Name: ______________________ Date: ______________

Lesson 2.2: “Designing Wheelchairs”

What else could have caused this pod to move differently? Knowing that the thrusters exerted the same strength force as the thrusters on other ACM pods does not explain why it failed to dock. In today’s lesson, you will learn more about another factor, mass, and how that could have affected the pod’s change in velocity. Your research will continue with an article called “Designing Wheelchairs for All Shapes and Sizes.” Remember, the Universal Space Agency is counting on your help!

Unit Question

- How do forces affect motion?

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?

Vocabulary

- cause
- effect
- exert
- force
- infer
- velocity

Name: ______________________ Date: ______________

Warm-Up

You have investigated many questions about forces and how different objects move using the Sim and other common materials (jar lids, table tennis balls, etc.). What are some questions you still have about forces, the movement of objects, speed, or velocity? What materials or tools would you use to investigate your questions?

List questions that you have:

Explain what materials you would use to investigate your questions:

After thinking of questions and materials, scientists often make predictions, or hypotheses, about what they might find in an investigation. Choose one of your questions from above and write a prediction, or hypothesis, about what you might find in your investigation.

Name: ______________________________ Date: ____________________

Reading "Designing Wheelchairs"

1. Read and annotate the article "Designing Wheelchairs."
2. Choose and mark annotations to discuss with your partner. Once you have discussed these annotations, mark them as discussed.
3. Now, choose and mark a question or connection, either one you already discussed or a different one you still want to discuss with the class.
4. Answer the reflection question below.

Rate how successful you were at using Active Reading skills by responding to the following statement:

As I read, I paid attention to my own understanding and recorded my thoughts and questions.

- ☐ Never
- ☐ Almost never
- ☐ Sometimes
- ☐ Frequently/often
- ☐ All the time

Active Reading Guidelines

1. Think carefully about what you read. Pay attention to your own understanding.
2. As you read, annotate the text to make a record of your thinking. Highlight challenging words and add notes to record questions and make connections to your own experience.
3. Examine all visual representations carefully. Consider how they go together with the text.
4. After you read, discuss what you have read with others to help you better understand the text.

Name: ______________________________ Date: ____________________

Lesson 2.3: Explaining Mass, Force, and Velocity

Through your investigations, you've learned that mass plays an important role in determining how much an object's velocity changes when a force is exerted on that object. It's time to apply what you know about the relationship between mass, force, and velocity change to the case of the pod that failed to dock. You will conduct tests in the Sim and reread a text, then create two models. These models will show how the pod's mass could have been a key factor in either explanation of the docking failure.

Unit Question

- How do forces affect motion?

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?

Vocabulary

- cause
- effect
- exert
- force
- infer
- velocity

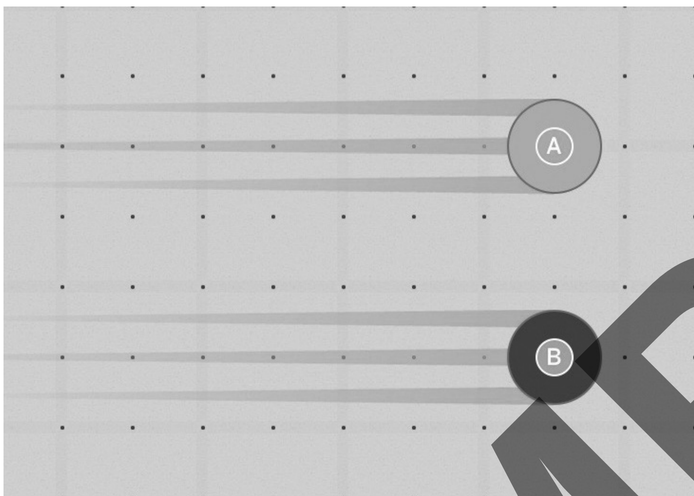
Digital Tools

- *Force and Motion* Simulation
- *Force and Motion* Modeling Tool activities: Claim 1, Chapter 2 and Claim 2, Chapter 2

Name: ______________________ Date: ______________

Warm-Up

1. Make some predictions about what will happen in the Sim when you exert the same strength force on two objects of different mass.
2. Run the tests in the Sim.
3. When the tests are complete, think about how you would answer this question: *Why did one object stop more easily than the other?* Be prepared to share your ideas with a partner.



