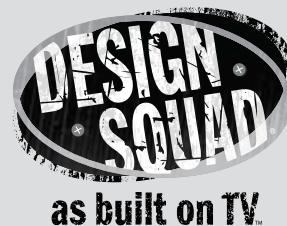
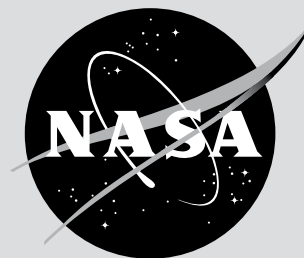


FEEL THE HEAT



Colder than Antarctica? Welcome to the moon! To survive on the moon, astronauts will need buildings that can protect them from temperatures as low as -250° Fahrenheit (-157° Celsius). One way to heat these buildings is to use sunlight to heat water and pump it through the rooms.

WE CHALLENGE YOU TO...

...design and build a solar hot water heater and see how big a temperature change you can get.

BRAINSTORM AND DESIGN

To heat water with your heater:

- What color should you make the tube and background?
- Being exposed to light is what heats water. How fast do you want water to flow through the tube?
- How can the way you zigzag the tube across the cardboard help the water in the tube absorb heat from the sun or light bulb?

BUILD

- 1. First, get water to flow through the tube.** Poke a small hole near the bottom of a cup. Put the tube into the hole. Set a second cup under the tube's other end. Test your system with water. Seal any leaks.
- 2. Then, build your hot water heater.** Use the materials to design a system that can help the water absorb a lot of heat energy.

TEST, EVALUATE, AND REDESIGN

- Put your heater in strong sunlight or 8 inches (20 cm) below the lamp. (SAFETY NOTE: Keep water away from the outlet, lamp, and bulb.)
- Measure and record the temperature of the water in the pitcher.
- Pour water from the pitcher into the supply cup.
- Record the temperature of the water as it comes out of the lower end of the tube.

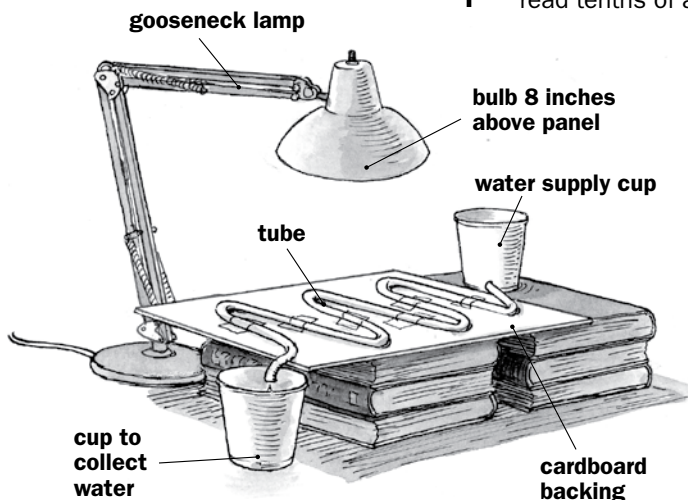
Starting temperature: _____

Ending temperature: _____

Temperature change: _____

MATERIALS (per heater)

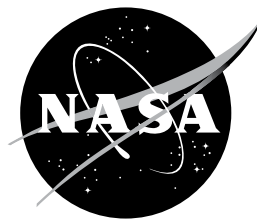
- aluminum foil
- large sheet of cardboard (e.g., 11 x 17 inches/ 28 x 43 cm)
- gooseneck lamp with an indoor 100-watt floodlight light bulb (optional if using sunlight)
- black marker
- black paper
- 2 paper cups (medium-sized)
- 3 feet (0.9 m) clear plastic tubing (Outside diameter: $\frac{1}{4}$ inch/6 mm)
- pitcher of water
- ruler
- scissors
- straws
- duct tape
- an indoor-outdoor digital thermometer that can read tenths of a degree



TEST, EVALUATE, AND REDESIGN (CONTINUED)

Can you get an even bigger change? Engineers test a design and improve it based on what they learn. This is called the design process. See how big a change you get.

- **Help the water absorb more heat**—Add materials above, below, or around the tube to focus more heat energy on the water. Also think how you can use color to help heat the water.
- **Slow the flow**—The longer the water stays in the light, the more it will heat up. Figure out how to make the water flow slowly through the tube.
- **Make your tube longer**—A longer tube can help water stay in the light for a longer time. Tape two tubes together.
- **Air bubbles clog the tube**—Blow into the tube to clear it.



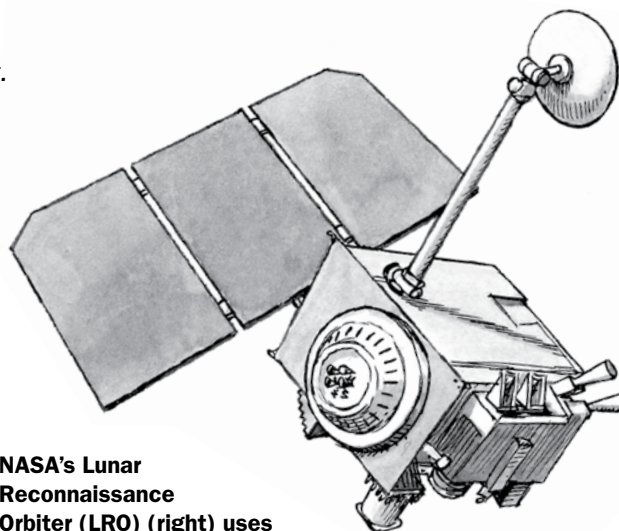
Check out NASA's moon missions at moon.msfc.nasa.gov.

WHAT SHALL I WEAR?

Ever have trouble deciding what to wear? Try packing for the moon! On the moon, daily temperatures can swing about 500° Fahrenheit (260° Celsius). It can get up to 250° F (121° C) during the day, and at night, it can drop to -250° F (-157° C). Earth's blanket of air—the atmosphere—keeps us at a comfortable average temperature of 60° F (16° C).

But the moon has no atmosphere to hold heat. Better bring a well-insulated space suit when you visit!

Buzz Aldrin wore a million dollar spacesuit (left) designed to protect him from the moon's extreme hot and cold temperatures.



NASA's Lunar Reconnaissance Orbiter (LRO) (right) uses a large solar panel to turn sunlight into electricity.

RUN BY THE SUN

Make your own electricity? In space, NASA's LRO spacecraft uses large solar panels to turn sunlight into electricity. They can produce about 1850 watts—enough to run a large microwave oven. But on average, LRO only uses 800 watts—enough to run a small toaster. The extra electricity is stored in batteries on board the LRO. When LRO goes into the shadow behind the moon, the darkness there prevents it from using the energy from the solar panels. So it powers itself with the batteries.

Watch **DESIGN SQUAD** on PBS or online at pbs.org/designsquad.

Major funding for Design Squad provided by



Additional funding for Design Squad provided by



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