Cycle for Science

Grade Levels: Elementary school and higher

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The Sol Cycle is a miniature, 3D-printable bicycle that uses solar power to run a small motor that turns the wheels. We cover three broad subjects in this lesson: renewable energy (solar), physics (including speed, distance, Ohm's law), and engineering design (3D modeling and printing). This lesson plan can be tailored to your needs and the interests of your students.

The goal is to involve the students as much as possible—to have them learn science by doing, rather than hearing about it. If there is only time for one 45-60 minute lesson, the Sol Cycles should be pre-printed and pre-assembled ahead of time. There is also room for more in-depth lessons on basic CAD design using Tinkercad, a free online software developed by Autodesk, and 3D-printing.

The Sol Cycle emerged out of a cross-country bicycle trip taken by Elizabeth Case and Rachel Woods-Robinson in the spring and summer of 2015. As two female scientists, they designed the Sol Cycle to be a hands-on, creative and engaging science demonstration for students aged 4-14. Find out more about the original trip at www.cycleforscience.org.

This lesson is flexible, and can be run in multiple ways. Here is a sample of how you can run a lesson, with some suggestions for other activities or topics that are interchangeable.

After this lesson, students should be able to

- *List the three parts of an atom.*
- *Explain how a solar panel works (briefly).*
- *Give one or more examples of renewable energy, and explain why it is important.*
- *Be able to calculate speed from distance and time.*
- *Have a basic overview of prototyping, especially in regards to 3D printing.*

Materials

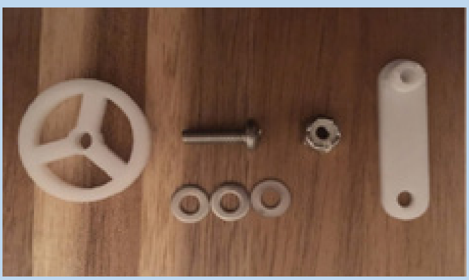
Donwload 3D-printable file from QESST Education website or from: https://tinkercad.com/things/7bJwCUMnaLb

- Bicycle parts
  - (1) frame
  - (1) front wheel
  - (1) back wheel with hub
  - (2) training wheels
  - (2) training wheel forks
  - (1) motor-stop (for keeping the rubber band "chain" on the motor)
  - (1) handlebars
- Nuts and bolts
  - (1) 1.75" back wheel bolt
  - (1) 3/4" front wheel bolt
  - (2) 2 5/8" training wheel bolts
  - (3) lock nuts
  - (4-8) washers
  - (2-4) lock washers
  - (2) nuts
- Miscellaneous
  - (1) set 5-inch velcro (hook and snag)
  - (1) thin rubber band, e.g.
  - (2) thick rubber bands, e.g.
  - (1) 6V, 1.5W RadioShack solar panel
  - (2) small alligator clips, e.g.
  - (1) high efficiency motor, e.g.
  - Heat shrink wrap, e.g. (optional)
- Tools
  - (1) pair of pliers
  - (1) pair of mini scissors or Swiss Army knife
  - (1) Phillips screwdriver

How to assemble the Sol Cycle

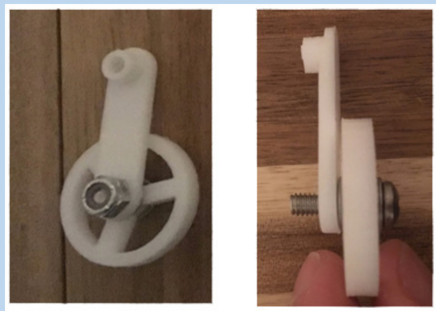
1. 3D-print all the parts you'll need, except for 1 locknut (3 needed in total: two for each training wheel and one for the front wheel).

2. Assemble the training wheels (x2) The number of washers you need will depend on the thickness of your washer – they are there to help your wheel spin, and also to make sure the screw fits snugly into the lock nut. Follow these steps for both training wheels.



2a. Add [washer(s) - wheel - washer(s)] to the bolt, so that there are washers on either side of the wheel.

2b. Screw on the training fork, making sure that the wheel is on the opposite side of the nub. Tighten on the locknut. The wheel should still spin freely – if it doesn't, remove some of your washers. You may need a screwdriver and pliers to tighten.

