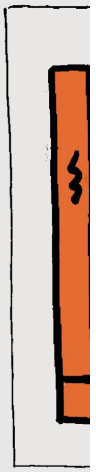
PAPER CIRCUITS

MIDDLE SCHOOL
LEVEL 2



Paper circuits are a cheap, easy way to learn about electrical circuitry. They are simple and easy to build on and make artistic. Your LEDs can be eyes for a bird, or twinkling stars in a night sky, or Carnival Lights for games and entertainment. Follow the directions to understand a paper circuit, plan your design, then start building. The below diagram will help you understand how to wire.

EDUCATIONAL STANDARDS:

NGSS CONNECTION:
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

COMMON CORE CONNECTION:
ELA/Literacy

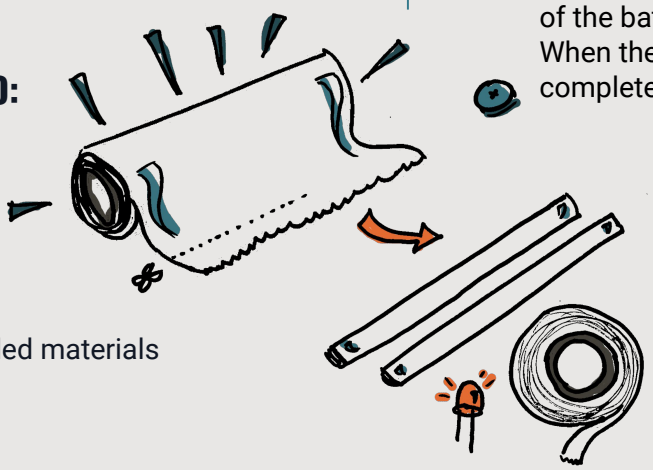
W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

DOK:
Level 3: Strategic Thinking
Level 4: Extended Thinking

MATERIALS NEEDED:

- ❑ Paper
- ❑ Aluminum foil
- ❑ Tape
- ❑ Coin battery
- ❑ LED
- ❑ Various upcycled materials



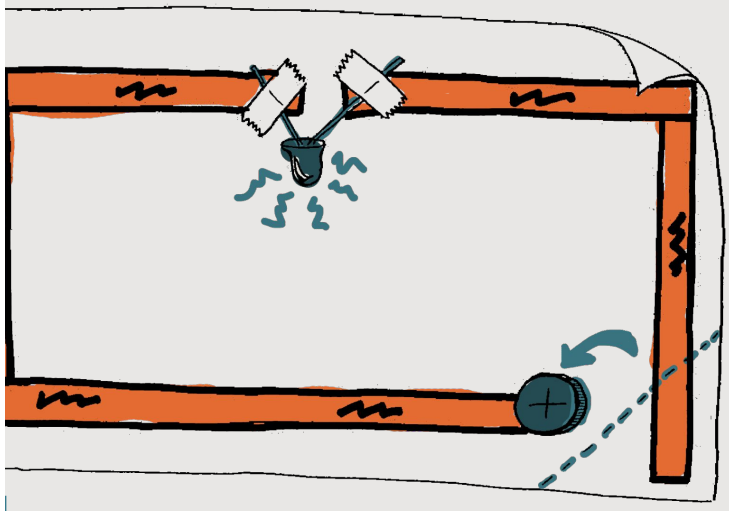
DIRECTIONS:

1. Aluminum foil is a conductor and will supply power from your battery to your LED. The grey circle on the diagram represents the paper corner that will fold over to complete the battery connection.

2. Run a strip of aluminum foil from the bottom of the battery to a terminal on the LED.

3. Run your other line of aluminum foil from the folding part of paper to the opposite LED lead. When folded, the foil will touch the top and bottom of the battery, completing your circuit and illuminating the bulb.

In your finished paper circuit, the battery sits on top of the aluminum foil, with another foil line running from the other side of the battery to the opposite LED terminal. When the page is folded over, the circuit is complete and the bulb lights up.



OBJECTIVE:

Students will be able to design and construct simple circuits. This can be used to illuminate carnival-themed toys and games should the school decide to hold a STEAM Carnival.

ESSENTIAL QUESTIONS:

- How might we use energy transfer in simple circuits to design and construct carnival-themed toys and games?

FUN FACTS

A. **Electricity travels at the speed of light—186,282 miles per second!**

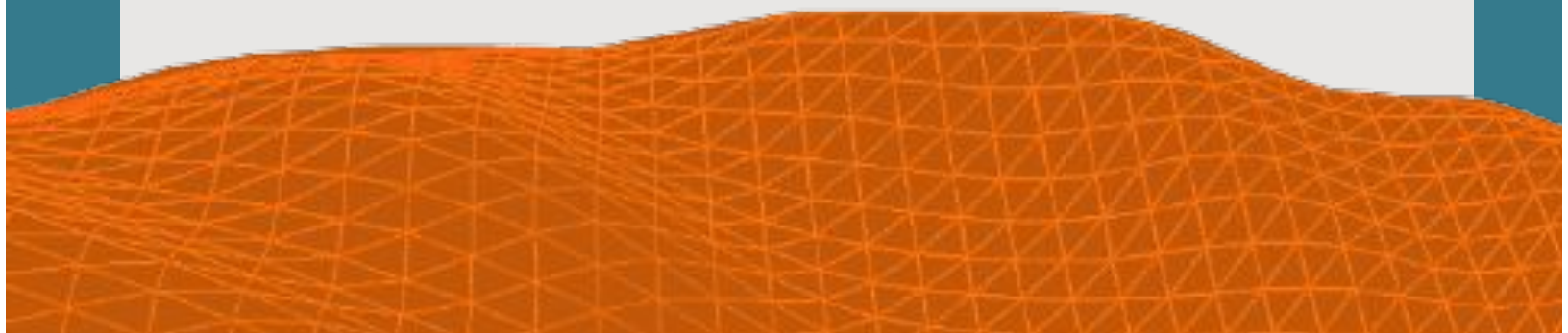
B. **Electricity plays an important role in the way your heart functions. A group of cells called the "sinoatrial node" creates electrical pulses which signal the heart to contract.**

