National Museum of the Marine Corps

NMMC at Home

PETROLEUM PRODUCTS AND RENEWABLE ENERGY

STEM ACTIVITY GUIDE

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18900 Jefferson Davis Highway
Triangle, VA 22172
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Petroleum Products and Renewable Energy

The materials included in this packet will supplement content for the NMMC at Home: The United States Marine Corps in the Persian Gulf program. Additional information is available on the NMMC website.

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Objective and Instructions

Age Range:

Our STEM activity guide is ideally suited for grades 6-12.

Objective:

Read this packet and use what you have learned to comprehend the various ways the Marine Corps and other organizations are creating renewable energy resources for the future.

Materials:

- *STEM activity guide*
- *Pen or Pencil*
- *The United States Marines Corps in the Persian Gulf introduction video [LINK]*
- *Various household materials for sail car activity*

Instructions:

1. For background to the role of the Marine Corps in the Persian Gulf and conflict in the Middle East, watch the introduction video HERE.

2. Read through the "Petroleum Products and Renewable Energy" lesson plan and fill in answers for reading comprehension and understanding.

3. With parental supervision, conduct the additional activities (Oil and Feathers Lab and Sail Car).

Lesson Plan

In August, 1990, the Iraqi army, under the leadership of Saddam Hussein, invaded Kuwait in hopes of gaining Kuwait's rich oil fields and evading the repayment of funds borrowed from Kuwait during the Iran-Iraq war. In response, President George H.W. Bush ordered the United States to lead a 35-country coalition to protect Saudi Arabia and free Kuwait, beginning what is known as Operation Desert Shield which became Operation Desert Storm in January 1991. Why was this invasion so significant that the United States military needed to intervene? One major reason was the stability of the world's oil supply. In 1990, the Middle East–made up of countries including Iraq, Iran, Saudi Arabia, and Kuwait produced half of the world's petroleum. With Iraq's invasion of Kuwait, the price of a barrel of oil doubled, and fear of another oil crisis, reminiscent of the 1970s and 1980s, as well as the fear of long term oil supplies dwindling, was at the forefront of many world leaders' minds.

(U.S. Marine Corps)

Why was it so important to maintain stability and flow of petroleum?

We use petroleum products every day, often without knowing it! The gas in our cars, the diesel fuel in our semi-trucks, and the jet fuel in our airplanes all come from petroleum, but did you know that many other products are derived from petroleum? Plastics, synthetic rubber, and even some products like crayons, toothpaste, and shampoo use petroleum! Over 6,000 products can be made utilizing petroleum!

(U.S. Marine Corps)

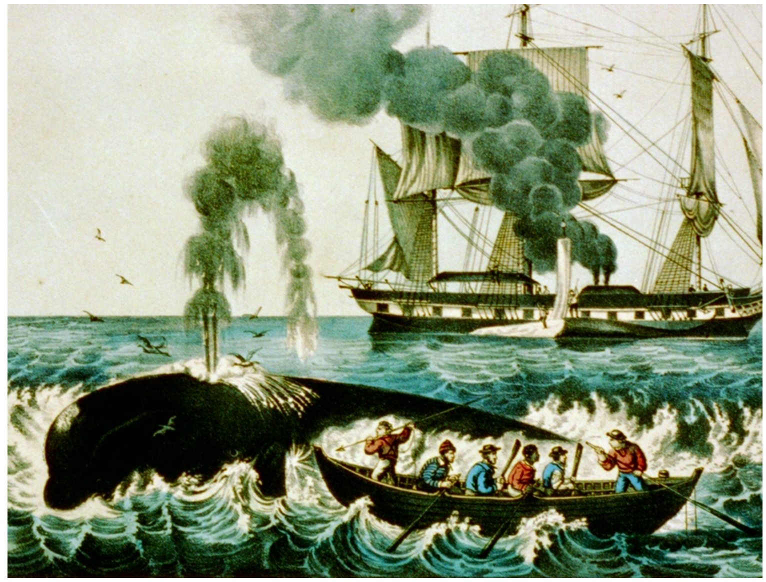
With Kuwaiti and Saudi petroleum supplies being threatened by war, the global impact on the prices and supply of oil and gasoline, as well as many of the household items used worldwide, was in jeopardy. Today, the United States has lessened its dependence on foreign oil, and is one of the biggest producers of petroleum in the world. But looking to the future, should we continue to rely on oil as a source of fuel for cooking, transportation, and heat? Petroleum is a fossil fuel and a non-renewable resource, meaning once it's used, it can't be replaced. What can we use instead?

(Wikimedia Commons)

In this lesson, we are going to explore what is petroleum, and where does it come from? We will also discover the difference between non-renewable and renewable energy sources, and what you and your family can do to ensure we don't use up non-renewable resources too quickly!

