Unit D: Electrical Principles and Technologies

Focusing Questions:

1. How do we obtain and use electrical energy?

2. What significant principles are involved in developing, selecting, and using energy-consuming devices?

3. How can the principles of electricity be applied in technology to promote efficient and effective energy use?

Key concepts:

- forms of energy
- energy transformation
- generation of electrical energy
- electric charge and current
- circuits
- electrical energy storage
- energy transmission
- measures and units of electrical energy
- electrical resistance and Ohm's law
- renewable and nonrenewable energy

Learning outcomes:

1. Distinguish between static and current electricity and identify example evidence of each.

2. Assess the potential danger of an electrical device by checking its voltage and amperage.

3. Distinguish between safe and unsafe activities when dealing with electricity.

4. Identify electrical conductors and insulators.

5. Evaluate the use of different chemicals, chemical concentrations, and designs for electrical storage cells.

6. Identify electrical conductors and resistors.

7. Compare the resistance of different materials.

8. Use switches and resistors to control current.

9. Use models to describe and relate electrical current, resistance, and voltage.

10. Measure voltage and amperage in circuits.

11. Calculate resistance using Ohm's law.

12. Draw circuit diagrams.

13. Compare and contrast microelectronic circuits and circuits in a house.

14. Identify, describe, and interpret examples of mechanical, chemical, thermal, and electrical energy.

15. Describe energy transfer and transformation.

16. Compare energy inputs and outputs of a device, and calculate its efficiency.

17. Describe techniques for reducing energy waste.

18. Identify and evaluate alternative sources of electrical energy including oil, gas, coal, biomass, wind, waves, and batteries.

Topic 1 – Electric Charges

Draw the Bohr model of the atom (chemistry unit):

The atom is composed of three _____ _____ **:**

Particle	Symbol	Charge	Location
Proton			
Neutron			
Electron			

When atoms rub together, _____ can be displaced resulting in a/an balanced/unbalanced charge. Materials can lose _____ (resulting in a _____ charge) or gain _____ (resulting in a _____ charge).

Static Electricity:

Copy and explain figure 4.2

Laws of Charge: 1.

2.

3.

Summarize the following demonstrations with diagrams and words:	
Running water:	Pith balls:
Electroscope:	Van de Graff generator:

Using the list of words below, complete the following sentences. Each word may be used more than once.

positive, positively, negative, negatively, unlike, opposite

(a) _____charges are unlike charges.

(b) Two like charges are either both _____ or both _____ .

(c) If two _____ charges are brought together, they will experience a force of attraction.

(d) If a _____ charged balloon is brought near a positively charged rod, the balloon is attracted to the rod.

(e) A piece of plastic has no charge on it. This means that it has the same number of _____ and _____ charges

Differentiate between **insulators** and **conductors** and provide two examples of each.

Differentiate between **semiconductors** and **superconductors** and provide one example of each.

Identify and explain two ways you can **neutralize** (balance) unbalanced charges.

Topic 2 – Electricity within a Circuit

Electric circuit:

Circuits may consist of the following:

Part	Definition	Examples
1. Source		
2. Conductor		
3. Load		
4. Control		

Use the electrical kits to make an electric circuit that contain the fours parts listed above. You must be able to turn the light bulb on and off!

Cell:

Battery:

When drawing circuits, you must know and use standard symbols. Complete the following chart:

1 cell	**conducting wire**	**switch**
battery consisting of 3 cells	**lamp**	**resistor**

Draw an electric circuit consisting of a battery made up of two cells, a switch, two lamps, and a resistor. Indicate the direction in which the current flows.

Electrical current:

- the symbol for electrical current is _____
- current is measured in _____ (___) or amps for short
- the simplest way to measure current is with an instrument called an _____
- *weaker* currents are measured in _____ using an instrument called a _____

Potential Difference (voltage):

- the symbol for potential difference is _____
- voltage is measured in _____ (___)
- the simplest way to measure voltage is with an instrument called an _____
- many electricians refer to the potential difference across a device as **voltage** _____

Instrument:	ammeter	galvanometer	voltmeter
Symbol:			

Explain how you would hook up an ammeter and a voltmeter. You need to know this before completing Investigation 4-A.

Investigation 4-A conclusions:

Topic 3 – Resisting the Movement of Charge

Resistance:

- the symbol for resistance is _____
- resistance is measured in _____ (___)
- the simplest way to measure resistance is with an instrument called an _____

Differentiate between **resistors** and **variable resistors (rheostat)**.

Poor conductors have _____ resistance. For example, the _____ **filament** in an incandescent light bulb turns electrical energy into _____ and _____. The _____ **wire** in toaster turns electrical energy into _____ and _____.

Based on the Find Out Activity on page 280, how does the length of the conductor affect the amount of resistance?

