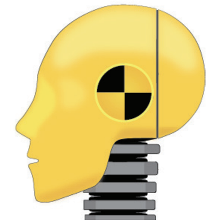
STUDENT ACTIVITY

Name: ____________________ Class: __________ Date: ___________

IIHS IN THE CLASSROOM

PAIN IN THE NECK



MATERIALS NEEDED

Per pair of students

» 1 tennis ball or similar size ball
» 1 hardcover textbook or clipboard
» 1 metric ruler

Per student

» 1 “Pain in the Neck” Student Activity Sheet

Key Question(s)

» What is whiplash?
» How does Newton’s first law of motion affect the type and severity of head/neck injuries resulting from rear-end collisions?
» How do well-designed vehicle head restraints help prevent head/neck injuries in a rear-end collision?

Purpose

» To investigate how a body responds to crash forces in a rear-end collision.
» To explain how Newton’s first law of motion (the concept of inertia) applies to the movements of a crash dummy’s head and neck during a rear-end collision.
» To identify the characteristics of seat/restraint designs that receive “Poor” versus “Good” IIHS ratings.

Did You Know?

Neck sprains and strains, commonly known as whiplash, are the most frequently reported injuries in U.S. auto accident insurance claims. The term “whiplash” is used to describe a variety of neck injuries that often occur in rear-end crashes. The IIHS uses crash dummies with a realistic moving neck and spine to conduct rear-end crash tests of seats and head restraints to determine how well they protect occupants against whiplash injuries. In this activity you will work with a partner to investigate the science behind rear-end collisions and learn how well-designed vehicle head restraints prevent whiplash injuries in these types of crashes.

Procedure

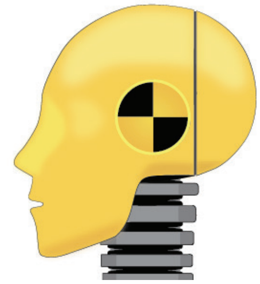
Part 1 - Simulating Crash Dummy Head Responses in Different Vehicle Movement Scenarios

1. Work with a partner and follow the steps below to investigate how a crash test dummy’s head responds to three different types of vehicle movement using a tennis ball to represent the dummy’s head and a book (or clipboard) to represent the dummy’s body seat-belted into a vehicle’s front seat. Then, use your observations and work together to answer the analysis question.

2. Decide which role each of you will perform: “walker” or “recorder/observer.”

  a. Walker: Hold the book or clipboard horizontally with the ball in the center on top of the book and walk forward or backward as described in each scenario. See Figure 1.

  b. Recorder: Record your team’s agreed-upon predictions, observe the movement of the ball relative to the book as the walker completes each simulation, and record these observations on both the walker’s and the recorder/observer’s Pain in the Neck Activity Sheets.



Procedure (continued)

3. Complete the predictions and observations for Scenarios 1, 2, and 3.

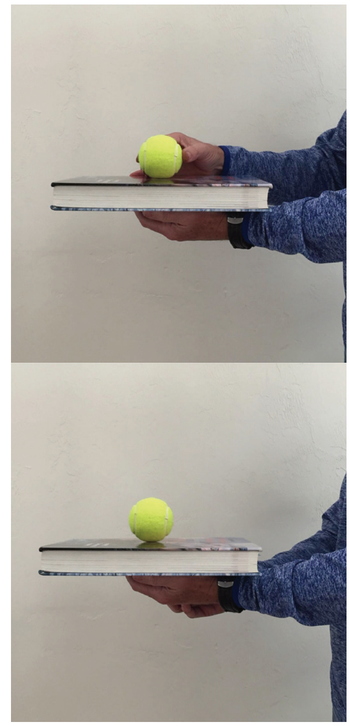


Figure 1

Scenario 1

a. Predict what direction the ball will move when the "walker" quickly walks the book **forward**.
We predict the ball will move: *(circle one)*

forward backward

b. **With the "walker" standing still and the tennis ball sitting motionless on top of the textbook, the "walker" should then take a few quick steps forward with the book. Observe which direction the ball moves.**
We observed the ball will move: *(circle one)*

forward backward

Scenario 2

c. Predict what direction the ball will move when the "walker" quickly walks the book **backward**.

