# 6th Grade

Fall 2019 Lesson Plans

# Vanderbilt Student Volunteers for Science

http://studentorg.vanderbilt.edu/vsvs/

# VOLUNTEER INFORMATION

**Team Member Contact Information**

Name:________________________________________ Phone Number:_______________________

Name:________________________________________ Phone Number:_______________________

Name:________________________________________ Phone Number:_______________________

Name:________________________________________ Phone Number:_______________________

Name:________________________________________ Phone Number:_______________________

**Teacher/School Contact Information**

School Name: ___________________________________ Time in Classroom: ____________________

Teacher's Name: __________________________________ Phone Number: ______________________

# VSVS INFORMATION

## VSVS Educational Coordinator:

Paige Ellenberger 615-343-4379
paige.ellenberger@vanderbilt.edu **VSVS Office:** Stevenson 5234

| | | |
|---|---|---|
| **Co-Presidents:** | Eric Zhang | eric.zhang@vanderbilt.edu |
| | Vineet Desai | vineet.desai@vanderbilt.edu |
| **Secretaries:** | Gabriela Gallego | gabriela.l.gallego@vanderbilt.edu |
| | Emily Chuang | emily.a.chuang@vanderbilt.edu |

**Vanderbilt Protection of Minors Policy**: As required by the Protection of Minors Policy, VSVS will keep track of the attendance – who goes out when and where.
https://www4.vanderbilt.edu/riskmanagement/Policy_FINAL%20-%20risk%20management%20v2.pdf

## Before You Go:

- The lessons are online at: http://studentorg.vanderbilt.edu/vsvs/
- Email the teacher prior to the first lesson.
- Set a deadline time for your team. This means if a team member doesn't show up by this time, you will have to leave them behind to get to the school on time.
- Don't drop out from your group. If you have problems, email Paige or one of the co-presidents, and we will work to help you. Don't let down the kids or the group!
- If your group has any problems, let us know ASAP.

## Picking up the Kit:

- Kits are picked up and dropped off in the VSVS Lab, Stevenson Center 5234.
- The VSVS Lab is open 8:30am – 4:00pm (earlier if you need dry ice or liquid $N_2$).
- Assign at least one member of your team to pick up the kit each week.
- Kits should be picked up at least 30 minutes before your classroom time.
- If you are scheduled to teach at 8am, pick up the kit the day before.
- There are two 20 minute parking spots in the loading dock behind Stevenson Center. Please do not use the handicap spaces – you will get a ticket.

## While you're there – Just relax and have fun!

| September | | | | | | |
|---|---|---|---|---|---|---|
| SUN | MON | TUES | WED | THU | FRI | SAT |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 Team Leader Training 6-8 pm | 26 | 27 VSVS Day of Service 3-5pm | 28 |
| 29 Team Leader Training 6-8pm | 30 Team Training 5th &7th Grade (come during your normal lesson time) | | | | | |

# October

| SUN | MON | TUES | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | 1 Team Training 5th &7th Grade (come during your normal lesson time) | 2 Team Training 5th &7th Grade (come during your normal lesson time) | 3 Team Training 5th & 7th Grade (come during your normal lesson time) | 4 Team Training 5th &7th Grade (come during your normal lesson time) | 5 |
| 6 | 7 Team Training 6th & 8th Grade (come during your normal lesson time) | 8 Team Training 6th & 8th Grade (come during your normal lesson time) | 9 Team Training 6th & 8th Grade (come during your normal lesson time) | 10 Team Training 6th & 8th Grade (come during your normal lesson time) | 11 Team Training 6th & 8th Grade (come during your normal lesson time) | 12 |
| 13 | 14 Lessons, Week 1 | 15 Lessons, Week 1 | 16 Lessons, Week 1 | 17 Lessons, Week 1 | 18 | 19 Mega Microbe 9am-2pm |
| 20 | 21 Lessons, Week 2 | 22 Lessons, Week 2 | 23 Lessons, Week 2 | 24 Fall Break (lessons scheduled 10/24 will be moved to the week of 11/14) | 25 Fall Break | 26 |
| 27 | 28 Lessons, Week 3 | 29 Lessons, Week 3 | 30 Lessons, Week 3 | 31 Lessons, Week 3 | | |

# November

| SUN | MON | TUES | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|
| | | | | | 1 | 2 |
| 3 | 4 Lessons, Week 4 | 5 Lessons, Week 4 | 6 Lessons, Week 4 | 7 Lessons, Week 4 | 8 | 9 |
| 10 | 11 Veterans Day, Metro Schools Closed | 12 Make ups, Week 1 | 13 Make ups, Week 1 | 14 Make ups, Week 1 | 15 | 16 |
| 17 | 18 Make ups, Week 2 | 19 Make ups, Week 2 | 20 Make ups, Week 2 | 21 Make ups, Week 2 | 22 | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 | 30 |

## CLASSROOM ETIQUETTE

Follow Metro Schools' Dress Code!

- No miniskirts, shorts, or tank tops.
- Tuck in shirts if you can.
- Please dress appropriately.

Metro student standard attire guideline:
http://jtmoorems.mnps.org/pages/JohnTrotwoodMooreMiddle/About_Our_School/8998762518461552450/Dress_Code

## COLLEGE Q&A SESSION

VSVS members should be candid about their experiences and emphasize the role of hard work and a solid body of coursework in high school as a means to get to college.

- Email the teacher prior to the first lesson.
  - They may want to have the students write down questions prior to your lesson.
  - They may also want to have a role in facilitating the discussion.
- Finish the experiment of the day and open up the floor to the students.
- Remind them of your years and majors and ask if they have specific questions about college life.
- If they are shy, start by explaining things that are different in college.
  - Choosing your own schedule, dorm life, extracurricular activities, etc.
  - Emphasize the hardworking attitude.

The following are some sample questions (posed by students):

- When is bedtime in college? Does your mom still have to wake you up in college?
- How much does college cost?
- What do you eat in college and can you eat in class in college?
- How much homework do you have in college?

# DIRECTIONS TO SCHOOLS

**H.G. HILL MIDDLE SCHOOL: 150 DAVIDSON RD** **615-353-2020**
HG Hill School will be on the right across the railroad lines.

**HEAD MAGNET SCHOOL: 1830 JO JOHNSON AVE** **615-329-8160**
The parking lot on the left to the Johnston Ave.

**J.T. MOORE MIDDLE SCHOOL: 4425 GRANNY WHITE PIKE** **615-298-8095**
From Lone Oak, the parking lot is on the right, and the entrance into the school faces Lone Oak, but is closer to Granny White.

**MEIGS MIDDLE SCHOOL: 713 RAMSEY STREET** **615-271-3222**
Going down Ramsey Street, Meigs is on the left.

**ROSE PARK MAGNET SCHOOL: 1025 9$^{th}$ AVE SOUTH** **615-291-6405**
The school is located on the left and the parking is opposite the school, or behind it (preferred).

**WEST END MIDDLE SCHOOL: 3529 WEST END AVE** **615-298-8425**
Parking is beside the soccer field, or anywhere you can find a place. Enter through the side door.

**EAST NASHVILLE MAGNET MIDDLE SCHOOL: 2000 GREENWOOD AVE** **615-262-6670**

**MARGARET ALLEN MIDDLE SCHOOL: 500 SPENCE LN** **615- 291- 6385**

From West End down Broadway, take 1-40E to exit 212 Rundle Ave. Left on Elm Hill to Spence Lane.

**VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE**
**http://studentorg.vanderbilt.edu/vsvs**

# Potato Power

**Goal:** To learn about the energy conversion from chemical energy to electrical energy.
To understand how a battery is made.
Fits TN State Standards: 6.ESS3 6PS3.1

**Lesson Outline**

**I. Introduction**
Discuss different sources of electrical energy.

**II. Chemical Energy → Electrical Energy – Potato Battery Demonstration**
Use a potato clock to demonstrate that potatoes and 2 different electrodes can provide enough electrical current to run a digital clock. This current is produced by the difference in activity of the copper and zinc electrodes that are inserted in the potatoes. This provides an example of chemical energy being converted to electrical energy.

**III. Making a Battery**
Demonstrates how a wet cell battery produces electricity

**IV. Review**

**Students will work in groups of 3 or 4. There are 10 sets of materials, so divide the class into enough groups to use all the materials.**

**Fun Facts!**

1) Lightning is a potent example of electrical energy being discharged. Bolts can travel up to 130,000mph and can reach 30,000°C!
2) Electricity travels at the speed of light – more than 186,000 miles per second! If you traveled as fast as electricity, you could go around the world 8 times in the time it takes to turn on a light switch.
3) When you scuff your feet against carpet the electrons travel through your bloodstream and collect in your finger, where they form a spark between another conductor.
4) Electric eels can produce strong electric shocks for both self-defense and hunting.
5) Electricity can be made from wind, water, the sun, and even animal poop!