Ohm's Law:

Rearrange the above equation to solve for current and voltage:

Note: you can also determine resistance by calculating the slope of a voltage vs. current graph

Mathematically Calculating Resistance

1. Complete the following chart:

Quantity	Symbol	Unit	Equation
Resistance			
Current			
Voltage			

2. Examples:

   a. An electric stove is connected to a 240 V outlet. If the current flowing through the stove is 20 A, what is the resistance of the heating element?

   b. A 30 V battery creates a current through a 15 Ω resistor. How large is the current?

   c. A motor has an internal resistance of 40 Ω. The motor is in a circuit with a current of 4.0 A. What is the voltage?

   d. A current of 625 mA runs through a bulb that is connected to 120 V. What is the resistance of the bulb?

3. Complete the following questions:

   a. A bulb of 15 Ω resistance is in a circuit powered by two 1.5 V batteries. What is the current in the circuit?

   b. A digital recorder plugged into a 120 V outlet has an operating resistance of 10000 Ω. How much current is flowing through the device?

   c. An electric heater draws 10 A from a 120 V source. What is the heater's resistance?

   d. A current of 1.5 A flows through two 15 Ω resistors that are connected across a battery. What is the battery's voltage?

   e. A current of 12 A flows through a vacuum cleaner motor that is plugged into a 120 V source. What is the internal resistance of the vacuum motor?

4. Complete practice problems 1 to 4 page 282.

   a. #1 b. #2

   c. #3 d. #4

5. If you need additional practice, complete the following:

a. An automobile headlight has an average resistance of 24 Ω. Car batteries provide a potential difference of 12 V. What amount of current passes through the headlight?

b. In a portable radio, 0.5 A of current are flowing through a conductor that provides 18 Ω of resistance. What potential difference is provided by the battery?

c. A 9 V battery maintains a current of 3 A through a portable radio. What is the resistance of the conductor?

d. What is the resistance of a 1100 W hair dryer plugged into a 110 V outlet with a 10 A current flowing through it?

e. A portable CD player, operating with four 1.5 V cells connected in series, provides a resistance of 15 000 Ω. What amount of current is flowing through the CD player?

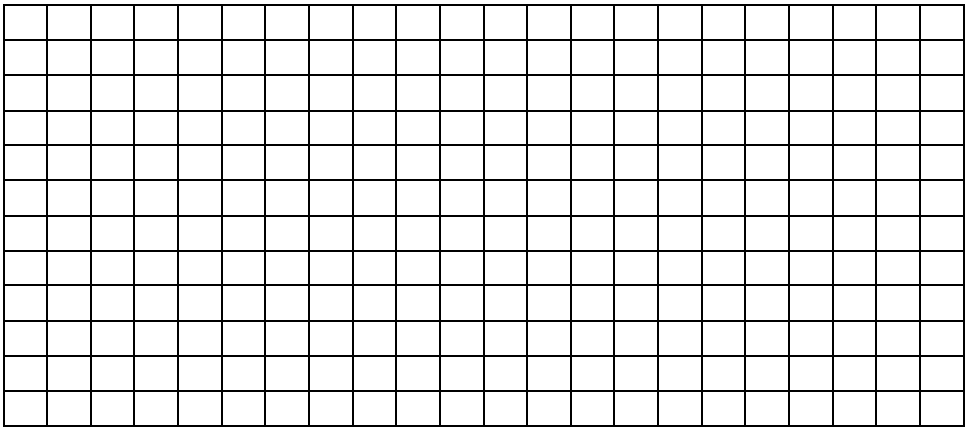
f. An electric motor has an operating resistance of 25 Ω when a 4.8 A current is flowing through it. What is the potential difference of the outlet the motor is plugged into?

Graphically Determining Resistance

1. Complete the table below.

Potential Difference *V*	Current *I (A)*	Resistance *R* (Ω)
1.0	3.4	
3.0	10.5	
6.0	20.5	
8.0	28	
11.0	38.00	
	Average Resistance	

2. Plot a graph of potential difference (*y*-axis) versus current (*x*-axis) on the grid below. Remember to label the axes and title the graph.



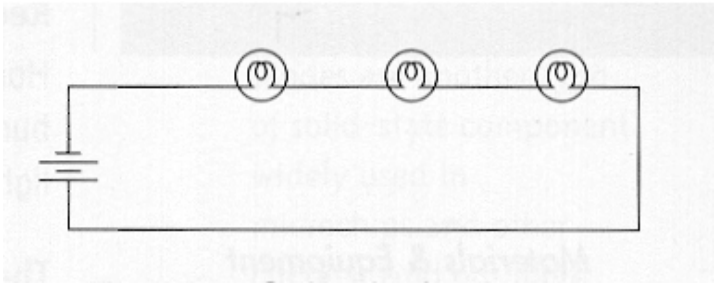
3. Calculate the slope of the line in questions 2. Remember to include units in your answer.

$$\text{Slope} = \frac{\text{rise}}{\text{run}}$$

4. Compare the slope in question 3 to the average resistance in question 1.

Types of Circuits

Series Circuit:



