Energy Explorations
LIGHT AND COLOR
Outline

Light and Color Station

Materials:

Incandescent light source
1 sheet red cardstock
1 sheet green cardstock
1 sheet white cardstock
Straws or pencils
Diffraction grating glasses (“rainbow glasses”)
Prism graphic
Rainbow graphic
Red film filters
Green film filters

I. Introductions

II. Review of Important Ideas

A. Visible light is a mixture of different colors or wavelengths of light. Red is the longest wavelength. Violet is the shortest wavelength.

- Visible or “white” light can be separated into its different colors by **refraction** such as using a prism to separate the light or water droplets refracting light to form a rainbow.
- Red light is refracted least, violet is refracted most.
- Visible or “white” light can also be separated into its different colors by **diffraction**.
- Diffraction occurs when waves move through small openings and spread out.

B. We see objects or materials based on which wavelengths of light they reflect and absorb.

- Black and white are not true colors of light.
- White objects reflect all wavelengths.
- Black objects absorb all wavelengths.

C. Colored filters allow specific wavelengths to pass through and absorb all others.

- Clear or transparent materials allow all wavelengths to pass through.
- Colored filters allow one wavelength to pass through and absorb all others.

III. Activities and Demos

A. Prism/Rainbow Graphics

- Discuss refraction of white light.
- Show graphics of prism, rainbow formation.

B. Rainbow Glasses - ***Distribute “rainbow” glasses and view white light source.***

- Diffraction gratings (“rainbow” glasses) separate white light into individual colors. This is called the visible light spectrum.

- Reinforce that each spectrum seen is always in the same order….from red (longest wavelength) to orange, yellow, green, blue, violet (shortest wavelength

C. Color cards – ***Place the three pieces of cardstock on the table and ask students to observe them. Remind them that they are observing them under the room lights (white lights).***

1. Red card absorbs all wavelengths except red. Red waves are reflected to our eyes. We see “red”.
2. White card reflects all wavelengths. We see all the waves mixed together as white light. We see “white”.
3. Green card absorbs all wavelengths except green. Green waves are reflected to our eyes. We see “green”.

D. Red filter- ***Distribute the red film filters which have been taped to pencils or straws. Have students observe the three cards through the red filter. Ask students what they observe.***

1. Red card reflects red waves only. The red waves pass through the filter. We see “red”.
2. White card reflects all waves. Only red waves are able to pass through the filter. The other waves are absorbed by the filter. We see “red”.
3. Green card reflects only green waves which cannot pass through the red filter. We see an absence of color or “black”.

E. Green filter - ***Distribute the green film filters which have been taped to pencils or straws. Have students observe the three cards through the green filter. Ask students what they observe.***

1. Red card reflects only red waves which cannot pass through the green filter. We see an absence of color or “black”.
2. White card reflects all waves. Only green waves are able to pass through the green filter. The other waves are absorbed by the filter. We see “green”.
3. Green card reflects green waves only. The green waves pass through the filter. We see “green”.

IV. Closing

A. Students return materials.
B. Fill in booklet or worksheet.
C. Farewells and reminders.
D. Straighten up and re-set station.

Question(s) in student booklet:

Visible light is a mixture of many wavelengths or ____**COLORS**____.

A red object reflects ____**RED**_____ wavelengths and ____**ABSORBS**____ all others.

Light and Refraction

Materials:

2 clear plastic cups
1 bottle of water
1 pencil
Convex lens (1 per student)
Simple picture or logo with printing (1 per student)
Large unruled index card or half sheet cardstock (1 per student)
1 clear incandescent light source

I. Introductions

II. Review of Important Ideas

A. Light travels through different media (air, water, glass, etc.) at different speeds. When light enters a different medium at an angle it is refracted or "bent".

B. Lenses are often used to refract light in useful ways.

- There are two basic shapes: convex and concave
- Convex lenses are the most useful type of lens.
- Convex lenses are in many optical devices (such as cameras, telescopes, our eyes).
- Convex lenses are thicker in the center than at the edges.

C. Convex lenses focus light to a point called the focal point.

- Objects closer than the focal point appear right-side-up and magnified.
- Objects beyond the focal point appear inverted (upside-down) and reversed.