**Complete teacher/school information on first page of manual.**

1. Make sure the teacher knows the VSVS Director's (Paige Ellenberger) office number and email (in front of manual).
2. Exchange/agree on lesson dates and tell the teacher the lesson order (**any changes from the given schedule need to be given to Paige in writing (email)**).
3. Since this is your first visit to the class, take a few minutes to introduce yourselves. Mention you will be coming three more times to teach them a science lesson.
4. Do the experiment with the classroom, and leave 10 minutes at the end to discuss aspects of college life with them. Some topics that could be included are in the manual.
5. **While one team member starts the Introduction, another should write the following vocabulary words on the board:**
   **fossil fuels, turbine, generator, voltage, amperage,solar energy, wind energy, battery, LED**

**Materials**
1 potato "battery" clock
2 potatoes
10 green liquid battery holders with zinc and copper electrodes
10 containers of distilled water (we use DI water)
10 containers sodium bisulfate (containing mini spoon)
10 coffee stirrers
10 M6 meters
10 green snap wires
10 yellow snap wires
10 LED's (black, D6)
10 snap circuit digital clocks
16 instruction sheets
32 observation sheets

## Unpacking the Kit

**Part II. Chemical energy → Electrical energy**
1 potato "battery" clock
2 potatoes

**Part III. Making a Battery**
**Divide the class into 10 groups, and give each group a set of materials:**
**A. Experiment give to each group:**
- 1 green container outfitted with copper and zinc electrodes
- 1 M6 meter
- 2 connecting wires (1 yellow and 1 green)
- 1 container of sodium bisulfate powder plus mini spoon
- 1 bottle distilled water (we use DI water)
- 1 coffee stirrer

**B. What could this battery power do?**
**Give to each group:**
- 1 LED (black, D6)
- 1 snap circuit digital clock

## I. INTRODUCTION

### A. Sources of Electricity

Where does electricity come from?
Ask students if they can tell you some different ways that electrical energy can be generated.

1. **Power plants burn fossil fuels** such as coal, oil, and gas. The burning of these fuels is used to create heat to convert water into steam. The steam turns a turbine which acts to convert mechanical energy into electrical energy.
2. **Nuclear power plants** produce heat energy by splitting apart atoms such as uranium and plutonium. The heat energy is used in the same way as in Fossil fuel plants.
3. **Hydroelectric power plants** use the force of falling water to turn a water turbine which powers a generator.
4. **Solar**: The light of the sun can be used to convert light energy to electrical energy via solar panels made up of thousands of solar cells.
5. **Wind**: Wind turns large blades on a windmill to produce mechanical energy which drives an

Your Notes:

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electric generator.

6. **Batteries**: Batteries store energy and convert chemical energy to electrical energy: A battery is also known as an electrochemical cell.

**This lesson will demonstrate the use of a chemical battery as a source of electrical energy.**

## II. Chemical energy → Electrical energy: Potato Battery Demonstration

**Materials**

1 potato "battery" clock
2 potatoes

Hold the potato battery clock so that students can see that it is working. (If it's not working, make sure each potato has a copper and a zinc electrode inserted in it.)

- Ask students: What is causing the clock to run? *Some students might say a battery*.
- Ask students if they see a battery? *There is no traditional battery*.
- Show students the clock and point out the parts. Have them look at the picture of the clock on their instruction sheet. :
  - There are 4 metal probes, 2 zinc and 2 copper. These are called electrodes. Electrodes are electrical conductors that can carry a current. Point out the 2 different metals (zinc is silver-colored, copper is orangish).
  - The electrodes have wires attached to them. The wires carry the electric current.
  - The potato provides the acid (phosphoric acid) which reacts with the zinc electrode to produce excess electrons. There is no electricity in the potatoes.
  - The electrons flow from the zinc to the copper metal. The flow of electrons produces electricity.
  - The electricity powers the digital clock.
- Tell the students that the digital clock needs 2 potatoes and 2 sets of electrodes to make it work well:
  - Pull one of the metal electrodes out of one potato to show that this causes the clock to stop working (the circuit is broken).
  - Put the 2 electrodes connected to the clock into 1 potato – the clock may work faintly, or not at all. 1 set of electrodes does not produce enough electricity to power the clock.
- Tell the students that the digital clock will also work with fruits such as apples, oranges, lemons, and limes.
- Ask the students to decide which energy they believe the chemical energy was converted to. Answer: ***Electrical Energy***

**For VSVS Information Only:** Although the chemistry is too advanced for middle school students, this is an oxidation-reduction reaction in which the zinc metal is being oxidized, the phosphoric acid solution in the potatoes is acting as the electrolyte, water is being reduced around the zinc electrode to give hydrogen gas (very small amounts which aren't visible), and the potato matter is serving as a membrane for ion flow between the electrodes

Your Notes:

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## III. Making a Battery

Tell students that they are going to make a **wet cell**. It is similar to the one first created by Alessando Volta in 1880.

**Divide the class into 10 groups, and give each group a set of materials:**

- 1 green container outfitted with copper and zinc electrodes
- 1 M6 meter
- 3 connecting wires (1 yellow and 1 green)
- 1 container of sodium bisulfate powder plus mini spoon
- 2 bottle distilled water (we use DI water)
- 1 stirrer

Give each student an observation sheet


Explain that the M6 meter can measure both voltage and current. Point out the 3 different settings and tell students to turn the switch to the left, for the 5V setting.

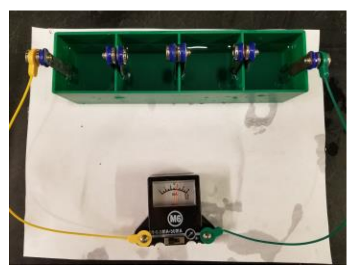
The voltage measurement (V) tells you how much pressure is present to move the electrons being pushed through the circuit.

The electric current measurement (A or mA) tells you how much electricity is flowing through the wires each second.

### A. Experiment:

Tell students to fill each compartment of the green container with DI water (about 1/2 full).

Tell them that the green container is now a liquid battery, with zinc and copper electrodes. Help students identify the **copper (orange colored) and zinc (silver colored)** electrodes. Point out the arrangement of the electrodes – the metals alternate.



1. Orient the green container so that the zinc electrode is on the left and the copper electrode is on the right.
2. Place the M6 meter below the green container. Tell students to follow the diagrams to connect the cables, meters, and green container.
3. Connect the green jumper cable from the RHS (+) terminal of the M6 meter, to the RHS of the container (the end that has the orange-colored copper electrode) and the yellow jumper cable from the LHS (-) terminal of the M6 meter to the lighter zinc electrode on the LHS end of the green container.
4. Make sure the black switch on the M6 meter is to the **left** for the **5V setting**, and then measure and record the voltage.
   Since the liquid used is distilled water, there should be **little to no voltage recorded**. **Distilled water** does not contain ions and thus does not conduct electrical currents.
5. Tell students to add 2 scoops of the sodium bisulfate powder to each compartment. Stir with a coffee stirrer. Students should see the voltage increasing as the sodium bisulfate is added and stirred.
6. Record the voltage. **The voltage should read around 3V**
7. Now change the green jumper cable from the right end of the green box to the copper electrode at the end of the 1st compartment and measure the voltage (0.75V)

Your Notes:

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8. Repeat by changing the green jumper cable from right end of the green box to the copper electrode at the end of the 2nd and then 3rd compartments. Record the voltage for both arrangements (1.5V and 2.3V).

**Discussion**:
Ask students what arrangement gave the highest voltage?
How did the voltage change with fewer compartments?
Each compartment produces about 0.75V. The 4 compartments are connected in series, so the voltages add together.

## B. What could this battery power do?

Is this battery strong enough to make a digital clock run, as did the potatoes in the potato clock apparatus?

Remove the jumper wire snaps from the meter and set the meter aside. Leave the wires attached to the battery tank.
Place the LED in front of the battery tank so that the arrow is pointing from right to left (words are upside down). Snap the leads into the LED, connecting the green jumper cable to the positive end and the yellow jumper cable to the negative end.

Does the LED light? Repeat the steps 7 and 8 above to find out how many compartments in the battery tank are needed to make the LED glow. (At least 2 are needed).
Replace the LED with the digital clock and check to see how many compartments are required to make it work.
Tell students that both these devices require very little voltage to work.

Note: but not all LED's will light up.

## Household Batteries.

Tell students: The most common household battery is a dry cell battery:

It has 2 electrodes, zinc and carbon. Zinc likes to give up its electrons.
The electrolyte is ammonium chloride or zinc chloride.
Electrolytes move or conduct an electric current.

An alkaline battery has manganese dioxide and zinc powder as the electrodes and potassium hydroxide as the electrolyte.

**Ask: What kind of battery have we produced (nuclear, biofuel, or chemical)?**

**Clean – up: Empty green boxes into the sink, making sure the electrodes do not fall out. Collect all snap circuit pieces, sodium bisulfate powder, coffee stirrers and mini spoons and return them to the kit.**

Lesson written by Pat Tellinghuisen, VSVS Program Coordinator, 1998-2018, Vanderbilt University
References: Snap Circuit Green Chemistry Manual.

Your Notes:

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**Potato Power Observation sheet**
**Name____________________**

Circle the correct answers:

1. What color are the copper electrodes orange silver
2. What color are the zinc electrodes orange silver
3. What kind of energy was the chemical energy in the clock converted to?
   : electrical mechanical light

4. Add 2 scoops of sodium bisulfate to each compartment and stir with a coffee stirrer. Measure and record the voltage from 4 compartments, then 1, 2, and 3.

**Voltage Measurements**:

| **Voltage measurement from 4 compartments using distilled water** | **Voltage measurement from 4 compartments after sodium bisulfate added.** | **Voltage measurement from 1 compartment** | **Voltage measurement from 2 compartments** | **Voltage measurement from 3 compartments** |
|---|---|---|---|---|
| | | | | |

5. What arrangement gave the highest voltage? ________________

6. How many compartments does it take to light up the LED? ________________

7. How many compartments does it take to make the clock work? _____________

**Potato Power Observation Sheet - Answers**
**Name____________________**

Circle the correct answers:

1. What color are the copper electrodes *orange*
2. What color are the zinc electrodes *silver*
3. What kind of energy was the chemical energy in the clock converted to? *electrical*

4. Add 2 scoops of sodium bisulfate to each compartment and stir with a coffee stirrer. Measure and record the voltage from 4 compartments, then 1, 2, and 3.

