The School Amateur Radio Club Network®
Electronics Workshop – Lesson Plans

"CQ CQ..."
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Contents

Introduction

The School Amateur Radio Club Network® is pleased to present a series of introductory electronics workshops on our SARCNET Website. These workshops include: Electronics, Electronic Components, Electronics Prototyping and Electronics Deconstruction. In conjunction with these workshops, we also provide a set of teacher lesson plans.

Lesson 1. Electricity, Conductors and Non-Conductors

Purpose

Introduction to SARCNET Electronics Workshops series, starting with basic conductors and non-conductors.

Introduction

"In this lesson we will learn about electricity and the materials that conduct and don't conduct electricity"

Safety

WARNING: DO NOT ALLOW THE BATTERY WIRES TO TOUCH EACH OTHER WHEN THE SWITCH IS ON. THIS IS CALLED A SHORT CIRCUIT AND CAN RESULT IN THE BATTERY AND WIRES GETTING HOT, MELTING THE PLASTIC, BURNING YOU OR EVEN STARTING A FIRE!

Key Learning Areas

1. Electricity, conductors and non-conductors
2. Batteries, switches and wires
3. Electronics prototyping

Leaning Outcomes

This lesson plan will give students an opportunity to learn that:

1. Electricity is created in a battery
2. Electricity can flow through wires
3. The flow of electricity can be switched on and off by a switch
4. An electronics prototyping-board can be used to connect electronic components
5. The flow of electricity can be indicated by the illumination of a Light Emitting Diode
6. A resistor is necessary to protect the LED from too much flow of electricity
7. Electricity flows through conductors and not through non-conductors
8. Conductors are usually metals
9. Non-Conductors are usually non-metals
10. The terms: Circuit, Resistors, Current and Electrons are introduced

Year Level

Year 5 or 6

Lesson Time

45 Minutes for one (1) teacher-built tester

90 Minutes for multiple student-built testers

Resources

You can build the simple electrical continuity tester with parts from the SARCNET STEM Kit #1 - Electronics Prototyping Kit, or you can purchase the following parts required separately. Note: This is for one (1) tester:

1. Switched Battery Holder (3V)
2. AA Batteries (x2)
3. 170 Contact Prototyping Board (Breadboard)
4. 510Ω 1/4W 5% resistor: Green, Brown, Black, Gold
5. Light Emitting Diode
6. 150mm Pin Leads (x2), or hook-up wire cut, stripped 10mm and tinned at each end

In addition, the class will need one (1) set of the following items:

1. A selection of different conductors and non-conductors to test
2. A pencil, split down the middle to reveal the lead
3. A small potato
4. An egg cup of tap water and some salt

