

# LESSON 11: How does a force change the motion of something that has a little mass compared to something that has a lot of mass?

## PREVIOUS LESSON

We planned and carried out an investigation to evaluate and revise the use of two spring scale launchers to speed up a cart to ensure they produced repeatable and reliable results and then used them to collect data on how the amount of force applied to a stationary object affects how much its motion changes.

## THIS LESSON

### INVESTIGATION

1 day



In this lesson, we talk about our results from the cart races in Lesson 11 and decide our thinking is incomplete. We know that applying a larger force to an object with constant mass changes the motion more. After testing a small force on a light object and a larger force on a more massive object, we also know that bigger forces don't always mean more speed. We plan and carry out an investigation to test the relationship between force and the motion of objects with different masses that we want to speed up.

## NEXT LESSON

We will discuss our evidence and ideas about forces, change in motion, mass, and speed and come to consensus about what scientific principles we are clear about and what questions we still have.

## BUILDING TOWARD NGSS

MS-PS2-1, MS-PS2-2



### WHAT STUDENTS WILL DO

**Plan and carry out an investigation** to collect data that helps explain how **the effect of a force changes depending on the mass of the object (cause)**.

### WHAT STUDENTS WILL FIGURE OUT

We have to push harder to get something with more mass to change its motion from zero to a high speed.

The effect of a force changes depending on the mass of an object.

The same net force makes a more massive stationary object speed up less and a less massive stationary object speed up more.

## Lesson 11 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	<b>NAVIGATION</b> Connect to prior lessons and elicit new wonderings about how mass impacts the effect that force has on the motion of objects.	A-B	
2	22 min	<b>PLAN AND CARRY OUT AN INVESTIGATION</b> Students plan and carry out an investigation to determine the relationship between force and its effect on motion for objects with different masses. Following the investigation, they discuss patterns they notice and make claims about the relationship between force and its effect on motion for objects with different masses.	C	student notebook, Change in Mass Lab
3	12 min	<b>LOOKING FOR PATTERNS IN DATA</b> Students will discuss patterns in data and make claims about the relationship between force and its effect on motion for objects with different masses.	D	computer and projector,
4	5 min	<b>NAVIGATION</b> Students will use evidence from prior investigations to make predictions about what leads to more damage in collisions-- mass or speed.	E	student notebook,

*End of day 1*

## Lesson 11 • Materials List

	per student	per group	per class
Change in Mass Lab materials		<ul style="list-style-type: none"><li>• 2 tracks taped down on the ends with painter's tape on a flat surface or table top</li><li>• hook and loop fasteners on the bottom of 2 launchers (push-pull spring scales ) at the end of one track</li><li>• 2 carts</li><li>• extra painter's tape for marking a finish line</li><li>• five large washers</li><li>• small piece of clay to secure washers</li></ul>	
Lesson materials	<ul style="list-style-type: none"><li>• student notebook</li></ul>		<ul style="list-style-type: none"><li>• computer and projector</li></ul>

### Materials preparation (20 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

#### Change in Mass Lab

- **Group size:** 4-5 students
- **Setup:**
  - Use the same 2-track setup from Lesson 10.
  - Supply 6 large washers per group that will be used to change the mass of carts.
  - Supply clay that can be used to secure the washers in the cart.
- **Safety:** Make sure there is a barrier at the end of the track so that the carts don't fly off the table.
- **Storage:** All materials can be stored and reused indefinitely.

## Lesson 11 • Where We Are Going and NOT Going

### Where We Are Going

In this lesson, students are solidifying their understanding that the more net force is applied to an object, the more the motion of the object will change. They are building on this understanding by confirming that it takes more net force to change the motion of an object with a lot of mass than it takes to cause the same change in motion of an object with smaller mass. They may also be starting to wonder about what leads to more damage in collisions, mass or speed.

### Where We Are NOT Going

It is important that in this investigation, students keep the applied force constant. The evidence gathered will support claims about how mass mediates the cause and effect relationship between applied force and the resulting change in motion of objects.

# LEARNING PLAN for LESSON 11

## 1 · NAVIGATION

5 min

**MATERIALS:** None

**Turn and talk about last lesson.** Remind students of the final question from Lesson 10 and say, *We said more mass of a moving object causes more damage and more speed does, too. What do we still need to figure out?* Display **slide A**.