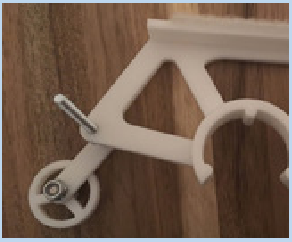


3a. Front wheel. Screw the bolt into the front wheel slot. You may need a screwdriver to do this. The head of the bolt should be on the opposite side of the protruding top bar (the same side as the flat face), so the front and back wheel will align.

3b. Add [washer - wheel - washer] and then tighten on the lock nut. The wheel should still spin freely. If it does not, remove one or both of the washers. If there is too much room on the screw and the wheel wiggles, add another washer.

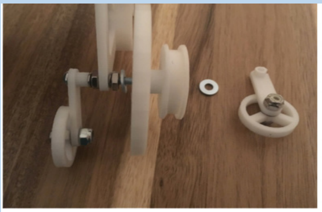
4a. For back wheel, twist the training wheel with the open hole onto the long (1.75 or 2" screw) with the nub facing in and the wheel facing out as shown.

4b. Add the [lock washer - nut], then screw bolt into the bicycle frame. This training wheel should be on the opposite side of the protruding top bar, on the opposite side of the front wheel.



4c. Add [lock washer - nut - washer] as shown. Then add on the back wheel, with the pulley-side of the back wheel facing away from the frame.

4d. Add a [washer], then carefully tighten on the other training wheel by lightly pressing the opening of the nub against the end of the bolt. It should turn 3-5 times but can easily break if you apply too much pressure.



5. Finishing touches: it is pretty tricky to get those back wheels to stay in place. The easiest way to do it is to make sure the training wheels are aligned and touching the ground, the nut on the opposite side of the back wheel is tightened all the way up against the training wheel, and then use pliers to tighten the nut closest to the back wheel. Play around with it.

Instructions

<u>Introduction (5-10 min)</u>

Introduce yourself and what you do as a scientist. Then introduce the lesson material. A few tried and tested questions include:

> *How many of you ride your bicycles to school? (bicycles, mechanics, physics)? How many know where plants get their energy? (solar panel, renewable energy, circuits). And yes, the sun! Every morning, sunlight streams from the furnace of the sun's surface to the surface of the earth. Do you know how long it take light to travel from the sun to the Earth? (8 min).*

Depending on the age group, ask if anyone knows what light is:

> *Light is made of photons, which are little packets of energy that don't weigh anything at all and speed reeallllly fast through the universe.*

Introduce the idea of atoms:

> *What are the really tiny things that make up everything? What are the three parts of an atom? (Electron, neutron and proton).*

<u>How a Solar Panel Works (10 min)</u>

Hold up the Sol Cycle. Ask everyone what it is (a bicycle!).

Point or hold up a separate solar panel - do any of the students know what it is? How about how it works?

> *Sun emits photons, photons transmit energy to electrons, electrons get excited and move through the surface of the panel, down the red wire and into the motor, which steals the photon/energy, and the electron returns to its nucleus to repeat the pathway,*

Ask for four volunteers – (1) a **sun**, (2) an atom of the solar panel represented by an **electron** (someone who wants to run around!) and (3) a **nucleus**, and (4) a **motor**.

> *The sun is given a starburst – this is a photon! A tiny packet of energy.*

Position the four students in a line. The **sun** at one end of the space, the **electron**, walking slowly, sleepily, around the **nucleus** about 5-10 feet away, and the **motor** stands inert at the far end. If desired, lay down red and black tape/paper beforehand to represent the wires.