(U.S. Marine Corps)

Prior to the second half of the 19th century, the majority of people used wood, coal, or animal blubber for heat, cooking, and light. Petroleum, a thick, sticky, and smelly substance that seeped up from the ground, was often overlooked as a source of energy. In the 18th and 19th centuries, one of the most popular sources of animal fat for light was whale oil, which is harvested and refined from whales. Among the many problems with this source of fuel, is that as demand increased, and whale populations decreased, whalers had to venture further and further into new hunting grounds, which was expensive and dangerous. *(To find out more about how the government assisted in gathering information for safer whaling voyages, check out our program on the United States Exploring Expedition by visiting our website* **HERE***)*



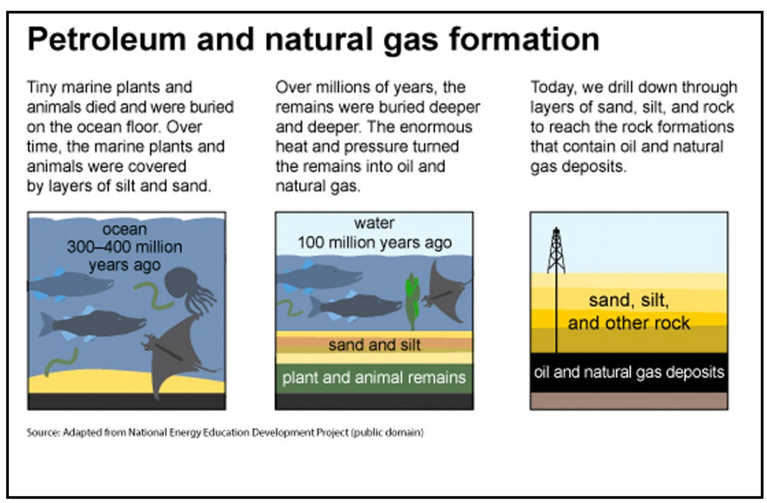
(Wikimedia Commons)

This demand on whale oil would wane with Abraham Gesner's discovery of kerosene in 1846, a burning oil extracted from albertite, a semi solid form of petroleum. Once Edward Drake perfected the method for drilling liquid petroleum in 1859, the world was ushered into a new era called the Age of Oil, in which humans quickly incorporated petroleum into their daily lives.

To sustain life or to accomplish work, humans, animals, plants, and machines must produce energy. Energy is the ability to do work. For example, energy must be spent to push, pull, or lift. There are many different types of energy: thermal, chemical, mechanical, electrical, and gravitational. To create energy, we need fuel. Humans create chemical energy by eating food. Plants use the sun to convert carbon dioxide into energy through a process called photosynthesis. We can also create mechanical and electrical energy by converting solar, water, or wind power into energy using generators. A combustion engine, like the one in your car, uses gasoline and air to create combustion (burning) to force hot, high pressured gasses to move engine parts like pistons, turbine blades, or rotors.

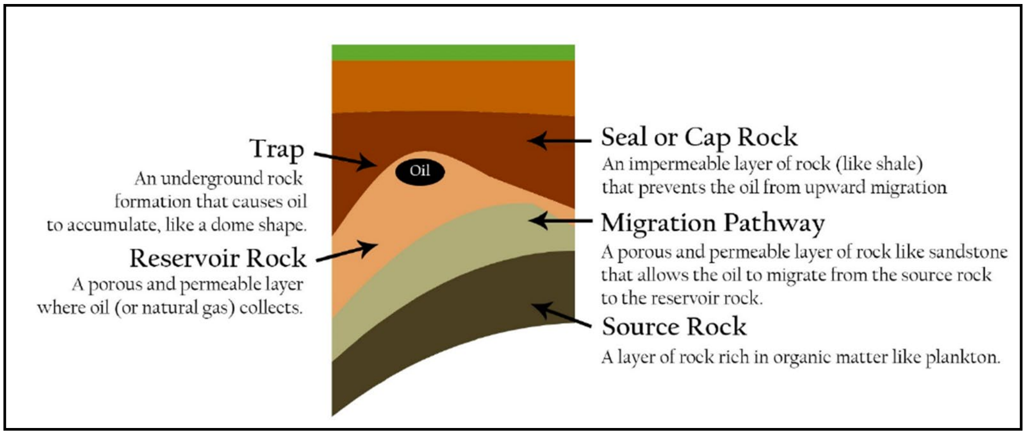
The Geology of Petroleum

Petroleum was produced millions of years ago from microscopic plankton (animals, algae, and bacteria) that flourished in warm ancient oceans. When they died, they sank to the bottom of the sea where they became covered in sediment (which over time would become sedimentary rock). The oxygen-depleted ocean floor kept bacteria from consuming the remnants of decayed organisms and instead allowed for them to be buried deep underground.



As the plankton gets buried deeper underground, the heat and pressure from the Earth begins to break down the molecules. Before the molecules become fossilized, plankton turns into a material called kerogen, which can be burned for energy, but has less stored energy than oil and natural gas. Eventually, after millions of years, and immense pressure and heat, the plankton turns into liquid oil or natural gas. (Natural gas requires more heat for it to form than oil).

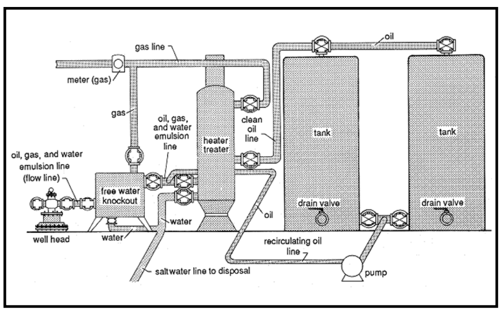
Did you know? Coal is also a fossil fuel, but is created from fossilized plants. As plants decompose, they become peat and eventually coal.