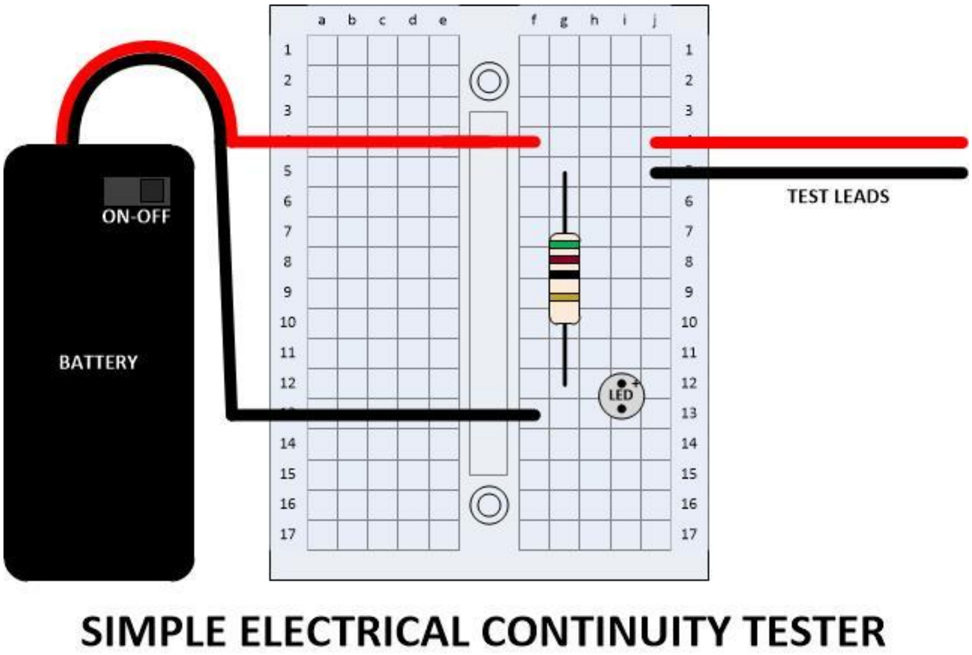

Figure 1 – Pictorial Schematic Diagram of the Tester

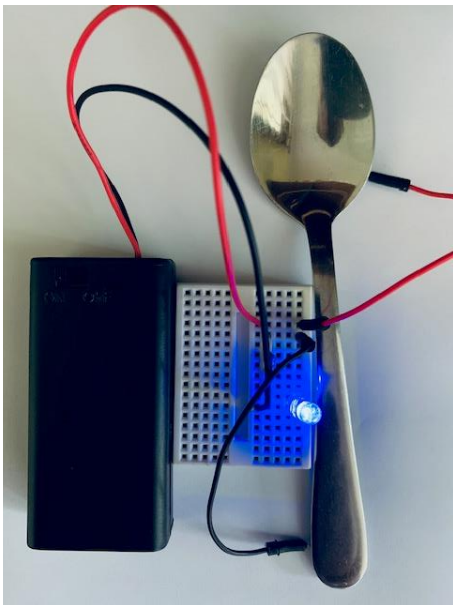

Figure 2 - Photograph of the Tester

Teacher Tasks

1. Provide students with the lesson introduction and safety briefing above
2. Pre-build one (1) simple electrical continuity tester; or
3. Provide sufficient parts and additional directions for all students to build their own. Note: Building their own will take students an additional 45 minutes. Do not provide batteries until the student's circuit is checked and the whole class has been briefed. The wiring of the tester is shown in Figure 1. The tester should look like the photograph in Figure 2.

4. Test the simple electronic continuity tester(s) to make sure it is working.
5. Briefly describe the name and function of each of the components in the simple electronic continuity tester (Note: This will be covered in more detail in a later lesson plan)
    a. "Electricity flows from the battery, through the switch and the test leads, through the item under test. It then flows back through the resistor and the LED to the battery. The electronics prototyping board is just used to connect all the electronic components and wires. If sufficient electricity flows, the LED will illuminate. Only good conductors will let sufficient electricity to flow. Note: The resistor is used just to protect the LED from too much flow of electricity which may damage it."
6. Demonstrate the operation:
    a. When you touch the ends of the test leads to a conductor the LED will illuminate. Try a spoon, a paper clip, aluminium foil, etc.
    b. When you touch the ends of the test leads to a non-conductor the LED will not illuminate. Try a plastic pen, a teacup, a glass, paper, etc.

Student Tasks

1. Students use the tester to discover which materials are conductors and non-conductors
2. Students sort the collection of materials provided into conductors (which illuminate the LED) and non-conductors (which do not illuminate the LED)

Discussion

1. Discuss the similarities and differences of the two types of materials identified.
2. Electricity always flows in a loop, from the source and back again. We call this an electric **circuit**. If you break the circuit, anywhere, the electricity stops flowing. Try it.
3. Some conductors are not very good. They resist the flow of electricity. We call them **resistors**. Try various lengths of pencil lead, a small potato or an egg-cup of water (into which you may need to dissolve one or two grains of salt), even your wet finger. The LED will only glow dimly for resistors.
4. The flow of electricity is what makes all electric circuits work. We call this electric **current**. But what is "flowing" in the wires? It is not water or air. It is **electrons** moving from one atom to the next. They are so small that you can't see them.

Evaluation

Ask the class questions. Encourage each student to answer.

1. What makes the LED illuminate? (Electricity flowing through the conductor)
2. Where does the electricity come from? (The battery)
3. What is inside a battery that makes electricity? (Chemicals)
4. Can batteries be dangerous? (Yes, if there is a short circuit they can create heat or fire)
5. Can you turn the electricity on and off with the switch? (Yes)
6. What types of materials allow electricity to flow and make the LED illuminate? (Metals) What do we call them? (Conductors)
7. What types of materials do not allow electricity to flow? (Non-metals) What do we call them? (Non-conductors)
8. What do we call poor conductors? (Resistors)
9. What do we call the loop along which electric current flows? (Circuit)
10. Can you trace the circuit though which the electricity flows? (Battery, switch, wire, board, wire, conductor, wire, board, resistor, board, LED, board, wire, battery)
11. What is another name for the flow of electricity? (Current)
12. All materials are made of atoms. What part of the atom flows inside metals? (Electrons)

Lesson 2. Batteries, Cells, Chemistries, Voltage, Capacity

Purpose

To understand batteries in depth.

Introduction

"In this lesson we will learn about the different types of batteries, how they work and how to use them"

Safety

WARNING: DO NOT SHORT-CIRCUIT BATTERIES BY CONNECTING THEIR TERMINALS TOGETHER. THE BATTERY AND CONNECTING WIRES CAN GET HOT, MELTING PLASTIC, BURNING YOU OR EVEN STARTING A FIRE! SHORT-CIRCUITED BATTERIES CAN GET HOT AND EXPLODE!

WARNING: DO NOT ALLOW CHARGING BATTERIES TO GET HOT. THEY CAN CATCH FIRE AND EXPLODE. ALWAYS MONITOR BATTERY CHARGING AND TURN OFF THE CHARGER WHEN FINISHED.

