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| **Target Grade***:* High School | **Lesson Title:** Designing a better helmet**Developed by: Cassie Whitecotton** |
| **Topic**: Engineering Design, Physics |
| **Three Dimensions Color Coding Key*** Disciplinary Core Ideas – Red Text
* Crosscutting Concepts – Green Text
* Science & Engineering Practices – Blue Text
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| **NGSS Performance Expectation**HS-PS2-3. *Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*HS-ETS1-2 – *Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering* |
| **Lesson Performance Expectations*** Ss will apply their understanding of Newton’s Laws to design a protective devise as a model for an athletic helmet.
* Ss will test and revise their model based upon data produced from their investigation.
* Ss will plan and conduct an investigation to find evidence to validate their claim.
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| **Materials Needed per group:****Non-consumables*** TI-Nspire CX
* Vernier Force Probes and EasyLinks or Lab Cradles
* Racquet ball and meter stick
* *Designing a better helmet* handout
 | **Materials Needed per group:****Consumables**Various materials – cotton, rice, bubble wrap, tape, sandwich baggies, etc. Any other materials that Ss could use to create a cushion. |
| **Phenomena - Problem**How can Ss design and refine a device that minimize the force on an object. |
| **What Is the Teacher Doing?**Before the Ss engage in the lesson Tt shows Ss a series of videos from the CDC ([https://www.cdc.gov/headsup/basics/index.html)](https://www.cdc.gov/headsup/basics/index.html%29) where the Ss would learn what a concussion is and how its caused. This would set the stage for the lesson. Could also use the *Getting a Head Start on Data* activity from Texas Instruments.**Gathering:***Ts should look for evidence of the following when students* ***Define the Problem*** *such as***:** * Recognizing patterns in observations and data
* Discuss and compare observations with others observing the events
* Ask questions to refine an engineering problem.
* Ask questions that require relevant empirical evidence

*Ts should look for evidence of the following when students* ***Developing and Using Models*** *such as****:*** * Describe the conditions necessary for phenomena to occur.
* Use representations to generate evidence.
* Use and/or construct models to predict and/or to test ideas about designed systems

*Ts should look for evidence of the following when students* ***Planning and Carrying Out Investigations*** *such as****:*** * Plan and carry test design solutions in a safe and ethical manner.
* Recognizing patterns in observations and data
* Collect data and generate evidence to test design solutions using multiple variables.
* Use representations to reflect on mechanisms of how things work
 | **What are the Students (Ss) Doing?**Ss are writing in their journals, taking notes about traumatic brain injuries and how they occur. **Gathering:*** After watching the video or completing *Getting a Head Start on Data,* Ss will brainstorm to define the problem to the teacher prompted question “How can a force acting on an object be reduced?”
* Teacher introduces an object to serve as the “head” to which students will target their design to protect. In small groups of 3-4, Ss collaboratively develop a model of their design to address the challenge of minimizing the force acting on the “head”.
* Using the TI-Nspire CX, Vernier Force Probes and consumable materials of their choice, Ss will plan an investigation to test their design based upon their model following the *Designing a better Helmet* handout.
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| **Reasoning:***Ts should look for evidence of the following when students* ***Analyzing Data*** *such as****:*** * Compare data to make sense of and explain phenomena and use comparisons as evidence
* Use graphical displays to analyze data in order to identify linear and nonlinear relationships.
* Use statistical and mathematical techniques (data displays, tables, and/or graphs to find patterns in data
* Use technology to generate and analyze data in order to determine the nest design solution

*Ts should look for evidence of the following when students* ***Engaging in Argument from Evidence*** *such as***:** * Use the model to explain the designed solution in a system.
* Use of mathematical expressions to represent phenomena to support evidence.
* Use evidence to generate or support explanations.
* Respectfully provide and receive critique on their arguments.
* Reflect on and revise arguments and design solutions in light of new evidence
 | **Reasoning:*** Ss analyze data from their investigation to determine which materials reduced the amount of force on the “head” when dropped. After each drop, Ss will revise/refine their design solution to test different materials for reduction of force.

 * Ss groups share their design solutions with the class and engage in argument from evidence based upon the evidence from their investigations to determine which materials best reduced the force impact upon the “head”. Ss discuss and compare the results from the different designs and use evidence to evaluate which design is most effective.
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| **Communicating:***Ts should look for evidence of the following when students* ***design solutions*** *such as:* * Work collaboratively to construct design solutions.
* Use patterns as evidence to support design solutions
* Reflect on the best evidence to support a specific explanation
* Use evidence to compare the advantages of the design to other solutions.
 | **Communicating:*** Ss individually evaluate their designed solution based upon evidence from their tests, and relate the how their device minimized the forces impacting on the “head”. Ss evaluate the merits and constraints of their design and suggest revisions to their design. Ss identify the forces in action during impact. Ss may communicate their findings through a written report, class presentation, or poster.
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| **Suggested Prompts Using Crosscutting Concepts to Stimulate Class Discussion:*** What are the boundaries of the system in which your investigation is designed to impact.
* Within your model what are the components of the system?
* How do the various components of the system interact?
* What are the inputs and outputs of the forces and energy within the system?
* Identify the causes of a brain injury and what are the potential effect upon the brain within the cranium?
* When your “head” is impacted by a force what patterns do you observe?
* Can you identify and describe any patterns exhibited by you designed device to protect the object?
* How are the materials that your device is constructed from affect the function of the device?
* What are the properties of the materials that would best serve the function of absorbing energy?
* Within the system of the test of your device how is energy conserved as a result of your device?
* What are the limitations of the model(s) that are used to represent interactions within the system?
* Which materials caused the most significant reduction of the force at impact?
* Which materials did not cause a reduction in force?
* Based upon your design how does your design effect the reduction of impact on the “head”?
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| **Assessment of Student Learning** SCORE 3 - Ss effectively communicates the advantages and constraints of their design using evidence from their data. Ss correctly identifies the force interactions which their device is designed to reduce.SCORE 2 - Ss communicates the advantages and constraints of their design using evidence from their data. Ss identifies the force interactions which their device is designed to reduce.SCORE 1 –Ss partially describes the advantages and constraints of their design using evidence from their data. Ss makes reference of the force interactions which their device is designed to reduce.SCORE 0 – One or more of the criteria of the assessment is not addressed. |