Physical Science Study Guide
Unit 6
Energy, Work, Electricity, Magnetism, Generators

Objectives:

PS-6.1 **Explain** how the law of conservation of energy applies to the transformation of various forms of energy (including mechanical energy, electrical energy, chemical energy, light energy, sound energy, and thermal energy).

PS-6.2 **Explain** the factors that determine potential and kinetic energy and the transformation of one to the other.

PS-6.3 **Explain** work in terms of the relationship among the force applied to an object, the displacement of the object, and the energy transferred to the object.

PS-6.4 **Use the formula**, $W = Fd$ to solve problems related to work done on an object.

PS-6.5 **Explain** how objects can acquire a static electric charge through friction, induction, and conduction.

PS-6.6 **Explain** the relationships among voltage, resistance, and current in Ohm's law.

PS-6.7 **Use the formula**, $V = IR$ to solve problems related to electric circuits.

PS-6.8 **Represent** an electric circuit by drawing a circuit diagram that includes the symbols for a resistor, switch, and voltage source.

PS-6.9 **Compare** the functioning of simple series and parallel electrical circuits.

PS-6.10 **Compare** alternating current (AC) and direct current (DC) in terms of the production of electricity and the direction of current flow.

PS-6.11 **Explain** the relationship of magnetism to the movement of electric charges in electromagnets, simple motors, and generators.

Key Terms and Concepts:

Law of conservation of energy
Work
Kinetic energy
Potential energy
Energy forms-
Mechanical energy
Electrical energy
Chemical energy
Light energy
Sound energy
Thermal energy
Energy transformation
Static electricity
Conduction, induction, friction
Electroscope
Ohms Law
Voltage
Current
Resistance
Series circuits
Parallel circuit
Dry cell/battery
Alternating current
Direct current
Electromagnet
Electromagnetic induction
Generator
Transformer (step up/step down)
Magnet
Magnetic poles
Electric motor

Energy:

Energy is the property of an object that enables it to do work (or cause change). Energy comes in many forms. There are ***seven*** different kinds of energy; mechanical; chemical; nuclear, electrical; thermal; light; and sound energy.
The ***Law of conservation of energy*** states that energy cannot be created or destroyed, but, can be transformed from one form to another, e.g. light bulb, car (gasoline-chemical potential energy into motion-kinetic energy), light energy from the Sun into chemical energy by plants (photosynthesis) etc. Most energy transformations are ***not*** 100% efficient, e.g. a car engine is only 23% efficient with energy lost in the form of heat.

Potential energy is energy that is ***stored***. The amount of potential energy depends on ***height*** and ***weight*** (mass times acceleration due to gravity, or $F_w = mg$) expressed as the equation PE = $m \times 9.8\ m/s^2 \times h$. Therefore, the ***greater*** the ***height*** the ***more gravitational potential*** energy the object has. Increasing the speed of an object does ***not*** affect its potential energy.
Kinetic energy is energy of ***motion***. The amount of kinetic energy depends on ***mass*** and ***speed*** (i.e. KE = $\frac{1}{2}mv^2$). Therefore, kinetic energy is greater when the speed and mass of an object is greater. Conversely, kinetic energy is less when the mass and speed of a moving object is less. It is ***not essential*** to solve problems related to potential or kinetic energy using the equations.
Transformations can occur between potential energy and kinetic energy, e.g. lifting an object and dropping it.
Mechanical energy is the total amount of potential and kinetic energy.

Work:

Work is done when a force is applied to an object, and the object ***moves*** in the direction of the applied force. Energy doesn't have to involve motion.
Be able to solve problems for any variable in the equation, W = Fd, F=W/d, or d=W/F.
Joules is the SI unit for energy AND work.
Watt is the unit of power. ***P=VI***. Be able to solve problems using P=VI.
It is **not** essential to solve problems for input and output work of simple machines, efficiency; friction; nor power.

Static electricity:

Static charge is the result of ***build–up/accumulation*** of electric charge, subsequently transferring that charge. ***Like*** charges ***repel*** each other and ***opposite*** charges ***attract***. Clouds build static and lighting is a large discharge of static discharge. A lightning bolt occurs when billions of ***electrons*** are transferred at the same time. A static discharge differs from an electric current in that a static discharge lasts for only a fraction of a second. Objects can be charged by three routes including: ***Friction*** when one object is rubbed against another the electrons leave one object and stick to the other leaving both objects charged (e.g. balloon expt.); ***conduction*** *w*hen a charged object touches another object some charge/electrons will transfer to the other object, and ***induction*** when objects can be charged by bringing a charged object near a neutral object.
The presence of an electric charge can be detected by an ***electroscope***. If the leaves of an electroscope spread apart, it indicates that the leaves of the electroscope have received a charge.

Electricity:

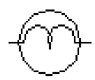
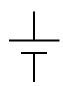
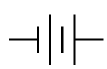
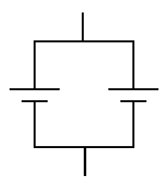
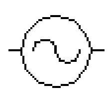
Voltage is the electric potential energy and is the ***push*** for electrons through the circuit. Voltage difference is measured in volts and has the symbol **V**. Voltage can be created by a chemical (dry) cell (i.e. battery) when it changes chemical energy to electrical energy, or by a generator when it changes mechanical energy to electrical energy. Electrons in the wire are pushed by the negative terminal and pulled by the positive terminal through the wire.
Electric current is the flow of charge/**electrons** through a conductor and is measured in *amperes* or **amps** having the symbol **A**.
Electric resistance opposes the flow of charge/electrons through a conductor. All conductors have some resistance to an electric current when the electrons flowing through the wire continually run into metal atoms and bounce around. These collisions can create thermal and/or light energy. Resistance is measured in ***ohms*** having the symbol Ω.