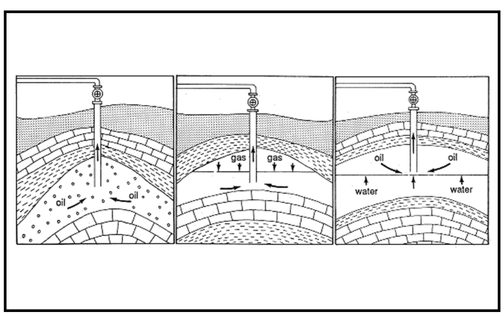
Where does the energy in fossil fuels come from? Living organisms used carbon and hydrogen to fuel their cells. The fossilized hydrocarbons in oil, natural gas, and coal serve as the fuel for fossil fuels when burned. Each crude oil deposit has a unique composition of these hydrocarbon molecules, and the ultimate use (whether they are used for gasoline, asphalt, or a household item like paint) is determined by the proportion of these molecules. Because these molecules are found in rock, they are called "petroleum," derived from the Latin words "petra" meaning rock, and "oleum" meaning oil.

When petroleum is formed, it does not stay in one place. This is because petroleum is created in porous rock, like sedimentary rock. Where it is formed is called the "source rocks." Source rocks are typically shale or limestone. These rocks are porous, but the pores are not large enough for fluid to move through, therefore, they are not "permeable." Due to the pressure exerted on petroleum during its creation, the pressure forces the fluid to move from the source rock to a "reservoir rock," another type of sedimentary rock, like sandstone. Since oil and natural gas are less dense than the water that is also found in sedimentary rock, this migration will continue upwards until it hits an impermeable layer of rock, and is trapped. These traps, either made by rock formation, fault lines, or other geological means create the reservoir geologists and geophysicists look for when searching for places to drill for oil or natural gas.

Extraction



Oil production, explained (Kansas University)



Reservoir energy (Kansas University)

Getting the crude oil from the ground and to a useable commercial product is a long and complicated process! It takes the collaboration of scientists, engineers, and many people who are trained in drilling to begin to collect crude oil that can be eventually refined into a petroleum product. Geologists and geophysicists must first prospect an area to determine if it is a likely spot to find hydrocarbons (crude oil/petroleum). However, even if they suspect they have found a site that can be drilled, they must first determine the environmental impact of drilling the site, and determine who owns the land!

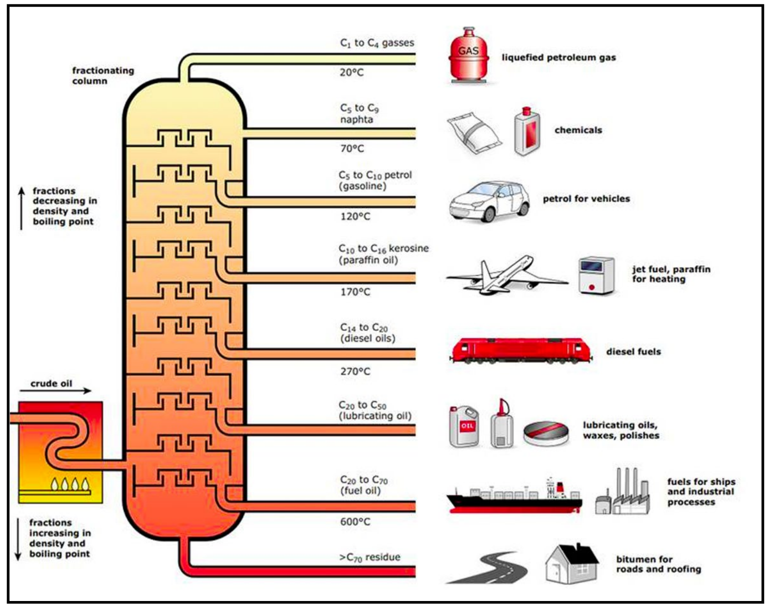
To confirm a reservoir of petroleum, engineers must drill into the reservoir rock, which could be thousands of feet into the ground! During the drilling process, care must be taken to ensure that the surrounding ground water is not contaminated by any petroleum spillage, as well as maintaining the stability of the drilling hole. To do this, the drilling hole is lined with cement, and while drilling, the hole is filled with "mud," a mixture of fluids, solids, and chemicals, which cools the drill bit, pushes the rock pieces to the surface, and maintains pressure in the hole. Once the hole is drilled, and the geologists determine that it is a producible well (meaning there is a significant amount of petroleum) the oil is ready to be moved to the surface.

At this stage, it is determined if the oil will move freely up to the surface by pressure, or if a pump is needed. The engineers then put the corresponding equipment on the well to extract the oil. When the oil comes to the surface, it must be separated from any possible natural gas and water that was also in the reservoir rock. Any natural gas collected travels by pipeline to a processing facility to create propane or butane. Using heat, the oil and water mixture is separated, and the oil is transferred to a refining facility.

Refining

Why can't we use petroleum straight from the ground?

The answer is because each deposit of petroleum, or the crude oil extracted from the ground, is made up of a unique number of hydrocarbon molecules. The lightest molecules, dissolved gases, have 1 to 4 carbon atoms, while the heaviest have over 20. These molecules are present in varying proportions depending on the deposit, meaning that each oil has its own composition and properties. Some petroleum deposits are black and viscous (meaning thick and sticky) and contain a lot of heavy molecules; others are brown, more fluid and lighter. Each also contains a certain amount of dissolved gas and highly corrosive products, such as sulfur or acids, which can sometimes be toxic.