D. Convex lenses can produce a real image.

- Real images are inverted and reversed and can be projected on a "screen".
- The film in a camera, the retina of our eye, the screen for a projector all act as a "screen" for the image to be projected onto.

III. Activities and Demos

A. Pencil in Cup Demo – ***Place the obviously straight pencil in the cup and fill halfway with water. Have students observe as you add the water.***

- The pencil appears to be bent or broken due to refraction of the light coming from the pencil to our eyes.
- The light is traveling through the water and then the air. When the light hits the air at an angle it changes direction slightly.
- Refraction is why things often appear differently when viewed in water or other transparent medium such as glass or plastic. (Ex: fish in aquarium, stick or fishing rod in water, etc.)

B. Lenses – ***Show convex lens to students. Discuss how convex lenses refract light in a useful way.***

- Name as many devices as possible that contain lenses. (camera, eyeglasses, microscope, telescope, projector, eyes, etc.) Encourage all students to contribute.

C. Convex lens – ***Distribute plastic hand lenses to students.***

- Use convex lens as magnifier. Students view picture/print close up.
- Use convex lens to find approximate focal point (where image appears blurred).
- Use convex lens to view objects at a distance. Be sure they see inverted, reversed image.

D. Viewing real image on "screen" – ***Distribute index card to each student. This will act as our "screen".***

- Use incandescent light bulb as object to demonstrate a real image on the card
- Students produce real image on their cards. If a window is available that works great. Other options: doorway to outside, room lights.

IV. Closing

A. Students return lenses and cards.
B. Fill in booklet or worksheet.
C. Farewells and reminders.
D. Straighten up and re-set station.

Question(s) in student booklet:

The bending of light as it passes from one medium into another is called**____REFRACTION____**.

A **____CONVEX____**lens is the most useful and is found in many optical devices.

Sound and Pitch Station

Materials:

1 Set of "Palm Pipes" (hollow PVC tubes)
Plastic rulers
Plastic leftover dishes
Pencils, unsharpened
Rubber bands (#33 size work well)
Wavelength/Frequency graphic
Palm Pipe Song graphic

I. Introductions

II. Review of Important Ideas

A. Sound energy travels in waves.

- Sound waves are produced when something vibrates and the vibrations travel through a medium such as air.
- All waves can be described by their wavelength and frequency.
- Wavelength is the distance between waves.
- Frequency is the number of vibrations per second.
- Wavelength and frequency are always inversely related. The longer the wavelength, the higher the frequency. In other words: As frequency increases, wavelength decreases.

B. Pitch is the term used to describe the frequency of sound waves.

- An object that vibrates fast has a high frequency and makes a high pitched sound.
- An object that vibrates slowly has a low frequency and makes a low pitched sound.

C. The pitch of a sound depends on what is vibrating. When we change something about what is vibrating, we can change the pitch of the sound it makes.

- Most musical instruments change the pitch of the sounds they make by changing the length, thickness, tension, or composition of what is vibrating.
- Many musical instruments have strings or columns of air that vibrate. The pitch is changed by changing the length of the strings or air columns.

III. Activities and Demos

A. Ruler Demo/Activity – ***Demonstrate and then have students try. Hold the ruler with about 2 inches hanging over the edge of the table. Place one hand firmly on the ruler at the table's edge and flick the end of the ruler to hear the sound. Gradually add an inch at a time to the length of ruler hanging over the edge of the table. Observe the sound difference as the length of the ruler increases.***

- The pitch will become lower as the length of the vibrating part of the ruler increases.
- As the vibrating part of the ruler becomes longer, the vibrations will become slower and more clearly visible.

B. Rubber Band/Dish Activity – ***Start out with the rubber band stretched around the longest part of the plastic dish with the pencil acting as the "bridge". Pluck the rubber band when the pencil is closest to the end of the dish, making the vibrating rubber band the longest possible. Observe the sound made. Give students the dishes and demonstrate how to gradually shorten the length of the vibrating rubber band by continuing to move the pencil.***

- The pitch will increase as the pencil shortens the length of the rubber band that is vibrating.
- Discuss how musical instruments such as guitars use this concept.

