BrainStorm STEM EDUCATION


# STEM KIT

# EDUCATOR GUIDE

## SOLAR RACER

**CREATED FOR BOTH HOME AND SCHOOL**

**PERFECT FOR THE CLASSROOM**

**DESIGNED BY TEACHERS FOR TEACHERS**

# TABLE OF CONTENTS

# LESSON OVERVIEW

## Class Information

**In this lesson students will learn about renewable and non-renewable energy, solar power basics, and solar car basics. Students will also learn the advantages and disadvantages of solar cars, as well as about the future of solar cars. Students will be able to glimpse the history of solar power, and the history of the solar car. After experiencing the excitement of building their own solar car, students will be able to put their knowledge to the test!**

## CONCEPTS

- **Renewable Energy**
- **Nonrenewable Energy**
- **Solar Power**
- **History of Solar Energy**
- **History of the Solar-Powered Car**
- **Pros and Cons of Solar Cars**

# LESSON OBJECTIVES

- Explain the difference between renewable and nonrenewable energy.
- Explain how solar energy becomes electrical power
- Detail the history of solar energy and the solar car
- Explain the advantages and disadvantages of solar cars

# EDUCATIONAL STANDARDS

## NGSS - Next Generation Science Standards

- **4-PS3-4.** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

- **4-ESS3-1.** Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

- **5-ESS3-1.** Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

- **MS-PS3.3.** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

- **MS-ESS3-5.** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

## CCSS MATH - Common Core State Standards Math

- **4.MD.A.1** Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table.

- **5.MD.A.1** Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

- **6.EE.A.2** Write, read, and evaluate expressions in which letters stand for numbers.

# INTRODUCTION

In today's lesson, students will be discussing renewable and non-renewable energy, and solar power. As well as learning about the history of solar cars. Once learning about the above, students will build their own solar car and harness the power of the Sun to run it.

# VOCABULARY

**Renewable Energy -** Energy that is naturally replenished

**Solar Cell -** an electronic instrument that converts light energy into electricity by the photovoltaic effect.

**Solar Panels -** Also known as photovoltaic (PV) panels, or an array, these are often composed of silicon (a semiconductive material).

**Photovoltaic -** process of converting light energy into electricity through the use of semiconducting materials. (photo meaning light and voltaic meaning electric)

**Conductor -** a substance or material that allows electricity to flow through it.

**Insulator** - a substance or material that keeps energy, such as electricity, heat, or cold, from easily transferring through.

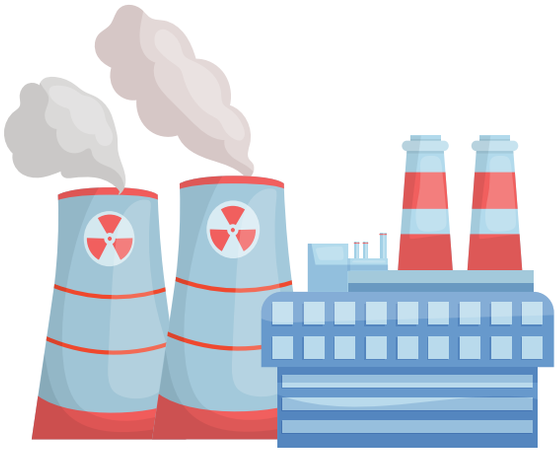
**Semiconductor -** material that can sometimes act as a conductor, or sometimes act as an insulator.

**Fossil Fuels -** carbon-based materials formed through Earth's crust acting on organic matter, such as that produced through photosynthesis. Examples include coal, oil, and natural gas.

# WHAT IS NONRENEWABLE ENERGY?

**Nonrenewable energy** often referred to as "dirty energy", is any energy derived from a source that will eventually deplete. This form of energy also tends to release more emissions into the atmosphere, ultimately affecting the climate in a negative way.

**Nuclear energy** is all energy derived from radioactive elements. The most common radioactive element is uranium, which is mined from ore and refined into fuel. There are a variety of issues with using nuclear energy including cost, time, mining lung cancer risk, the possibility of meltdown, emissions, and air pollution.

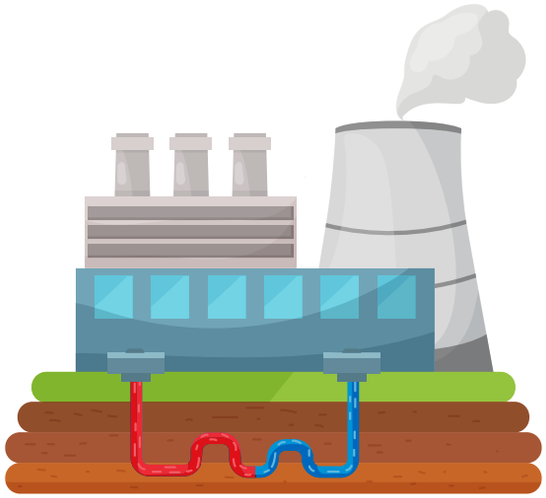


**Fossil fuels** are formed by dead plants and animals that, with the help of heat and pressure, have fermented for millions of years below the Earth's surface. Fossil fuels include oil, natural gas, and coal. These energy sources originally received their energy from the Sun through photosynthesis and were stored in the tissues of plant life. These plants were consumed by animals, which transferred the plant's energy into their bodies. When these types of energy are burned, they release the energy stored from dead plants and animals. Of the fossil fuels, both oil and natural gas can be pumped up from wells below the Earth's surface. Coal is a solid fossil fuel, buried beneath layers of sediment from fossilized swamps. Oil, sometimes referred to as crude oil, is used in gasoline and diesel fuel production. Natural gas, composed of mostly methane, is used for cooking and heating homes. Coal is often used for heating homes and generating power plants.

