

MACGILLIVRAY FREEMAN'S
**DREAM
BIG**
ENGINEERING OUR WORLD

PHYSICS:
**LED HOLIDAY
CARD**

Grade level: High School Physics

Lesson length: 150 minutes (can be broken down into multiple class periods)

Students design a greeting card that illuminates at least two LED lights by converting chemical energy in batteries to radiant energy when the card is opened.

In the Film

In the film *Dream Big*, engineers work to create renewable and sustainable energy. Traditionally, we harness the chemical energy found in fossil fuels and use technological devices to convert it to electrical energy. This electrical energy is then easily transferred over long distances and used in devices in our homes and businesses. As our technological capabilities continue to evolve, so too does the creativity of engineers in designing electrical circuits and grids to power our society. In this engineering challenge, we will use our own creativity to design a device that converts chemical energy to radiant energy.

NGSS Disciplinary Core Ideas

HS-PS3-3 Energy

Design, build, and refine a device that works to convert one form of energy into another.

NGSS Engineering Practices

HS-ETS1.A Defining and Delimiting Engineering Problems

Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.

Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

HS-ETS1.B Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.

Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.

Key Words/Vocabulary

Mechanical energy: Energy used in the physical movement of an object.

Chemical energy: Energy found within the chemical bonds of molecules.

Electrical energy: Energy found in the movement of electrons through a medium.

Radiant energy: Energy found in the movement of photons.

Circuit: A closed path through which electrons flow.

Controller: A component of a circuit that regulates the flow of electrons. A switch is an example of a controller.

Actuator: A component of a circuit that uses currents and voltage to perform an action. A lightbulb or buzzer is an actuator.

Materials

Per class:

- Materials for decorating the greeting card (markers, glitter, ribbon, glue stick, etc.)
- Color printer (optional)

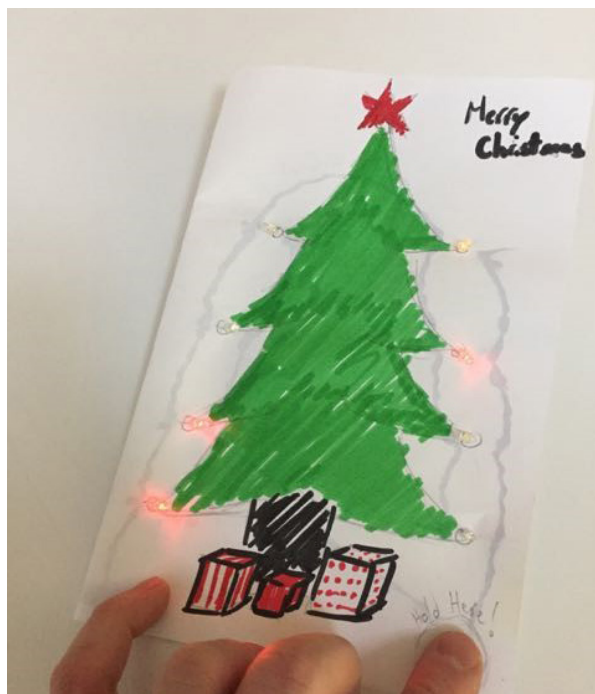
Per student:

- 3 two-legged LED lights (color irrelevant)
- 1 3V coin battery
- 1 tube of Bare Conductive paint or 1 meter of conductive copper or aluminum tape
- 1–2 pieces of cardstock
- Scissors
- Engineering a Greeting Card worksheet

Teacher Prep Notes

Gather examples of greeting cards that do something when opened, such as playing a song or lighting up. Alternatively, ask students to bring these types of cards in before class. You will need one card for each group of two or three students to examine and take apart.

Prepare to teach students about the directional flow of energy through circuits and the conversion of chemical energy from batteries to electricity and then to radiant energy. Also prepare to teach students about parallel and series circuits and how to identify their effect on volt and current flow through LEDs.