We predict the ball will move: *(circle one)* forward backward

d. ***SAFETY NOTE: Before the "walker" steps backward, make sure nothing or no one is directly behind him/her.*** Standing still with the tennis ball sitting motionless on top of the textbook, the "walker" should then take a few quick steps **backward** with the book. Observe which direction the ball moves.

We observed the ball moving: (circle one) forward backward

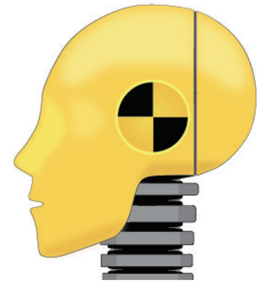
Scenario 3

a. Predict what direction the ball will move when the "walker" steadily walks **forward** with the ball on the book and then suddenly stops.

We predict the ball will move: *(circle one)* forward backward

b. While keeping the ball on top of the book with a light touch of his/her hand, the "walker" should then steadily walk **forward** at a constant pace as they gently let go of the ball so the ball remains motionless in the same spot on top of the book. Then the "walker" should stop suddenly. Observe which direction the ball moves.

We observed the ball moving: (circle one) forward backward



Analysis Question

4. Which scenario in the simulations you just completed best represents the way a crash dummy's head (tennis ball) would move if the body was buckled into a seat (the textbook) but the head was unsupported and the stationary vehicle was then hit from behind by another car?

Circle one:

a. SCENARIO 1 - Standing still and then quickly walking forward
b. SCENARIO 2 - Standing still and then quickly walking backward
c. SCENARIO 3 - Steadily walking forward and then stopping suddenly

Part 2 - Simulating a Rear-crash Test in a Seat <u>Without</u> a Head Restraint

5. When the IIHS conducts rear-end crash tests of seats and head restraints, the front seat is removed from a vehicle and bolted to a steel sled. A special dummy is then belted into the seat. *This special dummy, called a BioRID rear-impact dummy (see Figure 2), has a spine composed of 24 articulated vertebra-like pieces that produce the same movements that occur in human necks and spines during real-world rear-end vehicle crashes.* The sled is then hit from behind by an air-powered ram while the sled is standing still.

Using a tennis ball, textbook, and metric ruler, follow the steps below to simulate the effects of a rear-end crash test on a crash dummy's head and body if it is strapped into a seat without a head restraint. Then, after your teacher reviews Newton's First Law of Motion and the concept of inertia, use your observations from this simulation and work together to answer the analysis question.

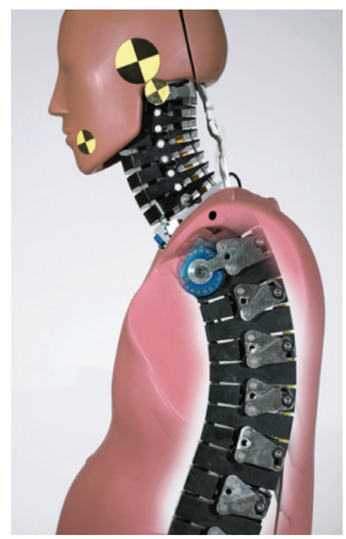


Figure 2

a. Place the textbook on top of a table or counter with about 6 cm of the bottom of the book hanging off the edge of the table. See Figure 3.

b. Place the tennis ball in the center on top of the book.

c. Strike the end of the book hanging off the edge of the table with the open palm of your hand and observe what happens to both the book and the ball.

d. On Figure 3 below, draw one line and arrow from the star on the ball and one line and arrow from the star on the book to show which direction each item moves during a simulated rear-end collision.

e. Draw a vertical line next to the ball indicating where a head restraint should be placed in order to best protect the crash dummy's head in a read-end collision.

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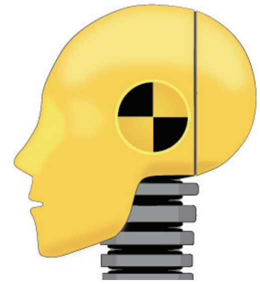

