PHYS 1200 Physics of Everyday Experience

Review questions and exercises for Lecture 28 (E&M-6)

1. What is electromagnetic induction? Who discovered it?
2. Why do transformers not work with DC?
3. What was Maxwell's contribution to the laws of electricity and magnetism?
4. What were Maxwell's and Hertz's contributions to electromagnetic waves?
5. What is an electromagnetic wave?
6. What are the relative orientations of the electric and magnetic fields of an electromagnetic wave?
7. What is the relation between the wavelength and frequency of an electromagnetic wave?
8. What is a typical wavelength and frequency of a microwave?
9. The frequency of an AM radio station is 850 kHz. Why is it possible to pick up this station anywhere between 845 and 855 kHz?
10. Why are microwavable means not packaged in aluminum containers?
11. Most cellular phones transmit and receive at 1.8 GHz (1 GHz = 10^9 Hz). What is the wavelength of this wave?
12. The green laser pointer used in class has a frequency of 5.645 x 10^{14} Hz. What is the wavelength?
13. What is the frequency of an x-ray that has a wavelength of 1 nm (nm = 10^{-9} m)?

Answers and solutions:

1. Electromagnetic induction in a phenomena in which current in induced in a coil if the magnetic field that penetrates through the coil changes in any manner.
2. Transformers are an application of the principle of electromagnetic induction, and therefore only work if the current in the primary changes in time.
3. Maxwell theorized that a changing electric field would generate a magnetic field.
4. Maxwell predicted theoretically on the basis of the laws of electricity and magnetism that electromagnetic waves should exist. Hertz first demonstrated experimentally the existence of electromagnetic waves.
5. An electromagnetic wave is a particular combination of time-varying electric and magnetic fields that propagate through space at the speed of light.
6. In an electromagnetic wave, the electric and magnetic fields are perpendicular to each other and to the direction of propagation of the wave.
7. $\lambda f = c$.
8. Microwaves have typical wavelengths of approximately centimeters. The corresponding frequency of a 1 cm microwave = $(3 \times 10^8 \text{ m/s}) / 0.01 \text{ m} = 3 \times 10^{10}$ Hz.
9. Broadcast transmitters produce electromagnetic waves over a certain bandwidth or range of frequencies.
10. Microwaves do not penetrate through conductors but are reflected from them. The aluminum container will prevent the microwaves from penetrating through and cooking the food.
11. $\lambda = c / f = 3 \times 10^8 / 1.8 \times 10^9 = 0.17 \text{ m} = 17 \text{ cm}$.
12. $\lambda = c / f = 3 \times 10^8 / 5.64 \times 10^{14} = 5.32 \times 10^{-7} \text{ m} = 532 \text{ nm}$.
13. $f = c / \lambda = 3 \times 10^8 / 1 \times 10^{-9} = 3 \times 10^{17}$ Hz.