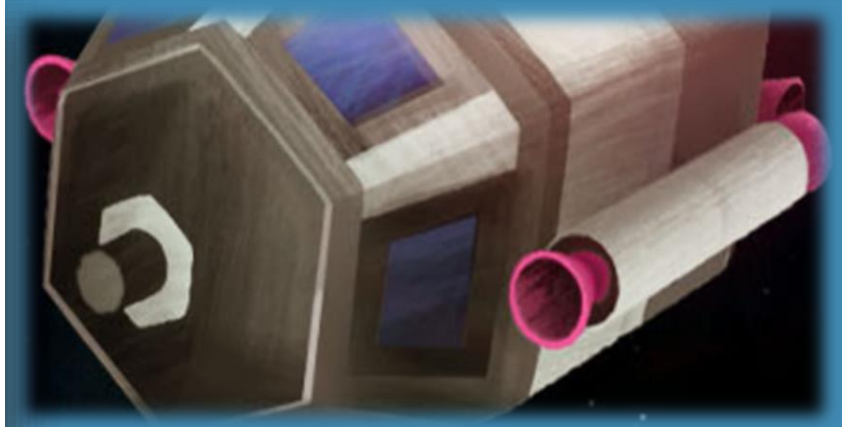
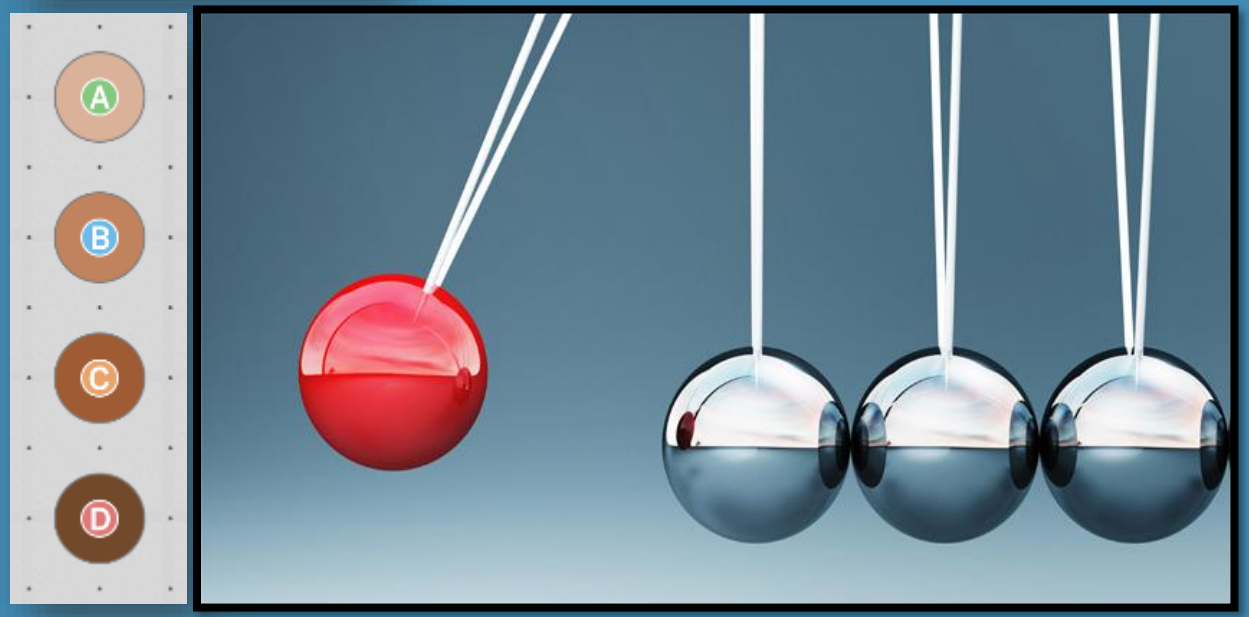
