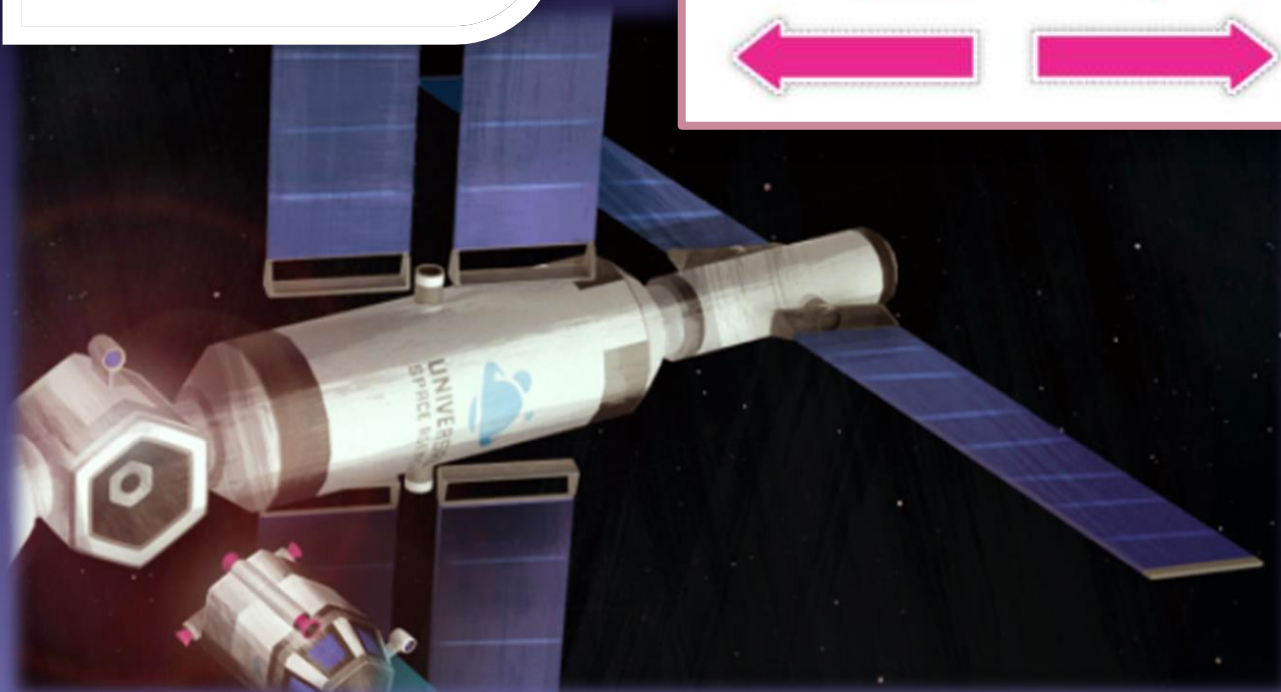


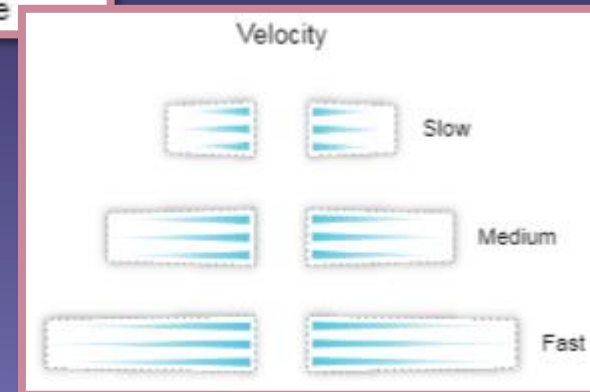
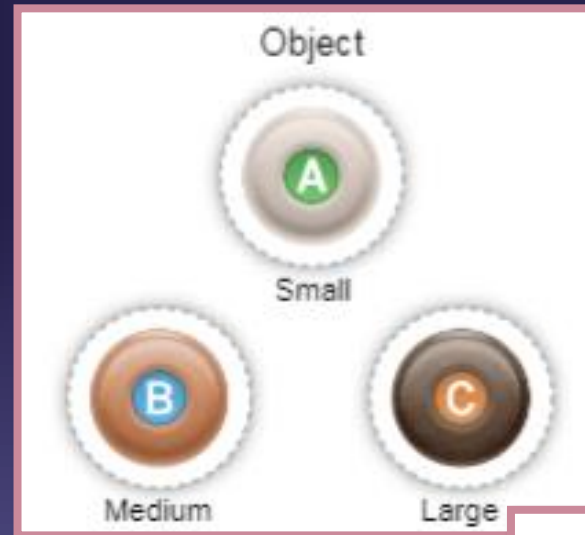
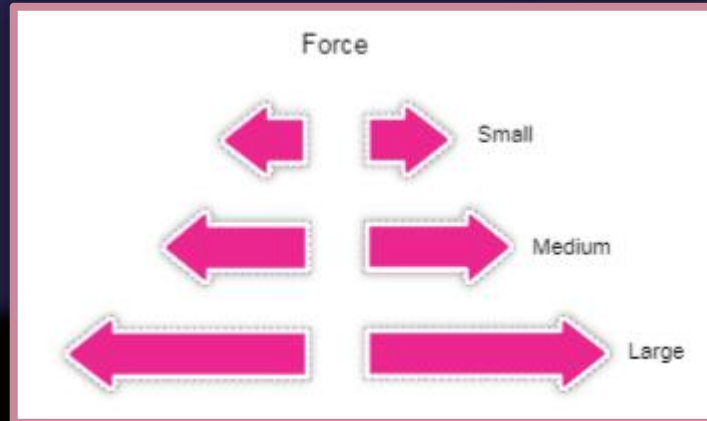
# Chapter 3: Collisions



Chapter 3: Collisions



## 2 | 3.2: Investigating Collision Forces





# FM: 3.2.1 WARM-UP

Students create visual models as a way to record their initial ideas about how forces act on objects during a collision. (5 min)

What are the forces like in a collision?

1. Open the *Force and Motion* Modeling Tool activity: **Collision Forces**.
2. Use the Modeling Tool to show your initial ideas.
3. When your model is complete, press HAND IN. (**Note:** You will revise this model in the Homework activity.)

**Goal:** Model the forces exerted when two objects collide (strength and direction).

**Do:**

- Drag force arrows to the During Force panel to show the strength and direction of the forces that are exerted on each object during the collision.



# FM: 3.2.1 WARM-UP

HAND IN

Students create visual models as a way to record their initial ideas about how forces act on objects during a collision. (5 min)

Hand In Instructions

Reset Undo Redo

Before Force During Force After Force

### Instructions

**Goal** Model the forces exerted when two objects collide (strength and direction).

**Do** Drag force arrows into the During Force panel so it shows the strength and direction of forces exerted on each object in the collision.

Small Medium Fast Medium Large

Medium Large



## FM: 3.2.2 EXPLORING DIRECTION OF COLLISION FORCES

Students observe velocity changes to infer the direction of forces that act on objects during a collision. (15 min)

***What are the forces like in a collision?*** *Lets model this to find out.*

You will use physical materials to gather data about forces in a collision. You will also notice how objects are affected by collisions. Students will use their data to infer the force direction for objects in a collision.