Key Learning Areas

1. Battery chemistry and sizes
2. Battery terminals, polarity and connections
3. Battery voltage and cells
4. Battery capacity and state of charge
5. Battery types: Non-rechargeable and rechargeable
6. Battery safety

Leaning Outcomes

This lesson plan will give students an opportunity to learn that:

1. Batteries store electrical energy using internal (dangerous/corrosive) chemicals and electrode structures
2. Batteries come in different shapes and sizes for different applications
3. Battery terminals are polarized, provide connection to external electrical circuits
4. Battery holders, clips and clamps provide for external wired connections
5. Battery rated voltage is determined by the number of cells and the chemistry in the cells
6. Battery rated capacity is related to battery size
7. Battery actual voltage and capacity is determined by the state of charge (charged/discharged)
8. Battery types: Carbon and alkaline non-rechargeable types
9. Battery types Nickel Cadmium, Nickel Metal Hydride, Lead-Acid and Lithium-Ion rechargeable types

Year Level

Year 5 or 6

Lesson Time

45 Minutes

Resources

1. As many different battery types as you can find. Charged or discharged, it does not matter.
2. As many different battery holders, or devices with battery holders, as you can find.
3. Sufficient charged batteries to fit in some of the battery holders.
4. At least one rechargeable battery type (discharged) and a suitable device and charger for it.
5. A Digital Multimeter to measure voltage. Preferably auto-ranging.
6. Images to illustrate some points, as follows:

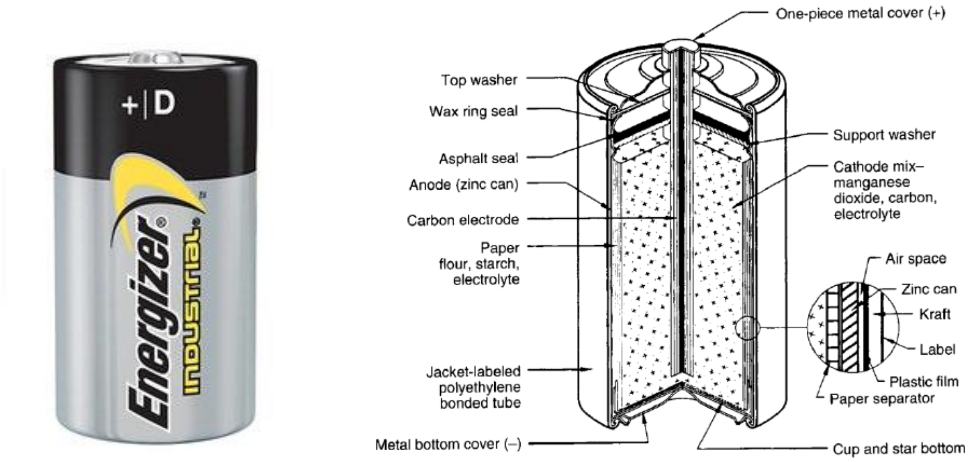

Figure 3 – Internal Structure of a Carbon-Zinc Battery

Figure 4 - Battery Shapes and Sizes

Figure 5 - Battery Chemistries

Table 1 – Battery Characteristics

Battery Type	Cell Voltage	Rechargeable	Application
Lead-Acid	2.0 V	Yes	Cars
Nickel Metal Hydride	1.2 V	Yes	Torches
Silver-Oxide	1.55 V	No	Watches
Mercury-Oxide	1.35 V	No	Cameras
Nickel Cadmium	1.2 V	Yes	RC Models
Lithium Ion	3.7 V	Yes	Laptops
Carbon-Zinc	1.5 V	No	Toys
Lithium	1.5 V	Yes/No	Remotes
Alkaline	1.5 V	No	Remotes

Teacher Tasks

1. Introduce the lesson.
2. Batteries store electrical energy using internal (dangerous/corrosive) chemicals and electrode structures
    a. Show a carbon-zinc D-Cell. Ask: What does a battery do? Ask: What is inside?
    b. Show and discuss Figure 3. Chemicals, called electrolytes, inside the battery react with the electrode material to produce electricity. Electrodes conduct the electricity to the battery terminals.
    c. Ask: What happens when a battery leaks? (Chemicals are poisonous and corrosive!).
3. Batteries come in different shapes and sizes for different applications

a. Ask: What would each battery in Figure 4 be used for?

