

## **Lesson Title: SunEzoon Solar Cars**

**Target Grade:** 4<sup>th</sup> – 8<sup>th</sup>

### **Overview:**

In this lesson, students will use solar cars to observe how the sun's rays can be captured to provide the energy needed to power a vehicle, to calculate the velocity of a vehicle as it runs on solar power, and to experiment with changes that might be made to the vehicle that would impact velocity.

The lesson may be adapted for multiple grade levels. It may also be adapted for use without solar cars, if the primary objective of the lesson is to study and calculate velocity and elements that may impact velocity. For example, you may use matchbox cars with a ramp or on a sloped surface to complete the timed trials.

### **Objectives:** (what students will know or be able to do):

- Students will observe how solar panels can be used to power solar cars
- Students will demonstrate use of the scientific method, experimentation, and how to craft experiments so that they yield the most accurate results possible
- Students will define velocity and calculate velocity using the standard formula
- Students will recognize how weight, friction, and drag effect a vehicles' efficiency of movement

### **Background:**

- Appendix I -Energy and Solar Power
- Appendix II - The Scientific Method

### **Materials:**

- Assembled Solar Cars (one car per five students or less is ideal)
- Measuring Tape
- Stopwatches
- Student Data Record Sheets
- Duct-tape to mark out start and finish line

**Prep Time: 30 MINUTES    Activity Time: 1 HOUR**

### **Nevada State Standards:**

- See Appendix III for Curriculum Standards Covered

### **Key Vocabulary:**

- **Photovoltaic Cells** –contain specially designed material that converts light energy into electrical energy; are arranged into panels to use solar-power to create electricity
- **Radiant Energy** – “light” energy, that is transmitted in the form of waves, rays, or particles (Example: sunlight, x-rays, ultraviolet light)
- **Drag** – (a.k.a – air resistance) force which opposes an object’s motion through a gas (air) or a liquid
- **Friction** – the resistance encountered by moving object, created by contact with another object; often produces heat (Example: resistance on a spinning axle of a car)
- **Velocity** – distance traveled in a given period of time in a particular direction

*If using this as part of a larger unit on energy the words below should complement:*

- **Thermal Energy** – heat energy that results from the increased motion of molecules
- **Mechanical Energy** – energy of an object created by its movement position or both (Example: pulley system, pencil sharpener, door handle)
- **Elastic Energy** – energy stored in a solid object when it is stretched or compressed (Example: rubber bands, springs)
- **Nuclear Energy** – energy stored in the nuclei of an atom and released through fission (splitting a nucleus) or fusion (combining of nuclei).
- **Chemical Energy** – energy stored in the molecular bonds of a substance and released during a chemical reaction (Example: burning wood, coal, oil, or cooking food)
- **Atom** – the smallest particle of an element, that still has all the same characteristics; composed of a nucleus that is encircled by a cloud of electrons
- **Nucleus (plural = Nuclei)** – the center of an atom composed of different numbers of protons and neutrons depending on which element it is

### **Activity:**

**\* Please note that SunEzoon Solar Cars are not essential to doing this activity with your students, it can still be engaging and effective using matchbox cars, or other toy vehicle, and a ramp or downward sloping paved surface. Resources section includes the website where SunEzoon Solar Cars can be ordered.**

**Step 1: MAKE SURE IT IS A SUNNY DAY!** All student groups involved in this lesson should have a completed solar-powered car, and students need to form groups of at least three. One student to release the car at the starting line, another to use the stopwatch to time the vehicle, and another to record the data discovered. Prior to beginning the time trials, the instructor should find a suitable outdoor location with the smoothest possible pavement, and use masking tape to delineate a starting line and finish line approximately 5 meters apart (16.4 feet).

**Step 2:** Pass out student handouts, each group should have their own set of handouts.

Explain that they will be testing their car's efficiency by doing time trials. Doing multiple trials to determine an average velocity for their car ensures the greatest accuracy possible. The instructor can determine how many trials the students should perform based upon the amount of time available, the handouts offer space for five trials.

**Step 3:** Once the student groups are at the time trial roadway, and have a chance to examine the trial location, they should hypothesize how they think their car will perform during the first set of time trials. Students can then begin releasing their solar-powered cars, timing, and recording how many seconds it takes for their car to reach the finish line. When all trials have been complete, the instructor can return with the students to the classroom to complete the calculations for velocity.

