Activity Title: Launch Your Crew Exploration Vehicle!

Activity Objective(s): The teams' challenge is to design and build a Reusable Launcher for the *Crew Exploration Vehicle* (CEV) that they built last week. The CEV should travel 3 meters when launched. The Reusable Launcher should produce repeatable results.

Ares Rocket and Altair Lunar Lander, Courtesy NASA

Grade Levels: 3 – 5

Lesson Duration: One 60-90 min session

Process Skills: measuring, calculating, designing, evaluating, graphing

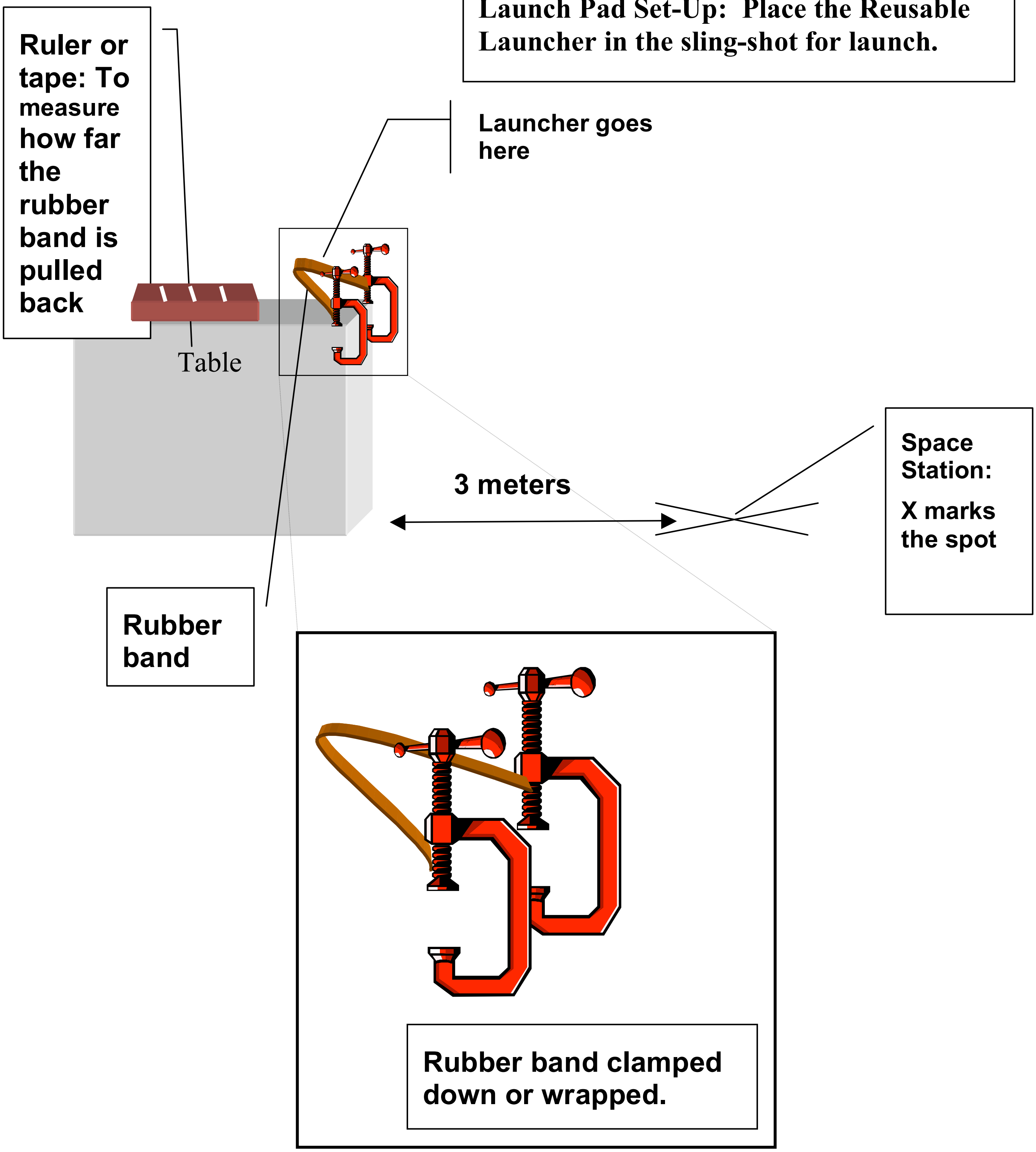
Materials and Tools (per group of three students):

- General building supplies and tools
- C-clamps and lots of rubber bands
- Model CEV that was built last week

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

1. Reusable Launcher Design Challenge: Imagine and Plan Sheets
2. Reusable Launcher Data Table
3. Graph Your Experiment Data
4. Summary Sheet - Questions/Discussions for Understanding
5. Fun With Engineering at Home
6. Quality Assurance Sheets - Checking Each Other's Reusable Launchers

Launch Pad Set-Up: Place the Reusable Launcher in the sling-shot for launch.



