Engineering in Space with Joan Melendez Misner: Safe Collisions

Watch the Video Here

Pages 1-4 Engineering in Space NGSS & CASEL lesson

Materials Required for This Lesson/Activity	
Quantity	**Description**
1 Per Group	Egg
Per Class	Cardboard
	Egg Cartons
	Cotton Balls
	Straws
	Wooden Skewers
	Rubber Bands
	Tape (Masking or scotch)
	String
	Plastic Bags
	Sponges
	Packing Peanuts
	Bubble Wrap
	Packing Foam
	Paper Towels
	Kleenex
	Dixie Cups
	Styrofoam Cups

Engineering in Space with Joan Melendez Misner: Safe Collisions

Grade/ Grade Band: High School	**Topic:** Physics

Brief Lesson Description: Students will understand collisions and use their knowledge to design a prototype to limit damage during a collision.

Performance Expectation(s):
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.

Specific Learning Outcomes:
Students will design a device to minimize the impact force of an object in freefall and then refine it in a second iteration to minimize the forces.

Narrative / Background Information

Prior Student Knowledge:
For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first but in the opposite direction (Newton's third law). The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. Forces on an object can also change its shape or orientation. All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame.

"5 Dimension 3: Disciplinary Core Ideas - Physical Sciences." National Research Council. 2012. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. doi: 10.17226/13165.

Science & Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
Constructing Explanations and Designing Solutions: Constructing explanations and designing solutions in 9-12 builds on K-8 experiences and progress to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. ● Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**PS2.A: Forces and Motion** ● If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by change in momentum of objects outside the system. **ETS 1.A: Defining and Delimiting and Engineering Problem** ● Criteria and constraints also include satisfying any requirements set by society such as taking issues of risk mitigation into account and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (*secondary)* **ETS 1.C: Optimizing a Solutions** ● Criteria may need to be broken down into simpler ones that can be approached systemically, and decisions about the priority of certain criteria over others (Trade-offs) may be needed. (*secondary)*	**Cause and Effect:** ● Systems can be designed to cause a desired effect.

Possible Preconceptions/Misconceptions:
- Momentum is only influenced by velocity and mass is not important.
- If an object has a bigger mass than the object has a bigger momentum and velocity is not important.
- All collisions are perfectly elastic

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LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

Start the lesson by showing students the images on slide 1 of the lesson slides. Ask students how they think these images are related. After class discussion on the prompt, explain to students that all of these images show ways that engineers have learned to protect items both big and small from collisions. Next, ask students how collisions would impact humans/devices if each of the examples were not invented. Discuss as a class.

Next, explain to students that today we will learn more about engineering to prevent these types of impacts at NASA. Then, show the X-STEM Video "Engineering in Space with Joan Melendez Misner."

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

In the video, Joan Melendez Misner discussed the NASA DART mission. The goal of this mission is to protect the earth from asteroid collisions by colliding spacecraft into an asteroid to change its path. NASA engineers used the force of an impact to control the impact and course of the asteroid. But what variables affect the impact of a collision? To answer this question, we will use an online simulator to see how variables of asteroids hitting the earth impact their force.

Students should be grouped into 6 Groups. Each group should then use the calculator at the Earth Impact Effects Program to collect data to answer their focus question found below. Based on the data they collect, they should then report their findings to the class. Students may use the Earth Impacts Effects Program Graphic Organizer to organize the data they collect.

Please note: This lesson assumes students will change one variable and keep constant parameters for all remaining parameters. It is suggested that if students are not familiar with this type of investigation, you establish set parameters to start from. If you choose to give these, you can use the data from the Impact Examples provided in the simulation.

Focus Questions:

Group 1: How does the diameter of an asteroid affect the effects of an asteroid impact?
Group 2: How does the density of an asteroid affect the effects of an asteroid impact?
Group 3: How does the impact velocity of an asteroid affect the effects of an asteroid impact?
Group 4: How does the impact angle of an asteroid affect the effects of an asteroid impact?
Group 5: How does the target type of an asteroid affect the effects of an asteroid impact?
Group 6: How does the distance from impact of an asteroid affect the effects of an asteroid impact?
*Note: For smaller classes, you can eliminate group 5 and/or 6 as needed.

Expected Findings:

Group 1: As diameter increases, the effects cause increasing damage.
Group 2: As the density of an asteroid increases, the effects cause increasing damage.
Group 3: As the impact velocity of an asteroid increases, the effects cause increasing damage.
Group 4: As the impact angle increases, the effects cause increasing damage
Group5: As the target type becomes denser, the effect cause increasing damage
Group 6: As the distance from an impact increases, the effect causes decreasing damage.