# WHAT IS RENEWABLE ENERGY?

**Renewable energy,** often referred to as clean energy, is all energy that comes from a source that replenishes faster than it can be used. Renewable energy has lower emissions than nonrenewable energy. Emissions are released greenhouse gases that go into the atmosphere, or specific area, over a period of time.

**Geothermal energy,** is energy harnessed by pumping hot water and steam from below Earth's surface. Hydrothermal reservoirs are wells that are naturally hot and permeable. Enhanced geothermal systems are hot, but can be improved through the use of hydraulic action. Once these energy sources are pumped to the surface they can generate electricity through the fluid being held at varying temperatures.



**Biomass energy,** or bioenergy, is energy that harnesses a variety of organic materials. These biomass materials can include wood, charcoal, a variety of manure, and biofuels produced through crops. The majority of bioenergy is produced for use in more rural areas and can be used for cooking, lighting, and heating. These forms of energy are more common among developing countries. While biomass energy creates emissions, they are much lower than burning fossil fuels. Despite bioenergy being a type of renewable energy, it should be used sparingly, as it can contribute to deforestation and land-use change.

# TYPES OF RENEWABLE ENERGY

**Solar energy,** which harnesses the power of the Sun, is the most abundant form of renewable energy available. Despite some thinking that solar energy can only be harvested on bright, sunny days, it can be harvested on cloudy days as well. Solar energy is most often gathered using solar panels, also referred to as solar photovoltaic panels (PV). Solar panels harvest solar energy through the photovoltaic effect, which uses a semiconductive material to free electrons and send them into an electrical current. Solar energy can be used for heating, cooling, natural light, and electricity. Solar panel costs have lowered in recent years, making them the cheapest form of renewable energy. As well as solar panels may last up to 30 years.

**SOLAR**

**Hydroelectric energy**, or water energy, is energy created through harnessing the natural flow of water from high to low points. Hydroelectric energy can come from either reservoir hydropower plants or run-of-river hydropower plants. Reservoir hydropower plants use water stored in reservoirs, while run-of-river hydropower plants use the energy produced through the flow of a river. Hydroelectric energy does more than produce electricity, it can also provide drinking water, provide water for irrigation, flood and drought control, and navigation services. While hydroelectric energy is the largest source of renewable energy, infrastructure to create large-scale plants can affect ecosystems negatively. Because of how ecosystems can be affected, small-scale plants are considered more environmentally sound.

**HYDRO**

# TYPES OF RENEWABLE ENERGY

**Wind energy** is energy generated by harnessing the kinetic energy of wind. Although it is considered a separate energy type, wind energy is a product of the Sun. One of the reasons wind occurs is due to the uneven heating of the Earth's surface by the Sun. Wind energy is clean, uses little to no water, and produces no emissions of air pollution. Wind energy is harnessed through the use of wind turbines. As the blades of a turbine spin, they are attached to a generator, producing electricity. A large group of wind turbines is known as a wind farm. Wind farms can be placed onshore, offshore, or floating.

**WIND**

**Tidal energy**, or ocean energy, is energy generated through the natural rise and fall of tides. Tidal energy is similar to hydroelectric energy. Just as hydroelectric energy uses the kinetic energy of the natural flow of water, tidal energy uses the kinetic energy of the natural rise and fall of the tides. The most common and effective way of harnessing tidal energy is by placing turbines in the path of a tidal stream. Tidal stream areas are areas in which there is a fast movement of the tides going in and out. This form of energy is considered quite efficient, due to the density of water.

**TIDAL**

# WHAT IS SOLAR POWER

As previously stated, solar power has been used throughout history.  As time has passed there have been advancements in solar energy. Currently, as of 2023, just over 3% of electricity in the United States comes from solar energy, both solar panels and concentrated solar thermal power.

The most common type of solar energy one may think of is solar energy provided through solar photovoltaic (PV) panels. These panels are composed of varying pieces. The smallest component of a solar panel is a solar cell. Each solar cell is composed of a semi-conductive material, that, when exposed to sunlight, can turn that solar energy into electrical energy. When sunlight hits the material, electrons become free and can be formed into an electrified current. This process is known as the photovoltaic effect. An example of a commonly used semi-conductive material is silicon. A group of solar cells then makes up a solar module. A group of solar modules makes up a solar panel, also called an array.

