TEACHER WARNING

This lesson includes **crashing a cart into a barrier as well as looking at data on likelihood of survival in collisions.**

This may evoke heightened emotional states due to related traumatic events that teachers, students, and/or their families may have experienced. Please see the unit front matter, the teacher reference associated with this lesson, and the callouts in the *Teacher Guide* for guidance around how to support social and emotional needs as you move through this unit. Never ask students to share their personal experiences unless they volunteer to do so.

Student Content Advisory

In this lesson, we will simulate vehicle crashes in the classroom and use a simulation to collect data on collision risk.

If needed, you can use strategies from the *Student Mindfulness Resource* handout.

If at any point in this unit you find you need additional support, let your teacher or another trusted adult know how you are feeling.

Be aware that your teacher and/or classmates may have experienced trauma related to this topic. Approach conversations about car crashes and car safety with respect, guided by your class's Community Agreements.

Navigation

With your class

What are some ways in which the body of the vehicle could be redesigned to make a collision safer?

Make a Prediction

The older car shown to the right has a more rigid body than the newer car.

1959 Chevrolet Bel Air

2009 Chevrolet Malibu

Assume that safety features like seat belts and airbags are the same in both cars, and focus only on the body of the vehicle.

Turn and talk

Which car do you think will be safer in a collision, and why?

➔ Be ready to share your ideas with the class.

Record Observations

On your own

Record your observations.

Observations of old vs. new car collision.

Slide E

Share Observations

Turn and Talk

Discuss your observations.

Slide F

Share Observations

With your class

How did the deformation of each vehicle compare at the front versus in the middle?

Crumple Zone

The crumple zone concept was developed in 1952 for Mercedes-Benz to increase passenger safety in a collision. It divided the car design into 3 sections:

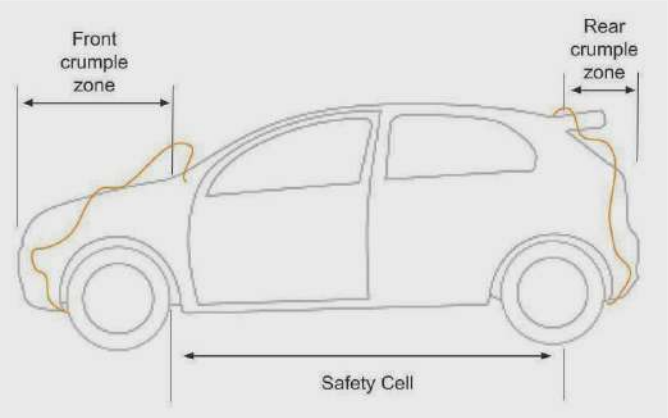


Image credit: qubodup

1. a crumple zone in the front of the car
2. a relatively rigid passenger compartment
3. a crumple zone in the rear of the car

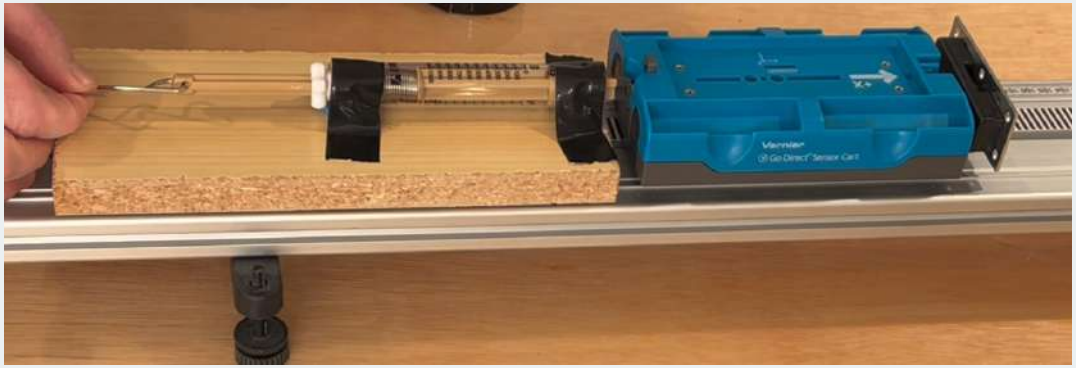
With your class

Why would crumple zones increase passenger safety?