4. Battery terminals are polarized, provide connection to external electrical circuits
    a. Batteries have two conductive metal terminals, identified as Positive (+) and Negative (-), to indicate the direction in which the electric current will flow in an external circuit connected to those terminals. Outside of the battery, electric current always flows from the positive terminal to the negative terminal.
    b. Since the terminals have opposite polarities (like the North and South poles). We say batteries are "polarized". It is very important to match the battery polarity with the external circuit. By convention, red wires are always connected to the positive terminal and black wires to the negative terminal.
5. Battery holders, clips and clamps provide for external wired connections.
    a. These are used to make good electrical connections to the battery, while also making it easy to replace the battery when it is flat.
    b. Since a battery is polarised, the battery holder always indicates the correct way to insert the battery?
    c. A battery holder or clip will have red and black wires indicating the polarity.
    d. Ask: What happens if a battery is inserted the wrong way into a battery holder? (The device may not work or could be damaged).
6. Battery rated voltage is determined by the number of cells and the chemistry of the cells
    a. Inspect a D-cell. Ask: Why is it called a cell and not a battery? (It only has one internal chamber)
    b. Inspect that it has a rated voltage of 1.5Volts.
    c. The voltage indicates how strong (or forceful) the cell is.
    d. The quantity of electrical voltage (symbol E) is measured in the units of Volts (symbol V), which is named after the Italian physicist Alessandro Volta (1745-1827).
    e. All carbon-zinc cells have the same voltage. Cells with different chemistry can have different voltages.
    f. Cells can be connected in series, like in the barrel of a torch, to increase the voltage. The cells are then formed into a battery. Ask: How many volts would there be with batteries made of 2, 3 or 4 cells? (3V, 4.5V, 6V)
    g. The more volts the brighter the torch!
    h. Ask: Which of the items in Figure 4 are cells and which are batteries (The 9V is a battery)
    i. Ask: How many 1.5V cells would be inside a 9V battery? (6)
    j. Demonstrate how to use the multimeter to measure the battery voltage. (Set to volts. Set to the appropriate range if not auto ranging. Connect red probe to the positive terminal, black probe to the negative terminal. Turn multimeter off afterwards to save its batteries)
    k. Measure the voltage of fully charged cells: One cell by itself (1.5V). Two and three cells in series (3V and 4.5V). Three cells in series, with one cell reversed (1.5V)
    l. Ask: Why is it only 1.5V not 3V? (The cell voltages are added 1.5V + 1.5V - 1.5V = 1.5V. One reversed cell effectively cancels out the voltage of another cell!)
7. Battery rated capacity is related to battery size
    a. Which cell in Figure 4 will power a torch for the longest time? (The D-cell, because it is bigger)
    b. Ask: If the 1.5V cells in Figure 4 all have the same strength, why are some bigger than others? (So that they last longer, when new)
    c. Ask: Why do bigger cells last longer? (Because they have more chemicals and greater rated capacity)
    d. The rated battery voltage indicates how strong the cell is (how bright the light) the rated battery capacity indicates how much energy it has (how long the light shines).
8. Battery actual voltage and capacity is determined by the state of charge (charged/discharged)

a. Ask: What is the difference been a new battery and a used battery? (The new battery is charged, the used battery is flat, or discharged).
b. Ask: If a new, fully charged, cell has a voltage of 1.5V, what is the voltage of a flat, or fully discharged cell? (Zero volts).
c. The actual battery voltage and actual battery capacity depend on the battery's state of charge, ranging from fully charged to fully discharged.
d. Ask: Which battery has a greater actual capacity and voltage: A 50% charged battery or a 25% discharged battery? (25% discharged battery = 75% charged battery).
e. Demonstrate how to compare the battery rated voltage with the battery actual voltage using a Digital Multimeter to determine the battery state of charge: Charged or discharged.
f. Supervise the activity.

9. Battery types: Carbon and alkaline non-rechargeable types
    a. Ask: What different battery chemistries can you see in Figure 5? (Lead-Acid, Nickel-Metal Hydride, Silver-Oxide, Mercury-Oxide, Nickel-Cadmium, Lithium-Ion, Carbon-Zinc, Lithium, Alkaline)
    b. Discuss: Table 1 – Battery Characteristics. Different batteries are suited to different applications.
    c. Ask: Which batteries last longer, carbon batteries or alkaline batteries (Alkaline)
    d. Ask: Why? (Alkaline batteries use more advanced chemicals, hence they cost more).
    e. Ask: Can you recharge carbon-zinc batteries? (No)
    f. Ask: Why? (The internal chemical reaction is not reversable, so they are not rechargeable and can explode if connected to a charger!)
    g. Ask: What do we do with dead batteries? (Take them to a re-cycling centre)
10. Battery types: Nickel-Cadmium, Nickel-Metal Hydride, Lead-Acid and Lithium-Ion rechargeable types
    a. Ask: What types of batteries can be recharged? (Nickel-Cadmium, Nickel-Metal Hydride, Lead-Acid and Lithium-Ion)
    b. Ask: How do we recharge them? (Connect them to an appropriate charger designed specifically for the battery chemistry)
11. Battery safety. **Important.**
    a. Ask: What could happen if we short-circuit a charged battery with a piece of wire? (The wire could get hot and burn, the batteries could overheat, explode and start a fire).
    b. What could happen if we put recharging batteries, or a device being recharged, under a blanket or pillow? (The batteries could overheat, explode and start a fire).
    c. Ask: What could happen if we use the wrong type of battery recharger? (The batteries could overheat, explode and start a fire)
    d. Ask: What could happen if we forget to turn off the charger when it is finished charging? (The batteries could overheat, explode and start a fire)

Student Tasks

1. Students answer questions and join in the discussions.
2. Students use a multimeter to discover the cell and battery voltages.
3. Students use a multimeter to discover which batteries are charged by comparing the actual measured voltage with the rated voltage printed on the battery.

Discussion

1. Why do we often call a D-Cell a battery? (The distinction is a technical matter. Now you know better.)
2. Why are batteries important for renewable energy production (They store intermittent solar and wind power)
3. Who invented the battery (Alessandro Volta, Italian Physicist in 1791. The scientific quantity of Voltage and its unit of measurement, the Volt, is named after him). Imagine if we had no batteries?
4. Why does it take so long to recharge batteries? (The chemical reaction would generate too much heat if we charged batteries faster).

5. Why don't rechargeable batteries last forever? (Each charge/discharge cycle corrodes the batteries electrodes. They eventually disintegrate.)

