CREW EXPLORATION VEHICLE

LESSON DESCRIPTION
Students will design and build a Crew Exploration Vehicle (CEV) that will carry two cm-sized passengers safely and will fit within a certain volume (size limitation).

OBJECTIVES
Students will:

- Engage in the engineering design process
- Design and build a model CEV within certain parameters
- Test their vehicle using a Drop Test and revise their designs

NASA SUMMER OF INNOVATION

UNIT
Engineering: Exploration

GRADE LEVELS
7^{th} – 9^{th}

CONNECTION TO CURRICULUM
Potential and Kinetic Energy, Acceleration due to gravity, Air Resistance, Measurement (Volume)

TEACHER PREPARATION TIME
15-30 minutes
LESSON TIME NEEDED
60-120 Minutes *Level: Intermediate*

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- Understanding of the nature of science
- Skills necessary to become independent inquirers about the natural world
- The dispositions to use the skills, abilities, and attitudes associated with science

Science and Technology
- Abilities of technological design
- *Understanding about science and technology*

Physical Science Standards
- Motions and forces

Common Core State Standards for Mathematics (NCTM)
Geometry
- Solve real-life and mathematical problems involving angle measure, area, surface area, and volume

ISTE NETS and Performance Indicators for Students (ISTE)
Creativity and Innovation
Students:
- apply existing knowledge to generate new ideas, products, or processes
- create original works as a means of personal or group expression
- use models and simulations to explore complex systems and issues
- identify trends and forecast possibilities

Critical Thinking, Problem Solving, and Decision Making
Students:
- identify and define authentic problems and significant questions for investigation
- plan and manage activities to develop a solution or complete a project
- collect and analyze data to identify solutions and/or make informed decisions
- use multiple processes and diverse perspectives to explore alternative solutions

MANAGEMENT

Read the challenge sheet to become familiar with the activity. Gather the materials ahead of time and set them up in a central location for student access. Build a sample Crew Exploration Vehicle.

CONTENT RESEARCH

Potential and kinetic energy—When the vehicle hits the surface, its motion (kinetic) energy is changed into stored (potential) energy, which gets stored in the shock absorber systems they create.
Acceleration due to gravity—The vehicle accelerates (speeds up) as it falls due to Earth's gravitational pull.
Air resistance—Air exerts a force on the vehicle as it falls, slowing it down.
Measurement—Students measure the various heights from which they drop the vehicle and the volume of the vehicle itself.

LESSON ACTIVITIES

- Introduce the challenge: NASA needs a vehicle to take people to the Moon. The Space Shuttle cannot do that, because it was never designed to leave the Earth's orbit. The Crew Exploration Vehicle must be designed to serve multiple functions and operate in a variety of environments. (scripted in the activity guide).
- Brainstorm and design: Students should be working in cooperative groups to develop a group design and using individual journals to record their decisions, design sketches, test results, etc. You may also use the provided activity pages for student drawings.
- Build, test, evaluate, and redesign: Each team should conduct two drop tests from about 1 meter. Test data, solutions, modifications, etc should all be recorded in their journals individually.
- Discuss what happened: Have the students show each other their CEV and talk about how they solved any problems that came up.
- Evaluation: Using the student's journaling, assess their mastery of content, skills, and the engineering design process.

Download the Educator Guide here:
http://www.nasa.gov/pdf/435856main_DesignaCEV_3to5.pdf

NASA BEST Student Web Page with multimedia:
http://svs.gsfc.nasa.gov/goto?10515

ADDITIONAL RESOURCES

NASA History: Future designs video
http://www.youtube.com/watch?v=aadr3spErt0&feature=related

Check out NASA's Exploration Mission Directorate at
http://www.nasa.gov/exploration/home/index.html

Check out NASA's Moon missions at
http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html

MATERIALS
(per rover)

- *Sections of 4" mailing tubes*
- *2 plastic people (army guys)*
- *Corrugated cardboard*
- *Large rubber bands*
- *Meter sticks or measuring tapes*
- *Plastic drinking straws*
- *Index cards*
- *Cotton balls*
- *Paper clips*
- *Plastic wrap*
- *Tape*
- *Scissors*
- *Other various building supplies you wish to provide…*

DISCUSSION QUESTIONS

- Why should they not tape or glue the people in place?
- What kind of shock absorbing material can you make from these materials to help soften a landing? *Answers will vary.*

- What forces affected your vehicle as it fell? *It accelerated [sped up] as it fell due to the pull of gravity. Air also pushed on it, and this air resistance slowed it down.*
- After testing, what changes did you make to your CEV? Did your modifications improve the CEV design and enable your design to meet the challenge? *Answers will vary.*
- Engineers' early ideas rarely work out perfectly. How does testing help improve a design? *Answers will vary.*
- What did you learn from watching others test their CEV? *Answers will vary.*
- The moon is covered in a thick layer of fine dust. How might this be an advantage? A disadvantage? How might this be an advantage? A disadvantage? *If the dust layer is soft, it would help cushion a landing. However, if it is too soft, a lander could sink into it and get stuck. Also, the lander's rocket engine could send up clouds of dust, which could get into the machinery and cause it to jam or malfunction.*
- What are the steps in the engineering design process? *Identify the Problem*, *Brainstorm, Design, Test & Evaluate, Share Solutions, Redesign, Test and continue to repeat testing, sharing solutions, and redesigning.*

ASSESSMENT ACTIVITIES

Journaling is a valuable tool for engineers as they prepare and test designs to solve complex problems and meet challenges. Students should record their brainstorming session ideas, labeled and annotated sketches of their prototype designs, test results, modifications to their designs with sketches, photos, and group solutions that allow them to meet the challenge in a journal. They should also record the number of crew their CEV can hold, whether it meets the size restrictions, and measurements of the hatch, and dimensions of the vehicle. Any science, math, engineering, or technology content that is connected to their work or that they used to meet the challenge should also be included in the journal. The journal should be used as a formative and summative assessment tool.

ENRICHMENT

How high can you go contest: Students drop their CEV from 1.5 meters. Eliminate all CEV's that bounce out their "astronauts." Next, raise the height to two meters. Continue in this fashion until a winner emerges. You can also increase the challenge by having kids add a third "astronaut" to their CEV designs.