**Step 4:** When calculations for velocity are complete, the instructor can invite the students to share their successes and challenges. **DISCUSSION QUESTIONS:** *What do you think made your car faster or slower? What changes can you make to your car to possibly improve performance?* (HINTS: change angle of solar panels, make lighter, reduce friction, reduce drag) Instructor should then give students time to make adjustments to their cars in an attempt to improve performance.

**Step 5:** Once groups have an opportunity to improve their car, the instructor can then give them an opportunity to test its performance again on the same raceway. Before testing student groups should hypothesize again how they think their car will perform (More or less effectively than the last set of trial?). Students should again perform a number of trials to best determine an average velocity, recording the time it takes for their cars to reach the finish line. Once back in the classroom they can again perform the necessary calculations to determine velocity.

**Step 6:** Again the instructor can invite the students to share their successes and challenges. **DISCUSSION QUESTIONS:** *Did your car's performance improve after you made adjustments? Why or why not?*

**Step 7:** Students should now collaborate in their groups to analyze the data they collected in an attempt to formulate their conclusion. They should consider both their hypotheses and determine whether they can be confirmed or rejected; and make possible recommendations to other students who may perform the same experiment to improve their car's performance even further. Once the groups have had a chance to come to a consensus on their car's performance the instructor can invite each group to share their conclusions with the class.

### Review Questions:

Some Review Questions are also included in the activity section

1. What did you do before you began your time trials? (HINT: Hypothesis) Why do you think this is important?
2. What do you think made your car faster or slower? What changes can be made to your car to possibly improve performance?
3. After the first set of trials, did you change your original hypothesis? Do you think scientists change their original predictions? Why or why not?

### Assessment/Evaluation:

- Have each student write a few conclusive sentences, using their handouts, on their car's performance, the effects of the adjustments they made, the effects of the conditions under which their trials were performed, and whether their hypotheses were confirmed or rejected.

### Constructed Response:

**a.** Through this activity you were behaving as a scientist, practicing the scientific method, by conducting an experiment to determine how well your solar-powered car performed. The scientific method is used to determine cause and effect. In this experiment you examined reasons and forces that caused your car to move faster or slower, and by performing multiple sets of trials you were able to make adjustments to attempt to improve your car between sets. Scientists use the same process of experimentation and success/failure (mostly failure by the way) to reach a more exact, solution to a problem or question (a.k.a hypothesis).

- Describe two things you determined affected your car's performance which led you to make the adjustments you decided to make.
- Explain whether you think your adjustments were successful and why (Example: "because it went faster").

**b.** You can find solutions for many problems through trial and error like a scientist does.

- Describe a situation when you may have used, or could use, a thinking process similar to that of a scientist.
- Explain why you think using this process worked well for you as you tried to solve your problem or answer your question.

### Cross-Curricular Extension:

- **Reading:**
  - a.) *The Kids' Solar Energy Book; even grown-ups can understand.* By Tilly Spetgang, and Malcolm Wells
  - b.) *Isaac Newton and Physics for Kids: His Life and Ideas with 21 Activities.* By Kerrie Logan Hollihan
- **Writing:**
  - a.) Write a creative story about a journey your solar-powered car might have.

Remember your car operates best when there is lots of sunlight, so as it takes a journey across your community or country, what might your solar car encounter, and what could possibly happen to it if it experiences a cloudy day.

b.) Choose a problem you are having in your everyday life (Example: you want to kick a soccer ball better). Use the scientific method to help you solve this problem. Keep a journal of your hypotheses, experiments, results and conclusions.

- **Math:** *The calculation of averages and velocities, are integral parts of this lesson; and can include multiplication, division, fractions, and/or decimals.*

a.) Students can graph the data they collected to better illustrate and communicate their results. This can be done in a line or bar graph format. Average velocities between the two sets of trials can be compared graphically.

b.) Create graphs for the data collected by the entire class, use these to compare the effectiveness of different solar-powered car designs, and to determine other factors that may have affected the car's performance (such as performing different trial sets on different days, therefore different amounts of available radiant energy).