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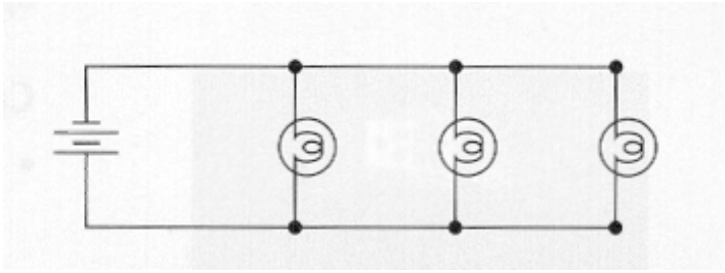
Parallel Circuit:



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Investigation 4-C

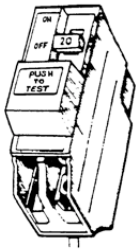
House Wiring

Houses *should* be wired with _____ circuits. Provide one advantage and one disadvantage to wiring your home this way:

Explain how the following prevent electrical shocks and overloads:

Three-prong plugs:

Fuses:



Circuit breakers:

The ability of a wire to carry more current and have a reduced resistance is usually identified by its_____ (AWG) number. Identify and explain 4 factors that affect resistance in a wire:

1.

2.

3.

4.

Topics 1–3 Assignment

1. If you comb your hair on a cold dry winter's day, your hair tends to stand on end because:
   (a) Each separate hair has a similar charge of electricity
   (b) Different hairs have opposite charges of electricity
   (c) Hair always sticks to plastic
   (d) Hair is a good conductor of electricity

2. The unit used to measure electrical current flow is the
   (a) second
   (b) ampere
   (c) volt
   (d) joule

3. The unit used to measure potential difference (or, voltage) is the
   (a) second
   (b) ampere
   (c) volt
   (d) joule

4. If the resistance of a conductor is 98 ohms and 2.6 volts are used, what is the current?
   (a) 0.027 A
   (b) 37.7 A
   (c) 100.6 A
   (d) 255 A

5. A voltmeter connected to an electric bell reads 3.0 V and an ammeter in series with the bell reads 0.75 A. The resistance of the bell is
   (a) 0.25 ohms
   (b) 0.75 ohms
   (c) 2.25 ohms
   (d) 4.0 ohms

6. Electrical circuits that have more than one circuit path are called
   (a) series circuits
   (b) parallel circuits
   (c) short circuits
   (d) complete circuits

7. Consider four small spheres A, B, C, and D. Sphere B is positively charged. B attracts A and C but repels D. A and C repel one another. What sign of electrical charge is on A, C, and D?

8. The "Laws of Charges" are in three parts. Two are listed below. Fill in the blank by writing in the third part of this law.
   1. Unlike charges _____
   2. Like charges _____
   3. _____

9. Make a circuit diagram to show a cell connected in series with a switch, a lamp, and an ammeter. Show the direction of electron flow on your diagram.

10. Match the appropriate term in column A with its definition in column B by placing the correct letter in the space provided beside each term.

	A	B
_____	1. neutral	(a) instrument used to measure larger currents
_____	2. conductors	(b) these offer zero resistance to the flow of electrons
_____	3. superconductors	(c) a combination of cells
_____	4. battery	(d) the cross-sectional area of a wire
_____	5. ammeter	(e) materials that allow charges to move freely
_____	6. gauge	(f) materials that do not carry excess electrical charge

11.(a) Consider the following statement: "For certain metallic conductors, the ratio of voltage to current is constant if the temperature remains constant." What is the name of this famous law in the study of electricity?

(b) A resistor connected to a 3.0 V battery produces a current of 0.040 A. Calculate the resistance of the resistor.

12. Two identical light bulbs are connected in series with a 3 V battery. If a third identical bulb is added in series with the first two, predict what change will occur to:
(a) the brightness of the bulbs.

(b) the current flowing through each bulb.

13. What is the purpose of a fuse or circuit breaker in a household electrical system?

14. Draw a diagram of a circuit that consists of a 9 V battery, an ammeter, and a 25 Ω resistor in series. Include a voltmeter that is measuring the potential difference across the resistor. Remember to label the positive and negative terminals of the voltmeter and ammeter.

    a. What will the reading be on the ammeter in question 14?

    b. What would the reading be on the ammeter in question 14 if you added a second 9 V battery in series with the first?

    c. Add a volunteer to the set-up in question 14. What is the reading on the voltmeter? Explain.

15. Draw an electric circuit consisting of a battery made up of two 1.5 V cells, a switch, two lamps, and an ammeter in series. Indicate the direction in which the current flows.

16. Draw an electric circuit consisting of a battery made up of four 1.5 V cells, one switch, one lamp, two 0.50 Ω resistors in series, and a voltmeter. Indicate the direction in which the current flows.

Topic 4 – The Energy Connection

1. **Energy** is the ability to do _____. Energy has many forms, for example, heating elements convert _____ energy into _____ energy or heat.

2. **Thermocouples**: convert _____ energy into _____ energy. They are used as sensors in safety and control devices for: _____

   Explain how they work:

   What is the relationship between temperature difference and current?

3. **Piezoelectric effect** is the use of crystals, such as *quartz* in watches, to convert _____ energy into _____. Barbecue "spark" lighters use this effect but in _____.

