Physics II

Maxwell's Equations

Problem 1.- True (T) or False (F):

( ) $c = \sqrt{\mu_\circ \varepsilon_\circ}$

( ) $\nabla.\vec{E} = 0$ in vacuum

Solution:

(**F**) $c = \sqrt{\mu_\circ \varepsilon_\circ}$

(**T**) $\nabla.\vec{E} = 0$ in vacuum

Problem 2.- True (T) or False (F):

( ) $\nabla.\vec{B} = 0$ means that there are no magnetic monopoles

( ) Newton's second law of motion F=ma is incorrect at high velocities

Solution:

(**T**) $\nabla.\vec{B} = 0$ means that there are no magnetic monopoles

(**T**) Newton's second law of motion F=ma is incorrect at high velocities

Problem 3.- In what units do you measure?

(i) Electric potential (ii) Electric field (iii) Magnetic field

Solution: Electric potential is measured in volts (V), electric field in newtons per coulomb (N/C) or volts per meter (V/m) and magnetic field is measured in tesla (T).

Problem 4.- Are the wavelengths of AM radio stations shorter or longer than those of visible light?

Solution: AM radio waves have **longer** wavelength than those of visible light.

Problem 4a.- Are the wavelengths of TV transmissions shorter or longer than those of visible light?

Solution: TV wavelengths have **longer** wavelength than those of visible light.

Problem 5.- If the electric field in an electromagnetic wave traveling south oscillates east-west, in what direction is the *magnetic* field oscillating?

Solution: The magnetic field is perpendicular to the electric field and also perpendicular to the direction of the wave, so it will be **vertical (it will oscillate up and down)**.

Problem 6.- How long does it take for a signal from Voyager-1 (currently 15.1×10^{12} m from our planet in 2007) to reach the Earth?

Solution: $\text{time} = \frac{d}{c} = \frac{15.1\times10^{12}\,\text{m}}{3\times10^{8}\,\text{m/s}} = \mathbf{5.04\times10^{4}\ s}$

So, it takes about 14 hours to get a signal from the spacecraft.

Problem 7.- Based on your newly acquired knowledge of electromagnetic waves, why would you say that water is heated in a microwave oven, but air not so much?

Solution: Air molecules (mainly N_2, O_2 and Ar) do not have dipole moments, so the coupling to the waves is weak.

Problem 8.- If a radio transmitter has a vertical antenna, should a receiver antenna (rod type) be vertical or horizontal to get the best reception? Why?

Solution: The best coupling to the electromagnetic wave will be when the antenna is parallel to the electric field, so it should be a vertical rod.

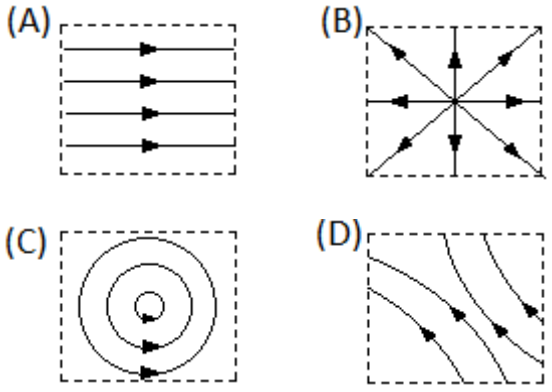
Problem 9.- A typical cell phone antenna is designed so it is ¼ of the wavelength of the carrier signal. Calculate the length of the antenna for a cell phone operating at 1.9GHz.

Solution: Using $c = \lambda f$ (fundamental equation of a wave) we get:

$\lambda = \frac{3\times10^{8}\,m/s}{1.9\times10^{9}\,Hz} = 0.1578m$ and the antenna needs to be $\frac{0.1578m}{4} = \mathbf{0.0394m}$

Or about 4 cm.

Problem 10.- One of Maxwell's laws is that $\oiint \vec{B}.d\vec{S} = 0$. This is also called the Magnetic Gauss Law. Which of the following graphs of magnetic lines violated this law?



Solution: We notice that in graph **B** there is a source of magnetic field lines, which violates that law.