Session 3.6 (Group 1)

Crash Science

LEARNING OBJECTIVES:

Science Concepts & Practices:

- Compare and contrast cars of different weights to predict which will cause more damage in a crash and which has more energy.
- Present evidence to support the claim that when the kinetic energy of an object changes, energy is transferred (moved) to or from the object.
- Conduct (do) an experiment to investigate the relationship between mass and energy.
- *Analyze (look closely at)* data and graphs to describe relationships between kinetic energy and mass of an object.

Language Skills & Knowledge:

- Put together information presented in words with information presented in visuals to understand science concepts.
- Read an informational text and identify key ideas about energy and motion.
- Respond to questions using new vocabulary, as appropriate.
- Explain how this experiment connects to the roller coaster problem using evidence from the lab.

KEY VOCABULARY IN SESSION 3.6:

convert

energy

energy transformation

kinetic energy

law of conservation of energy

mass

position

potential energy

speed

system

transfer

ACTIVITY 1: SET THE CONTEXT

PART 1 - Directions: Listen and follow along as your teacher reads the text. Work individually or with a partner to answer the questions. Then, debrief as a class.

Imagine two cars are driving towards each other at the same **speed**. The two cars are shown below. You are also told the *weight of each car* *(how heavy each car is)*.

→ ***speed:*** *how fast something is moving*

Mercedes C-Class

Weight: 3,527 lbs.

Smart Fortwo

Weight: 1,808 lbs.

1. ***Look at the two cars. Which car is heavier*** *(weighs more)****?***

☐ The Mercedes is heavier than the Smart car.

☐ The Smart car is heavier than the Mercedes.

*These questions ask what **you** think. There are no right or wrong answers.*

2. ***Both cars are moving at the same speed*** *(as fast as each other)****. Which car do you think has more energy? Say why you think that.***

I think the _____ [Mercedes/Smart car] has more energy because...

3. ***Imagine that these two cars crash into*** *(hit)* ***each other. Which car do you think will have more damage*** *(be more broken)****? Say why you think that.***

I think the _____ [Mercedes/Smart car] will have more damage because...

PART 2 - Directions: Listen as your teacher describes the video. Watch the video that your teacher plays. Work individually or with a partner to answer the questions. Then, debrief as a class.

Video Title:

Crash Test: Mercedes-Benz C-Class vs Smart ForTwo

Description:

The Insurance Institute for Highway Safety (IIHS) is a group that tests cars to make sure they are safe. The IIHS crashes cars on purpose in a lab to see what happens. The IIHS gives cars a score that tells people how safe each car is. The IIHS also tells car companies how to make cars safer.

In this video, the IIHS is testing what happens when a larger car and smaller car crash into each other. **The cars are both traveling 40 miles per hour (mph).**

NOTE: Miles per hour or mph is a measurement of speed. Speed is how fast something is moving. 40 mph means that the car could *travel (go)* 40 miles in one hour.

1. ***Which car looked more damaged after the crash?***

☐ The bigger, red car (Mercedes) ☐ The smaller, blue car (Smart)

2. ***Which car moved more after the crash?***

☐ The bigger, red car (Mercedes) ☐ The smaller, blue car (Smart)

3. ***When the two cars hit each other, where do you think the energy in the red car went?***

I think the energy from the red car went...

4. ***When the two cars hit each other, where do you think the energy in the blue car went?***

I think the energy from the blue car went...

5. ***Now that you have watched the video, which car do you think has more energy?***

☐ The bigger, red car (Mercedes) ☐ The smaller, blue car (Smart)

6. ***Why do you think that car has more energy?***
   - ➔ *Use evidence (information) from the video to explain your thinking.*

I think the _____ [Mercedes/Smart car] car has more energy because...

REMINDER:

The law of conservation of energy says that energy cannot be created or destroyed.

Energy can *transform (change into a different kind of energy)*.

Energy can *transfer (go from one object to another)*.