Predictions

1. If your goal is to make these objects slow down, in which direction should you apply a force? (circle one)

   up **down** **left** **right**

2. Object B is more massive than Object A. If you apply the same strength force (4 clicks) to both objects, which object will have a greater change in velocity? (circle one)

   Object A **Object B**

Sim Tests

1. Open the *Force and Motion* Simulation and select **2.3 Warm-Up** from the menu.
2. Press RUN, then press PLAY to begin.
3. Press PREPARE FORCE to pause the Sim while you set up your forces.
4. In the Force panel, select Object A and set up a force of 4 clicks in the direction that will make the object slow down.
5. Repeat step 4 for Object B.
6. Press EXERT FORCE and observe how each object's velocity changes.

Name: ______________________________ Date: ____________________

Revisiting "Designing Wheelchairs"

How would you design a wheelchair for basketball? The players need the wheelchair to be stable, or at least not tip over when there's contact between players. Players also need to be able to stop and start quickly and move fast so they can gain control of the basketball.

1. Reread paragraphs 3, 4, and 5 of "Designing Wheelchairs for All Shapes and Sizes." Highlight or annotate evidence in the text that helps you understand how massive a wheelchair for basketball needs to be.
2. Discuss your ideas with a partner after you finish reading.
3. Answer the questions and record your design ideas, including ideas from the text that support your design choice.
4. Be prepared to share your ideas with the class.

Questions

Which wheelchair would be more difficult to stop? (check one)

- ☐ more massive wheelchair
- ☐ less massive wheelchair

If the same strength force were exerted on both wheelchairs, which chair would go faster? (check one)

- ☐ more massive wheelchair
- ☐ less massive wheelchair

How would you design a wheelchair for wheelchair-using basketball players? Would you make it more or less massive? Explain how the text supports your choice.

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Name: ______________________ Date: ______________

Modeling the Effects of Different Masses

Claim 1

1. Open the *Force and Motion* Modeling Tool activity: Claim 1, Chapter 2.
2. When your model is complete, press HAND IN. If you worked with a partner, write his or her name here: ______________________

Goal: Model this pod's mass so it shows that the usual thruster force would cause it to move in the opposite direction.

Do:

- Choose an object that represents the mass of this pod. Drag it into all three panels in the second row.
- Show the pod's velocity in the Before and After Force panels.
- Show the direction and strength of the thruster force in the During Force panel.

Tips:

- The During Force panel for this pod should use the same strength and direction of force as the pod in the first row.

Name: ______________________________ Date: ____________________

Modeling the Effects of Different Masses (continued)

Claim 2

1. Open the *Force and Motion* Modeling Tool activity: Claim 2, Chapter 2.
2. When your model is complete, press HAND IN. If you worked with a partner, write his or her name here: ______________________________

Goal: Model this pod's mass so it shows that the usual thruster force would only slow the pod (not stop) and cause it to hit the space station.

Do:

- Choose an object that represents the mass of this pod. Drag it into all three panels in the second row.
- Show the pod's velocity in the Before and After Force panels.
- Show the direction and strength of the thruster force in the During Force panel.

Tips:

- The During Force panel for this pod should use the same strength and direction of force as the pod in the first row.

Name: ______________________________ Date: ________________

Homework: Explaining Two Claims

Why did this pod move differently? Could these claims be accurate if the pod had a different mass (a different number of asteroid samples)? Explain to Dr. Gonzales what would have happened in each claim that would cause the pod to move away from the space station.

Refer to your Modeling Tool diagrams, the word bank, and the cause-and-effect words and phrases.

Word Bank

force	exert	mass	velocity	cause	effect

Cause-and-Effect Words and Phrases

if . . . , then	because	as a result	this led to . . .
when	therefore	next	

Claim 1: Firing the thrusters would have caused the pod to move in the opposite direction if . . .

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Claim 2: Firing the thrusters only slowed the pod, it didn't stop; the pod hit the space station, which made it bounce and move in the opposite direction. This would happen if . . .

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People use wheelchairs for lots of different activities, and wheelchairs come in many styles.

Designing Wheelchairs for All Shapes and Sizes

People who use wheelchairs come in all different shapes and sizes—children and adults, tall and short, big and small—and so do the wheelchairs they use. Some wheelchairs have motors, and others are operated by hand. People who use wheelchairs do all kinds of different things. Wheelchair users may go to school or work in an office. They may sing in a rock band, take their dogs to the park, compete in races, or lead a parade through city streets.

Dr. Rory Cooper designs wheelchairs and other technologies for people with disabilities. Here, he demonstrates a robotic arm that attaches to a wheelchair and helps its user grasp items from far away.

Wheelchairs are designed for the people who use them and for the different activities they want to do. Dr. Rory Cooper knows all about designing wheelchairs: he's an engineer who works to improve wheelchair safety, comfort, and usefulness. He and his team design wheelchairs for many different purposes, from world-class racing and other sports to everyday mobility.