EXPLAIN: Concepts Explained and Vocabulary Defined:

Students will next learn about the science of collisions while watching "Crash Course Physics #10: Collisions." As they watch the video, they should take notes.

After watching the video, have students discuss how the results of their asteroid investigation relate to the information shared in the video.

Vocabulary: Collisions, Momentum, Impulse, Force, Acceleration, Elastic, Inelastic, Conserved, Newton's Third Law, Action, Reaction, Perfectly Inelastic Collision, Center of Mass

ELABORATE: Applications and Extensions:

Present the following task to your students:

"In the video, Joan Melendez Misner also discussed how engineers are working on successful devices to land on the Moon and Mars. In order to do this successfully, they must protect their spacecraft from the impact collisions of landing. Based on your learning in the simulation and crash course video, you will design an engineering solution to protect a payload as it lands.

Your task is to create a device to protect an egg as you drop it from a height of 8 feet above the ground*. Your device must be created in one class period and using only the provided materials. Prior to dropping your device, you should have a sketch that shows your design and how you think each of the components of the system will help protect the egg."

Start by having students brainstorm ways to reduce the momentum of falling objects. After discussing in small groups, have students share as a class and create an anchor chart for students to refer to. Possible ideas include decreasing mass, decreasing velocity with a parachute or other mechanism, raising the center of mass, adding cushioning to increase elasticity, etc.

Provide students time to build their devices. The following list is suggested materials that can be utilized–you may provide whatever is locally available.

Cardboard, egg cartons, cotton balls, straws, pipe cleaners, wooden skewers, rubber bands, sponges, plastic bags, strings, packing peanuts, bubble wrap, packing foam, paper towels, kleenex, tape (scotch or masking), dixie cups, styrofoam cups, etc.

During construction, students can use a “dummy” egg like a plastic easter egg or ping pong ball to test ideas without having the mess of real eggs.

Have students test their devices. Provide students the opportunity to share their design with others prior to dropping the device. After, have students open to see if their egg survived the collision.

After this initial phase of testing/design, challenge students to pick one of the factors discussed in the asteroid simulation to use to further improve their design. (For example, they may come up with a way to decrease the mass or a way to decrease the entry angle.) Provide them the opportunity to build and test this second iteration.

EVALUATE:

Formative Monitoring (Questioning / Discussion): Questions throughout the lesson, presentation of simulation experiment, presentation of egg drop.

Summative Assessment (Quiz / Project / Report): Have students create an annotated sketch of their egg drop designs. Have them explain how their design change from iteration 1 to iteration 2 decreased the momentum of their egg as it hit the ground.

Elaborate Further / Reflect: Enrichment:
There are several options to elaborate or build upon this lesson.

1. During the engineering design process, have students calculate the following mathematical quantities in advanced courses:
    a. Measure and record (in a chart) the mass of the egg, the mass of the device, the longest device dimension, the drop height, and the time of the descent.
    b. Determine maximum gravitational energy and final, impact kinetic energy.
    c. Determine theoretical and experimental final velocity
    d. Determine momentum of device on impact
    e. Determine the impulse of impact
    f. Determine average force of impact (assuming impulse occurs over 0.25 s).
    g. Determine the amount of energy lost in the collision (and transformed into non-mechanical forms).
2. Have students research the various methods NASA has used to land vehicles on the Moon and Mars. Allow them to redesign and build an egg drop device that uses similar mechanisms as inspiration.

SOCIAL EMOTIONAL LEARNING ACTIVITY

Casel Standard Addressed: Self-Awareness

In the X-STEM Video, Joan Melendez Misner shared her failures on the path to her career. Oftentimes in society, we assume that all failure is bad, but in reality, it is part of the learning process. Today, we will explore some famous failures and consider how the people overcame these failures.

First, show students the video “10 Famous Failures Who Never Gave Up and Succeeded in Life.” As students watch the failures, have them create a list of ways that each of the individuals overcome their failure.

After the video, have students create a class anchor chart of strategies that they can use each time they fail. Hang the poster in the classroom and have students use it when they are stuck. Reflect after a week or two on what strategies were most helpful.

INTERDISCIPLINARY CONNECTIONS/IDEAS

Math: Visit Space Math @ NASA and complete a variety of engineering related math problems Topics include design issues, data and telemetry, mission planning, and spacecraft design.

Career and Technical Education: Joan Melendez Misner has had a unique career path working for NASA and also becoming an astronaut in training for a commercial space flight organization. Have students investigate the paths of a variety of astronauts (NASA and/or commercial organizations) to see what fields of study have led them to space careers.

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	Styrofoam Cups

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