Be an Accident Investigator

Physics Question: *What happens when two objects with different weights collide?*

MATERIALS:

- Die-cast cars (2 per pair of students)
- Hex nuts (2 per pair of students)
- Model intersection sheets (1 per pair of students)
- Pencils
- Lab notebooks
- Accident Investigator Career Card
- Masking tape
- Optional materials:
  - Two or three balls of different weights or sizes, for demonstration
  - Rulers

Prepare

1. Make half of the cars into "trucks" by securely taping two hex nuts to the top of the car. (The flat, drag-racer style cars work well for this). The "trucks" will work most reliably when the hex nuts are as centered as possible on the car, and when the tape doesn't get in the way of the wheels. Once assembled, the "trucks" can be reused with multiple groups of students.
2. Before starting the activity, hang the "Research Lab" sign in a visible location.

Engage

1. Introduce the accident investigator career by showing the group the career card and asking questions to encourage students to think about what an accident investigator might do:
   - *What do you notice about this picture? What do you think this person is doing?*
   - *Have you ever heard the words "accident" or "investigate" before?*
   - *What do you think an accident investigator might do or study?*

2. Explain that accident investigators look at the scene of an accident after it happened and use evidence to figure out what happened during the accident and what caused it.
   - *What kinds of evidence do you think an accident investigator might find and use?*
3. Introduce the storyline of the activity like this:
   - Imagine that we are a team of accident investigators and this is our research lab. What does our lab look like?
   - We study evidence from traffic accidents that happen on city streets. We've been asked to investigate a small accident between a car and a delivery truck at an intersection (where two streets cross).
   - No one was hurt, but the town government wants to know more about what happened, to make the intersection safer so it doesn't happen again.
   - The place where the accident happened has been cleaned up already, so we can't go there ourselves. All we have is a diagram of where things were after the accident. How could we figure out what happened?

Some students may have personal experience with car accidents and/or feel anxious about them. Emphasize the positive aspects of the story: it was a small accident, no one was hurt, and the town wants to prevent it from happening again. Also be prepared to leave space for any students who need to step back from the activity or change the story to make it feel safer for them, for example, by putting it into a futuristic setting, the distant past, or a fantasy world. Adding some light humor to the story can help, too!

4. Point out that a traffic accident is about two objects bumping into each other. **Make connections** to students' experience by inviting the group to think about other situations they've seen where two objects run into each other. For example:
   - *Say you are standing on the playground and a ball hits you in the chest. What happens? Do you move? Does the ball move? Which direction?*
   - *Does it change if the ball is moving really fast? Or really slowly?*
   - *What if it's a really big ball? Or another kid who runs into you?*
   - *Can you think of other examples you've seen of things bumping into each other? Where does each object go?*
5. **Ask questions** to help the group draw conclusions from their examples about the factors that affect what happens when two objects collide:
   - *What do you think is important to know about two objects when they run into each other?*
   - *What can affect what happens to them? Size? How fast they're moving?*
   - *How could we use those ideas to help us with the accident investigation?*

For younger students, simplify this discussion by just asking them to share examples of things bumping into each other and describing what happened to each object. They may draw conclusions more easily by exploring with the cars directly. You could also demonstrate different scenarios with balls or other objects to give students concrete examples to discuss.

