Physics 214 HW07 Solutions
Gladden, Spring 2008

CHAPTER 22: Electromagnetic Waves

Answers to Questions

1. If the direction of travel for the EM wave is north and the electric field oscillates east-west, then the magnetic field must oscillate up and down. For an EM wave, the direction of travel, the electric field, and the magnetic field must all be perpendicular to each other.

3. Yes, EM waves can travel through a perfect vacuum. The energy is carried in the oscillating electric and magnetic fields and no medium is required to travel. No, sound waves cannot travel through a perfect vacuum. A medium is needed to carry the energy of a mechanical wave such as sound and there is no medium in a perfect vacuum.

5. The wavelengths of radio and TV signals are much longer than visible light. Radio waves are on the order of 3 m – 30,000 m. TV waves are on the order of 0.3 m – 3 m. Visible waves are on the order of 10^{-7} m.

7. Wavelength of 10^3 km: Sub-radio waves (or very long radio waves; for example, ELF waves for submarine communication fall into this category). Wavelength of 1 km: Radio waves. Wavelength of 1 m: TV signals and microwaves. Wavelength of 1 cm: microwaves and satellite TV signals. Wavelength of 1 mm: microwaves and infrared waves. Wavelength of 1 μm: infrared waves.

9. Two TV or two radio stations can be broadcast on the same carrier frequency, but if both signals are of similar strength in the same locality, the signals will be "scrambled". The carrier frequency is used by the receiver to distinguish between different stations. Once the receiver has locked on to a particular carrier frequency, its circuitry then does the work of demodulating the information being carried on that carrier frequency. If two stations had the same carrier frequency, the receiver would try to decipher both signals at once and you would get jumbled information instead of a clear signal.

12. Cordless phones utilize EM waves when sending information back and forth between the phone (the part you hold up to your ear/mouth) and its base (where the base is sitting in your house and it is physically connected to the wire phones lines that lead outside to the phone company's network). These EM waves are usually very weak (you can't walk very far away from your house before you lose the signal) and use frequencies such at 49 MHz, 900 MHz, 2.4 GHz or 5 GHz. Cell phones utilize EM waves when sending information back and forth between the phone and the nearest tower in your geographical area (which could be miles away from your location). These EM waves need to be much stronger than cordless phone waves (the batteries are usually much more sophisticated and expensive) and use frequencies of 850 MHz or 1.2 GHz. [Cell phones also have many more channels than cordless phones, so more people can be talking using the same carrier frequency.]