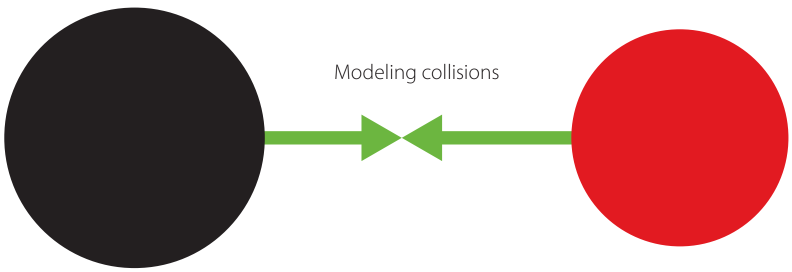
Unit 1

Contact Forces:

Why do things sometimes get damaged when they hit each other?

Student Work Pages



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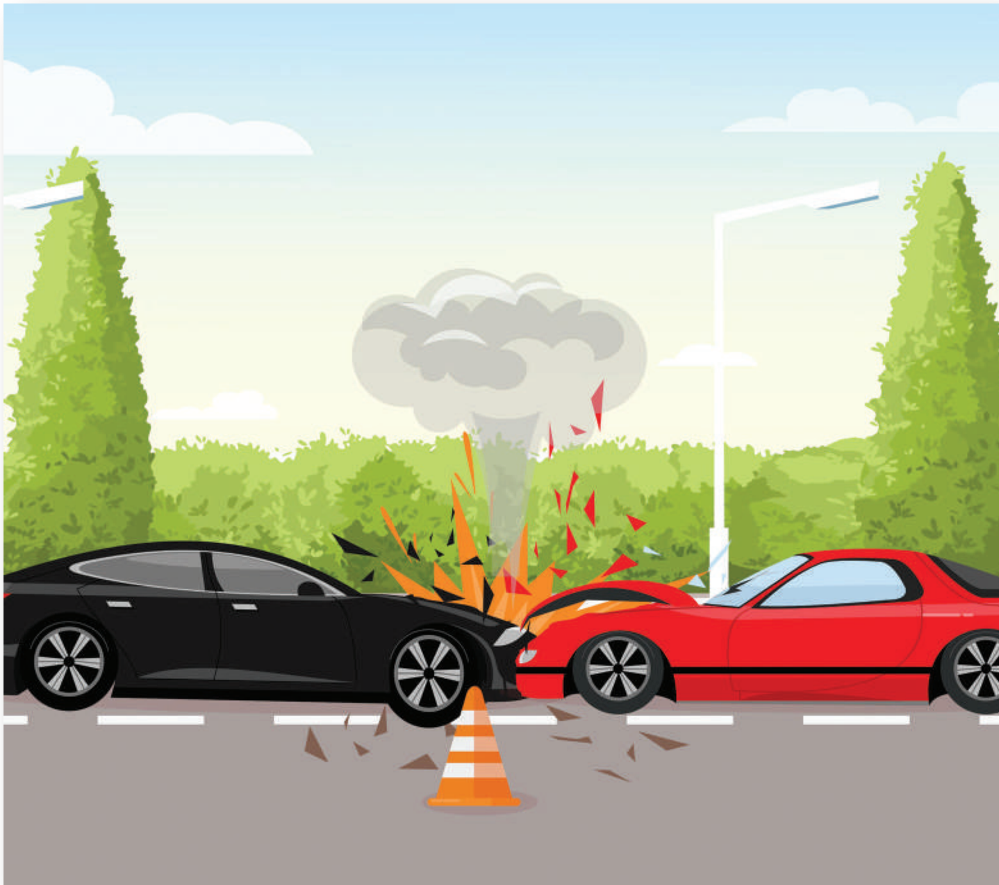

Contact Forces:

Why do things sometimes get damaged when they hit each other?

Student Work Pages

Core Knowledge Science

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Contact Forces:

Why do things sometimes get damaged when they hit each other?

Table of Contents

Science Literacy Exercise Pages

Initial Model: Objects During Collisions

What two objects collided? ____________________________ and _______________________

Is this a scenario from A, B, or C? _______ Was there damage in this collision? _______

Imagine you had special glasses that could stop time and let you watch both objects. Describe what you think you would see happening at these two points in time:

Time point 1: What would you see the materials they were made of doing if you could stop time the moment they first touch?	**Time point 2: What would you see the materials they were made of doing if you could stop time a split second later?**

Name: ____________________ Date: ____________________

Object Interactions During a Collision

Changes we could see: Now think about what you would see happening in between time point 1 and time point 2. Would you see any changes happening in each of the objects? How does that help explain why the object was damaged or not damaged?

Interactions we cannot see: Now think about the interactions between time point 1 and time point 2 that you cannot see happening. What interactions would be happening? How does that help explain why the object was damaged or not damaged?

- If you picked a collision with no damage, how would the interactions between the same objects have to change to cause damage in a collision?
- If you picked a collision that caused damage, how would the interactions between the same objects have to change to not cause damage in a collision?

Name: ______________________ Date: ______________

Exploring Horizontal Collisions

Our investigation question: ____

____

The two colliding objects	Object 1 (part of cart subsystem 1)		Object 2 (part of cart subsystem 2)	
	Was there a change in motion? (yes / no) If yes, did its direction, speed, or both change?	Did the shape of the object change? (yes / no) If yes, when did you see it happening? (during the collision, after the collision, or both)	Was there a change in motion? (yes / no) If yes, did its direction, speed, or both change?	Did the shape of the object change? (yes / no) If yes, when did you see it happening? (during the collision, after the collision, or both)

Claim and Observations Organizer

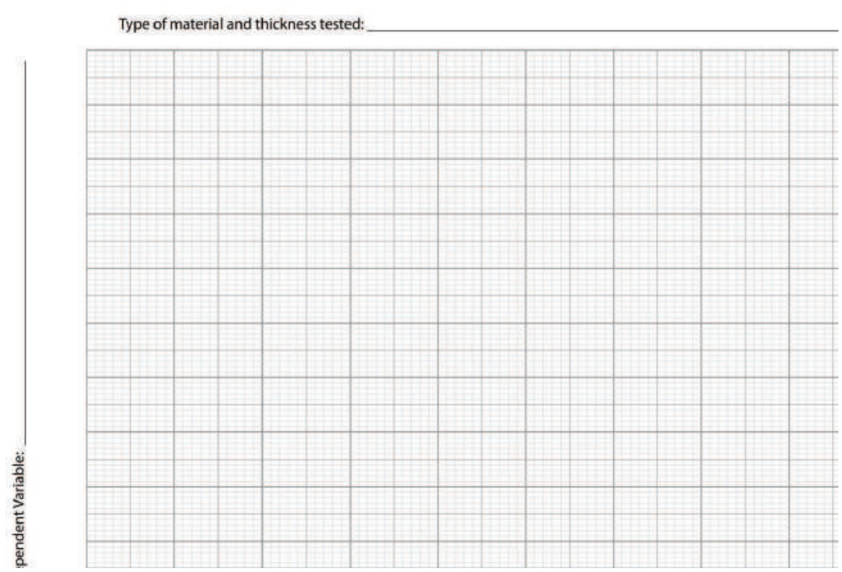
My initial claim		
All solid objects ________________ bend or change shape when pushed in a collision.		
Data source	**Observations**	**Does this support or refute your claim?**
Slow-moving car colliding with a stationary car		
Moving golf club colliding with a stationary golf ball		
Moving baseball colliding with a stationary bat		

Deformation Results

What object are you testing?: ______________________________

A. Downward force applied to the object (N)	B. Height before the force is applied (cm)	C. Height when the force is applied (cm)	D. Calculate the amount of deformation (cm)	E. Did the object return to its original shape when this force was removed? (yes or no)
O		N/A	O	N/A
Plot the data points using this key:				

○ Anywhere the beam returned to its original shape after the weight was removed, use this symbol.	● Anywhere the beam was damaged from the weight that was added, use this symbol.	× If your beam cracked at any point, use this symbol for that point.



Independent, Dependent, and Controlled Variables

The question we want to answer

To change, measure, or stay constant?

A variable is a factor you want to change or control in an investigation. There are three types of variables you should think about for your investigation:

- **Independent variable** - this is the variable to change each time you test.
- **Dependent variable** - this is the variable to observe the effects caused by a change in the independent variable.
- **Controlled variables** - these are variables to keep constant in each test.

Discuss the variables with your **class** and write down your variables in your investigation.

Independent variable:

Dependent variable:

Controlled variables:

Name: ______________________ Date: ______________________

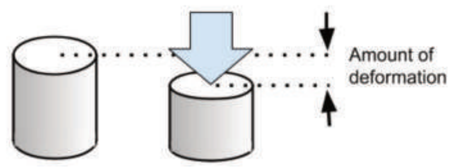
Results from Other Materials Tests

When engineers design a new structure or device they have to decide what materials to make it out of. Testing how different materials respond to different amounts of force applied to them provides useful information for helping make these decisions. A compression testing machine can be used to collect this type of data. An example of such a machine being used to test a cylinder shaped sample is shown in the image to the right.

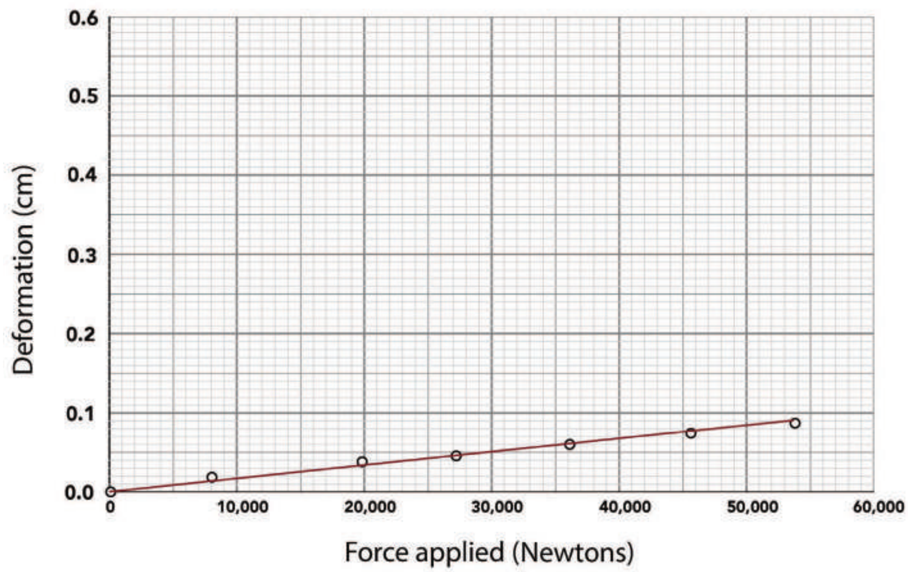
Students at a university used a similar machine to see how much two different types of metals deformed when different amounts of force were applied to them. The metals they tested were steel and aluminum. The samples they used in their tests were similar-sized cylinders.

The students calculated the deformation of each sample when it was compressed. For each test, they noted whether the sample returned to its original shape after they removed the compression forces on it.

