

# teach with space

## → MOON ROVER

*Building a solar-powered rover*





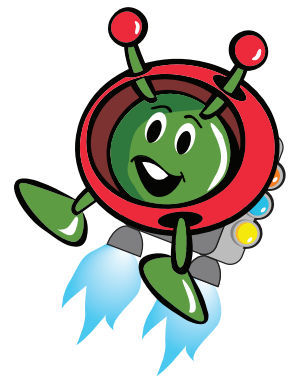
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# → MOON ROVER

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## Fast facts

**Subjects:** : Science, Physics, Arts

**Age range:** 8 – 14 years old

**Type:** student activity

**Complexity:** medium

**Lesson time required:** : 1 hour 30 minutes

**Cost:** Low(0-10 euros)

**Location:** classroom. Testing should be done outdoors on a sunny day.

**Keywords:** Moon, Exploration, Rover, Solar energy, Renewable energy sources

## Brief description

In this activity, students will compare the advantages and disadvantages of renewable energy sources and non-renewable energy sources and study simple electrical circuits. Using the Moon as context students will build a small Moon rover powered by solar energy, using a small motor and a solar cell. They will also identify the main features their rover must have to go to the Moon and improve their initial rover design.

## Learning objectives

- Identify types of renewable sources of energy and understand their advantages and disadvantages.
- Identify solar energy as one of the best options for powering a lunar rover.
- Learn about the environmental conditions on the Moon.
- Sketch simple electrical circuits.
- Build a simple rover and incorporate a solar cell and a motor.
- Improve their ability to work in a group and their creative thinking.
- Learn about the purpose of lunar rovers for Moon exploration.



## → Summary of activities

activity	title	description	outcome	requirements	time
1	Powering a lunar rover	Pupils will name different energy sources, and identify advantages and disadvantages of their usage. Students will also explore if they could be used on the Moon.	Pupils should understand the importance of having different energy sources in different locations.  Pupils should be able to draw simple electrical circuit diagrams.	None	30 minutes
2	Build a solar powered Moon rover	Building the rover from a given set of instructions and materials. Testing the rover and considering how to improve its performance.	Understand how to incorporate an electrical circuit into a model rover.  Identify that the environmental conditions on the lunar surface are different from Earth's.	Completion of Activity 1 is advised	60 minutes



## → Introduction

In space exploration, one of the most striking characteristics of satellites are their big solar panels. To travel through our Solar System, satellites and rovers require energy and the Sun is a convenient source of energy.

Solar energy is a renewable resource, it is naturally replenished on a relatively short timescale (within a human lifetime), and is non-polluting. It also has the advantages of requiring little maintenance or supervision and low running costs.

One of the next destinations to be explored by the European Space Agency will be the Moon! Special vehicles are being developed to travel on the Moon's surface to perform scientific tests and collect samples.



Figure 1

↑ A prototype rover is commanded to drive in and sample a quarry resembling a lunar site. The image shows a virtual reality impression of the test.

In this activity, students will investigate which sources of energy could be used on the Moon and construct their own Moon rover powered by solar energy.

## → Activity 1: Powering a Lunar Rover

In this activity, students will learn about the advantages and disadvantages of renewable sources of energy. They will learn about the Moon environment and consider which is the best power source for a lunar rover. The students will also sketch simple electrical circuits.

### Equipment

- Student worksheet printed for each group
- Pen/pencil

### Exercise

In this activity students will have to relate environmental conditions from different locations with the feasibility of using different renewable energy sources.

To complete the activity students need prior information about renewable and non-renewable energy sources, this activity can be used as a conclusion to the topic. Otherwise, start the exercise by presenting general information about renewable and non-renewable sources of energy to the pupils.

Distribute the student worksheets to each group and ask the students to fill in questions 1 to 4. Students should present their results to the whole class. Based on the answers to question 4 the class should create a general list with the advantages and disadvantages of using renewable energy sources.

Highlight to the students some of the general information about the environment on the Moon presented on the student worksheet. Ask them to complete question 5 to 7. In question 7, students may have different ideas about which source of energy is the best, they should realise that the perfect source of energy does not exist.

For questions 8 and 9 students will have to sketch simple electrical circuits in series, depending on their previous knowledge about electricity these questions may need an introduction to the topic. These questions can be complemented with the practical assembly of the electrical circuits.