**The investigation is in two parts:**

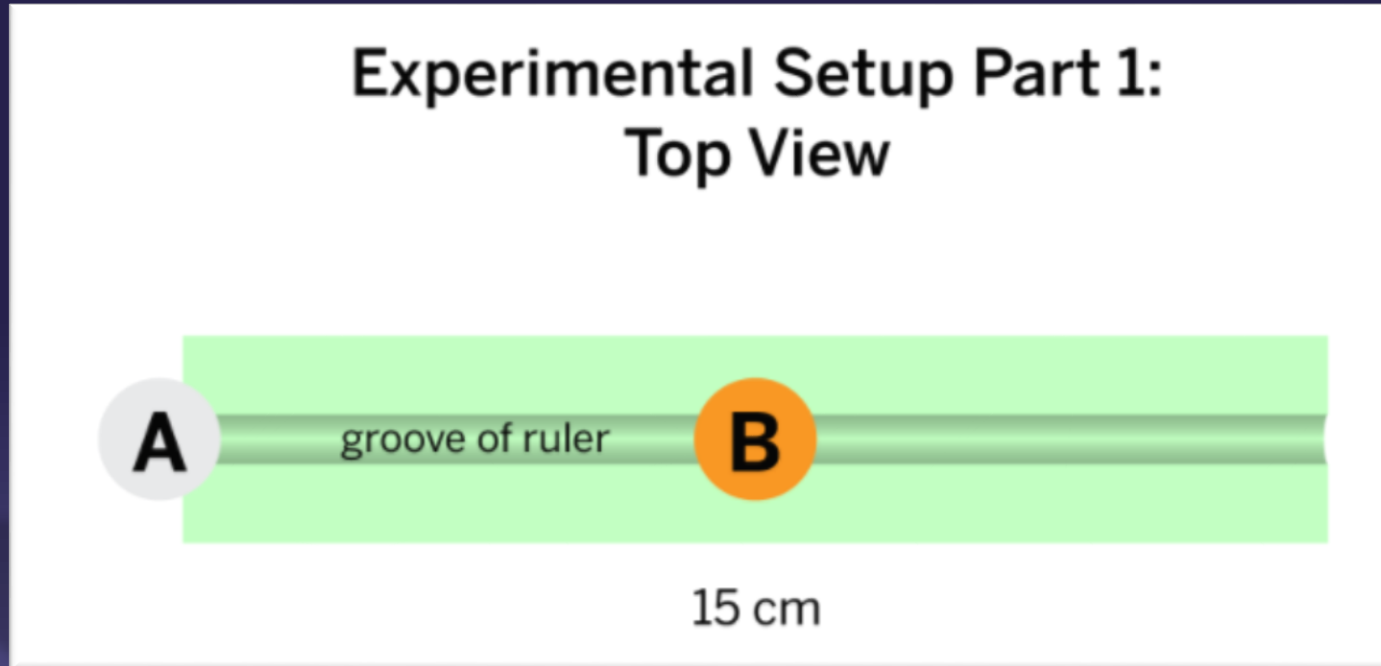
- Part 1: Collisions where a moving object hits a stationary object
- Part 2: Collisions where two moving objects hit each other



## FM: 3.2.2 EXPLORING DIRECTION OF COLLISION FORCES

Students observe velocity changes to infer the direction of forces that act on objects during a collision. (15 min)

