Physics 115: CONTEMPORARY PHYSICS III
Spring 2008
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HOMEWORK 7

Due Friday, May 30 in class

1. Effects of radiation

(review question 15 in chapter 23)

When discussing the effects of electromagnetic radiation on matter informally, physicists often talk about the effects on electrons in the matter. Why would they omit commenting on the effects on the nucleus, which is also charged?

Answer with reference to the appropriate equation(s)

2. Light from the Sky

(review question 20 in chapter 23)

At dawn, with the Sun just rising in the East, you face the Sun and look straight up to examine the blue sky with a Polaroid filter.

(a) Why is the light polarized?

(b) What is the direction of the electric field: E-W or N-S? Explain your answer.

3. Electric Field of a Spotlight

(problem 29 in chapter 23)

A 100 watt light bulb is in a fixture with a reflector that focuses the light to make a spot on the wall of radius 20 cm. Calculate (approximately) the amplitude of the electric field in the beam of the spotlight.

4. EM fields from Electric and Magnetic Dipole Antennae

(See two figures to be drawn in class. Each depicts a circuit and antenna. One is an "electric dipole antenna" while the other is a "magnetic dipole antenna.")

(a) What is the basis for the names of these two antenna types?

Note that each oscillating circuit causes its antenna to generate an oscillating E or B field, together with its associated B or E field.

(b) Draw a time series of 8 small diagrams that show the direction and relative magnitude of the E and B fields at point P in the "electric dipole" diagram that show a complete cycle of oscillation. Assume that the EM wave travels in the x direction in the circuit diagram, y is toward the top of the circuit diagram, and z is out of the page (blackboard when it was drawn). Careful: in what plane do the E and B fields lie? Draw your diagram in that plane!

(c) Same as (b), but for the magnetic dipole case.

5. Resistor Gets Energy from Empty Space

A cylindrical resistor has length l, radius a, and resistivity ρ. A steady current I flows through it.

(a) Show that the Poynting vector $\mathbf{S}$ at the surface of the resistor is everywhere directed normal to the outside surface of the cylinder (just the curved part, not the endcaps).

(b) By integrating the Poynting vector over the surface, show that the rate at which energy flows into the resistor through its cylindrical surface is equal to the rate at which internal energy is produced:

$$\int \mathbf{S} \cdot d\mathbf{A} = I^2 R$$

This result suggests that, according to the Poynting vector point of view, the energy that appears in a resistor as internal energy does not enter it throught the wires but through the space around the wires and resistor.

6. Gathering Momentum in the Sun

Suppose that you lie in the Sun for 2.5 h, exposing an area of 1.3m^2 to the Sun's rays of intensity 1.1kWm^{-2}. Assuming complete absorption of the rays, how much momentum is delivered to your body?