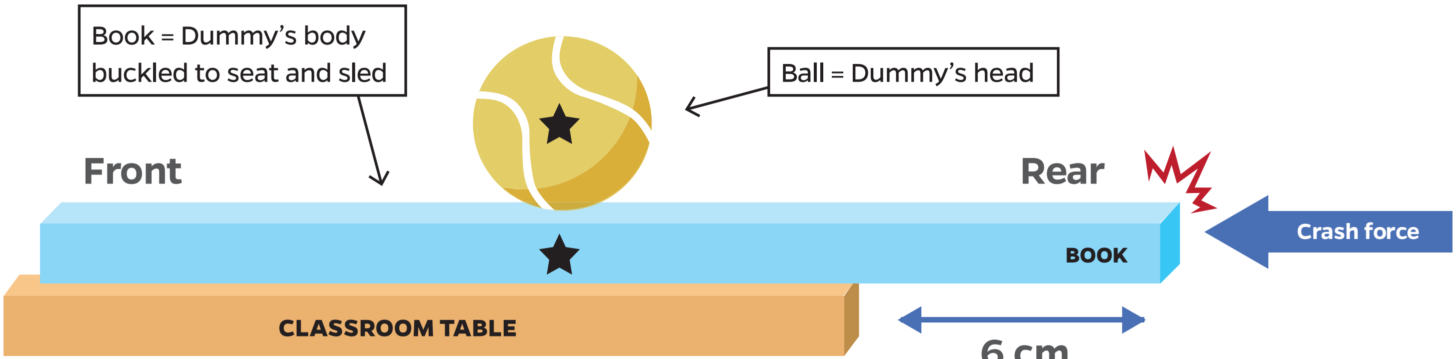

Figure 3

Analysis Question

6. The drawings in Figure 4 below depict the skull and 7 neck vertebrae in the BioRID dummy BEFORE and DURING a rear-end crash test using a vehicle seat that does not have a head restraint. According to Newton's First Law of Motion, an object at rest will remain at rest and an object in motion will remain in motion unless acted on by an outside force. This is also known as the concept of inertia. In the chart below, use the concept of inertia to explain the differences between the movement and positions of the skull and the neck vertebrae BEFORE and DURING a rear-end crash test of a seat without a head restraint.

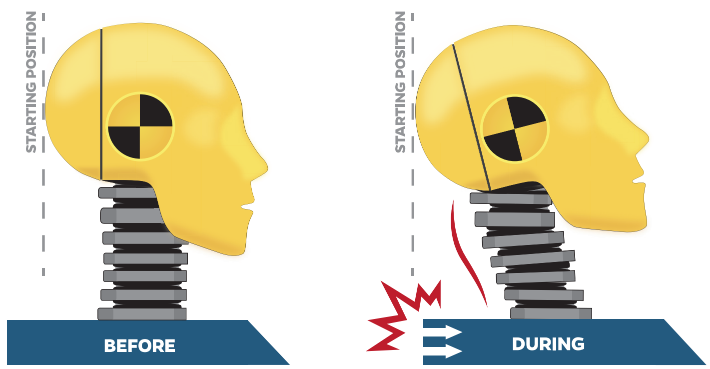

Figure 4

SKULL BEFORE REAR-END CRASH	SKULL DURING REAR-END CRASH

NECK VERTEBRAE BEFORE REAR-END CRASH	NECK VERTEBRAE DURING REAR-END CRASH

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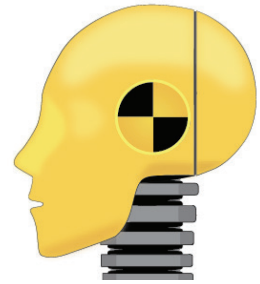

Part 3 - Identifying the Characteristics of Effective Vehicle Seat/Head Restraint Designs

Properly designed seats and head restraints can significantly reduce both the number and severity of whiplash injuries in the event of a rear-end collision. Watch the video segment and examine the photographs provided to learn more about how the IIHS determines the characteristics of effective seat/head restraint designs. Then work with your partner to answer the analysis questions.

7. With your class or partner, watch the 2.5-minute video **"Inside IIHS: Rear testing for whiplash prevention"** located on the *IIHS in the Classroom* homepage (classroom.iihs.org) within the Inside IIHS tab. While viewing the video, complete the fill-in-the-blank statements below with the correct terms.

a. At running time 00:35, David Zuby (Chief Research Officer) states:

"The measurements from the dummy are then used to judge which seats are doing a better job of moving the ______________________________ together with the rest of the body in a way that reduces the stresses and strains within the neck."

b. At running time 00:50, Ronnie Wells (Engineering Technician) states:

"The sled is a steel flatbed that runs on rails that can be programmed to produce specific ______________________________ and decelerations."

c. At running time 02:05 David Zuby states:

"We've done a study that shows the seats we've rated as ______________________________ do in fact reduce the risk of ______________________________ injury."