C. Palm Pipes Activity – ***Demonstrate by hitting one palm pipe in the palm of the hand.***

- This can be used as a musical instrument. It doesn't have strings. So what is vibrating? (the column of air inside the pipe)

Hand out the different palm pipes, one to each student. Have them take turns striking them on their palms.

- Observe and discuss how the pitch changes depending on the length.
- Shorter tubes produce higher pitched sounds
- Try organizing the students to "play" a simple song.
- Discuss how musical instruments such as flutes and chimes use this concept.

IV. Closing

A. Students return materials to the table.
B. Fill in booklet or worksheet.
C. Farewells and reminders.
D. Straighten up and re-set station.

Question(s) in student booklet:

The frequency of a sound wave is called its ____**PITCH**____.

As a string or air column gets shorter, its pitch becomes ____**HIGHER**____.

Sound Waves Station

Materials:

- 1 Slinky (metal)
- 2 Tuning forks (different frequencies)
- 1 Bottle of water
- 1 Plastic soup bowl
- Small paper or plastic cups (2 per student)
- Nylon or cotton string (3' per student)
- 1 Scissors
- 1 Tape
- Sturdy all-metal hanger (1 per student)
- Golf ball and ping-pong ball

I. Introductions

II. Review of Important Ideas

A. Sound is a form of mechanical energy. Sound is made when the particles of a substance vibrate and transfer their energy to particles nearby.

- The particles move back and forth. Energy is transferred but not the particles.
- Sound waves are made up of compressions (where the particles are close together) and rarefactions (where the particles are farther apart).

B. For sound to be made, two things are necessary:

1. Vibrations – Something must vibrate
2. Medium – Something the vibrations can move through (such as water, air, metal)

C. Different sounds are made depending on the properties of the object that is vibrating as well as the medium the waves are traveling through.

- The length, thickness, density, shape, and composition of an object determine the sound produced when the object vibrates
- The medium conducting the sound vibrations to our ears also determines the nature of the sound that we will hear.

D. Sound energy is transferred more efficiently through dense materials.

- We hear sounds better through solids and liquids than through air (a gas) because their molecules are more tightly packed (more dense).
- Solids, especially metals, make the best conductors of sound

III. Activities and Demos

A. Slinky Demo – ***Stretch the slinky out on the table with someone holding the other end still. Compress a few coils to show the sound energy being transferred through the slinky and back.***

- The coils of the slinky represent the medium that the sound energy might pass through.
- The energy is transferred to the other end but not the coils.
- The area where the coils are close together represents a compression.

B. Vocal Cords Demo – ***Demonstrate and direct students to place their fingers on the base of their throat and hum.***

- Everyone should feel the vibrations. What is felt are the vibrations made by our own vocal cords.
- When we talk we make sound energy by causing air to pass through the opening between our vocal cords. To make different sounds we control the tightness of these membranes.

C. Tuning Forks – ***Demonstrate the sounds made by two tuning forks of different frequencies.***

- Discuss the length of the tuning fork vs. the pitch of the sound
- The tuning fork is moving back and forth very fast. ***Have students look closely at the ends of the longer tuning fork***. It will look blurry indicating the mechanical energy or motion.
- ***Demonstrate the transfer of energy by touching the tuning fork to the water in a dish and a sheet of paper***. The water will splash and the paper will make a buzzing sound.

D. Ping-Pong Ball / Golf Ball Drop – ***Have students turn away or cover their eyes and drop the different balls on the table or floor. Students will identify which ball is being dropped by the unique sound that it makes.***

- Different objects vibrate differently and make unique sounds.
- Sounds made by a vibrating object depend on its composition, size, shape, and density.

E. Big Ben (hanger apparatus) Activity – ***(Demonstrate this first) Give each student a piece of string with cups taped securely to each end. Hang a metal clothes hanger on the string with the students holding the cups over their ears. Have them swing the hanger into nearby walls or chairs and listen.***

- The vibrations are much louder when heard through the string/cup device than through air.
- Sound vibrations travel best through solids, especially metals.

IV. Closing

A. Students return all materials to table.
B. Fill in booklet or worksheet.
C. Farewells and reminders.
D. Straighten up and re-set station.