Evaluation

Participation in answering questions and class discussion is a good sign that students are enthusiastically learning the presented material. If not satisfied, try increasing the amount of practical hands-on investigation, measurement, discovery and creativity. E.G. Make a 6V battery (4 x 1.5V battery in series). Make a 1.5V battery that will last longer (4 x 1.5V in parallel). Charge a flat rechargeable battery for 1, 2, 5 minutes to see how long it lasts in a torch.

Lesson 3. Voltage, Current and Resistance: Ohms law.

Purpose

To explore how voltage, current and resistance in a simple circuit are related by Ohm’s law.

Introduction

“In this lesson we will learn how the voltage, current and resistance in a simple circuit are related. We will use Ohms law to calculate the resistance of a circuit”

Safety

WARNING: DC REGULATED POWER SUPPLIES CAN GENERATE SUFFICIENT CURRENT IN A CIRCUIT TO MAKE WIRES AND RESISTORS HOT, MELTING PLASTIC, BURNING YOU OR EVEN STARTING A FIRE! ALWAYS USE A DC REGULATED POWER SUPPLY UNDER ADULT SUPERVISION.

Key Learning Areas

1. Use of a DC Regulated Power Supply instead of a battery
2. The quantity of electrical voltage (symbol E) is measured in units of Volts (symbol V), which is named after the Italian physicist Alessandro Volta (1745-1827).
3. The quantity of electrical current (symbol I) is measured in units of Amps (symbol A), which is named after the French physicist Andre-Marie Ampere (1775-1836).
4. The quantity of electrical resistance (symbol R) is measured in units of Ohms (symbol Ω), which is named after the German physicist George Ohm (17889-1854).
5. Common SI multipliers used in this lesson are milli (symbol m) and kilo (symbol k)
6. Ohm’s law: $R = E \div I$
7. Calculating electronic resistor values

Leaning Outcomes

This lesson plan will give students an opportunity to learn:

1. How to use a DC Regulated Power Supply
2. Why current flows in a circuit
3. Why more voltage causes more current to flow in a circuit
4. Why some materials resist the flow of current
5. How to find out how much resistance is in a circuit
6. How to calculate the resistance in a circuit
7. How to safely connect an LED to a 9V battery

Year Level

Year 5 or 6

Lesson Time

45 Minutes

Resources

1. A DC Regulated Power Supply with digital displays for voltage and current with a resolution of 10mV and 1mA as shown in Figure 6
2. Red and black banana plug leads with alligator clips as shown in Figure 7.
3. Two LEDs and a Component Tester if you have one
4. Split 2B Pencil. Carefully groove opposite sides of the pencil with a box-cutter blade. Repeat to gently deepen the cut to close to the lead. When deep enough, use your fingernails to split and remove the wood down one whole side of the pencil. The lead should remain attached to the wood on the other side of the pencil, which will prevent the lead from breaking. See Figure 8.
5. 1.2kΩ 1/4W electronic resistors
6. 9V Batteries
7. 9V Battery clips

Figure 6 - DC Regulated Power Supply

Figure 7 - Banana Plug Clip Leads

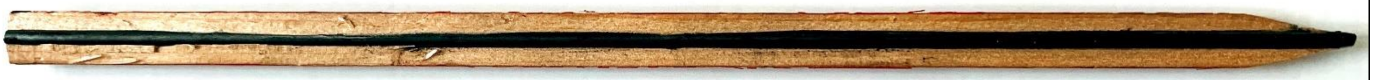

Figure 8 – Split 2B Pencil

Teacher Tasks

1. Introduce the lesson, as above.
2. Introduce the DC Regulated Power Supply
    a. Explain that the DC Regulated Power Supply can be used like a battery, where the maximum voltage and current can be precisely set and the actual voltage, current and power can be measured.
    b. Show connecting the power supply input plug to the AC mains
    c. Show the red and black output terminals
    d. Explain that the green terminal is connected to the metal case
    e. Ask: Which is positive (red) and which is negative (black)
    f. Ask: Is the power supply polarised or unpolarised? (Polarised: Meaning it matters which way you connect it to a circuit)
    g. Show how red and black banana plug leads with alligator clips, make it easy to connect it to a circuit
    h. Ask: How can I use the power supply to illuminate an LED? (Connect the LED to the alligator clips)
    i. Explain: The quantity of electrical voltage (symbol E) is measured in units of Volts (symbol V), which is named after the Italian physicist Alessandro Volta (1745-1827).
    j. Ask: What voltage should I use? (2V or as displayed on your component tester)
    k. Ask: What happens if I supply too little voltage? (The LED will not illuminate)
    l. Ask: What happens if I supply too much voltage? (The LED gets hot and burns out)
    m. Explain: The quantity of electrical current (symbol I) is measured in units of Amps (symbol A), which is named after the French physicist Andre-Marie Ampere (1775-1836).
    n. Ask: What happens if I supply too little current? (The LED will not illuminate)
    o. Ask: What happens if I supply too much current (The LED gets hot, burns out, and the wires get hot)
    p. Show how to turn on the power supply and connect the leads

