Radio waves and electromagnetic fields essay sample

•When you go to the simulation you will have a choice to either run the simulation or download the simulation. Run may not work on all computers. If it does not run, download the simulation and work from there. •When the simulation opens, play with the controls and buttons to become familiar with how the simulation works. •Note: A formal lab report is not required for this activity. You may cut and paste this worksheet to a new Word document and adjust the spacing to fit your needs. Procedures

•Open the simulation.

•Explain how the radiating electric field (or electromagnetic signal) is produced when radio stations broadcast. A radio wave (radiating electric field) propagates out from the source, traveling at the speed of light. The source, for example an antenna, creates oscillating electric(E)/ magnetic(B) fields. These fields are perpendicular not only to each other but to the direction of the traveling wave, and travel away from the antenna. The electromagnetic wave is, therefore, a transverse wave. The electric/ magnetic fields store the energy of the wave. Basically, the oscillating current to the antennas sets the electrons in motion. These electrons, being accelerated, create discontinuity in the electromagnetic field. •Briefly explain what is actually producing the radio signal. Energy, in the form of electromagnetic radiation, exerts steadily oscillating force on charges (electrons). The force is originally exerted strongly in one direction, but then reverses for the cycle to continue.

The radio waves push on the electrons in the metal in the antenna, causing the oscillating up and down the length of the source (antenna). The current is this created in the antenna. •Adjust the transmitter on the simulator so that it is in the sinusoidal mode and the electrons are oscillating up and down at a regular frequency. Ensure the “ display the curve” and the “ radiated field” boxes are checked. What does the curve represent? Briefly explain below. The curve represents the direction of the force exerted by the electromagnetic wave on a charge. Also, the strength of this force on an electron.•Set the frequency and the amplitude at the midpoint of the slider. Approximately how many grid marks is the wavelength of the wave? Round to the nearest whole grid mark. If the amplitude of the wave is increased, what happens to the wavelength? Support your answer with a proposed explanation. 10 grid points. The wavelength of the wave is the distance between either: (a) one peak and the next peak, (B) the minimum of one and the minimum of the next, or (c) any two points that make one complete wave cycle.

This distance is the wave’s travels from when the electron is at the peak of its motion and the next time it is at the peak of its motion. If the amplitude of the wave increased, the wavelength stays the same. The amplitude will affect the force’s strength (length of the foe vectors in the electromagnetic wave). However, the wavelength depends on the frequency with which the electron in the transmitting antennas is oscillating up and down (sped of light). Hence the equation: speed of light = wavelength x frequency. •Use the simulation to evaluate the following true or false statements. If the statement is false, what would have to change in order for the statement to be true? Type True or False and place comments or explanations in the boxes below. True or False: If the oscillation frequency of the transmitting electron decreases, the oscillation frequency of the electron in the receiver is instantaneously affected. False: the electron in the receiver will feel the force resulting from the electromagnetic wave at it's current location alone. It will know of the transmitting electron because of the effects the transmitting electron has on the electromagnetic waves.

The electron in the receiving antenna keeps oscillating at its original frequency (until the electromagnetic waves with the new frequency come). They will move in the direction towards the receiving antenna at the speed of light. True or False: The electron in the receiving antenna oscillates at a lower frequency than the electron in the transmitting antenna because of the distance between the two antennas. False: when the transmitting antenna's electron oscillates, it sets up on an electromagnetic wave that oscillates at the same frequency. This wave causes the electron in the receiver to oscillate at the same frequency. Electrons, therefore, in both the transmitter and receiver (antennas) oscillate at identical frequencies. True or False: If the frequency of oscillation increases but the amplitude of the electron oscillation remains the same, then the electron in the transmitting antenna is experiencing larger accelerations (recall what you know about acceleration and motion).

True: electrons must move faster as they oscillate back and forth in order for the frequency to increase while the amplitude remains the same. Delta velocity / time is a measure of the average acceleration. A larger change in velocity than at the old frequency if the electron is ovine faster towards its peak height than away from its peak height at the new frequency. Moreover, the time for this change is velocity to be seen is less than for the old frequency. These changes indicate acceleration is larger. True or False: If the amplitude increases but frequency remains the same, the electron at the receiving antenna experiences larger peak forces but oscillates at the same frequency as before. True: the larger the acceleration is, of the transmitting electron, the stronger the electromagnetic radiation emitted is (larger force vectors). When amplitude of the transmitting electron increases, larger acceleration is experienced by the electron in the transmitting antenna.