To Do

Determine the Problem or Question to Solve:

15 minutes

1. Before watching the IMAX movie *Dream Big*, give students an overview of what they are about to experience. This film is about engineering and the ways that engineering can inspire, challenge, and enrich our lives. Give students the following question to think about as they watch the film:
 - What are some innovative ways that engineers are creating usable energy for communities?
2. Debrief as a whole class after viewing the film. Allow students to verbally reflect on the guiding question you gave them.
3. Introduce the design challenge. Tell students that they are going to design a greeting card that illuminates at least two LED lights by converting chemical energy to radiant energy when the card is opened.



Research and Gather Information:

45 minutes

1. Organize students into pairs or triads. Give each group a greeting card that lights up or makes music upon opening, and a pair of scissors. To teach students about the common components of a circuit, have students carefully cut open the card so that they can see the components and what triggers the music or lights. Describe each circuit component: the energy source, actuators, and controllers. Make sure students can identify each one in their greeting card.
2. Distribute the “Engineering a Greeting Card” worksheet. Ask students to draw a circuit diagram of their greeting card as the first step under Research and Gather Information.
3. Teach students about the directional flow of energy through circuits and the conversion of chemical energy from batteries to electricity and then to the radiant energy of the LED bulb. Calculate the voltage and amperage drop across a circuit, identifying how changes occur because of the resistance found in activators like LED bulbs. Familiarize students with the appropriate symbols that engineers use when they are drawing schematics as part of the planning phase for a new project.
4. Teach students about parallel and series circuits to identify their effect on volt and current flow through LEDs. Allow students to experiment and determine the optimal circuit design to illuminate at least one LED.

Plan a Solution: 20 minutes

Tell students that they are now ready to each design their own greeting card. Review the Plan section of the “Engineering a Greeting Card” worksheet. Tell students to fill out this section as they decide how they want to make their greeting card. This includes drawing a circuit schematic using the appropriate symbols that represent their plan. The circuit schematic should include the power source, the direction of electron flow, the controller, and the resistor/bulb. Students should calculate the resistance, current, and voltage drop across each LED bulb. Finally, students should describe the controller device that they will use to complete the circuit when the card is opened.

If students are unfamiliar with the concepts of criteria and constraints in engineering, take the time now to introduce these two key ideas. Engineers look at challenges through the lens of criteria (what does my device have to do?) and constraints (what are the limitations I face in making, testing, and using the device?). Spend some time as a whole class brainstorming the criteria and constraints of this particular engineering challenge and have students write them down in their worksheets.

Make It: 30 minutes

When they are ready, students should create their greeting cards. As students work, walk around asking questions about the directional flow of electrons in the circuit. Encourage students to fluently discuss their card using circuit terminology.

Test: 10 minutes

As students finish creating their card, they should trade with another student who is also done. Students should evaluate each other’s cards based on the effectiveness of the switch: Have each student close and open the card under evaluation five times. How many times does it work properly? Students can also evaluate the aesthetics of the card and its layout and marketability (how likely are they to buy this card?).

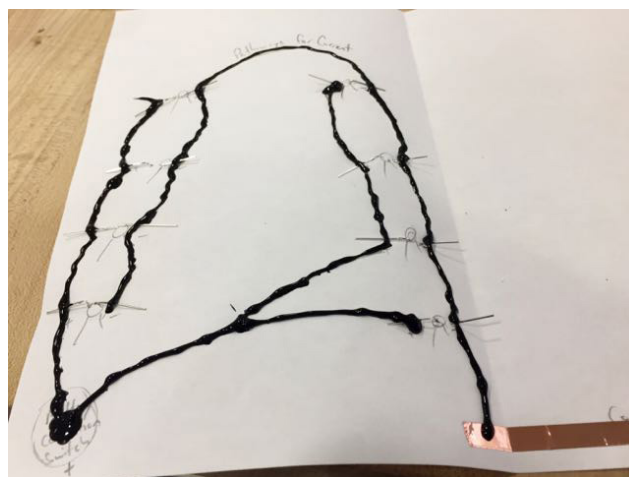
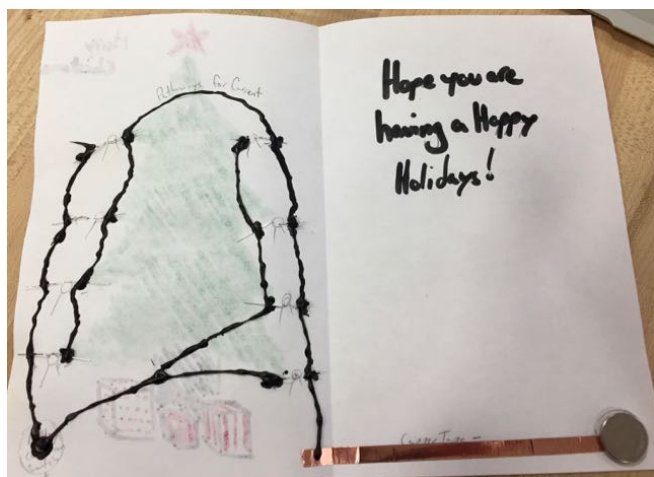
Evaluate: 30 minutes