4. **LEDs** stands for _____-_____ _____. They convert _____ energy into _____ energy when connected to a circuit in _____ direction.

5. **Photovoltaic cells,** which are also known as _____ _____, use a semiconductor such as silicon to convert _____ energy into _____ energy.

   Provide two examples:

Topic 5 – Portable Power

Electrochemical cells:

a. Originally called _____ _____, electrochemical cells converts _____ energy into _____ energy.

b. What are the main components in a **voltaic cell**? Describe the function of each component. Make a labeled diagram to illustrate how it works.

c. Differentiate between **anode** and **cathode**.

d. Differentiate between **wet** and **dry cells**. Provide examples of each.

e. Differentiate **primary** and **secondary cells**.

f. Differentiate between a **cell** and a **battery**.

g. Six 1.5 V cells connected in parallel would have a total voltage of ____ V while six 1.5 V cells arranged in series would have a total voltage of ____ V.

h. In a standard circuit, electrons leave the battery from the _____ terminal.

i. Assuming a large 1.5 V D-cell battery and a smaller C-cell battery supply the same current, which battery will last longer and why?

j. Using the learnalberta.ca website, complete the "Modifying Electrochemical Cells" experiment. Identify four factors within a voltaic cell that you could manipulate in order to produce a wet cell with the highest voltage. For each factor describe how you would manipulate it.

Fuel cells:

a. What are they?

b. How do they work?

c. What are their advantages and disadvantages compared other types of cells?

Topics 4–5 Review

1. Five 1.5 V cells are connected in parallel. Their total voltage is
   (a) 0.3 V
   (b) 1.5 V
   (c) 2.5 V
   (d) 7.5 V

2. Five 1.5 V cells are connected in series. Their total voltage is
   (a) 0.3 V
   (b) 1.5 V
   (c) 2.5 V
   (d) 7.5 V

3. Which of the following electrochemical cells would be classified as a "wet" cell?
   (a) a zinc-carbon cell
   (b) a zinc-air cell
   (c) a nickel-cadmium cell
   (d) a lead-acid cell

4. The scale on a certain voltmeter is designed to measure a maximum of 5 V and this scale is divided into 25 segments or divisions. Each division on the scale then represents a reading of:
   (a) 0.1 V
   (b) 0.2 V
   (c) 0.5 V
   (d) 1 V

5. What energy conversion is involved in each of the following:
   (a) a dry cell? _____
   (b) a thermocouple? _____
   (c) piezoelectric crystals? _____
   (d) light emitting diodes (LED's)? _____

6. Make a labeled diagram to illustrate the operation of a simple electrochemical (voltaic) cell.

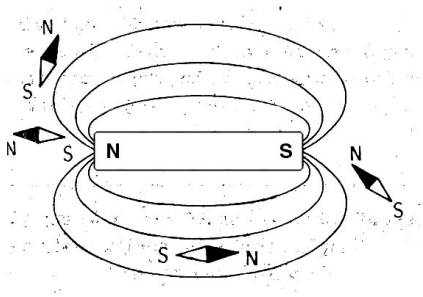
7. Match the appropriate term in column A with its definition in column B by placing the correct letter in the space provided beside each term.

	A	B
_____	1. thermocouple	(g) energy due to height
_____	2. photovoltaic cell	(b) device that converts heat to electricity
_____	3. elastic potential energy	(c) the two metals in a voltaic cell
_____	4. electrodes	(d) device that produces electricity from light
_____	5. gravitational potential energy	(e) energy stored in an object when it is forced out of its normal shape

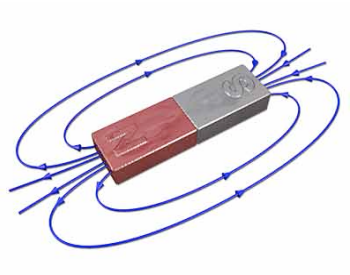
Topic 6 – Generators and Motors

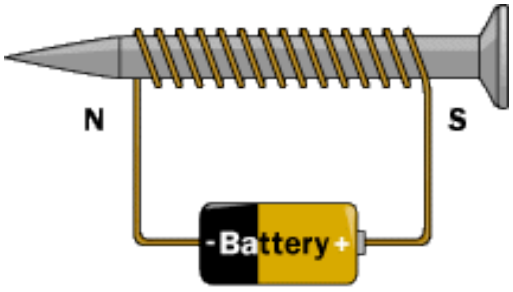
1. **Electricity to magnetism**: (p. 310)

   a. Hans Christian Oersted discovered that there is a relationship between _____ and _____. How did he make a compass needle move?



   b. There are two basic types of magnets: **permanent** (like a bar magnet) and **electromagnets**.





   How can you make an electromagnet?

