Crash Test Dummies – Worksheet

By Louise Lopes, based on the workshop investigation by Ian Bentley & John Long

Introduction:

One of the key elements of modern automobile design is safety. Forty years ago, cars were designed to withstand a crash with as little damage to the car as possible. Now cars are designed so that the car takes as much damage as possible, leaving the driver and passengers safer during a collision.

Figure 1 - Holden Astra (May 2017 – onwards) frontal offset test at 64km/h.

In this activity, you are an automotive test engineer. Your task is to investigate what happens to someone in a car during a crash. You will do this by taking high-speed video footage of different kinds of crashes and examining what happens to the occupant during the crash.


Figure 2

Activity One

Question:
In this experiment, teddy is a passenger at the back of the car and the car crashed into a wall. Ted is not wearing his seatbelt. What happens to Teddy during the crash?

Plan:

This investigation has been planned for you.

These are the **materials** you will be using:

- Trolley
- Beanie teddy bear (driver or passenger)
- 2-metre ramp
- Obstacle to crash into.
- Go-Pro camera or a modern I-phone with a high-speed camera.
- Computer with VLC media player (or equivalent) installed
- Cardboard for making a seat and a crumple zone.
- Sheets of photocopy paper
- Sticky tape.
- Blu-tack (or similar)
- Tape measure
- Stopwatch

Figure 3

These experiments contain fast moving objects. Ensure the area is cleared and you let others know when a trolley is in motion.

Conduct:

1. Using the supplied cardboard and sticky tape, construct a seat for Ted so that he does not fall off the trolley before the collision.

2. Construct a ramp for the trolley to run down. Use more cardboard to make a smooth transition between the ramp and the floor.

3. Use a motionless obstacle, like a brick, for a crash barrier to stop the trolley.

4. Run Ted and the trolley down the ramp and crash it into the crash barrier.

5. Video-record the collision with a high-speed camera. Place a stopwatch in the view of the camera to monitor time.

6. Perform the crash for three different heights of the ramp, corresponding to three different impact speeds – slow, fast, and fastest.

Analysis:

1. Draw a picture of your ramp and crash barrier.

2. Study the video footage in slow speed. For each ramp height, describe below the motion of the trolley and Ted during the collision.

3. From the stopwatch data, determine the average time it takes for the trolley to stop and Ted to stop.

Problem-Solving:

4. Below are Newton's three laws. Circle which law/s apply in this collision and make a note about how it applies. For one crash, how many collisions are there?

Newton's First Law

Objects at rest stay at rest. Objects in motion stay in a straight line motion unless subjected to an unbalanced force.

Newton's Second Law

The net force acting on an object is equal to the mass of the object multiplied by its acceleration: $F=ma$

Newton's Third Law

When one object exerts a force on a second object, the second object exerts an equal and opposite force back on the first object.

Activity Two

Question:
In this experiment, teddy is the driver at the front of the car and the car crashes into a wall. There is no windscreen and no seat belt. What happens to Ted during the crash?

Conduct:

1. Using the supplied cardboard and sticky tape, construct a seat for Ted so that he does not fall off the trolley before the collision, and the seat is at the same level as the front bulkhead of the trolley.

2. Construct a ramp for the trolley to run down. Use more cardboard to make a smooth transition between the ramp and the floor.

3. Run Ted and the trolley down the ramp and crash it into a motionless obstacle, like a brick.

4. Video-record the collision with a high-speed camera. Place a stopwatch in the view of the camera to monitor time.

5. Perform the crash for three different heights of the ramp, corresponding to three different impact speeds – slow, fast, and fastest.

6. For each ramp height, measure how far Ted flies away from the trolley.

Figure 4

Kinetic Energy: Energy that an object has by virtue of its motion

Analysis:

1. Study the video footage in slow speed. For each ramp height, describe below the motion of the trolley and Ted during the collision.

2. From the stopwatch data, determine the average time it takes for the trolley to stop and Ted to stop.

Problem-Solving:

3. Below are Newton's three laws. Circle which law/s apply in this collision and make a note about how it applies.

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4. Determine the pattern between ramp height and how far Ted travels from the site of the collision and where he stops.

Activity Three

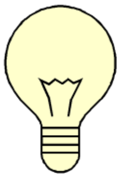
Question:

In this experiment, you will add a crumple zone to the front of the trolley. Does the crumple zone lessen the impact on Ted?

Conduct:

1. Using the supplied materials and sticky tape, construct two different crumple-zone bumpers for the trolley. One is paper, one is cardboard.

2. Repeat the previous two investigations with the different crumple zones.



Crumple zones: Parts of a car designed to take the hit so that the occupants are protected. The crumple zone absorbs the **kinetic** energy instead of the driver.

Analysis:

1. Draw a picture of your paper crumple-zone bumper.

2. Draw a picture of your cardboard crumple-zone bumper.

Problem-Solving:

3. Study the video footage and measurements in slow speed. For each ramp height, determine if the crumple zone gave Ted any protection during the crash. Which material made the more effective crumple zone? For instance, when Ted is the passenger, is there any change to his motion during the collision? When Ted is the driver, does he fly as far during the collision?

Activity Four

Question:

In this experiment, one trolley with Ted1 as passenger collides with the rear of a second stationary trolley with Ted2 as the driver. During the collision, what happens to both Teds?

Conduct:

1. Design and perform an experiment to determine what happens in a rear-end collision. The driver of the front trolley has a seat but his head is free to move. The passenger of the rear trolley is not secured to his seat. Perform the experiment for slow, fast, and faster impact speeds.

Figure 5

Analysis:

1. Draw a picture of the design of your rear-end collision.

Problem-Solving:

2. Below are Newton's three laws. Circle which law/s apply in this collision and explain how it applies.

Newton's First Law

Objects at rest stay at rest. Objects in motion stay in a straight line motion unless subjected to an unbalanced force.

Newton's Second Law

The net force acting on an object is equal to the mass of the object multiplied by its acceleration: $F=ma$

Newton's Third Law

When one object exerts a force on a second object, the second object exerts an equal and opposite force back on the first object.

For All Activities

Problem-Solving:

Discuss which results you got that were expected and which were unexpected.

Refer to the drawings you made, can you think of any problems with the experimental design which could have impacted the results **OR** what else could have been done to make the experiment more reliable (a fairer test)?

Conclusion:

What can you conclude about what happens during a front collision car crash?

What is the difference of sitting at the front versus sitting at the back in a car during a collision?

What can you conclude about designing a car to better protect passengers during a crash?

What can you conclude about what happens during a car on car collision?

Image References:

Figure 1 - Photograph © Australasian New Car Assessment Program (ANCAP). http://www.ancap.com.au/safety-ratings/holden/astra-25ad9072-b3da-4fb0-863e-37045a3cac7c/4fc8d4/images-and-video

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