- ➔ ***energy:*** *the power or strength to do things or make something work*
- ➔ ***speed:*** *how fast something is moving*

ACTIVITY 2: THE SCIENCE OF CAR CRASHES

Directions: Listen and follow along as your teacher reads the text. Work individually or with a partner to answer the questions. Then, debrief as a class.

How Does Mass Affect Energy in a Car Crash?

In the video, you saw what happened when a large car and a small car *crashed into (hit)* each other. The small car was pushed back more. The small car also *had more damage (was more broken)*.

But, *why* did this happen?

Objects with more **mass** have more **energy**. The larger car has more mass than the smaller car. So the larger car also has more **potential energy** than the smaller car. When the cars start to move, the potential energy changes into **kinetic energy**.

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1. Objects with more mass have...

☐ less energy ☐ more energy ☐ no energy

2. <u>BEFORE</u> a car starts moving, what kind of energy does it have?

☐ potential energy ☐ kinetic energy ☐ no energy

3. <u>AFTER</u> a car starts moving, what kind of energy does it have?

☐ potential energy ☐ kinetic energy ☐ no energy

→ ***mass:*** *how much matter (stuff) is in something*

→ ***energy:*** *the power or strength to do things or make something work*

→ ***potential energy:*** *energy something has because of where it is located or how it is shaped*

→ ***kinetic energy:*** *energy something has because it is moving*

What Happens to Energy in a Crash?

- Some **energy** ***<u>transfers</u>*** *(moves)* from one car to the other car.
    - Some of the **kinetic energy** from the large car pushed the small car backwards. Some of the **kinetic energy** from the large car also bent or crushed the metal that makes up the small car.
- Some **energy** ***<u>converts or transforms</u>*** *(changes)* into a different form of **energy**.
    - Some **kinetic energy** turns into sound **energy**. For example, when a car hits something it makes a loud noise.

REMINDERS:

Energy cannot be created or destroyed.

Energy can *transform (convert or change into a different kind of energy)*.

Energy can *transfer (move from one object to another)*.

KEY IDEAS: Objects with more mass have more energy. In a *collision (crash)*, kinetic energy *transfers (moves)* between the objects and *transforms (changes)* into different forms of energy.

4. ***What are two ways that kinetic energy is <u>transferred</u> (moved from one thing to another) in a car crash?***

Kinetic energy is transferred when...

5. ***What is one way that kinetic energy is <u>transformed or converted</u> (changed to another kind of energy) in a car crash?***

Kinetic energy is transformed into _____ energy when...

Use the cars below to answer questions 6–8.

Toyota Rav4

3,380 lbs.

Tesla Model Y

4,154 lbs.

Honda Civic

2,875 lbs.

6. ***Look at the cars above. Which car has the <u>most</u> potential energy? Why?***

The _____ [Toyota/Tesla/Honda] has the <u>most</u> potential energy because...

7. ***Look at the cars above. Which car has the <u>least</u> (smallest amount of) potential energy? Why?***

The _____ [Toyota/Tesla/Honda] has the <u>least</u> potential energy because...

*This question asks what **you** think. There is no right or wrong answer.*

8. ***Are you surprised about which car has the most potential energy? Explain your thinking.***

I _____ [am/am not] surprised about which car has the most potential energy because...

→ ***potential energy:*** *energy something has because of where it is located or how it is shaped*

→ ***mass:*** *how much matter (stuff) is in something*

→ ***energy:*** *the power or strength to do things or make something work*

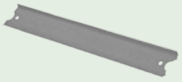
ACTIVITY 3: CRASH SCIENCE PRE-LAB

PART 1 - Directions: Listen as your teacher reads the text that introduces the lab, reviews the materials you will need, and tells you important safety rules.

During this lab, you will investigate how **mass** changes the amount of **energy** in an object. You will roll a car down a *ramp (hill)*. The car will crash into a bottle cap at the bottom of the *ramp (hill)*. You will measure how far the bottle cap moves. Then, you will add **mass** to the car to make it heavier. You will repeat the experiment with the heavier car to see what happens. In this **system**, the moving car **transfers energy** to the bottle cap, causing it to move.