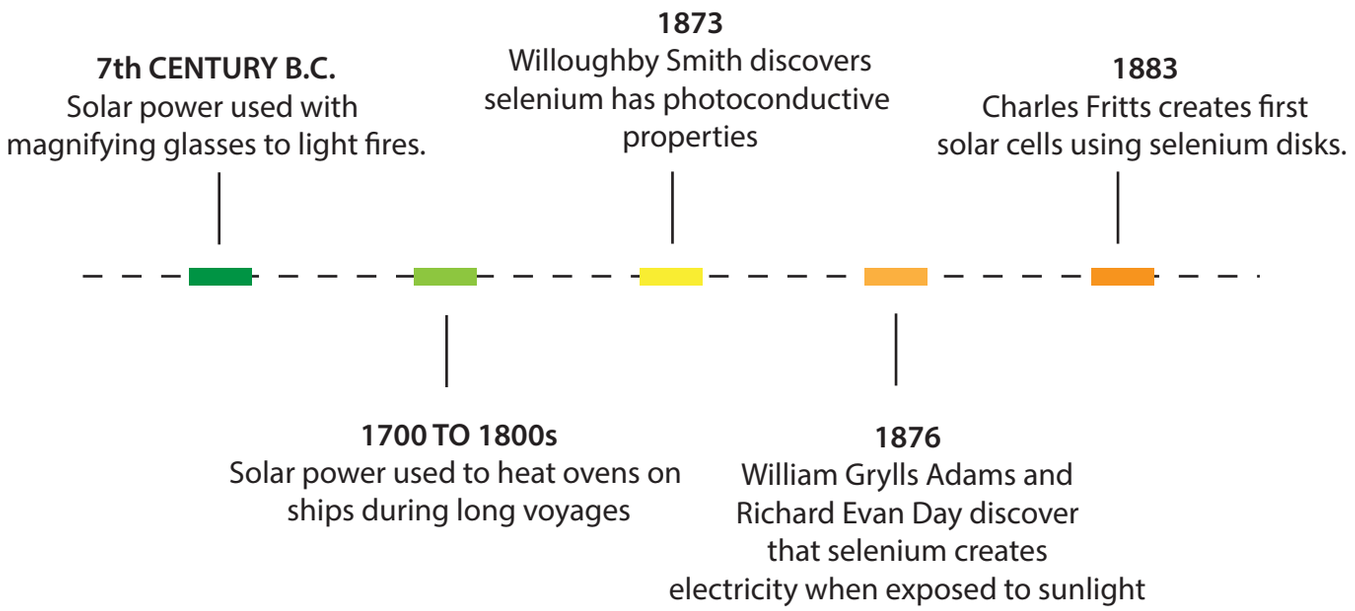
Solar panels work best in strong sunlight. There are specific times of the year in which more sunlight can hit them. During the middle of a summer day, the most electricity can be produced, while the early and late points during a winter day produce the least amount of electricity.


Similar to how electricity is generated for a power grid, solar-powered cars use photovoltaic cells to harness sunlight. PV cells are linked together, converting sunlight to electricity. Once electricity is generated, it's converted into volts and stored in the car's battery. The stored electricity allows the car to run once the Sun has set. However, some solar-powered cars use technology that transfers the electricity directly to the motor.

# HISTORY OF SOLAR

Solar energy has been harnessed for much longer than just after the invention of solar panels. The road to inventing solar panels was riddled with a variety of scientific contributions. The first recorded instance of the photovoltaic effect was witnessed by Edmond Becquerel, a French scientist, he was believed to be the first to observe this effect when he noticed that sunlight increased electricity when two electrodes were placed in a conductive solution. Scientists Daryl Chapin, Calvin Fuller, and Gerald Pearson were able to create solar cells from silicon in 1954 and is believed to be the first true invention of a solar cell. Since its true invention in 1954, solar cells, or photovoltaic cells (PV), have been used in a variety of ways. One of the first ways they were used was in space. In 1958 the Vanguard I satellite had one solar panel that powered the satellite's radios, and in 1964 NASA launched the Nimbus spacecraft that used a solar array to power the entire ship.

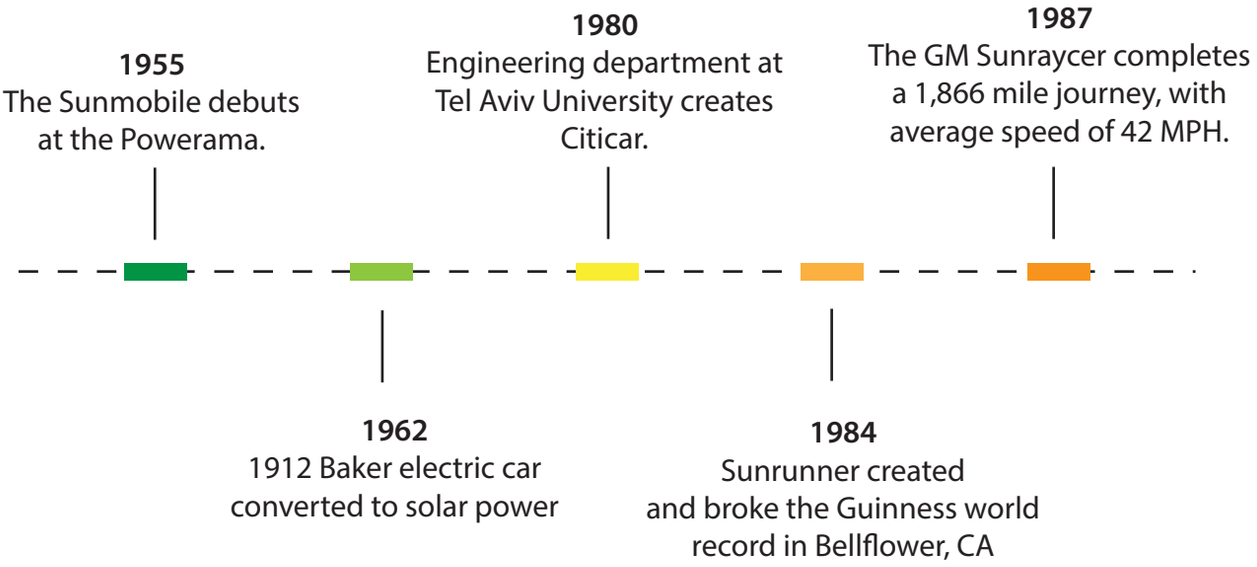
## SOLAR ENERGY



# HISTORY OF THE SOLAR CAR

Although solar energy has been used for quite some time, solar-powered cars didn't come about until 1955. Once the initial car was developed, scientists and engineers began experimenting with different designs. As time passed, designers sought to create a more efficient and aerodynamic solar-powered vehicle. The most common issue faced by designers was dealing with the weight and size of the solar panel themselves, and combining this with an efficient and powerful energy source.