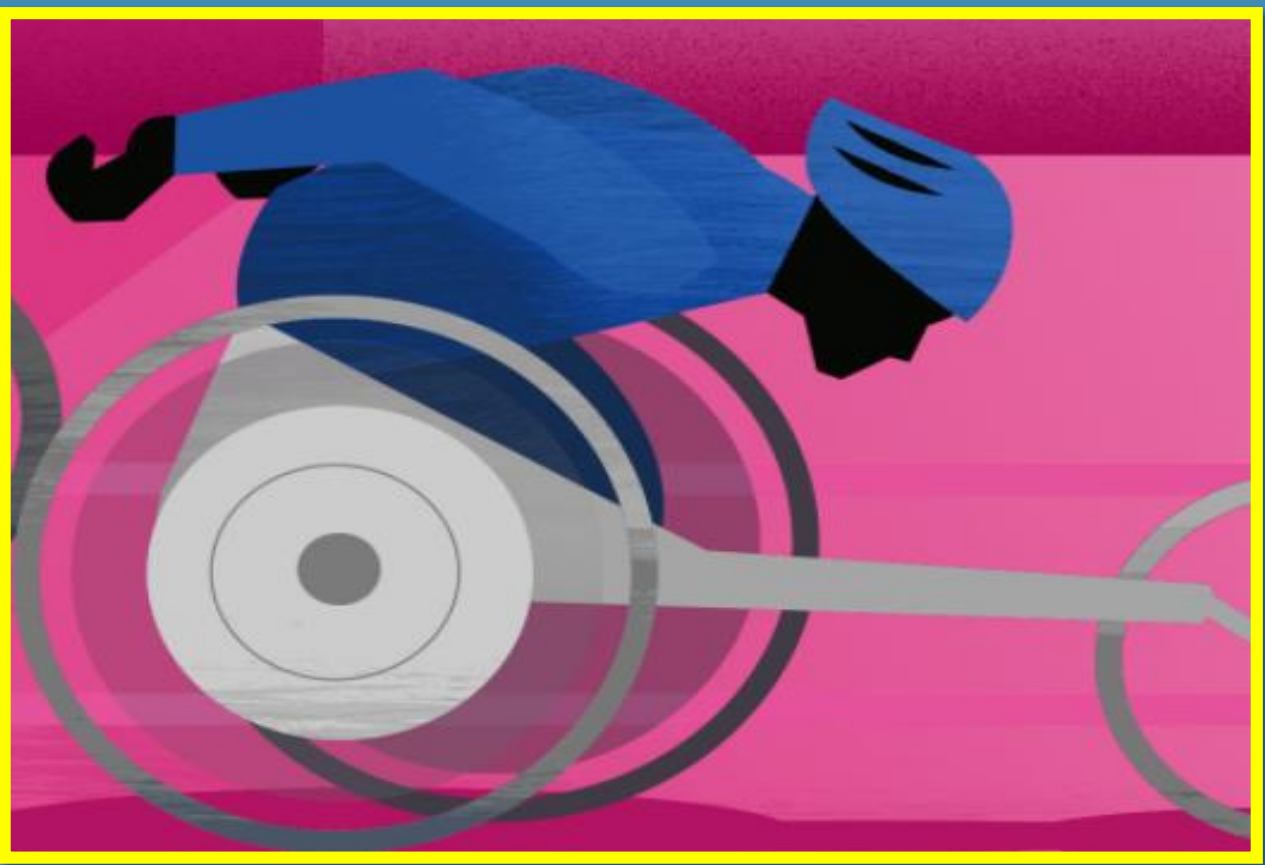
# CH.2 MASS AND VELOCITY