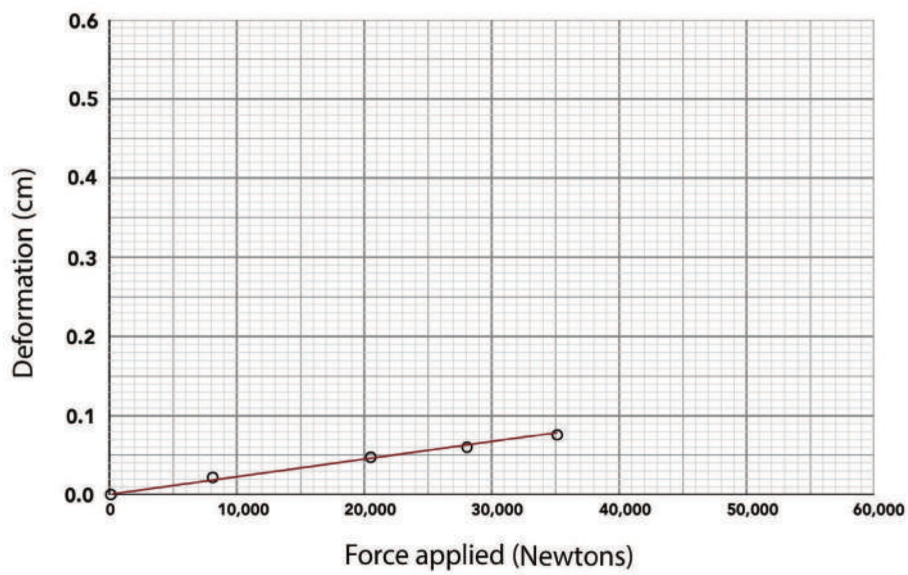
They incrementally increased the applied force to the samples with each test. At first they found that each sample that they tested returned to its original shape after the force was removed. The results from those tests are graphed on the next page.



Steel



Aluminum

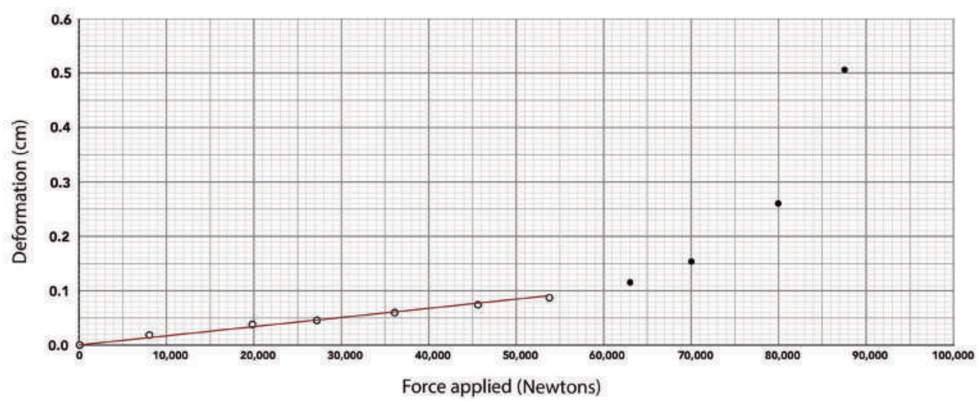


They also found that each sample eventually reached an *elastic limit*. This is the largest amount the sample could be deformed and still return to its original shape after the force on it was removed. The last point on each graph is close to the elastic limit for that sample. Based on these graphs, which material appears to have a higher elastic limit, aluminum or steel?

The samples were tested again, this time with even more force applied to them. Now each time the samples were removed from the machine they remained permanently deformed.

○ Anywhere the sample returned to its original shape after the force was removed	● Anywhere the sample was permanently deformed after the force was removed

Steel



If you compare these results to those reported by engineers for other materials, you will find that they all produce similarly shaped graphs. For example, the straight line relationship that appears on the first part of the graph exists for every solid material. But the steepness of that line varies from one material to another. That steepness can be described mathematically by the *slope* of that line. The slope of that line tells us about the relationship between force and deformation before the material reaches its elastic limit. The table below shows how this slope compares for some different materials.

Material	Deformation in inches per 1,000 pounds of force applied to the sample*
rubber	~ 0.1
plywood	~ 0.0009
concrete	~ 0.0004
diamond	~ 0.000006
*All values reported are calculated for cube-shaped samples, one cubic inch in volume.	

How do the results from your lab and the data in these graphs and tables help answer this question: ***How much do you have to push on any object to get it to deform (temporarily or permanently)?*** Add this question to your individual Progress Tracker and summarize what you figured out.

Data for graphs adapted from: Khylystov, N., Lizardo, D., Matsushita, K, & Zheng, J. (2013). *Uniaxial tension and compression testing of materials*. Retrieved from: http://web.mit.edu/dlizardo/www/UniaxialTestingLabReportV6.pdf

Name: ______________________ Date: ______________

Comparing Forces on Two Push-Pull Spring Scales

Testing Pushes

Condition	Possible outcome	Prediction	Observation
Spring scale A is pushed and B is held in place.	More force on A than on B	☐	☐
	Less force on A than on B	☐	☐
	Same amount of force on A and B	☐	☐
Spring scale A is held in place and B is pushed.	More force on A than on B	☐	☐
	Less force on A than on B	☐	☐
	Same amount of force on A and B	☐	☐
Both spring scales A and B are pushed.	More force on A than on B	☐	☐
	Less force on A than on B	☐	☐
	Same amount of force on A and B	☐	☐

Testing Pulls

Condition	Possible outcome	Prediction	Observation
Spring scale A is pulled and B is held in place.	More force on A than on B	☐	☐
	Less force on A than on B	☐	☐
	Same amount of force on A and B	☐	☐
Spring scale A is held in place and B is pulled.	More force on A than on B	☐	☐
	Less force on A than on B	☐	☐
	Same amount of force on A and B	☐	☐
Both spring scales A and B are pulled.	More force on A than on B	☐	☐
	Less force on A than on B	☐	☐
	Same amount of force on A and B	☐	☐

Lesson 5: Independent, Dependent, and Controlled Variables

The question we want to answer

To change, measure, or stay constant?

A variable is a factor you want to change or control in an investigation. There are three types of variables you should think about for your investigation:

- **Independent variable** - this is the variable to change each time you test.
- **Dependent variable** - this is the variable to observe the effects caused by a change in the independent variable.
- **Controlled variables** - these are variables to keep constant in each test.

Discuss the variables with your **class** and write down your variables in your investigation.

Independent variable:

Dependent variable:

Controlled variables:

Name: ______________________ Date: ______________

Reviewing Our Driving Question Board

Instructions: Look back at the Driving Question Board with a partner. Pick at least **three** questions you think we have **made progress on**. List them below.

Questions we have made progress on
1.
2.
3.

Pick **one** other question that you think you **can now answer**. Write the question below.

Question we can now answer

If someone asked you the question you starred above, what answer would you give? Write or draw out your current answer below, using evidence from our past investigations to support your answer:

____

____

____

Name: ______________________ Date: ______________________

Changes in Kinetic Energy: Investigations 1 & 2

Our question: *How much does doubling the speed or doubling the mass affect the kinetic energy of an object and the resulting damage that it can do in a collision?*

Investigation 1: Damage Comparisons

	Condition A	Condition B	Condition C
mass	original:	double:	original:
length of the track (cm)			
time to reach the end of the track (seconds)	original:	original:	half:
average cart speed (cm/sec)	original:	original:	double:

Investigation 2: Quantifying the Amount of Kinetic Energy for a Moving Object

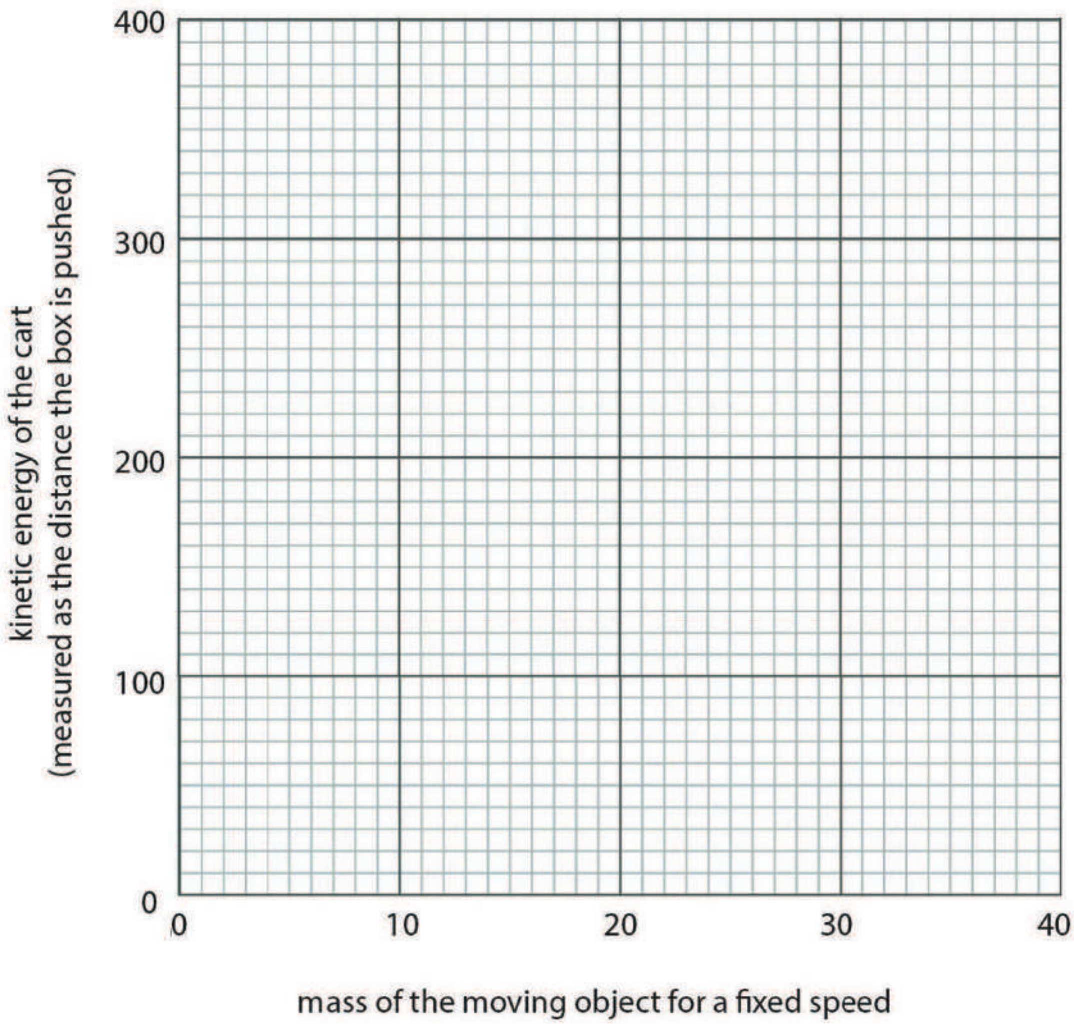
	The same spring-scale launcher position (force in N) were used for these conditions as were used in investigation 1		
	Condition A	Condition B	Condition C
mass (g)	original:	double:	original:
average cart speed (cm/sec)	original:	original:	double:
distance the box was pushed before coming to a stop (cm)			