Have students assess their greeting card with the rubric found on the “Engineering a Greeting Card” worksheet.

Create a class data set that includes information such as:

- Card design trends
- Number of cards using series vs. parallel circuits
- Number of LEDs illuminated

Students can then determine the longevity of their card. How many times can it be opened and still function, or how long will the lights stay on if the card is left open? Students should then graph the data to see if there are any trends in circuit design and longevity.



Taking It Further

Use software: Digital design software can be used to create the look of the card that utilizes a circuit in fun, meaningful ways. Recommended software: Inkscape, CorelDraw, GIMP, and so on.

Use hardware: Using microcontrollers, sensors, speakers, and so forth, students can design and build a card that is interactive—that plays music or blinks lights in a specific sequence based upon environmental stimuli.

Learn about this engineering in the real world: Batteries provide an excellent source of energy to smaller circuits by converting chemical potential into electrical energy flow. Batteries, however, have their environmental limitations. They are nonrenewable energy sources, losing their ability to produce electrical current as the chemical potential stabilizes. When they are disposed of improperly

in landfills, they release harmful chemicals into the groundwater system. Engineers are finding innovative ways to solve this problem. Previously, renewable energy sources like solar panels would have been too large and expensive to substitute for batteries. Engineers in South Korea are solving this problem as they create small flexible solar panels that can fit into any thickness of device. Follow this link to learn more about this device: engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/12683/Flexible-Solar-Cells-with-Flexible-Applications.aspx

Document your students' work through our social media outlet: #dreambigfilm

Dream Big: Engineering Our World is a film and educational project produced by MacGillivray Freeman Films in partnership with the American Society of Civil Engineers and presented by Bechtel Corporation. The centerpiece of the project is a film for IMAX and other giant screen theaters that takes viewers on a journey of discovery from the world's tallest building to a bridge higher than the clouds and a solar car race across Australia. For a complete suite of *Dream Big* hands-on activities, educational videos, and other materials to support engineering education, visit discover.org/dreambig. The *Dream Big* Educator Guide was developed by Discovery Place for the American Society of Civil Engineers. ©2017 American Society of Civil Engineers. All rights reserved. Next Generation Science Standards ("NGSS") is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and do not endorse it.

ENGINEERING A GREETING CARD

Name: _____

Problem to Be Solved

Design a greeting card that illuminates at least two LED lights by converting chemical energy to radiant energy when the card is opened.

Research and Gather Information

Dissect a greeting card, and draw a circuit diagram of its inner workings below. Label the actuators and energy sources within the circuit. Where is the controller within the card? How does it work?

Evaluate

Create a rubric to assess your design.

Criteria for this design challenge (fill in each row with a description of criterion that needed to be met)	Did your design meet the criterion for the challenge?	Why or why not?
Constraints for this design challenge	Did your design follow the constraint?	Why or why not?
Marketability of this design	What is marketable?	Why or why not?
What is the environmental impact of your device?		
What are the aesthetics of your device?		

DREAM BIG VIDEO SERIES WATCH INNOVATIVE ENGINEERS: OUR HIGH-TECH FUTURE

Engineers look for problems and try to solve them. See how Bechtel engineers, who have worked on megaprojects all around the world, use today's technologies—virtual and augmented reality, drones and massive interactive touch-screens—to collaborate, test big ideas, and create a world of innovations. Go to discovere.org/dreambig/media-assets and visit Educational Webisodes.