**Voltage Measurements**:

| **Voltage measurement from 4 compartments using distilled water** | **Voltage measurement from 4 compartments after sodium bisulfate added.** | **Voltage measurement from 1 compartment** | **Voltage measurement from 2 compartments** | **Voltage measurement from 3 compartments** |
|---|---|---|---|---|
| *0 or very small* | *About 3V* | *0.75V* | *1.5V* | *2.3V* |

5. What arrangement gave the highest voltage? *4 compartments*

6. How many compartments does it take to light up the LED? *At least 2*

7. How many compartments does it take to make the clock work? *At least 2*

**VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE**

# Conduction, Convection and Radiation

Goal: **To introduce students to conduction, convection and radiation.**
**TN Curriculum Alignment*:* 6PS34.4**

VSVSer Lesson Outline

**______1. Introduction – What is Temperature? What is Heat?**
Students discuss the difference between temperature and heat.

**______2. Introducing Liquid Crystal Thermometers**
Liquid crystal sensors are introduced.
**A. Experiment**. **Students observe the color changes when they put their fingers on the sensor.**
B. **How Do Liquid Crystals work?**

**______3. How is Energy Transferred?**
Tell students they are going to "see" conduction, convection and radiation by using the liquid crystal sensors.

**______A. Radiation:** A liquid crystal sensor is exposed to a lamp and/or sunlight and the color changes noted.

**______B. Convection:** A heat pack is activated and a liquid crystal sensor held above it and the color changes noted.

**______C. Conduction:**
1. Students visualize conduction in copper, iron and wood strips, using a heat pack as the heat source.
2. Students observe that ice melts faster on one of two black squares.
3. Students measure the temperatures of 3 materials, using liquid crystal temperature strips, and discover that it is the same for all. VSVS members put a piece of ice on the 3 materials. Students will observe that the ice on the aluminum melts faster than on the wood or Styrofoam.

**______D. Results and Discussion**
Students conclude that the aluminum metal square is a good conductor and that the Styrofoam would be a good insulator.

**LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM**
**https://studentorg.vanderbilt.edu/vsvs/lessons/**
**USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.**

**1. Before the lesson:**
**In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.**

1. Why is hot water warmer than cold water? Be sure to mention how energy is involved.
2. List what form of heat transfer each of these examples is:
   Rays of the sun hitting you, microwaves heating your frozen dinner, sand feeling hot under your feet…..
3. You hold an ice cube in your hand. Explain why your hand feels cold and the ice cube melts.

4. Different materials have different conductivities. If you wanted to go into space, what would you make your space suit out of? What material would you definitely not use in your spacesuit?

**2. During the Lesson:**
**Here are some Fun Facts**

- When sunrays hit an object, more rays will be absorbed by darker colors than lighter ones. As a result, they are better at absorbing radiation. This is why black pavement is so hot during the summer.
- People actually build computers in fish tanks filled with water to keep them cool
- Earthquakes are actually caused by convection! The hot mantle in Earth has many convection currents that move the Earth's crust in separate plates.
- Conduction works better in metals than other solid materials because metal atoms are more "flexible" and can more easily transfer heat energy from one molecule to the next. That's why your metal pots and pans have wooden or plastic handles. The heat can very easily move from the bottom of the pan to the handle if it was all metal.

## Unpacking the Kit – What you will need for each section:

VSVSers do this while 1 person is giving the Introduction. Note that students are put into **10 groups (or 3 per group)**

Write the following vocabulary words on the board:

**Temperature, heat, liquid crystals, conduction, convection, radiation**

### For Part 2. Introducing Liquid Crystal Thermometers

10 liquid crystal sensors, 25-30$^{o}$ C. 1 per group of 3

### For Part 3. How is Energy Transferred?

**A. Radiation:** 1 work light, 1 large laminated liquid crystal sensor, 30-35$^{o}$ C, 1 infrared thermometer

**B. Convection:** 10 white foam board rectangles, 10 heat packs (recyclable) plus 10 liquid crystal sensors from Part 2

**C. Conduction:**

a. **Experiment 1 - Visualizing Conduction**

10 thermal conductivity foam blocks with a strip of copper, iron and wood attached, plus 10 liquid crystal sensors from Part 2

b. **Experiment 2. Observing ice melt on 2 black squares**

10 sets of 2 identical looking black squares (1 is aluminum and the other plastic), Ice, 10 paper towels

c. **Experiment 3. Ice melting on 3 different materials**

10 plastic bags containing: 1 aluminum metal square, 1 styrofoam square, 1 wood square, 1 Thermometer strips, 10 foam board rectangles (students should already have), Ice

### 1. What is Temperature? What is Heat?

**Learning Goal:** Students understand that adding heat energy to a medium causes an increase in temperature

**Your Notes:**

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Ask students: what is temperature?

Temperature is the scientific measure of how hot or cold something is.
It is measured with a thermometer.
It is a measure of the average kinetic energy of the molecules in a substance.

- Hot tea has more average kinetic energy than ice tea. The temperature of hot tea is higher than ice tea.

Ask students: what happens when we add ice to hot tea?

- The ice melts – its temperature becomes warmer. Energy from the hot tea is transferred to the ice cube. This transfer of energy is called **heat.** Thus the temperature of the ice tea is cooler since kinetic energy is lost during the transfer

## 2. Introducing Liquid Crystal Temperature Sensors

**Learning Goal:** Students identify different tools that can be used to measure the transfer of energy

- Ask students if they have ever seen anything that changes color with temperature?
  Answers may include mood rings, strip thermometers.

Hand out a laminated liquid crystal temperature sensor to each group of students.
Tell students that they will be using these to visualize temperature changes and how heat flows.

**Note:** The temperature of the classroom determines which sensor is more effective. The laminated sensor changes color between 25-30$^{o}$ C. The sensors attached to the metal strips used in Part 3C of the lesson sense changes between 30-35$^{o}$ C. The sensors should be black at the lowest temperature they measure, so if the classroom temperature is above 25$^{o}$C, it will have already turned green or red-orange without being touched.

Give the students the following rules for using the sensors:

1. The sensor must not be placed in the sun or near a heat source such as room heater, computer, hot drinks etc, since this will skew the results of the experiments.
2. Always hold the strips using the clear laminated part (show students how to do this).
3. Do NOT touch the liquid crystal unless instructed to do so.

### A. Experiment

1. Tell students to look at the liquid crystal sensor and note the temperatures written on the colored tab. Explain that different sensors have different temperature ranges.
2. Tell students to hold the liquid crystal temperature sensor by the clear plastic part. Tell students to note the color of the sensor. Turn the sensor over and note that it is covered with white paper.
3. Tell students place the sensor on the white foam pad, black side facing up.
4. Tell one student in each pair to place the pad of a fingertip on the liquid crystal sensor for 15 seconds and then remove it. Record what happens, and note the pattern of colors produced. Some observations will include:
   - the color of the sensor changes.
   - color changes spread out from the center of the finger and changes color as it spreads.

**Your Notes:**

5. Ask students:
   - What color is in the center of the finger print? At the outer edge? What color fades first? Last?
   - What color indicates the coolest temperature? – Black
   - What color indicates the warmest temperature? – Blue
   - What is the order of temperature colors from cooler to warmer? Black, yellow, red, green, blue.

**Explanation:** Blue represents the warmest area because that was the area in direct contact with the finger. The surrounding area's colors were not directly touched by the fingertips, but were produced as a result of **conduction** of heat through the crystal.

6. Place the strip back on the desk top and watch it return to room temperature.

## B. How do Liquid Crystals work?

**Information for VSVS team** – use it if you feel the class can grasp the topics. (This information is from NanoDays Exploring Materials – Liquid Crystals.)
**The way a material behaves on the macroscale is affected by its structure on the nanoscale.** Changes to a material's molecular structure are too small to see directly, but we can sometimes observe corresponding changes in a material's properties. The liquid crystals change color as a result of nanoscale shifts in the arrangement of their molecules.

**Nanotechnology** takes advantage of special properties at the nanoscale to create new materials and devices. Liquid crystals are used in cell phone displays, laptop computer screens, and strip thermometers. They're also being used to create nanosensors—tiny, super-sensitive devices that react to changes in their environment.

1. Liquid crystals represent a phase in between liquid and solid. The molecules can move independently, as in a liquid, but remain somewhat organized, as in a crystal (solid).
2. The liquid crystals are *thermotropic*, which means that they respond to changes in temperature by changing color. As the temperature increases, the color of the liquid crystal changes from red to orange, yellow, green, blue, and purple.
3. The liquid crystals are made of mixtures of long, thin molecules stacked in rotating layers, like a spiral staircase (helix).
4. When light strikes a liquid crystal, some of the light is reflected. The color of the reflected light depends on how tightly twisted the helix is.
5. More tightly twisted helixes reflect wavelengths on the blue end of the spectrum.
6. More loosely twisted helixes reflect wavelengths on the red end.
7. As the temperature of the liquid crystal changes, the spacing of the helix changes. This changes the wavelength of light that is reflected and the color that you see.

- Explain to students that liquid crystals are sensitive to temperature, and will change colors according to the temperature of the crystal. Black is the coolest color. (Note: it only appears black because of the black background glued onto the back side of the sensor. The lowest temperature is actually clear!) Changes are from red to orange, yellow, green, blue, and purple.

  Liquid crystals are used in displays for cell phones, laptop computers, and other electronics.
- Where does the thermal energy come from to change the liquid crystal color?
  Answer: your skin temperature is about 10 degrees C higher than room temperature. When you touch something at room temperature, heat flows from your fingers into the object.
- Where does the energy go when the color changes back to its colder temperature?
  Answer: it is transferred to the desk or Styrofoam pad, which is at room temperature. Heat flows from the warmer sensor to the colder desk.

**Your Notes:**

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### 3. How is Energy Transferred?