Name: ______________________________ Date: ______________________

Graphing Kinetic Energy Relationships

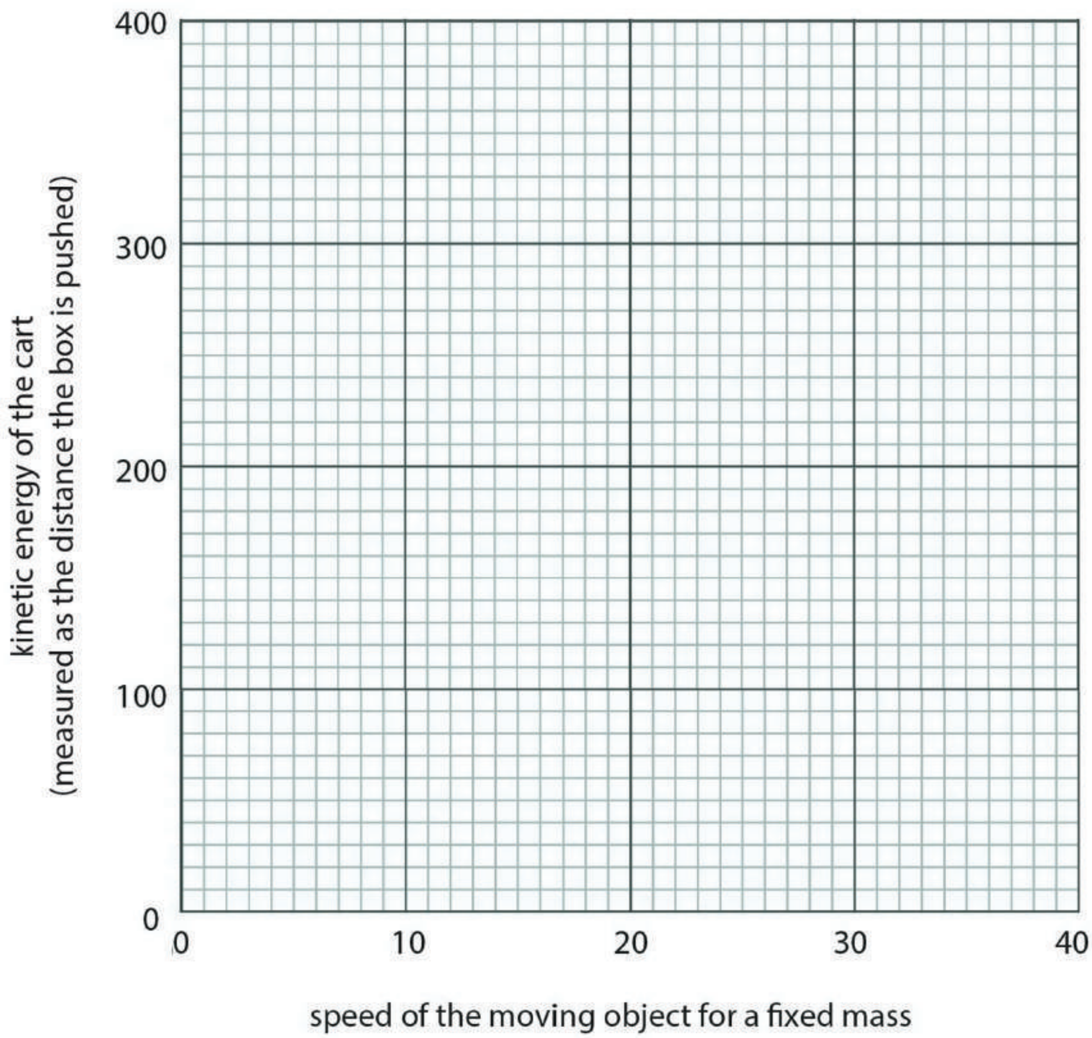
Name: ______________________ Date: ______________________

Alternate: Graphing Mass vs. Kinetic Energy



Name: ______________________ Date: ______________________

Alternate: Graphing Speed vs. Kinetic Energy



Name: ______________________ Date: ______________________

Looking Back: Explaining and Predicting Kinetic Energy Changes in the System

You carried out three different investigations to determine what affected the kinetic energy of an object more, changes in its mass or changes in its speed.

- Investigation 1: Measuring how much damage a spring-launched cart does to a cracker
- Investigation 2: Measuring how far a spring-launched cart pushes a box
- Investigation 3: Measuring how far a virtual cart pushes a virtual box in a simulation

Q1) Which investigation(s) produced results that helped you best understand the relationship between the amount of kinetic energy and the amount of damage it can do in a collision with a stationary object?

____

Q2) Which investigation(s) produced results that helped you best understand the relationship between how changes in mass and speed of a moving object affect the amount of kinetic energy it has?

____

Q3) How much would the kinetic energy of an object decrease if you reduced its mass in half but not its speed?

____

____

____

Q4) How much would the kinetic energy of an object decrease if you reduced its speed in half but not its mass?

____

____

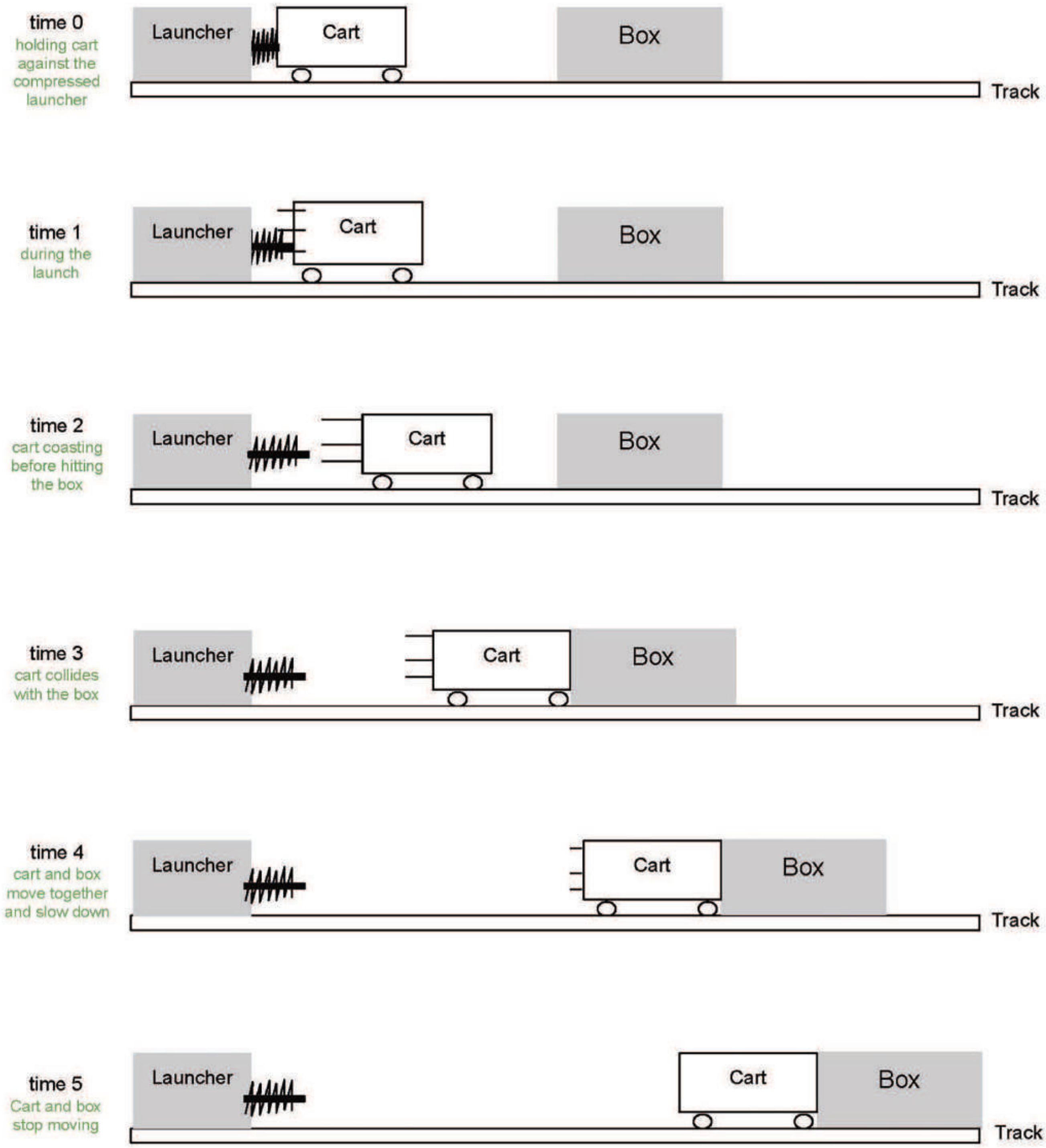
____

Q5) How do the mathematical relationships you figured out about the effects of mass and speed of an object on its kinetic energy help you make more-accurate predictions for whether a collision would produce damage in some cases and not others?

Name: _______________________ Date: _______________

Energy Transfers and Contact Forces in the Launcher, Cart, Track, and Box System

Energy transfers and contact forces in the launcher, cart, box, and track system



Name: ______________________ Date: ______________

Investigating Interactions with the Air

You saw that when the spring-launched cart made contact with the box it pushed the box forward. Changing the mass or speed of the cart affected how far the box was pushed. Even though the cart was applying a force to the box when it was in contact with it, the box and cart always eventually came to a stop.

Do you think changing the shape of the box or cart would affect how far they traveled before coming to a stop? Why?

Engineers often try to design the shape of vehicles like cars, trucks, trains, and planes so that they don't require a lot of fuel to stay in motion. Such vehicles tend to coast once they are moving, even without the engine running. Why would the shape of the vehicle affect how quickly these vehicles slow down?

Use the materials your teacher sent home with you to investigate the interactions that occur between a moving object and the air it moves through. You have four index cards you will use in your investigation. Before carrying out the procedure, consider this question: *If you weighed each of the index cards separately, would you expect their mass to be the same or different?*

Now carry out the investigation by following this procedure:

- Brainstorm some ways you could fold, roll, or shape an index card to make it fall **more** quickly when you drop it from a specific height.
- Brainstorm some ways you could fold, roll, or shape an index card to make it fall **less** quickly when you drop it from a specific height.
- Take 4 index cards of the same size and mass, and label the corner of each one (A, B, C, and D).
- Fold them, roll them, and/or shape them into 4 different designs. *Note: You can use scissors to cut them too, but do not completely cut off any part of the index card. You want to keep the mass of each index card the same*.
- Include a sketch of each design on the next page.
- Drop 2 of them together from the same height and record your results.
- Repeat this for all the different combinations (A and B, B and C, C and D, A and C, A and D, B and D) to determine which design moved fastest and which moved the slowest through the air.

Observations and Results

If each index card weighs the same, this means that gravity is pulling each card down with the same amount of force as it falls. Why, then, do some card designs fall slower when released from the same height?

The cart and box also moved through the air as they traveled down the track. How do your results from your index card investigation help support the argument that there is also a contact force between the cart or box and the air as they travel down the track?

How would the contact force(s) from these collisions affect the kinetic energy of the cart or the box over time?

Name: ______________________ Date: ______________________

Investigating Surface Interactions

You saw that when the spring-launched cart made contact with the box it pushed the box forward. Changing the mass or the speed of the cart affected how far the box was pushed. Even though the cart was applying a force to the box when it was in contact with it, the box and cart always eventually came to a stop.

What are some everyday phenomena where objects seem to stop on their own after being put into motion?

____

____

What causes all these moving objects to eventually come to a stop?

____

____

Just like an object coming to a stop, it can also be harder to get different objects on different surfaces to start moving. As we have found with objects of different masses when we apply a force, it can take more force to get some objects moving. There seems to be something about the object interacting with the surface that is causing this to happen.

Use the materials your teacher sent home with you to carry out an investigation to figure out why some objects start and stop moving on some surfaces easier than others. You will use the rubber band to measure the amount of force it takes to pull a shoe across a surface. If the rubber band has to stretch more, then more force is being applied. If the rubber band stretches less, then less force is being applied. Use a ruler (or fold up the last page of this handout to use the paper ruler provided on it) to measure how far you have to pull the rubber band in the investigations you will carry out on the next page.

Investigation Procedure

Get a ruler or use the one on the last page of this handout.

Pick any shoe in your house that has shoe laces or a loop. Take the rubber band and create a knot called a cow hitch knot by looping the rubber band around the shoe string and putting one end of the rubber band through the rubber band loop. You have now attached a rubber band force detector to your shoe.

Pick any surface in or around your house. The surface could be carpet, wood, tile, grass, concrete, or some other surface. It is your choice. Place your shoe with the rubber band tied to it on the surface.

Hook one finger of one hand under the end of the rubber band. Start to pull gently on the rubber band. Hold a ruler a little to the side of the rubber band with your other hand so you can measure how far you stretch the rubber band before the shoe will move.

Record in the table below the distance the rubber band stretched before the shoe moved.

Investigate four different surfaces. Keep track of how far the rubber band stretches for each surface.

