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 build a *Crew Exploration Vehicle* (CEV) that will carry people and an internal tank for holding liquids. This CEV must fit within a certain volume (size limitation), carry two cm-sized passengers safely and have a hatch that opens and closes.

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

Grade Levels: 6 - 8

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. CEV Design Challenge and Data Table
2. CEV Imagine and Plan Sheets
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 Sheet*** (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.
- Ask members of each team to check mathematical calculations and check designs and models to make sure they are within specified design constraints.

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: 1 each at 1, 2 and 3 meters. They should record their results.

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

- Students **IMPROVE** (Re-Design and Re-Build) CEV models based on results of the EXPERIMENT phase.

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 6: 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. They will conceive of a design (IMAGINE) on their own – there is not a pre-designed launcher.

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*** 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. The Quality Assurance Teams will conduct a 2-m Drop test. Note, Quality Assurance Teams should also check the mass of the CEV using a balance.
- 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.

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 2-m Drop Test.
- Include an internal holding tank for liquids, able to hold at least 20 cm^3 of liquid.
- Have a mass of no more than 100 grams.
- Fit within the mailing tube provided. (Each club received two or three mailing tubes. The teams can share to see if their CEV fits.)
- Have one hatch that opens and closes. The hatch should remain shut during a 2-m Drop Test.

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1. CEV Design Challenge, Data Table and Questions

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.
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CEV Data Table

Please complete entries in table.

CEV components	Use	Measurement or Calculation
Little plastic people	Crew	Mass: _____ g each; _____ g total
Internal tank	Stores liquids	Mass:_____ g Volume_____ cm^3
Hatch	Allows entry and exit	Dimensions: _____ cm (long) x _____ cm (wide)
Mailing Tube	To test size constraint	Volume _____ cm^3
CEV	Transport people	Mass:_____ g Volume _____ cm^3

2. CEV Imagine and Plan Worksheet *Page 1*

How will you calculate the volume of the internal tank?

How did you decide where to put the internal tank?

How will you make sure that the people can fit through the hatch?

How will you make sure the hatch doesn't pop open during the Drop Test?

CEV Imagine and Plan Worksheet Page 2

Top View of CEV:

Outer View of CEV with Hatch:

CEV Imagine and Plan Sheet Page 3

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

Cut-away view of CEV to show inside with internal tank:

3. EXPERIMENT – Drop tests

Your dependent variables are the conditions that you are testing.

EXAMPLE of dependent variable: Number of people that stayed in their seats during drop test.

Control Variable – Height of Drop	**Dependent variable(s)**
1 meter	
2 meters	
3 meters	

How will you improve your design using these results?

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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.

Why was it important that the hatch stay closed during the Drop Test?

What process will your CEV undergo that makes it important for the people to be secured safely in their seats?

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Team Name:_____

Fun with Engineering at Home

Activity 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?
- 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
- This NASA site talks about new NASA spacecraft:
  http://www.nasa.gov/mission_pages/constellation/main/index.html

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Quality Assurance – Checking Each Other's CEV Models

Team Name:_____

Participants' Names: _____

_____

_____

To be answered by the Quality Assurance team:

Total mass of the CEV is: _____grams

What volume of liquid will the internal tank hold? _____ cm3

How did you determine the volume of the internal tank?

_____

_____

_____

Does the CEV fits within specified dimensions: YES or NO

Does the hatch open and close? YES or NO

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

Does the hatch stay closed during the Drop Test? YES or NO

Specific Design Strengths

Please Turn Over

Specific Design Weaknesses

How would you improve this design?

Inspected by Team: _____

Participant Signatures _____

_____

_____