ENGAGE / EXPLORE:

1. Introduction to the essential question.
2. How might we light up a LED (Light-Emitting Diode)?
    a. Students should be given the materials outlined.
    b. Opportunity and time to work in pairs/small groups to explore the way to make a LED illuminate.
3. How might we light up two LEDs?
    a. Ask students to assemble methods of illuminating two LEDs
        i. There are two ways (parallel and series)
        ii. Students do not have to know these names at this time but ought to recognize patterns in their foil patterns.
4. How might we light up 3 LEDs?
    a. Ask students to assemble methods of illuminating 3 LEDs
        i. This can be given as a requirement or optional extra credit based on student population.
        ii. 4 methods of assembly are possible.
5. How might we make one LED turn off and on?
    a. Ask students to assemble methods to make a light turn off and on
    b. Students are inventing ways to create a switch
        i. This language does not need to be used
        ii. However students may use academic language from prior knowledge.
6. Ask students to make observations of their circuits (can be done at each step or after finishing all circuits).
    a. Some facilitating questions to guide students observations
        i. What has to happen for the light to turn on?
        ii. Do you notice any differences in brightness of lights? When?
7. Evaluation criteria
    a. Observations of patterns in circuits.
    b. Problem solving and effort
    c. Reasoning

EXPLAIN:

1. Teacher asks students a series of investigational questions for students to discuss and respond to in small groups and whole group.
    a. Does the number of LEDs affect overall brightness?
        i. When, where, what, how, why?
        ii. What are the pros and cons of one pattern of assembly over another?
    b. Teacher should monitor student discussions
        i. Encourage creative thinking even if it may be wrong
        ii. Ask follow-up questions to clarify student ideas
            1. Students should be using academic language at this time from prior learning and/or new introduction of language by teacher
            2. Topics such as energy being transferred via electrons, energy being shared between LEDs, current flows.
        iii. Assign the simulator
            1. https://phet.colorado.edu/en/simulation/circuit-construction-kit-dc
                a. Students construct model circuits (similar patterns to the engage component)
                b. Play simulator and draw conclusions of energy transfer via electrons.
                c. Does the number of LEDs affect overall brightness?
                    i. When, where, what, how, why?
                    ii. What are the pros and cons of one pattern of assembly over another?



2. Teacher may use guided questions to clarify student responses, demonstrate and fix misconceptions on learning using demos and simulations.
3. It may be best if this is done alternating between whole group and small groups
    b. Small group
        i. Draw circuit in simulator
        ii. Write out observations in notebook or paper
    c. Whole group
        i. Share observations
        ii. Ask facilitating questions as class discussion

2. Evaluation criteria
    a. Ability to identify patterns and their cause and effects in circuits
    b. Problem solving and reasoning abilities
    c. Teamwork and discussion
        i. Identifying and questioning ideas of their peers
        ii. Honoring and respecting the ideas of other group members
    d. Use of academic language in expressing their ideas

ELABORATE:

1. Response to the essential question
    a. How might we use energy transfer in simple circuits to create and design carnival-themed toys and games?
    b. Students in pairs should be provided Two Bit Circus Foundation materials to create and design a simple toy or game that incorporates circuitry
        i. Ideas can include but are not limited to animal puppets, game buzzers, lights, eye masks, small prizes. (they may use buzzers, small speakers rather than lights or both!)
        ii. This can be left open-ended for students or confined by teacher discretion
    c. Students should be expected to create an opportunity for observation
        i. This could be done as presentation, gallery walk, class carnival, etc.
        ii. Explanation should include Intended purpose
        iii. How it works
            1. As toy or game
            2. The energy transfer in their circuitry
            3. Specifics of their circuits
    d. Students should have the opportunity to observe the work of their peers
        i. Select one project and observe it functioning (Could be done during gallery walk or class carnival)
        ii. Design a simple experiment to identify potential circuit types.
            1. Make observations of brightness, sound, heat in circuits
            2. Intended purpose based on design
        iii. Use their observations to draw a conclusion from evidence on the circuit design, energy transfer, and intended purpose
        iv. Students should compare their observations and conclusion with the designer.
2. Evaluation criteria
    a. Design of game/toy
        i. Functionality
        ii. Creativity
        iii. Durability
    b. Observations of a peer's project
    c. Explanation (Claim, Evidence, Reasoning) of energy transfers present in their project circuits.

PAPER CIRCUITS

STUDENT HANDOUT

NAME:_____

Number of Lights	Drawing of Circuit	Observations	What Would You Call this Circuit?
1 Light			
2 Lights			
2 Lights			
3 Lights			
3 Lights			
3 Lights			
3 Lights			
1 Light Off/On			

DIRECTIONS:

Use the table below after brainstorming to describe the Carnival Project that you will create.

Number of Lights:	
Circuit(s):	**Description of Purpose:**