**Subject area/course**: Science/Physics

**Grade level/band**: 9-12

**Task source**: Virtual Learning Academy Charter School (VLACS) in collaboration with the Center for Collaborative Education (Primary Author: Natalie Berger)

**Newton’s Helmet**

**TEACHER'S GUIDE**

1. **Task overview**:

In this task, students take on the role of a research assistant in a materials lab tasked with testing various materials to determine the best materials to use in a sports helmet to limit the force of impact. Students will conduct research on what is already known about helmet design, test a variety of materials, make measurements, and draw conclusions. Students will create a helmet design based on their research and present a final design to the fictional lab director.

1. **Aligned standards:**
2. **Common Core State Standards**

[WHST.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.](http://www.corestandards.org/ELA-Literacy/WHST/11-12) (HS-PS2-3),(HS-PS2-5)

[WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.](http://www.corestandards.org/ELA-Literacy/WHST/11-12) (HS-PS2-1),(HS-PS2-5)

1. **Critical abilities**

Modeling, Design, and Problem Solving: Use quantitative reasoning to solve problems arising in everyday life, society, and the workplace, e.g., to plan a school event or analyze a problem in the community, to solve a design problem or to examine relationships among quantities of interest. Plan solution pathways, monitoring and evaluating progress and changing course if necessary, and find relevant external resources, such as experimental and modeling tools, to solve problems. Interpret and evaluate results in the context of the situation and improve the model or design as needed.

Communication in Many Forms: Develop a range of interpersonal skills, including the ability to work with others, to participate effectively in a range of conversations and collaborations.

1. **Next Generation Science Standards**

HS-PS2-1.Analyze data to support the claim that Newton’s Second Law of Motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

1. **Time/schedule requirements:**

Depending on class hours available, this work could be split over 3 weeks with other class work being completed as well.

1. **Materials/resources:**

Newton’s Laws:

* <http://www.physicsclassroom.com/class/newtlaws/>
* <http://csep10.phys.utk.edu/astr161/lect/history/newton3laws.html>
* <https://www.khanacademy.org/science/physics/forces-newtons-laws>
* <http://www.physics4kids.com/files/motion_laws.html>
* <http://hyperphysics.phy-astr.gsu.edu/hbase/newt.html>
* <http://www.theroboticist.org/learning-resources/science-resources/newtons-laws/>

New helmet designs:

* <http://www.technologyreview.com/news/409516/preventing-concussions/>
* <http://engineering.mit.edu/ask/can-better-helmets-make-football-safer>
* <http://news.yahoo.com/blogs/this-could-be-big-abc-news/building-better-helmet-022045269.html>
* <http://www.huffingtonpost.com/2013/12/16/football-concussions-debate-helmet-ban_n_4440669.html>

Note-taking templates:

* <http://library.wrdsb.ca/research/note-taking/note-taking-templates/>

Measuring force:

* Force of impact can be measured using probeware
* A less expensive way to measure the force of impact is to use a scale that retains the maximum force reading

1. **Prior knowledge:**

Prior to this task, students must be familiar with experiment design and implementation. Students should also be familiar with Newton’s Laws, though they may be learning much of this during the task.

1. **Connection to curriculum:**

Due to the nature of Virtual Learning Academy Charter School (author of this task), this task was built to be used as an independent study task, but can be modified to be embedded naturally into a unit of study or course. The instructions on the student handout are for how the task was originally laid out to be administered.

1. **Teacher instructions:**

This task was designed to be used as an independent study task, but can be modified to fit within a unit of study.

1. Part 1 (5-7 hours): Students will gather background research on sports helmets and the force of impact. Students will submit their notes with their cited sources for review.
2. Part 2 (5-7 hours): Students will design an experiment and test potential materials. Students will conference with the teacher or in peer groups about their design. Encourage students to modify their designs based on the feedback they receive.
3. Part 3 (5-7 hours): Students will submit final helmet design and presentation.

At Virtual Learning Academy, every Performance Assessment culminates with a Discussion Based Assessment (DBA). A DBA is an individual conversation between the student and teacher where the teacher asks questions about the content and the product the student created. The following sample DBA questions and prompts might be helpful in planning instruction:

* How could you accelerate while keeping a steady speed of 30 miles and hour?
* What does a negative acceleration mean?
* State and explain Newton’s Three Laws.
* Explain how the “action and reaction” forces in Newton’s Third Law are different from “cause and effect.”
* How could Newton’s Second Law of Motion help explain why big trucks use more gas than small cars?
* How would aerospace engineers use Newton’s Laws in their work designing space craft?

1. **Student support:**

Possible accommodations for specific students should be discussed in advance with SPED and/or ELL teachers, and could include:

* Extended time – the hours listed above are suggestions, but could be modified.
* Provide a shorter and more targeted list of suggested research materials selected by the teacher for clarity and/or language level.
* Provide outline supports for the presentation.
* Provide websites accessible in other languages.
* Support students with translation of website language.

1. **Extensions or variations:**

Designing a helmet relates even more clearly to the idea of impulse. A possible extension would be to have students be able to justify their design choices as it relates to impulse and therefore force and time.

Parts 2 and 3 would be ideal times for students to work in pairs. This would allow students to consolidate their research and then design a solution, test the solution, and present their design together. In this configuration, students’ final step could finish the project with a short individual write-up connecting Newton’s Three Laws to their group’s helmet design.

1. **Scoring:**

Student work can be scored using the SCALE Science and Engineering Practices Rubric.