The electrical circuit the students sketch in question 9 will be implemented in the construction of the Moon rover in Activity 2.

### Results

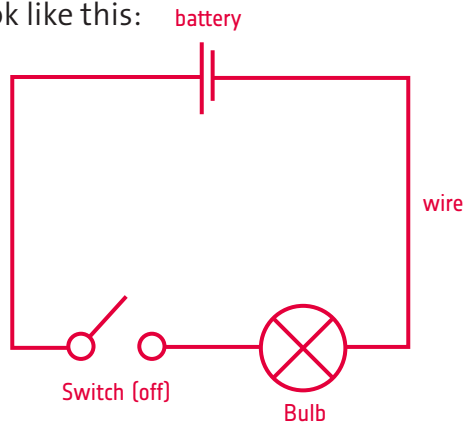
1. a) solar, b) wind, c) biomass, d) geothermal,
2. Renewable energy sources include:
  - water, hydropower can be obtained in hydroelectric dams in rivers and reservoirs, converting energy of the tides and capturing the energy of the ocean waves;
  - hydrogen energy.



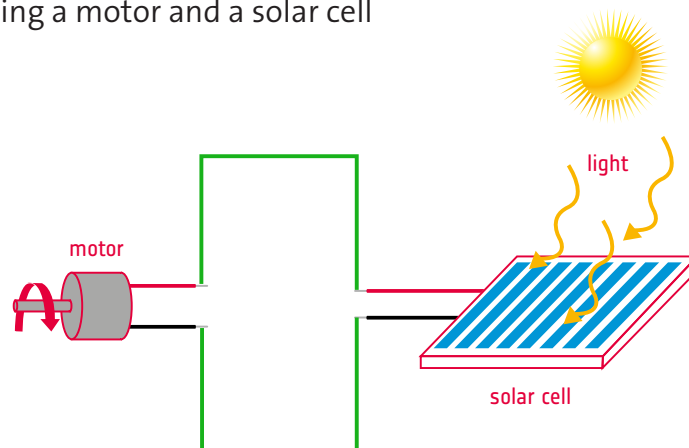
3. Non-renewable energy sources include:
  - fossil fuels like gas, petroleum and coal;
  - nuclear energy.
4. Examples of advantages and disadvantages of renewable energy sources.

<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>• natural/non-polluting</li> <li>• sustainable</li> <li>• infinite supply - replenished on a short timescale</li> <li>• safe</li> <li>• require less maintenance/supervision</li> <li>• low running costs</li> </ul>	<ul style="list-style-type: none"> <li>• high initial installation costs</li> <li>• location/weather dependent</li> <li>• not available all the time so they need to be able to store the energy</li> <li>• can still generate some pollution</li> <li>• can create disturbances in wildlife (e.g. wind turbines, hydroelectric dams)</li> </ul>

5. With basically no atmosphere and no liquid water we are unable to use wind, tides, waves or hydroelectric dams. Students may also mention biomass since in these conditions life can not exist.
6. Solar power - you will always be able to use solar power during daylight.
7. A rover on the Moon could be powered by solar energy, but it would be limited to work only during daylight periods. The rover would have to have large batteries to store the energy produced or a complimentary energy source such as nuclear energy, which is being used for example in NASA's Curiosity rover on Mars.
8. The circuit diagram should look like this:



9. Electric circuit including a motor and a solar cell



## → Activity 2: Build a Solar-powered Rover

In this activity, pupils will build a solar-powered rover using a solar cell, a motor and craft supplies.

### Equipment

- Student worksheet printed for each group
- Annex printed for each group
- 1 solar cell – recommended a photovoltaic cell of 5V or 2V
- 1 motor – recommended a DC motor of 3V, or 1.5V for a photovoltaic cell of 2V
- 2 electrical wires
- 4 plastic bottle caps or 4 big toy car wheels
- 1 rubber band
- 1 small carton package (e.g. from food or beverage)
- 2 wooden sticks
- Thick cardboard
- 1 cork stopper
- 1 straw
- 1 marker
- 1 box cutter knife
- Hot glue
- Double-sided adhesive tape (optional)
- Additional craft materials for the additional decoration of the rover

### Exercise

The students should work in groups of 2 or 3 to build their Moon rover.

