Activity Title: Design the new *Crew Exploration Vehicle*!

This activity was adapted from NASA educational products:
NASA's KSNN™ 21st Century Explorer newsbreak "What will replace the space shuttle?"
http://education.jsc.nasa.gov/explorers/pdf/p5_educator.pdf

Components of the Orion CEV: Image Credit: Lockheed Martin

Activity Objective(s): The teams' challenge is to 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).

The CEV will be launched in next week's activity.

Grade Levels: K - 2

Lesson Duration: One 60-90 min session

Process Skills: measuring, calculating, designing, evaluating

Materials and Tools (per group of three students):

- General building supplies and tools
- (2) small plastic people (approx 2 cm each)

Club Worksheets: (Make copies for each student to put in binder)

1. CV Imagine and Plan Sheets
2. CEV Data Table
3. Experiment Notes
4. Summary Sheet - Questions/Discussions for Understanding
5. Fun With Engineering at Home
6. Quality Assurance Sheets - Checking Each Other's CEV Models

Club Facilitator or Teacher Notes by Stage:

(Based on those running 60-minute Clubs)

Stage 1: Set the Stage, Ask, Imagine, Plan (Approx 10 minutes)

- Share the **Design Story and Challenge** orally with the students (provided in teacher pages). This story provides the context and motivation for trying to accomplish the challenge. This is the **ASK** phase of the Engineering Design Process.
- Put the students in teams of 3 around the room – try to separate the teams so they are not working "on top" of one another.
- Hand out the ***CEV Design Challenge, Imagine and Plan Sheets*** (1 of each of these worksheets per team).
- Let the challenge begin - Encourage them to **IMAGINE and PLAN** before building. Ask them to use their worksheets to capture their design ideas. Ask them to list the challenges they face in meeting the design constraints. Why should they not tape or glue the people in place?

Stage 2: Create (Approx 20 minutes)

- Challenge the teams to **CREATE** or build their CEVs based on their designs. Remind them to keep within specifications.

Stage 3: Experiment – (Approx 5 minutes)

- Discuss how important **EXPERIMENTING** is for engineers. The *imagine, plan, create, experiment, improve* loop is key for engineers to be successful.
- Each team should conduct three drop tests from about 1 meter. The students can simply hold the CEV model over their heads and drop it. They should record their results after each test, and note what changes they plan to make as a result of the drop test.

Stage 4: Re-Design and Re-Build - Improve (Approx 10 minutes)

- After each drop test, the students **IMPROVE** (Re-Design and Re-Build) CEV models based on the results of the experiment.

Stage 5: Challenge Closure (Approx 10 minutes)

- Give out the ***Summary: Questions/Discussion for Understanding*** worksheet (1 per team). Ask each team to fill out the worksheet.

PLEASE COLLECT THE SUMMARY SHEETS AND SAVE IN A FOLDER FOR NASA.

- In summary have a short discussion with all teams. Ask them, "What was the greatest challenge for your team today?" Expect answers such as:
    - Planning and creating a CEV so that the people and the tank fit inside safely. (They should mention the constraints.) For example, designing a tank to fit within a certain volume, when no shape was given.
    - Keeping the people in the seats without tape or glue. Keeping the hatch shut during the drop test.
    - Work as a team, communicate
    - Imagine, plan, create, experiment, improve steps

  If you do not get these types of answers, try to facilitate an interaction where you put these thoughts in play and ask for feedback. Encourage all teams to offer thoughts.