### *Collisions with One Moving Object:*

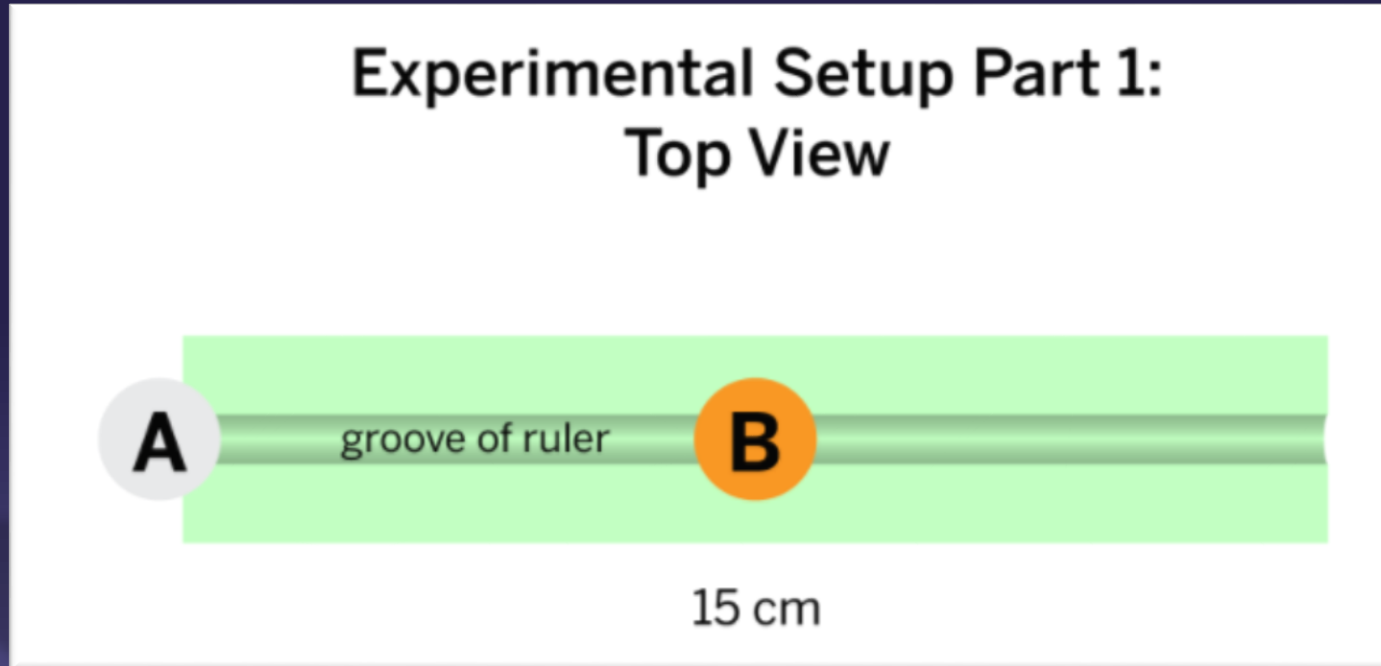




## FM: 3.2.2 EXPLORING DIRECTION OF COLLISION FORCES

Students observe velocity changes to infer the direction of forces that act on objects during a collision. (15 min)

### *Collisions with One Moving Object:*





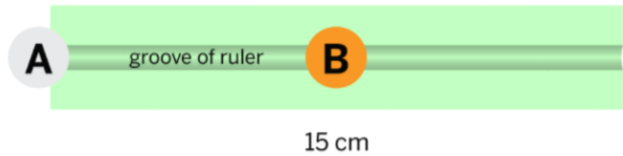
# FM: 3.2.2 EXPLORING DIRECTION OF COLLISION FORCES

NEXT >

Students observe velocity changes to infer the direction of forces that act on objects during a collision. (15 min)

## Collisions with One Moving Object:

### Experimental Setup Part 1: Top View



What are the forces like in a collision?

Use the data table to set up the collisions and record the results.

1. Use the image as an example to set up your objects.
2. Roll Object A toward Object B and observe how the objects change velocity when they collide. Record your observations in the data table. Choose from the following options:

- speed up
- slow down
- stop moving
- change direction

3. Based on the velocity changes, infer the direction of the force (if any) acting on each object and record it in the table. Choose from the following options:

- left
- right
- none

4. Repeat these steps for all three collisions.

Collision	Object A (moving to right before collision)	Object B (NOT moving before collision)	Effect: Object A	Effect: Object B	Force direction: Object A	Force direction: Object B
1	rubber ball	rubber ball				
2	golf ball	rubber ball				
3	rubber ball	golf ball				



## FM: 3.2.2 EXPLORING DIRECTION OF COLLISION FORCES

HAND IN

Students observe velocity changes to infer the direction of forces that act on objects during a collision. (15 min)

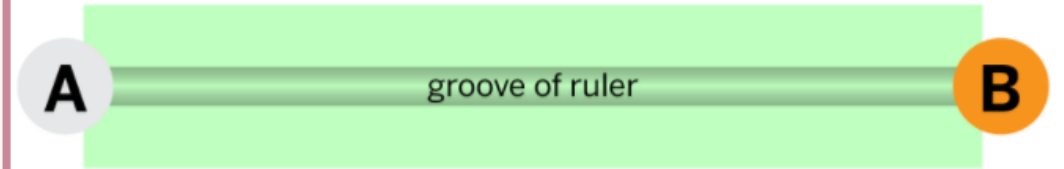
### *Collisions with TWO Moving Objects:*

What are the forces like in a collision?

Use the data table to set up the collisions and record the results.

1. Use the image as an example to set up your objects.
2. Roll Object A and Object B toward each other, and observe how the objects change velocity when they collide. Record your observations in the data table. Choose from the following options:
  - speed up
  - slow down
  - stop moving
  - change direction
3. Based on the velocity changes, infer the direction of the force (if any) acting on each object and record it in the table. Choose from the following options:
  - left
  - right
  - none
4. Repeat these steps for the second collision.

