

Seat Belts and Airbags

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Abstract

Safety restraints are an important feature of many vehicles, from cars and airplanes to roller coasters and boats. The purpose of Seat Belts and Airbags is twofold. It lets participants discover what makes a good safety restraint and why. Also, it gives participants the opportunity to play scientist. Using simple, non-intimidating equipment and studying something with which they are familiar, participants will feel confident about their own conclusions. Seat Belts and Airbags was originally developed as part of a college-level introductory physics laboratory.¹

Keywords: seatbelt, airbag, safety, momentum, force, impulse, pressure

Content Standards

K	1	2	3	4	5	6	7	8
	1.2.1			4.2.1				8.2.1
								8.3.2

History & Process Standards

K	1	2	3	4	5	6	7	8
	1.6.1			4.6.1				

Skills Used/Developed:

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I. OBJECTIVES

Students will:

- design various safety devices for clay passengers in toy cars and test their effectiveness.
- understand how seatbelts and air bags prevent injuries and save lives.

II. SAFETY

Do not stand on the ramps.

III. LEVEL, TIME REQUIRED, AND NUMBER OF PARTICIPANTS

A. LEVEL

This activity is intended for K-6th grade students.

B. TIME REQUIRED

45 minutes

C. NUMBER OF PARTICIPANTS

2 or 3 participants per setup. ScienceWorks has 4 complete setups.

IV. LIST OF MATERIALS

Each setup requires:

- Ramp
- Two bricks
- Small cart
- Clay
- Rubber tubing
- String
- Rubber band
- Shoelaces
- Small balloon

Also need:

- Scissors
- tape
- Standard screwdriver

V. INTRODUCTION

Safety restraints are designed to prevent injury in the event of an accident. Using the formal concept of momentum, force, impulse, and pressure, one can explain how safety restraints do just that.

In this activity, participants collide a toy car and clay passenger with a brick wall several times using a different safety restraint each time. With a real car and passenger, a collision with a solid wall would stop the car because the wall pushes on the car. But what stops the passenger? Before the collision, the passenger is moving just as fast as the car. Something has to push the passenger to stop it. The windshield or dashboard can stop the passenger, but that push is typically too hard and injures the passenger. The job of safety restraints then is to push the passenger to a stop in such a way that the passenger is uninjured.

From a physics point of view, the passenger has momentum (mass times velocity), and we must apply a force (push or pull) to stop the person, which will make the person's momentum equal zero because it will make the person's velocity equal zero. Momentum characterizes how hard it is to stop something. The more massive it is and the faster it's moving, the harder it is to stop and the more momentum it has. (For example: Could you stop a person walking toward you? How about a semi-truck speeding toward you?)

The passenger will be injured if the force applied to any part of its body is too large. A good safety restraint will minimize this force. One way to do this is to spread your push over a longer time. A smaller force applied over a longer period of time will slow an object just as a larger force over a smaller period of time. For example, a person bungee-jumping from a platform gets a smaller force (from the bungee cord) over a longer period of time (while falling), while the person who jumps without a bungee cord receives a large force (from the ground) over a very short period of time (when they hit the ground).

Another way to minimize the force is to spread the force over a larger area. A smaller force applied over a larger area will slow an object just as a larger force applied over a smaller area. For example, if someone throws you a baseball, you can stop it with the palm of your hand (large area, small force) or with your fingertip (small area, large force, and painful).

The safety restraints studied here are the padded dashboard (rubber tubing), the seat belt (string, rubber band, and shoelace), and the airbag (balloon).

VI. PROCEDURE

A. SETUP

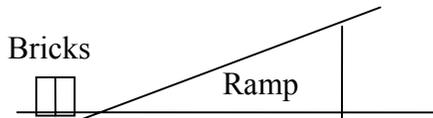
As with any demonstration, if this is your first time with Seat Belts and Airbags, make sure you run through it before presenting it. You should familiarize yourself with what kind of damage is done to the clay passenger and how to attach the seat belts and airbag.

Table space is preferable, but the equipment is durable and may be set up on any flat surface (on the sidewalk, in the grass, etc.) Lock the hinges of the ramp in place and you are ready to start. It is advised that you do not pass out any other equipment (cart, clay, seatbelts, etc.) until ready to use.