Orient to the Crash Testing Track

With your class

- Orient to the crash testing track setup.
- Launch a cart that has no crumple zone and collide it with the stationary barrier at the end of the track.



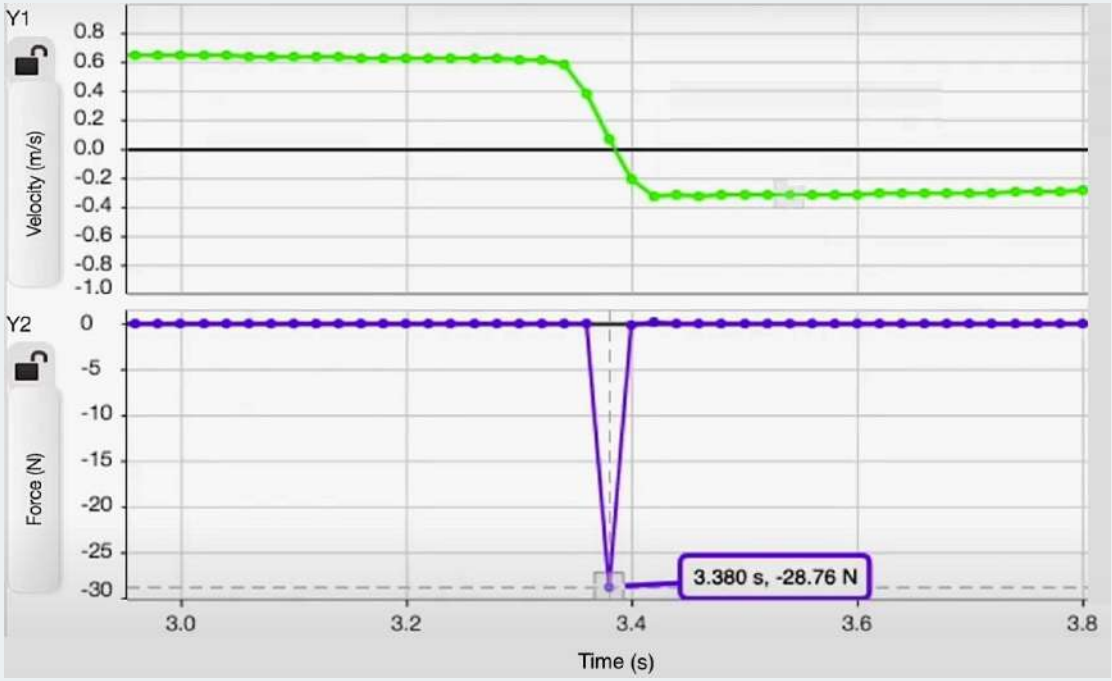
Analyze and Interpret Data

The data below are from the cart without a crumple zone.

With your class

What do we notice?

- What should adding a crumple zone do to both graphs?



Created using PASCO SPARKvue

Define the Problem and Identify Criteria

With your class

- What is the problem that we are trying to solve with a crumple zone?
- What criteria are we using to evaluate different possible design solutions?
- How would comparing all of our results help us understand how crumple zones work?