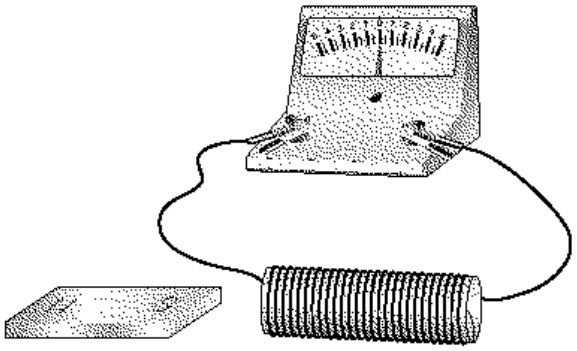
   Identify two ways you can make the electromagnet stronger.

   How can you reverse the polarity of an electromagnet?

   Make one!

2. **Magnetism to electricity**: (p. 312)

   a. Michael Faraday used the relationship between electricity and magnetism to create an electric current. Explain how?



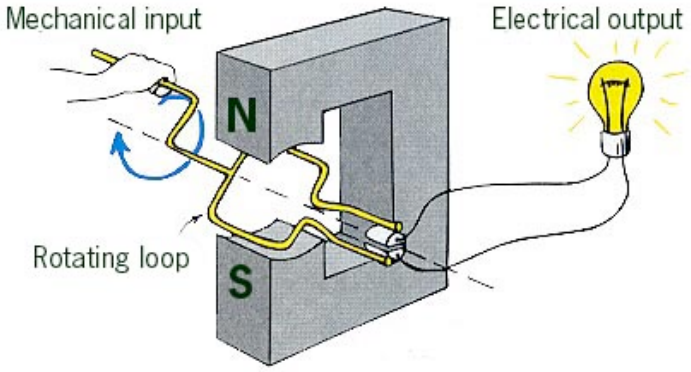
   b. In order for a current to be "induced", the magnet must be _____ relative to the coil of wire. This principle is used to develop generators and motors.

   c. Identify three factors you could change in order to increase the reading on the galvanometer (current).

3. **Generators**: (p. 310, 313-314)

   a. **Electrical generators** convert _____ energy into _____ energy.

   b. Explain how generators work.

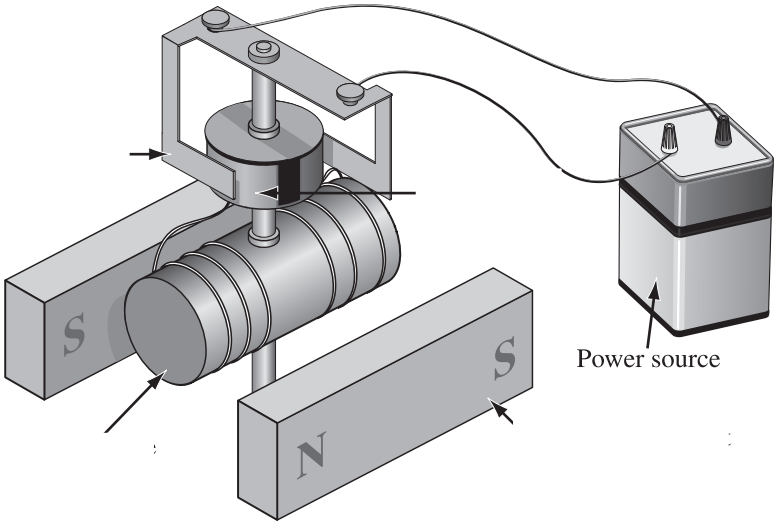


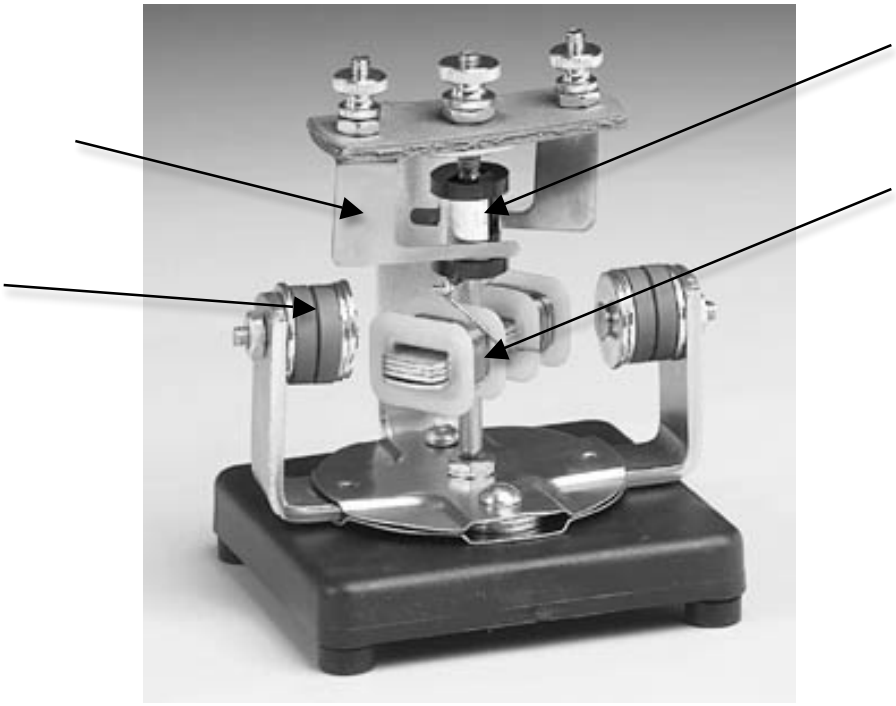
   c. What's the difference between **alternating currents (AC)** and **direct currents (DC)**? Why do we use AC in our homes?