   q. Show how to adjust the power supply voltage to 2V
   r. Show how to adjust the power supply current to 0A (the voltage will also drop to zero)
   s. Show how to connect the alligator leads together and adjust the maximum current to 1A
   t. Show how to connect the LED to the alligator leads: Red to long lead, black to short lead.
   u. Show that the LED illuminates. Record the electrical current drawn by the LED (0.006A).
   v. Ask: What is the direction of current flow? (From the positive terminal to the negative terminal)
   w. Ask: What is the path of electrical current flow called? (A circuit)
   x. Show how to reduce the voltage – The LED does not illuminate
   y. Show how to increase the voltage, slowly, above 2V – The LED grows dim, hot and burns out
   z. Show that the LED is now permanently damaged: Back at 2V it is dim or burnt out.
   aa. Throw the LED in the bin. QED.
3. Electrical current flows in a circuit whenever a voltage is applied to it
   a. Set the power supply to 1V
   b. Show that connecting the leads causes current to flow in the circuit
   c. Ask: Why is the power supply voltage now zero. (There is a short circuit)
   d. Adjust the maximum current to 1A
   e. Show that disconnecting the leads returns the current to zero
   f. Connect the leads to the ends of the pencil lead 15cm apart
   g. Show that some current is flowing, but not the full 1A as before
4. The power supply can be used to measure the amount of electrical current flowing into the circuit.
   a. Show the A symbol on the power supply current meter
   b. Show the decimal point on the power supply meter
5. It is common to use milli as a standard multiplier: One thousandths of an Amp is called one milliamp "mA".
   a. Measure and record the current in pencil lead in mA
   b. Explain that the measured current was 0.200A = 200mA
   c. Explain 0.001A = 1mA, 0.01A = 10mA, 0.1A = 100mA, and 1.0A = 1000mA
   d. Ask: What is 2.5A in milliamps? (2500mA). What is 0.87A in milliamps? (870mA).
6. The more voltage applied to a circuit, the more current flows in the circuit
   a. Show how increasing and decreasing the voltage, a little, increases and decreases the current
7. Resistors are poor conductors of electric current
   a. Show that connecting the good conducting leads together permits 1A of current to flow
   b. Explain that the pencil lead lets less current flow in the circuit because it is a poor conductor
   c. Explain that poor conductors resist the flow of electric current
   d. Explain that this is because the atoms in the poor conductor are not uniformly spaced, like in a metal which is a good conductor, and the electrons are not as free to flow between the atoms
   e. Explain that the pencil lead is made from graphite, a form of carbon
   f. Explain that poor conductors can be useful in electric circuits to reduce current flow to safe levels
   g. Explain that poor conductors used for this purpose are called resistors
8. The more electrical resistance in the circuit, the less current flows in a circuit
   a. Show that moving the alligator clips closer together on the pencil lead increases the current
   b. Show that moving the alligator clips further apart on the pencil lead reduces the current
9. The quantity of electrical resistance (symbol R) is measured in units of Ohms (symbol Ω), which is named after the German physicist George Ohm (17889-1854).
10. It is common to use kilo as a standard multiplier: One thousand Ohms is call one kiloohm "kΩ"
11. The resistance in a circuit is equal to the voltage across to the resistor, divided by the current flowing in the circuit:
   a. If the voltage is E, the current is I and the resistance is R, then R = E ÷ I (Ohm's law)
   b. Connect the allegator clips to either end of the pencil lead (15cm apart)

c. Measure and record the voltage, in Volts, across the pencil lead (1.000V)
d. Measure and record the current, in Amps, flowing through the pencil lead (0.200A)
e. Calculate the resistance of the pencil lead, in Ohms, using Ohm's law:
R = E ÷ I
= 1 Volt ÷ 0.2 Amps
= 5 Ohms, written as 5Ω

12. A resistor can be used to reduce the current flowing through a circuit to a safe level. Use Ohms law to calculate the resistance required to permit a 2V LED to operate safely on a 9V battery:
    a. Note that there are now three components in the circuit: The power supply, the resistor and the LED. If the power supply maintains a voltage of 9V then the voltage across the resistor and the voltage across the LED must add up to 9V. If the voltage across the LED is 2V, then the voltage across the resistor must be:
    E = 9V – 2V = 7V
    b. If the safe current flowing through the LED is I = 6mA = 0.006A, this must also be the same as the current flowing through the resistor.
    c. We can now use Ohms law to calculate the resistance of the required resistor:
    R = E ÷ I = 7 ÷ 0.006 = 1166 Ohms, which be written as 1.166kΩ.
    d. Electronic resistors only come in "preferred" values: A 1kΩ or 1.2kΩ resistor should be close enough
    e. Adjust the power supply voltage to 9V
    f. Connect a 1.2kΩ resistor to the red alligator clip
    g. Connect the short wire of the LED to the black allegator clip
    h. Connect the free end of the resistor to the long wire of the LED using another allegator clip lead (or your fingers. (The LED illuminates normally)
13. Build your own 9V LED circuit
    a. Connect a 9V battery clip to a Prototyping Board
    b. Connect a 1.2kΩ resistor the Prototyping Board
    c. Connect a LED to the Prototyping Board
    d. Check the circuit
    e. Connect a 9V battery to the 9V battery clip
    f. Check the LED illuminates

Student Tasks

1. Students answer questions and join in the discussions.
2. Students help adjust the voltage and current of a DC regulated power supply under adult supervision
3. Students build a circuit using a 9V battery, 1.2kΩ resistor and an LED

Discussion

1. What would happen if you connected the LED to the 9V battery without the resistor?

Evaluation

Participation in answering questions and class discussion is a good sign that students are enthusiastically learning the presented material. If not satisfied, try increasing the amount of practical hands-on investigation, measurement, discovery and creativity. E.G. Calculate the resistor value for powering a LED from 12V, using the power supply.