- **Physical Education:**

a.) Have students see if they can run faster than their cars, use stopwatches to time them on the same raceway, using multiple trials, and recording the data. Students can then calculate their own average velocity in miles per hour.

b.) Have students experiment with their own velocity. They can run trials on different surfaces to affect friction, holding sheets to affect drag, or holding heavy objects to affect weight. Use this as an opportunity for students to be creative scientists! Have the students record their times over a given distance, performing multiple trials for accuracy, using the data to calculate and compare their velocities and accelerations under the different conditions.

### **Differentiation:**

- **Learning Intelligences Addressed:** Verbal/Linguistic; Logical/Mathematical; Bodily/Kinesthetic; Intrapersonal and Interpersonal. Visual/Spatial can be addressed through Math Extension a.).
- **Gifted and talented:**

a.) Research the history of solar power, and the invention of photovoltaic cells. Learn in depth about how they work, and create cross-section diagrams. Research the most recent technological advances in the field of solar power. Give a presentation on your findings to your classmates.

b.) Examine solar power use in your local community and state. What are some ways it is being used? Make some recommendations on how solar power could be used more

efficiently and frequently? Give a presentation on your findings to your classmates.

c.) Investigate further the physics of vehicle efficiency. Who are some pioneers in the car and airplane engineering? What are some of the advances they made? What is some of the new technologies that make our vehicles more effective? Give a presentation on your findings to your classmates.

## **APPENDIX I**

### **Energy and Solar Power**

Energy is defined as the capacity to do work. Potential energy is energy that is stored, and kinetic energy is the energy possessed by a moving object. Energy comes in many forms including thermal (heat), electric, radiant (light), nuclear, chemical, mechanical, and elastic. Energy cannot be created or destroyed, only changed from one form into another. For example when a light bulb is turned on, that energy is changed from electrical energy into light and heat!

The sun itself creates energy through nuclear fusion, when hydrogen nuclei pair up to form a helium atom, and releases huge amounts of energy in the form of heat and light! The sun provides the earth's inhabitants with energy that drives our carbon cycle; providing energy to green plants through photosynthesis, and subsequently to other living things who eat the green plants and organisms that eat the organisms who eat green plants. Through the carbon cycle the sun is also responsible for giving us the fossil fuels and natural gas that we utilize as a non-renewable energy resource. Renewable energy resources include solar, geothermal, hydropower, wind, and biomass or plant materials.

One way solar energy is used directly to produce electricity is through photovoltaic cell technology. Photovoltaic cells were invented in the 1950s and contain a specially designed material that reacts with light to produce electricity. Photovoltaic cells can be arranged in panels and used to power many different devices including swimming pool heaters, roadside call boxes, cars, and even entire power plants. Since these cells can only make electricity when it is sunny, batteries can be connected to the panels to store power for use on cloudy days!

Solar cars are powered by the sun through panel of photovoltaic cells that are mounted directly on the vehicle. The electricity generated is channeled either directly into the motor or into a storage battery for later use. Factors such as drag, weight, and friction effect how efficiently a solar-powered car will work. These factors can be improved by making the car more aerodynamic, lighter, and/or reducing the friction in the axles and gears. The surface on which the car is running can also affect how efficiently the solar-powered car will work. Adjustments students can make to their cars include: angle of the solar panel, removal of the paper shell, greasing axles, changes to the tires, etc. Encourage student creativity when adjusting their cars!

## **APPENDIX II**

### **The Scientific Method**

The scientific method is a tool used to investigate the unknown, attempt to solve a

problem, to find answers to questions, and ultimately to acquire new knowledge. Conclusions are reached through asking questions, formulating guesses, creating and performing experiments, and analyzing the results. Often scientists will repeat this process until they achieve an adequate volume of data to analyze, or find an answer to the problem they are investigating. It is important to remember that the scientific method is used to find answers to unknowns; and a scientist must use their experiments to explore without bias the consequences of their experiments and then through analyzing the results determine a conclusion whether it confirms or rejects their original beliefs. Though a scientist is always free to question their results, and especially think about why their experiment may have yielded unexpected results! The thinking process involved in the scientific method can also be applied to other walks of life, and once an individual learns to approach issues in this way they will have the power to solve problems!