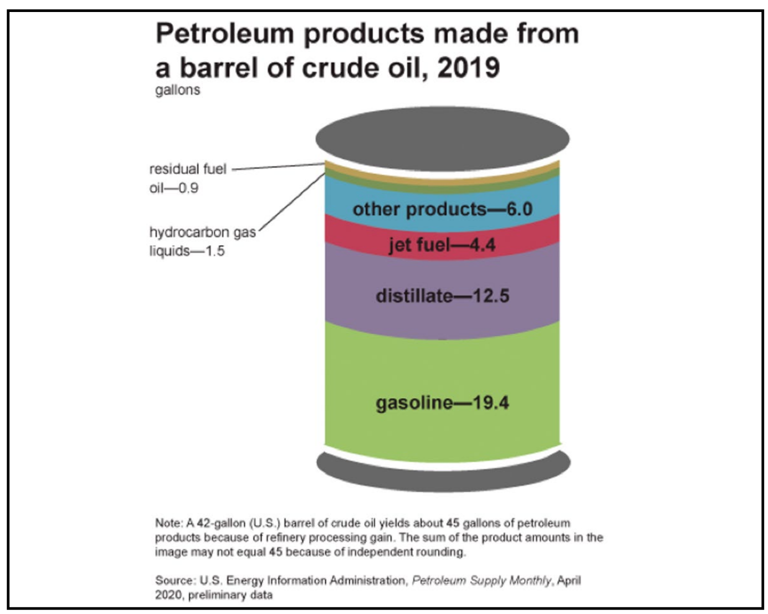


(Marquard-Bahls)

The crude petroleum is heated and the hot gases are passed into the bottom of a distillation column. As the gases move up the height of the column, the gases cool below their boiling point and condense into a liquid. The liquids are then drawn off the distilling column at specific heights to obtain fuels like gasoline, jet fuel, and diesel fuel. Some of the liquid undergoes further refining to create other products like chemical feedstock, which will eventually become things like plastics or paint.

How much petroleum is consumed in the United States?

According to the U.S. Energy Information Association, in 2019 the United States consumed an average of about 20.54 million barrels of petroleum per day, or a total of about 7.50 billion barrels of petroleum products. The total consumption of oil in the world is estimated (in 2016) to be 96 million barrels, per day.



(U.S. Department of Energy)

The use of petroleum products is essential to our way of life. We use gasoline, diesel fuel, aviation fuel, and chemicals derived from petroleum every day. But what are some of the impacts of using petroleum? Do some research on how producing petroleum impacts the environment. Start your research at their website.

What are some of the impacts you found?

1. ____

2. ____

3. ____

Petroleum is a non-renewable resource. Since it took millions of years for the fossilized plankton to be converted into crude oil, humans are using it faster than it will be replenished, and therefore it has a finite amount. A renewable energy source is one that is naturally replenished by the earth's natural resources that are not exhaustible, like wind or sunlight.

Think about what would happen if you woke up one day, and there wasn't gasoline, plastic, or cooking fuel. What would you do? Let's look at one of them.

Think about a world without plastic. Write down 5 things that you use every day (or almost every day) that are made from plastic. Then think about an alternative material that can be used. Some things are harder than others! Computers, keyboards, phones, most of our technology uses plastic! That is why recycling plastics is so important!

(The Guardian UK)

I use plastic for:	**An alternate material could be:**
1. Plastic food container	1. Glass container
2.	2.
3.	3.
4.	4.
5.	5.
6.	6.

Using Alternative and Renewable Resources and "Going Green"

Since petroleum is a non-renewable resource, it is important to start thinking about and start conserving non-renewable resources, and using alternative and renewable ones. In the box below, without looking them up, brain storm and write down all the different types of renewable resources, and how you can lower your use of petroleum products.

Wind power

Walk/ride my bike to the grocery store

Turn off the lights when leaving a room

U.S. Navy and Marine Corps Green Initiatives

Why is it important for the Navy and Marine Corps to "Go Green?"

According to the Department of the Navy's (DON) 2008 Environmental Strategy, *environmental stewardship protects and preserves the mission capabilities of our installations and training areas, ensures operational flexibility by meeting environmental laws and regulations, and sustains the resources and public support needed to carry out the mission…maintaining and improving environmental quality on installations and ranges can help ensure our ability to use them for their intended purposes, raises the quality of life for Sailors, Marines, and the local community, and avoids significant liabilities that require cleanup, restoration, or other actions, allowing our bases and operating areas continue to meet critical mission requirements.*

View the environment policy statement from the Secretary of the Navy **HERE**. How does the Navy and Marine Corps accomplish environmental stewardship?

Marine Environmental Engineers

The Military Occupational Specialty (MOS) Environmental Engineer is concerned with scientific and engineering principles for the protection of human populations from the effects of adverse environmental factors. This includes the protection of environments and the improvement of environmental quality. An environmental engineer is responsible to study the air, ground, and water to identify and analyze sources of pollution and its effects on their installation.

(Department of Defense)

Department of the Navy Energy Goals:

- Sail the "Great Green Fleet"
- The "Great Green Fleet" was a year-long DON initiative that demonstrated the Navy's efforts to transform its energy use. Throughout 2016, ships, aircraft, amphibious, expeditionary forces, and shore installations will use energy efficient systems and/or alternative fuel
- Reduce Petroleum Use in Non-Tactical Vehicles
- The DON strives to reduce petroleum use in the commercial fleet by 50 percent
- Increase Alternative Energy Ashore
- By 2020, DON will produce at least 50 percent of shore-based energy requirements from alternative sources.
- Increase Alternative Energy Use Navy-wide
- By 2020, 50 percent of total DON energy consumption will come from alternative sources
- Increasing efficiency

Fewer people needed to transport non-renewable energy means more people available for other important tasks. Being able to produce energy, without depending on bringing in energy from the outside, is also part of solution for energy security. Energy security means a military installation can provide power to its most critical operations, even if the civilian power grid or energy supply is completely down.