Question(s) in student booklet:

What two things are necessary for sound to be made? **VIBRATIONS** and a **MEDIUM**

Sound vibrations travel best through **SOLID** materials.

Energy Explorations
STATES OF MATTER STATION
Outline

States of Matter Station

Materials:

States of matter cards
Plastic water bottles (with lids, small size)
Plastic beads (approx. ¼ c per bottle)
1 Water molecule model
Phase change arrow cards
Solid/Liquid/Gas particle graphic

I. Introductions

II. Review of Key Concepts

A. Before we begin looking at states of matter, we need to ask "What is Matter?"

- Matter is anything that takes up space and has mass. It is all around you.
- Matter can be found in different states, not like Ohio, but states like solids, liquids and gases. Air, water, and YOU are matter.
- All matter is made up of atoms, tiny particles. Like water is H_20, which is made up of hydrogen atoms and oxygen atoms – like this model. ***Demonstrate water molecule model.*** In fact, YOU are made of the 3 major states of matter:
    1. What are examples of solids in you? Bones, some organs
    2. What about liquids? Blood, water
    3. What about gases? Air in our lungs, gases in our stomach (air bubbles)

B. Each of the states of matter can change.

- Let's pretend you are a cube of ice sitting on the counter. What will happen to you if just hang out there on the counter? *Yes, you will melt.* Why? *You have taken heat energy from the air and reached your melting point and turn into a liquid.*

- Next, you take a trip to the stove and are now in a pan to become tea. How is that going to happen? *You are taking in lots and lots of energy from the stove and you are going to reach a certain temperature, the boiling point and turn into a gas!*

- How do I turn you back into a cube again??? *I have to take away lots of energy by removing heat energy.* First, let's turn you back into a liquid, that's the condensation point. To go back to a cube, I have to remove even more heat energy, so I'm putting you back in the freezer! You have reached the freezing point and are now a cube of ice again.

III. Activities and Demos

A. Bottle/Bead Activity ***- Let's review the three states of matter with bottles with beads representing atoms:***

- Solids – Atoms in a solid, like this table, vibrate in place but do not move past each other. Solids have definite shape and volume. ***Demonstrate and then have the students model how the atoms would be moving in a solid.***

- Liquids - How do we go from a solid to a liquid? *Yes, we have to add more heat energy. Those atoms will be moving around a lot more in your bottles.* Liquids take the shape of the container they are in. The atoms in a liquid move faster and slide past each other. ***Demonstrate and then have the students model how the atoms would be moving in a liquid.***

- Gases – How do we show a liquid becoming a gas? *We have to add a lot more heat energy.* Gases have no definite shape and no definite volume. They also take the shape of their container. They will spread out in all directions and fill as much space as they are given. ***Show me a gas with your bottles - your atoms are going CRAZY!***

B. Quick Quiz / Phase Change Activity

- ***Before beginning, explain that even in solids, like ice, the atoms have energy. The point at which the atoms have no energy at all, not even vibrational, is called absolute zero.***
- ***Hold up the states of matter cards plus the absolute zero card and have students use the bottles to demonstrate the motion of the particles. Get them really going by showing the words quickly so they have to act fast.***

C. Phase Change Vocabulary Puzzle

- ***Now, using those same states of matter cards, have students put the words FREEZING, MELTING, BOILING AND CONDENSATION showing what happens in each scenario between the states of matter word cards.***
    - Solid to liquid – melting
    - Liquid to a gas – boiling
    - Gas to a liquid – condensation
    - Liquid to a solid - freezing

IV. Closing

- Fill in leadership guide
- Straighten, re-set

Leadership Guide question:

Solid + heat energy = <u>LIQUID</u> + heat energy = <u>GAS</u>

Thermal Energy Station

Materials

1 Coffee cup (paper or ceramic)
1 Plastic cup
2 Arrows (cardstock)
2 Thermometers
Sample Insulators – Such as: carpet square, bubble wrap, fleece, potholder, weather stripping, cup of air, styrofoam
Sample Conductors – Such as: metal pan, tile, cup of water
Insulation Example graphics
2 Thermometers
Conductor / Insulator cards
1 Small roll of weather stripping (optional)
1 Pack of draft stoppers (outlet gaskets)

I. Introductions

II. Review of Important Ideas

A. Law of Thermodynamics

- On a cold winter day, what will happen to energy if you open the door of your home? Energy will flow from where it's warmer (inside) to colder (outside).
- The **Second Law of Thermodynamics** involves the direction of heat transfer. Heat energy always moves from an area of greater energy to lesser energy until equilibrium is achieved. In other words, heat moves from HOT to COLD until equal.

