13237A

Help System



Save, export, print, or submit your work.

Store your snapshots in the journal.

Take a screenshot when you see SNAPSHOT.

Browse the help system.

In Your World

Moving to a new home is a lot of work. First you pack everything in cardboard boxes. Then comes the hard part – *moving* all those boxes.

Push one box and it slides easily. It's full of something light – pillows, maybe. Another box won't budge. It's full of heavy books. Why does it take different amounts of force to get different boxes moving?

Introduction

When Push Comes to Shove

Say you want to move a box of books across the room. You need to push hard enough to overcome friction between the box and the floor. But you also must overcome inertia. This basic law of motion says that an object at rest tends to stay at rest, and an object in motion tends to keep moving at the same speed in the same direction.

It takes a force to overcome inertia. And the more mass something has, the more force you need to overcome its inertia. To counter the tendency of that box to stay at rest, you have to push on it. To overcome the tendency of a rolling soccer ball to keep moving, you could stop it with your foot – or wait for friction with the air and grass to bring it to a stop.

Now that a foot has stopped this soccer ball, what is the effect of inertia on the ball?

Introduction

Free of Friction

Moving objects on Earth usually don't just keep moving. Friction slows them down. But in space, there are no air molecules to create friction. So a moving object keeps going in a straight line until a force – like gravity – acts on it.

For instance, a robotic space probe called *New Horizons* is racing toward Pluto at about 87,000 kilometers per hour (54,000 miles per hour). But its rockets are shut off! Because of inertia, *New Horizons* will keep moving at the same speed in the same direction until it meets another force, like Pluto's gravity.

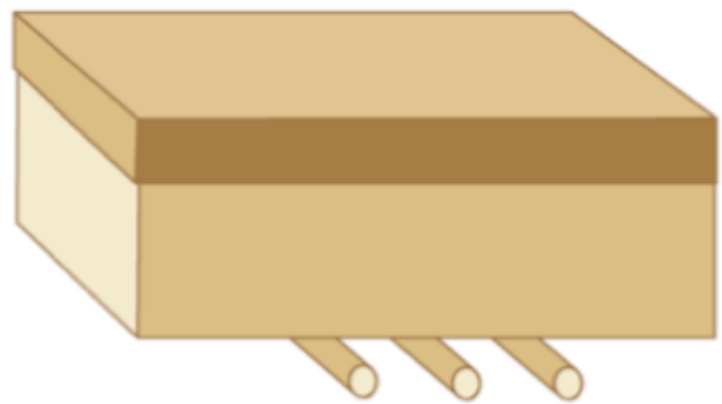
Now it's your turn – investigate inertia by measuring the force it takes to move boxes of unknown masses.

A drawing shows *New Horizons* in space. What force keeps it moving?

Materials and Equipment

Each group needs these materials.

- Force sensor
- Rubber bumper accessory
- Access to a class set of five covered shoeboxes containing unknown amounts of mass
- Wooden dowels
- Safety goggles for each student



Safety

Add this rule to your regular classroom procedures.

- Wear safety goggles throughout the investigation.

Investigation

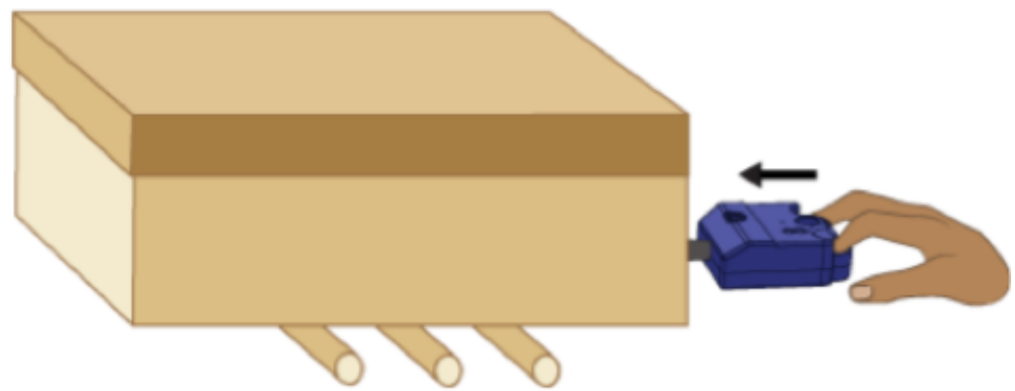
You will measure the force it takes to get several boxes of unknown mass moving. You will also observe what happens when the boxes start moving. Do you think the mass of the objects will affect the amount of force needed to move them? Why or why not?

