ELECTRIFYING
THE FUTURE

Electrifying the Future - Goodman School of Mines, Laurentian University
Lesson Plan 1: Solar Powered Car Engineering

Lesson Description:

This lesson covers the properties of DC electrical circuits and Solar Panels. Two activities have been included in the lesson, an educational kit that allows students to explore how different factors alter the electrical output of solar panels, and a solar powered car that is assembled and raced by students. This lesson specifically fits into Ontario's grade 6 and grade 9 science curriculum, but there may be alternative outcomes in the curriculum that may be fitting for this lesson.

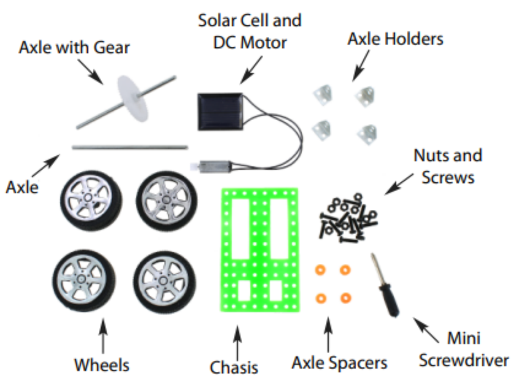
The most applicable curricular elements that this lesson relates to are contained primarily in grade 6 and grade 9, but please note that there may need to be additional complexity added to the lesson based on students' age, knowledge, and capacity (i.e. students create a solar car best suited for a specific task from a bucket of different materials [different tire size, motor size, wire size, etc.]).

Lesson objective(s):

- Students will learn and utilise the appropriate terminology relating to electrical circuits and mechanical systems
- Students will learn how mechanical and electrical systems influence the velocity of a vehicle.
- Students will learn and utilise STEM concepts associated with electric vehicles and apply those concepts to the development of a solar powered vehicle.
- Students will develop strategies based on principles of engineering that give their solar cars a competitive advantage.

Lesson Considerations:

- Some of the components are small and may be challenging to assemble. In situations where dexterity and fine motor control is limited, extra time and support may be required for success.



Site/Space Considerations:

- Assembly requires table space for a class that is separated into groups of 2-3 students.

- Where available (and necessary), computers can be used to present videos demonstrating how to assemble the kits.
- Competition requires a space that is approximately 15m lengthwise. A hallway may work with flashlights, but an atrium with lots of natural light or an outdoor space with a flat surface may allow for the competition to better represent the learning environment intended for the activity.

Required Materials:

Solar Car Kit (**Xump.com** Item # 16090), Solar Educational Deluxe Kit (**Kidder.ca** CAT# 80-3598823), Flashlights, Measuring Tape, Markers/Tape for Competition

Curricular Outcomes:

See end of document for Grade 6, 8, & 9 outcomes that may apply to this lesson.

Safety notes:

Given the nature of this activity (lesson), please consider the following.

Electrical Safety Considerations: The activity is centred on creating electrical circuits. As a result, there is a chance of shock. The voltage and amperage of the circuits are small enough to not be harmful in most cases, but be aware that electrical and magnetic components may interfere with medical devices (such as pacemakers) under the right circumstances. Please consider everyone's medical history before beginning this activity.

Note: Please review electrical safety with participants and facilitators with an emphasis on not touching exposed wires or components without guidance and supervision.

Environmental Awareness: This activity works best on a flat, smooth surface that is in direct sunlight. If the only available areas that fit this description are located in spaces where hazards may be present (such as automotive traffic), consult the appropriate offices to best keep participants and facilitators safe.

Emergency Preparedness: Clarify and convey (and where necessary, develop) institutional Emergency Action Plans (EAP) to facilitators, participants, and administrators. Such EAP's may include procedures for contacting emergency services, relocation, evacuation, and how to attend to any medical emergencies that may arise.

Sun Protection: When part or all of this activity is held outdoors, it is recommended that all participants use appropriate methods to protect individuals against the sun (i.e. sunscreen, hats, clothes that cover the skin, and sunglasses). Be aware that heat stroke and other heat related issues may also be an issue in certain weather conditions.

Equipment Inspection: Regularly inspect all solar car equipment, such as batteries (where included), wiring, and solar panels, to ensure they are in good working condition. Replace or repair any damaged or faulty equipment promptly.