### Experimental Setup Part 2: Top View



Collision	Object A (moving <i>right</i> before collision)	Object B (moving <i>left</i> before collision)	Effect: Object A	Effect: Object B	Force direction: Object A	Force direction: Object B
1	rubber ball	rubber ball	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	golf ball	rubber ball	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>





## FM: 3.2.2 EXPLORING DIRECTION OF COLLISION FORCES

Students observe velocity changes to infer the direction of forces that act on objects during a collision. (15 min)

**Based on the velocity change of each object, what did you infer about the direction of forces during a collision?**

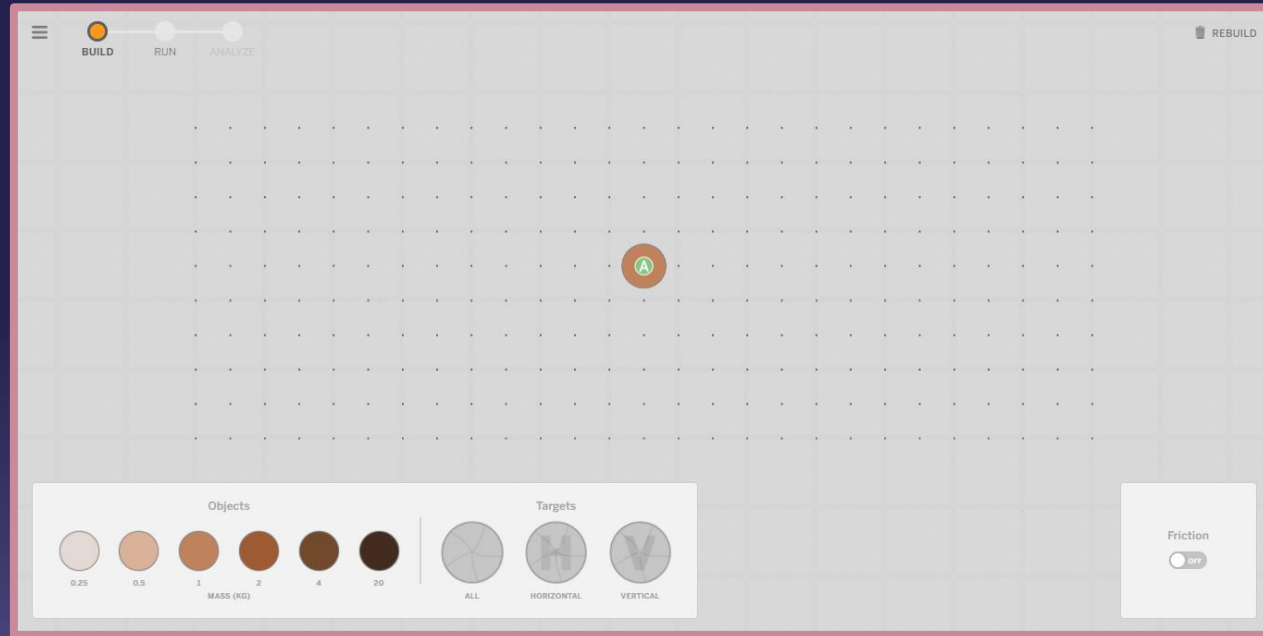
- We observed that the velocity of each object changed during a collision, so we can infer that a force had to be exerted on each object. However, the motion of the objects changed in different ways.
- The object that was moving forward slowed down, so I can infer that the force must have pushed backward on this object.
- The other object started moving forward, so the force must have pushed forward on that object. If one force was backward and one force was forward, then the forces pushed the objects in opposite directions.



## FM: 3.2.3 EXPLORING STRENGTH OF COLLISION FORCES

Students use the Sim to determine whether the force strength on the objects in a collision are equal or different. (20 min)

Now you have information about the direction of forces in a collision. To develop a more complete picture, you will now use the SIM to gather evidence about the strength of forces in a collision. This activity will also provide additional opportunities to observe how colliding objects are affected.