Alternative Energy for Vehicles

In 2010, the Marines received two Newton Electric trucks from a company called Smith Electric for the training facility at Camp Pendleton, CA. The Marine Corps plans to use them to carry equipment and personnel on the base. Although the trucks may not be ready for combat just yet, they do carry up to eight tons of cargo and can go as far as 100 miles on a single charge.
The trucks are fuel-emission free, making them an excellent start for the Marine Corps' goal to increase reliance on renewable electrical energy to 25 percent by 2025.

Biofuels

(Department of Defense)

A biofuel is a fuel that is produced with biomass. Biomass is organic material made from plants and animals. Examples include wood, crops, manure, and algae. Biomass contains stored energy which is released from burning or turning it into gas or fuel like ethanol or biodiesel. Biomass is a renewable energy source because we can grow more trees and crops, and there will always be waste.

In honor of Earth Day, the Navy conducted a test flight of the Green Hornet, an F/A-18 Super Hornet fighter jet which is powered by a biofuel blend.

Skysails

(Beluga Projects)

These are kites designed to tow large commercial ships. The idea came from kitesurfing, a sport where people hold on to kites and use their power to surf the waves.

Skysails conserve fossil fuels and would reduce the Navy's dependence on oil, coal and natural gas to run their ships. Military Sealift Command, a part of the Navy that is focused on transportation and logistics, is currently looking at ways to contribute to the skysail project.

There are some problems to overcome with skysails before they can be used. It is very expensive to install skysails and only reduces the use of fossil fuels by 10-15 percent.

Wind Turbines

(U.S. Marine Corps)

Wind turbines at U.S. Naval Station Guantanamo Bay reduce fuel consumption by 650,000 gallons annually. The wind turbines are located on John Paul Jones Hill, providing energy for the Naval Station and Joint Task Force Guantanamo.

Solid State Lighting

Using light-emitting diodes (LEDs) saves energy when replacing incandescent fixtures, and they last longer, reducing maintenance needs.

Solar Power


(DFAS)

Marines used the Ground Renewable Expeditionary Energy System, or GREENS, a portable power system developed for the Marine Corps which uses rechargeable batteries and solar panels, to provide 300 watts of continuous electricity for Marines in remote locations and lessens the need for fuel resupply, reducing the associated threats to vehicle convoys in Afghanistan and Iraq.
Solar panels, or photovoltaic (PV) systems, are now powering some of the larger Navy buildings at Pearl Harbor, HI.

Estimates indicate the new PV system will provide an annual avoidance of approximately 5,667 barrels of oil and 3,118 tons of carbon dioxide emissions. The carbon dioxide avoided is equivalent to taking 550 passenger cars off the road.

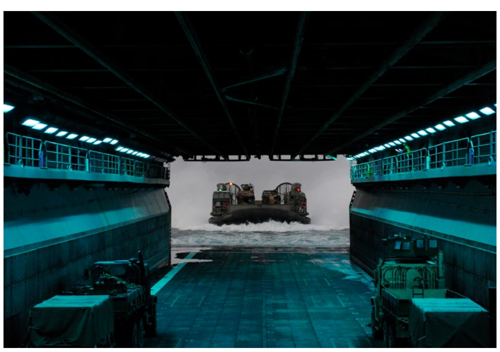
Hybrid Electricity and Green Ship Design


(U.S. Navy)

In an effort to make ships more efficient, the Navy is pioneering better hull coatings and better hull forms and is now looking at a hybrid electric drive to reduce fuel consumption on ships.

Hybrid electric drives provide greater operational capabilities by allowing ships to operate longer without refueling.

A key component of the hybrid electric drive is an uninterruptable power supply. Ships typically run two generators simultaneously to provide shipboard power requirements, with one acting as an emergency back-up for possible power loss. The uninterruptable power supply would allow ships to routinely run one generator.


(U.S. Navy)

Only running one generator at 70 percent load versus two generators at 35 percent load saves about 10 percent of the fuel, somewhere on the order of six to seven thousand barrels of fuel a year.

USS *Makin Island* is the final amphibious assault ship built in the LHD-1 *Wasp*-class, but is the first of the class built with gas turbine engines and electric drive.

The Navy projects that this advance will save nearly $250 million in fuel costs over the ship's lifetime. During the ships transit from Pascagoula, MS, to San Diego, *Makin Island* consumed over 900,000 gallons less fuel than a steam ship completing the same transit, saving more than $2 million in fuel costs. Other environmentally-friendly initiatives include the use of an electric plant to power auxiliaries, meaning no steam or associated chemicals; and the use of reverse osmosis water purification systems that negate the need for chemicals like bromine or chlorine.

Green Roofs

The military has put to use three different, yet equally effective roof technologies. Cool-roof technology keeps the interior of the building cool, thus cutting off the need of air conditioning.

Vegetable roof technology consists of the use of low growing plants being planted on cool roofs to use the water from rainfall for the plants, and lessen the amount of run-off water by 80%. Renewable energy technology uses solar technologies to generate electrical power and heat water.

Did you know the National Museum of the Marine Corps has a green roof?

Critical Thinking and Research Activity

Research a government site, like a military installation, public school or local government building in your area. What changes has it made to help improve its environmental stewardship? What more can they be doing? Research a way in which the site can further incorporate renewable energy. Then write a letter to your Congressman/woman or local county government representative to share your idea. Let us know your idea by emailing us at nmmckids@gmail.com.