Lesson 4. Power and Energy: Watts law and Joules Law.

Purpose

To explore how power is used to transfer energy in a circuit.

Introduction

“In this lesson we will learn how energy can be transferred from an energy source to a circuit using electrical power. We will use Watts law to calculate the power needed and Joules law to calculate the amount of energy transferred.”

Safety

WARNING: DC REGULATED POWER SUPPLIES CAN GENERATE SUFFICIENT CURRENT IN A CIRCUIT TO MAKE WIRES AND RESISTORS HOT, MELTING PLASTIC, BURNING YOU OR EVEN STARTING A FIRE! ALWAYS USE A DC REGULATED POWER SUPPLY UNDER ADULT SUPERVISION.

Key Learning Areas

1. A battery, or power supply, can supply energy to a circuit
2. A battery is a primary source of energy – it contains chemicals which react to generate electrical energy.
3. A power supply is a secondary source of energy – it uses electrical energy generated at a power station.
4. In an electrical circuit containing just an energy source and a resistor:
   a. The voltage at the source is the electro-motive force pushing electrical current through the resistor
   b. The flow of electrical current through the resistor causes it to get hot
   c. A resistor converts the electrical energy from the source into heat energy
   d. The voltage and current combined provide the power needed to transfer the energy
   e. The energy transferred is equivalent to the amount of power needed over a given time
5. The quantity of power (symbol P) is measured in units of Watts (symbol W), which is named after Scottish inventor James Watt (1736–1819).
6. The quantity of energy (symbol Q) is measured in units of Joules (symbol J), which is named after English physicist James Joule (1818–1889).
7. The quantity of time (symbol T) is measured in units of seconds (symbol s)
8. The power required is the voltage (E) multiplied by the current (I). P = E x I. Watts law.
9. The energy transferred is the power (P) multiplied by the time (T). Q = P x T. Joules law.
10. Calculating power and energy

Leaning Outcomes

This lesson plan will give students an opportunity to learn:

1. How to transfer energy from a power supply to a resistor
2. How to convert electrical energy into heat energy
3. How to measure the voltage across the resistor and the current in the resistor
4. How to calculate the power needed to transfer energy to the resistor
5. How to calculate the energy transferred to the resistor
6. That energy cannot be destroyed only converted into other forms of energy

Year Level

Year 5 or 6

Lesson Time

45 Minutes

Resources

1. A DC Regulated Power Supply with digital displays for voltage, current and power, with a resolution of 10mV, 1mA and 100mW. See Figure 9
2. Red and black banana plug leads with alligator clips as shown in Figure 10.
3. Split 2B Pencil. Carefully groove opposite sides of the pencil with a box-cutter blade. Repeat to gently deepen the cut to close to the lead. When deep enough, use your fingernails to split and remove the wood

down one whole side of the pencil. The lead should remain attached to the wood on the other side of the pencil, which will prevent the lead from breaking. See Figure 11.

Figure 9 - DC Regulated Power Supply

Figure 10 - Banana Plug Clip Leads

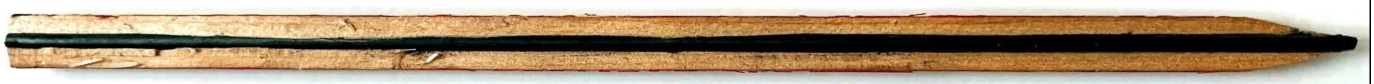

Figure 11 – Split 2B Pencil

Teacher Tasks

1. A battery, or power supply, can supply energy to a circuit
    a. Show a 1.5V cell, it only has one chamber
    b. Show a 9V battery, which is made of 6 cells connected in series
    c. Show a DC regulated power supply, which can be set to 1.5V or 9V easily
2. A battery is a primary source of energy – it contains chemicals which react to generate electrical energy.
    a. Show a diagram of the internal structure of a battery. It contains chemicals.
3. A power supply is a secondary source of energy – it uses electrical energy generated at a power station.
    a. Show that the power supply has an input cable and output terminals
    b. Explain that it cannot generate electricity by itself
    c. Ask: "Where does its energy come from?" (A power station)
4. In an electrical circuit containing just an energy source and a resistor:
    a. The voltage at the source is the electro-motive force pushing electrical current through the resistor
        i. Show the voltmeter on the power supply
        ii. Set it to 2.2V. Teacher note: The set voltage is dependent on the pencil's resistance. The pencil shown had a resistance of 5Ω. With 2.2V applied to the pencil the current drawn was 0.440A and the power used was 0.968W. The voltage you set should indicate a power of about 1W on the power supply. Any more than 1W will get the pencil too hot. 5W could burn the pencil and start a fire! Do not leave the power supply unattended.
        iii. Show the voltage is indicated on the power supply voltmeter