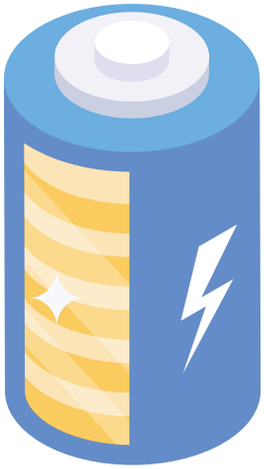
## SOLAR CAR TIMELINE



# THE ADVANTAGES OF SOLAR-POWERED CARS

As gasoline prices rise, society is always looking for a way to save money. An option for this may be to have a car that doesn't rely on gasoline at all. Besides eliminating the need for gasoline, there are many other pros to solar-powered vehicles. Due to running on electricity, solar-powered vehicles have lower charging costs for their batteries. Also, because of running on electricity, these vehicles are considered environmentally friendly and sustainable. Conventional, gasoline-powered vehicles, contribute to air and noise pollution. With solar-powered vehicles, air and noise pollution would be a thing of the past. A fear for some may be that the car won't run at night, but with the electricity being stored in the battery, driving at night is possible. As technology progresses, lighter and more efficient batteries and PV panels may also promote the use of solar-powered vehicles. A final perk, for some drivers, is that solar-powered vehicles are splendid for those who live in sunny areas and drive short distances.

**Save Money**

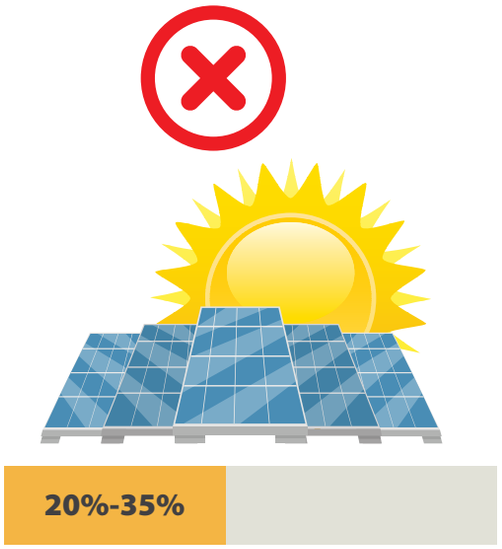


**Store Power**

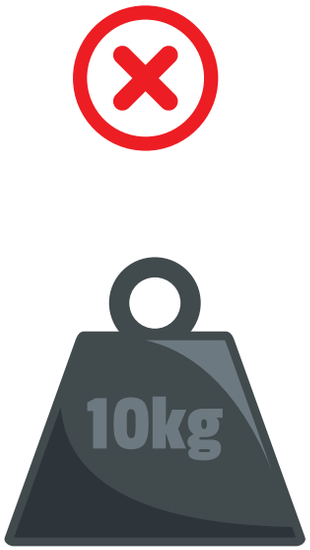
**Less Pollution**

# THE DISADVANTAGES OF SOLAR-POWERED CARS

Although purchasing a solar car may sound like the best thing to do to help the environment, there are several cons to consider before making the decision. One major disadvantage is the rate that solar panels convert sunlight into electrical energy. Solar panels are only able to convert sunlight at about a 20-35% efficiency; so much more would be required to get some serious power. There are also design issues with solar cars. Because of the amount of space required for the solar panels, there are limits to the overall design of the vehicle. The weight and efficiency of the solar panels also affect the design, as lighter solar panels may be a better option for the design, they may not be as effective as heavier ones. There are technical issues as well when dealing in solar cars. Due to the amount of technical parts, getting the cars serviced may be difficult. While the energy stored in the car's battery would allow it to drive without sunlight, for it to be ideal, sunlight would need to be present; this would make it a poor choice for those in regions where the climate is cold and there is minimal sunlight.




**Not 100% Effective**




**Heavy Materials**

**Relies on the Sun**

# THE FUTURE OF SOLAR CARS

The future of solar-powered cars is truly bright. Of the variety of advancements in solar power, from more efficient systems to space-based solar power, there have also been advancements in solar-powered vehicles. A Dutch company, Lightyear, produced the first production car featuring solar panels in the fall of 2022. The car, titled Lightyear 0, features curved solar panels along the roof, hood, and trunk. It will use the electricity generated to top up the battery while driving, or parked. On sunny days with a full 12 hours of exposure, the 53 square feet of solar panels can generate up to 84 miles total. While the car is in production ready, the first run only produced a total of 946 vehicles which were only produced in Europe. The listed price for one Lightyear 0 is $169,000.00 in U.S. currency. This advancement has sparked more interest in solar-powered or solar-assisted vehicles, and society may be able to see more coming to the market in the future.

# PROJECT OVERVIEW

Today's project will have the students building and testing the Brainstorm wooden solar car. The car, once built, will be powered by the Sun. Students will be able to test how much Sun the car needs to be powered, or whether it can be powered on a less sunny day. Students will perform different trials to see what amount of Sun powers their car best.

# SAFETY WARNINGS:

**Please read all safety warnings before use:**

**Choking Hazard:** Small parts not for children under 6 years or any individual who have a tendency to place inedible objects in their mouths.