Oil and Feathers Lab

"The Marine Corps protects and preserves its watersheds, wetlands, natural landscapes, soils, forests, fish and wildlife, and other natural resources as vital Marine Corps assets."

The United States Marine Corps takes environmental protection very seriously, and the quote above comes from the Environmental Compliance and Protection Manual, a document sent from Headquarters, Marine Corps to outline the guidance and instructions on how the Marine Corps will follow both Department of Defense and Federal environmental legislation.

By following the instructions set forth by the Federal government and the Department of Defense, Marines can avoid contaminating their local waterways, soil, and potentially harming local wildlife, with oil, paint, and other damaging materials.

In this lab, we will be investigating how oil reacts with feathers, and find out why oil spills are so dangerous to birds. One of the largest oil spills in history occurred in 1989, when the oil tanker, Exxon Valdez spilled approximately 11 million gallons of crude oil into Alaska's Prince William Sound. Among other environmental problems, this spill caused the death of thousands of birds, due to the oil coating their feathers. Feathers help insulate birds (keep them warm), and they provide buoyancy (allow them to float on water).

Hypothesis #1: Write a sentence about how you think a feather will behave in water. (Do you think the feather will absorb water? Or repel water? Will a feather sink or float?)

____

____

Hypothesis #2: Write a sentence about how a feather will behave in oil. Will it be different than the water? Why or why not?

____

____

Materials Needed:

- A clean feather (not artificial)
- Toothbrush
- Dish detergent
- Bowls

Procedure:

1. Place a feather in water. Observe how the water reacts to the feather, and how the feather behaves in the water. Write your observations once you place the feather into fresh water:

____

2. Take the feather out of the water. Pour some oil into the water. Observe how the water and oil react to each other. When you mixed the oil and water together, what happened?

____

3. Put the feather into the oily water. When you added the feather to the oily water, what happened to the feather?

____

4. Get a clean cup of water. Place the oily feather into the fresh water. Observe the feather, does it behave the same way as before?

____

5. Try to clean off the oil in the fresh water. What happens? Were you successful in cleaning off the oil in fresh water? Why or why not?

____

6. Carefully place the oily feather into some soapy water and clean it. Place it back into the clean water. Does it behave the same as in step 1?

____

Conclusion: Write 2-3 sentences on your observations on how oil affects feathers.

____

____

____

How do oil spills affect birds? Oil penetrates feathers and becomes vulnerable to hot and cold temperatures. When they preen (clean) their feathers, birds will ingest the oil which causes health problems. It also affects their buoyancy, and it is harder for birds to float. Oil coated feathers also make it harder for birds to fly, which prevents migration, hunting for food, and makes them susceptible to predators. Further, the oil covered birds are a threat to the food chain. When a predator eats the bird, the predator is then also poisoned and could potentially die. Learn more at the U.S. Fish & Wildlife and Service website HERE.

Going further: Read about the explosion on the Deepwater Horizon oil rig. What happened? What were the environmental impacts? Were any policies changed due to the disaster?

Environmental Compliance and Protection Manual: Click for link to the PDF

Learn more about the Marines' environmental management: Click for the link to the PDF

Do-It-Yourself Sail Car

Student Objectives:

Read about how the Marine Corps is using alternative fuel sources in the STEM packet, Petroleum Products and Renewable Energy. Then look around your house for some recyclable items to make your own alternative fuel car!

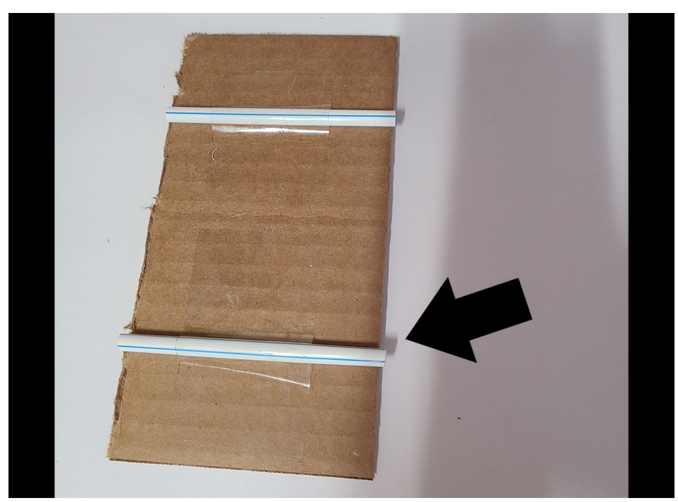
Supplies Needed:

- Cardboard
- 2-3 wooden skewers
- 2 straws
- 4 screw-on container lids (like from soda bottles)
- Paper
- Tape
- Glue (hot glue or super glue)
- An adult helper with a drill, scissors, and/or utility knife
- Optional: Markers, crayons, stickers, and other materials to decorate your car.

Procedure:

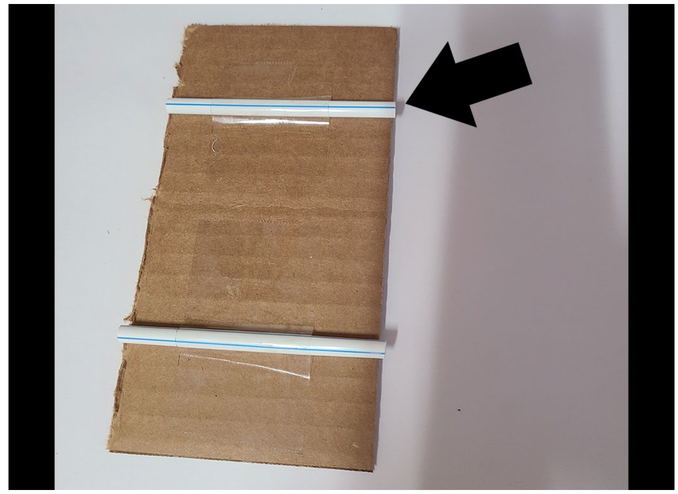
1. Decide how large you want the base of your car to be. With your adult helper, cut out a rectangle from your cardboard. Tip: use the flap of a cardboard box! If desired, color and decorate the cardboard.