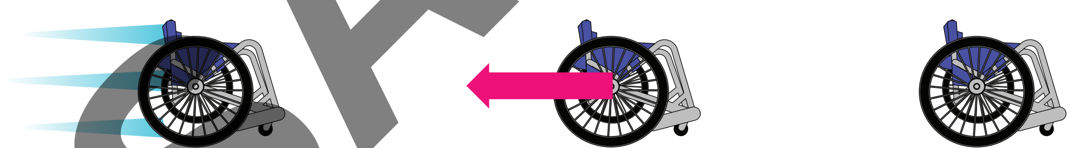
Dr. Cooper served in the United States Army. During his service, he was injured and began using a wheelchair. After he left the military, he went to college and studied engineering. Today, Dr. Cooper runs the Human Engineering Research Labs (HERL) at the University of Pittsburgh, Pennsylvania. There, he works with other scientists on technologies that help people with disabilities. Dr. Cooper is also an athlete: he won a bronze medal in wheelchair racing at the 1988 Paralympics. The Paralympics are a series of athletic events for people with disabilities. They take place just after the Olympics and in the same location as the Olympics.

Dr. Cooper designs each wheelchair to fit the person who will be using it and the activities it will be needed for. One way he and his team can change the design of a wheelchair is by changing the mass of the chair. Mass is the amount of matter that makes up an object—on Earth, objects with more mass are heavier than objects with less mass. By changing the mass of a wheelchair, Dr. Cooper can make it change velocity more easily or less easily. That makes each chair useful for certain activities. For example, some wheelchairs are built especially for playing different sports.

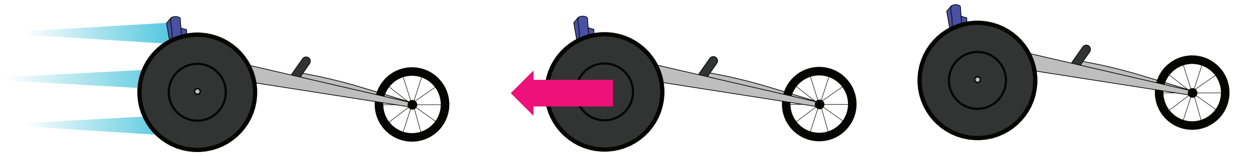
Wheelchairs used for wheelchair racing are built for speed. That means they need to be light. Lighter chairs change velocity more easily than heavier ones, so it's easier for a racer to go from sitting still to racing speed in a light chair. It also takes less force from the racer to stop a light chair than it takes to stop a heavy chair. Dr. Cooper's racing wheelchairs are made of materials that are light and strong, so the racer can start the race and speed up as quickly as possible using the least possible force.

Not all athletes in wheelchairs want to change velocity easily. Another popular sport that

Rugby wheelchair design



Racing wheelchair design



The strength of force needed to stop a quickly moving wheelchair will vary depending on how massive the wheelchair is. Rugby wheelchairs take more force to stop than those used in racing because they are more massive.

uses wheelchairs is wheelchair rugby, a fast, full-contact sport played on a court similar to a basketball court. Wheelchair rugby players need stability—they crash into each other often, and it's important that they don't tip over in a collision. For this reason, rugby wheelchairs are heavier than racing wheelchairs. Their weight means players need to use more force to get them moving when they're stopped and to make them stop moving once they get going, but it also means they aren't affected as much by the forces involved in collisions, so they are less likely to fall over during a crash. Rugby players in heavy, stable wheelchairs are more likely to stay upright and play successfully for their teams.

Designing wheelchairs with less mass for racing and wheelchairs with more mass for sports like rugby is just one example of how wheelchairs can be designed for different users and activities. When engineers design wheelchairs, the most important consideration is the person who is using the chair. A smaller person needs a different wheelchair than a larger person. Some wheelchair users turn the wheels of their chair by hand, while others use chairs with electric motors. Some wheelchair users are able to operate their chairs simply by moving their eyes. Wheelchair users choose chairs that work for their needs, fit their budget, and suit their own personal styles.

Wheelchairs come in many types—and thanks to Dr. Cooper's work at HERL, wheelchair users have more options than ever before.

Wheelchairs built for racing need to be light. The less mass the chairs have, the farther they can go on a single push.

The heavy wheelchairs used for wheelchair rugby are very stable. Even when they run into each other, they are hard to tip over.

Some people use special wheelchairs to play tennis. These wheelchairs are light, strong, and easy to adjust quickly for different types of matches.