Explore

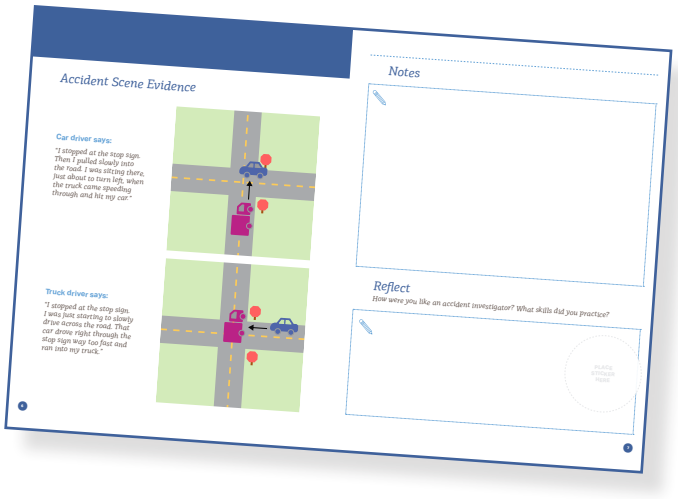
1. Point out that real cars are big and expensive; your team can't just buy a bunch and try crashing them in different ways to see what happens! When scientists need to study something that's too big or complicated, they use a **model**—a simpler or smaller version that can help them understand the real thing.
2. Introduce the first part of the model system they will use: the car, car with hex nuts, and grid sheet. Ask the group to make connections between the model and the real-life situation:
   - *What do you think this car with extra parts attached stands for in real life?*
   - *How do you think we could use these things to test what might happen in a real-life accident?*
3. Explain that they will start with some research about what happens to a car and a truck when they run into each other in different ways.
   - *What things could we change about how the car and truck run into each other?*
4. Hold up the model car and truck and use them to help the group visualize students' suggestions. Some possibilities:
   - The truck stands still and the car runs into it
   - The car stands still and the truck runs into it
   - Both are moving
   - One or both moving fast vs. slowly
   - Hitting head-on (both on the same street) vs. at a right angle (on intersecting streets)
5. Point out that the goal of the tests is to see how the vehicles move on their own. Once students start the vehicles moving toward each other, they should let go and not guide them, change their direction, or touch them again until they have stopped moving.
6. Invite the group to use the grid during their tests, to help them see how far each vehicle travels and where it ends up after each test. Demonstrate an example test, if needed, to illustrate the procedure.
7. Divide the group into pairs of research partners. Give each pair a car, "truck," and intersection sheet. Invite them to test some of the different collision possibilities the group discussed and draw or write notes in their lab notebook about what they find out.

For older groups, you could introduce features of experimental design for creating a fair test. For example:

- **Multiple tests: test each possibility at least three times to see if they get similar results each time.**
- **Measurement: count grid squares or use rulers to measure how far the vehicles travel**
- **Controlling variables: think about what factors should stay the same between tests to make it fair (starting the cars from the same spots, pushing with the same force to start them, etc.)**

8. As students work, **encourage scientific thinking** by asking them to make observations, test ideas, and draw conclusions:
   - *Pick up the car and truck. What do you notice about how they feel? How do you think that could affect how they move?*
   - *What do you think will happen if the car is moving faster than the truck? Try it and find out!*
9. Bring the group together to review their findings.
   - *What possibilities did you test, and what did you find out about how the vehicles moved?*
   - *How do your results compare with other groups who tested the same possibility?*

10. Explain that they are now ready to look at the evidence of the actual accident. Ask the group to look at the accident scene diagram on p. 5 of their lab notebooks. Invite the group to make observations about the diagram.
    - *What do you notice on the diagram? How could that help us figure out what happened?*



11. Introduce the drivers' statements on p. 6 of their notebooks. You may want to read them aloud together and help the group connect the statements to the accompanying diagrams.
    - *What do you notice about the drivers' descriptions?*
    - *How do these descriptions match the possibilities you tested earlier?*
    - *How could we figure out what really happened?*
12. Introduce the intersection diagram on the back of the grid sheet. Invite pairs to test each driver's scenario using the model cars and the intersection diagram. Encourage them to mark in their notebooks on each driver's diagram where the car and truck end up. Suggest that they test each one two or three times to see if they get similar results each time.
    - *How do these results compare to the accident scene diagram? How well do the two drivers' stories fit with the evidence?*
    - *Are there any other possibilities that might fit the evidence better?*

> **For younger groups, simplify the activity by omitting the two drivers' stories. Ask students to look at the accident scene diagram and notice where the car and truck landed after the collision. Invite them to figure out what happened by testing different possibilities until they find one(s) that produce a similar result.**

Reflect

1. Gather the whole group together. **Cultivate rich dialogue** by inviting students to share and discuss their results.
    - *What other possibilities did you test? Which one fits the evidence the best?*
    - *What should we tell the town government about what really happened? Is there other evidence or information we'd want to have to make a decision?*
    - *Do you have any ideas about what the town could do to keep accidents like this from happening?*
2. Encourage the group to reflect on how they were like scientists during the activity. You may want to show the accident investigator career card again, or refer to the science skills stickers in their notebooks:
    - *What are some of the things we did today as accident investigators?*
    - *How did we think like scientists? What science skills did we use?*
    - *What did you do today that made you feel like a scientist?*
3. Allow time for students to draw or write their reflections in their lab notebooks. Invite them to choose a science skills sticker that reflects a skill they used and add it to their notebooks.