III. Activities and Demos

A. Beverage cup scenario

- If I take a cup of ice and let it sit on the table for a couple of hours what will I find when I return? The ice will have melted and the water will be room temperature. ***Show with the arrow the direction of heat transfer***. (From the outside air to the ice.)
- What if I set this cup of hot coffee on the table and return in a few hours? The coffee will be room temperature. ***Show with the arrow the direction of heat transfer***. (From the coffee to the surroundings.)

B. Tile versus Carpet – which one is cooler?

- I want one of you to put your hand on the tile and the carpet and tell me "which one is cooler". ***Choose one student to place one hand on the tile and the other hand on the carpet. Ask the student if the materials are the same temperature or if one is cooler than the other.***
- Haven't they both been in the same room all day? Isn't the temperature of this room about 72 degrees? Well, let's check our thermometers and see which one is actually cooler. ***Have a thermometer laying on both the carpet and the tile for students to view.***

- Whoa!! They are the same!! Why does the tile feel cooler? The tile feels cooler because heat is quickly being transferred from our hands, which are warmer, to the tile. The tile is still room temperature just like everything else in the room.
- What do we call something that transfers heat easily? **(*A conductor)*** The tile is an example of a conductor.
- What about the carpet? If the tile is a conductor, then what do you think the carpet is? Carpet feels the same because it has lots of air spaces and resists the transfer of heat so our hand does not transfer heat to the carpet rapidly like the tile. What do we call something that resists heat easily? **(*An insulator)*** The carpet is an example of an insulator.

C. More Insulators and Conductors ***- For each of the following items, I would like for you to move around the table and feel each one and ask yourself - does it feel cooler, or the same temperature?***

- Once the students have all had a turn to place their hand on each material, distribute the Conductor/Insulator cards and help them use the cards to label each material. ***Discuss: what do the insulators all have in common? (They all contain air pockets…)***
- Metal pan, water, tile – conductors
- Pot holder, bubble wrap, fleece, cup of air, cork or weather stripping – insulators
- **Which one is both a conductor and an insulator?** Pan with rubber handle (The pan conducts heat to the food but the handle insulates your hand from being burned.)

D. Practical Applications and Examples of Insulators in Nature – ***Use the picture graphics to facilitate a brief discussion.***

- Insulators in nature – Fur, Feathers, Blubber
- Insulators people use – Home insulation, Down coats and comforters
- Examples on hand – Draft stoppers (for electrical outlets), Weather stripping

IV. Closure

- Fill in leadership guide
- Straighten up, re- set

Leadership Guide Question:

Thermal energy (or heat) always flows from ______**HOT**______ to ______**COLD**______ until equal.

Energy Transformation Station

Materials

1 Set of energy equation cards
1 No-Battery Flashlight (dynamo)
1 Solar Toy
1 Pair of blaster balls
1 Clamp Light with 100w incandescent bulb
1 Toy car (battery operated)

I. Introductions

II. Review of important ideas

A. Law of Conservation of Energy

- Energy cannot be created or destroyed, it only changes form

B. Six forms of energy (cards)

- Energy can exist in many forms. We are going to recognize six forms today.
- To make our time together easier, we will abbreviate each form of energy with one letter:

E – electrical - energy of moving electrons
M – mechanical - energy of motion
N – nuclear - energy in the nucleus of an atom
R – radiant - electromagnetic energy that travels in waves
C – chemical - energy stored in the bonds of atoms and molecules
T – thermal (or heat) – the internal energy of an object

Optional:
S – sound (or acoustic-mechanical energy) - energy of vibrations transferred through a medium
L – light – one of the forms of radiant energy