Activities

Educational Displays

Time: 20-30 minutes

Materials: 1 x Solar Educ. Kit *per group* (https://kidder.ca/solar-educational-kit-cat-80-3598823.html)
1 x Flashlight *per group*

Instructions: Depending on the class size, gather students into groups of four to five to interact with the Solar/EV educational kits. Students are expected to experiment with different configurations of the electrical circuits and answer the following guiding questions:

1. What happens when you change the amount of electrical supply or load into the system? *i.e. more solar panels in parallel/series, intensity of light, load in series or parallel, etc*.
    a. If the load fails to produce any output, what might be the cause or rationale?
    b. Describe what might be the factors that determine the intensity of the loads.
    c. What are the scientific terms that describe what is happening?
2. What happens when 50% of a solar panel is covered? How about 25%? 10%?
    a. Describe the intensity of the load in each scenario?
    b. How similar was the load's intensity in each scenario?
    c. What is the rationale for what happened in each scenario?

Solar Car Assembly & Racing Activity

Time: 45-90 minutes

Materials: 1 x Solar Car Kit *per group* (https://www.xump.com/science/solar-diy-micro-car-kit.cfm),
1 x Flashlight *per group*

Instructions: In groups of two to three students, students are expected to assemble and test their solar cars. If extra materials are available to allow for student experimentation (i.e. change the angle of the solar panel, motor size, gear size, grease the axle, tires of different circumference and width, etc.), there may be some opportunity for students to conjecture what might give them an advantage over their counterparts. Make sure there is time for assembly and testing before the competition begins.

Upon the collective assembly of their cars, students compete in a round-robin and/or bracketed style of competition where students race a specific distance against their peers. If helpful, time between races or sections of competition to allow students to modify their vehicles further may be helpful.

Note: When this activity was initially created, students raced on sheet metal roofing that contained ridges along its length to keep the cars on track. Although this is not specifically needed, cars may not be balanced and may go off track. Student created tracks may be helpful to the activity.

Note: If assembly is challenging, there are visual instructions for assembly on the following page with troubleshooting instructions on the page after.

Guiding Questions:

1. How is the speed of the car affected by different lighting conditions?
    a. Under classroom lights.
    b. By a window.
    c. From a flashlight (different proximities).
    d. Under direct sunlight.
    e. Cloudy conditions.
    f. Not oriented directly towards a light source (to varying degrees).
2. What affects the speed of the car?
3. Are there any modifications that you can make to the car that will give your team a competitive advantage over the other teams?

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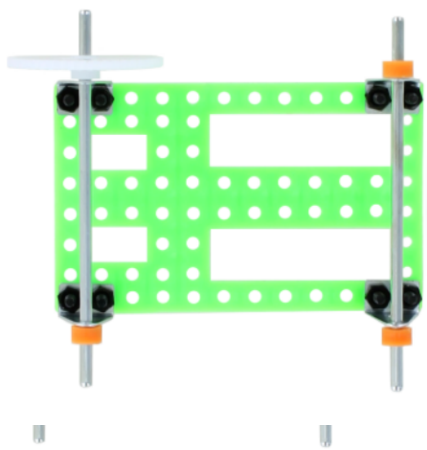
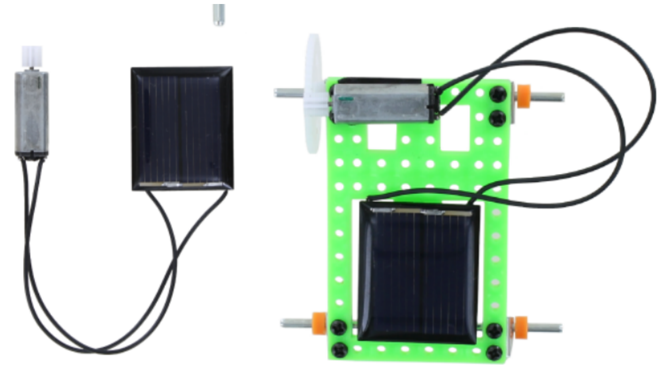
Activity Procedure:

1 Attach the axle holders to the bottom of the chasis corners using two screws and two nuts.

2 Insert both axles through the axle holders (top hole) and attach the gear and axle spacers. Do not attach the axle spacer on the gear side.



3 The mini DC motor will come pre-soldered to the solar cell. Mount the solar cell to the chasis using the adhesive on the back. Then, do the same with the DC motor. Make sure the gears are aligned and making contact with each other.



4 Attach the wheels to the axle ends. Remove the protective plastic cover (if any) from the solar cell if you haven't already. Expose the solar cell to sunlight and watch as the front wheels spin.