Safety Protocols

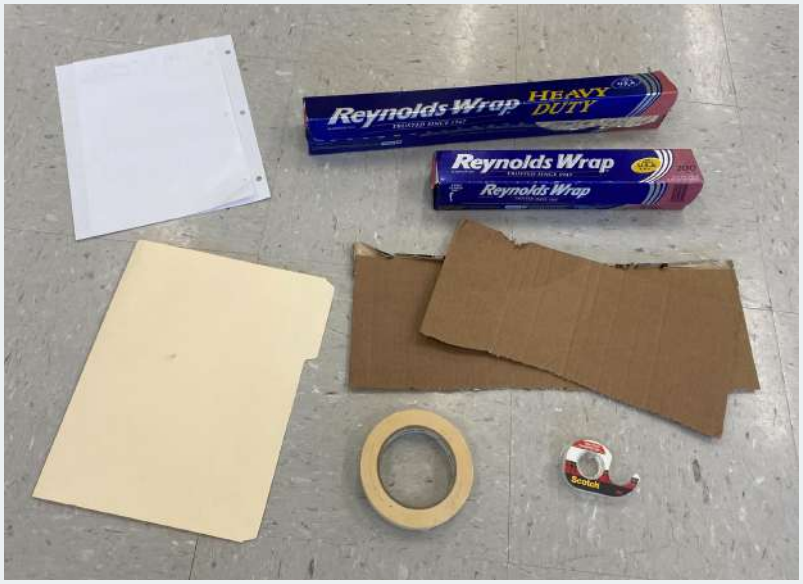
With your class

- Read the safety protocols on the lab handouts, follow the activity instructions, and only conduct the assigned activities.
- Dress appropriately: closed-toe shoes, long hair and loose clothing tied back, and safety glasses.
- Keep workspace and floor clear and check equipment for damage.
- Stay a safe distance from the collision area.

Design Your Own Crumple Zones

With a partner or small group

Use the materials provided to design crumple zones to test.



Test Your Crumple Zone Designs

With a partner or small group

1. Add your names to your index cards.
2. Design crumple zones to test.
3. Record 2 of your designs in Part B.

When you are ready to carry out a test:

4. Take a **before** picture of your design and your index card together (green is for your first design, blue for your second ...).
5. Get in line to test your design.
6. Take a picture of the force and velocity graphs and your index card.
7. Take an **after** picture of your design and your index card.
8. Upload the 3 related pictures and add to a row in our virtual space

Compare Your Results

On your own

- Which of **your** designs best met our design criteria? What is your evidence?
- What about its structure enabled it to do this?

Navigate

With your class

What criteria did we decide to use to compare/evaluate all of our different designs?

Analyze Data and Evaluate Designs

With a partner

Look at the class designs and data.

Identify 3-5 designs that best met our criteria.

- What do you notice about what they have in common in terms of their materials and/or designs?
- What patterns do you notice in their data and/or the shape of their graphs?

Identify Characteristics of Safest Designs

Bring your ideas to a Scientists Circle.

- Which of our designs best met our criteria?
- What patterns do you notice in their data and/or the shape of their graphs?
- What do you notice about what they have in common in terms of their materials/designs?

Connect to People and Safety

With your class

- How do we think these crumple zones affect the forces on the people in the vehicle?
- How is this related to passenger safety?

Orient to the Simulation

With your class

Review the variables that we can change in the simulation.

Vehicle Mass	1500 kg	[1000–3000 kg]
Crumple Zone Length	1 m	[0.1–1.5 m]
Crumple Zone Rigidity	1000 kN	[50–3000 kN]
Vehicle Speed	25 mph (11.2 m/s)	[10–100 mph]

Make a Claim about the Crumple Zone

On your own

Select the letter corresponding to the **rigidity** and **length** combination you think will result in a safer design for the driver.

		RIGIDITY		
		Low	Medium	High
LENGTH	Short	A	B	C
	Medium	D	E	F
	Long	G	H	I

Test Crumple Zone Designs

With your class

Test a control condition that would be unsafe for the driver. Then test the combinations that you predicted would be safer for the driver.

		RIGIDITY		
		Low	Medium	High
LENGTH	Short	A	B	C
	Medium	D	E	F
	Long	G	H	I

Analyze Survivability Data

With a partner

- How do the initial survivability results compare to your predictions?
- How are these results related to crumple zone design and peak force on the vehicle?

		RIGIDITY		
		Low	Medium	High
LENGTH	Short	A: 79%	B: 79%	C: 79%
	Medium	D: 88%	E: 80%	F: 79%
	Long	G: 100%	H: 80%	I: 79%

Navigate

The forces we were studying were on the vehicle--more specifically, on the crumple zones--not on the person

With your class

- Why would the peak force on the car be related to the likelihood of survival? What information are we still missing in order to answer this question?

Licensing Information