III. Devices and Demos

A. No Battery Flashlight –mini generator of electricity

- Let's show the energy transformation with these cards. What energy goes into the device? *Mechanical*
- What energy comes out of the device, what do we use it for? *Radiant (Light)*
- Are any other forms of energy involved? Look closely. ***Point out the absence of a battery and that there is a small generator (spinning magnet, coil of wire) using the mechanical energy to produce electrical energy.***

- Let’s show our energy transformation by illustrating it with these cards. It will look like a simple equation:

M → E → R + T + S

B. Solar Toy

- Where does this toy get its energy? *The sun/light.*
- Let’s see what happens when we bring in the “sun.” ***Hold lamp to solar panel.***
- What is our energy transformation equation?

R → E → M + T

C. Blaster Balls

- What kind of potential energy is stored on the surface of these? *Chemical*
- When the balls strike together the friction causes a small combustion reaction. The energy is released in what forms? *Sound and Thermal*
- How should the energy equation look?

C + M → S + T (+R)

D. Toy car (motion, sound, light)

- Where does the car get its energy? *Batteries*
- What kind of potential energy is stored in batteries? *Chemical*
- The batteries transform the chemical energy into what type of energy? *Electrical*
- The car transforms the electrical energy into what forms? *Sound and Radiant and Mechanical (and they would be correct if they also say Heat or Thermal)*
- How should the energy equation look?

C → E → S + R + M

IV. Closing

A. Fill in booklet or worksheet
B. Farewells
C. Straighten up, re-set

Answer to questions in student booklet:

The Law of Conservation of Energy says, “Energy cannot be created or destroyed, it only changes **FORM**.”

Watts Up? Station

Materials:

Kill-A-Watt Meter
Power strip
Extension Cord
2 Bulb holders or lamps
1 Incandescent bulb
Fan
Hair dryer
IL Christmas Light Strand
LED Christmas Light Strand
1 CFL

I. Introductions

II. Review of Important Ideas

A. What is electricity and how do we measure it?

- Electrical energy is the flow of electrons. Electrical power is the rate at which electricity is transferred or used. To measure electric power we use watts.
- A kilowatt is 1,000 watts. It is used to measure larger amounts of electricity.
- Kilowatt-hours measure the electricity, or energy, that we use. Measuring electricity is confusing because we cannot see it. We use electricity to perform many tasks.
- A kilowatt-hour measures the amount of electricity used in one hour. We pay for the electricity we use in kilowatt-hours. Our power company sends us a bill for the number of kilowatt-hours we use every month.
- Does anyone know the abbreviation for kilowatt-hour? kWh Most residential customers in Ohio pay an average of eleven cents per kWh

B. Why is it important to know how many watts an appliance uses?

- The electric company charges us by the kilowatt-hours (1,000 watts) x hours.
- It is not just the power an appliance uses but time is also an important factor. The more kilowatts we use and the more time we use them, the more our electric bill will be.

III. Activity

A. Prediction
- Predict how you think the appliances will rank in their energy use, which will be measured in watts, with one being the lowest watts and six being the most watts. ***Allow discussion as a group.***

B. Measure
- Plug the appliances one at a time into the Watt-meter.

C. Record

- Have the students record the watt reading.
- Repeat until each student has had an opportunity to take a reading from the Watts up meter and all appliances have been recorded.

D. Process

- Did anyone get them all right? Were any of the appliances a surprise?
- Remember that any time you change the temperature of something; more energy is required (hair dryer requires more energy than the fan.) When heat is produced, more energy is consumed (the incandescent light bulb uses more energy than the compact fluorescent light bulb (CFL).
- What about the two strands of Christmas lights (IL vs. LED)? ***Possibly discuss how many strands of lights might be used by a typical home and how the savings could be multiplied…***
- What is one change you can make at home to save more energy?

