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Crash Dummy Fun

Description: Middle level students will soon be behind the wheel of a car. They are told that wearing a seat belt when riding in or driving a car is important and it is the law. For some young people, however, being told the right thing to do does not make it happen. Science class investigations of motion and force give the young driver information and experiences for assessing risk and making decisions. The study of motions and forces causing motion provide concrete experiences on which a more comprehensive understanding of force can be based. (taken from the NSTA Pathways to the Science Standards p.99)

Nils Bohlin, a Swedish scientist, developed the three-point safety belt that we use today. Students will read his short biography on the website www.ScienceHeroes.com and then conduct investigations dealing with Newton's first law (inertia).

Grade level: 6-8

Time: (2) 45 minute class periods

National Science Education Standards: (Objectives)

As a result of this activity students will develop a greater understanding about scientific inquiry and the ability to do it.

KEY INQUIRY SKILLS from National Content Standard F:

Personal Health:

The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal decisions. Injury prevention has personal and social dimensions.

KEY INQUIRY SKILLS from National Content Standard A:

- Pose investigable questions that may be answered through scientific investigations
- Design and conduct a scientific investigation
- Use simple measurement tools to collect data
- Identify dependent and independent variables and constants
- Present data in an organized format
- Use mathematics to analyze data
- Interpret data to form conclusions
- Apply experimental results to solve problems

UNDERLINED: UNDERLYING SCIENCE CONCEPTS (KEY IDEAS): National Content Standard B

- Newton's Law Number One: an object at rest will remain at rest unless acted on by an unbalanced force. An object in motion continues in motion with the same speed and the same direction unless acted upon by an unbalanced force. This law is often called "the law of inertia".
- This means that there is a natural tendency of objects to keep on doing what they're doing. All objects resist changes in their state of motion. In the absence of an unbalanced force, an object in motion will maintain this state of motion.
- When an unbalanced force acts on an object, the change in speed and/or direction depends on the size and direction of the force.
- An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.
- **Friction** happens when things rub against each other, and it slows down things in motion.

Materials:

Pencil, Paper or Science Notebook

Board or heavy cardboard (for ramp-length about .75m to 1.0 m and width at least 15-20 cm)

Books for propping up the board and one book for the barrier

Clamp (to fasten barrier down at end of table)

Toy cart or little car (available at dollar stores or science catalog)

Modeling clay

Meter tapes, one for each group of 4 members

Computer with internet access

Procedures:

Engage

Engage the students with a demonstration of what could happen when riding in a car without your seat belt on. Make a pendulum by attaching a hardboiled egg to a string (with tape) and attaching the string to a ring stand. Swing the egg so that it will hit a hard object. Tell the students to think of the egg as their head in a collision and what might happen to it without a seatbelt.

Ask students: Have we always had seat belts in cars? Why do we wear seat belts? Whose idea was it anyway? Have them go to www.ScienceHeroes.com on the computer and find the biography of Nils Bohlin. Tell them that after reading about this scientist they'll do an investigation that shows how his idea works and why it was necessary to prevent deaths.

Explore

1. Have students work in groups of 4 with each student making their own observations, collecting data, and answering questions in their science notebooks.

2. Mark the ramp into 20 cm intervals. Raise one end of the ramp about 30 cm from the table. Clamp a book down as a barricade about 50 cm from the bottom of the ramp.

3. Have one or two of the students in each group make a modeling clay "passenger". Place the passenger on or in the cart. Place the front of the cart at the 20 cm mark.

4. (It may be more realistic if students try to shape the clay in to a roughly human form.)

5. Ask them what they think will happen to the passenger when the cart hits the book.

6. Release the cart. Observe the motion of the passenger during and after the collision.

7. Measure the distance the passenger moves from the collision point to where it stops.

8. They should do at least 3 trials from this height recording their observations and measuring the distance. Make a table or chart to record your data. Be sure to average your data.

9. Release the cart from several different distances up the incline to vary the speed. Observe the motion of the passenger and measure the distances as above.

