Heavy Lifter

LESSON THEME
This lesson includes a series of activities that are based on Robotics applications.

OBJECTIVES
In this challenge, students follow the engineering design process to do the following:

• Design and build a crane out of cardboard.
• Determine methods to reinforce the crane's arms so it doesn't collapse under a heavy load.
• Build a crank handle

NASA SUMMER OF INNOVATION

UNIT
Robotics and Engineering

GRADE LEVELS
6th - 9th

CONNECTION TO CURRICULUM
Science, Mathematics, and Technology

TEACHER PREPARATION TIME
20 min

LESSON TIME NEEDED
1.5 hours

NATIONAL STANDARDS
National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- An appreciation of 'how we know' what we know in science
- 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 Standards
- Abilities of technological design
- Understanding about science and technology

Science in Personal and Social Perspectives
- Personal health
- Risks and benefits
- Science and technology in society

History and Nature of Science
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

ISTE NETS and Performance Indicators for Students (ISTE)
Creativity and Innovation
- Apply existing knowledge to generate new ideas, products, or processes
- Use models and simulations to explore complex systems and issues
- Identify trends and forecast possibilities

Communication and Collaboration

- Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media
- Communicate information and ideas effectively to multiple audiences using a variety of media and formats
- Develop cultural understanding and global awareness by engaging with learners of other cultures
- Contribute to project teams to produce original works or solve problems

Critical Thinking, Problem Solving, and Decision Making

- 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

Model and demonstrate the simple crane arm at the beginning of class. Students could begin their design process using the teacher's design. Another alternative is to show pictures of several cranes from the Internet as examples.

CONTENT RESEARCH

The following link provides additional resources for teachers and students and not necessarily a NASA resource but rather private industry, colleges, universities and organization that have taken an interest in one form or another in robotics, robotics competition, teaching, and design.
Please review content from the following resource:
http://robotics.nasa.gov/edu/6-8.php

LESSON ACTIVITIES

Heavy Lifting

Students make use of a crane here on Earth and apply how to use a crane in other places like the moon. At a lunar outpost, astronauts will need machines to build structures and move materials. One of those machines will be a crane. You've probably seen cranes lifting materials and moving them around a construction site. Cranes have a long arm, which holds a cable with a hook on the end. Whether they are on Earth or the moon, cranes have to be strong to lift heavy loads without breaking.

www.nasa.gov/audience/foreducators/topnav/materials/listbytype/OTM_Heavy.html

ADDITIONAL RESOURCES

Station Robotic Arm

Canada has contributed an essential component of the International Space Station, the Mobile Servicing System. This robotic system played a key role in space station assembly and maintenance: moving equipment and supplies around the station, supporting astronauts working in space, and servicing instruments and other payloads attached to the space station. Astronauts receive robotics training to enable them to perform these functions with the arm. http://www.nasa.gov/mission_pages/station/structure/elements/mss.html

Robonaut 2, the latest generation of the Robonaut astronaut helpers, launched to the space station aboard space shuttle Discovery on the STS-133 mission in 2011. It is the first humanoid robot in space, and although its primary job for now is teaching engineers how dexterous robots behave in space, the hope is that through upgrades and advancements, it could one day venture outside the station to help spacewalkers make repairs or additions to the station or perform scientific work.
http://www.nasa.gov/mission_pages/station/main/robonaut.html

Mars Science Laboratory:
Mars Science Laboratory is an unmanned robotic rover designed to land on Mars and assess whether Mars ever was, or is still today, an environment able to support microbial life -- to determine the planet's habitability. The rover, named Curiosity, is about the size of a small sport-utility vehicle. It will carry an advanced suite of instruments to study Martian terrain and soil.
http://sse.jpl.nasa.gov/missions/profile.cfm?MCode=MarsSciLab

Curiosity Robot cam:
Curiosity Cam takes you inside the clean room at NASA's Jet Propulsion Laboratory in Pasadena, Calif., so you can watch the next Mars rover being built. The camera may be turned off periodically for maintenance. The rover may occasionally be out of view as it is moved around the clean room. When Curiosity Cam is off air, you will see a slideshow of Mars and rover images.
http://www.nasa.gov/mission_pages/msl/building_curiosity.html.

NASA Robotics:
To create a human, technical, and programmatic resource of robotics capabilities to enable the implementation of future robotic space exploration missions.
http://robotics.nasa.gov/

eClips:

There are several video clips on robotics from which to choose: Real World: Robotic Arm; Real World: TriATHLETE - The Engineering Design Process in Action; NASA 360 Mind Body Connection
http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms=robotics

DISCUSSION QUESTIONS

- How will you keep the crane's arm from breaking off the box as it lifts a heavy load? *Attach the arm firmly to the box. Students can cut slits in the box top and insert the cardboard strip[s]. They can also tape the end of the arm firmly to the box.*

- How will you stop a heavy load from pulling the arm to the left or right? *Students can add extra pieces of cardboard above, below, and next to the arm as extra support. They can also run string from the top of the arm to the back and sides of the box.*

- How will you wind and unwind the cable so the hook can go up and down? *Students will see that a pencil is the best item to use as a spool for the string. It's challenging, however, to build something to hold the pencil. One way is to make flaps—cut them out of the top of the box, bend them up, and poke the pencil through. Another way is to build a holder out of pieces of cardboard, which kids attach to the top of the box.*

- What kinds of tasks might astronauts use a crane for? *In mining, cranes could lift minerals or ice into vehicles. Cranes could also be useful for assembling structures, such as buildings, satellite dishes, or solar panels.*

- Engineers' early ideas rarely work out perfectly. How does testing help them improve a design? *Testing helps you see what works and what doesn't. Knowing this lets you improve a design by fixing the things that aren't working well or could work better.*

- What force was affecting your crane, and how did the design of your crane deal with it?

A crane has to overcome gravity, which pulls down on the cable and arm. The arm and any extra supports, such as string or additional pieces of cardboard, help spread the forces equally. If all forces are equal and balance one another, the arm won't move.

- How does the way you orient a cardboard strip affect how much it can hold?
  A cardboard strip's strength depends on how it is oriented. When the strip is oriented vertically, like a wall, most of the cardboard resists the load's downward pull. This is the strongest orientation of the strip. In contrast, when a strip is oriented horizontally, like a ceiling, only a little cardboard resists the load's downward pull. This is the weakest orientation of the strip.

ASSESSMENT ACTIVITIES

Review the tables or charts created by your students.

ENRICHMENT

- Students can enter First LEGO Robotics Competitions http://robotics.arc.nasa.gov/events/2011_sponsorship.php
- NASA Robotics: http://robotics.nasa.gov/students/sumo.php
- Robotics Summer Camps: http://robotics.nasa.gov/students/summer_camps.php
- NASA-KSC Luna-Botics : http://www.nasa.gov/offices/education/centers/kennedy/technology/lunabotics.html