4. **Motors**: (p.315 – 317)

   a. **Electrical motors** convert _____ energy into _____ energy.

   b. St. Louis motors are classic examples of a **DC motor**. After your teacher demonstrates how one works, label the diagrams below and explain the function of the (split-ring) **commutator, brushes**, **permanent magnets** and **armature**.





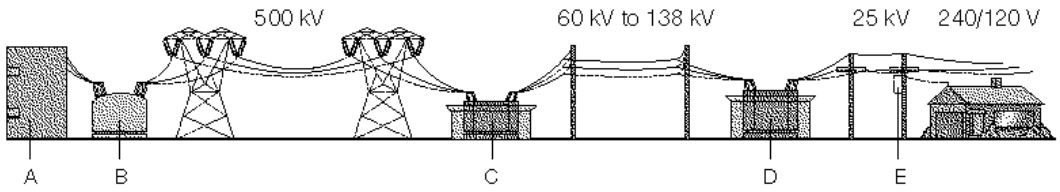
Topic 7 – Electricity in the Home

1. **Electrical Energy Transmission**:

   a. To minimize the amount of electrical energy lost from power lines, power companies transfer electricity at high _____. However, 120 000 V is too much for your blender to handle. Therefore there is a need to change voltage and this can only be done with _____ currents.

   b. _____ are devices that _____ (**step up**) the voltage or _____ (**step down**) the voltage.

   c. Explain how electricity gets from an electrical generating station to your home.



2. **House Wiring**:

   A _____ _____ on the side of your home records your electrical energy consumption. After being recorded, electricity then passes through the main _____ _____ located at the top of the _____ _____. Older homes may have _____ instead. (We studied these in topic 3). Individual breakers/fuses are located in the bottom of the panel for individual _____ _____.

3. **Microelectronic circuits**:

   Calculators, computers and other digital devices use microelectronic circuits that are _____ (short/long) in length. The current in these circuits is _____ (low/high) and the resistance is _____ (low/high). Microelectronic circuits uses _____ (switches/transistors) to control the flow of electrons.

4. **Measuring Power**:

   a. **Energy** (**E**), which is measured in **joules** (**J**), is defined as:

   b. **Power** (**P**) is defined as:

   c. The unit of power is the _____ (**W**). Because 1 W = 1 J/s, a 60 W light bulb uses 60 J of energy every second.

   d. Complete the following chart:

Quantity	Symbol	Units
Voltage		
Current		
Resistance		
Energy		
Time		
Power		Or J/s

   e. Power can be calculated using two different equations. Manipulate each equation to solve for each variable:

$$E = Pt$$

$$P = IV$$

Power Problems

A. Examples: Don't forget to use the G.R.A.S.S. format!

1. A hair dryer that has a power rating of 1000 W is plugged into a 120 V outlet. Calculate the current flowing through the dryer.

2. A microwave that has a power rating of 800 W is used for 30 minutes, how many joules of electrical energy were converted to heat?

3. A television draws 1.5 A when connected to a 120 V outlet. What is the power rating of the TV?

4. A 60 W light bulb is left on for 3 hours and a 100 W bulb was left on for 2 hours. Which bulb used more energy and how much more?

B. Calculate the following:

1. A gasoline-powered generator consumes 15000 J of energy in 5 minutes. How much power did it produce in this time?

2. A toaster connected to a 110 V power source has 6.0 A of current flowing through it. How much power is dissipated as heat?

3. A light bulb draws 1.25 A of current from a 120 V gas-powered generator. (a) How much power does the generator produce? (b) If the generator runs for 5 minutes, how much energy will the lamp convert into light and heat?

C. Complete Practice Problems #1 – 4 page 324.

1.

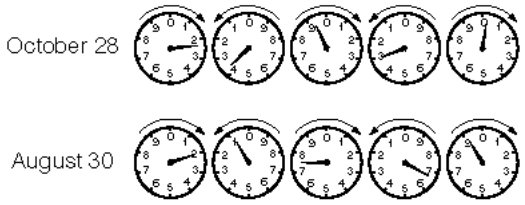
2.

3.

4.

5. **Paying for Electricity**:

   a. Use figure 4.47 (p. 324) to interpret how to read the following power meters:



   b. It doesn't take common electrical devices long to consume a large number of joules. For this reason, the **kilowatt hour** (**kWh**) is often used as a unit for energy.

1 kWh = 3.6 x 10^6 J

1 kW = 1000 W
1 h = 3600 s
1 kWh = 1000W x 3600 s = 3 600 000 J

   c. A household electrical bill shows the amount of electricity used and the price per kWh.

Pricing Problems

A. Examples

1. If a small 300 W appliance is left on for 40 hours, how much would it cost in total if the price of electricity were $0.07 per kWh?