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. This story provides the context and motivation for trying to accomplish the challenge. This is the **ASK** phase of the Engineering Design Process. The story is the last item in the Teacher Pages (p. 5). Keep the students together as a group to discuss how to approach this activity. They need to build the container that will hold their CEV. That container (plus the CEV) will be put into the sling-shot mechanism.
- 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 ***Reusable Launcher 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. It is important to emphasize that <u>the objective is to build a launcher that gives repeatable results</u>. It is more important that the CEV is launched the same distance using the same set-up than it is to get the CEV to launch the farthest distance.

Stage 2: Create (Approx 10 minutes)

- Challenge the teams to **CREATE** or build their Reusable Launchers 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 15 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 tests: 3 launches each with a different pull-length for the designed Launcher. They would launch the CEV three times at three different "pull-lengths" (ex. 10 cm, 15 cm, and 20 cm) and record those results. The goal is to achieve repeatable results at each of these lengths and determine which length is the best for the designed vehicle.

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

- Students **IMPROVE** (Re-Design and Re-Build) Reusable Launchers 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:
    - Figuring out how to design a Launcher that could be used again and again.
    - Getting repeatable results.
    - Landing near the 3-meter mark.
    - Working as a team, communicating
    - 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)

- Next week we will switch gears from getting off the Earth to landing on the Moon.
- Ask teams to think about how a spacecraft might land on the Moon safely. Ask them to think about why it doesn't make sense to use a parachute on the Moon (There is no air to fill up the parachute!).

Here is a link to a great NASA animation of a lunar landing!

http://www.nasa.gov/mission_pages/constellation/multimedia/index.html

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 Reusable Launcher 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 worksheet. The Quality Assurance Teams will conduct a launch test with the CEV. How close does it come to the 3-meter mark?
- Teams then return to their stations and discuss the comments from the Quality Assurance Team. What changes were suggested? Do they make sense?

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 this story that makes the science, technology engineering and mathematics come to life.

It's Time to Launch into Space!

Last week, you built a model of a Crew Exploration Vehicle. This week, you must design and build a Reusable Launcher. You will then launch your CEV!

On the way to the Moon, your CEV is going to rendezvous with the International Space Station to pick up some supplies. When you launch your CEV, the goal is to get into orbit close to the International Space Station.

This is a picture of the International Space Station (courtesy NASA). If you want to see real footage of people on the International Space Station, you can see videos from space on the ReelNASA YouTube channel:

http://www.youtube.com/reelnasa

There's a great shot of a shuttle launch there, too! Turn the sound up **LOUD**!

Design Challenge

Your Reusable Launcher must meet the following Engineering Design Constraints:

- Launch the CEV into orbit so that it may rendezvous with the International Space Station. The goal is to launch the CEV 3 meters.
- Be able to be used over and over again.
- Demonstrate a repeatable outcome. If you set up the Launcher the same way twice, the CEV should travel the same distance both times. It is more important that the CEV is launched the same distance using the same set-up than it is to get the CEV to launch the farthest distance.

1. Reusable Launcher: Imagine and Plan Worksheet

It's Time to Launch into Space!

Last week, you built a model of a Crew Exploration Vehicle. This week, you must design and build a Reusable Launcher. You will then launch your CEV!

On the way to the Moon, your CEV is going to rendezvous with the International Space Station to pick up some supplies. When you launch your CEV, the goal is to get into orbit close to the International Space Station.

Design Challenge

Your Reusable Launcher must meet the following Engineering Design Constraints:

- Launch the CEV into orbit so that it may rendezvous with the International Space Station. The goal is to launch the CEV 3 meters.
- Be reusable. It must not fall apart when you use it!
- Demonstrate a repeatable outcome. If you set up the Launcher the same way twice, the CEV should travel the same distance both times. **It is more important that the CEV is launched the same distance using the same set-up than it is to get the CEV to launch the farthest distance.**

What job does a Reusable Launcher do?

What are important parts of a Reusable Launcher and what must it be able to do well?

What building materials do you have that might be useful in building the components you mentioned above?

Reusable Launcher Imagine and Plan Worksheet Page 2

Top View of Reusable Launcher:

Side View of Reusable Launcher:

2. Reusable Launcher Data Table

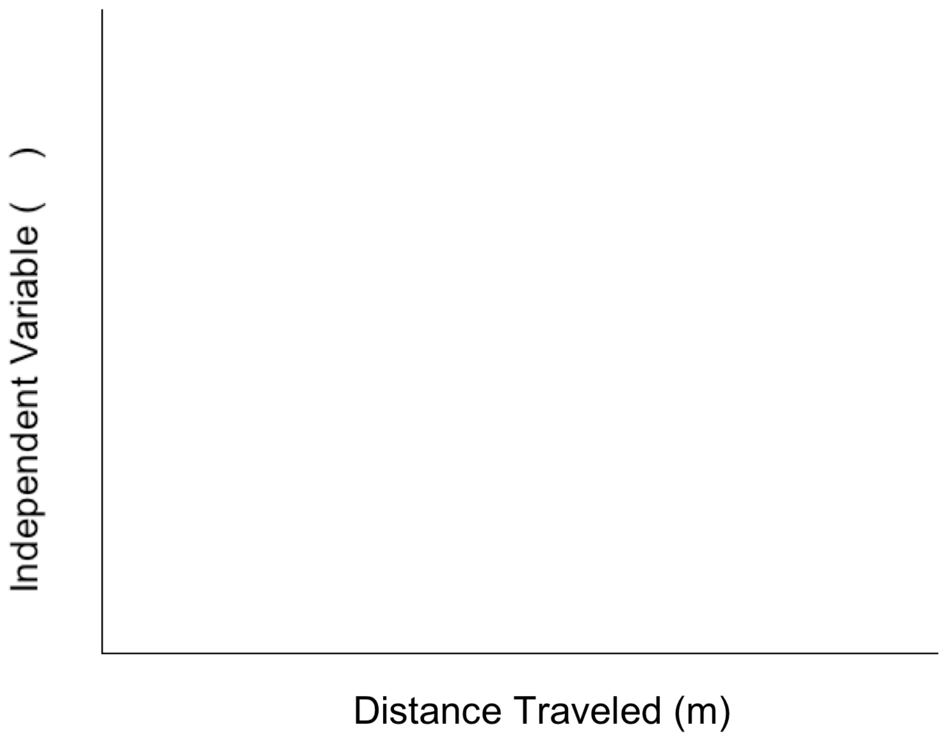
The component of the Reusable Launcher set-up that you will be changing is the distance that you pull the rubber band backwards prior to launch. This is the **Independent Variable**. What might you be trying to learn or observe by changing the distance that you pull the rubber band backwards before launching?

In the first column, write the distance the rubber band will be pulled in the first set of launches. Be sure to measure from the edge of the launching surface to the point of release. You would then change that distance, and enter the new distance in the second three boxes. Change it again for the third set.

Independent Variable: **Distance the rubber band is pulled backwards prior to test launch.**	**Trial Number**	**Dependent Variables**	
		Distance traveled (meters)	**Distance from target (meters)**
Set-up 1: ______ cm	1.1		
Set-up 1: ______ cm	1.2		
Set-up 1: ______ cm	1.3		
Set-up 2: ______ cm	2.1		
Set-up 2: ______ cm	2.2		
Set-up 2: ______ cm	2.3		
Set-up 3: ______ cm	3.1		
Set-up 3: ______ cm	3.2		
Set-up 3: ______ cm	3.3		

3. Graph Your Experiment Data

Use the data from the data table to make a graph of your results. You should fill in the units for the independent variable, and make tick marks on the graph with numbers so that you will be able to plot your data.



Describe the results are seen on the graph. What is the relationship between the Independent Variable and the Distance Traveled?

4. Summary: Questions/Discussions for Understanding

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

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

Why was it important that the launcher be reusable?

Why was it important that your results were repeatable?

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Team Name:____

Fun with Engineering at Home

Activity 3: Launch Your Crew Exploration Vehicle

Today you designed and built a Reusable Launcher to launch the CEV model that you built last week. You were designing the Reusable Launcher to get to a certain distance (3-meters), so that the CEV could meet up with the International Space Station on its way 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 Reusable Launcher. Finally, we **EXPERIMENTED** or tested our launcher by trying three different set-ups to see how that affected the distance that the CEV traveled. Last, we went back to our team station and tried to **IMPROVE** our Reusable Launcher. These are the same 6 steps engineers use when they try to solve a problem or a challenge.

Home Challenge: Next week we will switch gears from getting off the Earth to landing on the Moon. Here are some questions to talk about with your parents, grandparents, brothers or sisters:

How a spacecraft might land on the Moon safely?

Why it doesn't make sense to use a parachute on the Moon?

Here is a link to a great NASA animation of a lunar landing!

http://www.nasa.gov/mission_pages/constellation/multimedia/index.html

For Fun:

This is a picture of the International Space Station (courtesy NASA). If you want to see real footage of people on the International Space Station, you can see videos from space on the ReelNASA YouTube channel:

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Quality Assurance– Checking Each Other's Reusable Launchers

Team Name:____

Participants' Names: ____

____

____

To be answered by the Quality Assurance team:

Describe what component of the Reusable Launcher set-up is changing in order to change how far the CEV is launched. This is the Independent Variable.

Use the set-up that the team says will get the CEV closest to 3 meters.

Independent Variable: **Distance the rubber band is pulled backwards prior to launch.**	**Trial Number**	**Dependent Variables**	
		Distance traveled (meters)	**Distance from target (meters)**
Set-up 1:	QA.1		
Set-up 1:	QA.2		
Set-up 1:	QA.3		

Specific Design Strengths

Specific Design Weaknesses

How would you improve this design?

Inspected by Team: ________________________________

Participant Signatures ________________________________

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