- → ***mass:*** *how much matter (stuff) is in something*
- → ***energy:*** *the power or strength to do things or make something work*
- → ***system:*** *a group of parts or things that work together*
- → ***transfer:*** *to move something from one place to another*

MATERIALS:

- ☐ meter stick 
- ☐ toy car 
- ☐ pennies 
- ☐ car ramp 
- ☐ large book 
- ☐ bottle cap 
- ☐ scale 

SAFETY RULES:

- No throwing or dropping cars – only roll cars down the ramp.
- Pick up any cars that roll away to make sure other people do not trip.

PART 2 - Directions: Work with your partner to set up your lab station and complete the "Practice" tasks. Your teacher will walk around the room as you work and answer your questions. After practicing, answer the questions. Then, debrief as a class.

SET UP YOUR LAB STATION:

Step 1:

Build your ramp. Place one end of the car ramp inside a book.

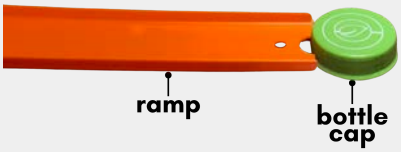
The other end of the ramp should be on your desk or the floor.

The top of the ramp (inside the book) should be about 1 in. above your desk/floor.

Step 2:

Place the bottle cap on your desk or the floor in front of the ramp.

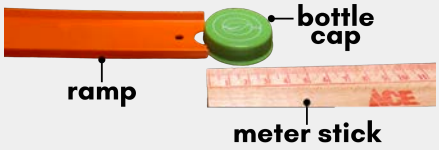
The bottle cap should just touch the end of the ramp.



Step 3:

Place the meter stick flat on the floor or your desk next to the bottle cap.

The 1 cm end of the meter stick should be next to the bottle cap.

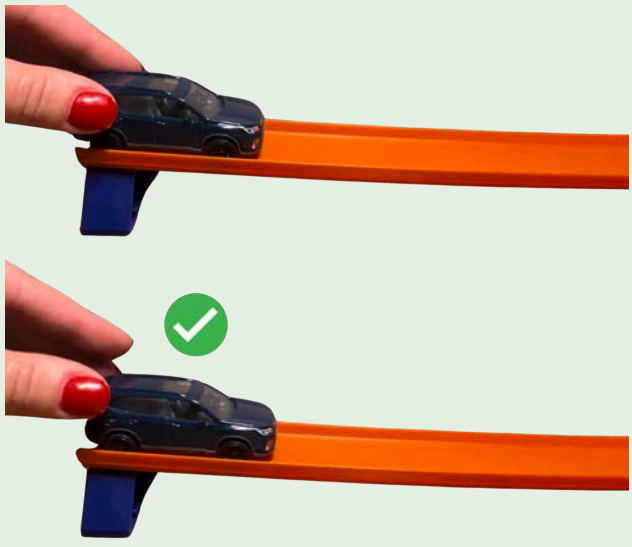


PRACTICE:

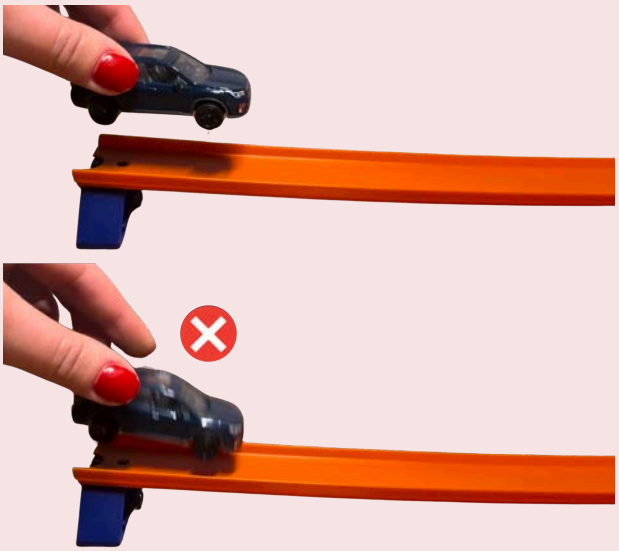
Rolling Cars

In this lab, you will place the car on the ramp and let go. Give the car **potential energy** by placing it on the ramp. When you let go, the **potential energy** will turn into **kinetic energy** as the car rolls down the hill. Practice rolling cars down the ramp. Take turns with your partner.