**Learning Goals:**

- Students explain that energy is transferred through a solid during conduction, a liquid/gas during convection, and any medium during radiation.
- Students identify different tools that can be used to measure the transfer of energy

- Thermal energy is transferred by heat.
- Heat always flows from a hotter object to one that is cooler. In this case, your body is warmer than room temperature and heat flows from your finger to the sensor.
- Ask students if they know the different ways thermal energy is transferred?
  Energy can be transferred by conduction, convection, or radiation.
- Tell students we are going to "see" conduction, convection and radiation by using the liquid crystal sensors.

## A. Radiation

- Radiation is the transfer of energy by electromagnetic waves, such as light, UV, Infrared, X-Rays.
- Ask students if they can name some sources that transfer heat by radiation?
  *The sun, a fire, bar heater, incandescent light bulb ….*
- Radiation is a method of heat transfer that does not rely upon any contact between the heat source and the heated object. Radiation can even be transferred through space where there is a vacuum (where there are no particles in air to carry heat). We can feel heat from the sun even though we are not touching it, AND there is no air in space.

**Note:** Make sure that the large crystal sensor being used in this demonstration has been kept out of sunlight and has not been exposed to heat. The color needs to be black before starting.

**Demonstration - Visualizing Radiation**

- A VSVS member holds the large liquid crystal sensor up so that all students can see it. Note the color.
- Hold the lamp in a vertical position, turn it on and hold the large sensor vertically, about 5 inches away.
- Wait for a few minutes until the sensor changes color, then remove the light and let students observe the changes.

**Demonstration: Visualizing Sun Radiation** (if the sun is shining into the classroom)

Now hold the sensor in the sunlight and note the color changes.
Point out that there is no contact between the lamp and the sensor.
Other experiments with the sensor and sunlight are at the end of this lesson and can be done if there is time, after convection and conduction experiments are finished.

**Demonstration: Infrared Thermometer**

The IR thermometer uses a sensor to measure the surface temperature of an object.

- To use the thermometer press (do not hold down) the "Meas" button while the sensor is pointed at a surface.
- Hold the sensor in place while the thermometer takes a reading.

**Your Notes:**

- Use this thermometer to measure the surface temperature of the lamp.
- Compare the temperature of the light bulb to the temperatures of various surfaces around the classroom. You should find that objects directly exposed to light have significantly higher surface temperatures than objects that receive less light.

## B. Convection

- Convection is the transfer of thermal energy by the movement of liquids or gases.
- Ask students if they can name some sources that transfer heat by convection?
  Heating water, fans, hot air balloons…

### Experiment – Visualizing Convection

- Show students how to activate the hot pack and place it on the white foam board.
- Tell students to hold their hands above it to feel the transfer of heat through convection through the air. Hold a hand to the side and below it. The air will feel warmer above the hot pack.
- Hold the liquid crystal sensor (by the clear plastic part) about 10 cm above the heat pack and note the color changes
  **Explanation:** When the heat pack warms up it begins to warm the air next to it (through conduction). The warm air molecules move more quickly, which forces them to spread out. This causes the air to become less dense, so the warmer air rises. The sensor changes color.

> **Note:** Do not spend too much time in discussions. The heat pack needs to be used with the next experiment while it is still hot.

## C. Conduction

> **Learning Goal: Students use evidence to demonstrate that metal is a better conductor than wood**

- Conduction is the transfer of thermal energy between objects that are **touching.** Thermal conduction is slow – it moves from one side of an object to the other.
- Remind students that they have already "seen" conduction when they put a finger on the sensor.
- Tell students that some materials are better conductors than others.
  Ask students if they can name a good thermal conductor and poor thermal conductor?
  Metals are usually good conductors (which is why most cooking pots are made of metal.

### Experiment 1 - Visualizing Conduction

- Hand out the thermal conductivity boards. Explain that the 3 different materials have been covered with a liquid crystal sensor, mounted on a Styrofoam board and covered with plastic.
- Ask students if they can identify the 3 different materials? (They are copper, wood and iron.)
- Tell students to place the heat pack on top of **the bottom edges** of the 3 exposed prongs, being careful to keep the heat pack from contacting the sensor.
- Watch the liquid crystal change colors (or not). Students will need to wait a few minutes before they see any changes.
- Ask students to describe what they see.

**Your Notes:**

Answers should include: The color change starts nearest the heat pad.
The color change travels up the materials.
The rate that the color change travels is different for the 3 materials.
Therefore heat is travelling up the materials at different rates.

- Which material had the fastest changing temperature sensor? **Copper**
- Which material had the slowest changing temperature sensor? **Wood**
- Ask students which material is the best conductor of heat? **Copper**
- Tell students that copper and iron are both good conductors of heat and have high thermal conductivity. Wood is a poor conductor and has a low thermal conductivity.
- Tell students to remove the sensor and watch which metal loses energy faster.
  The sensor on the copper strip returns to its original color faster.
- Collect the liquid crystal sensors, heat packs and thermal conducting blocks.

## Experiment 2. Observing ice melt on 2 black squares

Materials

10 sets of 2 identical looking black squares (1 is aluminum and the other plastic), Ice

> Important: do not tell the students that the identical-looking black blocks are actually made of different materials. They will be asked to come to that conclusion after the experiment.

- Distribute the pairs of black blocks at student's tables so that all can see the next experiment.
- Do not explain that the 2 blocks are made from different materials.
- Place some ice in the middle of each block and tell students to watch what happens.
- Ask students if they can explain this. Tell them that it has something to do with **conduction of heat**. Do not spend more than a few minutes on discussion.

## Experiment 3. Ice melting on 3 different materials

Materials

10 plastic bags containing:

1 aluminum metal square, 1 styrofoam square, 1 wood square, 1 Thermometer strips

10 foam board rectangles (students should already have)

- Pass out the plastic bags containing the wood, styrofoam and metal squares and thermometer strips to groups. Spread the materials on the long piece of foam board.
- Tell the students they must not touch the blocks being handed out until they are told.
- Tell the students to:
  1. Briefly place a palm on top of each block (for no more than 1 second).
  2. Decide, as a group, and put the blocks in order from coolest to warmest.
  3. Report the order to VSVS members who will record the results on the board.
     Results may vary, but make sure that students in each group all agree which one feels colder (the aluminum square should feel coldest, the foam board will feel warmer, and the wood may be in between, but definitely warmer than the aluminum ).
  4. Set aside the squares so that they can return to room temperature (ie. do not touch while the next demonstration is done.)
- Show the students the strip thermometer and the degree markings (in F and C) on it. Explain that the thermometer strips are made of the same liquid crystal material, with a temperature scale added.

## Your Notes:

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- Note the temperature where the **dark blue** color is.
  Explain that this is room temperature, and all measurements will be compared to this number. Explain that these thermometers are not highly accurate but are good enough measure changes in temperature.
- Tell them to place a thermometer strip in the middle of the wood block and record its temperature. Repeat with the Styrofoam and metal blocks.
- Ask students if the temperatures of the blocks are different?
  There should be no significant difference within a group. Temperature readings will differ from one group to another.
- Ask students what they think will happen to ice if it is placed on the blocks?
  Will the ice melt faster on one?
  Tell students to place a small piece of ice in the middle of each block and to record the results. The ice on the metal will melt in just a few seconds.
  Wipe the ice off the metal block and measure its temperature again.
  The temperature will have dropped significantly.
- Ask the students why the ice on the metal melted faster?
  Since the metal is a good conductor, it transfers heat from it to the ice faster than the other 2 materials.
- Based on these results, what materials are the 2 black squares made from?

## 4. Results and Discussion

| Learning Goal: Students use evidence to demonstrate that metal is a better conductor than wood |
|---|

- Ask students why the metal square felt cooler than the others, when the actual temperature is the same? *The square that felt colder is CONDUCTING heat away from your hand so it is actually your hand that is cooling. Your hand is not a thermometer!*
- Ask students which object is the best conductor? *This metal square is the best conductor.*
- Ask students which object would be a good insulator? *Styrofoam.*

**Clean-up:** Place all materials back in kit. Wipe off wet surfaces.
Discard leftover ice at the school if possible. Return kit immediately to SC 5233

**Radiation extension:**
A VSVS member can cast a shadow on the sensor by blocking the radiation reaching half the sensor with a book.
Students will see that the sun's radiation does not travel through the book.
Ask students how this could relate to weather on a cloudy day? (Clouds prevent or block radiation.)
The sensor can also be held at an angle to the lamp's or sun's rays rather that facing it directly, and note the sensor warms up slower.
Ask students how this can relate to the seasons. *As Earth orbits the sun, its tilted axis always points in the same direction. So, throughout the year, different parts of Earth get the sun's direct rays.*
Lesson written by:
Pat Tellinghuisen, VSVS Director and Faculty Advisor, Vanderbilt University

**Your Notes:**

Conduction, Convection and Radiation Observation Sheet

## 2. Introducing Liquid Crystal Temperature Sensors

Record what happens when you put your finger on the liquid crystal sensor. Note the pattern of colors produced.

______________________________________________________________________

Circle the color indicating the coolest temperature

Black Red Orange Yellow Green Blue Purple

Circle the color indicating the warmest temperature

Black Red Orange Yellow Green Blue Purple

## 3. How is Energy Transferred?

**A. Radiation**

What color does the sensor change to when the lamp is shone on to it? ________________

What does this show?__________________________________________________________

**B. Convection**

What color does the sensor change to when it is held above the heat pack? _____________

What does this show?__________________________________________________________

**C. Conduction**

**1. Using the Thermal Conductivity boards**

Circle the material that had the fastest changing temperature sensor. Copper iron wood

Circle the material had the slowest changing temperature sensor. Copper iron wood

Circle the material that is the best conductor of heat. Copper iron wood

**1. Ice melting on the 2 black squares.**

What do you observe? _______________________________________________

**2. Ice melting on 3 different materials**

Which block feels the coldest? __________________________________________

Which block feels the warmest?__________________________________________

What are the temperatures of the 3 blocks?_______________________________

Which block melts ice the fastest? _______________________________________

What do you think the black squares (in #2 above) are made of?

