MAINE MOBILE BIOLAB
STUDENT HANDOUT

Name:	

It's All in Your Head

Understanding Concussions and Helmet Design

Concussions, a type of Traumatic Brain Injury, may be caused by a blow to the head or a violent shaking of the head and body. Concussions are a hot topic in sports that involve regular head impacts, such as football and soccer. Victims may also suffer concussions from car accidents, epileptic seizures, and extreme sports such as skateboarding and cycling. If an individual suffers a large number of concussions during their lifetime, long term effects including **neurodegeneration**, the progressive loss of structure or function of neurons, may occur. As research on the mechanism behind concussions and the long-term effects continues, there may be a way to prevent neurodegeneration in at-risk individuals**.**

One of the main ways to prevent long term injury is to prevent as many high impacts as possible. Taking ideas from military helmets, engineers around the world have been designing helmets that decrease the force of an impact to lessen the chances of a concussion during sporting events. The National Football League was one of the first organizations to make helmets a mandatory piece of equipment in their games in 1943. Since then, other sports organizations, like the NHL and MLB, have also required helmets for their games. Even some state legislatures have written laws requiring people to wear helmets when riding bicycles or horses.

Helmets utilize Newton's Third Law of Motion to help reduce injuries. Newton's Third Law of Motion states that every force has an equal and opposite reactionary force. For example, when a person punches a brick wall, their fist exerts a force on the wall and the wall exerts an equal force in the opposite direction on the fist. Helmets help to reduce the forces experienced in these types of collisions.

As a materials engineer, it is your job to help design a helmet that will decrease the chances of a concussion. To do so, you will utilize slow motion cameras with a model brain to visualize what happens to the brain during an impact to cause a concussion. You will then test a series of different materials for their ability to decrease impact forces.

QUICK CHECK: What are concussions and how are they caused?

PART 1 – Understanding Concussions Using a Model

Goal: To identify and explain the mechanism behind concussion.

MATERIALS:

- Brain model
- Metal stand and clamp
- Tennis ball on string
- Phone/camera

1. Locate the plastic container that will serve as a model skull. The golf ball inside is a model brain, and the fluid simulates cerebrospinal fluid.
2. Lift the tennis ball to a 45˚ angle, keeping the string taut.
3. Record a slow-motion video of the brain model from the side as you release the ball.
4. Observe the video and record your observations in Table 1.

TABLE 1

Part of Model	Observations
Skull and Fluid	
Brain	

QUICK CHECK: The action force was provided by the falling tennis ball. Was there a reaction force from the skull? How do we know? *(Hint: If there was no reaction force, the tennis ball would continue moving in the same direction.)*

5. Lift the tennis ball to a 90˚ angle, keeping the string taut.
6. Record a slow-motion video from above the side as you release the ball.
7. Observe the video and record your observations in Table 2.

TABLE 2

Part of Model	Observations
Skull and Fluid	
Brain	

QUICK CHECK: How does the increase in angle affect the motion of the brain?

PART 2 – Materials Testing for a Helmet

Goal: To identify and explain the mechanism behind concussions.

MATERIALS:

- Force plate
- LabQuest
- 6 lb. medicine ball
- Flexible foam
- Microbead pillow
- Meter stick

Zeroing the Force Plate

1. On the LabQuest, click on the upper left corner picture of an odometer. A red bar with the Force Meter should appear. Click anywhere in the red bar and a drop-down menu will appear. Select "Zero," making sure there is nothing on top of your force plate and cords are not touching the surface.

Data Collection:

2. To collect your data, hit the green play button on the bottom left-hand corner of your screen. The screen should say "Waiting for trigger value to rise above 2.5 N."
3. Hold the medicine ball so the bottom of it is 50 cm above the center of the force plate.
4. Drop your medicine ball onto your force plate and a graph will appear on the LabQuest.
5. Use your finger to highlight the collision. This is the large curve that appears. Select from t=0 until the graphed curve shows a force of 0. (From where the red line leaves the x-axis, to where it touches the x-axis again.)
6. From the top menu bar, select "**Analyze**," then "**Statistics**," and finally "**Force**."
7. On the right side of the screen the data from your trial will appear.
8. Write down your peak force data (max) and the time in milliseconds (Δx) in the data table below.
9. Repeat steps 2-8 two more times, then calculate the average of the three trials.

No Helmet Materials	Peak Force in N (max)	Time in ms (Δx)
Trial 1		
Trial 2		
Trial 3		
Average		

10. Repeat this test procedure (steps 2-9) with a protective material placed on the force plate. Be sure to zero the force plate after the material has been placed. Note: Protective materials can be tested individually or in combination.

Material(s):		
	Peak Force in N (max)	**Time in ms (Δx)**
Trial 1		
Trial 2		
Trial 3		
Average		

Material(s):		
	Peak Force in N (max)	**Time in ms (Δx)**
Trial 1		
Trial 2		
Trial 3		
Average		

Material(s):		
	Peak Force in N (max)	**Time in ms (Δx)**
Trial 1		
Trial 2		
Trial 3		
Average		

QUICK CHECK: Which material(s) worked the best at reducing force in the impact?

QUICK CHECK: Using Newton's Second Law, explain how increasing the time of the collision reduced the maximum force experienced?

QUICK CHECK: If the force of the medicine ball on the force plate was decreased with these materials, how would that affect the force of the force plate acting on the medicine ball?

PART 3 – Designing a New Helmet

With your data, notate the materials you would use in a sports helmet. Keep in mind the listed criteria (goals) and constraints (limitations).

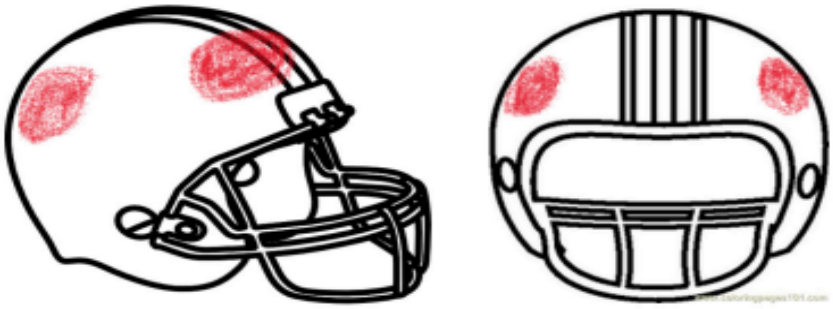
Criteria:

- Helmet must have padding in 4 sections: front, back, left, and right sides. These sections are marked in red below.
- Should be designed to help reduce forces in head-on collisions (force coming to the front of the helmet).

Constraints:

• You have only $350 to spend on materials. The padding materials have the following costs:

Material	Cost
Flexible foam	$75 per section
Microbeads	$100 per section



Make your selections in the table below. You can combine materials in a certain location if you choose.

Side	Material	Cost
Left		
Right		
Front		
Back		
	Total Cost	

Explain why you chose your materials for each section.