2. Lay a straw across the width of the cardboard. Cut the straw to the width of the cardboard.

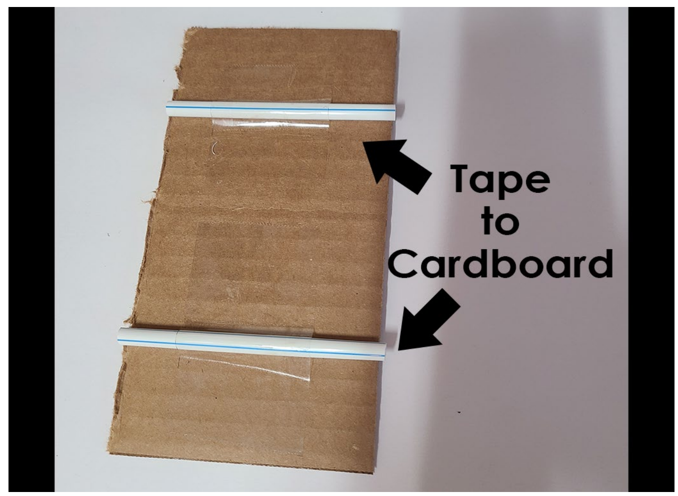


Do-It-Yourself Sail Car

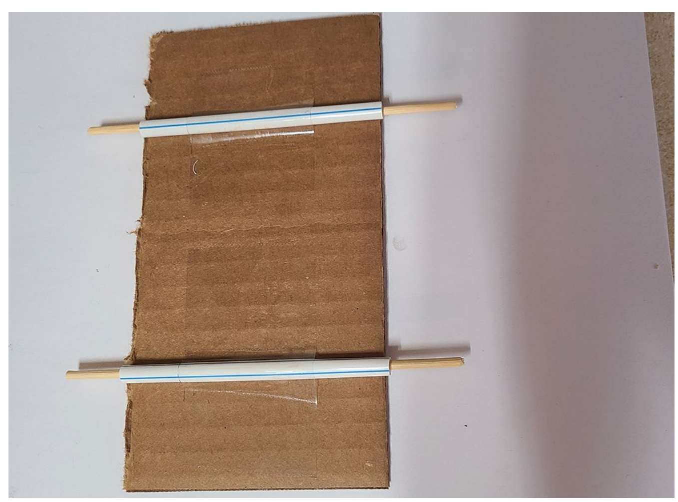
3. Repeat with second straw.



4. Tape one straw about ¼ of the way from the top of the cardboard, and tape the other about ¼ of the way from the bottom.



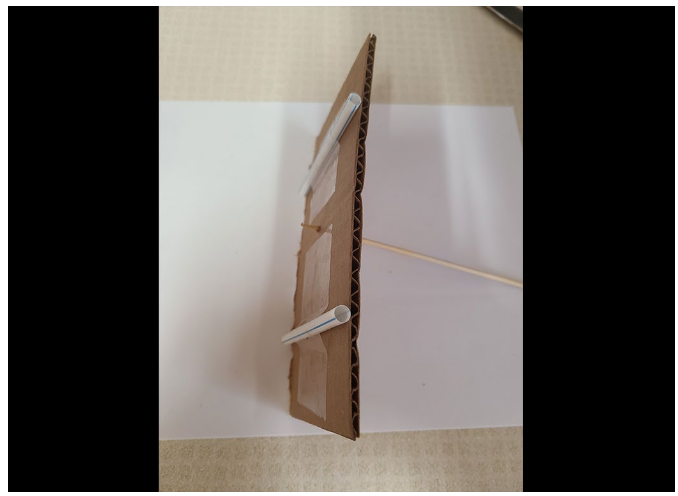
5. Thread a skewer through one of the straws. With your adult helper, cut the skewer so there is about ½ to ¾ inch of skewer on each side of the straw (you want to make sure the wheels can turn freely, and won't hit the cardboard). You may only have to cut a skewer in half to make both axles. If needed, cut another skewer to make the second axle.



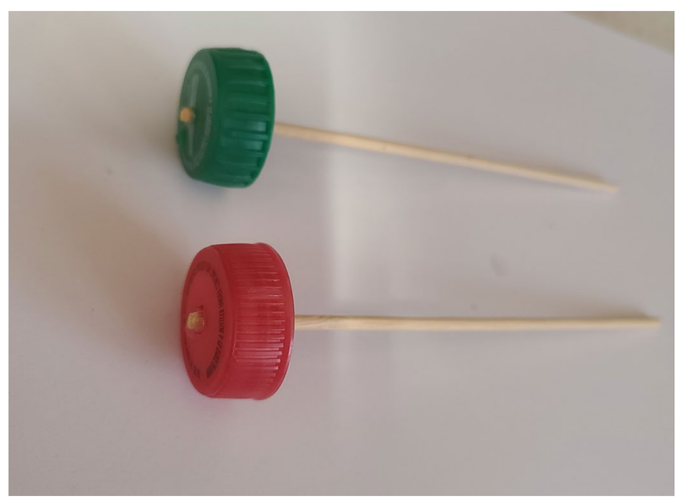
Do-It-Yourself Sail Car

6. Have your adult helper drill holes in the middle of each bottle top. (We used an 1/8th drill bit)

7. Determine how long you want your mast to be, and cut an additional skewer to that length. Using the pointed edge, poke the skewer through the middle of the cardboard and secure with glue.