Distribute to each group the necessary materials and the detailed instructions on how to build the rover, available in the Annex. Depending on the students' age, they may need assistance using the cutter knife and the hot glue.

After building the rover, ask the students to test the rover they have built. The testing should be done outside on a sunny day, alternatively a strong lamp can be used.

The students should note what works well and what needs to be improved. Students should answer question 4 on the student worksheet and discuss which improvements should be made to the rover to work in the Moon environment. They can also compare their rovers with other groups and discuss how they can all be improved to work on the Moon.

### Results

The performance of the rovers will depend on the light source (how sunny it is) and how well-made the rovers are.

Common issues are:

- not enough sunlight,
- solar cell is not adequate to power the motor,
- a poor connection between the wires and the solar cell,
- the rubber band not being stretched tight enough,
- the rubber band jumping off the wheels if the wheels do not have a deep enough cavity around the circumference.

### Discussion

Discuss with the students whether their rovers would be suitable for travelling on the lunar surface. Are the rovers able to travel for long distances? When testing the rovers, students could be encouraged to test on different types of surfaces (such as soil, small rocks and large rocks). One of the main components of the rover are the wheels, students can propose a different type of material to make the rover move better in different types of terrain.

Students could also test their rovers with different levels of illumination.

Students can also study the functionalities of other planetary rovers for inspiration, such as ESA's ExoMars rover, and propose scientific missions to be done with their lunar rovers.





# → MOON ROVER

Building a solar-powered rover

## → Activity 1: Powering a lunar rover

1. Can you name the renewable energy sources being shown in the pictures below?

a) \_\_\_\_\_



b) \_\_\_\_\_



c) \_\_\_\_\_



d) \_\_\_\_\_



2. Can you think of any other sources of renewable energy?

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3. List 2 sources of non-renewable energy.

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4. Think of four advantages and four disadvantages of renewable energy sources compared to non-renewable energy sources.

<b>Advantages</b>	<b>Disadvantages</b>
<ul style="list-style-type: none"> <li>• _____</li> <li>• _____</li> <li>• _____</li> <li>• _____</li> </ul>	<ul style="list-style-type: none"> <li>• _____</li> <li>• _____</li> <li>• _____</li> <li>• _____</li> </ul>

**Did you know?**

The environment on the Moon is very different from Earth. The Moon's surface is very rocky, covered with very thin dark dust, similar to sand known as regolith. Day and night are also very different on the Moon. One day on the Moon lasts almost the same as one month on Earth. This means that on the Moon it is daytime during 15 Earth days straight and then night-time for 15 Earth days straight.



5. The Moon has basically no atmosphere, no air, and no liquid water, no oceans or rivers. Which renewable sources will we be unable to use because of this?

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6. There are no clouds on the Moon. For which renewable source is this good? Explain why.

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7. A rover would allow astronauts to explore a new environment with greater mobility and in a safe way. Equipment like drills and cameras can be transported safely to greater distances. What is the best way to power a rover on the Moon? Explain why.