UNIVERSAL SPACE AGENCY





1 WARM UP
Warm-Up

# FM: 2.1.1 WARM-UP

Students record their initial ideas about why the same thruster force resulted in a different change in velocity for this pod. (10 min)

## Thruster Force Data

Read the new message from Dr. Gonzales and then answer the question below the message.

Thank you for sharing your models and explanations. This information is very helpful!

We analyzed the thruster data from the pod and found that the thrusters exerted the ***same strength force*** as in other missions. Since this pod didn't stop, we'll need to look at another cause.

The pod had been collecting asteroid samples, and we aren't sure how many it was carrying. Could a difference in the number of asteroid samples explain why the same thruster force caused a different change in velocity? We'd really appreciate your help with this.

**Dr. Ana Gonzales, Program Scientist**
**Asteroid Collection Mission**

Do you think the number of asteroid samples a pod is carrying could make a difference?

Might that explain why the same strength thruster force caused this pod to have a different change in velocity?

Explain your ideas, even if you are unsure.

1 WARM UP
Warm-Up

# FM: 2.1.1 WARM-UP

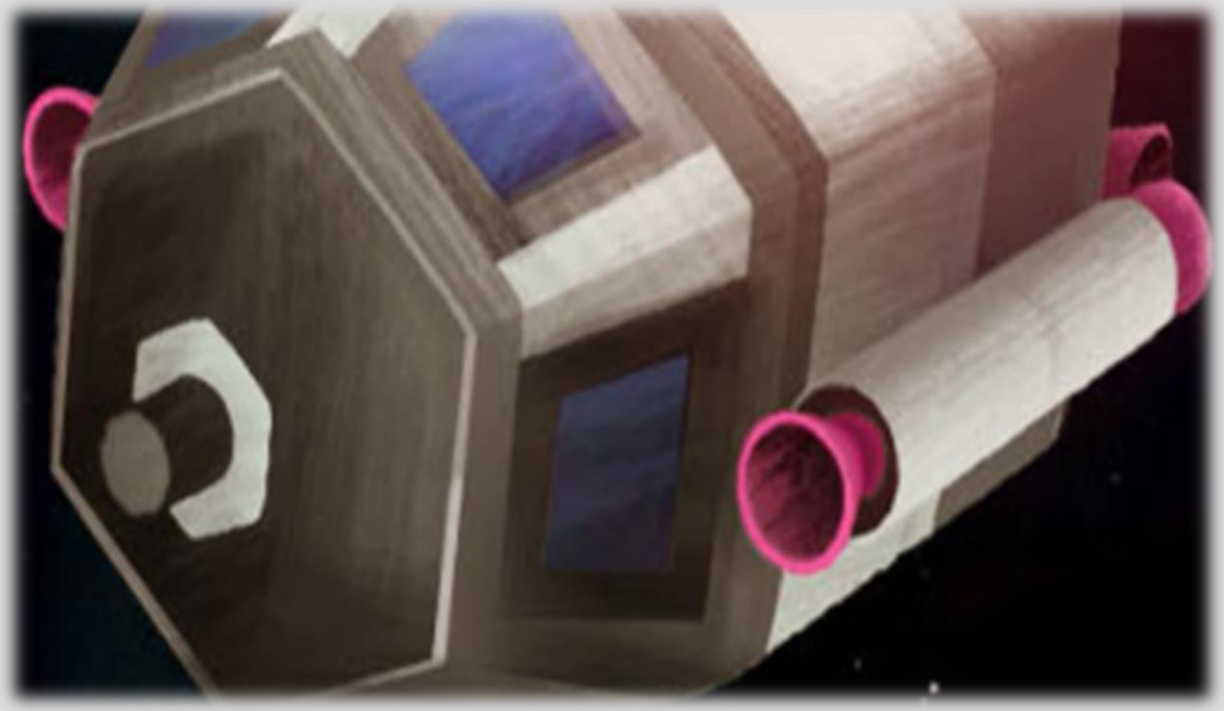
## Chapter 2 Question:

*The thrusters on the ACM pod exerted the same strength force as thrusters on other pods, so why did this pod move differently?*

We know something was different about how this pod's thrusters affected its motion. The thrusters exerted the same strength force as they do for pods on other missions, so why was this pod different?