    iv. Show that the current flowing in the circuit is zero because it is not connected
  b. The flow of electrical current through the resistor causes it to get hot
    i. Connect the allegator leads to the either side of the pencil lead
    ii. Show that current is now flowing as indicated on the power supply ammeter
    iii. After a minute or so allow the students to touch the pencil lead – It will be quite warm.
  c. A resistor converts the electrical energy from the source into heat energy
    i. Ask "Where is the energy coming from?" (The power station, via the power supply)
    ii. Ask "What type of energy is it?" (Electrical energy)
    iii. Ask "Where is the energy going to?" (The pencil lead, which is a resistor)
    iv. Ask "What type of energy is it?" (Heat)
    v. Ask "What has converted the electrical energy into heat?" (The resistor)
  d. The voltage and current combined provide the power needed to transfer the energy
    i. Explain "Just like the voltage provides the electro-motive force needed to push current through the resistor, the combination of voltage and current provides the power needed to push electrical energy into the resistor."
    ii. Ask "What is the voltage applied to the resistor?" (2.2V as shown on the voltmeter)
    iii. Ask "What is the current flowing through the resistor?" (0.440A as shown on the ammeter)
  e. The energy transferred is equivalent to the amount of power needed over a given time
    i. Ask "Is the power supply transferring energy to the resistor?" (Yes, because it is getting hot)
    ii. Ask "What is causing the energy transfer?" (The electrical power from the power supply – Not just the voltage or the current, but a combination of both)
    iii. Ask "Is the amount of energy being transferred changing?" (Yes, it is increasing with time)
5. The quantity of power (symbol P) is measured in units of Watts (symbol W), which is named after Scottish inventor James Watt (1736–1819).
  a. Explain "The power needed to transfer energy to the resistor is provide by the both the voltage, which forces the current through the resistor, and the current which flows through the resistor."
  b. Ask "What is the power needed to heat the resistor?" (0.9W as shown on the wattmeter)
6. The quantity of energy (symbol Q) is measured in units of Joules (symbol J), which is named after English physicist James Joule (1818–1889).
  a. Ask: "Suppose 60 Joules of energy is transferred to the resistor in 1 minute, how much would be transferred in two minutes?" (120J)
  b. Ask: "Will the resistor keep getting energy from the power supply when it reaches its maximum temperature" (Yes, although the power input [voltage and current] is constant, the energy transferred to the resistor is increasing all the time)
  c. Ask: "Will the resistor keep getting hotter and hotter?" (No, it will reach a maximum temperature and stay there, in equilibrium, because surrounding air currents are taking the heat energy away)
  d. Ask: "Where is the energy from the power station going? (The electrical energy from the power station is transferred to the resistor via the power supply. The resistor converts the electrical energy into heat energy. The surrounding air transfers the heat energy to the Earth's atmosphere. The Earth's atmosphere transfers the heat energy to space as infrared radiation).
  e. Explain "Energy cannot be destroyed only converted into other forms of energy – This is called the Law of Conservation of Energy."
  f. Ask: "What are the other forms of energy?" (Mechanical, chemical, electrical, thermal, radiant and nuclear energy)
7. The quantity of time (symbol T) is measured in units of seconds (symbol s)
8. The power (P) needed is the voltage (E) multiplied by the current (I). P = E x I. Watts law.
9. The energy (Q) transferred is the power (P) multiplied by the time (T). Q = P x T. Joules law.
10. Calculating power and energy:

a. Ask "If the voltage across the resistor is 2.2V and the current flowing through the resistor is 0.44A what is the power in the resistor?" (2.2 x 0.44 = 0.9W)
b. Ask "If the power in the resistor is 0.9W, how much energy is transferred to the resistor over 120 seconds. (0.9 x 120 = 108J)
c. Explain: "One Joule is actually a very small amount of energy. It is equivalent to the energy of one watt of power over one second of time". Much larger quantities of energy, measured over a period of one hour are more commonly used. For example, one kilowatt hour (1 kWh) equals 3,600,000 Joules or 3.6 Mega Joules (3.6 MJ)."

Student Tasks

1. Students answer questions and join in the discussions
2. Students adjust the power supply voltage and sense the heat coming from the pencil lead
3. Students write down equations and use a calculator to find the correct answer

Discussion

1. Ask: "What would happen if you increased the voltage so that the power in the resistor was 5W?" (It would get too hot and burn the wood, possibly starting a fire)

Evaluation

Participation in answering questions and class discussion is a good sign that students are enthusiastically learning the presented material. If not satisfied, try increasing the amount of practical hands-on investigation, measurement, discovery and creativity. E.G. Try different voltages and pencil lead resistance by sliding the allegator clips along the lead. Calculate the power and energy for different values of voltage and current.

Lesson 5. Semiconductors: Diodes, Light-Emitting Diodes, Solar Cells.

Lesson 6. Resistors and Capacitors.

Lesson 7. Transistors.

Lesson 8. Electronic Components.

Lesson 9. Electronic Circuits, Component Symbols and Schematic Diagrams.

Lesson 10. Electronics Prototyping: Build your own circuits.

Lesson 11. Electronics Deconstruction: See how things work.