Place the car on the ramp.
Then, let go of the car without pushing it.



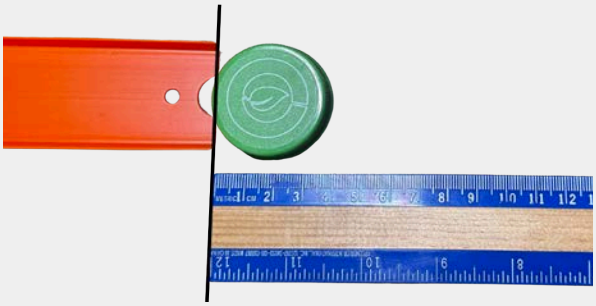
Do not *drop the car onto the ramp or push the car.*



PRACTICE:

Measuring Distance

In this lab, you will measure how far the bottle cap moves. Roll the car down the ramp. The car will hit the bottle cap and push it. Practice measuring how far the bottle cap moves. Take turns with your partner.



- *Put the bottle cap in front of the ramp.*
- *Place the meter stick next to the bottle cap.*
- *Make sure the edge of the meter stick is lined up with (matches with) the edge of the bottle cap that is closest to the ramp.*
  - *The bottle cap is at 0 cm on the meter stick.*

- *Roll the car down the hill. Let the car hit the bottle cap.*
- *Wait for the bottle cap to stop moving.*
- *Look at the edge of the bottle cap that is closest to the ramp.*
- *See which number on the meter stick lines up (matches with) that edge of the bottle cap now.*
  - *In the picture above, the edge of the bottle cap lines up with 14.5 cm. This means the bottle cap moved 14.5 cm.*

1. What kind of potential energy does the car have when you hold the car at the top of the ramp (hill)?

☐ gravitational potential energy ☐ elastic potential energy ☐ chemical potential energy

2. What kind of kinetic energy do you notice after you release (let go) of the car?

➔ *The types of kinetic energy are: motion, sound, light, and thermal (heat).*

I notice...

3. What happened to the kinetic energy in the car when the car hit the bottle cap?

The kinetic energy in the car went...

PART 3 - Directions: Listen and follow along as your teacher *explains (tells)* and *demonstrates (shows)* how to collect data during the lab using the data table.

REVIEW HOW TO COLLECT DATA DURING THE LAB:

Each time you roll the car down the ramp and it hits the bottle cap, you will measure how far the bottle cap moves. You will *record (write)* the *distance the bottle cap travels (how far the bottle cap moves)* in a data table on your lab handout. Listen as your teacher reviews how to use the data table using the example below.

- **Column 1** is where you will write the mass of the car. Use your scale to find the mass of the car in grams.
    - **Example:** The mass of my car is 28 g.
- Roll the car down the hill and write in column 2 (under trial 1) how far the bottle cap moved**. Trial 1 is the first time you rolled the car down the ramp.**
    - **Example:** The first time I rolled the car, the bottle cap moved 27 cm.
- Roll the car down the hill again and write how far the bottle cap moved in **column 3**.
    - **Example:** The second time I rolled the car, the bottle cap moved 30 cm.
- Roll the car down the hill again and write how far the bottle cap moved in **column 4**.
    - **Example:** The third time I rolled the car, the bottle cap moved 30 cm.
- Then, find the average of the three distances. *Distance means how far the bottle cap moved.* Write the average distance in **column 5**.
    - **Example:** The average that the bottle cap moved is 29 cm.

      27 + 30 + 30 = **87** 87 ÷ 3 = **29**

DATA TABLE

	column 1	column 2	column 3	column 4	column 5
	Car Mass	*Distance the Bottle Cap Traveled*			*Average Distance*
		Trial 1	*Trial 2*	*Trial 3*	
row 1	28 g	27 cm	30 cm	30 cm	29 cm
row 2					
row 3					
row 4					

Weigh the car and write the mass here.

