Unit 4: Contact Forces
7th Grade Science
14 Class Meetings

Revised May 2024

Essential Questions

- Why do things sometimes get damaged when they hit each other?

Enduring Understandings with Unit Goals

EU 1: There are balanced and unbalanced forces that act upon objects due to their mass and motion as defined by Newton's Laws.
- Develop the procedure of the experiment, which includes providing evidence as to why the object is in motion.
- Compare and contrast the balanced or unbalanced forces acting on the object.
- Interpret which factors will serve as independent and dependent variables in the experiment

EU 2: The force that will be exerted by one object onto another object is equal in strength to the force the second object exerts onto the first, but in the opposite direction.
- Identify the components within the system that are involved in the collision.
- Predict the force that will be exerted by the first object on the second object.
- Apply Newton's third law to design the solution to a problem.

EU 3: Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed.
- Create graphical displays to organize data (mass, speed, and kinetic energy of an object)
- Interpret the graphs and identify relationships between kinetic energy, mass, and speed.

Standards

Next Generation Science Standards:
- **MS-PS2-1:** Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
- **MS-PS2-2:** Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
- **MS-PS3-1:** Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
- **MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how they meet the criteria and constraints of the problem.
- **MS-ETS1-3:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Common Core State Standards:
- **CCSS. ELA-Literacy.RST.6-8.1:** Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- **CCSS. ELA-Literacy.RST.6-8.3:** Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

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- **CCSS.ELA-Literacy.RST.6-8.7:** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.
- **CCSS. ELA-Literacy.WHST.6-8.7:** Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
- **CCSS.MATH.7.G.A.1:** Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
- **CCSS.MATH.7.RP.A.2:** Recognize and represent proportional relationships between quantities.
- **CCSS.MATH.8.F.B.5:** Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear).
- **CCSS.MATH.8.EE.A.1:** Know and apply the properties of integer exponents to generate equivalent numerical expressions.

ISAAC Vision of the Graduate Competencies

Competency 1: Write effectively for a variety of purposes.
Competency 2: Speak to diverse audiences in an accountable manner.
Competency 3: Develop the behaviors needed to interact and contribute with others on a team.
Competency 4: Analyze and solve problems independently and collaboratively.
Competency 5: Be responsible, creative, and empathetic members of the community.

Unit Content Overview

1. **Force interactions between colliding objects.**
   - Compare and contrast situations where objects break or surprisingly did not break.
   - Identify the factors that contribute to damage occurring in some collisions and not others.

2. **Relationship between forces and energy transfer in collisions.**
   - Develop diagrams and models to explain the effects of relative forces, mass, speed, and energy in collisions.

3. **Mitigate the damage that a collision can cause.**
   - Investigate which materials limit damage during a collision.
   - Engineer something that will protect a fragile object from damage in a collision.

Interdisciplinary Connection:

- Language Arts– Students carryout multi-step procedure investigations to gather evidence. Students cite textual evidence to support analysis of science and technical texts. Students apply what they have learned and researched to design a solution to a problem.
- Math – Students use qualitative reasoning about positive and negative associations to describe the relationship among force, mass, and change in motion during collisions.

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Daily Learning Objectives with *TWPS*

Students will be able to…

- Develop a model to describe interactions between two objects as they collide and show the changes that occur in the structure of both objects.
    - *What happens when two things hit each other?*
- Collect data and develop a logical argument using evidence on changes in the motion and shape of colliding objects that serve as the basis for evidence that energy transfer occurs during collisions and there are forces between colliding objects.
    - *What sort of changes do you think you might observe during a collision?*
- Construct and revise a written argument using evidence that all objects do bend or change shape when pushed in a collision.
    - *Do all objects change shape or bend when they are pushed in a collision?*
- Investigate the amount of force applied to an object and the amount it deforms. Develop a logical argument that all objects behave elastically to a limit.
    - *What is the topic of the graph? What is the trend? Use evidence from the graph.*
- Investigate, identify patterns in data, and develop a model that represents how mass and speed affect the forces on those colliding objects.
    - *How does speed and mass affect force?*
- Demonstrate mastery of the unit goals so far. (EU 1 & 2 Quiz)
- Investigate, identify patterns in data, and develop a logical argument to describe how mass and speed affect the kinetic energy on those colliding objects.
    - *How does increasing either the speed or the mass of a moving object affect its kinetic energy? How do these changes affect the peak forces in a collision? How would these changes affect the amount of damage done in a collision?*
- Develop and use a model to identify where energy in our launcher system came from and after the collisions where the energy goes.
- Develop and revise a model to identify other contact forces (air resistance and friction) causing energy transfers.
    - *How do other contact forces, like friction and air resistance, cause energy to be transferred between a moving object and other parts of a system?*
- Demonstrate mastery of the unit goals so far. (EU 3 Quiz)
- Analyze data to determine which materials reduce peak force in a collision. Develop a model to show how the structure of those materials changes and contributes to their function during a collision.
    - *What materials best reduce the peak forces in a collision?*
- Construct an explanation for how (and why) the structure of a cushioning material affects the peak forces produced in a collision.
    - *What makes a bike helmet effective?*
- Develop and use a series of models to represent the strength of forces, force interactions, and the direction of the forces to describe the effect of peak forces on heads during a collision. Construct an explanation for why a design solution will limit contact forces and injury to a cheerleader's head during a collision.
- Demonstrate mastery of the unit goals (Unit Test)

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Instructional Strategies/Differentiated Instruction

- Whole group instruction
- Guided notes
- Student-led instruction
- Independent problem-solving
- Collaborative problem-solving
- Graphic Organizer
- Cross-curricular problem solving (independent and collaborative)
- Accountable Talk
- Homework
- Word walls with visuals
- Small group instruction
- Manipulatives

EL Differentiated Instruction:

- Sentence starters
- Simplified directions
- Prompting and questioning
- Alternate responses when needed
- Explicit modeling
- Key vocabulary
- Visuals
- Graphic organizers
- KWL charts
- Venn diagram
- Glossary

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Assessments

FORMATIVE ASSESSMENTS:

- Do Now
- Notebook checks
- Mid-class check-ins
- Exit Slips
- Accountable Talk Discussions- TWPS
- Homework
- NGSS Interim Assessment

SUMMATIVE ASSESSMENTS:

- Quiz 1 – EU 1 & 2
- Quiz 2 – EU 3
- Unit Task- *Cheerleading Headgear Evaluation*
- Unit 4 Test

Unit Task

Unit Task Name: *Cheerleading Headgear Evaluation*

Description: Students will evaluate other engineers' design solutions to protect cheerleaders from concussions in collisions using the science and engineering ideas we have figured out over the course of the unit. Students will develop and use a series of models to represent the strength of forces, force interactions, and the direction of the forces to describe the effect of peak forces on heads during a collision (EU 1 & 2). Students will construct an explanation for why a design solution will limit contact forces and injury to a cheerleaders head during a collision (EU 1, 2, & 3).

Evaluation: Assessment rubric and Problem-Solving Rubric

Unit Resources

- Open Sci Ed unit resources
- Science notebooks
- Laptops
- NGSS Interim Assessments