Maxwell's Equations

James Clerk Maxwell – Scottish physicist who showed that ______________ and ______________ together create ________________ waves

Maxwell's Equations

1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________

Maxwell predicted that the __________ of electromagnetic waves would be

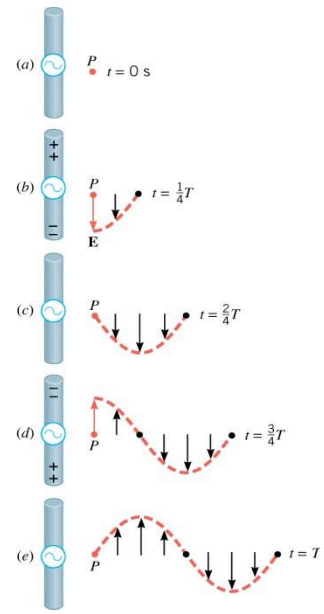
$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3.00 \times 10^8 \frac{m}{s}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$$

$$\mu_0 = 4\pi \times 10^{-7} \frac{T}{Nm}$$

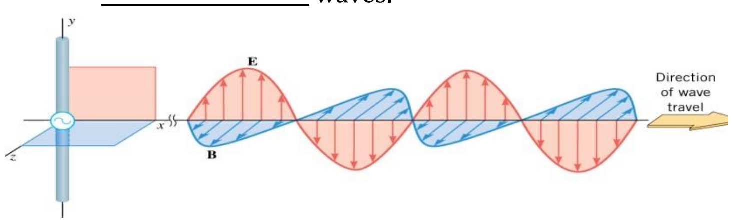
Heinrich Hertz was the first scientist to __________ and __________ EM waves.

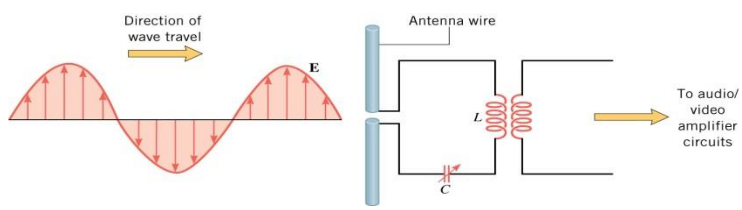
Production of EM Waves



Creation of electromagnetic waves

- Two __________ are connected to either side of an __________ generator to form an __________.
- As the __________ of the generator changes a __________ __________ between the __________ of the wires is created.
- The potential difference makes an __________ field.
- As the AC generator changes __________, the electric field direction is __________.
- Also, as the potential difference changes __________, the __________ in the antenna __________ to the other ends creating a __________.
- Current __________ a __________ ________________ to the wire.
- Electromagnetic waves are both __________ and __________.
- Field are ______________ to each __________ and the __________ of travel.
- ______________ waves.



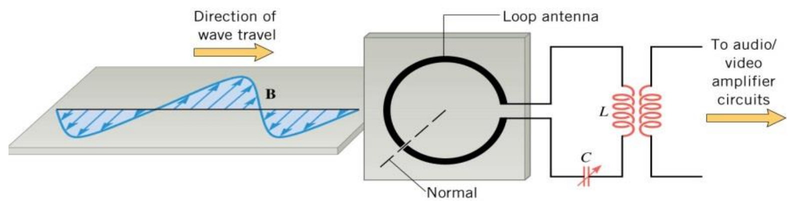


To detect EM waves

- Need __________ to receive either __________ or __________.
- E-field – __________ antenna
  - The E-field causes __________ to flow in the opposite direction creating __________ that changes with time as the E-field changes.
  - The __________ attached to the antenna let you pick the frequency (LC-circuit) and __________ it for speakers.

Physics 11-01 Maxwell's Equations and Production of EM Waves Name: ____________________

- B-field – __________ antenna
  - The B-field flowing through the loop __________ a __________ that changes as the B-field changes.



Relating the E-field and B-field strengths

- Stronger __________ creates greater __________ which makes greater __________

$$\frac{E}{B} = c$$

EM waves can travel through a __________ or material because E- and B-fields can exist in both.

- All EM waves travel the same __________ in a vacuum.

$$c = \underline{\hspace{3cm}}\ \frac{m}{s}$$

- Frequency of the wave is determined by the __________.

Homework

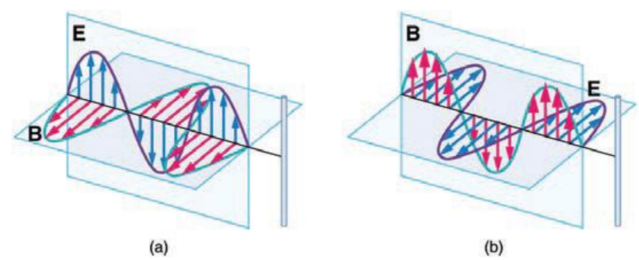


Figure 1

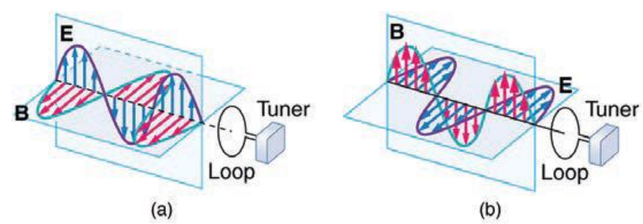


Figure 2

1. In which situation shown in Figure 1 will the electromagnetic wave be more successful in inducing a current in the wire? Explain.
2. In which situation shown in Figure 2 will the electromagnetic wave be more successful in inducing a current in the loop? Explain.
3. Should the straight wire antenna of a radio be vertical or horizontal to best receive radio waves broadcast by a vertical transmitter antenna? How should a loop antenna be aligned to best receive the signals? (Note that the direction of the loop that produces the best reception can be used to determine the location of the source. It is used for that purpose in tracking tagged animals in nature studies, for example.)
4. Verify that the correct value for the speed of light c is obtained when numerical values for the permeability and permittivity of free space (μ_0 and ε_0) are entered into the equation $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$. (OpenStax 24.1) $\mathbf{3.00 \times 10^8\ m/s}$
5. What is the maximum electric field strength in an electromagnetic wave that has a maximum magnetic field strength of 5.00×10^{-4} T (about 10 times the Earth's)? (OpenStax 24.3) **150 kV/m**
6. The maximum magnetic field strength of an electromagnetic field is 5×10^{-6} T. Calculate the maximum electric field strength if the wave is traveling in a medium in which the speed of the wave is 0.75c. (OpenStax 24.4) **1 kV/m**
7. (a) Neil Armstrong was the first person to walk on the moon. The distance between the earth and the moon is 3.85×10^8 m. Find the time it took for his voice to reach earth via radio waves. (b) Someday a person will walk on Mars, which is 5.6×10^{10} m from earth at the point of closest approach. Determine the minimum time that will be required for that person's voice to reach earth. (Cutnell 24.2) **1.28 s, 190 s**