Roll the car down the ramp. Write the distance the bottle cap moved here.

Roll the car down the ramp again. Write the distance the bottle cap moved here.

Roll the car down the ramp again. Write the distance the bottle cap moved here.

Find the average distance. Add the three distances together. Then divide that number by 3.

NOTE: In a science experiment, a trial is an attempt or try. In this experiment, the first trial is the first time you shot the rubber band into the cup.

ACTIVITY 4: CRASH SCIENCE LAB

Directions: Work with your partner to complete the steps in the procedure. When you finish the procedure, answer the questions on the bottom of your lab handout. Then, debrief as a class.

PROCEDURE

Step 1 Make sure your lab station is set up correctly. See the SET UP YOUR LAB STATION box on page 6.

Step 2 Use the scale to weigh your car in grams.

Record (write) **this number in Row 1, Column 1 of the Data Table on your Lab Handout.**

Step 3 Place the car at the top of the ramp. Let go of the car and let it roll down the ramp.

- ***NOTE:*** *Do not drop the car onto the ramp or push the car down the ramp.*

When the bottle cap stops moving, measure how far it moved.

- ***REMINDER:*** *To measure, look at the side of the bottle cap closest to the ramp. Match that side of the bottle cap to a number on the meter stick.*

Write the *distance* *(how far the bottle cap moved)* in Row 1, Column 2 of the Data Table on your Lab Handout.

Step 4 Put the bottle cap back to the starting **position** (just touching the end of the ramp).

→ ***position:*** *the place where something is*

Place the car at the top of the ramp. Let go of the car and let it roll down the ramp.

Measure how far the bottle cap moved.

- **Write the distance in Row 1, Column 3 of the Data Table on your Lab Handout.**

Step 5 Put the bottle cap back to the starting **position** (just touching the end of the ramp).

Place the car at the top of the ramp. Let go of the car and let it roll down the ramp.

Measure how far the bottle cap moved.

- **Write the distance in Row 1, Column 4 of the Data Table on your Lab Handout.**

Step 6 Calculate the average distance the bottle cap moved.

- Add the three distances together. Then, divide that number by 3.
- **Write the average distance in Row 1, Column 5 of the Data Table on your Lab Handout.**

Step 7 Add mass to your car by sticking a coin to the top of your car.
Use the scale to weigh your car in grams.

- *Record (write)* this number in **Row 2, Column 1** of the Data Table on your Lab Handout.

Step 8 Repeat steps 3-6.

- Roll the car down the ramp **three** times. Measure how far the bottle cap moves each time.
- *Record (write)* your data in **Row 2** of the Data Table on your Lab Handout.

Step 9 Add more mass to your car. Stick another coin to the top of your car.

Use the scale to weigh your car in grams.

- *Record (write)* this number in **Row 3, Column 1** of the Data Table on your Lab Handout.

Step 10 Repeat steps 3-6.

- Roll the car down the ramp **three** times. Measure how far the bottle cap moves each time.
- *Record (write)* your data in **Row 3** of the Data Table on your Lab Handout.

Step 11 Add more mass to your car. Stick another coin to the top of your car.

Use the scale to weigh your car in grams.

- *Record (write)* this number in **Row 4, Column 1** of the Data Table on your Lab Handout.

Step 12 Repeat steps 3-6.

- Roll the car down the ramp **three** times. Measure how far the bottle cap moves each time.
- *Record (write)* your data in **Row 4** of the Data Table on your Lab Handout.

When you are finished with the procedure, answer the questions on the bottom of your Lab Handout.

ACTIVITY 5: GRAPH YOUR DATA

Directions: Listen and follow along as your teacher explains the activity, reviews the line graph template, and reviews the model line graph. Work with your partner to create a line graph on your Lab Handout. Answer the questions in writing. Then, debrief as a class.