____________________________________________________________________

# Conduction, Convection and Radiation Answer Sheet

## 2. Introducing Liquid Crystal Temperature Sensors

Record what happens when you put your fingers on the liquid crystal sensor. Note the pattern of colors produced.

*color changes spread out from the center of the finger (blue/green) and changes color as it spreads*

What color indicates the coolest temperature? *Black*

What color indicates the warmest temperature? *Blue*

## 3. How is Energy Transferred?

### A. Radiation

What color does the sensor change to when the lamp is shone on to it? *From black to yellow/red/green/blue*
What does this show? *Heat is being transferred from the lamp to the sensor via electromagnetic radiation*

### B. Convection

What color does the sensor change to when it is held above the heat pack? *From black to yellow/red/green/blue*
What does this show? *Thermal energy is being transferred from the heat pack to the sensor by convection currents.*

### C. Conduction

**1. Using the Thermal Conductivity boards**

Which material had the fastest changing temperature sensor? *Copper (orange metal)*

Which material had the slowest changing temperature sensor? *Wood*

Which material is the best conductor of heat? *Copper*

**1. Ice melting on the 2 black squares.**
What do you observe? *Ice melts very fast on one of the blocks, and does not melt on the other. Both blocks look the same. One is heavier to hold.*

**2. Ice melting on 3 different materials**
Which block feels the coldest? *Aluminum (silver colored)*

What are the temperatures of the 3 blocks? *The temperatures of the 3 blocks are nearly the same within each group. The thermometers are not accurate and can differ from one group to another.*
Which block melts ice the fastest? *The aluminum metal.*

What do you think the black squares (in C2 above) are made of? *One is aluminum and the other is a material similar to Styrofoam.*

**VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE**
**http://studentorg.vanderbilt.edu/vsvs**

# Deep Ocean Currents

**Goal:** To teach students about deep ocean currents by allowing them to visualize and understand how and why the currents form.
To introduce students to convection in liquids .
Fits Tennessee standards 6.ESS2.1, 6.ESS2.2

**VSVSer** **Lesson Outline:**
________ **I. Introduction to Ocean Currents**
________ **II. Density Background Information:**
a. Demonstration – students will observe that a liquid with lower density (oil) will float on water.
_______ **III A. Saltwater in the Ocean:**
a. The VSVS team will share some information about oceans with the students.
b. Saltwater demonstration: Students will add colored salt water to one side of a partitioned rectangular container and fresh water to the other side. Plugs in the partition will be removed and students will watch the flow of water. Pepper will be added to the surface of the water on both sides and students will observe the circulation.
**B. Cold Water in the Ocean**
Students will observe the flow of cold water into warm water.
________ **IV. Where Are The Deep Ocean Currents?**
a. Students look at a map of deep ocean currents.
________ **V. Review**

**LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM**
**https://studentorg.vanderbilt.edu/vsvs/lessons/**
**USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.**

## 1. Before the lesson:

**In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.**

Deep Ocean Currents & Air Convection Currents Lesson Quiz

1) Which ocean current is driven by the temperature and density of the water? (Deep vs surface)
2) Which is denser? Pure water or salt water?
3) Why does the sea contain so much salt, but lakes, streams, and rivers do not have much salt at all?
4) True or False? With time, the seas have gotten less salty.
5) Why was pepper used in one of the experiments?
6) Where does deep water formation occur?
7) True or False? When ocean water freezes into icebergs and ice sheets, the ice is made up of water with no salt.
8) Which is denser? Cold water or warm water?

## 2. During the Lesson:

**Here are some Fun Facts**

- A. well-known density-driven current occurs where the saltier Mediterranean Sea empties into the Atlantic Ocean. During World War II submarines used this current to enter and leave the Mediterranean without even turning on their engines http://sciencehowstuffworks.com/

- If the salt in all of the earth's seas could be removed and spread evenly over the Earth's surface, it would form a layer more than 500 feet thick – that's about as tall as 2.5 Batman buildings (in Nashville)!
- The oceans move 1.4 trillion cubic kilometers of water each day!
- Radioactive tritium is used to trace the world's currents because it is easily detected and it travels at the same speed as the water carrying it.
- It takes a minimum of 500 years and up to 1,000 years for the oceans' water to cycle itself globally.

## <u>Unpacking the Kit– What you will need for each section:</u>
## Divide the class into 10 groups (of 3).

### For Part II. Density Background Information and Demonstrations
10 oil/salt water bottles (1 per 3-4 students)

### For Part III. Movement of Saltwater in the Ocean
10 containers of salt, 10 spoons, 10 rectangular containers, 10 16oz/500 mL bottles water
20 16oz cups with marked water level [~250mL]
2 blue food coloring dropper bottles
1 pair plastic gloves (for VSVS members to wear when using food coloring)
2 pepper container
10 oval plates

### For Part IIIB. Cold Water in the Ocean
20 2oz jars with holes in lids
2 16oz styrofoam cups containing ice
2 L water
Food Coloring from Part III
10 plastic plates
10 Clear plastic squares
**<u>Set-up:</u>**
**<u>VSVSers will put 2 drops of blue food coloring in 10 of the jars and then pack with ice.</u>**
**<u>(*Just before the students do this experiment, VSVSers will pour room temperature water into all containers so they are FULL.*)</u>**

### For Part IV. Where Are The Deep Ocean Currents?
32 World Maps with Ocean Salinity

### I. Introduction to Ocean Currents

| **Learning Goals: Students understand the two types of ocean currents** |
|---|

**Why is the science in this lesson important?**
The movement of deep ocean currents are partly responsible for global temperatures, as they cycle cold water to different areas of the globe. Changes in deep ocean currents due to climate change can alter ecosystems around the world.

**Ask students if they know the names of the 2 types of ocean currents?**
Ocean currents are divided into 2 types - **surface** and **deep**.

Your Notes:
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**Surface currents** are driven by the wind blowing over the ocean, the earth's rotation, and large land masses.

Surface currents occur at the surface of the ocean.

They are only about 400m (1300ft) deep (occur in the top 400m of the ocean).

*That's about that the height of two Batman Buildings! (192m (630.5ft ))*

**Deep ocean currents** are driven by the temperature and density of the water.

Sometimes they are called submarine rivers.

90% of the ocean water is moved by deep ocean currents.

Ocean water becomes denser when it is colder and has more salt dissolved in it.

Tell students they will investigate the behavior of dense salt water, which is similar to that found in the deep ocean waters AND the behavior of cold water compared with room temperature water

## II. Density Background Information

**Learning Goals: Students observe how manipulations of mass and volume affect density.**

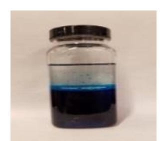
- Ask the students if they know what density is. Tell them that they can think of density as how much mass there is in a given fixed volume. A good example would be the different densities of a golf ball and ping pong ball. They have the same volume but different mass.

### A. Density of Liquids - Demonstration

**Learning Goals: Students investigate solutions with different densities and find that a lower density solution layers on top of a solution with higher density.**

**Materials**

10 oil/salt water bottles (1 per 3-4 students)



Pass out the oil/salt water bottles. Tell students that the water was colored blue to make the layers easier to see.

Share that density is a **property** of solids, liquids, and gases.

- Ask students: what do you notice? *There are two separate layers, the saltwater is on the bottom and the oil is on the too*
- Ask students: why do you think the two liquids layer? *Saltwater is more dense than oil, so the oil floats on top of the saltwater*.

Write these facts on the board:

Pure water has a density of $1 g/cm^3$.

Ocean water at the sea surface has a density of about $1.027 g/cm^3$.

Oil has a density of $0.83 g/cm^3$ (depends on type of oil – we used baby oil).

**Tell students that a liquid with low density will float on top of a liquid with a high density.**

## III. Saltwater in the Ocean

**Learning Goals: Students understand and observe how density drives deep ocean currents.**

**Why does ocean water have a higher salinity?**

- Ocean water is saltier than fresh water.
- Ask students why they think the sea contains so much salt but lakes, streams, and rivers do not have much at all.

Your Notes:

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- The salt in the ocean comes from the gradual process of weathering and erosion of the Earth’s crust, as well as the wearing down of mountains.
  - Rain and streams then transport the salt to the sea.
- Some salts may have come from volcanic emissions when earth was being formed.
- Some salts also come from the magma at the mid-ocean ridges.
- As time has passed, the seas have actually gotten saltier. Evaporation of water from the ocean leaves salts in the ocean while weathering continues to add salts.

**What kind of salts are in the ocean?**

- Seawater is actually very complex and contains salts made up of combinations of at least 72 elements, most in very small amounts. Salts of sodium, chloride, magnesium, sulfate and calcium are the most abundant.

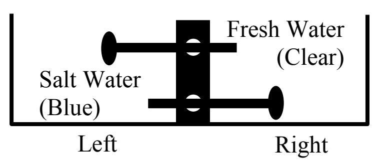
**Divide the class into 10 groups (of 3).**

Tell students they will make their own salt water and observe what happens when it “meets” fresh water.