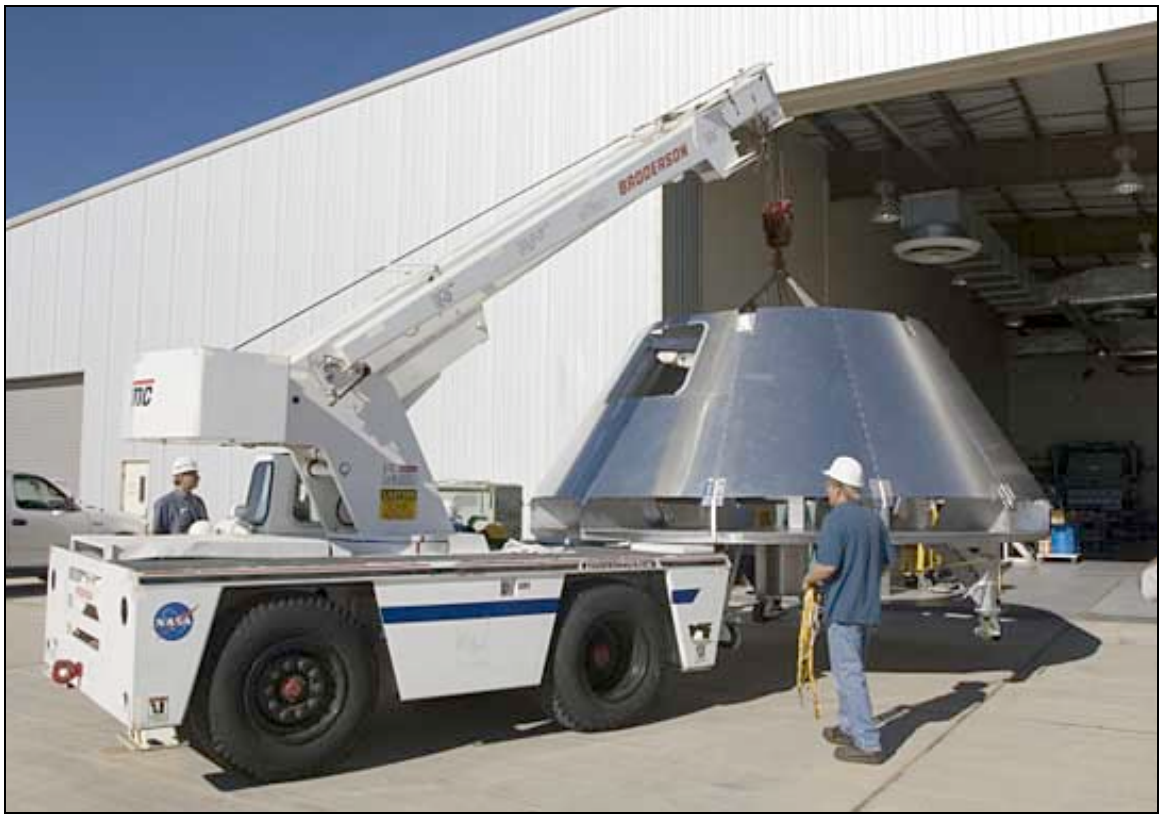
Stage 7: Previewing Next Week (Approx 5 minutes)

- Ask teams to bring back their CEV model for use in next week's club challenge. You may want to store them in the classroom or have one of the facilitators be responsible for their safe return next week.
- Ask teams to think about potential launch mechanisms during the next week. Tell them they will be building a launcher out of the standard materials that have been available to them, including large rubber bands.

Special Notes: For Those with 90 minute Clubs

Quality Assurance - (Approx 15 minutes)

- Discuss how important FEEDBACK is for engineers. Hand out the ***Quality Assurance*** worksheets (1 per team) and ask them to fill out the top section with team name and participants' names.
- Ask each team to put their CEV model together with their Quality Assurance Test worksheet around the edges of the room. Ask each team to move one notch clockwise to offer feedback to the neighboring team, using the Quality Assurance Test worksheet.
- Teams then return to their stations and discuss the comments from the Quality Assurance Team. What changes were suggested? Do they make sense?



Mock Up of Orion CEV, courtesy NASA

Design Story and Challenge:

This is the story you will tell the students to paint the picture or set the context for this first challenge. It is important that you set the context with this story before jumping into the challenge. It is this story that makes the science, mathematics and engineering come to life; it is the story that makes the hands on activities have relevance and meaning.

