Helmet Design Lab

Use test evidence to improve a protective device

HAP.6.9 "Enrichment: Use an engineering design process to develop, model, and test preventative devices for neurological injuries and/or disorders (e.g., concussion-proof helmets or medications for addiction and depression).*"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the team's goal and constraints, circle the model features that may change head motion, and number the test and redesign steps in order.

A Helmet That Needs Another Test

1. After a cyclist crashes, a helmet can reduce the risk of a serious head injury, but no helmet can guarantee that a concussion will not occur. A school engineering team wants to improve a bicycle helmet for riders who travel on bumpy streets. Their goal is to reduce how quickly the head slows during a crash. Their constraints are a mass under 450 grams and enough vents to keep the rider comfortable. To plan their design, they identify the problem first: a sudden change in head motion can injure the brain inside the skull.

2. The team builds two helmet models with identical outer shells. Model A has a single layer of crushable foam. Model B has two foam layers separated by a thin, flexible sheet that allows a little sideways movement. Foam can lengthen the time over which a model head stops, while limited sideways movement may reduce twisting motion. The team predicts that Model B will produce lower peak linear acceleration and lower peak rotational acceleration. They keep the shell shape and model head mass the same so a change in either measurement is more likely to come from the inner design.

3. To test their idea, the team drops each helmet onto a flat surface from the same height, using a sensor inside a model head. They run three drops per model, replacing crushed foam between drops. Model B gives lower peak rotational acceleration in all three comparisons, but its peak linear acceleration is higher in two comparisons. It also weighs 470 grams, above the mass limit. The team decides to make the flexible sheet lighter and adjust the foam thickness, then repeat both acceleration tests and weigh the helmet again. A model-head drop test cannot prove how well a helmet prevents concussions in people.

2 ANSWER WITH EVIDENCE

Use the passage

1. What injury-related goal does the team set, and what two constraints must its design meet?

2. How are Model B's foam and flexible sheet meant to change the motion of a model head?

3. Name two things the team keeps the same to make the drop-test comparison fair.

4. Use the test results to name one needed revision and one measurement the team should repeat.

3 YOUR TURN

Your own words

Choose a setting other than cycling. In four or five sentences, propose a device that could lower the risk of a neurological injury, explain how it works, describe a fair model test with a measurable result, and state how you would revise it if the result falls short.

ANSWER KEY

Helmet Design Lab

PART 1 · READ AND MARK

Underline the team's goal and constraints, circle the model features that may change head motion, and number the test and redesign steps in order. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	What injury-related goal does the team set, and what two constraints must its design meet?	**The goal is to reduce how quickly the head slows during a crash. The helmet must weigh under 450 grams and have enough vents for comfort.**
2	How are Model B's foam and flexible sheet meant to change the motion of a model head?	**The foam may lengthen the time it takes the head to stop. The sheet allows limited sideways movement that may reduce twisting.**
3	Name two things the team keeps the same to make the drop-test comparison fair.	**Accept any two of these: outer shell shape, model head mass, drop height, flat impact surface, or replacement of crushed foam between drops.**
4	Use the test results to name one needed revision and one measurement the team should repeat.	**The team could lighten the sheet and weigh the helmet again, or adjust the foam thickness and repeat the acceleration measurements.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

For slippery school hallways, I would make a shoe sole with deep rubber grooves to reduce falls that could cause head injuries. The grooves could improve grip on wet floors. I would pull two equally weighted model shoes, one with the new sole and one with a plain sole, across the same wet tile and measure the force needed to start sliding. If the grooved sole needs no more force than the plain sole, I would change the groove pattern and test again.

For the open task, accept a plausible device that targets a neurological injury risk, a test that controls relevant conditions and measures an outcome, and a revision linked to a disappointing result. Students should not claim that a device guarantees prevention.