Western Engineering Outreach

Helmet Protection

Grades 6-8

Meet Today's ENG HERO!

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Dr. Mao has worked as a research scientist to create a blast-induced traumatic brain injury (TBI) research program. He has spent many years conducting research with many impact biomechanics research institutes. Recently, his research has included understanding the mechanics of TBI and proposing engineering solutions for better protecting the brain. Dr. Mao's research group also conducts research to improve active/passive vehicle safety for better occupant/pedestrian safety in car crashes. Learn more about his research here: https://www.eng.uwo.ca/mechanical/faculty/mao_h/index.html

Learning Goal:

- Students will learn about Newton's first law of motion and the concept of inertia
- Students will consider how forces affect the system of a cyclist
- Investigate the forms a helmet can take to perform its function
- Curriculum Connections: Grade 7: Form and Function, Grade 8: Systems in Action

Materials Needed:

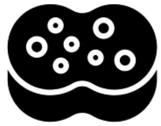
Today's activity is a design challenge. Here is a list of suggested materials, but whatever you have on hand can be used for this activity.

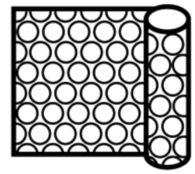
For the "brain" simulation

- Jell-o (Make according to package instructions)
- A container for the jello
- Alternatively: a small watermelon

For the helmet:

- Cardboard
- Plastic containers
- Glue
- Scissors
- Tape
- Paper
- Bins
- Bubble wrap
- Sponges
- Styrofoam



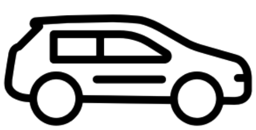


Engineering and Science Connections:

Today we will be talking about inertia and the forces at work on the system of an individual riding a bike. Understanding these forces will demonstrate how important it is to wear a helmet on your bike.

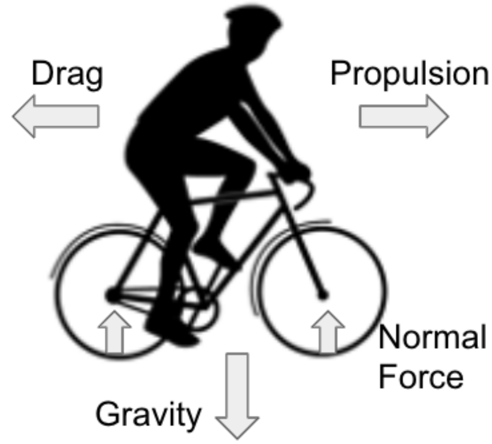
Inertia

Have you ever wondered why you feel yourself continuing to move forward when a car or bus stops at a red light? Why your skateboard continues to roll even if you take a spill? This is due to Newton's first law of motion, also known as the law of inertia. It states that "an object at rest and an object in motion stays in motion with the same speed and same direction unless acted upon by an unbalanced force". Basically, objects have the tendency to continue doing what they're doing and resist changes in their state and motion. This tendency is referred to as **inertia**.



If it weren't for friction, the law of inertia would dictate that objects would continue to move at a constant speed and direction indefinitely unless another force acts on them. We see this in space, which is a vacuum in which friction is not a factor. Spacecraft barely need any propulsion to move forward once they're in space because once friction and air resistance are eliminated the spacecraft's inertia keeps it in a constant state of motion.

System: A Cyclist



The above diagram shows the system of a cyclist.

- Gravity is a force we are likely all familiar with. It acts towards the centre of the Earth, pulling objects (and us) to the ground.
- The normal force is also known as the reaction force by the ground onto the object. This is the force that keeps objects from being pulled into the ground to the centre of the Earth by gravity.
- The propulsion force is created by the rider by cycling the pedals.
- The drag force includes both air resistance and the friction on the wheels in this diagram. This force acts in the opposite direction to the propulsion force.

If the cyclist in the diagram were to suddenly stop pedalling, they would continue to move forward but would slowly decelerate due to the lack of propulsion force. The drag force would overpower the propulsion and slow the cyclist to a stop.

Now imagine our cyclist was going very fast down a hill and suddenly hit a big rock.

Inertia, which we covered in the last section, dictates that the cyclist will continue to move forward in the same direction with the same speed, even when the bike has stopped moving. Now, the only force acting on the cyclist is gravity, which is why they will have quite a nasty fall as soon as the bike is no longer holding them up.

Clearly, the faster you're going, the worse the spill will be if you hit an obstacle. This is why bike safety is crucial. As exciting as it can be to rip down a hill on your bike, as students of physics we understand the laws of motion and know exactly what will happen if we hit an obstacle due to the concept of inertia. Our brains control every single thing we do and need to be well protected on a bike ride. Luckily, there are handy things that exist to do just that: helmets!

Parts of a Helmet

- hard and slick shell
  - an outer protective layer. Smooth to reduce air resistance.
- crushable liner
  - helps distribute the force of a crash to the entire padding layer
- padding layer
  - the soft part that helps absorb the impact force
- strap system
  - holds the helmet onto your head
- Vents
  - Allows air flow in the helmet

Video Recommendation: *How DO Helmets Work? Let's use science to find out!*

https://www.youtube.com/watch?v=wF-Ft8FG2Mg

In the above video, watermelons are thrown on the ground with and without helmets on with some very interesting results!

Activity:

Before you start, think about the following questions:

- How does the law of inertia explain cycling and skateboarding accidents?
- What do you think will happen when you throw the helmet and 'brain' on the ground?

Out of Stock

Because of the COVID-19 restrictions, more and more people are taking up cycling as a fun activity or a means of exercise. The demand for bikes and bike safety equipment has increased hugely! Unfortunately, bike shops have been struggling to keep up with the demand and a lot of helmets are going out of stock. Specifically, the helmets aimed towards teenagers and preteens. Obviously, running out of helmets is a big problem. However, the bike shops have taken this opportunity to reach out to local youths to get their design ideas to make some new helmets.

Your challenge is to design a helmet that will protect a bowl of Jell-o or a small watermelon. Keep in mind it needs to absorb and distribute a lot of force that comes from a crash. Also, keep in mind the different parts of a helmet and their function to create a helmet with the proper form. Additionally, the helmet should be aesthetically pleasing and geared towards teenagers/preteens.

The Test

Once your helmet is designed and the prototype is built, place the Jell-o 'brain' or small watermelon into the helmet and throw it on a hard surface on the ground (outside, of course). A paved driveway would make an ideal test location. Make observations on the condition of the helmet and the 'brain'. Did whatever happen match your predictions? Why or why not? Make note of what went well and what could be improved upon.

Using the results of your first test, improve and redesign your helmet and test it again. What changed? Were the results better or worse?

What Did You Learn?

- What is inertia?
- Which forces act on a cyclist while riding? When an obstacle is hit?
- What are the parts of a helmet and their purposes?
- How does the law of inertia explain why falling off a moving bike hurts a lot more than falling while standing still or walking?

Future Learning

- Try the test on a jello 'brain' or small watermelon **without** a helmet. What changed? What does this tell you about bike safety?
- Research the most common causes of bike accidents. How does this relate to the principles and forces that we discussed?

Share your creations!

We would love to see what you made. Email as at discover@uwo.ca or tag us on social media.

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Thanks for discovering with us!