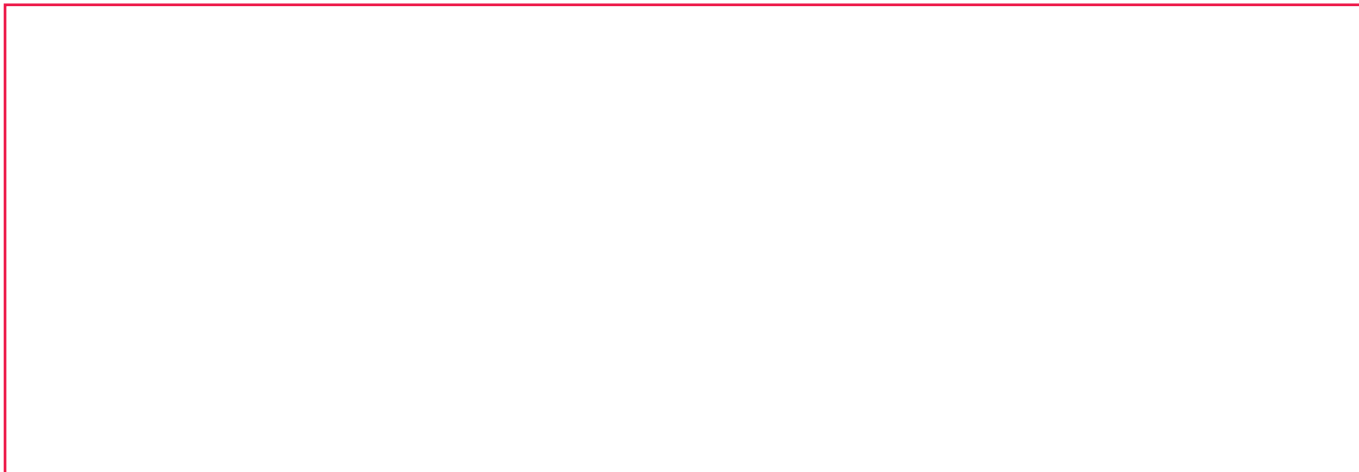
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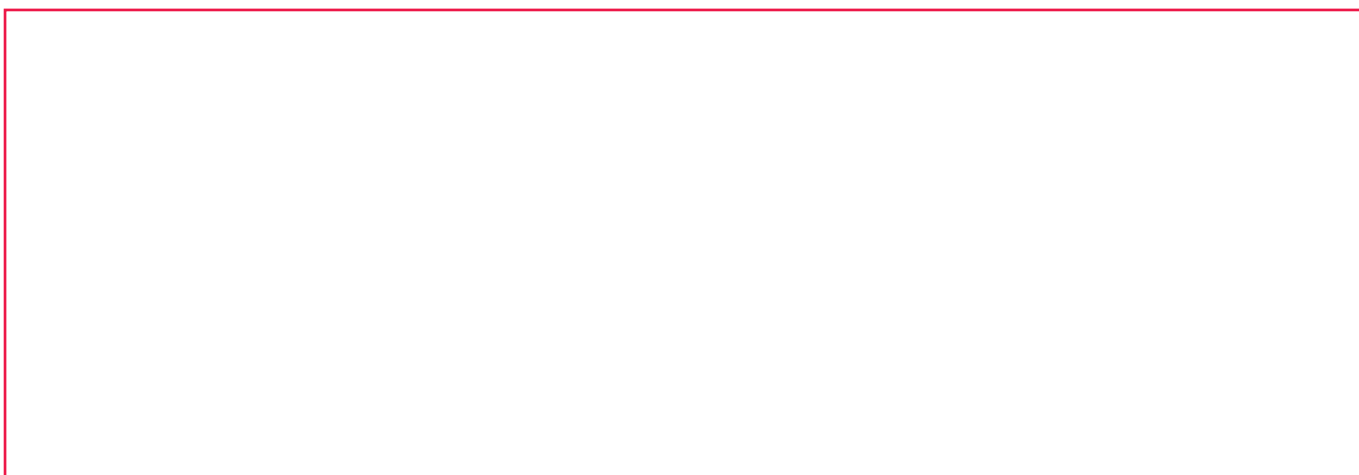
8. For a rover to work, it needs electricity. In the box below, draw a sketch of a simple electrical circuit that includes: a **battery**, a **light bulb** and a **switch**.



9. Imagine now that you are building a lunar rover that is powered by solar energy. Can you sketch the electrical circuit needed?

Include in your circuit:

- **1 solar cell** (which turns sunlight into electricity)
- **1 motor** (which will control the wheels)



## → Activity 2: Build a solar powered Moon rover

### Did you know?

A Moon rover will have to be designed to travel unfamiliar rocky terrain, covered with regolith and with unknown slopes. The rover should have specially designed wheels that can overcome these conditions without having any problems. It will also have to carry scientific instruments such as cameras and drills to take samples. The rover should also have autonomy and power to cover long distances.



1. Check the equipment list and confirm that you have all the necessary materials to build your Moon rover.
2. Build your moon rover by following the instructions provided by your teacher. Do not forget to incorporate the electrical circuit you sketched on Activity 1.
3. If it is sunny, take your rover outside the classroom and test its performance. After your initial test, list three features of your rover that you would change to improve its performance on the Moon. Explain why.

a)

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b)

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c)

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5. Apply the suggested changes to your rover! Compare it to your colleagues' rovers. Which would be the ideal Moon rover?