Shoe and Surface Investigation Data Table

	Surface #1	Surface #2	Surface #3	Surface #4
Description of the surface tested				
How far the rubber band stretched before the shoe moved (cm)				

Making Sense of Your Results

You probably noticed that in some cases the rubber band stretched more than others, and some surfaces felt like they required more force to move the shoe across them. Look at those surfaces. What about those surfaces would cause the rubber band to stretch further or make the shoe harder to pull? What do you think is happening between the surface and the shoe that more force would be needed to move the shoe?

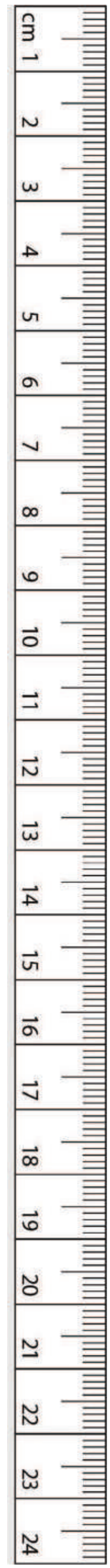
Do you think the type of shoe matters? Why or why not?

Imagine you took the shoe you tested and launched it from a spring launcher with an equal amount of kinetic energy but changed the surface it slid across each time. On which of the surfaces you tested would it slide the furthest distance before coming to a stop? Why?

On which of the surfaces you tested would it slide the least distance before coming to a stop?

The cart and box also made contact with a surface as they traveled down the track. How do your results from this investigation help support the argument that there are similar contact forces between the box and the track as it slides down the track?

How would this contact force affect the kinetic energy of the box over time?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Name: ______________________ Date: ______________________

Modeling Other Force Interactions in the Launcher, Cart, Box, and Track System

Q1) Draw and label two free body diagrams showing the contact forces between the box and the cart as they are moving together at time 4.

Q2) Besides the cart, what other objects or subsystems is the box either making contact with or colliding with at time 4?

Q3) Redraw in the space to the right your free body diagram for the box. Show all these additional forces on it as well as the contact force from the cart at time 4. Don't worry about representing the relative strength of these forces. Focus on showing which direction the forces would be pushing on the box and which surface they would be pushing on.

Q4) Do you think these kinds of forces are also acting on the cart as it coasts down the track at time 2? Why or why not?

Q5) Where does this tell you some of the energy in the system might be going as the box and cart move down the track?

Name: ______________________ Date: ______________________

Tracking Energy Transfers in Our Launcher System

What did your group do to the launcher so that it could eventually transfer energy to the cart?	
What did your group do differently to the launcher so that it could transfer more energy to the cart in conditions B or C compared to condition A?	
What part of the launcher subsystem directly transferred energy to the cart to get it moving?	
How did that part of the launcher subsystem transfer energy to the cart?	

Name: ______________________ Date: ______________

Data Collection from Stations

Station 1. Cart with sail interacting with air	
Description	**Observations / Insights**
Cart with a sail	
Cart without a sail	

Station 2. Analyze air resistance data	
Description	**Observations / Insights**
Cycling in a headwind: Percent energy loss	
Estimate of ship fuel consumption and wind speed	
Average miles per gallon by vehicle type	

Station 3. Analyze friction between differences in surface textures	
Description	**Observations / Insights**
Rough surface	
Smooth surface	

Station 4. Magnified images of different surface textures	
Description	**Observations / Insights**
Carpet	
Coarse sandpaper	
Medium sandpaper	
Fine sandpaper	
Carpet	
Tile	
Particle-level computer interactive	

Name: ______________________ Date: ________________

Jigsaw Feedback Discussion

Station 1. Cart with sail interacting with air	
Discussion question	**What ideas do you want to add to our model?**
How are forces on the cart different with and without the index card sail?	
How is the behavior of the index card evidence that there is a contact force on part of the cart subsystem?	
What are all the forces acting on the index card and how would you represent them?	

Station 2. Analyze air resistance data	
Discussion question	**What ideas do you want to add to our model?**
What insights do you have about forces based on the data for pitch speed versus wind speed?	
What relationship between forces and energy do you notice when examining the cycling and percent energy loss data?	
What does the overall trend in fuel consumption tell you about applied forces from wind on ships?	

Station 3. Analyze friction between differences in surface texture	
Discussion question	**What ideas do you want to add to our model?**
In which scenario are there stronger contact forces? • rougher surfaces • smoother surfaces How do you know?	
What is happening to the speed of particles on the surfaces of the objects as they are sliding past each other?	

Station 4. Magnified images of different surface textures	
Discussion question	**What ideas do you want to add to our model?**
Which way do surface structures bend when objects are sliding past each other?	
Based on what you know about equal and opposite forces, how would you describe the direction of friction forces on the moving object and on the surface it is in contact with?	

Big Ideas Table

Lesson	Big Ideas
9	**9.a** Friction and air resistance can affect a moving object's kinetic energy.
8	**8.a** Objects with different speeds and masses require different amounts of force to speed them up or slow them down. **8.b** Energy can be transferred into or out of an object when it comes in contact with another object due to the forces that act on each object. **8.c** It takes more force to speed up a more-massive object the same amount as a lower-mass object.
7	**7.a** The more kinetic energy an object has, the more damage that object can do in a collision. **7.b** Changes in the kinetic energy of a moving object are proportionally related to changes in the mass of that object. **7.c** Changes in the kinetic energy of a moving object are related to changes in the speed of that object.
5	**5.a** Forces are applied on both objects in equal strength and opposite directions during a collision. **5.b** Speed and mass increases lead to KE increases, which can lead to higher peak forces.
4	**4.a** All objects deform up to a point. **4.b** Once their elastic limit is reached they permanently deform. **4.c** Different materials, shapes, and thicknesses result in different elastic limits and breaking points for different objects.
3	**3.a** All objects bend or change shape in a collision.
2	**2.a** Collisions can cause shape and motion changes. **2.b** Energy transfers in a collision. **2.c** There are forces in a collision.

Name: ______________________ Date: ________________

Explaining a Collision

1. Look back at your Different Collisions poster. Decide amongst your group who will do each collision type. Circle **your** choice below.
   a. Collision type A - A moving object was damaged OR was not damaged when it collided with a motionless object.
   b. Collision type B - A motionless object was damaged OR was not damaged when a moving object collided with it.
   c. Collision type C - A moving object was damaged OR was not damaged when it collided with another moving object.

2. Look at the related phenomena next to the collision type you have chosen. What real-world example would you like to explain?

____

____

3. In the first two boxes below, use the real-world example you have picked to show what happens before and during a collision. In the last box, explain what factors would change the outcome of the collision (either by creating damage or limiting damage).

Show both objects before they collide. Make sure to indicate which objects are moving and give their relative amounts of force and KE. Indicate what factors affect the objects' ability to cause damage before they collide.	**Show what happens as the two objects come into contact with one another that would cause them to break or not to break. Give all factors you think are relevant and how they contribute to the outcome of the collision.**	**Consider the moment of collision again. If the objects were originally damaged, show what would have to change in the system to create less damage or no damage. If the objects were not damaged, show what would have to change to create damage.**

Name: ____________________ Date: ____________________

Drafting Our Protection Device Design

Draft a model of a protection device on your own.

<u>Your design drawing</u>: Draw and label the object you are protecting and the shape, structure, and type of material(s) of the device you would use to protect it.	**<u>Your zoomed-in view</u>: If you could stop time a split second after something collided with your object, what would you see the material(s) that make up your protection device doing? Show a zoomed-in view for this.**

Explain **<u>how</u>** your protective device reduces the peak forces on the object it is protecting in a collision. What is the device doing during the collision that enables it to perform this function?

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Name: ______________________ Date: ______________

Protection Device Design Thinking

Think about an object that you would like to better protect from damage. List the object you would like to protect here: ______________________

Define the purpose: What would be the overall goal of your protection device? What is the purpose of making this device?

____

____

____

Criteria: What does the device need to have to meet the goal? What does it need to do?

____

____

____

Constraints: List any limits to the design or things buyers would want or need in a protection device.

____

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Answer the questions below about your design:

a. What design and shape would you use and why? (examples: square, rounded corners, pointy)

____

____

____

b. What about the structure and materials of your design would make it function better than other materials you could have picked?

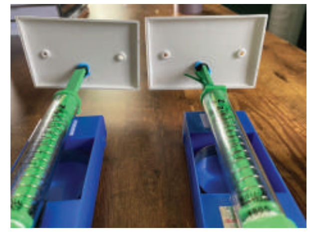
____

____

____

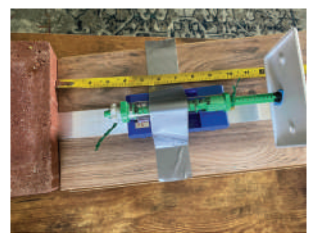
Cushioning Materials Testing Procedures

Establishing a Baseline Reading (Control)



1. Set up your ramp so that it matches your teacher's setup using the flooring, track, brick, and binders or books. Make sure that your ramp is at the same angle and height as your teacher's ramp.
2. Get the electrical plates and sticky tack. Place the sticky tack slightly below the middle of the electrical plates. Use sticky tack to put the electrical plates on the ends of the spring scale rods. Make sure the curved edges of the electrical plates (the backs) are facing towards the carts.
3. Using a scale, add clay to your carts until both carts weigh exactly 200 grams each.
4. Place your carts on the track. Bring the two carts together and make sure that the electrical plates are not touching the track as they move.
5. With the two carts together, adjust the electrical plates so that they are flat against each other with no big, visible gaps between them. Try to line up the edges and corners the best you can.

6. Place the cart with the twist tie collar near the bottom of the ramp with the electrical plate facing up the ramp. Tape the cart down about 4 inches from the bottom of the ramp.



7. Confirm that the force collar is on the spring scale on the cart at the bottom of the ramp. Make sure that it is secure but can still easily move when the plunger is pushed in. Adjust the force collar on the scale so that it is at the base of the rod.

8. We need to establish a baseline reading so we can compare the peak force of the control collision with the peak force of the collision using a potential protective material. To do this, place the second cart at the top of the ramp with the electrical plate facing down the ramp. Release this cart towards the nonmoving cart at the bottom of the ramp.

9. Observe where the twist tie collar comes to rest on the rod on the spring scale. Record the data in the chart found at the end of this instruction set. Remember, each little line represents 1/10 of a newton. Each larger line represents 0.5 newtons.

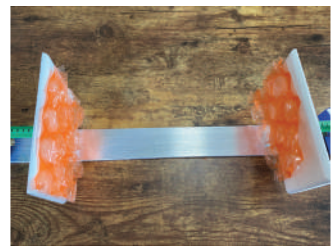
10. Run this test 5 more times using steps 7-9 to check the accuracy of the readings.
11. Find the average of the force collar readings at the bottom of the table.

Force Collar Readings *without* Potential Protective Material	
Trial	**Force collar reading (N)**
1	
2	
3	
4	
5	
6	
Average reading	

Testing a Protective Material (Experimental)

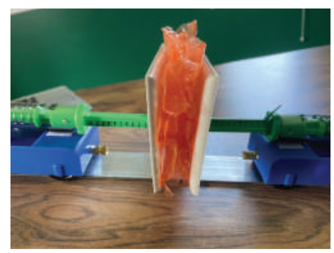
1. Place transparent tape circles on the back of the potential protective material you are testing.

2. Tape the material to the front of the electrical plates on each cart.



3. Using a scale and the clay, adjust the weight of the carts to 200 grams.

4. Make sure that the pieces of your material on the electrical plates on the two carts touch the best they can without any gaps when they are brought together.



5. Adjust the force collar on the spring scale of the nonmoving cart so that it is at the base of the rod.

6. Place the colliding cart at the top of the ramp with the material facing down the ramp. Release the cart towards the nonmoving cart at the bottom of the ramp.