### Suggested prompt

*Where did we end up last class in our thinking about forces and the mass of objects we might try to launch?*

*What do we still need to figure out?*

### Sample student response

*We wondered what would happen if we changed the mass of the carts in our races.*

*We think more force speeds things up more but wonder if more mass might be harder to speed up.*

*We need to figure out whether increasing the mass affects how much something speeds up when we apply a force.*

**Discuss with a partner.** Ask students to talk with a partner about how motion might change if we apply a constant force but change the mass of the objects. Display **slide B**.

Give students time to think and talk with a partner. There is no need to hear ideas as a whole group at this point.

## 2 · PLAN AND CARRY OUT AN INVESTIGATION

22 min

**MATERIALS:** Change in Mass Lab, student notebook

**Plan and carry out an investigation.** Students will plan an investigation and collect data for applying a constant force to carts with different masses. Display **slide C** (and optional **slides C.1-C.2** as needed for differentiation).

Ask, *How do you think force changes the motion of something that has a lot of mass compared to something that has a little mass? And how could we test this?*

This is a good place to give students an opportunity to take ownership of planning an investigation. They will be able to leverage their experience from Lesson 10 to determine that force should be kept constant and that mass can be added to their carts using the washers provided.

If students are struggling with identifying variables, you can use optional **slide C.1** to guide a conversation by asking these questions:

- *What is our dependent variable (what we want to measure) in this question? What are some tools we could use to measure the dependent variable?*
- *What is our independent variable (what we want to change)? How many different ways could we change the independent variable to answer this question?*
- *What might be some controlled variables (things we want to keep the same)?*

If students are unclear about how to set up a data table, display optional **slide C.2** and have them copy it into their notebooks. This slide will also help you clarify units of measure that should be used during data collection.

Give students time to discuss the question on **slide C** and to design an investigation for how they will test the effects of force on different masses.

- Students will use carts and tracks from Lesson 10 and will add 2 in washers to change the mass of the carts.
- Students should be familiar with the procedures for applying force from the previous lesson.

### 3 · LOOKING FOR PATTERNS IN DATA

12 min

**MATERIALS:** computer and projector



**Look for patterns in the data.** Direct students to work with their groups to look for patterns in the data and make a claim about the relationship between force and its effect on motion for objects with different masses. Display **slide D**.

Give students time to talk with group members about patterns in their data and what claims they can support with evidence about the relationship between force applied to an object, the mass, and how much the motion of the object changes.

Listen for students to notice that the more massive their cart, the more likely it would lose the race because it sped up less than the lighter cart.

Ask students to write claims in their notebooks. An example of a claim might be “The same force makes a less massive object change motion (speed up) more than a more massive object.”

Allow 2-3 groups to share their claims and evidence with the whole group. Highlight any competing ideas that emerge.

### 4 · NAVIGATION

5 min

**MATERIALS:** student notebook

**Turn and talk.** Students will consider all of their evidence from prior investigations to predict what the most important factors are in designing a destructor. Display **slide E**.

*Say, We've figured out a lot of things about how large forces and small forces act on a constant mass and about how a constant force acts on heavy things and light things.*

*In Lesson 9, we started talking about how we could build a destructor and ensure it could cause as much damage as possible to a delicate object. What do you think are the most important things to consider if we want to make a really awesome destructor?*

Give students two minutes to talk with a partner and allow a few students to share their thinking with the class. Possible student responses might include the following:

- *A heavier (more massive) destructor will do more damage.*
- *A faster destructor will do more damage.*
- *A heavy, fast destructor will do the most damage.*
- *It's hard to get something heavy (massive) moving really fast.*

*Say, Tomorrow, let's keep working through our ideas together.*

**SUPPORTING  
STUDENTS IN  
MAKING  
CONNECTIONS IN  
MATH**

**MP.2 Reason abstractly and quantitatively.**

In this lesson, students will make sense of quantities and their relationships by making qualitative comparisons of forces applied (net force), mass, and resulting changes in motion. They might talk about how quickly objects with different masses speed up and compare the differences in speeding up between objects with a lot of mass and objects with a little mass. Students might describe a proportional relationship between how quickly an object speeds up and the amount of net force applied to the object. Students might also describe how quickly an object speeds up as the result of an applied force is inversely proportional to the mass of the object.

**SUPPORTING  
STUDENTS IN  
MAKING  
CONNECTIONS IN  
ELA**

**TST.6-8.3 Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks.**

In this lesson, students will develop and follow a multi-step procedure when carrying out the investigation. The investigation gives students an opportunity to collect evidence to answer a self/class-generated question.