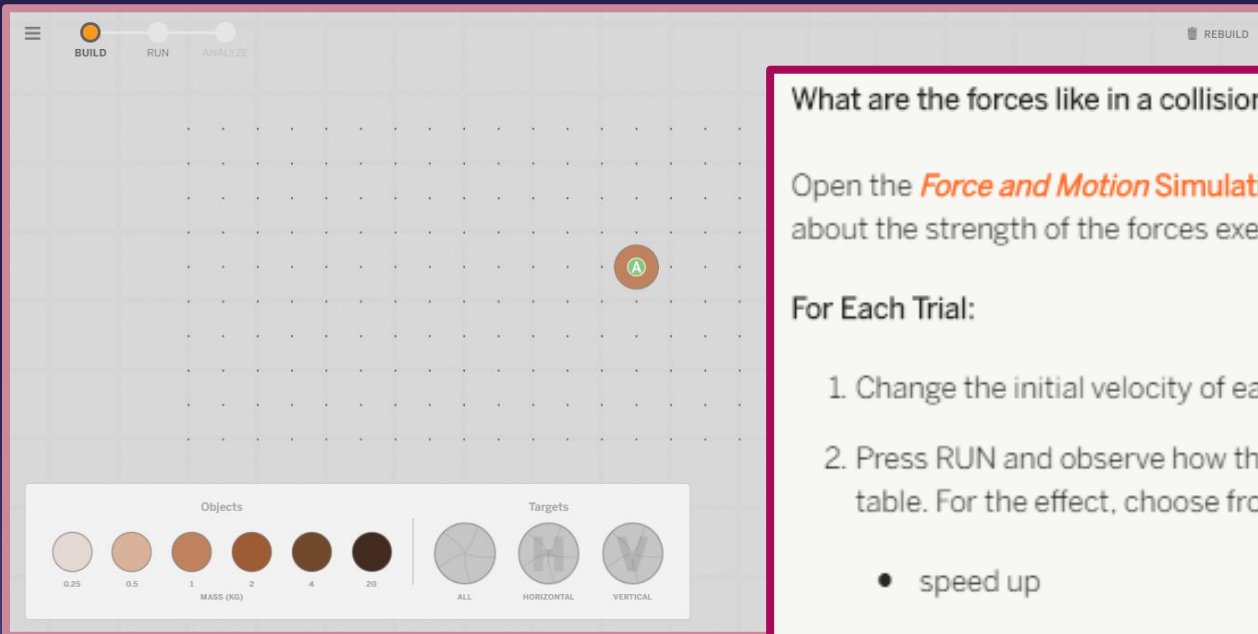
- During this first part of the activity, have one partner open the Sim and perform the tests, while the other partner records data on the student screen.



## FM: 3.2.3 EXPLORING STRENGTH OF COLLISION FORCES

Students use the Sim to determine whether the force strength on the objects in a collision are equal or different. (20 min)

### Forces in Collisions: Objects with the Same Mass.



What are the forces like in a collision?

Open the *Force and Motion Simulation* and select **3.2 Same Mass Collisions** from the menu bar. Use the Sim to gather evidence about the strength of the forces exerted during collisions between objects that have the same mass.

For Each Trial:

1. Change the initial velocity of each object as described in your data table.
2. Press RUN and observe how the velocity of each object changes due to the collision. Record your observations in the data table. For the effect, choose from the following options:
  - speed up
  - slow down
  - start moving
  - stop moving
  - change direction
3. Press ANALYZE to determine the strength and direction of the force exerted on each object. Record in the data table.

