Orion Design Challenge

Objectives

Students will:

- Design an Orion capsule that will keep astronauts safe on a simulated re-entry in the ocean
- Test their Orion capsule to be water-tight and buoyant

Suggested Grade Level

3rd -12th

Subject Areas

Space Science, Engineering Design

Timeline

60 minutes

NGSS Standards

- **3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- **MS-ETS1-1** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- **HS-ETS1-1** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

21st Century Essential Skills

Critical thinking & problem-solving, creativity & innovation, communication and collaboration, carrying out investigations, teamwork

Background

NASA's Orion spacecraft has been built to take humans into deep space. Orion will carry the crew to space, provide emergency abort capability, sustain the crew during the space travel, and provide safe re-entry. Orion will launch on NASA's new heavy-lift rocket, the Space Launch System.

When the Orion reenters, it will travel through the atmosphere at high rates of speed, experience extreme heat, and land in the Pacific Ocean. NASA needs to assess how the capsule will handle parachute-assisted landings by taking into consideration the wind speeds, entry angle, wave heights, and much more. Testing has been done to determine weak points in the capsule.

Vocabulary

Suspension, impact, force, gravity, kinetic energy, transfer of energy, submersion, buoyancy

Materials

- Wax paper squares
- Regular-size marshmallows
- Bubble wrap
- Plastic sheeting (cut up plastic bags)
- Transparency sheets
- Aluminum foil
- Foam sheets (peel and stick kind)
- Foam plates
- Dixie cups
- Craft sticks
- Straws
- Masking tape
- Water bucket
- Tongs
- Paper towels
- Water-soluble markers

Lesson

1. Discuss the Orion capsule, its constraints, and its current progress. (See videos below.)
2. Provide students with the challenge of designing and constructing a watertight capsule that will protect the two astronauts (marshmallows) from water infiltration and deep-water extraction. Therefore, the capsule must be buoyant.
3. Provide students with the parameters of the mission.
    a. Astronauts must not be harmed. (Punctured, squished, or wet.)
    b. Astronauts must include team name in water-soluble marker.
    c. Capsule must be water-tight.
    d. Capsule must be buoyant.
    e. Capsule may only use 5 pieces of material.
    f. Each capsule will be submerged at approximately 10 cm for 10 seconds.
    g. Winning design will have a dry astronaut, buoyant capsule, and lowest building cost.
    h. Capsule dimensions must be 7cm x 7cm x 7cm.
    i. Astronauts must be easily removed/have an escape hatch.
4. Pass out budget sheet. Allow students to select up to 5 pieces of material. Students must adhere to their budget (amount at your digression).
5. Write team's name on the astronauts using a water-soluble marker. (Permanent markers will not work because it will not run if exposed to water.)

6. Have each group discuss their design with the class and explain why they chose that design.
7. Execute the submersion. Each capsule will be submerged in a container of water at a depth of approximately 10 cm for 10 seconds (if possible, have students film and live stream on a screen in the classroom).
8. Release the capsule under the water to test the buoyancy.
9. Have students release the astronauts to see if they remained dry.
10. Assess student's design. A successful mission would be a dry astronaut, buoyant capsule, and lowest building costs. Students can also be assessed on their plan, communication, evaluation of data, and design solutions.

Extensions

1. Record each test in slow-motion and have students analyze problem areas.
2. Allow students to redesign after initial testing.
3. Challenge the students to design a vehicle that will survive from ever-increasing heights and angles.
4. Have the students apply for positions within the team.
5. Require a drop and then submersion test.
6. Create a budget and limit the supplies to complete the capsule.

Resources

Garcia, M. (2015, January 15). Orion Spacecraft. Retrieved from https://www.nasa.gov/exploration/systems/orion/index.html

Video Resources

Orion Explanation. https://www.youtube.com/watch?v=DlkjMnWNjic

Orion Takes Vertical Plunge from 9 feet. https://www.youtube.com/watch?v=zPxmGzI2Aek

Orion MPCV Water Landing Test at Hydro Impact Basin.
https://www.youtube.com/watch?v=Raou4AV_B-E

Orion Spacecraft Crew Exit Tests 2015 NASA Johnson Space Center
https://www.youtube.com/watch?v=kxXNzU_3ANk

NASA Tests Orion Crew Exit Plans in Gulf of Mexico.
https://www.youtube.com/watch?v=ldmZnq9olYA

Orion Design Capsule Challenge Supply Sheet

SUPPLIES	PRICE	QUANTITY	SUBTOTAL
Wax Paper	$200,000		
Bubble Wrap	$800,000		
Aluminum Foil	$300,000		
Transparency Sheet	$400,000		
Foam Sheet	$800,000		
Foam Plate	$200,000		
Dixie Cup	$500,000		
Craft Sticks (3)	$300,000		
Straws (3)	$200,000		
Plastic Bag	$600,000		
		Total Cost	$

Test Results, Analysis and Improvements

Was your capsule buoyant?

Analysis:	Improvements:

Did your astronaut get wet?

Analysis:	Improvements:

What improvements would you make towards the total cost of your capsule?

If given a budget of five million dollars to repeat this lesson, describe what materials you would use and how you would build Orion II.