IV. Closing

A. Fill in booklet or worksheet

B. Farewells

C. Straighten up, re-set

Answers to questions in student booklets:

APPLIANCE	PREDICTED RANK #1=Lowest Watts #6=Highest Watts	WATT-METER READING (watts)	ACTUAL RANK #1=Lowest Watts #6=Highest Watts
Incandescent Light Bulb			
Hairdryer			
LED Christmas Lights			
CFL			
Incandescent Christmas Lights			
Fan			

Electric Circuit Station

Materials:

1 switch	2 D batteries	1 piece wood	1 key
2 battery holders	4 wire leads	1 paper clip	1 plastic spoon
3 bulbs	2 bulb holders	1 coin	1 piece paper
1 "circuit" ball	1 piece foil	1 glass tile	Conductor/Insulator cards

I. Introductions

II. Review of Important Ideas

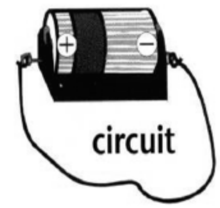
A. Electricity is simply moving electrons.
- Atoms are the building blocks of the universe. Electrons are tiny particles found in atoms.
- The center of an atom is called the nucleus, made of particles called protons and neutrons.
- Electrons are constantly spinning and moving in shells around the nucleus.

B. Circuits
- Electrons flowing through a wire make a complete path, called a circuit.
- A battery produces electricity – moving electrons – only when it is part of a circuit.
- A battery produces direct current (DC).
- Electricity flows from the negative to the positive terminal when it has a path of conductors.
- When a switch is open no electricity flows or makes a complete path.
- Different materials are "conductors" of electricity. Some materials do not conduct electricity.
- Circuits are often described as either series or parallel.

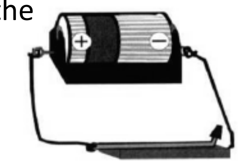
III. Activities

A. Circuit Ball
- Form a circle and hold the hand or wrist of the people beside you. Two people will put one finger on the metal electrodes of the circuit ball. The ball will light up and make a sound when everyone is touching.
- This represents a **closed circuit** - everyone is touching allowing a pathway for the electrons to flow.
- Two people release their hands – This represents a **switch**. The circuit ball will not light up or make sounds. This is an **open circuit**
- Allow different pairs of students to act as the switch by opening and closing the circuit. Explain that this represents a **series** circuit.
- Optional (if enough time and students) – Reach across the middle of the circle of students to demonstrate a **parallel** circuit by giving the electrons more than one path. Open and close a "human switch" on each separate part of the circuit.

B. Complete Circuit – Place a battery in the battery holder. Using one wire, attach the ends of the wire to the terminals on the sides of the battery holder. This is a circuit. *Only allow the wire to complete the circuit for a few seconds to avoid draining the battery.*



C. Circuit with Switch – Add a switch to this circuit. Close the circuit by pushing on the handle of the switch until it closes. This is a closed circuit. When we open the switch it is an open circuit. *Do not allow the switch to remain closed for more than a few seconds to avoid draining the battery.*


circuit with switch

D. Circuit with Load – Place a light bulb in the bulb holder. Using wire leads, add a bulb and holder to the circuit. This represents a "load" on the circuit. A load is considered anything that uses electricity and offers resistance. This is an example of a circuit such as in a lamp. When we turn the knob on a lamp we have an open switch, when we turn the knob again the light comes on, this is a great example of a closed circuit.


circuit with switch and load

E. Add a Battery – Add another battery and battery holder to the circuit. Be sure that the battery is aligned correctly with the negative terminal of the second battery attached to the positive terminal of the first battery. Close the switch to complete the circuit. *Do you notice anything different? The bulb will glow more brightly.*

F. Conductors of Electricity – Remove the switch from your circuit. Test the following eight materials (paper, coin, foil, wood, plastic, glass, key, paper clip) by replacing the switch and touching the two wire leads about one inch apart to each material in turn. If the material is a conductor of electricity it will complete the circuit and the bulb will light.
Use the cards to keep track of which materials are electrical conductors and which are electrical insulators. *Discuss what the conductors of electricity have in common. (They are all metals.)*
Also, point out that conductors and insulators of electricity and conductors and insulators of heat are different.

Conductors: *key, coin, foil, paper clip*
Insulators: *paper, wood, glass, plastic*

IV. Closing

A. Fill in booklet or worksheet
B. Farewells
C. Straighten up and re-set station

Question(s) in student booklet:

The flow of electrons is called ____**ELECTRICITY**______ .