Crew Exploration Vehicle

NASA needs a vehicle to take people to the Moon. The Space Shuttle cannot do that, because it is not designed to leave the Earth's orbit. NASA scientists and engineers are working on a space vehicle that can take astronauts to the Moon, Mars, and beyond. This spacecraft is called the Crew Exploration Vehicle (CEV). The CEV is a vehicle to transport human crews beyond low-Earth orbit and back again. The CEV must be designed to serve multiple functions and operate in a variety of environments.

To learn more about what NASA is doing to build a CEV, go to the following website:

http://education.jsc.nasa.gov/explorers/p5.html

Using your supply of building materials, you will design and build a CEV model.

Design Challenge

Your Crew Exploration vehicle must meet the following Engineering Design Constraints:

- Safely carry two little plastic people. You must design and build a secure seat for these people, without gluing or taping them in place. The people should stay in their seats during a Drop Test from over your head.
- Fit within the mailing tube provided. (Each club received two or three mailing tubes. The teams can share to see if their CEV fits.)

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1. CEV Design Challenge, Imagine and Plan Worksheet

Design Challenge

Your Crew Exploration vehicle must meet the following Engineering Design Constraints:

- Safely carry two little plastic people. You must design and build a secure seat for these people, without gluing or taping them in place. The people should stay in their seats during a 2-m Drop Test.
- Fit within the mailing tube provided.

Top View of CEV:

Cut-away view of CEV to show inside with people:

2. CEV Data Table

Please complete entries in table. The blank boxes are for you to add additional components.

CEV components	**Use**	**Measurement or Calculation**
Little plastic people	Crew	How many?
CEV	Carries crew to Moon	Does it fit in the mailing tube?
Hatch	Allows entry and exit	How many people wide? How many people high?

3. EXPERIMENT – Drop tests

Drop your CEV from over your head.

Answer the questions in the table.

Go back and IMPROVE your design before the next test.

Trial Number	Results
1	Did the people stay in their seats? Did the door fly open? How will you improve your design?
2	Did the people stay in their seats? Did the door fly open? How will you improve your design?
3	Did the people stay in their seats? Did the door fly open? How will you improve your design?

4. Summary: Questions/Discussions for Understanding

What was the greatest difficulty you and your team had today while trying to complete the CEV challenge?

Tell how you solved your greatest team difficulty in 2-3 sentences.

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Team Name:_____

Fun with Engineering at Home

Lesson 3: Building a Crew Exploration Vehicle

Today we designed and built a Crew Exploration Vehicle (CEV) model to carry people to the moon. We used the same process that engineers use when they build something. We had to **ASK**: what is the challenge? Then we thought, talked and **IMAGINED** a solution to the challenge. Then we **PLANNED** with our group and **CREATED** our model CEV. Finally, we **EXPERIMENTED** or tested our model by having other groups look at it and give us feedback. Last, we went back to our team station and tried to **IMPROVE** our CEV. These are the same 6 steps engineers use when they try to solve a problem or a challenge.

Home Challenge: During this week, see what you can learn about satellites and rockets get launched into orbit. Next week, you will be designing a launcher for the Crew Exploration Vehicle. It will be important to launch the CEV without hurting the people inside it. Sending humans SAFELY into space is very important for NASA.

Here are some questions to talk about with your parents, grandparents, brothers or sisters:

Are you interested in sending humans to the Moon?

Do you want to go to the Moon?

What are some reasons that people might want to go to the Moon?

What might be some of the dangers for humans in the CEV?

What is the most dangerous part of the journey to the Moon?

The NASA website has lots of information on space travel. Go to http://www.nasa.gov and type CEV into the search box. What do you learn?

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Quality Assurance – Checking Each Other's CEV Models

Team Name:_____

Participants' Names: _____

_____

_____

To be answered by the Quality Assurance team:

Does the CEV fits within specified dimensions: YES or NO

Do the people stay in their seats during the Drop Test? YES or NO

Specific Design Strengths

Specific Design Weaknesses

How would you improve this design?

Inspected by Team: _____

Participant Signatures _____

_____

_____