#### Collisions

3.1 Homework

**3.2 Same Mass Collisions**

3.2 Different Mass Collisions

3.3 Warm-Up

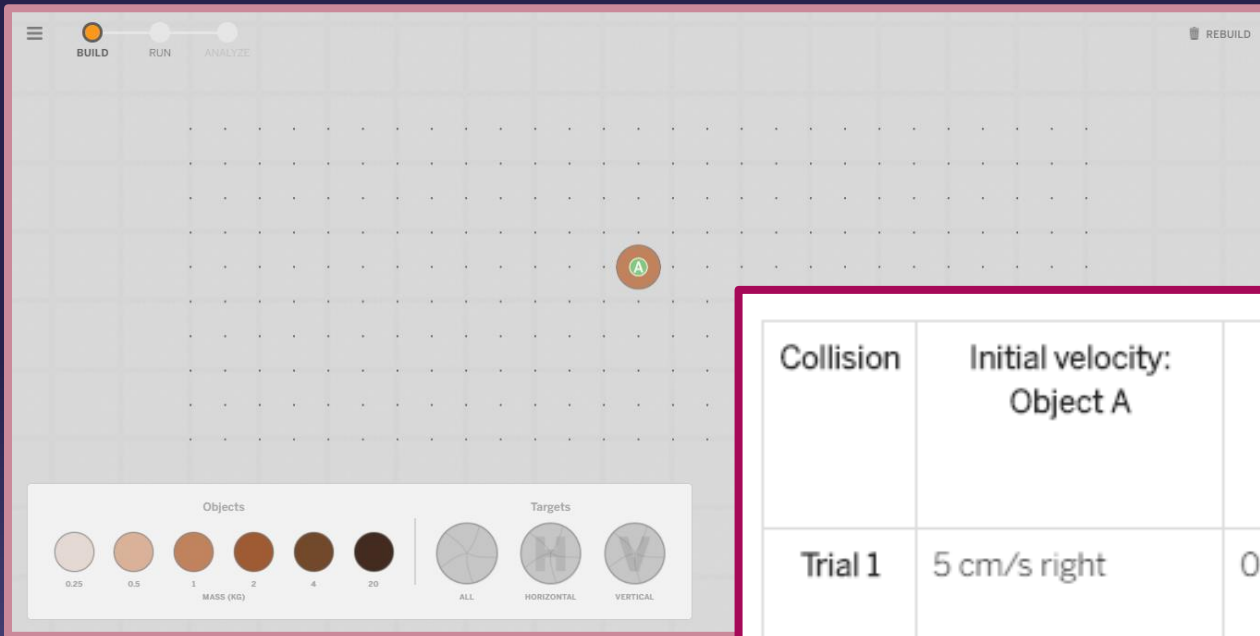


## FM: 3.2.3 EXPLORING STRENGTH OF COLLISION FORCES

NEXT >

Students use the Sim to determine whether the force strength on the objects in a collision are equal or different. (20 min)

### Forces in Collisions: Objects with the Same Mass.



Collision	Initial velocity: Object A	Initial velocity: Object B	Effect: Object A	Effect: Object B	Force strength/ direction: Object A	Force strength/ direction: Object B
Trial 1	5 cm/s right	0 cm/s	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Trial 2	5 cm/s right	2 cm/s left	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Trial 3	5 cm/s right	2 cm/s right	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>



# FM: 3.2.3 EXPLORING STRENGTH OF COLLISION FORCES

NEXT >

Students use the Sim to determine whether the force strength on the objects in a collision are equal or different. (20 min)

## Forces in Collisions: Objects with Different Masses.

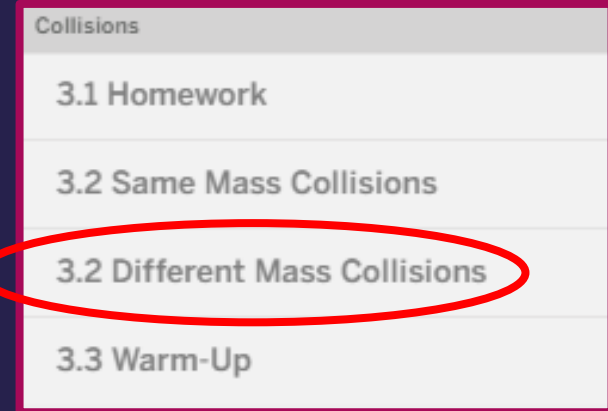
What are the forces like in a collision?

Open the *Force and Motion Simulation* and select **3.2 Different Mass Collisions** from the menu bar. Use the Sim to gather evidence about the strength of the forces exerted during collisions between objects that have different masses.