**The pod was collecting asteroid samples.**

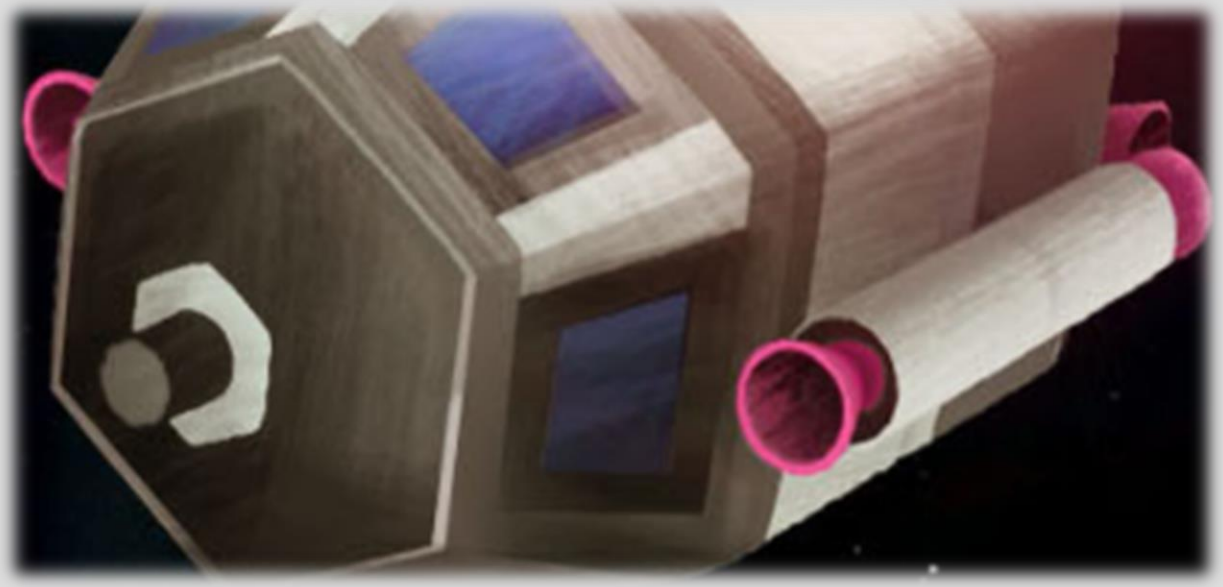
Details from the Ana Gonzales email says the USA does not know how many asteroid samples the pod was carrying.



1 WARM UP
Warm-Up

# FM: 2.1.1 WARM-UP

How can 2 identical PODS with different amount of asteroid samples cause a different velocity change when the thrusters exerted the same strength force?



Do you think the number of asteroid samples a pod is carrying could make a difference? Might that explain why the same strength thruster force caused this pod to have a different change in velocity? Explain your ideas, even if you are unsure.

- The pod may be heavier or lighter than normal, depending on the number of asteroid samples.
- Based on everyday experience, heavier objects are more difficult to move as compared to lighter objects, which are easier to move.

2 **HANDS ON**
Exploring Forces on Different Objects

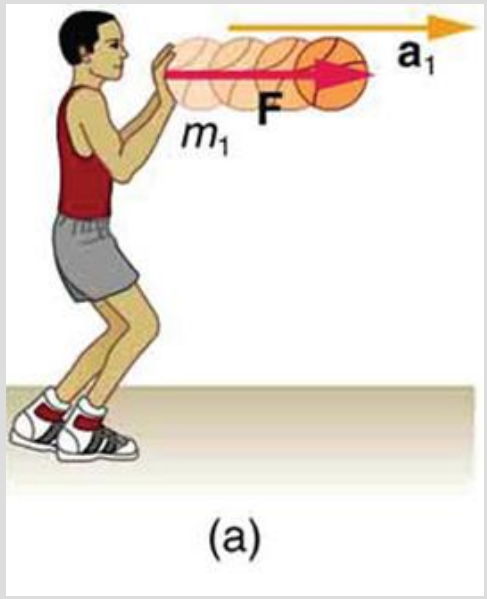
# FM: 2.1.2 HANDS ON EXPLORING FORCES ON DIFFERENT OBJECTS

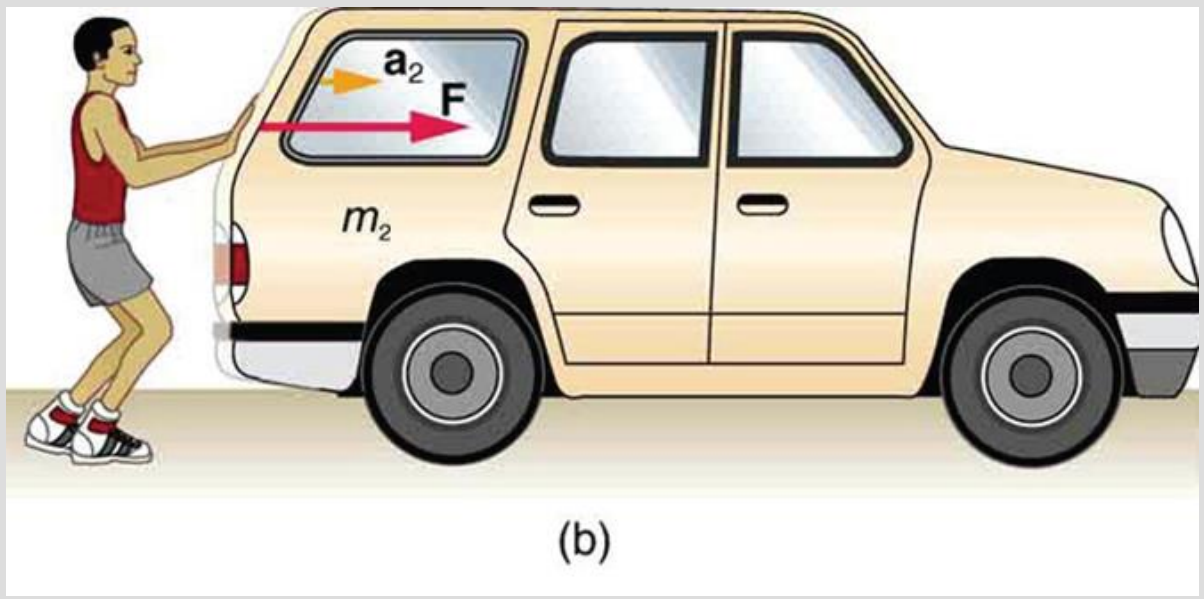
Students use physical objects to explore how exerting the same force on different objects can cause different velocity changes. (15 min)