Set up the scenario, narrating:

> *At night, the electron is sleepy and has no energy to move away from its nucleus,*

so the student who has volunteered to be the **electron** rotates around the **nucleus**

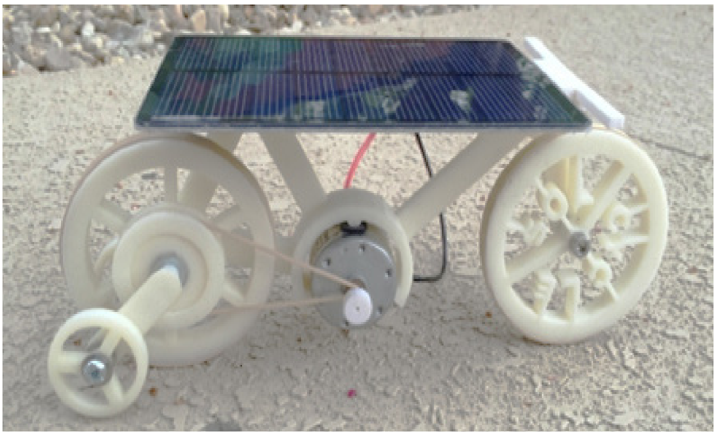
> *The sun rises and wakes up and tosses the starburst/photon to the electron. The electron now has lots of energy.*

The student runs around the room, then down the red wire to the **motor**.

> *The motor is hungry – it's breakfast time in motorland – and steals the starburst from the electron and starts spinning.*
>
> *The electron returns, exhausted, to the nucleus (its "parent") and slowly rotates again.*

<u>Sol Cycle Assembly (5-10 min)</u>

Students get in groups of 3-5. Invite one student per group to collect a Sol Cycle kit: a sol cycle (fully assembled, as shown above), a motor, a solar panel, and some rubberbands (two fat, one thin for the wheel "tire" and "chain" respectively. Final assembly should look like below:



Group assembles one cycle together. Walk around the room and help any that are stuck by asking leading questions

> *Think about a real bike. What happens when you pedal? What's moving? Are the tires plastic/metal or do they have something (e.g. a tire) around the edges?*

<u>Sol Cycle Activity (15 min)</u>

Each group receives a worksheet, a meter stick, and a timer. Each group takes five trials of how long it takes for their Sol Cycle to travel a meter.

Calculate speed, translate into miles per hour (from feet per second) and compare to: walking example, car example, bicycling example.

Have students experiment and observe. Some qualitative and quantitative questions are:

> *Does the angle of the solar panel matter? How close or far from a building? The texture of the ground? The angle of the ground?*

After doing some experiments, have students race their Sol cycles—20 feet or so is usually enough to make it really exciting.

Renewable Energy Discussion (5-10 min, optional)

What is renewable energy? Are solar panels an example of renewable energy?

What are some other examples of renewable energy?

Answer: wind, tidal, geothermal

What are some examples of non-renewable energy?

Answer: oil, gas, ethanol.

Why is renewable energy important? What is climate change?

Answer: The natural patterns and geologic ages of the earth are changing because of the pollution we emit into the atmosphere, and put into the ocean and the ground. Oil and gas release greenhouse gasses when they are burned. This traps heat in the atmosphere, and/or has torn a hole in our atmosphere, which means more radiation can reach the earth. Climate change is also affecting wildlife, causing animals and plants to go extinct. Healthy biodiversity healthy humans.

3D Printing (5-10 min, optional)

Sol-cycle design is available online to be 3D printed, so it can be a great opportunity to introduce students to 3D printing.

If a student has done any 3D printing, ask them to explain the process. In big strokes, the two steps are 1) giving the machine a design, and 2) the machine melts plastic and extrudes it onto the "drawing" board in layers microns to millimeters thick.

You can discuss with the students cool examples or uses of 3D printing. Some examples are for medical applications, like practicing surger on 3D printed skulls; for family —blind mothers receive a 3D printed "statue" or plate of the ultrasound image of their baby,— or even for printing parts for other 3D printers.

There are resources they can use to design their own bicycles (or anything they can dream of), like Tinkercad (free online software), or 3D hubs for printing ("amazon turk" for 3D printing -- someone does it for you on their own machine).

Wrap up (5 min)

Review with students how solar panels work, what the smallest element of matter is, how fast their Sol Cycle went, and how it was made.

Also, give students some take-home questions: how would they make the Sol Cycle better, or what would they like to 3D print? Have them draw out all the individual pieces that make up their design.

Next Generation Science Standards

This lesson was designed around the middle school Next Generation Science Standards (NGSS) and covers the following standards:

- **MS-PS3-2**: Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- **MS-PS3-5**: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- **MS-ETS1-1**: Define the tcriteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.