2. At a cost of 10 cents per kWh, how much would it cost to leave a 60 W light bulb on for one day?

3. At a cost of 13 cents per kWh, how much would it cost to leave a 100 W exterior light bulb on if you were on holiday for two weeks?

B. Complete the following:

1. A meter reader determines that a business has used 3550 kWh of energy in two months. If electricity costs 10 cents per kWh, calculate the bill.

2. An electric heater draws 1100 W of power. Electricity costs $0.08 per kWh. How much does it cost to operate the heater 3 hours a day for 30 days?

3. A 750 W toaster and a 1200 W electric frying pan are plugged into the same 100 V outlet. How much will cost per hour to operate the two appliances at 8 cents per kWh?

C. Complete Practice Problems 1 – 3 p. 325 and the following Applied Power Problems page:

1.

2.

3.

6. **Electrical Efficiency**:

Unfortunately, we do not live in a 100% electrically efficient world. Energy is lost in many ways, for example, incandescent light bulbs produce wasteful heat and car engines produce heat and sound.

The most common type of energy loss in electrical devices is _____!

The efficiency of an object can be calculated as a percentage using the following formula:

$$efficiency = \left(\frac{output}{input} \right) x100\%$$

Calculating Efficiency

A. Examples:

1. A clothes dryer has a power rating of 4356 W. It takes an average of 45 minutes to dry a load of clothes. If the dryer used 8820 kJ of energy during this time, how efficient is the dryer?

2. Reading for an hour followed by an hour of homework, a student decides to check the efficiency of the halogen desk lamp used. The lamp is rated a 20 W and used 20.88 kJ of energy, how efficient is it?

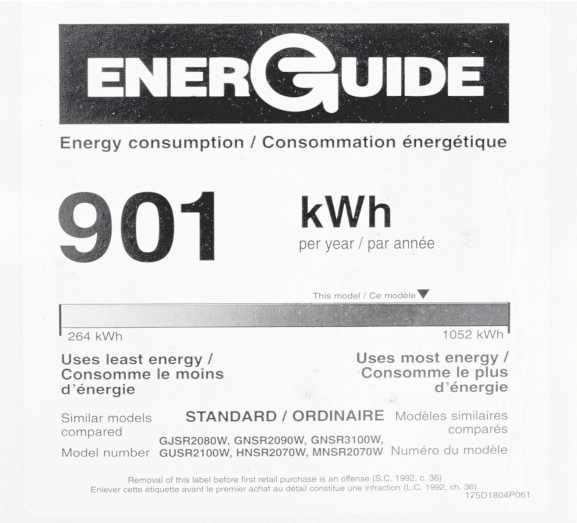
B. Complete Practice Problems 1 – 2 on p. 329

1.

2.

7. **Power Rating**:

The _____ labels, such as the one shown below, show how much energy an electrical device uses per year. Describe three ways in which electrical energy could be conserved with respect to home lighting (p. 328 may be helpful).



8. **Home Safety**:

Why are frayed or worn out electrical cords dangerous?

Topic 8 – Electricity Production and the Environment

1. Most of the electrical energy used in Alberta comes from non-renewable resources. Differentiate between **renewable** and **non-renewable** resources.

2. Summarize the following ways to generate electricity, indicate if the method is renewable or not, explain how the electricity is made, describe the energy conversions involved and identify the advantages (benefits/pros) and the disadvantages (costs/cons) of each method.

<table>
<tr><td>Fossil fuel (oil, gas, coal) combustion</td><td>Renewable/Nonrenewable</td></tr>
<tr><td colspan="2">How is the electricity produced?</td></tr>
<tr><td colspan="2">Energy Conversions:</td></tr>
<tr><td>Advantages:</td><td>Disadvantages:</td></tr>
</table>

Biomass	Renewable/Nonrenewable
How is the electricity produced?	
Energy Conversions:	
Advantages:	Disadvantages:

Hydroelectric	Renewable/Nonrenewable
How is the electricity produced?	
Energy Conversions:	
Advantages:	Disadvantages:

Nuclear Fission	Renewable/Nonrenewable
How is the electricity produced?	
Energy Conversions:	
Advantages:	Disadvantages:

Solar	Renewable/Nonrenewable
How is the electricity produced?	
Energy Conversions:	
Advantages:	Disadvantages:

Wind	Renewable/Nonrenewable
How is the electricity produced?	
Energy Conversions:	
Advantages:	Disadvantages:

Tidal	Renewable/Nonrenewable
How is the electricity produced?	
Energy Conversions:	
Advantages:	Disadvantages:

Geothermal	Renewable/Nonrenewable
How is the electricity produced?	
Energy Conversions:	
Advantages:	Disadvantages:

Topics 6–8 Review

1. Which factor below does *not* affect the strength of an electromagnet?
   (a) amount of current
   (b) direction of current
   (c) number of coils of wire
   (d) type of material in the core

2. A magnet can induce a voltage (potential difference) in a wire
   (a) when either the magnet or the wire move at an angle
   (b) when either the magnet or the wire move parallel to each other
   (c) only when the wire moves
   (d) only when the magnet moves