Pass out the following materials to each group:

1 16oz bottle water
2 16 oz cups marked at the 250ml level
1 2 oz container of salt
1 spoon
1 plastic container with divider in middle and holes punched at bottom & top with plugs (aka nails) inserted
1 oval plate

1. Tell students to add water to ONE of the cups and add 3 full spoons of salt to it. Set this cup aside until the VSVS member comes to your table.
2. A VSVS member will add a squirt of blue food coloring to the SAME salted water cup until the solution is **dark blue**. **This is your salt water cup.**
3. Now add water to the second cup to the 250 mL mark. **This is the freshwater cup.**
4. Make sure the students understand the differences between the 2 waters. *The salt water (blue) is denser than the “fresh” water (clear).*
5. **VSVS members:** Draw a sketch of the container with the divider on the board. Tell students they will be adding the salt water to the LEFT side and fresh water to the right side **BUT NOT YET!** (point out that the sides of the container are labeled & make sure they have it turned the correct way)




6. Ask the students to predict what will happen when the 2 waters are added and plugs are removed.
   Accept all answers and write them on the board. Students may not have the correct answer at this time! **Do not correct them.**
7. Have one student per group be responsible for the salt water and another responsible for the fresh water. Tell these students to pour their water solutions into the correct sides **AT THE SAME TIME**

Your Notes:

______________________________________________

______________________________________________

______________________________________________

**Check that the water level on both sides is above the top nail. If it is not, add water so that the level is above the nails. Do not proceed until this is done.**

8. Tell the students that they are going to be removing the plugs and that they ALL need to be ready to observe the water from the sides of the container once the plugs have been removed.
   Have one student be in charge of the top plug on the salt water side and another student in charge of the bottom plug on the fresh water side.
   Tell them they will remove both plugs on the count of 3. **Count to 3 loudly, so everyone can hear.**
9. Have VSVS members go to each group to sprinkle pepper on the top of the water on BOTH sides. Once this is done, the students should also observe the water from the top.
   **The other VSVS members should be circulating the room helping students.**
10. Students should make their observations through of the sides and from the top of the container for about 5 minutes and record their observations on their observation sheet. Students may need to have their eyes at the level of the lowest nail to see what is going on.

11. Ask students what happens to the salt water.
    *It moves through the bottom hole underneath the clear fresh water.*

12. Ask the students what happens to the fresh water.
    *It moves through the upper hole and layers on top of the blue salt water.*

13. Ask the students what they noticed when the pepper was added.
    *The pepper/water on the right (originally just clear water) seemed not to move much, but the pepper/water on the left side (originally blue salt water) is moving away from the hole and is circling around that side.*

**Explain to the students they have just created currents, similar to those in the ocean. The blue salt water is more dense than the fresh water, so it acts like the colder, saltier water of the ocean while the fresh water acts like the warmer, less salty water of the ocean. Deep ocean currents are formed when denser water sinks/flows beneath less dense water, which in turn flows on top of the denser water, as they observed in their experiment.**

You can also mention that when the pepper water hits the side of the container and circles around the left side, the effect is similar to that of water hitting large landmass – one of the causes of surface currents.

Set aside the model – the students can refer to it as they look at the map of ocean currents. They will observe the model again before the end of class to see that there are 2 distinct layers that do not seem to be mixing.

## IIIB. Movement of Cold Water in the Ocean

**Learning Goals:** Students understand and observe how temperature drives deep ocean currents.

Your Notes:

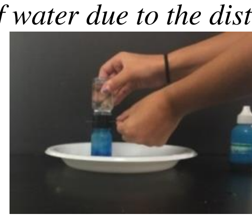
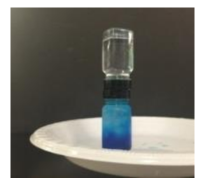
**Materials**
20  2oz jars with holes in lids
Ice
Water
Food Coloring
Plates
Plastic squares

## Set-up:

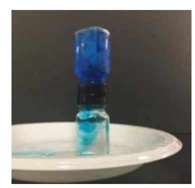
VSVSers will have already put 2 drops of blue food coloring in 10 of the jars packed with ice.
Now pour room temperature water into all containers so they are FULL.
Tell students that the blued water tells them that the water is COLD.

# Students must do the following in this order:

1. Take one bottle of cold and one of room temperature. Place the plastic square on top of the ROOM TEMPERATURE bottle. Hold the square securely to keep water from pouring out, turn it upside down and place on top of a bottle of blue cold water. Once in place, have one member of the group (or VSVSer) hold the 2 bottles securely and slide the plastic square out. Observe what happens. *Not much! There may be some initial movement of water due to the disturbance created when the plastic is removed*.

2. Separate the 2 bottles (a little water will spill, so keep on the plate. “Top” up the bottles with water if needed. (It is important to have both bottles full to the top.)

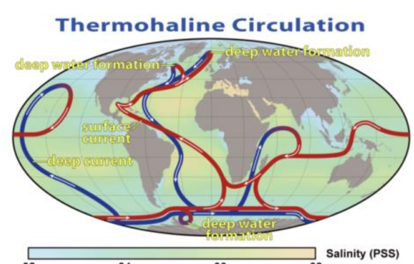


*3*. Place the plastic square on top of the COLD bottle, turn it upside down and place on top of the room temperature water bottle. Once in place, have one member of the group (or VSVSer if needed) hold the bottles securely and slide the plastic square out. Observe what happens. *The cold water will flow, and continue to flow, into the bottom warmer bottle*.

**Explanation:** Cold water is denser than warm water and so will sink to the bottom. Warm water will rise up through cold water. Cold water will sink below warmer water.

## IV. Where Are The Deep Ocean Currents?

Tell students to look at the map of ocean currents (pass this out if you haven’t already).
Have the students notice where **deep water formation** occurs (*3 areas in the Arctic & Antarctic)*.



Robert Simmon, NASA
http://earthobservatory.nasa.gov/Features/Paleoclimatology_Evidence/paleoclimatology_evidence_2.php

**Explanation:**

- The biggest source of deep water is highly saline surface water from the Gulf Stream in the North Atlantic. This water is cooled by the polar air and sinks to the bottom. It flows south to Antarctica.

Your Notes:

______________________________________________

______________________________________________

______________________________________________

- The densest water is in the Weddell Sea of Antarctica. It forms in the southern winter when sea ice forms, leaving more salt in the water below the ice. This water sinks to the bottom of the ocean and flows north.

- The average temp of **surface** sea water is 17.5 ºC (63.5 ºF). 75% of **all** ocean water has a temperature of between 0 ºC (32 ºF) and 5 ºC (41 ºF). So most of the water that fills the oceans is much colder than surface water.

- When ocean water freezes into icebergs and ice sheets, the ice is made of pure water with no salt. That salt is left in the water, so the ocean becomes saltier and denser. (This can be related to the marble demonstration - if all of the salt remained but a few marbles were removed, (became ice) then there would be more salt per marble).

- Have them trace the paths of the current with their fingers, following the arrows. Start at the northern-most point. Tell students that the entire trip for the current to return to its starting point can take over 1000 years!

- Have students look at where the water appears to warm up (blue changes to red). *This happens in warm areas of the world, near Hawaii and off the coast of Africa*.When the blue line turns red, the water has become less dense by warming up and/or becoming less salty, and hence rises above the denser water.

Have students look once more at their water experiment to notice the layering effect of the salt water and fresh water. Explain to them that these layers will remain separated for several hours

## V. Review

- Ask students why saltwater is more dense than freshwater? *For the same volume of saltwater and freshwater, saltwater is more dense because it has a higher mass*.
- Ask students: What can we say about cold water versus warm water?
  *Cold water sinks*.
  *Warm water rises*.

Lesson written by: Patricia Tellinghuisen, Program Coordinator of VSVS 1998-2018, Vanderbilt University
Courtney Luckabaugh, VSVS Lab Assistant, Undergraduate, Vanderbilt University

Your Notes:

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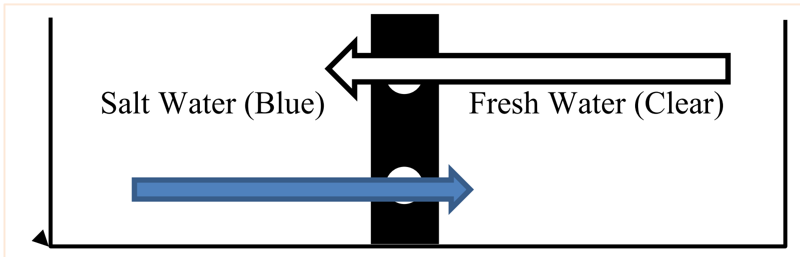
# Deep Ocean Currents Answer Sheet

Name ______________________________

1. **Draw arrows on the diagram below showing the movement of the blue salt water and the clear fresh water.**

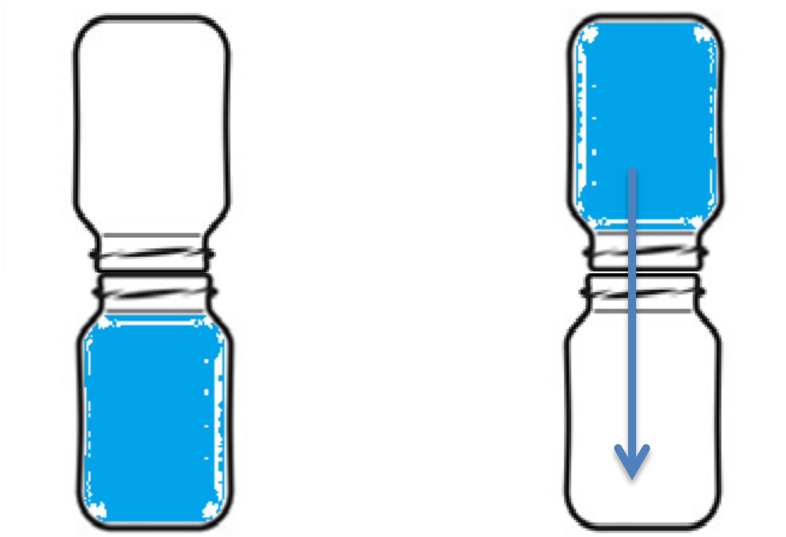



What happens to the salt water? *Moves through the bottom hole and stays below the fresh water*

What happens to the fresh water? *Moves through the top hole and stays above the salt water*