#### Steps to the Scientific Method:

- **Ask a Question/Find a Problem/Query a Phenomenon** – this must be related to something that can be observed so that the answer is about something that can be measured
- **Do Background Research** – this is necessary in order to properly craft your experimentation to yield results that can potentially answer the question you are asking; also you want to ensure you are not repeating past failures, though making adjustments to a past experiment to potentially yield different results would be valid!
- **Construct a Hypothesis** - formulate an educated guess as to the possible answer to your question. Try using “If \_\_\_[I do this]\_\_\_, then \_\_\_[this]\_\_\_ will happen.” Your hypothesis should be stated in a way that you can easily measure its acceptance or rejection.
- **Do an Experiment to Test your Hypothesis** – this is a test of the validity of your hypothesis, whether you can accept or reject it. Craft your experiment so that all conditions are the same except one (have only a single variable) that way you know it is that single difference that is affecting the results. For example, if you are examining how light affects the speed at which a type of plant grows, every plant in your experiment would get the same type and amount of food, and water; be planted in the same soil and containers; and be kept at the same temperature etc. BUT they would each receive different amounts of light each day, that way you would know their differing growth rates were dependent only upon the different amounts of light they were given. Repetitions should be done as well to add to the validity of your results and provide as much evidence as possible for your conclusions, and to prove your results weren’t just accidental.
- **Record your Results** – it is important for scientists to keep very complete, timely, and accurate record of the results of their experiments, and their observations, usually by keeping a journal. If you were doing the plant experiment you should measure the height of the plant, count the leaves etc.; and write observations as to the plant’s observable qualities; at very regular intervals, daily for example, to provide as

extensive a picture possible of your experiment as it progresses.

- **Analyze your Results** – do an unbiased examination of the results you have achieved.
- **Draw a Conclusion** – here is where you examine the meaning of your results, speculating on why certain data resulted from your experiment.
- **Accept or Reject your Hypothesis** – look carefully without bias at your results and your conclusions, can you confirm your hypothesis with the data you collected? Was your experiment extensive enough to accept your hypothesis? If your hypothesis is rejected, or is shown to be true but not to a significant degree, restructure your hypothesis, make adjustments to your experiment, and test your hypothesis again!
- **Share your Results!** – prepare a written report, and/or presentation board for your experiment. Be sure to include some of your background information, hypothesis, data, analysis, and conclusion.

It is important to remember that though the scientific method seems to be a rigid series of steps that must be performed in an orderly fashion, new information can be integrated into the experiment at anytime, and one can also back up and repeat steps if needed. Just remember to record everything! Then those to whom you present your findings can judge for themselves whether they think your experimentations and conclusions are valid. When a question or problem is repeatedly experimented on and yields the same or significantly similar results and the analysis always leads to the same conclusions... you finally have an answer, which is also known as a theory!

## **APPENDIX III**

### **Nevada State Curriculum that can be Addressed using this Activity**

- **Science, Technology, and Society (Nature of Science Unifying Concept A)**

N.5.A Students understand that science involves asking and answering questions and comparing the answers to what scientists know about the world.

N.8.A Students understand that scientific knowledge requires critical consideration of verifiable evidence obtained from inquiry and appropriate investigations.

N.12.A Students understand that a variety of communication methods can be used to share scientific information.

N.5.A.1 Students know scientific progress is made by conducting careful investigations, recording data, and communicating the results in an accurate method. E/S

N.8.A.1 Students know how to identify and critically evaluate information in data, tables, and graphs. E/S

N.12.A.1 Students know tables, charts, illustrations and graphs can be used in making arguments and claims in oral and written presentations. E/S

N.5.A.2 Students know how to compare the results of their experiments to what scientists already know about the world. I/L

N.8.A.3 Students know how to draw conclusions from scientific evidence. E/S

N.8.A.2 Students know how to critically evaluate information to distinguish between fact and opinion. E/S

N.12.A.2 Students know scientists maintain a permanent record of procedures, data, analyses, decisions, and understandings of scientific investigations. I/S