The magnitude/ strength of the force on the electron produced is, therefore, larger. The force on the electron results from the strength of the electromagnetic wave. The frequency of the wave determined the speed that the electron oscillates. True or False: If the frequency of the transmitting electron decreases by a factor of 2, it will now take longer for the electromagnetic signal to reach the receiving antenna. False: the speed of light is constant, which is the sped at which electromagnetic waves travel. True or False: If the frequency decreases, the wavelength decreases. False: If the frequency decreases , the wavelength would increase. This is easily seen, as wavelength and frequency are related by the following: frequency x wavelength = speed of light. meaning, wavelength = speed of light / frequency. True or False: The electromagnetic waves generated by the transmitting antenna produce currents in the receiving antenna.

True: electrons in the receiver move up and down, responding to the forces put on them by electromagnetic waves. This results in current being detected in the receiver (a current consists, after all, of moving charges). True or False: When the electron in the transmitting antenna is at its peak height, the electron in the receiving antenna is always also at its peak height. False: two receivers are set up a distance away from each other equal to 1/2 of the wavelength of the electromagnetic waves. When electrons in the first are pushed upwards, the electrons in the second are pushed downward. If, therefore, the electrons in the first antennas were at their peak height at the same time the electrons in the transmitting antennas, the electrons in the second would be at their lowest height. State clearly how the simulation supports your answers to these questions.

Don’t just guess true or false. •For the radio wave transmitter in the simulation, which of the following orientations of the receiver antenna will pick up the signal? (Select all that apply.) a. An antenna oriented vertically b. An antenna oriented horizontally (parallel to the ground) with one tip pointing towards the transmitting antenna (so it is oriented east-west) c. An antenna oriented horizontally and perpendicular to the antenna in the previous answer (so it is oriented north-south) Support your choice(s) in the box below.

a. an antenns oriented vertically

c. an antennas oriented horizontally and perpendicular to the antennas in the previous answer (so it is oriented north-south) Antennas work best parallel with the transmitter (electromagnetic wave forces push electrons along the length of the receiver, back and forth). An electromagnetic wave’s force doesn’t push electrons (no current flow) when the receiver is perpendicular to the transmitter antenna. Then electrons will feel a force along the rod’s radius. •Which one of the following sets of graphs (position vs. time, velocity vs. time, and acceleration vs. time) corresponds with the motion of the electron in the receiving antenna? (It may help to remember the relationship between force and acceleration, and use the “ Step” feature to step through the motion of the electron and have the vectors display the " force on an electron."). •Support your choice(s) in the box below.

F: the position, velocity, and acceleration oscillate smoothly (a/b are out). Also, when the electron is at its maximum or minimum, its velocity is zero. Furthermore, when the electron is the highest it can go, its acceleration must be downwards and when the electron is the lowest it can go, its acceleration must be upwards. This is because the velocity is zero, instantaneously; soon it will be positive so the acceleration must also be positive. Graph F alone satisfies these criteria. •Final conclusion/comments: How did this simulation activity enhance your understanding of how radio waves are transmitted and received? As stated above, the source such as an antenna creates oscillating electric and magnetic fields. These fields are perpendicular (to each other and the wave's direction) and store the energy of the transverse wave. The antenna converts lactic currents into radio waves. A radio transmitter applies the oscillating radio frequency lactic current to the antenna's terminals; the antenna radiated energy from the current (electromagnetic. radio waves). This is transmission. Lab Question

1. When an electromagnetic wave is reflected from a moving reflector, the frequency of the reflected wave is different from that of the initial wave. Explain physically how this happens. Solution: This is the Doppler Effect phenomenon. As the wave source moves, the wave pattern changes shape. The time between one peak wave emitted and the next allows the source to move (shells are not concentric). Waves are closer together in front of the source as it travels, and are farther apart behind it. This translates into a

wavelength change. The speed of light remains constant, the equation is only satisfied if the frequency changes, correspondingly. Lab Problem

Radio station WCCO in Minneapolis broadcasts at a frequency of 830 kHz. At a point some distance from the transmitter, the magnetic field amplitude of the electromagnetic wave from WCCO is 4. 82E-11 T. Calculate:

a. The wavelength of the electromagnetic wave, λ

b. The wave number

c. The angular frequency

d. The electric field amplitude

Show all work.

Given, frequency = c (speed of light) / wavelength, wavelength = c / frequency

c = 2. 99 E8 m/s wave number = 2pi/ wavelength angular frequency = 2pi x frequency

E/H = ratio of electric to magnetic field = c x u

Therefore,

E = H*c*μ_o

H = 4. 82 E-11 T

Solution:

a. When frequency = 830 E3 Hertz, then wavelength = 3. 61 E2 meters

b. 1. 74 E-2

c. 5. 21 E6 rad/s

d. 4. 82 E-11 T * 2. 99 E8 m/s * 4pi E-7 = 1. 81 E-8 N/C