What happens to the pepper? *The pepper/water on the right (originally just clear water) does not move much, but the pepper/water on the left side (originally blue salt water) moves away from the hole and is circling around on that side.*

2. **Draw arrows on the diagram to show the movement of blue cold water and the clear room temperature water.**



**Look at the map of ocean currents to answer the following questions.**

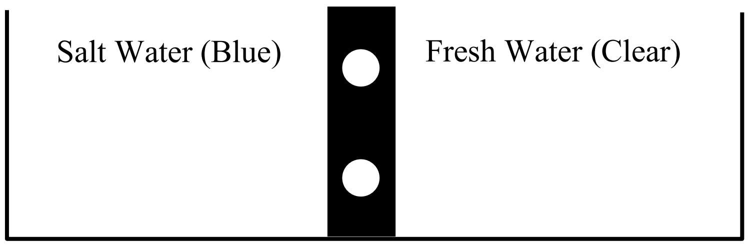
In what parts of the Earth does deep water formation occur? *3 areas in the Arctic & Antarctic*

Why does deep water formation occur in these regions? *Cold temperatures and salty water.*

# Deep Ocean Currents Observation Sheet

Name ______________________________

1. **Draw arrows on the diagram below showing the movement of the blue salt water and the clear fresh water.**




What happens to the salt water? ______________________________________________

What happens to the fresh water? ____________________________________________

What happens to the pepper? _________________________________________________

2. **Draw arrows on the diagram to show the movement of blue cold water and the clear room temperature water.**



3. **Look at the map of ocean currents to answer the following questions.**

In what parts of the Earth does deep water formation occur? _______________________

Why does deep water formation occur in these regions? ___________________________

Your Notes:

_______________________________________________________________________________

_______________________________________________________________________________

_______________________________________________________________________________

**VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE**

# Electrical Circuits

## Series and Parallel Circuits

(Adapted from Student Guide for Electric Snap Circuits by Elenco Electronic Inc.)

Acknowledgement: We want to thank NASA and the Tennessee Space Consortium for funds to purchase the electric circuit kits.

**Goal:** To learn about series and parallel circuits and their properties through the use of Elenco Snap Circuit™ kits.

Fits Tennessee standards 6.PS3.1, 6.ESS3.1, 6.ESS3.2, 6.ESS3.3

**VSVSer Lesson Outline**

________ **I. Introduction**
Discuss electric circuits (series and parallel circuits) and write the vocabulary on the board. Discuss electrical energy conversions illustrated by a hand generator.
Show students the Energy stick and how to complete a "human circuit".

________ **II. Activity – Making a Simple Circuit**
Students work in pairs and build a simple circuit.

________ **III. Activity– Using a Switch**
Students place a switch in the circuit in part II.

________ **IV. Activity – Measuring Current**
Students test the simple circuit with a meter. Students replace the bulb with an LED and observe that it uses less current.

________ **V. Activity – Building Series and Parallel Circuits**
One pair of students in the group builds a series circuit while the other pair builds a parallel circuit. Then they compare brightness of bulbs and current measurements to see what happens when one light is unscrewed in each circuit. After they have finished, students review series and parallel circuits.

________ **VI. Optional -** 2 pairs of students make parallel circuits using more than 2 light bulbs, with the meter in the circuit. Students unscrew a bulb, one at a time and record current measurements. Students understand the need to conserve electrical energy.

_________**VII Discussion**
Review the results of the lesson and the vocabulary words.

**LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM**
**https://studentorg.vanderbilt.edu/vsvs/lessons/**
**USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.**

## Unpacking the Kit – What you will need for each section::

VSVSers do this while 1 person is giving the Introduction.

**Important Note:** Divide students into groups of four so that there are **7 groups**. There are fourteen sets of materials for pairs of students within groups to do the activities. Students will be working in pairs, so that one pair of the group will build the series circuit while the other pair of the group builds the parallel circuit. This will allow them to look at both circuits to see the difference in brightness of bulbs and meter measurements.

**For Part I. Introduction**
4 “Energy Sticks” in SEPARATE plastic bags, 2 hand generators, 1 bulb

**For Parts II, III and IV Activities**
14 ziploc bags containing circuit boards and materials,
14 sets of instruction sheets for building simple, series, and parallel circuits
30 observation sheets. Students have their own pencils.
**For Parts V. Activity: Building Series and Parallel Circuits**
Same as above, with Extra circuit for Demonstration
**For Parts VI.**

## I. Introduction

**Learning Goals:**
**Students differentiate between static and current electricity.**
**Students understand that electrons can flow only if the circuit is complete.**

**Why is the science in this lesson important?**
Computer engineers are largely responsible for developing computer chips and circuit boards that are found in all of our technology. These chips and boards are made of complex electrical circuits just like the ones the students learn about in this lesson.
Scientist are developing robotic exoskeletons – the circuits in the machinery are responsible for the sensors and motors that strengthen the wearer.
**Do not hand out materials until you have discussed the following background information.**
Write the following vocabulary words on the board: **electricity, current, simple circuit, series circuit, parallel circuit, LED**

**What is Electrical Energy?**
Electrical energy is the energy of electric charges.

Ask students to tell you what they know about static electricity and current electricity:

Make sure the following is included in the responses:
There are 2 types of electricity, **static** and **current.**

**Static electricity** is the build-up of electrical charge. It does not flow. It can make your hair stand on end, or “zap” you when it is discharged. Lightning is an excellent example of static electricity being discharged.
**Current electricity** is moving electrical charge, (electrons). It moves as a result of electric charge build-up.
Current electricity flows through a **circuit**.

**Ask students: Where does Electrical Energy come from?**
Examples should include power plants, batteries, photocells, thermocouples, generators,
Show students the hand generator and tell them to look at the diagram on their observation sheet. Rotate the handle to activate it. Emphasize that there are NO batteries in the generator.

Ask students what energy conversions are taking place in this device. Have them circle all the conversions on their observation sheet.

**Your Notes:**

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How can electrical energy be stored?
Show students a battery. A battery supplies energy to an electric circuit by converting chemical energy to electric potential energy. Chemical reactions provide the energy that causes the electrons to flow in a circuit.

**The electrons can flow only if the circuit is complete.**

1. Show students one of the Energy sticks. Put a hand on each of the foil ends of the Energy Stick. The stick will flash lights and buzz.
2. Tell students that the stick is activated only when an electrical circuit has been completed.
3. Remove one hand to show the students that the stick no longer flashes or buzzes. The Energy Stick contains a small battery, and has a circuit that is highly sensitive. It can detect very small amounts of electricity that travel through the moisture on your skin.
4. Now have 2 or more VSVS members form a connected circle (by holding hands). Have 2 VSVSers each hold the foil at the opposite ends of the stick to complete a human chain of electricity. Show them a "human switch" by having one member drop a hand and break the circle, and then rejoin.
5. Tell students to look at their Observation sheet and ask them if they can name some energy conversions when the stick is activated. Tell them to circle the correct answers – chemical to electrical (battery to electrical) and the electrical to sound and light.
6. If time permits at the end of the lesson, see how many students can form a circle and activate the Energy stick. Or do this with smaller groups and a VSVS member.

Tell students they will be following diagrams on their instruction sheets to build a simple circuit.

## IIA. Activity: Making a Simple Circuit

**Learning Goals: Students understand how electrons flow through a circuit.**

Materials

| | |
|---|---|
| 14 | ziploc bags containing materials for series or parallel circuits |
| 14 | sets of instruction sheets for building simple, series, and parallel circuits |
| 30 | observation sheets |

**Diagram #1**

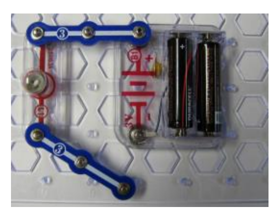

**Diagram 2**

1) Hand out one bag containing circuit materials to each pair.
2) Tell the students to look at the grid and its components, and compare it with **Diagram #1** on their Instruction sheets. Tell them they will need to replace the components in the same way when they are finished with the activities.
3) Tell the students that the **snap circuits** we will use today contain flattened wires. Tell them to remove one of the **#3 connectors** and look at its underside. Point out the flattened wire connecting the two snaps. This wire carries the electrical current.
4) **Review the correct way to unscrew a light bulb – demonstrate the "righty tighty, lefty loosey" concept.**
5) Have **all pairs** of students follow Diagram #2 to build the simple circuit on their board.

6) Tell them **not** to connect one of the **#3 snaps** until they are **told to do so**.

**Your Notes:**

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7) Ask the students if the circuit is complete. *No.*
8) How can they tell? *The light bulb does not come on. No electrical flow*
9) What does it take to complete the circuit? *Connect the last snap, as seen in Diagram #2*
10) Tell the students to do this, and to note that the bulb now glows.
**11)** This is called **a closed circuit.** Once the circuit is closed, electrons can flow through the circuit.
12) Ask the students which way the electricity is flowing. *Electrons flow from the negative end (the "flat" end of a battery) to the positive end (the end with the "knob").*
13) Ask the students: What happens if you unscrew the light bulb? *The light goes out because the circuit has been broken.*

## III. Activity: Using a Switch

**Learning Goals: Students understand how electrons flow through a circuit.**

1. Tell the students to replace one of the #3 snaps with the switch **(Diagram #3)**.
2. Sliding the switch to the "on" position is the same as completing the circuit – the light bulb then glows. Sliding the switch to the "off" position is the same as breaking the circuit—the light bulb no longer glows. Tell the students this is a simple way to control flow through the circuit.