Create a line graph for your *data* *(information)* on page 2 of your lab handout.

Use the information in your data table to make your line graph.

- Place one *point* *(dot)* for each car mass you tested.
- The point will show the average distance the bottle cap moved.

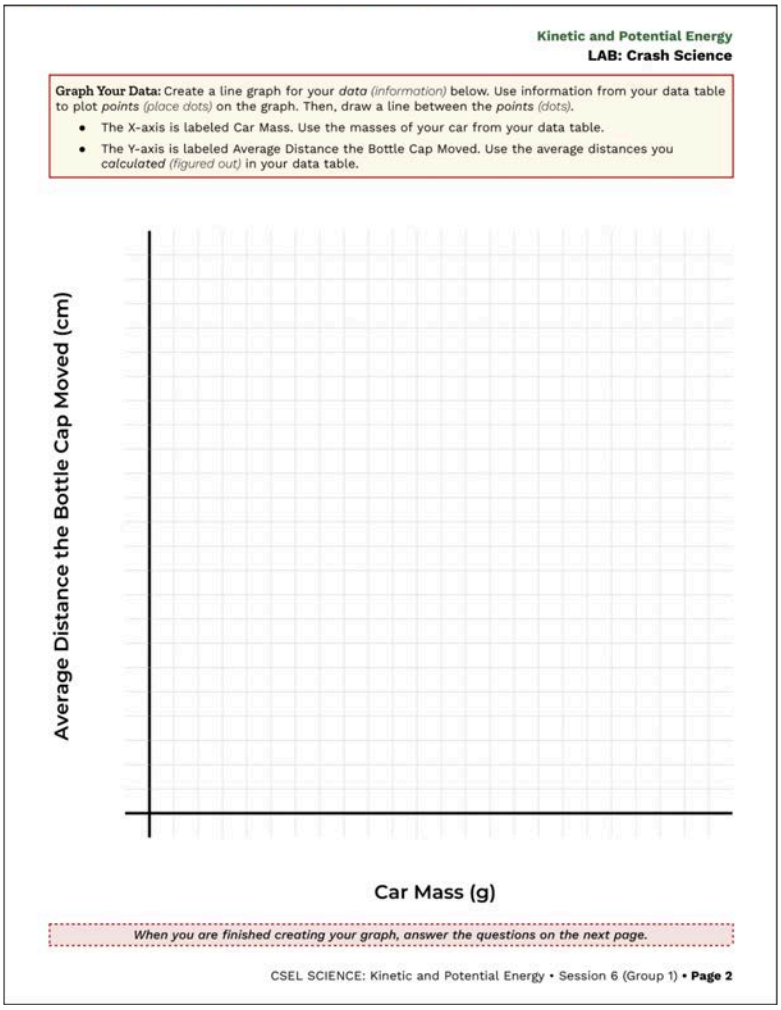
The X-axis is labeled Car Mass.

- Use the masses of your car from your data table.

The Y-axis is labeled Average Distance the Bottle Cap Moved.