10. After all measurements are taken, secure the clay passenger into the cart using a rubber band as a seat belt. Roll the car down the ramp and observe what happens. Record your observations. Average the distances

Explain:

Seat Belts and Inertia

Moving objects have **momentum**. Newton's First Law of Motion says that unless an outside **force** acts on an object, the object will continue to move at its present speed and direction. Automobiles consist of several objects, including the vehicle itself, the passengers inside and any other loose objects in the vehicle. Unless the objects inside the car are restrained they will continue moving at whatever speed the car is travelling even if the car is stopped by a crash. Changing or stopping an object's momentum requires a force acting over a period of time. If momentum changes instantly, as in a car crash, the force is very, very great! If the momentum can be changed over a period of time, even a fraction of a second, much less force needs to be applied with less damage or injury. In a head-on collision, if a passenger flies into the dashboard of a car, their momentum is instantly stopped, and serious injury is often the result. If the passenger is restrained by a seatbelt, their momentum is reduced more gradually by the constant and smaller force of the belt acting over a longer period of time. Seatbelts can reduce the impact of a passenger to one-fifth of the impact suffered by the body of the car. (*may be a good place to end day #1)*

The Human Collision

Imagine running as fast as you can - into a wall. You'd expect to get pretty banged up. Do you think you could stop yourself if the wall suddenly loomed up when you were two feet away from it? This is exactly the situation you face when the front of your car hits something at only 15 miles an hour. The car stops in the first tenth of a second, but you keep on at the same rate you were going in the car until something stops you – the steering wheel, dashboard or windshield - if you're not wearing your safety belt..This is bad enough at 15 miles an hour, but a 30 miles you hit "the wall" four times as hard as you would at 15. Or to put it another way, with the same impact you'd feel as if you fell three stories.

Vocabulary. (*You may want to make sure your students understand these terms.)*

Momentum:

The product of the mass and the velocity of an object. Momentum is why the driver of a car applies the brake to stop the car rather than just taking his foot off the accelerator. The car has gathered momentum and will continue to move forward after the driver stops accelerating it. The greater the mass of the object, the more the momentum. Therefore it is harder to stop a large tractor trailer than a small compact car. Freight trains take much longer to stop than a short passenger train.

Velocity:

Speed in a certain direction (e.g. a car travelling along a straight road with a speed of 70 km/hour also has a velocity of 70 km/hour. A car traveling at 70 km/hour round a bend in a road has a velocity that is continuously changing as the car undergoes acceleration because its direction is constantly changing while in the curve.

Force:

A push or pull which causes acceleration, or a change in the shape of an object, or a reaction. A force is measured by the change in momentum produced in one second. A force cannot be seen, only its effects can be seen.

Elaborate and Connect:

Go to www. ScienceHeroes.com to answer the following in your science notebook.

- How many lives has the seat belt saved?
- How many injuries have been prevented because of the seat belt?
- How has this scientist impacted your life?
    - Can you think of a “catchy” headline to advertise the accomplishments of the science? Or draw a cartoon or picture to capture his work?
    - What was the forerunner of the current “cross the chest” seat belt? What were the problems with it?
    - Click on “Fun and Games” and then go to “Wit of the Sciences” and create your own cartoon about Nils Bohlin and the Seat Belt.

Evaluate:

After the above activities, have the students orally discuss or write into their science notebooks the answers to these questions:

- Describe the motion of the passenger during and after the front-end collision.
- How did the speed just before the collision change as the cart was released from further up the ramp?
- How did the distance the passenger rolled after the collision change as the cart was released from further up the ramp?
- Describe the motion of an unbelted passenger in a car which collides with a stationary obstacle.
- Seatbelts prevent a passenger from being thrown from the car. Why is it usually more dangerous to be thrown from the car than to remain in it?
- Can you design a “safety belt” for your “clay passenger”?
- Why can't air bags help when a car is rear ended?
- Should there be a law making wearing seat belts mandatory?
- How did Nils Bohlin’s knowledge of physics help him to design a better seat belt?

This lesson plan was written by Catherine Hesseldenz of Lexington, KY. She is a retired science teacher with over 33 years of experience at every grade level ranging from kindergarten to college seniors. Holding a Masters degree, she has also worked as the County Science Resource Teacher for the Fayette County Public Schools (50 schools) for 11 years, including organizing the county science fair and developing teaching materials for middle school programs through the University of KY.