Troubleshooting:

Check the sunlight exposure: Ensure that the solar panels are placed in an area that receives ample sunlight throughout the day. Make sure there are no obstructions like trees, buildings, or shadows that could block the sunlight. Adjust the position or angle of the panels if necessary. This may include checking the weather prior to the lesson.

Examine the wiring connections: Check the wiring connections between the solar panels and any devices or batteries being powered. Make sure all connections are secure and properly connected. Loose or faulty connections can result in a loss of power or a complete failure of the system.

Inspect for damage: Examine the solar panels for any signs of physical damage, such as cracks, breaks, or corrosion. Damage to the panels can reduce their efficiency or prevent them from working altogether. If any damage is found, consider replacing the affected components.

Test the devices: If the solar panel project involves powering specific devices, such as small motors or lights, test those devices independently. Ensure that the devices are functioning correctly and receiving power from the solar panels. If a device is not working, troubleshoot its individual components or connections.

Monitor weather conditions: Be aware of how weather conditions, such as cloudy days or rain, can affect the performance of solar panels. Cloudy or overcast weather can reduce the amount of sunlight available, resulting in lower energy production. Educate kids about the impact of weather on solar energy generation.

Seek guidance or assistance: If troubleshooting efforts do not resolve the issue, don't hesitate to seek guidance from individuals with experience. They can provide further assistance and guidance in identifying and resolving any problems that may arise during the solar panel project.

Science Background:

Solar panels are devices that convert sunlight into electricity, making them an important tool for harnessing clean and renewable energy. The science behind solar panels lies in the phenomenon known as the photovoltaic effect. This effect occurs when sunlight, which is composed of tiny particles of energy called photons, strikes the surface of a solar panel. The solar panel is made up of a semiconductor material, such as silicon, which contains atoms with loosely bound electrons. When photons from sunlight hit the semiconductor material, they transfer their energy to the electrons, causing them to break free from their atoms. This generates an electric current, which can then be captured and used to power various devices.

The structure of a solar panel plays a crucial role in its ability to generate electricity. Solar panels typically consist of multiple interconnected solar cells, which are the individual units responsible for converting sunlight into electrical energy. These cells are made up of layers of different materials, such as silicon, which are carefully engineered to maximise the efficiency of the photovoltaic effect. One key component is the p-n junction, where the layers of different materials meet. This junction creates an electric field that helps separate the liberated electrons and holes (positive charges) within the semiconductor material, further enhancing the efficiency of the solar cell.

To ensure optimal performance, solar panels must be positioned to receive the maximum amount of sunlight throughout the day. The angle and orientation of the panels are crucial factors in capturing the most sunlight. In general, solar panels are tilted and positioned facing south in the Northern Hemisphere and north in the Southern Hemisphere to align with the path of the sun. This ensures that the panels receive sunlight at the most direct angle, maximising their energy output. Additionally, factors such as shading from trees, buildings, or other obstacles should be minimised to avoid blocking sunlight and reducing the efficiency of the solar panels.

Ontario Curricular Outcomes (Intermediate)

The following outcomes are projected to directly relate to the following lesson. Detail can be added to the lesson to match a specific unit plan or extend the learning of the experience. Please note that this list may not include all relevant outcomes.

Grades 1-8

- **A1.1** use a scientific research process and associated skills to conduct investigations
- **A1.2** use a scientific experimentation process and associated skills to conduct investigations
- **A1.3** use an engineering design process and associated skills to design, build, and test devices, models, structures, and/or systems
- **A1.4** follow established health and safety procedures during science and technology investigations, including wearing appropriate protective equipment and clothing and safely using tools, instruments, and materials
- **A1.5** communicate their findings, using science and technology vocabulary and formats that are appropriate for specific audiences and purposes

Grade 6

- **C2.2** describe current, electricity, and compare and contrast current electricity with static electricity
- **C2.3** identify materials that are good conductors of electric current and materials that are good insulators
- **C2.4** describe how technologies transform various forms of energy into electrical energy
- **C2.5** describe ways in which electrical energy is transformed into other forms of energy
- **C2.6** explain the functions of the components of a simple electrical circuit
- **C2.7** distinguish between series and parallel circuits, and identify common uses of each type of circuit

Grade 8

- **D2.3** identify the various processes and components of a system that allow it to perform its function efficiently and safely
- **D2.4** use the scientific terms displacement, force, work, energy, and efficiency to describe everyday experiences
- **D2.5** demonstrate an understanding of the relationships between work, force, and displacement in simple systems
- **D2.6** explain the relationship between input and output forces and determine the mechanical advantage of various mechanical systems, including simple machines
- **D2.7** identify ways in which energy can dissipate from mechanical systems, and describe technological innovations that make these systems more efficient

Related Curricular Outcomes (Intermediate)

In addition to the list of curricular outcomes that are directly related to this lesson, there are curricular outcomes that indirectly relate to solar cars that can be addressed in a lesson or unit tied to the current lesson.

