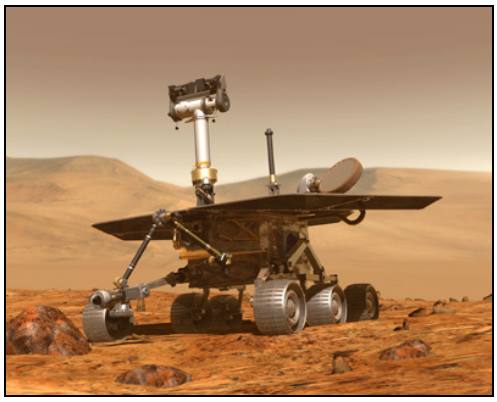
Activity Title: Design a Lunar Transporter Rover!

Activity Objective(s): The teams' challenge is to design and build a model of a Lunar Transporter Rover that will carry equipment and people on the surface of the Moon. It must be able to roll down a ramp. Next week they will design and build a landing pod for this rover, and the week after that, they will simulate a lunar landing. The goal is that the rover survives the landing so that it can roll down a ramp.



Artist conception of a Rover: Courtesy NASA
Two rovers that look like this are on Mars NOW!
See http://marsprogram.jpl.nasa.gov/ for more information on the Mars Exploration Rovers

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)
- (1) plastic egg
- (4) plastic wheels
- Something to use as a ramp (a book would work, but preferably a flat surface that would enable the rover to roll for 50 cm or more)

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

1. Lunar Transporter Rover Design Challenge
2. Lunar Transporter Rover Imagine and Plan Sheets
3. Data Table
4. Fun With Engineering at Home
5. Quality Assurance Sheets

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** (in the Unit 2 Overview) and **Challenge** (in teacher pages) orally with the students. The story provides the context and motivation for trying to accomplish the challenge. This is the **ASK** phase of the Engineering Design Process.
- Show the Mars Rover Entry, Landing and Descent video called "Six Minutes of Terror." (Available on Blackboard Site) Ask them to pay attention to the ways NASA slowed the rovers down as they entered the atmosphere. Tell them to keep in mind that some of the techniques will work on the Moon, and some will not. They should think about what the difference would be (no atmosphere on the Moon which means a parachute device won't work).
- The NASA website with more video on the Mars rovers is: http://marsrover.nasa.gov/gallery/video/challenges.html
  The "Six Minutes of Terror" video is near the bottom of the page in the **Entry, Descent and Landing (EDL)** section.
- 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 ***Lunar Transporter Rover 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.

Stage 2: Create (Approx 20 minutes)

- Challenge the teams to **CREATE** or build their Lunar Transporter Rovers based on their designs. Remind them to keep within specifications. Remind them that they have a mass limit that includes the rover they are making today plus the Landing Pod that they will make next week (300 grams max).
- 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 10 minutes)

- They should set up a ramp to let their rover roll. They should describe the slope of the ramp in terms of "rise-over-run." In other words, "rise" is how high off the table the "up" end of the ramp is, and "run" is how long the ramp is.

- They need to discover what slope to set up the ramp to get the rover to roll. They also need to discover what slope is too steep for their rover. NASA would be very concerned about both the safety of the rover and the safety of the people. If the ramp is too steep, the rover might tumble or slide dangerously, or the impact at the bottom might jar the egg or the astronauts loose.
- This is a "Goldilocks" experiment. What slope is too little? What slope is too much? What slope is JUST RIGHT? They should record their results.

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

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

Stage 5: Challenge Closure – After week 3

The Summary of this activity will come after the simulated lunar landing.

Stage 6: Previewing Next Week (Approx 5 minutes)

- Ask teams to bring back their Lunar Transporter Rover 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 Landing Pods during the next week. Tell them they will be building the Landing Pod out of the standard materials that have been available to them. The pod, with the rover carrying the egg inside the pod, will be dropped from as high as possible (out a second story window? Or at least off a tall ladder, or the top of a staircase.)

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 Lunar Transporter Rover 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 test a ramp with a ratio of rise-over-run of 1-over-3. Note, Quality Assurance Teams should also check the mass of the rover 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?