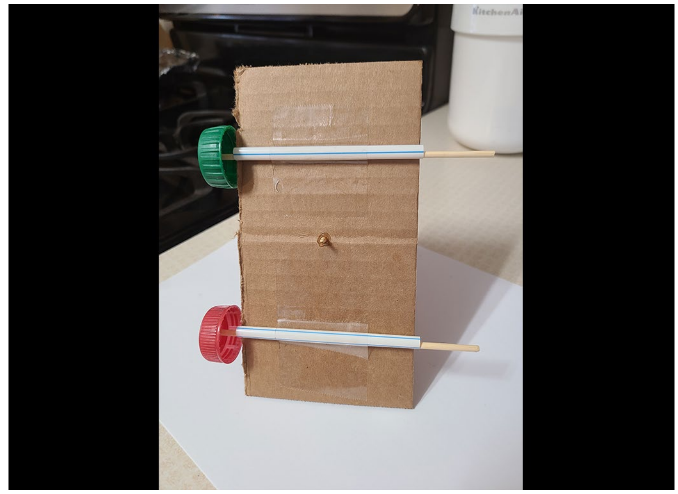


8. Remove your wooden axles from the straws. On one end of each axle, thread the skewer through the bottle top and secure with glue.

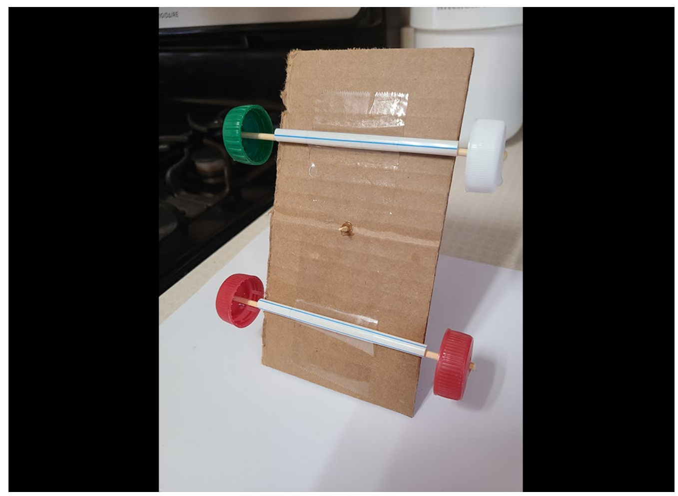


Do-It-Yourself Sail Car

9. Thread the axles through the straws.



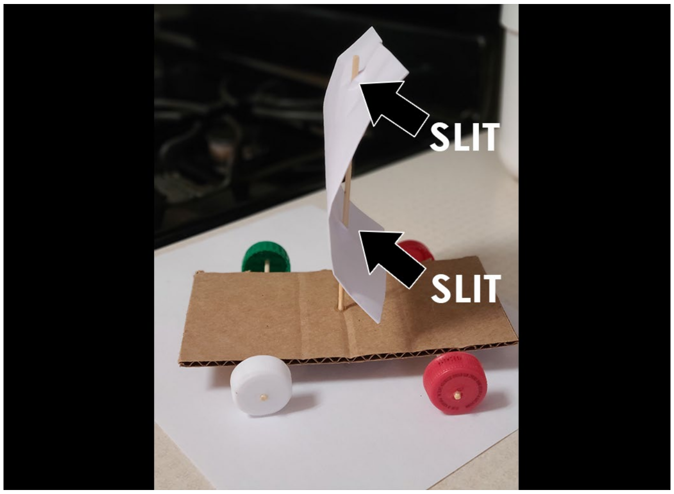
10. Secure the other two wheels to the ends of each axle with glue.



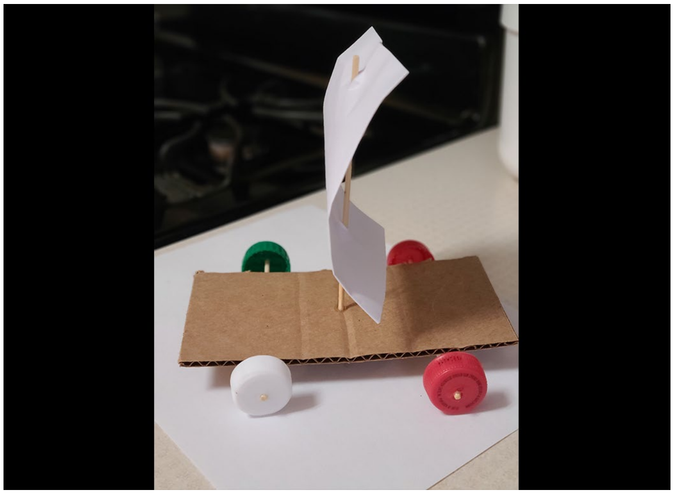
11. Take a piece of paper and fold into fourths. Decorate, if desired.

Do-It-Yourself Sail Car

12. Make two slits with scissors in the folded paper, about ¼ from the top, and bottom.



13. Thread the mast through the paper to make your sail.



14. Once the glue is dried, take a deep breath and try out your sail car!