| **Investigation Question** | If the same strength force is exerted on two objects, why might they be affected differently? |
|---|---|

If you push two things with the same force, why might one of the objects have a greater change in velocity?




We know the force is the same, so there must be something different about the objects.

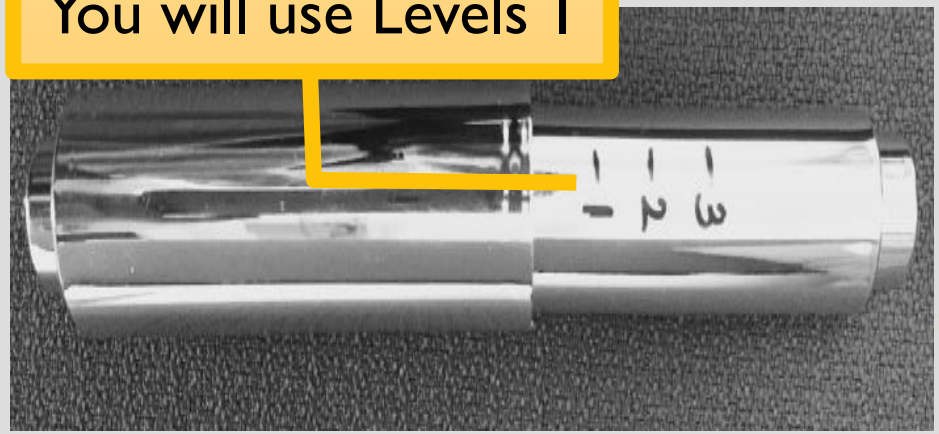
2 **HANDS ON**
Exploring Forces on Different Objects

# FM: 2.1.2 HANDS ON EXPLORING FORCES ON DIFFERENT OBJECTS

**Hands-On Activity**

You will be exploring general ideas about exerting the same strength force on different objects in order to gather data to help you explain what may have happened to the pod.

You will use Levels 1





In this activity, we will use the launchers to exert the same strength force and see how it affects different objects.

Hold the launcher flat on the floor with one hand and pull the narrow end back with their other hand.

The launcher tip should be touching the object before it is released.

2 **HANDS ON**
Exploring Forces on Different Objects

# FM: 2.1.2 HANDS ON EXPLORING FORCES ON DIFFERENT OBJECTS

## Exploring Forces on Different Objects

Use the launcher to exert the same force on different objects. Measure how the objects' velocities change.

Pick up the golf ball and the table tennis ball. Compare the two objects and record your observations.

1. Lighter object: ▾
2. Heavier object: ▾



Select the dropdown to indicate which object is lighter / Heavier

2 **HANDS ON**
Exploring Forces on Different Objects

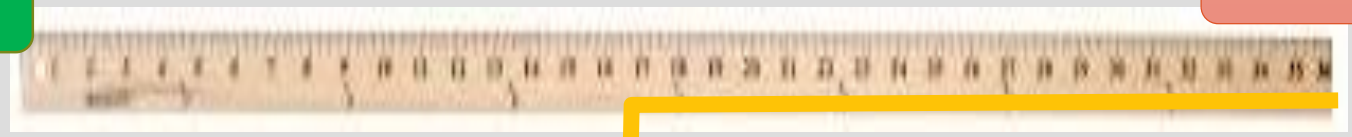
# FM: 2.1.2 HANDS ON EXPLORING FORCES ON DIFFERENT OBJECTS

Count down from three and start the stopwatch at the same time your partner releases the launcher.