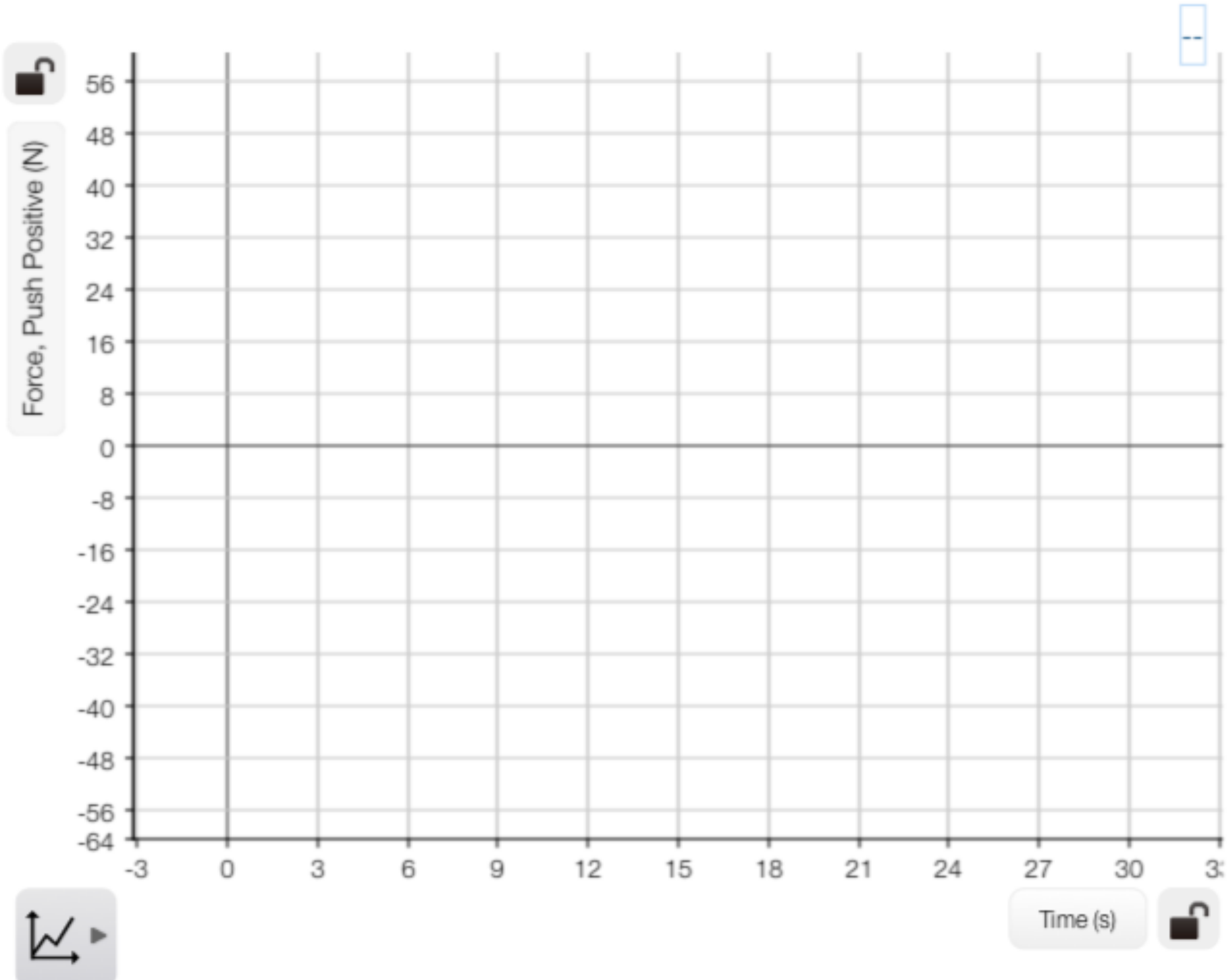
SNAPSHOT

I predict that . . .

Investigation

1. Connect the force sensor.
2. Lay the force sensor flat on the table in front of the first mystery box. Press the “zero” button on the force sensor.
3. Begin recording data. Lift the force sensor and push on the box with the bumper.
4. Once the box is moving, stop recording data and stop pushing with the force sensor.





5. Use the graphing tools to find the maximum force exerted. Label the maximum on the graph.
6. Repeat the steps with the other mystery boxes to find the amount of force needed to move each box.
7. Label the maximum force applied for each mystery box. **SNAPSHOT**

	Groups	Box A (N)	Box B (N)	Box C (N)	Box D (N)	Box E (N)
	Run 1	Run 1	Run 1	Run 1	Run 1	Run 1
1						
2						
3						
4						
5						
6						
7						
8						
9						

8. Record your group's name. Then enter the maximum force value under each box.
9. Confer with another group of students and record their data for the same boxes in the second row. Record the name of their group.
10. Continue to record other groups' data.

SNAPSHOT

	Groups	Box A (N)	Box B (N)	Box C (N)	Box D (N)	Box E (N)
	Run 1	Run 1	Run 1	Run 1	Run 1	Run 1
1						
2						
3						
4						
5						
6						
7						
8						
9						

11. Use the table tools to find the average force for each box.
12. Rank the boxes from least to most force.

SNAPSHOT

Boxes ranked by least force to most force required:

13. Your teacher will show you a ranking of the boxes from lightest to heaviest. How does your ranking of the amount of force required to move the boxes compare with your teacher's ranking of their masses?

14. How do the results compare to your prediction?

SNAPSHOT

My ranking and the teacher's ranking were . . .

Compared to my prediction . . .

Interpretation

1. **What is the reason for placing the boxes on rollers (dowels)?**

SNAPSHOT

The purpose of the dowels . . .

Interpretation

2. **What did you observe about the movement of the boxes after you stopped pushing them? Suggest an explanation for what you observed.**

SNAPSHOT

After I stopped pushing them, the boxes . . .

because . . .

3. **Before you pushed the boxes, inertia caused them to . . .**

a) be pulled toward the table top.
b) roll forward.
c) roll backward.
d) sit still.

4. **After you pushed the boxes, inertia caused them to . . .**

a) continue rolling forward.
b) come to rest.
c) be pulled downward.
d) slide backward.

SNAPSHOT

Write the letter
of your answer:

Explain why you
chose this answer.

Write the letter
of your answer:

Explain why you
chose this answer.

5. **Suppose a crash-test dummy is riding in a car going 80 kilometers (50 miles) per hour. The dummy is not wearing a seatbelt. The car hits a brick wall. What happens to the car and the dummy in terms of their inertia? If the dummy gets smart and fastens his seatbelt before the crash, does the effect of inertia change? Explain your answer.**

SNAPSHOT

Without seatbelts in a car crash, the inertia would . . .

With seatbelts in a car crash, the inertia would . . .

I think this would happen because . . .