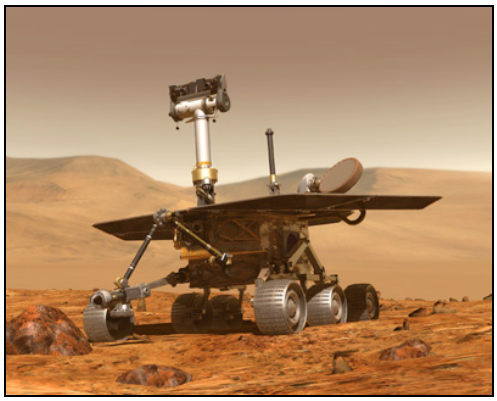
Design Challenge:

Design Challenge

The Lunar Transporter Rover must meet the following Engineering Design Constraints:

- Carry one plastic egg snugly. The egg may NOT be taped or glued into place. (The egg will be what materials are carried in around the Moon.)
- Have room for two plastic people. (The people do not land with the rover. They will get in the rover on the Moon and drive it around.)
- Roll on its own down a ramp with a rise-over-run of 1-over-3 for a distance of approximately 50 cm.
- Survive the "landing." This means it should be able to roll down the ramp after the landing, and the plastic egg should not have popped open.
- Determine the "best" slope for a ramp for your rover. Which "rise-over-run" allows your rover to safely roll the farthest on its own?
- Looking forward to next week: the combined mass of the Lunar Transportation Rover and the Landing Pod must be less than 300 grams.

1. Lunar Transporter Rover Design Challenge



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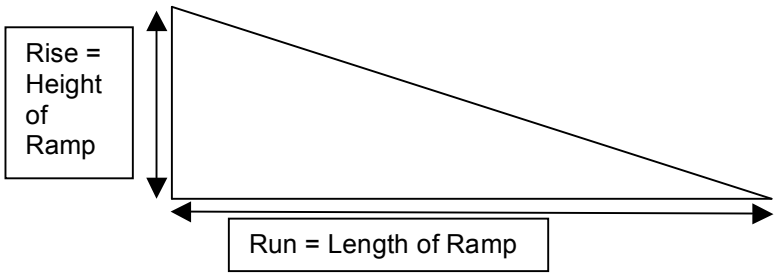

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2. Imagine and Plan Worksheet *Page 1*

What parts do you need to make your rover roll?

What will hold the egg in place?

How does the steepness (slope or "rise-over-run") of the ramp affect your design of the rover?

What is the total mass of the components you are using?

Imagine and Plan Worksheet Page 2

Top View of Lunar Transportater Rover:

Sketch of how you are building the wheel assembly:

Data Table

You need to determine how steep the ramp needs to be to get the rover to roll. You also need to determine how steep the ramp is when the rover no longer rolls, but falls or slides. Make several tests to determine how steep it is for it to be "just right." Make sure to do one test at rise-over-run of 1-over-3, since that is in your Design Constraints.

Trial	Rise-over Run	Distance Traveled (cm)
1	1-over-3	
2		
3		
4		
5		
6		

Would it have made more sense to measure the distance in meters? Why or why not?

Experiment Notes

Use this page to makes notes about the design of your rover as you test its performance as a function of the slope of the ramp.

For example, at what slope does the egg fall out?

Do you need to make changes to the rover design?

Team Name:_____

Fun with Engineering at Home

Activity 5: *Design a Lunar Transporter Rover!*

Today we designed and built a Lunar Transporter Rover model to transport people and cargo on 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 Lunar Transporter Rover. 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 rover. 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 rovers that NASA has already built and used. For example, you can learn about the challenges in building the Mars Exploration Rovers from this website:

http://marsrover.nasa.gov/gallery/video/challenges.html

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

NASA used a parachute to slow the descent of the Mars rovers onto Mars. Why can we not use a parachute to land a spacecraft on the Moon?

They also used a heat shield on the Mars entry spacecraft. Why do we not need one of those on the Moon?

What is the most important consideration when designing a rover that will carry people and cargo?

What kind of cargo might the rover need to carry on the Moon?

Describe how the "rise-over-run" (we call this "slope") of the ramp affects how fast and far the rover rolls. In order to get the rover to roll, a force must be acting on it. If you do not push the rover, and it rolls anyway, what force is acting on it?

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Quality Assurance – Checking Each Other's Lunar Transporter Rovers

Team Name:_____

Participants' Names: _____

_____

_____

To be answered by the Quality Assurance team:

Total mass of the Lunar Transportation Rover is: _____grams

How much mass is left for the Landing Pod? _____ grams

How far does the rover roll on a ramp with slope of 1-over-3? _____ cm

Did the egg fall out on the ramp with slope of 1-over-3? YES or NO

Specific Design Strengths

Specific Design Weaknesses

How would you improve this design?

Inspected by Team: _____

Participant Signatures _____

_____

_____