7. Record where the twist tie collar comes to rest on the chart found at the end of this instruction set. Each little line represents 1/10 of a newton. Each larger line represents 0.5 newtons.

8. Run this test 5 more times using steps 5-7 to check the accuracy of the readings.

9. Find the average of the force collar readings at the bottom of the table.

Force Collar Readings *with* Potential Protective Material	
Trial	Force collar reading (N)
1	
2	
3	
4	
5	
6	
Average reading	

Finding the Average Reduction in Peak Force

To figure out how well the material worked to reduce peak forces, we have to subtract the average force reading of the materials test from the average force of the control test without the materials.

average of test *without* materials ________________N

(subtract) –

average of test *with* materials ________________N

____

average amount of peak force reduction ________________N

The average peak force reduction of our material ________________ is ______ newtons.

Name: ____________________ Date: ____________

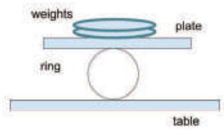
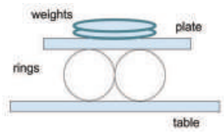
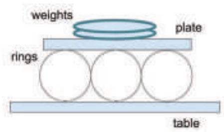
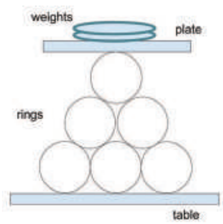
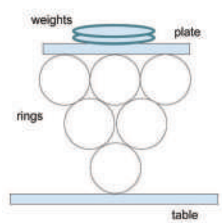
How can materials reduce peak force on the objects they protect?

Time point 1: Zoom in to the protective material before the collision. Identify the structure(s) and function(s) of the material that might help reduce peak forces before a collision occurs.	Time point 2: Zoom in and show what you think is happening to the structure(s) of the material as the collision occurs. Explain how the changes occuring in the material structure help it function as a protective device.

How are these changes helping to reduce the peak force?

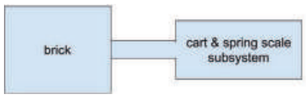
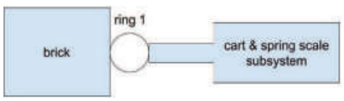
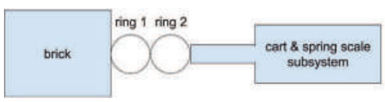
Name: ______________________ Date: ______________

Exploring Shape of a Cushioning Material

Condition	Diagram	Predictions	Observations
1 ring between between two objects		*N/A*	
2 rings side by side between two objects			
3 rings side by side between two objects			
A triangular stack of 6 rings, with the narrowest part of the triangle against the plate and the widest part of the triangle against the table			
A triangular stack of 6 rings, with the widest part of the triangle against the plate and the narrowest part of the triangle against the table			

Name: ______________________ Date: ______________________

Free Body Diagrams for Collisions with and without Cushioning Structures

Collision condition & system diagram	Free body diagrams
Nothing between the colliding objects 	
1 ring on either object 	
2 rings on either object 	

Name: ______________________ Date: ______________

Observations from Adding Additional Ring Structures

Collision condition	Peak force in collision	Other observations
A. Nothing added between the colliding objects		
B. Adding 1 ring to the stationary object		
C. Adding 1 ring to the moving object		
D. Adding 2 rings to the stationary object		
E. Adding 2 rings to the moving object		

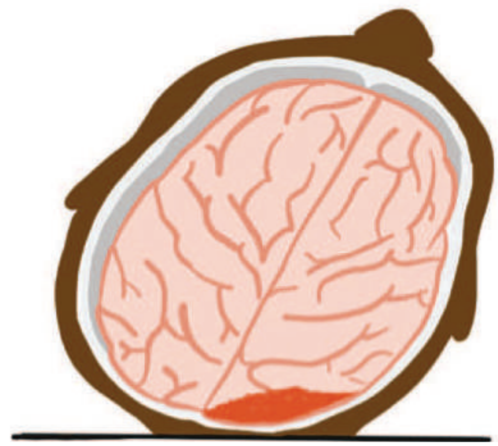
Observations from Adding Additional Ring Structures

Collision condition	Peak force in collision	Other observations
A. Nothing added between the colliding objects		
B. Adding 1 ring to the stationary object		
C. Adding 1 ring to the moving object		
D. Adding 2 rings to the stationary object		
E. Adding 2 rings to the moving object		

Name: ____________________ Date: ____________________

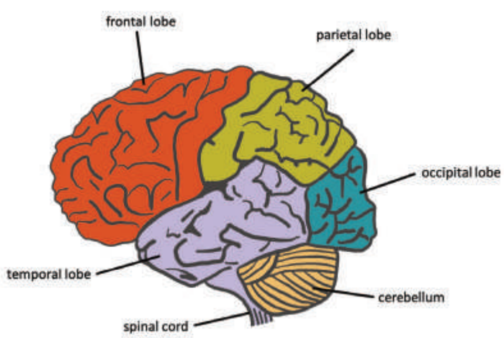
Reading: Anatomy of a Bike Helmet

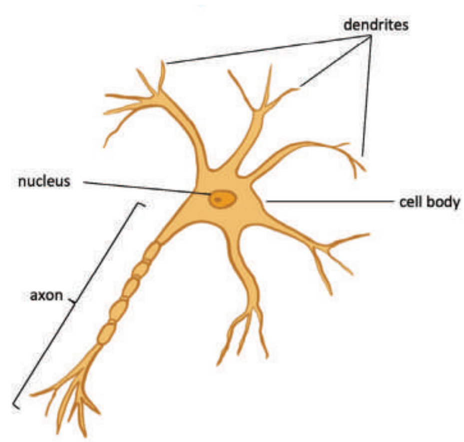
Have you ever fallen while riding a bicycle? Hopefully you were wearing a helmet! Hitting your head on a hard surface like the road or a sidewalk might result in a serious brain injury. For example, the occipital lobe of your brain, located in the back of your head, is where your vision is processed. A hard blow to the back of your head could leave you with severe vision loss or even total blindness.



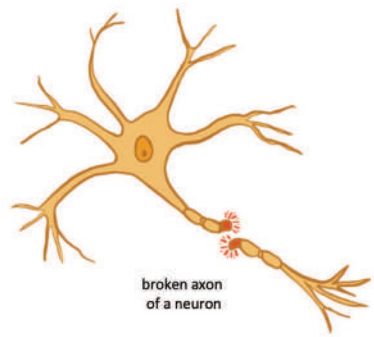
When the head collides with the ground, the brain can collide with the inside of the skull.

You may remember that long nerve cells called neurons are responsible for your sense of touch and for sending messages to and from your brain and spinal cord. Your brain contains neurons too. You may also remember that neurons send chemical signals from one axon of a cell to another cell to communicate with each other. Neuron activity and connections between neurons in your brain are very important to memory formation.





Contact forces to your head can transfer energy to your brain, causing it to twist and collide with the inside of your skull. This can result in a concussion. Contact forces to the brain can cause cell damage. Some effects of cell damage include headaches, trouble concentrating, and memory loss. An impact to the head that causes a concussion can cause the long, connecting nerve cells in the brain to stretch and break. Some nerve cells can recover from injury, but more severely injured cells lose their ability to send signals.



1) How do you think concussions and nerve cell damage can lead to memory loss?

____

____

____

2) What might happen if a person gets multiple concussions?

____

____

____

Wearing a helmet during certain activities, like cycling, can protect your brain from injury and reduce the chance of getting a concussion. You may be wondering why helmets look the way they do. The thickness and shape of all helmets are purposely designed to protect your brain from impact forces caused by collisions. Helmets designed specifically for bicycle riders are important safety gear that can protect your brain. In fact, wearing a helmet can reduce the amount of peak forces on the skull and can lead to a 60% decrease in serious head injuries for riders who hit their heads during falls or accidents.

So what makes a helmet effective? The Consumer Product Safety Commission is the regulating agency in the United States that determines safety standards for many products, including bicycle helmets. There are many choices in helmets, and prices range from very expensive to very affordable. Expensive helmets are not necessarily better. Low-cost helmets that meet the safety standards are good choices for bicycle riders.

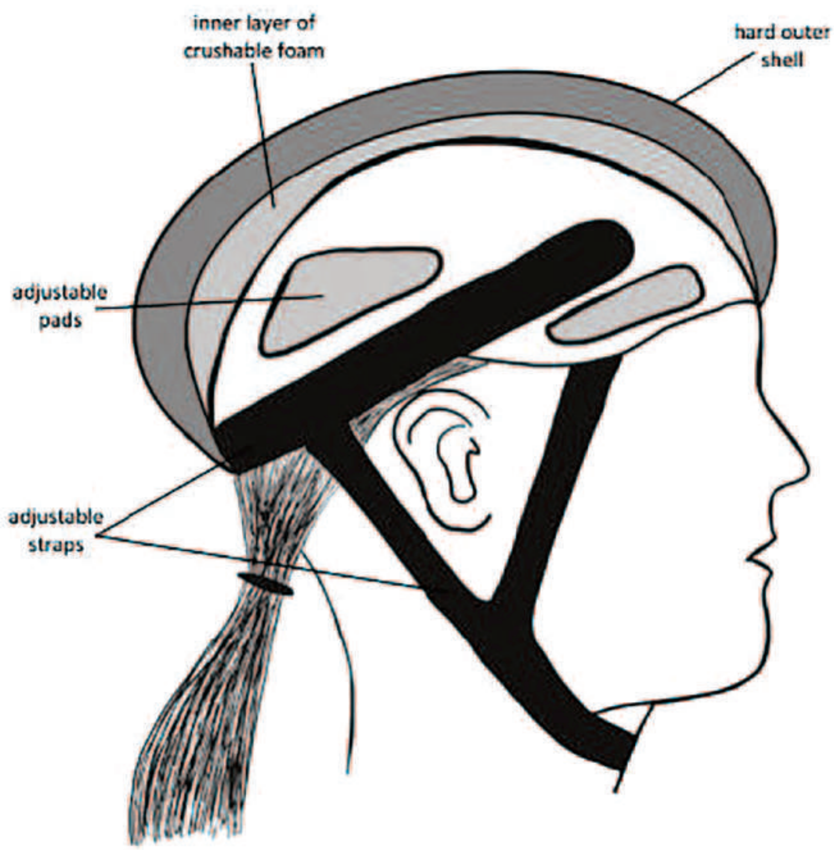
When choosing a helmet, you should always make sure that it is approved by the Consumer Product Safety Commission. There are other considerations for helmet manufacturers and bicycle riders, too. A helmet should

- fit snugly and stay in position when you are moving around,
- have easily adjusted straps,
- be lightweight and comfortable, and
- not block your vision in any way.

Companies want helmets to stabilize your head and your brain during a fall. But they also want them to meet the criteria of looking cool so consumers will wear them. Let's take a look at the structure of a bicycle helmet.

Helmets have hard outer shells made of lightweight materials like polycarbonate or fiberglass. There are often vents in the outer shell to allow air to flow over the cyclist's head. This hard layer can crack during a collision.

Helmets have an inner layer of crushable foam. The foam has air pockets that are designed to squish during a collision—but not too quickly!



3) Helmets have other design features like adjustable straps and pads to ensure a snug and stable fit for many different head sizes. Why is a snug and stable fit important?

If you have a bicycle helmet that doesn't meet current safety standards or that doesn't fit well, you should replace it. You should also replace your helmet if it's been in a collision because it might not effectively protect you in another collision.

4) Why would small cracks in the outer shell of a helmet make it unsafe?

5) If the inner foam layer of a helmet was crushed in one spot, would the helmet be unsafe?

Name: ______________________ Date: ______________

Decision Matrix

Evaluating our designs against our stakeholder feedback on a scale of 1 to 5.

- 5 points means that the design **meets** the criterion or constraint very well.
- 1 point means that the material **does not meet** the criterion or constraint.