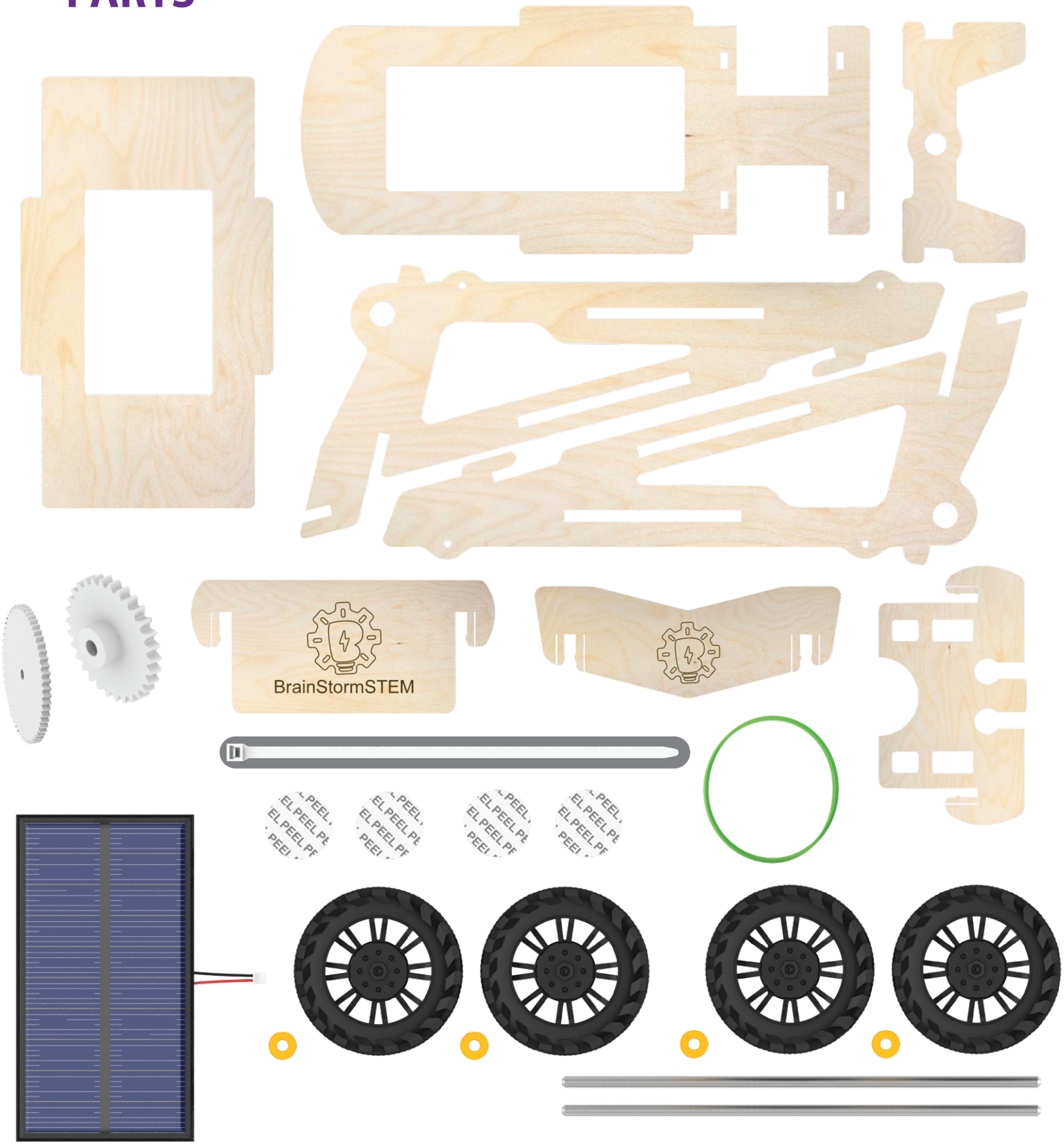
Surfaces may be hot, handle with caution and care.

Adult supervision required.

# MATERIALS

Durable wooden construction pieces
Generator Motor
Solar Panel
Wheels
Metal Axle
Gear Medium
Gear Large
Ziptie

# PARTS



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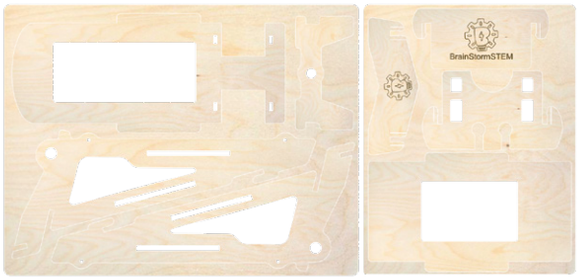
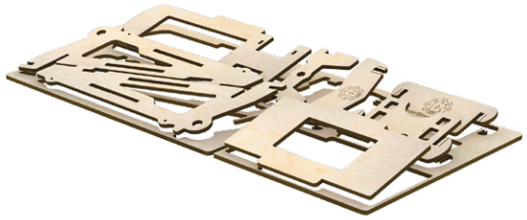
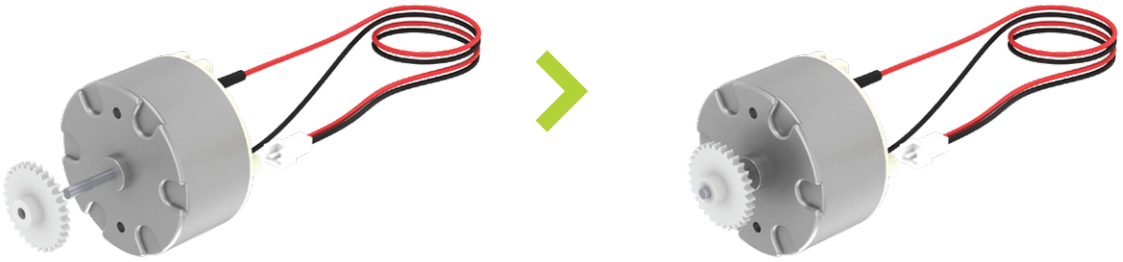


**NOTE:** If you can not break out the pieces by hand, use a blunt tool or a small knife to cut or punch them out. If you have no experience with tools or use a knife, get help from an adult. If there are any burrs, points or rough spots due to breaking or cutting, smooth them with a piece of sand paper.