- N.5.A.4 Students know graphic representations of recorded data can be used to make predictions. E/S
- N.8.A.3 Students know different explanations can be given for the same evidence. E/S
- N.12.A.3 Students know repeated experimentation allows for statistical analysis and unbiased conclusions. E/S
- N.5.A.5 Students know how to plan and conduct a safe and simple investigation. E/S
- N.8.A.4 Students know how to design and conduct a controlled experiment. E/L
- N.12.A.4 Students know how to safely conduct an original scientific investigation using the appropriate tools and technology. E/L
- N.8.A.5 Students know how to use appropriate technology and laboratory procedures safely for observing, measuring, recording, and analyzing data. E/L
- N.5.A.6 Students know models are tools for learning about the things they are meant to resemble. I/S
- N.8.A.6 Students know scientific inquiry includes evaluating results of scientific investigations, experiments, observations, theoretical and mathematical models, and explanations proposed by other scientists. E/S
- N.12.A.5 Students know models and modeling can be used to identify and predict cause-effect relationships. I/S
- N.5.A.7 Students know observable patterns can be used to organize items and ideas. E/S
- N.8.A.7 Students know there are multiple methods for organizing items and information. E/S
- N.12.A.6 Students know organizational schema can be used to represent and describe relationships of sets. E/S

- **Science, Technology, and Society (Nature of Science Unifying Concept B)**

- N.8.B Students understand the interactions of science and society in an ever-changing world.
- N.8.B.2 Students know scientific knowledge is revised through a process of incorporating new evidence gained through on-going investigation and collaborative discussion. E/S
- N.12.B.3 Students know the influence of ethics on scientific enterprise. E/S
- N.5.B.3 Students know the benefits of working with a team and sharing findings. E/L
- N.12.B.4 Students know scientific knowledge builds on previous information. E/S

- **Atmospheric Processes and Water Cycle (Earth and Space Science Unifying Concept A)**

- E.5.A.1 Students know the Sun is the main source of energy for planet Earth. E/S
- E.12.A.1 Students know the Sun is the major source of Earth's energy, and provides the energy driving Earth's weather and climate. E/S

- **Energy (Physical Science Unifying Concept C) - The total energy of the universe is constant. All events involve the transfer of energy in one form or another. In all energy transfers, the overall effect is that the energy is spread out uniformly.**

- P.5.C Students understand that energy exists in different forms.
- P.8.C Students understand transfer of energy.
- P.5.C.3 Students know heat is often produced as a byproduct when one form of energy is converted to another form (e.g., when machines and living organisms convert stored energy to motion). E/S
- P.12.C.2 Students know energy forms can be converted. E/S
- P.8.C.3 Students know physical, chemical, and nuclear changes involve a transfer of energy. E/S
- P.8.C.4 Students know energy cannot be created or destroyed, in a chemical or physical reaction, but only changed from one form to another. E/S
- P.12.C.6 Students know electricity is transferred from generating sources for consumption and practical uses. I/S

- **Math**

- 1.3.7 - Add and subtract two- and three-digit numbers with and without regrouping. E/S
- 1.3.8 - Generate and solve two-step addition and subtraction problems and one-step multiplication problems based on practical situations. E/S
- 1.4.7 - Add and subtract multi-digit numbers. Multiply and divide multi-digit numbers by a one-digit whole number with regrouping, including monetary amounts as decimals. E/S
- 1.4.8 - Generate and solve addition, subtraction, multiplication, and division problems using whole numbers in practical situations. E/S
- 1.5.7 - Add and subtract decimals. Multiply and divide decimals by whole numbers in problems representing practical situations. E/S
- 1.5.8 - Generate and solve addition, subtraction, multiplication, and division problems using whole numbers and decimals in practical situations. E/S
- 1.6.7 - Calculate using fractions, decimals, and percents in mathematical and practical situations. E/S
- 4.7.9 - Make and test conjectures to explain observed mathematical relationships and to develop logical arguments to justify conclusions. I/L
- 4.8.9 - Represent logical relationships using conditional statements. I/L
- 5.6.1 - Pose questions that guide the collection of data. Organize and represent data using a variety of graphical representations including circle graphs and scatter plots. I/S
- 5.7.1 - Formulate questions that guide the collection of data. E/S
- 5.7.2 - Interpret graphical representations of data to describe patterns, trends, and data distribution. I/S
- 5.8.1 - Formulate questions and design a study that guides the collection of data. E/S

## **RESOURCES:**

- To order SunEzoon Solar Cars for your classroom visit:  
<http://shop.pitsco.com/store/detail.aspx?ID=2210&bhcp=1>
- Nemzer, M., Page, D., & Carter, A. (2005). *Energy for Keeps: Electricity from Renewable Energy*. Tiburon, CA: Energy Education Group.