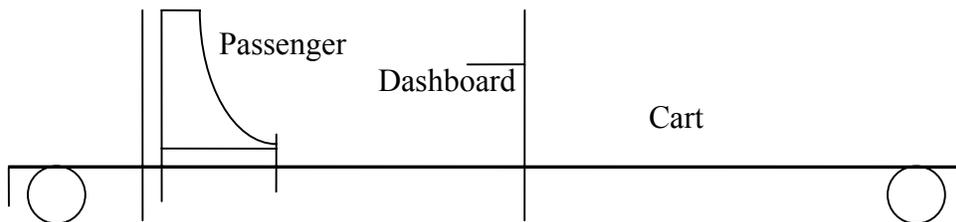
Note: The wheels on the carts tend to become loose and can be tightened by hand or with a screwdriver.

B. EXECUTION

- Start with a group discussion of seatbelts. Do the participants wear them? Why?
- Hand out the lab worksheet and have each student or each group of students do the following (the procedure is also written on the worksheet).
- Set up a ramp and bricks as shown in the drawing.



- Make a passenger out of the clay. Be sure the surface of the passenger is smooth. Place it in the cart (metal switch box) as shown.



- Place the cart at the top of the ramp and release it so that it runs into the bricks.

The passenger had gashes on the chest and arm and the bottom of the passenger was scraped. Note that the ‘injury’ to the passenger may be more or less when you try this demonstration depending on the angle of incline of the ramp, the shape of the passenger, etc. The important thing is to make sure that the shape of the passenger, the smoothness of the passenger, the angle of incline of the ramp, etc is the same for each safety device so that valid comparisons can be made. Passenger must be well smoothed after every crash to distinguish from damage done during previous crashes.

Group Discussion: Participants should understand that passenger keeps moving even though the cart has stopped and that a safety restraint is needed to stop the passenger. Discuss how to protect passenger.

- Place the rubber tubing over the dashboard. You’ve just made a “padded dashboard”. Remodel the passenger and place it in the cart. Put the cart at the top of the ramp and release it.

Here there were no gashes on the chest or arms, but the bottom of the passenger was again scraped.

- Remove the rubber tubing and remodel the passenger. Make three different seat belts using a thread, rubber band, and a shoelace. Test each seat belt in turn by releasing the cart from the top of the ramp and observing the results.

When using the thread, the sides of the passenger's torso were cut by the thread.

When using the rubber band, there were gashes on the chest and arm. The bottom of the passenger was also scraped, but it was not scraped as much as it had been with no seatbelt.

When using the shoelace, the passenger appeared unharmed.

- Remodel the passenger. Choose the seat belt that worked the best and make a shoulder harness from the same material. Put the seat belt and shoulder harness around the passenger. Place the cart at the starting mark and release.

With the shoelace lap and shoulder restraints the passenger appeared unharmed.

Group Discussion: What makes a good seatbelt? Discuss idea of reducing the push (force) on the passenger to prevent injury. Discuss idea of "smaller force over longer time" (impulse) and "smaller force over larger area" (pressure). Compare shoelace to string. String applies larger force to a smaller area. Compare shoelace to rubber band. Rubber band applies smaller force over larger time (it stretches), but does not slow passenger enough to keep it from hitting the dashboard.

- Remove the seat belt and shoulder harness and remodel the passenger. Prepare the balloon as described:
 - The balloon should be filled with just enough air to support its walls. (If the balloon is over-inflated, the passenger may bounce back with considerable force.) The ends may be tied with thread to prevent the air from being pushed into either end of the balloon.
 - Tie or tape the balloon to the cart so that it covers the dashboard. Press you finger into the balloon. The balloon should resist so that you do not feel the dashboard. (You may have to put more air in the balloon.)
 - Put a strip of tape around the sides of the car to keep the passenger inside.
- Place the car at the top of the ramp and release it.

The bottom of the passenger was scraped about as much as it was with the rubber band.

- Now you could see what happens in other sorts of collisions. Ask the participants for ideas or suggest some yourself. e.g.: head on collision of two cars, side collision with another car, small versus large passengers, and the ever popular four-car pile-up.

C. CLEANUP

- Make sure clay is in ziploc bags and bags are sealed. Otherwise the clay dries up.
- Tiny bits of clay will be scattered about during the lab. Warn your host ahead of time and make appropriate arrangements if cleanup is a problem.
- Return all equipment to the tubs.