START

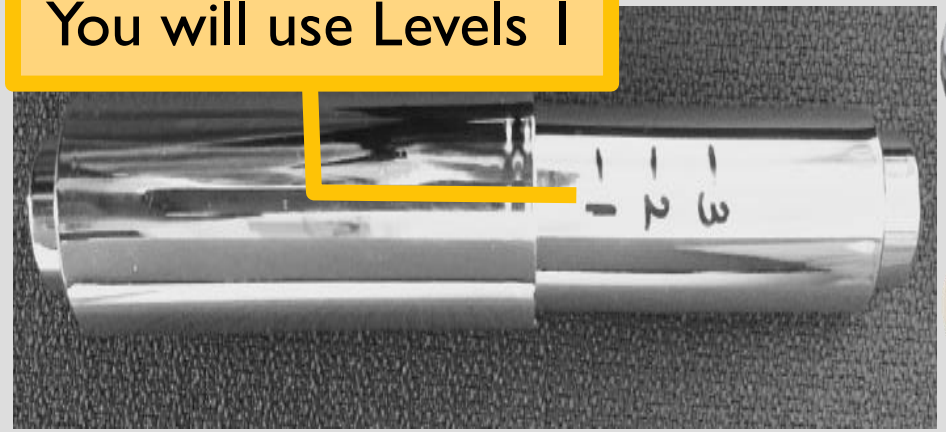
Three, two, one, GO

STOP



Repeat for Table Tennis Ball

You will use Levels 1





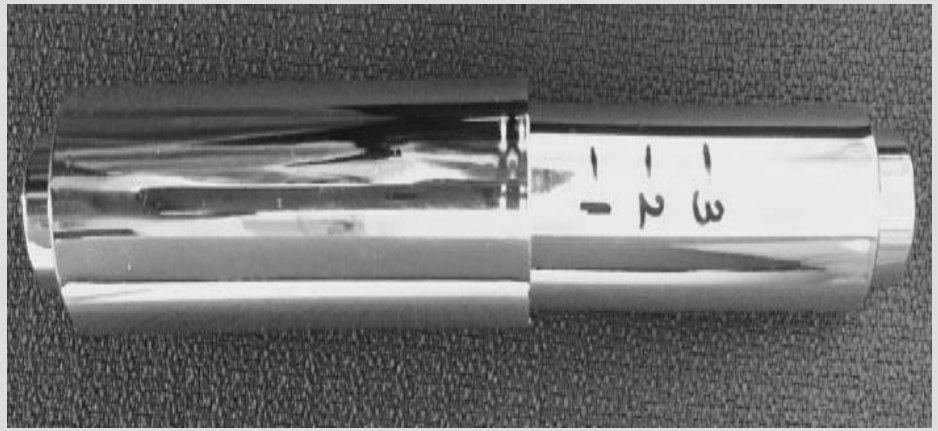
Record the time elapsed in the data table.

**Note**: On a stopwatch, 00:01:29 means 1.29 seconds.

| Object | Time to travel 100 cm (seconds) | Velocity d/t (cm/s) and direction |
|---|---|---|
| Golf ball | | |
| Table tennis ball | | |

2 **HANDS ON**
Exploring Forces on Different Objects

# FM: 2.1.2 HANDS ON EXPLORING FORCES ON DIFFERENT OBJECTS




| Object | Time to travel 100 cm (seconds) | Velocity d/t (cm/s) and direction |
|---|---|---|
| Golf ball | | |
| Table tennis ball | | |

Velocity is the speed in a particular direction so you will need to determine the speed and indicate the direction.

To calculate the change in velocity for each object:

- Divide the distance traveled (100cm) by the time it took to travel that distance.
- Indicate the direction of motion.

Example, let's calculate the velocity for an object that traveled to the right 100 cm in 2 seconds.

d = 100 cm
t = 2 s
S = ?

$$\text{Speed} = \frac{d}{t} = \frac{100\ \text{cm}}{2\ \text{s}} = 50\ \text{cm / s}$$

To indicate velocity add the direction "to the right."