3. A light bulb is rated at 100 watts if it
   (a) must be operated from a 100 volt supply
   (b) draws a current of 100 amperes
   (c) burns out after using 100 joules of energy
   (d) transforms 100 joules of electrical energy every second

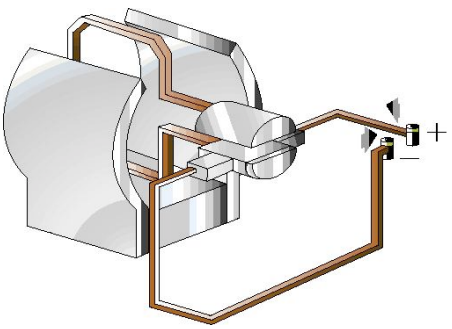
4. The function of the ground wire in an electrical circuit is to
   (a) return low-energy electricity to the generator
   (b) reduce the risk of electrical shock
   (c) supply high-energy electricity to the load
   (d) strengthen the cables and cords in the circuit

5. Thermal pollution from generating plants is controlled by
   (a) returning cooling water directly to lakes and rivers
   (b) returning cooling water to underground storage caverns
   (c) using cooling water in cogeneration systems
   (d) sending cooling water through ponds or towers before releasing it

Short Answer

Answer the following questions in the spaces provided.

6. Label the following parts of the motor on the picture below.
   (a) armature
   (b) brushes
   (c) commutator
   (d) field magnet



7. Arrange the following devices in their correct order in the electrical distribution system in a home.
   (a) step-down transformer
   (b) branch circuit
   (c) electrical appliance
   (d) power meter
   (e) outlet
   (f) branch circuit breakers of fuses
   (g) electrical panel and main breaker

8. Give the full name and the proper symbol for each unit of measurement below.
   (a) electrical energy (SI unit)
   (b) electrical energy (customary unit)
   (c) electrical power

9. Write the proper formula for each calculation listed below.
   (a) finding power from measurements of current and voltage
   (b) finding efficiency from measurements of input energy and output energy

10. Rank in order of efficiency (least efficient to most efficient).
    (a) halogen light bulbs
    (b) fluorescent light bulbs
    (c) incandescent light bulbs

11. State two simple safety measures for using electricity. Explain how each precaution reduces the risk of injury from electrical shock.

12. A 1200 watt electric heater in a garage is accidentally left on for seven full days. If the price of electrical energy is 11.0 cents per kilowatt hour, how much money was wasted by running the heater unnecessarily?

	Electrical Energy Source	Environmental Problem
13.	thermonuclear generators	A. waste gases cause air pollution
14.	hydroelectric plants	B. storage of radioactive waste
15.	coal-burning thermoelectric plants	C. water reservoirs change ecosystems
		D. static electric discharge affects wildlife

Match each term with the most appropriate definition.

	Term	Definition
16.	alternating current	A. basic element in digital circuits
17.	direct current	B. removes polluting chemicals from exhaust gases
18.	transistor	C. direct path for electricity to ground
19.	non-renewable resource	D. voltage is easily changed
20.	scrubber	E. consumed faster than can be replaced
		F. flows in one direction

21. Choose *one* alternative energy source from the list below. Briefly describe how it is used to produce electrical energy, what conditions are necessary for its use, and one environmental benefit it offers.
    Alternative energy sources: geothermal wind solar tidal

Unit D Review – "I Can" Statements

I can: (Topic 1)

- Explain static electricity and provide examples
- Explain the laws of charge
- Identify examples of electrical conductors and insulators

I can: (Topic 2)

- Explain current electricity
- Draw a circuit diagram of a series circuit showing loads, conductors, and switches
- Measure voltage and amperage in a circuit using a multi-meter

I can: (Topic 3)

- Explain resistance
- Differentiate between resistors and variable resistors
- Describe Ohm's law
- Mathematically solve for resistance when given current and voltage
- Compare a water flow analogy to electric current flow
- Explain the characteristics of series and parallel circuits
- Describe the factors that affect resistance.

I can: (Topic 4)

- Define and interpret examples of mechanical, chemical, thermal, and electrical energy
- Provide different examples of energy transfer

I can: (Topic 5)

- Design an electrochemical cell
- Evaluate different electrodes and electrolytes in an electrochemical cell

I can: (Topic 6)

- Describe how generators work
- Identify how you can manipulate the output of a generator
- Describe how motors work

I can: (Topic 7)

- Compare a house circuit to a microelectronic circuit
- Define and calculate power using the appropriate formula
- Define and calculate energy using the appropriate formula
- Calculate the cost of energy used by electrical devices
- Give examples of waste energy
- Define and calculate the efficiency of a device using the appropriate formula

I can: (Topic 8)

- Distinguish between renewable and nonrenewable sources of energy
- Explain sources of electrical energy and their benefits: coal, gas, oil, hydro, nuclear, wind, solar, tidal and biomass
- Describe by-products of electrical energy generation and their impacts on the environment.