Material choice	Consideration #1	Consideration #2	Consideration #3	Consideration #4	Consideration #5	Consideration #6	Total points

Name: ______________________ Date: ________________

Redesigning Your Protective Device

We have learned a lot about material shape, structure, and properties. Let's apply those science ideas to refine our designs. In the box below, redraft your design with improvements related to our science ideas. Label the materials you are using and explain how the materials will function to help the device meet the criteria of protection for your object. Feel free to add in any explanations on the lines beside the box.

Let's reflect on the changes that were made. In the first column, list the new changes you have made to your previous design. In the second column, use your science ideas to explain why you changed those features or properties. In the final column, list what potential consequences these changes might have on your protective device. If you made more than 3 changes, focus on the biggest changes you have made for the chart below.

Change I have made to my protective device	The scientific reasoning behind the change I have made	Effects of that change on the performance or structure of the device (positives or negatives)

Name: ______________________________ Date: ______________________

Stakeholder Feedback Form

Part 1: Preparing for Feedback

When getting ideas from stakeholders, it can be easier to start off by asking them what thoughts they have about criteria or constraints for existing designs or problems that do not have designs yet that meet the need of protection, before sharing any of your own ideas.

Step 1: Complete the chart below to determine what you will ask your stakeholders.

Does the object you are trying to protect already have any protective devices that are being put to use in the real world?

Yes

What are some of those devices?
List them below.

____

____

____

Say: I am wanting to create a protective device for a ________. There are already some devices out there for this purpose, like (*give examples above*). If someone were to improve upon a device for the protection of that object, what would you want the designers to consider or be concerned about?

No

What is the purpose of your device?
What is it designed to protect?

Purpose: ____________________________

____

Designed to protect: __________________

Say: I am trying to design a protective device for a ________. I do not know of anything that exists to protect that object. If someone were to design something to protect that object, what are some things you think the designers should consider or be concerned about?

Now, use one of these two boxes as your script to get initial ideas from your stakeholders.

Step 2: Think about your protective device design. When you created your draft, you made trade-offs. Summarize why you made those trade-offs. List them in the table below.

Trade-off	Why you decided to make this trade-off

Part 2: Home Learning

Step 3: Read the script from step 1 to someone you have identified as a stakeholder. Record below what your stakeholder lists as concerns or additional design considerations. If you want, you can ask more than one stakeholder for different perspectives.

Step 4: Share your design with the stakeholder. Look back at step 2 and explain the trade-offs you have made in your design. Ask your stakeholder what additional trade-offs they want you to consider **and** ideas they have to improve your design. List them below.

Additional trade-offs to consider	Ideas for design improvement

Step 5: Ask your stakeholder for an honest product review and to explain why they would or would not purchase this product. You are welcome to give this paper to your stakeholder for them to write in this area. Ask them to be nice but honest about any areas for improvement since we want to use this review to help optimize our designs.

Name: ______________________ Date: ______________________

Final Design Proposal

Sometimes design solutions have to be pitched to investors to receive funding for the creation of the product. During that pitch, the engineers have to justify their choices and explain why the stakeholder would want to utilize their design (sometimes over other preexisting designs out there). The pitch helps the funders, investors, and product developers see the value in the design. It will also help the advertisement team better market the design to stakeholders.

Use this handout to help you start drafting the key parts of your design proposal pitch.

Part 1: Introduce the problem and claims for a solution

The first thing we have to do in a pitch is establish a purpose. In the space below, tell a little bit about the problem you have identified. Write it so that the investor will feel the need to fix the problem.

Next, you will need to explain the purpose of your device and make a claim about what your proposed design solution will be able to do.

Part 2: Show off your solution

In the space below, show your design solution to investors. Highlight any key features that help meet the needs of the design that separate your device from others.

If there are already devices available to consumers that are meant to protect your object, explain how this design will work better than the devices already on the market.

Part 3: Present your research

Investors and others who you are pitching to will want to know that you have done your research and are making the best choices. They will want to know that you are making decisions based upon stakeholder needs and attitudes, making the device easier to sell.

Explain any feedback you received from stakeholders that you *are* using in your design:

Feedback	Where and how it is being utilized

Explain any stakeholder feedback you *are not* using and why you have made that choice:

Feedback	Why it is *not* being utilized

List any other criteria or constraints you took into account when making this device.

Part 4: Justify your design decisions

Investors will want to know that you have made good decisions in your design. Explain what you ranked as your primary vs. secondary vs. tertiary considerations and why. Explain how these decisions have helped to optimize your design.

Stakeholder consideration	Your ranking (P, S, T)	Explain why this choice helps to optimize your design

Name: ______________________________ Date: ______________________

Reviewing Our Driving Question Board

Instructions: Below is a list of questions from our Driving Question Board (DQB).

Mark questions you think the class has answered by putting different symbols next to each question:

- We did not answer this question or any parts of it yet: **O**
- Our class answered some parts of this question, or the ideas we developed helped me see how I could now answer some parts of this question: ✔
- Our class answered this question, or the ideas we developed helped me see how I could now answer this question: ✔+

(Teacher supplies questions from the class Driving Question Board for the left column of the table)

Questions from Driving Question Board	Mark

Name: ______________________________ Date: ______________________

Creating a Scale Model

Consider the device you are wanting to create. Is it a larger design? If so, you may need to create a scale model instead of making the design actual size. Sometimes for a presentation, a designer will create a prototype, or a physical model, of the device they are wanting to mass manufacture. Some smaller prototypes allow investors to envision how the product might function in real life, but other prototypes would be too big or expensive to create for the investors to view. Due to size or price constraints for creating a prototype, some designers create prototypes to scale.

To create a prototype to scale means that the prototype is made into a smaller version of the original device design and includes all parts of the design. If you have a larger device and need to scale down the design, follow the steps below to determine how to create the prototype.

Step 1

Draw out your current design below in Section A and include the measurements of your device. Do not worry about explaining the design features on this model, just focus on the size of the components. Make sure to include how wide and tall the design would be in real life (the dimensions of your device). Give your best approximations.

Section A Current design with dimensions	Section B Scale model design with dimensions

We want a model to be easily passed around and manipulated by the investors. A scale model of 6-12 inches works well for this purpose. When we scale down the model, we want it to be between 6 and 12 inches on its longest part.

When scaling down, we need to look at factors for each dimension of our device. We can use the Factors and Multiples Chart to help us determine the size that best fits our scale model. On this chart, the sizes we want our device to scale down to, or factors, are on the far left. The multiples of those numbers are to the right of that.

Factors and Multiples Chart

	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17	x18
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108
7	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126
8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144
9	18	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153	162
10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
11	22	33	44	55	66	77	88	99	110	121	132	143	154	165	176	187	198
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

For example, if your device is 48 inches tall, there are several options for scaling down the device. Both 6 and 8 are factors of 48. This means that the device can easily be scaled down in size to a 6-inch or 8-inch scale model. The same thing goes for devices that are 48 feet tall. Something 48 feet tall can easily be scaled down into something that is either 6 or 8 inches tall by using the scale factors.

Factors and Multiples Chart

	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17	x18
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108
7	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126
8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144
9	18	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153	162
10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
11	22	33	44	55	66	77	88	99	110	121	132	143	154	165	176	187	198
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216

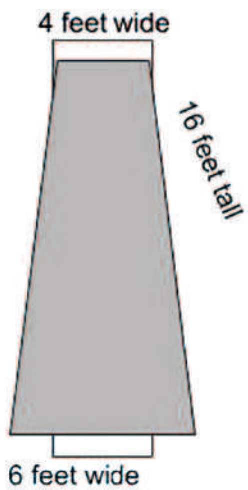
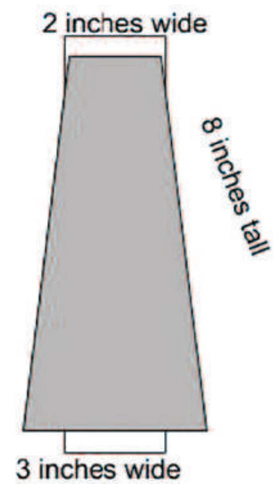
Step 2

Look at the Factors and Multiples Chart and see if the largest size you have identified on your drawing in Section A is on this table. If that size falls between 2 numbers in the table, round up or down to the nearest factor. Remember, you drew your model with your best approximation of the real size of your device. If you are having trouble picking out a scale factor, ask your teacher for help.

Step 3

Now that you have picked your scale factor, look back at your design drawing in Section A. Use Section B to redraw your device, but this time take each dimension in Section A and divide it by the scale factor you have identified for your scale model.

Following is an example for a pier, or post, that supports a bridge. The posts are being hit by boats, and the design is a padded barrier to help reduce the force of boats hitting the pier.

Section A **Current design with dimensions**	**Section B** **Scale model design with dimensions**
	

Step 4

Once you have your scale model drafted out, check with your teacher to be cleared for making an actual prototype.

Name: ______________________ Date: ______________

Determining Your Prototype Testing Conditions

When testing a prototype for a protective device, it is important to think about the different ways in which a real object would be used or get damaged. For example, a cell phone would normally suffer damage from a drop of 4 feet or less, so in order to test a protective device for a phone we would want to drop the device from a height of 4 feet or less.

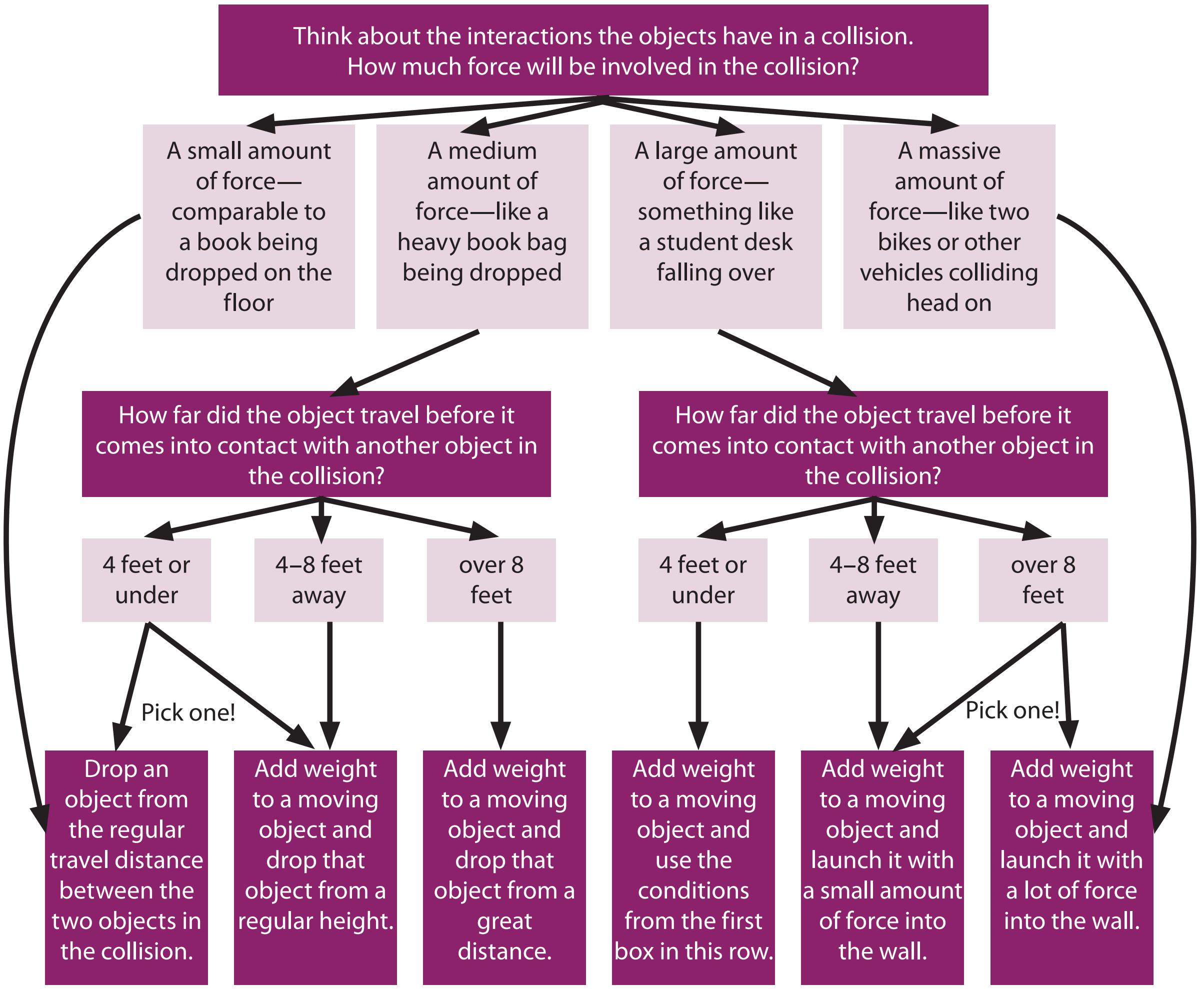
We know that some of the objects that we will be testing protective devices for break easily or are very expensive. Because of that, we will be using something to simulate that material. Engineers call these substitutions *proxies*. Looking at the following list, think about the shape of your object and the breakability of it. Circle below the proxy object that best fits your testing needs.

