CYCLE FOR SCIENCE LESSON PLAN

INTRODUCTION

Hello! We're so glad you're interested in bringing the Sol Cycle into your classroom.

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 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 criteria 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.

PARTS

3D-printable file can be found at: https://tinkercad.com/things/7bJwCUMnaLb

1. 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

2. 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
3. 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)
4. Tools
   - (1) pair of pliers
   - (1) pair of mini scissors or Swiss Army knife
   - (1)Phillips screwdriver
5. Other materials that might be useful during the lesson
   a. Starbursts ("photons") or other energetic prop

SOL CYCLE ASSEMBLY

To be added

LEARNING GOALS

After this lesson, students should be able to:

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

LESSON

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

(5-10 MIN) INTRODUCTION

A few tried and tested questions include:

- How many kids ride their bicycles to school? (bicycles, mechanics, physics)
- *How many know where plants get their energy? (solar panel, renewable energy, circuits)
  - The sun!
  - Every morning, sunlight streams from the furnace of the sun's surface to the surface of the earth
    - How long does 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

(10 MIN) ACTIVITY: HOW A SOLAR PANEL WORKS

- 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 - a sun, an atom of the solar panel represented by an electron and a nucleus, and 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: at night, the electron is sleepy and has no energy to move away from its 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 -- and steals the starburst from the electron and starts spinning.
- The electron returns, exhausted, to the nucleus and slowly spins.

(5-10 MIN) SOL CYCLE ASSEMBLY

- Students get in groups of 3-5
  - One student is invited to collect a Sol Cycle kit: a sol cycle (fully assembled), a motor, a solar panel, and some rubberbands (two fat, one thin for the wheel "tire" and "chain" respectively.
  - 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?)

(15 MIN) SOL CYCLE ACTIVITY

- 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
- Observation and experimentation
  - Qualitative and quantitative questions
    - 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?
- Sol Cycle races
  - Students race their Sol cycles -- 20 feet or so is usually enough to make it really exciting

(5-10 MIN OPTIONAL) RENEWABLE ENERGY

- Solar panels are an example of renewable energy
  - What is renewable energy?
    - An action that creates electricity using
- What are some other examples of renewable energy?
  - Wind, tidal, geothermal
- What are some examples of non-renewable energy?
  - Oil, gas, ethanol
- Why is renewable energy important?
  - What is climate change?
    - 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
    - Animals and other species going extinct
        - Healthy biodiversity = healthy humans

(5-10 MIN OPTIONAL) 3D PRINTING

- Students are introduced to 3D printing
    - If a student has done any 3D printing, ask them to explain the process
        - Machine is given a design
        - Melts plastic and "extrudes" it onto the "drawing" board in layers ~microns to millimeters thick
    - Cool examples of 3D printing
        - Medical (practice surgery on 3D printed skull)
        - Family (blind mothers receive a 3D printed "statue" or plate of the ultrasound image of their baby)
        - 3D printers that can print the parts for other 3D printers
        - Other?
    - Resources they can use to design their own bicycles (or anything they can dream of)
        - Tinkercad (free online software)
        - 3D hubs for printing ("amazon turk" for 3D printing -- someone does it for you on their own machine)

(5 MIN) WRAP UP

- Variety of students are asked to review: how solar panels work, what the smallest element of matter is, how fast their Sol Cycle went, and how it was made
- Take home question: 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