## → LINKS

### ESA resources

Moon Camp Challenge

[esa.int/Education/Moon\\_Camp](https://esa.int/Education/Moon_Camp)

Animations about Moon exploration

[esa.int/Education/Moon\\_Camp/Working\\_on\\_the\\_Moon](https://esa.int/Education/Moon_Camp/Working_on_the_Moon)

ESA classroom resources

[esa.int/Education/Classroom\\_resources](https://esa.int/Education/Classroom_resources)

ESA Kids

[esa.int/kids](https://esa.int/kids)

### ESA space projects

ESA's applications for planetary exploration

[esa.int/Our\\_Activities/Space\\_Engineering\\_Technology/Automation\\_and\\_Robotics/Applications\\_for\\_Planetary\\_Exploration](https://esa.int/Our_Activities/Space_Engineering_Technology/Automation_and_Robotics/Applications_for_Planetary_Exploration)

ESA's animation of concepts for future Moon robots

[esa.int/Our\\_Activities/Human\\_and\\_Robotic\\_Exploration/Exploration/Landing\\_on\\_the\\_Moon\\_and\\_returning\\_home\\_Heracles](https://esa.int/Our_Activities/Human_and_Robotic_Exploration/Exploration/Landing_on_the_Moon_and_returning_home_Heracles)

### Extra information

Moving on the surface of the Moon

<https://lunarexploration.esa.int/#/explore/technology/228?ha=299>

Renewable energy development

[esa.int/Our\\_Activities/Observing\\_the\\_Earth/Benefiting\\_Our\\_Economy/Renewable\\_energy\\_development](https://esa.int/Our_Activities/Observing_the_Earth/Benefiting_Our_Economy/Renewable_energy_development)

Putting renewable energy on the map

[esa.int/Our\\_Activities/Preparing\\_for\\_the\\_Future/Space\\_for\\_Earth/Energy/Putting\\_renewable\\_energy\\_on\\_the\\_map](https://esa.int/Our_Activities/Preparing_for_the_Future/Space_for_Earth/Energy/Putting_renewable_energy_on_the_map)





## → Annex: Build a solar powered rover

### Equipment

- 1 solar cell
- 1 motor
- 2 electrical wires
- 4 wheels
- 1 rubber band
- 1 small carton package
- 2 wooden sticks
- Thick cardboard
- 1 cork stopper
- 1 straw
- 1 marker
- 1 box cutter knife
- Hot glue
- Double-sided adhesive tape (optional)



### Instructions to construct the solar rover

Cut the straw into 2 equal parts (Figure A1). They will be the rover wheels' axles. Glue the 2 halves of the straw on the same side of the carton package with hot glue (Figure A2). Use the largest side of the package to provide more stability to the rover.



Figure A1



Figure A2

Cut the wooden sticks in order to give them the desired length. Make sure that both sticks are long enough so that the wheels can be attached on the sides and still keep a minimum distance of 1 cm to the rover (Figure A3). Insert each wooden stick inside each half of the straws glued to the rover (Figure A4).