Electrons flow through a wire making a complete path, called a ___**CIRCUIT**__________.

Developed by the Ohio Energy Project

Thermal Images Station

Materials

3-5 Thermal Imaging Cameras	1 LED (60w equiv.)
5 Pair of plastic safety glasses	1 Incandescent Light bulb 60w
Laminated photo samples	1 CFL (60w equiv.)
Laminated thermal image samples	1 Hand Warmer
3 Bulb stands	1 Pair Black Socks
1 Power strip	

I. Introductions

II. Review of Important Ideas

A. Electromagnetic Waves

- Infrared waves and visible light waves are both forms of electromagnetic radiation. Our eyes respond to visible light waves but not infrared waves.
- Other electromagnetic waves include radio waves, microwaves, ultraviolet, X-rays. Our eyes do not visually respond to these.
- Everything emits infrared radiation. The higher the temperature the more infrared is emitted.

B. Images or Photographs

- A visible light image (photo) is a record of visible light waves reflected or emitted by a subject.
- An infrared image (thermal image) is a record of infrared radiation reflected or emitted by a subject which has been made into a visible image. The infrared camera (our thermal imager) converts infrared energy emitted from a surface into the visible spectrum. Hence, it is visible to the human eye.

C. Uses of Thermal Imaging

- Briefly mention practical applications of thermal imaging such as:

Meteorology	*Military purposes such as detection and targeting*
Search and Rescue	*Detection of insulation issues and air leaks*
Monitor earth/oceans	*Detection of electrical and other construction problems*
Astronomy	*Medical diagnosis and detection*

III. Activities and Demos

A. Regular Photo vs Thermal Image

- Show and discuss the laminated photos and thermal images. Explain that the photo is a record of visible light reflected while the thermal image is a record of the infrared radiation or "heat" emitted and reflected.

B. Thermal Imager / Face

- Briefly demonstrate how to hold and use the thermal imaging camera

- Use the thermal imager to determine the thermal properties of a face (the high school leader or one of the student group)
- Discuss how the thermal image is different from what you see in a normal visible light setting
- Discuss: What part of the face is coldest? Hottest? Possible reasons….?

C. Protective Eyewear

- Students use the thermal imager to view the same face, now wearing plastic protective eyewear.
- What is observed? Compare how the eyes look with glasses to how they looked with no glasses. *The thermal energy (infrared radiation) is not able to pass through the thick plastic. The infrared rays are scattered or reflected by the plastic so the eyes do not appear as a higher temperature or "hotter" color. What you see with the thermal imager is the scattered and reflected thermal energy from the room.*

D. Thermal Handprint

- Students place their hand on the table for 5-10 seconds then remove the hand and use the thermal imager to scan the table where their hand was. *What do you see using the thermal imager? What happens to the thermal image over time?*
- Thermal energy was transferred from your hand to the table. This causes the table where your hand was to emanate more infrared radiation than the rest of the table. Over time the infrared energy will dissipate and the table will cool, giving off less thermal energy.

E. Heat Bulb vs Light Bulb

- Use the thermal imager to observe all three bulbs at the same time. Notice the temperature differences between the three different types of light bulbs, all 60w or equivalent: IL, CFL, LED. *Which bulb is the hottest, coolest?*
- Note that the majority of the incandescent light bulb's energy is transferred into thermal energy rather than light energy.
- All three bulbs emit the same amount of visible light (lumens) but the incandescent light bulb emits much of its energy in the infrared (heat) range. This makes it very inefficient.

F. Black Sock w/ Hand Warmer (Optional, if time)

- Place two black socks on the table (one with an activated hand warmer). Observe both socks in visible light. (They look the same)
- Observe both socks using the thermal imaging camera. (They look much different)
- Infrared waves have longer wavelengths than visible light waves. This enables the infrared radiation to pass through the socks while visible light waves cannot.

IV. Closure

- Fill in leadership guide
- Straighten up, re- set

Leadership Guide Question:

A thermal image is a record of the amount of _____________________________ an object emits or reflects.

(***Infrared energy or heat energy)***