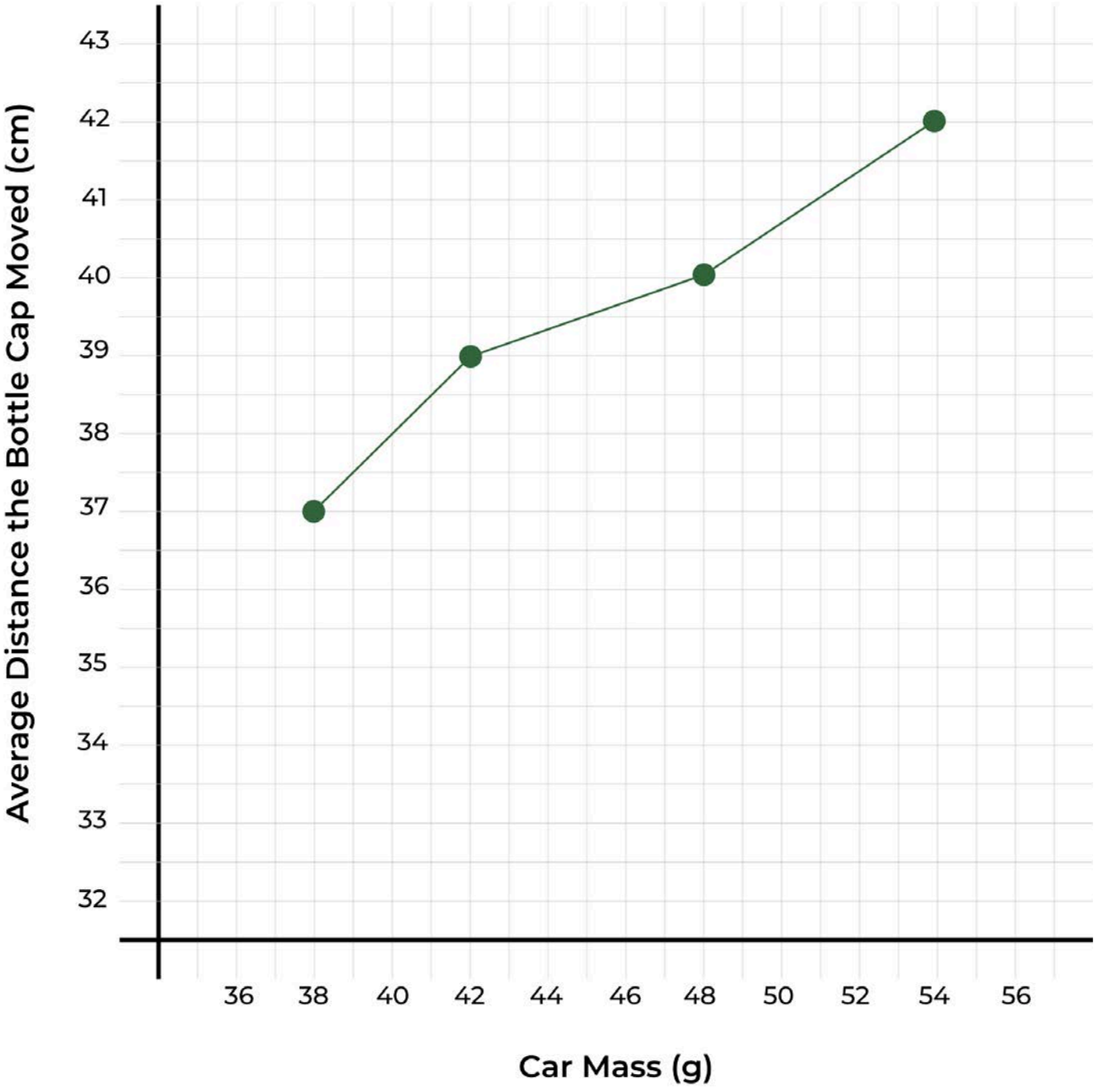
- Use the average distances you *calculated* *(figured out)* in your data table.

THE GRAPH TEMPLATE IS ON PAGE 2 OF YOUR LAB HANDOUT!



There is a model line graph on the next page!

Model Line Graph



ACTIVITY 6: CONNECT TO THE ROLLER COASTER PROBLEM

Directions: Work with your partner to discuss and answer the questions. Then, debrief as a class.

*Use the word bank to answer the **first** question. Each word will be used one time.*

Word Bank:

energy transferred adding kinetic farther mass

1. ***What did you learn about the relationship** (connection) **between mass and energy from doing this lab?***

I learned that objects with more _____ have more _____. During the lab, I saw that _____ mass to the car caused the car to push the bottle cap _____. The car's _____ energy _____ to the bottle cap and made the bottle cap move.

Think about the science scene from the beginning of the unit and answer the question below. In the science scene, the roller coaster car did not have enough energy to go around the loops and finish the ride.

2. ***Do you think adding mass to the roller coaster car would help the car get through the loops and finish the ride? Explain your thinking using evidence from the car crash lab.***

I think adding mass to the roller coaster car _____ [would/would not] help because...