Topic 14: Electromagnetic Waves

Source: *Conceptual Physics* textbook, CPO textbook, CP lab book and CPO lab book

Types of Materials: Textbooks, lab books, demonstrations, worksheets, video and websites, good stories

Leading to: Now that electric fields and magnetic fields have been studied, especially the fact that a charge in motion produces a magnetic field that spreads out from the charge in addition to the electric field that surrounds the charge at all times, at rest or moving, the production of the electromagnetic wave should easily follow without the rather nasty mathematics approach. Students can then study that the frequency of the oscillating charge determines the EM wave, and generally the visible part of the spectrum is studied because it is obviously easier to work with. This part of physics is called optics. For visible and other forms of light, various behaviors such as diffraction, interference, polarization, speed of light and the creation of holograms could be pursued. Other parts of the spectrum can be studied and experimented with like radio waves (crystal radio kit), microwaves (demo apparatus available), and so on.

Links to Physics: As mentioned above, each part of the spectrum can be safely studied through UV, higher frequencies the UV should be "read about" due to extreme danger. Gamma radiation will be addressed when studying nuclear radiation ($\propto$, β, γ). Practical applications include the radio, FM for television, microwave ovens, IR home radiators, seeing, blacklights for plants, X-ray used in medicine, and Gamma (no application that I know) – it can be detected, but in large doses RUN for the hills! By studying wave properties, humans can use the EM waves to do good for others! For example, scientists point telescopes to the sky to see who's out there! Once we see that light also consists as photons (thanks Max and Albert), solar cells can play a part in our energy crisis.

Links to Chemistry and Biology: In chemistry, the atomic spectrum (emission) uses the spectroscope, photons and quantum physics are experimented with and studied. Biology uses light absorption to explain photosynthesis. The higher frequencies (energies) like UV, X-rays, and cosmic rays act as descriptors for causing DNA mutations. Another application is infrared microscopy.

Materials:

(a) Hewitt
    Lensless Lens

(b) Hsu

1. Frequency and Wavelength of Light
2. Waves and Photons

(c) My Activity

EM Wave Properties

(d) Worksheet

EM Waves

(e) Demonstration

(Same as My Activity)

(f) Websites and Videos

1. ocw.mit.edu/ocwWeb/Physics/8-03Fall-2004/VideoLectures/index.htm
   (Site shows lecture/video from MIT professor.)
2. http://video.google.com/videoplay?docid=58624158025167369
   Site shows Budweiser commercial using the wave at a football field—not too educational, but fun!)
3. http://www.astronomynotes.com/copyright.html
   (Site shows animation with theory—OK to use in reference to astronomy.)

(g) Good Stories

James Clerk Maxwell – Maker of Waves

James Clerk Maxwell – Maker of Waves

Jams Clerk Maxwell's extensive research into electromagnetic wave theory eventually led him to conduct experiments in color perception. Previously Isaac Newton had stated that white light was composed of three primary colors: red, blue and green. Later, Thomas Young had evidence that light was a wave and that the eye contains three types of receptors, each sensitive to a primary color and that the eye recognizes color by the superposition of images of these receptors.

Maxwell attempted to produce a color image, a projection on a screen, by combining the theories of Newton and Young with the new technology of the day photography. He took three black and white photographs of a multicolored ribbon. Each photograph was taken through a filter of a primary color. Positive transparencies were made from the negatives and each placed into a projector. In front of each projector was placed the color filter that was used to take the photograph. When the images were superimposed and focused on a screen, a full color picture was produced.

It emerged much later that there was a curious anomaly about the demonstration. The photographic emulsions available at the time were sensitive to blue light, slightly sensitive to green light and not at all sensitive to red light. By all accounts the demonstration should have been a failure, yet it worked.

The anomaly of Maxwell's color demonstration went unnoticed and unchallenged for nearly one hundred years. Then Edwin Land, of the Polaroid Land Corporation, picked up the challenge, forming what he called the "Retinex" theory of color perception in an attempt to produce the worlds first sixty-second color picture.