Extend

- Investigate the role of the vehicles' weight in the collision. Ask students to change their model system by adding weights to or removing weights from the vehicles. How does changing the vehicles' weights affect what happens in different crash scenarios? Some possibilities to test:
  - The truck is only a little heavier than the car (remove some weight)
  - The truck is much heavier than the car (add more weight)
  - Both vehicles are cars (no weights)
  - Both vehicles are trucks (equal weights on both)
- Encourage students to create their own collision scenarios, test them with their model system, and draw accident scene diagrams with evidence based on the results of their tests. Challenge students to trade scene diagrams with each other and try to recreate the collision scenario from the scene diagram.
- Find out more about traffic engineering and the safety features road planners use to reduce collisions (speed limits, speed bumps, traffic lights, etc.). Imagine that the town government has asked your team to redesign the intersection where the accident happened to help avoid future accidents. Challenge students to find ways to model different safety features with their model systems, test how well they work, and create a drawing or physical model of their improved intersection.

Background

- **Accident investigators** examine evidence from an accident to determine what caused it. They might examine traffic accidents, aircraft or boat accidents, or accidents in a workplace or public area that caused injury or damage. Their reconstructions of an accident could be used by law enforcement and courts to determine who is at fault or should pay damages; they might also be used by local governments or businesses to make improvements that will keep similar accidents from happening in future. Because many accidents involve moving objects, accident investigators need to understand the **physics of motion** to work backwards from evidence like a vehicle's final position and determine how fast a vehicle was moving or where it traveled.
- **Any object that is moving has motion energy.** (Physicists use the terms *kinetic energy* and *momentum* to talk about two different aspects of this energy.) The amount of motion energy an object has depends on how heavy it is and how fast it is moving. **The heavier an object is, or the faster it is moving, the more motion energy it has.** An object's motion energy can be changed by applying a force to it, such as giving a ball a push to start it rolling, catching it to stop it rolling, or the friction of the ball against the floor gradually slowing it down.
- **When two objects collide, motion energy can transfer between them.** The collision can change how fast and in which direction each object is moving. The effect on each object depends on how heavy each one is and how much motion energy each one starts with. If a small, lightweight ball bumps into a (much heavier) child standing still, not much motion energy will transfer to the child. The child will stay still, and the ball will bounce off in the opposite direction. If a tall teenager bumps into the (much lighter) child, enough energy transfers to the child that they move backward—and probably fall over! In this activity, students explore collisions between a heavier object (the truck) and a lighter object (the car) to find out how factors like speed and direction affect the way motion energy transfers between them.

Accident Investigator Quick Guide

ACTIVITY SECTION	DO	ASK
Engage	Use career card to discuss career Introduce story: • Work for a team investigating traffic accidents • Look at evidence from car/truck collision to find out what happened Discuss everyday examples of collisions (ball hitting person)	*What do you think this person is doing?* *Have you heard the words "accident" or "investigate" before?* *What kinds of evidence might we use to find out what happened?* *If a ball hits you in the chest, what happens? Do you move? Does the ball move?* *What factors might affect how objects behave when they bump into each other?*
Explore	Introduce model system Test collision possibilities with car, truck, and grid sheet Test two drivers' scenarios and compare to accident scene diagram	*How do you think we could use these things to test what might happen in a real-life accident?* *What do you think will happen if the car is moving faster than the truck?* *How do these descriptions match the possibilities you tested earlier?* *How could we figure out what really happened?*
Reflect	Share group results Report conclusions Reflect on career connections Use stickers & notebook to draw/write reflections	*Which crash possibility fit the evidence best?* *What recommendations should we give the town about what happened?* *Do you have ideas about what the town could do to keep accidents like this from happening?* *How were we like accident investigators today?* *What science skills did you use?*