## 2



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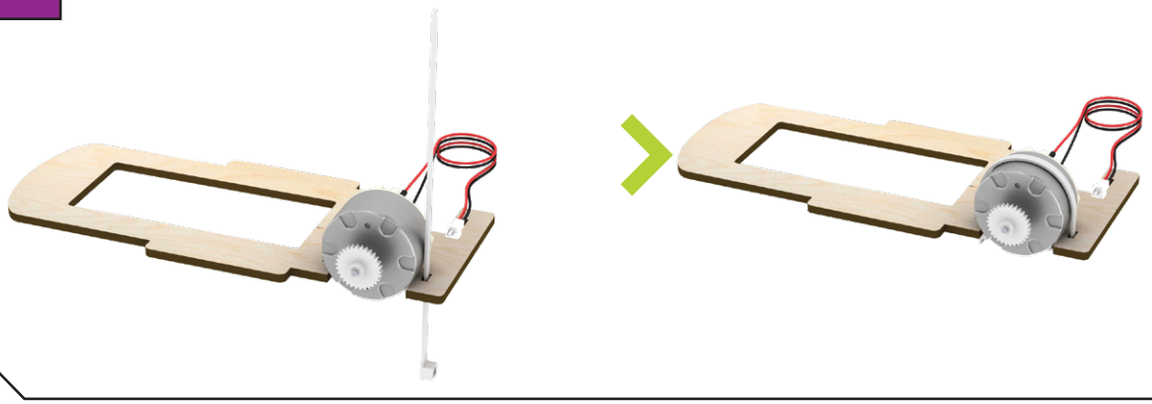

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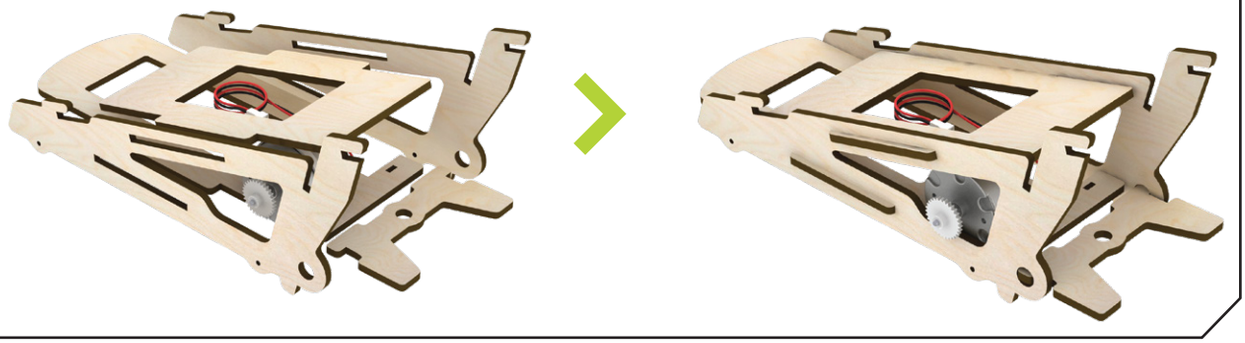

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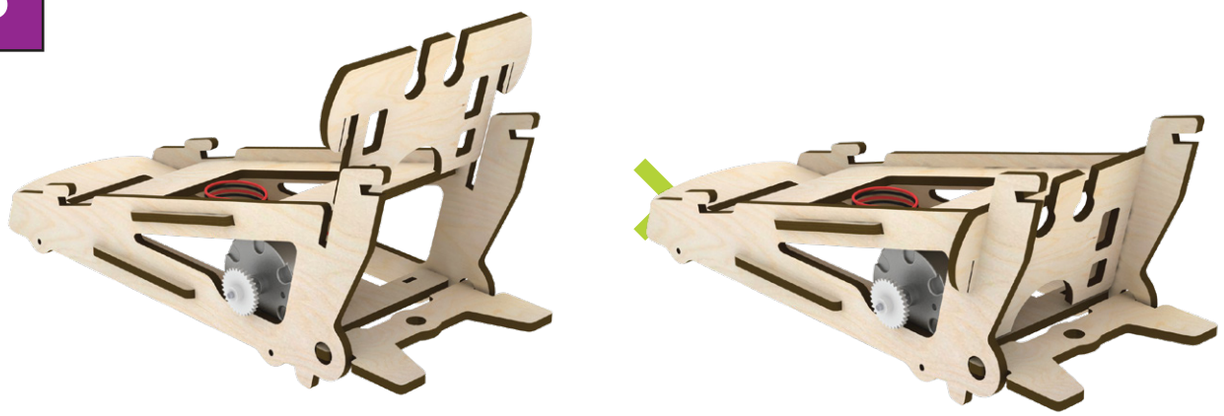

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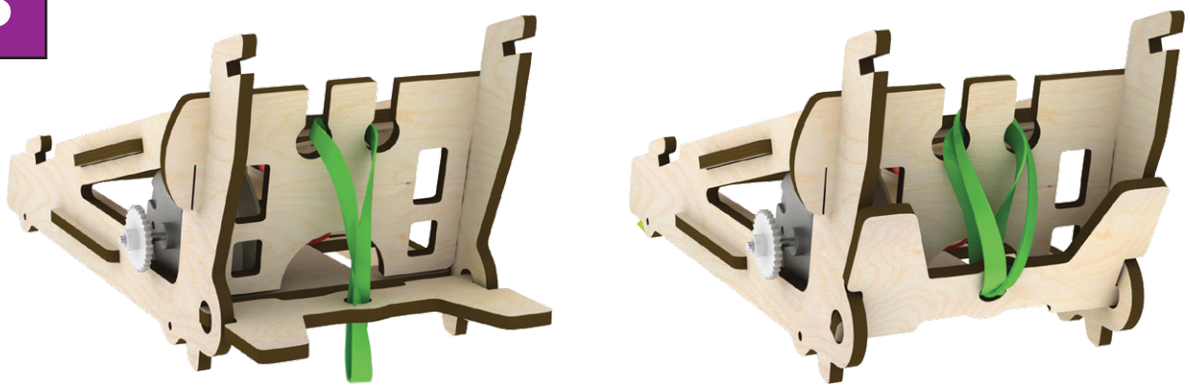

