Name ________________________________

EM Wave Activity Page

Station 1: The Wave Equation

As you saw in the electromagnetic spectrum diagram, the wavelength and frequency of a wave determine the characteristics of a wave. Through the wave equation, we know that the speed of a wave is equal to the wavelength times the frequency.

$$v = \lambda \cdot f$$

Where v is the velocity or speed, measured in meters per second (m/s), λ is wavelength, measured in meters, and f is frequency, measured in inverse time (1/seconds).

Sometimes a scientist can measure some of the values but not the others, which means they must be able to manipulate the equation to find the missing values. Below are some practice problems. Please work with your partner to complete them.

The speed of electromagnetic (EM) radiation, including "light" and "radio" waves, is constant in any given medium. For our purposes, it is precise enough to state that the speed of EM radiation in space and Earth's atmosphere is 3.00×10^8 m/s. This constant value of the speed of light is given the symbol c.

$$c = 3.00 \times 10^8 \text{ m/s}$$

1) Researchers determined an electromagnetic wave had a wavelength (λ) of 4.87×10^{-7} m. What is its frequency?	2) The AM radio band extends from 5.4×10^5 to 1.7×10^6 Hz. What are the longest and shortest wavelengths in this frequency range?

3) FM radio stations in the United States broadcast in the “very high frequency” (VHF) portion of the radio spectrum between 88 and 108 MHz. If an FM station is broadcasting at 97.5 MHz, what is the wavelength of the EM radiation?

4) Most modern microwave ovens operate at a frequency of 2.45 GHz. What is the wavelength of this radiation?
   a) in m? b) in cm?

5) Gamma-ray busters are objects in the universe that emit pulses of gamma rays with high energies. The frequency of the most energetic bursts has been measured at around $3.0 \text{ X } 10^{21}$ Hz. What is the wavelength of these gamma rays?

6) Shortwave radio is broadcast between 3.50 and 29.7 MHz. To what range of wavelengths does this correspond? Why do you suppose this part of the spectrum is called shortwave radio?

7) What is the frequency of an electromagnetic wave if it has a wavelength of 1.0 km?

8) The portion of the visible spectrum that appears brightest to the human eye is around 560 nm in wavelength, which corresponds to yellow-green. What is the frequency of 560 nm light?

9) What is the frequency of highly energetic ultraviolet radiation that has a wavelength of 125 nm?	10) What is its wavelength if an electromagnetic wave has a 7.57 X 1014 Hz frequency? To what part of the spectrum does this wave belong?
11) The compound eyes of bees and other insects are highly sensitive to light in the ultraviolet portion of the spectrum, particularly light with frequencies between 7.5×10^{14} Hz and 1.0×10^{15} Hz. To what wavelengths do these frequencies correspond?	12) The brightest light detected from the star Antares has a frequency of about 3×10^{14} Hz. What is the wavelength of this light?
13) What is the wavelength for an FM radio signal if the number on the dial reads 99.5 MHz?	14) What is a radar signal's wavelength with a frequency of 33 GHz?
15) Why do astronomers observing distant galaxies talk about looking backward in time?	

Station 2: Electromagnet Station

All non-living materials are made up of atoms. Each atom is made of three subatomic particles: protons, electrons, and neutrons. The electrons in an atom are continuously rotating both around the nucleus (similar to the Earth around the Sun) and on its axis. Since electrons carry a charge, this continuous rotation creates an electrical current. Typically, a material contains equal numbers of electrons spinning in opposite directions, so these electric currents cancel each other. However, in some materials, more electrons spin in the same direction, which causes an electric current which in turn causes that material to be potentially magnetic. Many objects made of these materials do not act as a magnet. However, that is because the atoms with electrons spinning in the same direction are scattered throughout the object. This separation keeps these materials from acting as a magnet. However, suppose an action, such as beating or introducing an electric current, takes place. In that case, the atoms can be rearranged into magnetic domains. When this happens, the once non-magnetic object acts as a magnet. An electromagnet is a device that uses electricity to create a magnetic field. At this station, you will attempt to create a magnet with some everyday household items.