VII. FREQUENTLY ASKED QUESTIONS

Why aren't there seat belts on buses?

Most accidents are with other cars. When a bus hits a car, the bus is so much bigger that usually it keeps going. You may be thrown into the seat in front of you, but usually not hard enough to cause serious injury.

VIII. HANDOUT MASTERS

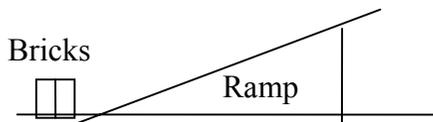
The following lab handout is reprinted from *Multimedia Physics Laboratory I*, V.L.Plano, C.J. Moore, R.G. Fuller, C.R. Lang and adapted from "Packaging Passengers", Individualized Science Curriculum Study, Florida State University. © 1994 University of Nebraska

SEAT BELTS AND AIRBAGS

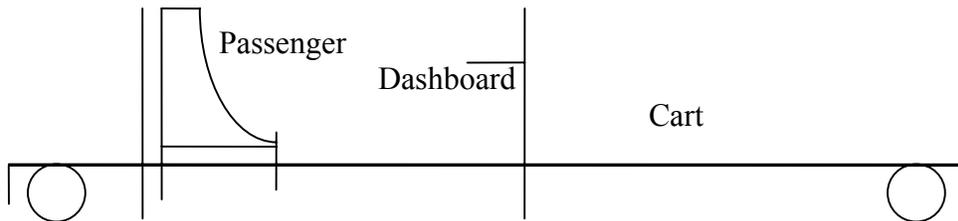
Equipment:

- Ramp
- Cart
- Modeling Clay
- Bricks, 2 per ramp
- Rubber Tubing
- Thread, Rubber Bands, and Shoelaces
- Balloon
- Tape

- Set up a ramp and bricks as shown in the drawing.



- Make a passenger out of the clay. Be sure the surface of the passenger is smooth. Place it in the cart (metal switch box) as shown.



- Place the cart at the top of the ramp and release it.

1. What happens?

2. Describe the damage to the passenger.

- Place the rubber tubing over the dashboard. You've just made a "padded dashboard".

Remodel the passenger and place it in the cart. Put the cart at the top of the ramp and release it.

3. Describe what happens to the passenger this time when the cart hits the bricks.

- Remove the rubber tubing and remodel the passenger. Make three different seat belts using a thread, rubber band, and a shoelace. Test each seat belt in turn by releasing the cart from the top of the ramp and observing the results.

4. What happened when you used the thread?

5. What happened when you used the rubber band?
 6. What happened when you used the shoelace?
 7. Compare the effect of the three types of seat belts.
- Remodel the passenger. Choose the seat belt that worked the best and make a shoulder harness from the same material. Put the seat belt and shoulder harness around the passenger. Place the cart at the starting mark and release.
8. Describe any damage to the passenger.
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- Remove the seat belt and shoulder harness and remodel the passenger. Prepare the balloon as described:
 - The balloon should be filled with just enough air to support its walls. (If the balloon is over-inflated, the passenger may bounce back with considerable force.) The ends may be tied with thread to prevent the air from being pushed into either end of the balloon.
 - Tie or tape the balloon to the cart so that it covers the dashboard. Press your finger into the balloon. The balloon should resist so that you do not feel the dashboard. (You may have to put more air in the balloon.)
 - Put a strip of tape around the sides of the car to keep the passenger inside.
 - Place the car at the top of the ramp and release it.
9. Describe what happens to the passenger and any damage it sustained.
 10. Considering your results from this experiment, write a few sentences about whether or not people should use seatbelts.

IX. REFERENCES

Multimedia Physics Laboratory I, V.L.Plano, C.J. Moore, R.G. Fuller, C.R. Lang. Adapted from “Packaging Passengers”, Individualized Science Curriculum Study, Florida State University. © 1994 University of Nebraska. All rights reserved

X. GLOSSARY

Safety Restraint - Any device, such as seat belts, airbags, and padded dashboards, designed to prevent injury to a person.

Momentum - characterizes how hard it would be to stop a moving object. [Momentum = Mass x Velocity]

Force - a push or a pull

Impulse - measure of the strength and duration of a collision. [Impulse = Force x Time]

Pressure - the force applied to a surface. [Pressure = Force/Area]