Object in real life	Object is thin, flat, and easily damaged.	Object is thin, flat, but not easily damaged.	Object is flat but thicker and not easily damaged.	Object is round and easily damaged.	Object is round and not easily damaged.
Your proxy material	sugar glass	2-3 sheets of rice paper	thick sugar glass	an egg wrapped in a small plastic bag	water balloon

Think about the object you chose above. How will you know it is damaged? What would a little damage look like, a medium amount of damage look like, and a lot of damage look like? Draw diagrams below to show the amount of damage done in different collisions.

What my proxy will look like after experiencing just a little damage	What my proxy will look like after experiencing a medium amount of damage	What my proxy will look like after experiencing a lot of damage

We know that forces are distributed evenly among the objects in a collision, so we can test all objects by dropping them with different amounts of force. We just have to make sure that the amounts of force in a real-life collision would be comparable to our testing situation. Use the decision tree below to determine how you will test your design and how much force to use. Depending on the amount of force needed, you will be either dropping or launching your protective device and object.



Think about the option above that best fits your testing conditions. What collision factors can you change to ensure equal amounts of kinetic energy are in the system compared to an actual, real-world collision for these objects?

Now that you know how you will test your design and keep it as realistic as possible, let's begin to piece together a more precise plan. Use the following chart to determine what will be moving and what will not be moving and the positions of objects in this interaction.

Draw a diagram that shows your protected object moments before a collision. Before the collision, what parts are moving and what parts (if any) are nonmoving? What part or section of your protected object is involved in the collision?	
Copy here the diagram you drew in the first row above, but this time modify it to show the protected object in a dropping scenario. In this dropping scenario if any object needs to be hit at a certain angle, show it at the moment of contact with the floor or wall, positioning the area to be hit so that it is directly struck in the collision. (example: Cell phones normally break when they are hit on a corner, so the phone would be positioned so that the corner would be the main section that comes in contact with another object in the test.)	

Draw a recording table below to keep track of your result(s). Check with your teacher to see how many tests can be run in the classroom or elsewhere at school, what materials your teacher has ready to be tested, and how much time you have available. Make sure to include space for multiple trials and any notes that you may want to share with investors.

Indicate how and when in your presentation you will present this information to your investors:

Investor Design Feedback Form

List the name of the protective device designer here: ___________________________

What device are you reviewing as an investor? ___________________________

What is the most promising design idea or feature? Why?	What question(s) do you have for the designer?	What suggestion or idea do you have to help improve their design?

What improvements to this design would make you want to buy it more?

____

____

____

____

Name: ______________________ Date: ________________

Outlining an Investor Pitch Presentation

Look back at *Final Design Proposal*. We used this last lesson to consider what important information to have in a briefing for investors. Since we have already collected this information we will use this handout as a guide for developing your pitch presentation. Each area of this handout will need to be included in your presentation.

Some parts on *Final Design Proposal* are reflected in the following steps. As you transfer over important information to this document, think about how you will present this information in an engaging and informative way. Consider any visual or physical aids you want to include for each step. Be sure to think about what you will say and do so you can rehearse your presentation.

Step 1

Introduce the problem and claims for a solution

Before an investor can be shown a design solution, they need to understand the problem it is trying to solve and the purpose of the design. See Part 1 of *Final Design Proposal* to help you complete this step.

What important information are you communicating about the purpose of the design? Will you give an example or tell a story of the problem this design is solving?	
What will you say your design does to solve this problem or meet its purpose?	
Describe any visuals or physical aids you are going to include for this step that would be appealing or helpful for your presentation.	
Develop a script outline for this step. What are you going to say to your investors about this visual or physical aid and the information you are presenting?	

Step 2

Show off your solution

Consider how you are going to show your design to your investors. Investors will want to either see a well-drawn picture or have a physical model to pass around and check out during the presentation. See Part 2 of *Final Design Proposal* to help you complete this step.

Will you be showing a cleaned-up, color drawing from *Final Design Proposal* or creating a physical model?	
Describe any visuals or physical aids you are going to include for this step that would be appealing or helpful for your presentation.	
Develop a script outline for this step. What are you going to say to your investors about this visual or physical aid and the information you are presenting?	

Step 3

Present your research

Investors want to know that you are making informed decisions to optimize your design. Your stakeholders will also want to know what criteria and constraints were considered in the creation of your design. See Part 3 of *Final Design Proposal* to help you complete this step.

List the feedback from your stakeholders you are sharing.	
List the criteria and constraints you considered when creating your design.	
Describe any visuals or physical aids you are going to include for this step that would be appealing or helpful for your presentation.	
Develop a script outline for this step. What are you going to say to your investors about this visual or physical aid and the information you are presenting?	

Step 4

Identify relevant trade-offs to communicate to investors

An important step should be considering your stakeholders. Investors want to know that this device was designed with stakeholders in mind. Begin by using the table below to record the different stakeholders you considered when designing your device. Because this sheet is being used to craft a presentation for investors, this step will be slightly different from Part 4 of *Final Design Proposal*. Consider using the primary, secondary, and tertiary consideration rankings and information from Part 4 of *Final Design Proposal* to help you complete this step.

Stakeholder category	Stakeholders who fall into that group
Those who will use the device	
Those who will benefit from others using the device	
Those who will be impacted by the device	

In your pitch presentation, the investors will want to know that you have considered your stakeholders and their needs. Investors will want to know that decisions have been made that will make the device effective, useful, and profitable. Use the following table to determine how you will present this information. Consider your stakeholders and explain what trade-offs they think are important and how you will present those trade-offs to your investors.

Stakeholders	Trade-offs valued by the stakeholder	How will you present this information so that it shows you value stakeholder feedback and explain why this trade-off is important to stakeholders? How will you help the investor understand how this trade-off will help the device be effective, useful, and profitable?

Describe any visuals or physical aids you are going to include for this step that would be appealing or helpful for your presentation.	
Develop a script outline for this step. What are you going to say to your investors about this visual or physical aid and the information you are presenting?	

Step 5

Prepare for questions and answers

After a pitch presentation, the potential investors will ask questions about the design. Think about what questions they may ask and what your answers would be. Record those questions and answers below.

Questions investors may ask	Your answers

Begin Your Presentation

Now that you have all your needed information and a plan drafted on this handout, it is time to start putting together your presentation. **Have your teacher check over the information and plan with you before you begin.**

Name: ____________________ Date: ____________

Determine Your Presentation Format

When we are considering how to present information to our potential investors we will use a process to make our decisions, just like we did in the unit. While we used a decision matrix in the unit to evaluate a design, to prepare for a presentation we will have to use a presentation organizer. Use the following organizer template to walk through the process of deciding what information will be included in your presentation, how it will be presented, and what preparation will need to be conducted for your presentation. Keep in mind that all decisions made will be to help your investors understand the purpose of your design and how well this design will meet the needs of the stakeholders.

Technology has allowed investors and designers to engage in new ways, and not all presentations have to be done in person. Your first step is to determine if your presentation will be in person or in a digital format. If you are presenting digitally, will it be live or prerecorded? Make your decision in the following table and share your choice with your teacher.

Will you be presenting your information in person or by using an electronic format?
____________________ ____________________
If you are presenting in person
Will you be using a poster or a presentation tool like slides to present? What presentation tool are you considering? ____________________ ____________________
If you are presenting electronically
Will you be prerecording your presentation and then having a question and answer session after the presentation? **OR** Will you be presenting in real time electronically with the question and answer session after the presentation? ____________________ ____________________

Optional Project Extensions

OPTIONAL: Visual Aids for Your Presentation

Sometimes if designers have time, they will develop additional materials to make their designs look more attractive in a presentation. If you find yourself with additional time and are wanting to add a visual aid to your presentation other than your prototype, different options to enhance your investor presentation are below. You also may think of something that is *not* on this list. Check with your teacher if you would like to explore a project option that is not listed here. If you choose a digital option, make sure that you can access at least 1 digital resource on your personal electronic device that can help you assemble your project-enhancement materials. Share and discuss with your teacher what option you pick.

Project option	Project details	Materials needed	Digital resources available to assemble project
Poster	Create a poster to be displayed during your presentation.	Hard copy: paper, colored pencils, markers, ruler Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote
Brochure	Create a brochure to be either handed out or displayed.	Hard copy: paper, colored pencils, markers, ruler Digital: computer	Google Slides, Google Docs, Google Draw, Adobe software, PowerPoint, Keynote, Microsoft Word
Flyer	Create a flyer to be passed out to potential investors.	Hard copy: paper, colored pencils, markers, ruler Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Piktochart, Adobe Spark, Microsoft Word
Infographic	Create an infographic to be passed out to or displayed for investors.	Hard copy: paper, colored pencils, markers, ruler Digital: computer	Google Slides, Google Draw, Adobe software, PowerPoint, Keynote, Piktochart, Adobe Spark

Name: ______________________ Date: ______________________

Science Literacy Exercise Page 1 Use with Reading Collection 1

Roadmap for Reading

This week's reading collection focuses on collisions and how to describe and model them. The selections include examples of collisions, some involving humans and others not.

"Collection 1: Collisions" consists of four selections.

1 Designing for Collisions
2 Describing Collisions
3 Modeling Collison Systems
4 Beyond Cars and Crashes

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Be sure to "read" the photos and diagrams as carefully as you do the text.
- Consider how each part of the reading relates to knowledge you gained from the previous part and from your previous understanding of the topic.

Written Response

Your writing exercise is to draw a concept map that summarizes important ideas about collisions from the four selections in this collection.

- Draw your map on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Start with the word "Collisions" in the center of your page.
- Write a complete sentence describing one big idea from each reading.
- Connect supporting detail sentences to each big idea.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	There is inadequate organization, with two or more selections not summarized and two or more statements not accurate.	There is adequate organization, but one selection was not summarized or at least one statement was not accurate.	Organization of map is logical and shows accurate understanding that collisions can be described and modeled and their effects on humans can be reduced with engineered solutions.	
Supporting sentences (details)	One or more big ideas do not have supporting details; examples come from only one or two of the readings.	There are one or two accurate examples supporting each big idea; examples come from at least three readings.	There are two or more accurate details supporting each big idea; details come from all four readings.	
Design	Connections are not clear; color is absent or detracts from the overall design.	Connections are mostly clear; text is somewhat easy to read; color is used but contributes little to the overall design.	Connections are clearly visible; text is easy to read; color is used effectively.	
Grammar and mechanics	There are no complete sentences; there are four or more errors in grammar or spelling.	Most but not all big ideas and details are expressed as complete sentences; there are two or three errors in grammar or spelling.	Big ideas and details are expressed as complete sentences; there is one or no errors in grammar or spelling.	