Grades 1-8

- A3.1 describe practical applications of science and technology concepts in their home and community, and how these applications address real-world problems
- A3.2 investigate how science and technology can be used with other subject areas to address real-world problems

Grade 6

- C1.1 assess the short- and long-term impacts of electrical energy generation technologies in Canada on society and the environment, including impacts on First Nations, Métis, and Inuit communities, and on climate change
- C1.2 assess choices that reduce personal use of electrical energy from both renewable and non-renewable sources, and advocate for the responsible use of electrical energy by the school community
- E2.6 identify various technologies used in space exploration, and describe how technological innovations have contributed to our understanding of space

Grade 8

- D2.4 use the scientific terms displacement, force, work, energy, and efficiency to describe everyday experiences
- D2.7 identify ways in which energy can dissipate from mechanical systems, and describe technological innovations that make these systems more efficient
- D2.9 describe technological innovations involving mechanical systems that have increased productivity in various industries
- D2.10 identify social factors that influence the evolution of a system

Ontario Curricular Outcomes (High School)

The following outcomes are projected to directly relate to the following lesson. Detail can be added to the lesson to match a specific unit plan or extend the learning of the experience. Please note that this list may not include all relevant outcomes.

Grade 9 (SNC1W)

- **A1.1** apply a scientific research process and associated skills to conduct investigations, making connections between their research and the scientific concepts they are learning
- **A1.2** apply a scientific experimentation process and associated skills to conduct investigations, making connections between their observations and findings and the scientific concepts they are learning
- **A1.3** apply an engineering design process and associated skills to design, build, and test devices, models, structures, and/or systems
- **A1.5** apply their knowledge and understanding of safe practices and procedures, including the Workplace Hazardous Materials Information System (WHMIS), while planning and carrying out hands-on investigations
- **A2.1** design an experiment or a prototype to explore a problem relevant to a STEM-related occupation, such as a skilled trade, using findings from research
- **D2.1** conduct investigations to explain the behaviour of electric charges in static and current electricity, and to relate the observed behaviour to the properties of subatomic particles and atomic structure
- **D2.3** identify the components of a direct current (DC) circuit and explain their functions, and identify electrical quantities, their symbols, and their corresponding International System of Units (SI) units

Related Curricular Outcomes (High School)

In addition to the list of curricular outcomes that are directly related to this lesson, there are curricular outcomes that indirectly relate to solar cars that can be addressed in a lesson or unit tied to the current lesson.

Grade 9 (SNC1W)

- A2.2 describe how scientific innovations and emerging technologies, including artificial intelligence systems, impact society and careers
- A2.3 analyse how the development and application of science is economically, culturally, and socially contextualised, by investigating real-world issues
- A2.4 apply scientific literacy skills when investigating social and environmental issues that have personal, local, and/or global impacts
- D1.1 assess social, environmental, and economic benefits and challenges resulting from the production of electrical energy from various sources
- D1.2 evaluate how electrical energy production and consumption impact various communities locally or globally, and describe ways to achieve sustainable practices
- D1.3 develop a plan of action to address a local or global electrical energy production or consumption issue, including strategies for energy conservation
- D1.4 analyse social, environmental, and economic impacts of emerging technologies related to electrical energy production, consumption, storage, and conservation
- D2.2 determine the conductivity of various materials by investigating their ability to hold or transfer electric charges
- D2.4 investigate the relationships between electric current, potential difference, and resistance in electrical circuits, and develop a mathematical model to represent the relationships
- D2.5 apply a mathematical model to calculate electric current, potential difference, and resistance in real-world situations
- D2.6 construct series and parallel circuits to compare electric current, potential difference, and resistance in both types of circuits
- D2.7 explain the difference between electricity and electrical energy
- E1.3 assess ways in which technological innovations related to space observation and exploration are applied in various fields, including their contributions to sustainable practices on Earth
- E2.2 explain how the Sun’s energy causes natural phenomena on Earth, and how these phenomena contribute to renewable energy production