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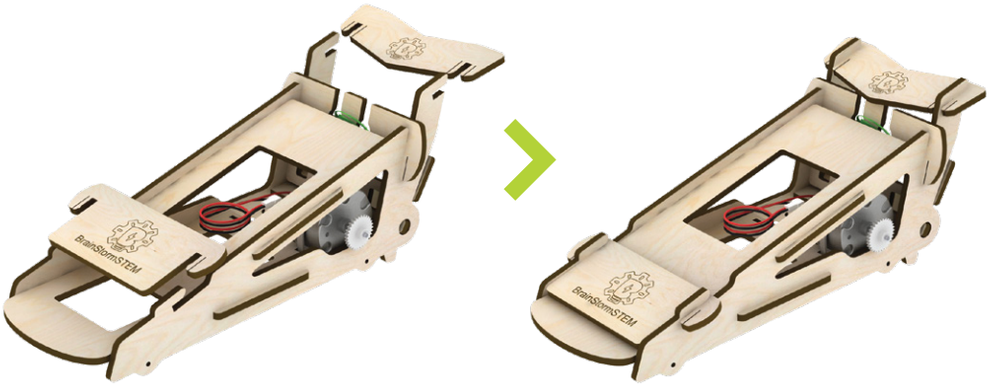


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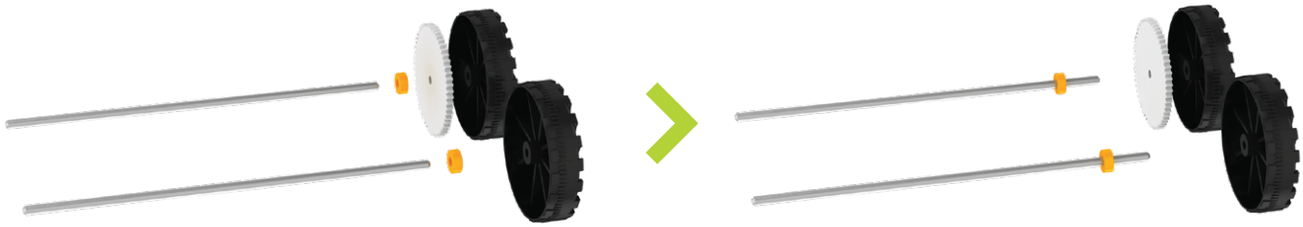

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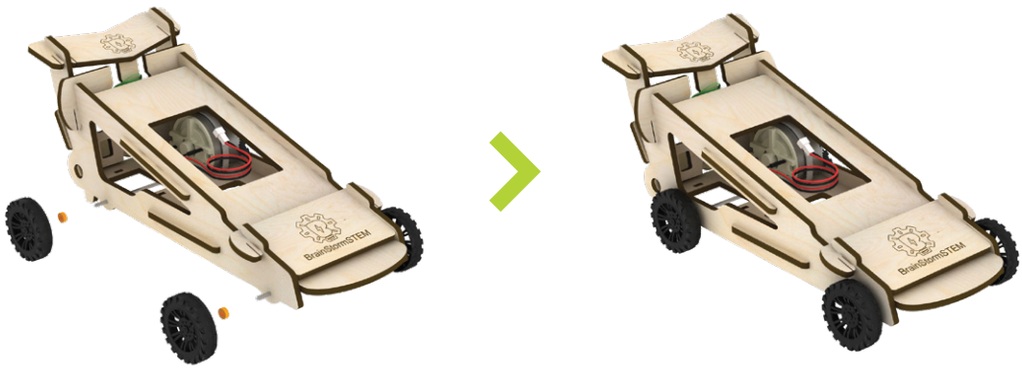
**10**

**11**


BrainStormSTEM
BrainStormSTEM

**12**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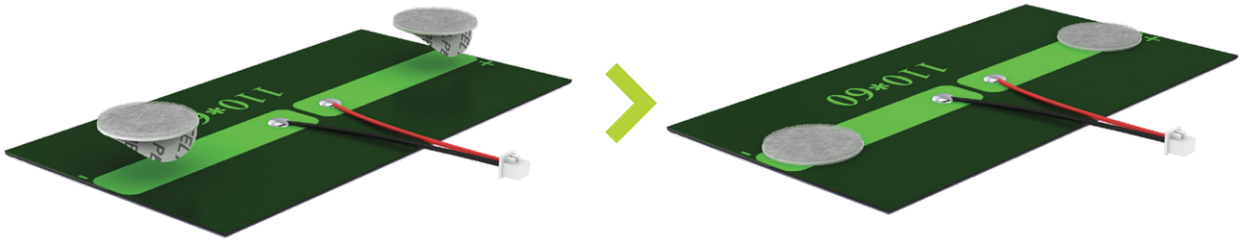

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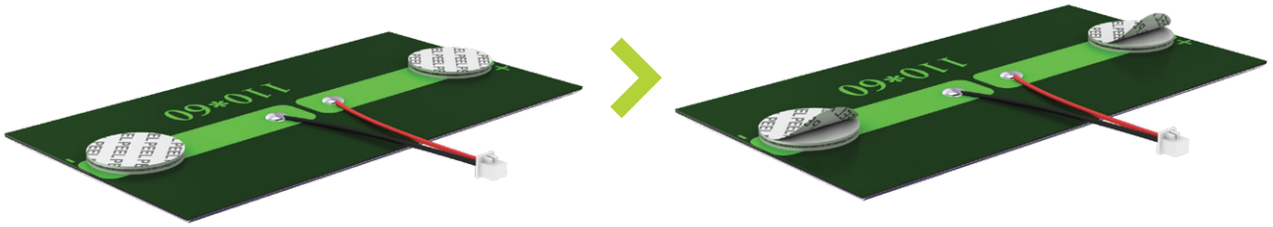