Additional Feedback Notes:

Name: ______________________ Date: ______________________

Science Literacy Exercise Page 2 Use with Reading Collection 2

Roadmap for Reading

This week's reading collection focuses on how and why objects and materials deform in response to forces. The selections include explanations of how materials behave at extremely tiny scales you cannot see.

"Collection 2: Bounce Back, Bend, Break, or Push" consists of five selections.

1 Materials That Stretch and Bend
2 Bottles and Baseballs
3 Collisions Up Close
4 Sharp and Pointy
5 Collisions with Fluids

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how graphics support the text and how text clarifies the graphics.
- Consider how each part of the reading relates to knowledge you gained from the previous part.

Written Response

Your writing exercise is to develop an infographic that summarizes big ideas related to the topics of deformation or collisions from each of the readings in Collection 1.

- Compose your infographic on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Title your infographic, "5 Things to Know About Collisions and Deformation." Or you may think of a title of your own.
- Draw five panels on your infographic with the following headings.
  1 *What "Deformation" Means*
  2 *What "Elastic" Means*
  3 *Too Much Deformation*
  4 *Chemical Bonds and Collisions*
  5 *Concentrating Force in Collisions*
- In each panel, write a sentence or two of explanation and add a simple drawing to illustrate.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	Only one or two science ideas and examples are accurately stated; only one or two drawings accurately support the text.	At least three of the science ideas and examples are accurately stated; only three of the drawings accurately support the text.	All five science ideas and examples are accurately stated; all drawings accurately support the text.	
Supporting details	There are only one or two summarizing sentences; there are only one or two drawings	There are at least three of the summarizing sentences for each of the five subheadings; there is a simple drawing for at least three details.	There is an important summarizing sentence for each of the five subheadings; there is a simple drawing for each detail.	
Design and writing style	Inforgraphic uses less than half of the page; some titles missing; color is not used; writing style does not engage the reader.	Infographic fills most of the page; titles are all displayed but some not prominently; color is used but not effectively; writing style is uneven but interesting in places.	Infographic fills the page; titles are prominently displayed; five supporting text boxes use color and drawings effectively; writing style is interesting to read.	
Grammar and mechanics	There are six or more errors in punctuation, capitalization, and spelling.	There are three to five errors in punctuation, capitalization, and spelling.	There are fewer than three errors in punctuation, capitalization, and spelling.	

Additional Feedback Notes:

Name: ______________________ Date: ______________

Roadmap for Reading

This week's reading collection focuses on some interesting and practical examples of objects involved in contact forces. The selections include explanations of why some collisions cause more damage than others.

"Collection 3: Kinetic Energy and Objects in Contact" consists of five selections.

1 Through Thick and Thin
2 What's Wrong with This Picture?
3 Human Tissues and Elastic Limits
4 The Danger Zone
5 Impossible Superhero Physics

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Consider how data and graphics support the narrative text and how narrative text clarifies the data and graphics.
- Consider how the reading selections are interrelated and support one another.

Written Response

Your writing exercise is to design a thought-provoking internet meme to share that combines ideas about motion, collisions, and human safety from Collection 3.

- Sketch your meme inside a rectangle on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Think about which examples from the reading struck you as important for other people to know because they affect their ability to stay safe.
- Draw an image that will catch people's attention.
- Write one or two lines of thought-bubble or thought-provoking text.
- Make sure your meme meets your school rules and is not offensive.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	The meme has an image and text, but the point is not clear. The science ideas seem inaccurate or unclear. The image and text seem unconnected.	The meme's point is not particularly thought provoking, but the science ideas are accurate. The image and text work together fairly well.	The meme is thought provoking. The image and text refer to scientific ideas about energy, collision, and keeping people safe. The two work together effectively.	
Design	The image is not in a rectangle. The text is too light, unreadable, or not present.	The image is in a rectangle. The text is bold and fairly readable but could be better positioned.	The image is catchy and inside a rectangle. The text is bold, easy to read, and well positioned related to the image.	
Grammar and mechanics	There are two or more errors that were not intentionally used to draw attention to the message.	There is at least one error that is not intentionally used to draw attention to the message.	Any errors are intentional texting language or slang used to draw attention to the message.	

Additional Feedback Notes:

Name: ______________________ Date: ______________

Science Literacy Exercise Page 4 Use with Reading Collection 4

Roadmap for Reading

This week's reading collection focuses on design problems involving collisions. The selections include explanations of how stakeholders define criteria and constraints on solutions.

"Collection 4: Materials, Design, and Outcomes" consists of five selections.

1 Corked Baseball Bats
2 Criteria and Constraints
3 Plastics
4 Confessions of an Online Retailer
5 Protective Produce Packaging

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Ask yourself, What's the main idea of this selection?
- Consider how each selection relates to knowledge you gained from a previous selection.

Written Response

You read how two people think about plastic packaging for apples. Your problem is to find a way to transport a single apple in your school backpack each day in a way that will insure you want to eat it when you finally get time for an end-of-school snack. Your writing exercise is to complete a T-chart describing your goal and identifying a list of criteria and constraints that will be helpful when designing your solution.

- Compose your T-chart on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Copy the blank chart shown on this exercise page.
- Write the goal in your own words.
- List criteria and constraints that you think will result in a successful solution to the problem.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Science Literacy Exercise Page 4, continued

Goal:	
Criteria	**Constraints**

Evaluation Guidelines

Element	1	2	3	Feedback
Content	Goal is missing or shows misunderstanding of the scenario. Criteria and constraints are mixed up, showing lack of understanding of the meaning of these terms.	Goal is stated but shows limited understanding of the scenario. Criteria and constraints are appropriate to the goal and mostly, but not all, show understanding of the meaning of these terms.	Goal is stated as a problem to be solved and shows understanding of the scenario. Criteria and constraints are appropriate to the goal and show understanding of the meaning of these terms.	
Details and originality	One side of the T-chart has no information, and the details present will not result in a solution that goes beyond those discussed in the readings.	There is one criterion and at least two constraints, and some are likely to push the design toward unusual solutions.	There are at least two criteria and four constraints, and all are likely to push the design toward unusual solutions.	
Grammar and mechanics	There are six or more errors in punctuation, capitalization, and spelling.	There are three to five errors in punctuation, capitalization, and spelling.	There are fewer than three errors in punctuation, capitalization, and spelling.	

Additional Feedback Notes:

Name: ______________________ Date: ______________________

Science Literacy Exercise Page 5 Use with Reading Collection 5

Roadmap for Reading

This week's reading collection focuses on structures that distribute forces and reduce the forces in collisions. The selections include several that are related to sports.

"Collection 5: Structures and Forces" consists of five selections.

1 Arches and Domes
2 Snap! That's a Great Idea After All
3 Getting to the Point(s)
4 Sneaker Mania
5 Sports Op-Ed

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or an attempt to persuade?
- Look for boxes that highlight vocabulary or ask questions that help you evaluate the selection.
- Consider how each part of the reading relates to knowledge you gained from the previous part.

Written Response

Your writing exercise is to complete an outline that summarizes the readings in Collection 5.

- Complete the partial outline shown on the reverse side of this sheet.
- Fill in the missing information in the outline by writing short, complete sentences.
- Write main ideas at the upper level of the outline and supporting details at the lower level.
- Use wording that links how things are made to their functions.
- Use cause-and-effect language to explain how collisions, weight, and other forces are involved.
- Check your grammar, punctuation, and spelling.

Structures and Forces

I. Arches and domes are designed to support weight and distribute forces.
   A. Your feet have arches.
   B. ______________________________
   C. ______________________________

II. Bubble wrap has little domes to distribute weight.
   A. ______________________________
   B. ______________________________

III. Many points of contacts help distribute force.
   A. If the nails are close together, you can lie on a bed of nails without getting injured.
   B. A turntable has pads or feet that reduce contact.
   C. ______________________________
   D. ______________________________
   E. Furniture pads under the feet help distribute the force pressing on the floor.

IV. ______________________________
   A. For sprinting, spikes or cleats concentrate forces to dig into the ground.
   B. ______________________________
   C. If shoe soles are too soft, it would be hard to produce enough force to move forward.

V. Traumatic brain injuries are related to sports.
   A. There are constraints on the design of equipment if players are to play the game as intended.
   B. ______________________________
   C. Brain injuries can also happen when the head is moved quickly, even if there is no collision.

Name: ______________________ Date: ______________________

Science Literacy Exercise Page 6 — Use with Reading Collection 6

Roadmap for Reading

This week's reading collection focuses on solving real-world problems through investigation, debate, and applying basic science concepts. The selections are written from different perspectives, including those of middle school students and of public officials.

"Collection 6: Applying Ideas about Materials and Forces" consists of three selections.

1 Egg Drop Competition

2 Debate Transcript

3 Controlling Collision Factors

As you read:

- Consider the general purpose of each part: is it a description, an explanation, a procedure, or attempt to persuade?
- Notice when there is more than one perspective, and think about who is speaking and how they view the topic.
- Consider how each part of the reading relates to knowledge you gained from previous collections.

Written Response

Your writing exercise is to complete a thoughtful paragraph that will settle the argument introduced in the Preface to this unit. You'll explain the causes and effects of diving into the pool from different heights and in different positions.

- Compose your paragraph on a separate sheet of paper; attach this page to the front of it when you turn it in.
- Write a topic sentence that restates the equation for force ($F = m \times a$) in plain English.
- Write supporting details for each of the factors that affects how hard a diver will hit the water.
- Refer to the characters in the Preface to orient and engage your readers.
- Write a concluding sentence to describe how you would dive in the water and why.
- Before you begin, review the criteria in the Evaluation Guidelines that follow to help you clearly understand the expectations of the exercise.

Evaluation Guidelines

Element	1	2	3	Feedback
Content	There is an inadequate explanation of how the acceleration experienced by an object depends on both its mass and the net force acting on it; unclear explanation of the scenario.	There is adequate completion of a structured paragraph about the scenario in the Preface, but it is weak in explanation of how the acceleration experienced by an object depends on both its mass and the net force acting on it.	There is an adequate topic sentence; there is thorough discussion of the factors affecting force when jumping into water, summarizing key points related to acceleration.	
Supporting sentences (details)	There are incomplete sentences or details irrelevant to the paragraph topic.	There are complete sentences, but there are too few, they are lacking in support from the Preface, or they have an unclear relationship with the topic sentence.	There are at least three complete sentences, encompassing three major points from the Preface and readings that support the topic sentence.	
Organization and transitions	There are statements with little clear relationship to the topic sentence or each other; concluding sentence is absent.	Key supporting details and a concluding sentence are present, but transitions are absent or choppy.	Ideas are in an order that helps the explanation make increasingly more sense; a concluding sentence recaps the scenario.	
Grammar and mechanics	There are six or more errors in punctuation, capitalization, and spelling.	There are three to five errors in punctuation, capitalization, and spelling.	There are fewer than three errors in punctuation, capitalization and spelling.	

Additional Feedback Notes:

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Michael Novak, Unit Lead, Northwestern University
Susan Kowalski, Field Test Unit Lead, BSCS Science Learning
Zoë Buck Bracey, Writer, BSCS Science Learning
Joel Donna, Writer, University of Wisconsin - River Falls
Shelly Ledoux, Writer, The Dana Center at University of Texas -Austin
Dawn Novak, Writer and Reviewer, BSCS Science Learning
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Thomas Clayton, Teacher Advisor, Columbia Middle School, Berkeley Heights, NJ
Amanda Leighton, Teacher Advisor, Haddonfield Middle School, Haddonfield, NJ
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Katie James
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Kristi Young

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Core Knowledge Foundation Science Literacy Development Partner

Six Red Marbles
Carri Walters
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