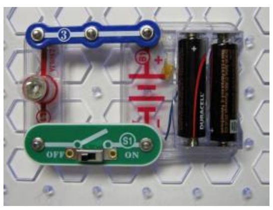
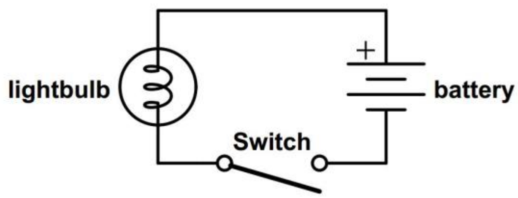



**Diagram 3.**




**Simple Circuit**

3. Tell students to look at the diagram of the simple circuit on their observation sheet and point out the relationship between the symbols and the electrical parts.

## IV. Activity: Measuring Current

**Learning Goals: Students understand how electrons flow through a circuit.**
**Students investigate electrical energy consumption using a regular light bulb and an LED.**
**Students observe energy losses using a regular light bulb.**

1. Show the students the meter and tell them it can measure both current and voltage. Briefly explain that voltage is a measure of electrical potential energy between two points. Explain that voltage is measured in volts and current is measured in amperes.

**Your Notes:**

2. Show the students that the meter has 3 positions.

| Move switch to: | You are measuring: | You read the scale located at: |
|---|---|---|
| All the way to the left (the 5V setting) | Voltage (V) | Upper scale reads between 0-5 volts |
| All the way to the right (the 1A setting) | Current (A) | Upper scale reads between 0-5 amps) |
| In the middle (1mA setting) | Very small current | Lower. Reads in milliamps |

3. Measuring Current:

Tell the students:

1. That the meter must be in the circuit for it to be able to measure current.
2. Move the switch to the 1A setting.
3. Look at **Diagram #4** on the Instruction sheet. Remove the remaining #3 snap and replace it with the meter, as shown.

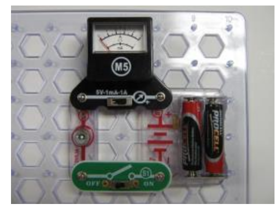


Diagram # 4

4. Turn the switch on and measure the current in amps (A).
5. Touch the light bulb and determine if the bulb feels warmer than its surroundings.
6. Record your observations and measurements in Part A on the Observation sheet.
7. Remove the snap containing the light bulb and replace it with the snap containing the LED.
8. Repeat steps 4-6.

Ask students:

Which light bulb saves electrical energy? How do you know?

Which light bulb would be more useful for keeping cooler temperatures in the house?

What energy conversions are taking place? Answers should include:

1. Electrical to Light.
2. Electrical to thermal (feel the light bulb while the circuit is closed).

## V. Activity: Building Series and Parallel Circuits

**Learning Goals: Students model energy flow and energy conversions in series and parallel circuits.**

**<u>Series and Parallel Circuits</u>**

Tell students that there are two ways that a circuit can be connected: **series** and **parallel**.

- The difference between the two is how their parts are connected
- Each has properties that are unique to it.
- A normal circuit may have both series and parallel elements..
- The behavior of light bulbs in a circuit can be used to observe the differences between the types of circuits.

Diagram 5

Diagram 6

**Your Notes:**

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The instruction sheet also includes some questions under the diagrams for the series and parallel circuits to guide their observations of the difference between the two circuits.

1. Tell **one** pair in the group to build the **series circuit (Diagram #5)** while the **other pair** of the group builds the **parallel circuit (Diagram #6)** - point out that a #1 connector is placed on top of lamp holder on the left before a #3 is used to connect to the switch).
2. Tell the pairs within the group to compare the brightness of the bulbs in the two different circuits.
3. Measure the current flowing and record the data in Part B on the observation sheet.

**Note:** Students will observe the lights are dimmer in the series circuit but not in the parallel circuit. They will observe that the current in the series circuit is less that that in the parallel circuit. See Answer Sheet.

4. Tell the pairs within the group to show each other what happens when the one bulb is unscrewed.
5. Point out the relationship between the symbols and the electrical parts.

**Note**: Students will observe the other bulb goes out in the series circuit but not in the parallel circuit. (See Answer Sheet.)

Tell students to respond to the questions in Section B on the observation sheet for the circuits they have just tested.

**Demonstration:** One VSVS team member should take the demonstration simple circuit bag out, screw in the light bulb, and connect #3 snap to complete the simple circuit (from IIA). Go around the room and show them the bulb brightness in the simple circuit so they can compare brightness to that as well. (It's the same as the parallel circuit.)

If students are curious, help them to set up the parallel circuit as in **Diagram #7** and measure the current going through only 1 bulb in the parallel circuit. *It is about the same current as in the simple circuit*.

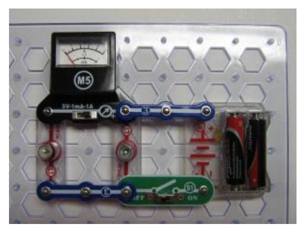


Diagram #7

## VI. Optional:

Allow the 2 pairs of students make **parallel circuits** using more than 2 light bulbs, with the meter in the circuit.
Unscrew a bulb, one at a time and record current measurements. Explain to students that this is the equivalent to turning off a light.
Electrical power is directly related to current used. The lower the current used, the less electrical power used.
While new technologies (such as solar power, wind power, LED lights…) can help reduce dependence on fossil fuels to generate electrical power, it is also important to conserve electrical energy by turning off appliances such as lights, heaters etc that are not being used.

**Your Notes:**

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

## VII. Discussion of Series and Parallel Circuits

**Learning Goals: Students model energy flow and energy conversions in series and parallel circuits.**

After students have finished responding to the questions about the series and parallel circuits they built, take a few minutes to review the differences that they observed. Make sure to include the following in your discussion:

- A series circuit only has one pathway for the electric current – a break in the circuit stops all flow of electric current.
- A parallel circuit has multiple pathways for the electric current to travel
    - a break in one pathway will still allow the current to go through the other pathways.

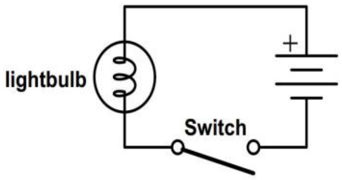
Review the responses for what happened with the light bulbs in their series and parallel circuits in terms of these concepts.

Lesson modifications by:
Dr. Mel Joesten, Professor Emeritus, Vanderbilt University
Pat Tellinghuisen, VSVS Program Coordinator, Vanderbilt University
Matt Majeika, NSF Undergraduate Teaching Fellow, Vanderbilt University
By Matt Jackson, NSF Undergraduate Teaching Fellow, Vanderbilt University and
David Harris, VSVS Co-President, Spring 2010

**Your Notes:**

# Electric Circuits  Observation Sheet

**Name** ________________________________________



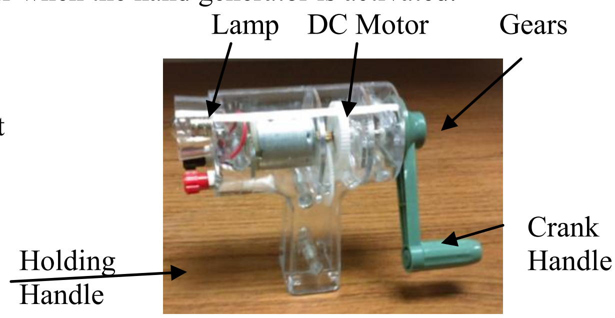

**2 1.5V batteries**

**Wire** --------

## Introduction – Hand Generator

Circle the energy conversions that occur when the hand generator is activated.

chemical to electrical
mechanical to nuclear
mechanical to sound
mechanical to electrical to light
mechanical to electrical




## Energy Stick

Circle the energy conversions when the stick is activated.

chemical to electrical
chemical to nuclear
electrical to sound
electrical to light
electrical to mechanical

## A. Current Measurements

Current in the Simple Circuit with regular light bulb ____________

Current in the Simple Circuit with LED ____________

Which light bulb is warmer – regular or LED? ____________

Which light bulb saves electrical energy? How do you know? __________________________

Which light bulb would be more useful for keeping cooler temperatures in the house? _________

Current in the Series Circuit with regular light bulbs ____________

Current in the Parallel Circuit with regular light bulbs ____________

## B Series and Parallel Circuits – Circle your answer.

1. The light bulbs in the series circuit were (brighter, dimmer, the same brightness) as those in the parallel circuit.

2. When one light bulb was unscrewed, the other light went out in the (series, parallel) circuit.

3. When one light bulb was unscrewed, the other light remained on in the (series, parallel) circuit.

4. The light bulb in the simple circuit was (brighter, dimmer, the same brightness) as the light bulb in the parallel circuit.

**Observation Sheet – Answers**
**Electric Circuits**

## Introduction – Hand Generator

Circle the energy conversions that occur when the hand generator is activated.

~~chemical to electrical~~
~~mechanical to nuclear~~
mechanical to sound
mechanical to electrical to light
mechanical to electrical

## Energy Stick

Circle the energy conversions when the stick is activated.

chemical to electrical
~~chemical to nuclear~~
electrical to sound
electrical to light
~~electrical to mechanical~~

## B. Current Measurements

Current in the Simple Circuit with regular light bulb **~1.2 A**
Current in the Simple Circuit with LED **~.5 A**

Which light bulb is warmer – regular or LED? Regular

Which light bulb saves electrical energy? How do you know? LED

Which light bulb would be more useful for keeping cooler temperatures in the house? LED

Current in the Series Circuit with 2 regular light bulbs **~1 A**

Current in the Parallel Circuit with 2 regular light bulbs **~2.5 A**

## A. Series and Parallel Circuits – Circle your answer.

1. The light bulbs in the series circuit were (brighter, **dimmer**, the same brightness) as those in the parallel circuit.
2. When one light bulb was unscrewed, the other light went out in the (**series**, parallel) circuit.
3. When one light bulb was unscrewed, the other light remained on in the (series, **parallel**) circuit.
4. The light bulb in the simple circuit was (brighter, dimmer, **the same brightness**) as the light in the parallel circuit.