Velocity = 50 cm /s to the right.

2 **HANDS ON**
Exploring Forces on Different Objects

# FM: 2.1.2 HANDS ON EXPLORING FORCES ON DIFFERENT OBJECTS

NEXT >

## Exploring Forces on Different Objects

Use the launcher to exert the same force on different objects. Measure how the objects' velocities change.

## FOLLOW DIRECTIONS

1. Lay a meter stick on the floor and place a golf ball next to it at 0 cm.
2. Depress the launcher to the *1* and hold it so it is touching the golf ball.
3. Release the launcher and start the stopwatch. Measure the time it takes for the golf ball to reach the far end of the meter stick. (**Note**: On a stopwatch, 00:01:29 means 1.29 seconds.)
4. Record the time elapsed in the data table.
5. Repeat these steps with the table tennis ball.
6. Calculate the change in velocity for each object: divide the distance traveled (100cm) by the time it took to travel that distance. Indicate the direction of motion.
7. Record the velocity change in the data table.

## FILL OUT TABLE

| Object | Time to travel 100 cm (seconds) | Velocity d/t (cm/s) and direction |
|---|---|---|
| Golf ball | | |
| Table tennis ball | | |

## ANSWER QUESTIONS

3. Which object ended up moving faster (had the greater change in velocity)?

| | |
|---|---|
| a | golf ball |
| b | table tennis ball |

4. Which object ended up being slower (had less change in velocity)?

| | |
|---|---|
| a | golf ball |
| b | table tennis ball |

2 **HANDS ON**
Exploring Forces on Different Objects

# FM: 2.1.2 HANDS ON EXPLORING FORCES ON DIFFERENT OBJECTS

**Brief class discussion – Share/Summarize your observations.**

The same force caused a smaller change in velocity for the heavier golf ball

A greater change in velocity was observed for the lighter table tennis ball.

Instead of using vague terms like *heavy* and *light*, scientists prefer more specific language such as *more massive* and *less massive*.

3. Which object ended up moving faster (had the greater change in velocity)?

| | |
|---|---|
| a | golf ball |
| b | table tennis ball |

4. Which object ended up being slower (had less change in velocity)?

| | |
|---|---|
| a | golf ball |
| b | table tennis ball |

2 **HANDS ON**
Exploring Forces on Different Objects

# FM: 2.1.2 HANDS ON EXPLORING FORCES ON DIFFERENT OBJECTS

**mass:** the amount of matter that makes up an object

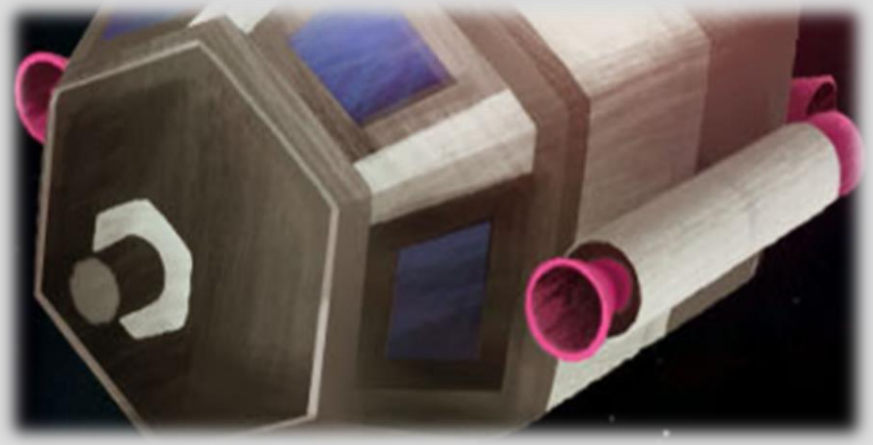
HAND IN

*Which object would have a greater change in velocity if you exerted the same strength force, a toy car or a full-size car?*

Toy car.

*Which pod would have a greater change in velocity if you exerted the same strength force, a less massive pod or a more massive pod?*

A less massive pod.



3 SIM
Investigating Force and Mass

# FM 2.1.3 SIM
# INVESTIGATING FORCE AND MASS

Students use the Sim to determine how exerting the same force on different objects affects each object's change in velocity. (20 min)