Ohms law describes the relationship between voltage, current, and resistance (**V = I R**). One volt will pull one amp of current through one ohm of resistance. If the voltage increases and the resistance remains the same, the current will increase and vice-a-versa. Be able to solve for any of the variables in the equation (V=IR, or I=V/R, or R=V/I).

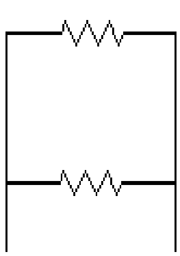
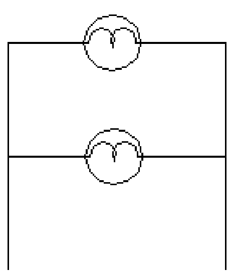
Components of an ***electric circuit:*** sources of voltage are chemical cells (e.g. a battery-dry cell and car battery-wet cell), solar cells, and generators. Sources of resistance are resistors, light bulb filaments, and other electric devices.

A fuse, or a circuit breaker, is a device used to keep electrical circuits from overheating.

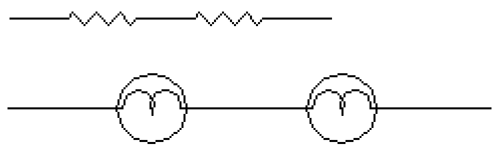
Be able to ***draw/represent the following components/***symbols of a circuit:

Wires	
Resistors	
Light bulbs	
Switches	
Chemical cell	
Battery circuit with 2 cells wired in series	
Battery circuit with 2 cells wired in parallel.	
AC source (generator)	

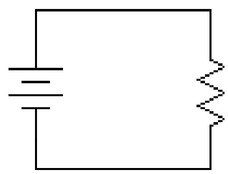
AND represent a circuit with resistors or light bulbs ***wired in parallel***.

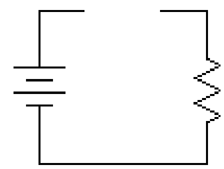
 

AND a circuit with resistors or light bulbs ***wired in series***.



Be able to ***represent circuits by drawing a circuit diagram*** from a circuit which is pictured or described. ***Interpret a circuit diagram*** such as whether it is a ***series or parallel, and/or an open or closed circuit***, e.g.





Closed circuit with a battery and a resistor   Open circuit with a battery and a resistor

The current that flows in an electric circuit carries electrical energy.
A device that increases (step-up) or decreases (step-down) voltage in a power line is a transformer.
In the United States, power lines can carry power voltages as high as 750,000 V, a step-down transformer reduces the voltage to 120 V for home use.
An insulator is a material that does allow electrons to flow through it easily whereas a conductor allows the floe of electrons. List two materials that are conductors and two materials that are insulators.
Different household appliances use electrical energy at different rates.
The rate at which an electrical device converts energy from one form to another is called electrical power.
A ***series circuit*** has a ***single path*** for electrons to flow. The current in the circuit decreases when additional resistors are added. When light bulbs are wired in series and one is removed or burns out all of the lights in the circuit go out such as on a Christmas tree lights.
When resistors are wired in ***parallel***, there is ***more than one path*** that the electrons can travel. The voltage in each path is the same. When another resistor is wired in parallel, then the total resistance is reduced. If light bulbs are wired in parallel and one bulb burns out or is removed, the other bulbs keep burning because the circuit is still complete. You do not need to be able to calculate the total resistance, current in each branch, nor total voltage in a series or parallel circuit.
Chemical cells can be wired in series to make a battery and will increase the voltage of a battery. When wired in parallel to make a battery the voltage does not change.
Direct current (DC) flows in one direction. One source of constant electric (DC) current is a dry cell (i.e. battery). When a circuit is connected to the battery terminals the electrons will move from the negative terminal to the positive terminal.
Alternating current (AC) moves back and forth. Your home outlets provide 120 Volts AC. AC current is produced by a generator using the principle of ***electromagnetic induction***. The current is produced when a magnet moves relative to a coil of wire. In a generator the magnet (or coil) spins causing the terminals of the generator to alternate between positive and negative.

Magnetism, Motors, & Generators:

Magnetism is the region around a magnet where the magnetic forces act is the magnetic field. The atoms in a magnet are aligned according to magnetic fields, or domains. Objects that keep their magnetic properties for a long time are called permanent magnets. The magnetic force of a magnet is strongest at the poles. When you bring the south end of two magnets close together, they repel each other.

Electromagnetic induction is when a wire or a coil of wire moves in a magnetic field producing an electric current. A device that uses an electromagnet to measure electric current is a galvanometer.

Electromagnets: Electric currents in wires produce magnetic fields around the wire. The magnetic field can be increased/strengthened in several ways including: wrapping the wire in a coil; increasing the number of turns in the coil, adding a *core* (like iron), and increasing the current in the coil.

Electric motors change electrical energy to mechanical energy. Motors contain an electromagnet called an ***armature***. Motors use the magnetic force from magnets to spin an armature (magnetized by an electric current) and thus change electric energy to mechanical energy.

Generators change mechanical energy into electric energy using electromagnetic induction to produce an electric current. A generator is similar to an electric motor and produces AC current. In a generator at a power plant another type of energy, e.g. stream turns a turbine which spins a magnet past a coil of wire (having a magnetic field) pushing electrons through the wire.