Important You must follow the directions about hooking up the battery to your coil. Failure to do so could result in electric shock.

Materials: battery holder, D battery, magnet wire, sandpaper, an iron nail, a battery holder, and paper clips.

Procedures

1. Make sure the battery is out of the battery holder
2. Take a length of copper wire. Use the provided ruler and record the length of this wire in cm and record in the appropriate spot under #6.
3. If the ends are not already stripped, use the sandpaper and carefully remove the outer coating for the last ½ inch of wire on each end.
4. Then wrap the wire around the nail a few times (you don't need to use the entire wire), leaving the exposed or stripped ends free.
5. Use the alligator clips to connect the ends of the wrapped wire to the wires on the battery box.
6. Once the wires' exposed ends have been connected, you may place the battery in the holder. **Caution ** DO NOT TOUCH THE EXPOSED PORTIONS OF WIRE ONCE THE BATTERY IS IN THE BOX!
7. Pick up the nail and see if you can pick up any paper clips.
8. Record the following.
   Length of wire ________________

   Number of coils around the nail __________

Direction of coil (clockwise or counterclockwise) ______________________

Number or paperclips picked up __________________________

9. Remove the battery from the holder. ONLY AFTER THE BATTERY IS OUT should you touch the wires. Then, carefully unwind the wires and take apart your apparatus, smoothing out the wire.
10. How can you improve your magnet? First, choose one of the variables listed in number 6 and change your procedures. Then, on the lines below, describe what you will do differently and why.

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11. Reset up your apparatus by repeating the steps in #2. REMEMBER, THE BATTERY STAYS OUT OF THE HOLDER UNTIL THE VERY END! Record your observations below.

    Length of wire _________________

    Number of coils around the nail ___________

    Direction of coil (clockwise or counterclockwise) ______________________

    Number of paperclips picked up __________________________

12. Take the apparatus apart. REMEMBER, THE BATTERY COMES OUT FIRST!
13. Conclusions
    a. Was your hypothesis correct? Did your second setup pick up more paper clips than the first? If not, explain your observations.

Station 3: Electromagnetic Induction

Electric and magnetic fields affect one another to create an electromagnetic wave. Michael Faraday was an influential British scientist during the 17th century. He made several important scientific discoveries during his lifetime, including one about electrical and magnetic fields referred to as Faraday's Law of Induction. Faraday's law tells us that we can induce voltage into a conductor if it is exposed to a magnetic field.

At this station, you will test the idea that a magnet can be used to create electricity.

Do you believe in Faraday's results? Why or why not?

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Materials: magnet wire, sandpaper, galvanometer, a bar magnet, alligator clips

Procedures:

1. Take a length of wire and loosely wrap it around two of your fingers several times, creating a coil. Be sure you leave two inches loose on each end in order to connect to the meter.
2. Take a small piece of sandpaper and gently remove the insulation from the last ½ inch of the two ends of the wire.
3. Use the alligator clip to connect one end of the wire to the red post of the meter. Use the other alligator clip to connect the other wire end to the black post. Follow your teacher's instructions about how to clip onto the post.
4. Hold on to the coil and pass the bar magnet through quickly. The other members of the group should be focused on the meter. Do this several times – until the group has three accurate readings.

5. Average the three readings and record your value here ____________

How can you improve this number? What variables have the potential to affect the amount of voltage created? -

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6. Determine which variable you are going to focus on. _____________________________

7. In the space below, describe the experiment you will carry out.

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8. Repeat step 4 above. Record your value here _________________________

How can you improve this number? What variables have the potential to affect the amount of voltage created? -

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9. Determine which variable you are going to focus on. _____________________________

10. In the space below, describe the experiment you will carry out.

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11. Repeat step four from above. Record your value here ___________________________
12. From your experimentation, write a general rule about how to increase the voltage created through electromagnetic induction.

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Station 4: Reading the textbook on electromagnetism

You will spend time reading the assigned pages on electromagnetism at this station. Follow your teacher's instructions regarding the page numbers and reading strategies you will employ during this activity.

After you have finished the reading, write a one-page position paper that supports either a wave or particle model. You should support your choice with evidence from the readings.