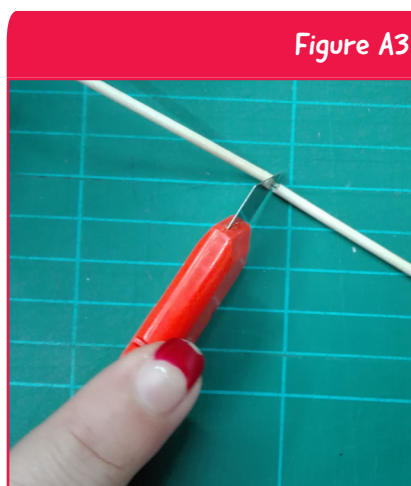


Figure A3

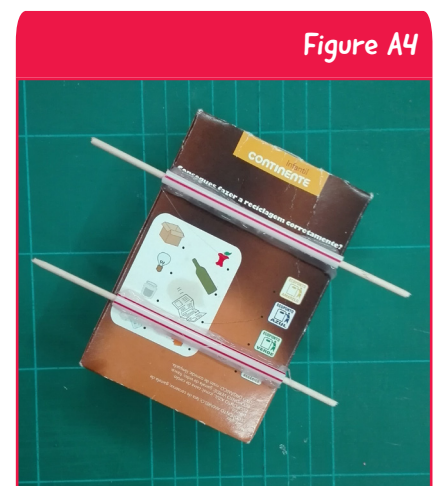
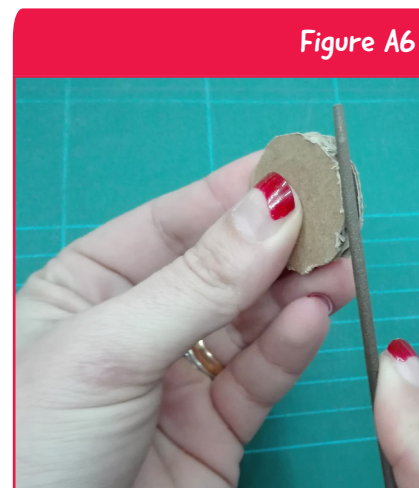


Figure A4

Make a wheel out of cardboard with the help of a box cutter (Figure A5). Create a small cavity in the central region around the cardboard circumference, in order to insert a rubber band that can rotate without jumping out (Figure A6). This will be the driving wheel of the rover, it will be later attached to the motor.



Glue the cardboard wheel to the top side of a bottle cap, then pierce both in the centre and use hot glue to attach to one end of a wooden-stick-axle (Figure A7). Attach the three remaining bottle caps to the ends of both axles, ensuring they always face the same sides and maintain equal distances between them and the rover (Figure A8).



Cut out a small cork stopper disc, with an approximate diameter of 8 mm and about 1 cm thick. Scrape/sand the disc along its circumference (Figure A9), allowing the rubber band to tightly encircle it (Figure A12).



The placement of the motor is one of the most important steps of this activity it will determine whether the rover will work well or not (Figure A10). To pinpoint where the motor should be fitted, stretch the rubber band around the driving wheel and pull it along the side of the carton, until the band is completely stretched. Mark this position on the cart with an 'X' and pierce the carton there (Figure A8).



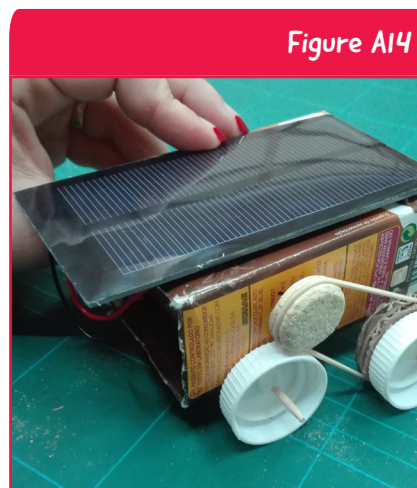
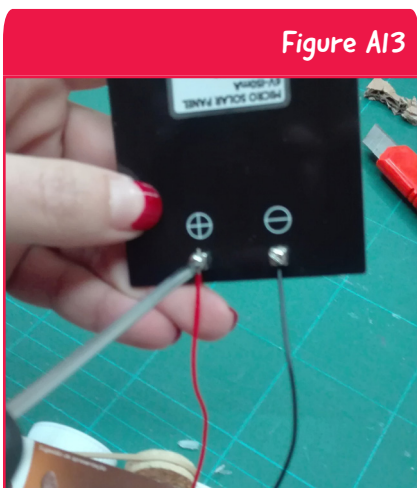
Glue the motor onto the inside of the carton, where it was pierced in the previous step (Figure A10), assuring that the spindle remains on the outside, as shown in Figure A11. Connect two electrical wires to the motor (unless the motor already has them).

Attach the cork disc to the motor spindle. Make sure that the rubber band goes around the cork disc and the driving wheel (Figure A12). Pierce the top of the carton and pull out the motor electrical wires through the hole(s).



Connect the motor wires to the solar cell (Figure A13), the electrical circuit should be similar to the one you sketched in Activity 1, question 9.

Glue the solar cell on the top of the cart (Figure A14). Optional - use a thick piece of cardboard and double-sided adhesive tape for a stronger bond, if needed.



Your Moon rover is now ready to be tested. Test the solar-powered rover outside on a sunny day. If the rover moves backwards, swap the wire connections to the solar cell around.