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8. Figure 5 below contains a series of photographs from slow-motion videos of rear-end crash tests of vehicle seats/ head restraints from two different vehicles: one with a "Poor" rating and one with a "Good" rating. Compare the four picture frame sequences for the tests of Seat 1 and Seat 2 to answer the analysis questions. (HINT: Look closely at the positions of the crash dummy's head compared to the head restraint during each frame of the sequence.)

FRAME 1 **FRAME 2** **FRAME 3** **FRAME 4**

SEAT 1

SEAT 2

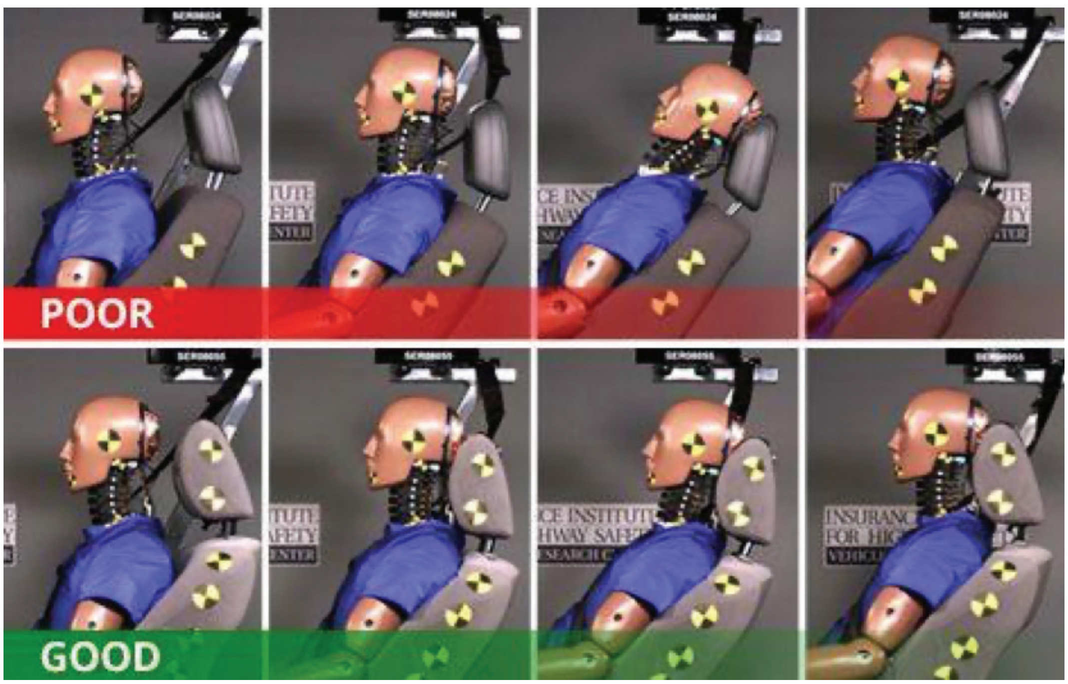
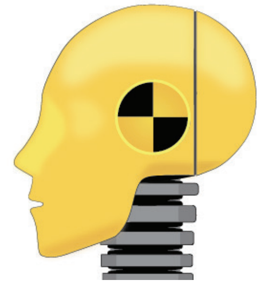


Figure 5 - Rear-End Crash Test Slow-Motion Video Images

For each frame, describe how the positions of the head, neck, and headrest differ for Seat 1 and Seat 2 in Figure 5.

FRAME	SEAT 1	SEAT 2
1		
2		
3		
4		



9. Based on your analysis of these images, identify the characteristics of a head restraint that provides more protection against whiplash injuries in a rear-end collision by circling the best responses.

a. Horizontal distance between the head rest and the back of the dummy's head

Circle one: Head rest close to the back of the dummy's head

Head rest farther away from the back of the dummy's head

b. Vertical height of the head rest relative to the top of the dummy's head

Circle one: Head rest well below the top of the dummy's head

Head rest near the top or above the top of the dummy's head