For Each Trial:

1. Change the initial velocity of each object as described in your data table.
2. Press RUN and observe how the velocity of each object changes due to the collision. Record your observations in the data table. For the effect, choose from the following options:
  - speed up
  - slow down
  - start moving
  - stop moving
  - change direction

3. Press ANALYZE to determine the strength and direction of the force exerted on each object.



Collision	Initial velocity of Object A	Initial velocity of Object B	Effect: Object A	Effect: Object B	Force strength/direction: Object A	Force strength/direction: Object B
Trial 1	5 cm/s right	0 cm/s	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Trial 2	5 cm/s right	2 cm/s left	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Trial 3	5 cm/s right	2 cm/s right	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>



## FM: 3.2.3 EXPLORING STRENGTH OF COLLISION FORCES

Students use the Sim to determine whether the force strength on the objects in a collision are equal or different. (20 min)

### Reflecting on Forces in Collisions.

You will write a claim that describes the direction and strength of forces in a collision.

- Use the words in the word bank.
- Elaborate on their initial observations about how forces affect the objects in a collision.

### Key Concept

When two objects collide, a force is exerted on each object. The two forces are exerted in opposite directions, but they are the same strength.



## FM: 3.2.3 EXPLORING STRENGTH OF COLLISION FORCES

HAND IN

Students use the Sim to determine whether the force strength on the objects in a collision are equal or different. (20 min)

### Reflecting on Forces in Collisions.

You will write a claim that describes the direction and strength of forces in a collision.

- Use the words in the word bank.
- Elaborate on their initial observations about how forces affect the objects in a collision.

#### Word Bank

collision	force
same	opposite
direction	velocity
strength	

What are the forces like in a collision?

**ANSWER HERE**

1. Discuss the hands-on activity with your partner: *What did you learn from this activity about the direction of forces in a collision?*
2. Discuss the Sim activity with your partner: *What did you learn about the strength of forces in a collision?*
3. Write a claim that describes the strength and direction of forces exerted on objects during a collision. Use at least four of the words from the word bank in your response.



## FM: 3.2.4 SPACE STATION AND POD COLLISION FORCES

Students apply what they have learned to describe the collision forces between the pod and the space station. (5 min)

What you learned about collision forces will help you understand what happened to the pod during the seconds when the space agency lost communication.

Let's review what we already know about the motion of the pod and space station:

Describe the motion of the pod and space station before the collision?

The pod was moving toward the space station. The space station was stationary.

Describe the motion of the pod and space station after the collision?

The pod changed direction and is now moving away from the space station; the space station is also moving.

**We know that both objects experienced velocity changes. Now we will use our understanding of collision forces to make inferences about what happened to cause those changes in velocity.**





## FM: 3.2.4 SPACE STATION AND POD COLLISION FORCES

Students apply what they have learned to describe the collision forces between the pod and the space station. (5 min)

From our investigation of what forces are like in a collision, we learned that when two objects collide, a force is exerted on each object. The two forces are in opposite directions but the same strength. This allowed us to infer that an equal strength force was exerted on the space station and the pod, but in opposite directions.

As a result, the space station and the pod are moving in opposite directions. We need to learn more about the effects of collisions on each object's motion so we can report back to Dr. Gonzales at the space agency.

**Did the collision force exerted on these objects affect the pod and the space station's speed in the same way?**



## FM: 3.2.4 SPACE STATION AND POD COLLISION FORCES

Students apply what they have learned to describe the collision forces between the pod and the space station. (5 min)

### Discussing the Collision of the Pod and Space Station

Discuss these questions with your partner:

1. What can you infer about the strength and direction of forces experienced by the pod and space station when they collided?  
What evidence from today's activities supports your inference?
2. In a message from Dr. Gonzales, we learned that the space station is moving as a result of the collision. Say which direction you think it is moving and explain why.



# FM: 3.2.5 HOMEWORK

HAND IN

Students revise digital models to show their updated understanding of the forces in collisions.

## Modeling Collision Forces

1. Open the *Force and Motion Modeling Tool* activity: **Collision Forces**.
2. Revise the model that you began in the Warm-Up so it reflects your current thinking.
3. When your model is complete, press HAND IN.

**Goal:** Model the forces exerted when two objects collide (strength and direction).

**Do:**

- Drag force arrows to the During Force panel to show the strength and direction of the forces that are exerted on each object during the collision.

Press HAND IN to see a screenshot of your completed model.