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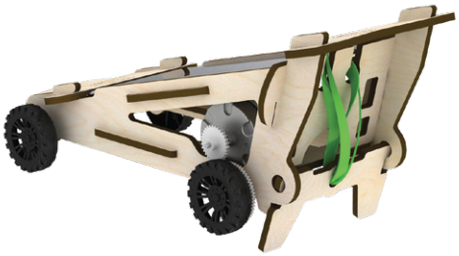
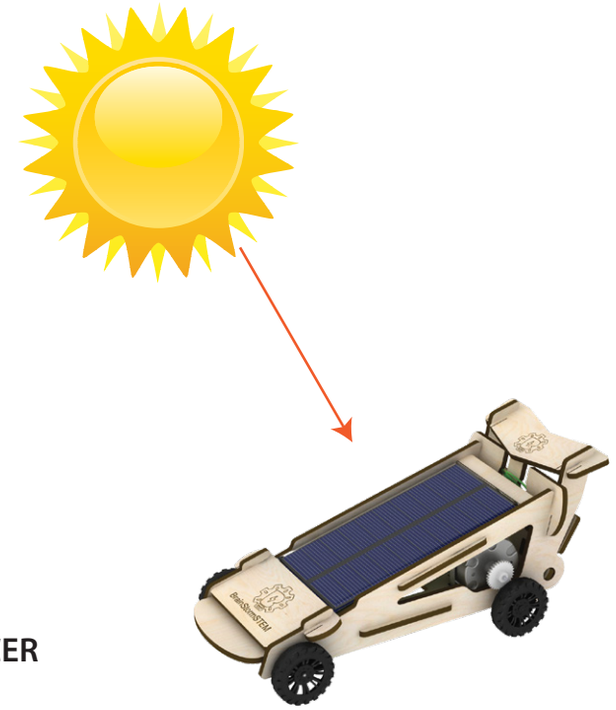
## 16

# HOW TO USE



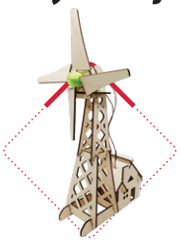


1. PLACE KICKSTAND IN THE DOWNWARD POSITION.

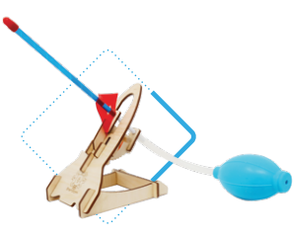
2. PLACE THE SOLAR RACER IN DIRECT SUN LIGHT.

3. CAREFULLY PUSH THE SOLAR RACER TO DISENGAGE THE KICKSTAND.

***If you enjoyed this STEM Kit, check out some of our other Kits!***



WIND TURBINE



AIR-POWERED ROCKET

EARTHQUAKE ENGINEER

AND MORE!

# ACTIVITY FOR PROJECT

The Brainstorm solar car can be used just to build, test, and have fun. But if you would like the solar car to be used as a more engaging classroom activity, it can be paired with the provided worksheets. There are both beginner and advanced worksheets to adjust to the level of your student's understanding.

The Solar Car will allow students to see how fast the car will travel while powered by the sun. On a bright sunny day, students will see the car travel much quicker than on a shadowy day.


Each of the worksheets is geared towards having the students figure out how the brightness of the sun will affect the speed of the solar car. As well as getting to see the direct application of solar energy on movement. On the advanced worksheet, the students will be introduced to how to find the speed of the car based on the distance covered over time.

Students can figure out how the car will travel faster in the brighter sun and slower when covered in shadow.

# WORKSHEET ( BEGINNER )

Name(s): _____

Date: _____

## An ARRAY of Energy

Circle three types of renewable energy:

Solar Wind Coal Tidal Natural Gas Hydropower

Nuclear Biomass Oil Geothermal

What's one thing you would add to your solar car?

_____

_____

Test your car multiple times. How far did your car go (in inches)? Record how many inches it went for each trial.

| | Trial #1 | Trial #2 | Trial #3 | Trial #4 |
|---|---|---|---|---|
| Inches | | | | |

Draw what your Solar Car looks like:

# WORKSHEET ( Advanced )

Name(s): _____

Date: _____

**Answer the following questions about renewable and non-renewable energy.**

**1.What is used to harness solar energy so that it may be used for electricity?**

_____

_____

**2. "PV" stands for?**

_____

**3. What is one disadvantage of a solar car?**

_____

_____

_____

**Once you've built your solar car, it's time to find out how fast it goes. Today we will be using inches per second. Test your rover over a desired distance, and time it during this test. Once you have the distance (measured in inches) and the amount of time it took to go over said distance (in seconds), you will select the correct equation to find out how fast your solar rover goes. Record your information below.**

**Distance = Speed X Time | Time = Distance / Speed | Speed = Distance / Time**

| | Distance (in.) | Speed (in./sec.) | Time (sec.) |
|---|---|---|---|
| Trial #1 | | | |
| Trial #2 | | | |
| Trial #3 | | | |