Physics 51 Section
Homework 10
Monday, November 2, 2020

38P11: A coaxial cable (inner radius a, outer radius b) is used as a transmission line between a battery $\mathscr{E}$ and a resistor R, as shown in Fig. 38-28.

(a) Calculate E, B for $a < r < b$.

(b) Calculate the Poynting vector $\vec{\mathbf{S}}$ for $a < r < b$.

(c) By suitably integrating the Poynting vector, show that the total power flowing across the annular cross section $a < r < b$ is $\frac{\mathscr{E}^2}{R}$. Is this reasonable?

(d) Show that the direction of $\vec{\mathbf{S}}$ is always from the battery to the resistor, no matter which way the battery is connected.

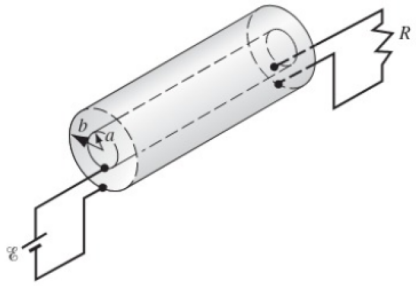

FIGURE 38-28. Problem 11.

38E14: Figure 38-21 shows an *LC* oscillator connected by a transmission line to an antenna of a magnetic dipole type. Compare with Fig. 38-5, which shows a similar arrangement but with an electric dipole type of antenna.

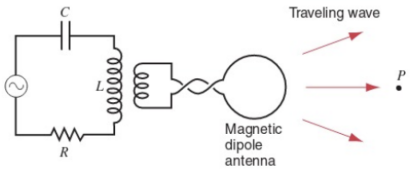

FIGURE 38-21. Exercise 14.

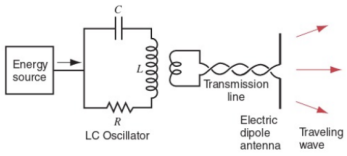

FIGURE 38-5. An arrangement for generating a traveling electromagnetic wave.

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

(b) Draw figures corresponding to Figs. 38-6 and 38-7 to describe the electromagnetic wave that sweeps past the observer at point *P* in Fig. 38-21.

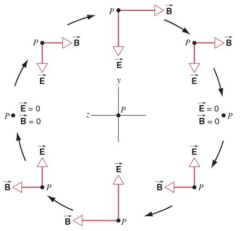

FIGURE 38-7. Eight cyclical "snapshots" of the plane electromagnetic wave radiated from the oscillating dipole of Fig. 38-6 observed at point *P*. The direction of travel of the wave (*x* direction in Fig. 38-6) is out of the plane of the page. Lines of $\vec{E}$ are vertical, and lines of $\vec{B}$ are horizontal.

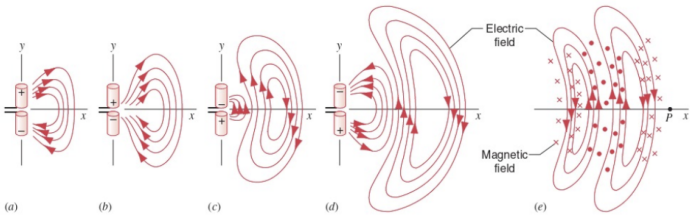

FIGURE 38-6. Successive stages in the emission of an electromagnetic wave from a dipole antenna. In (*a*)–(*d*), only the electric field patterns are shown. In (*e*), the magnetic field is shown as perpendicular to the plane of the page.

38E16: The electric field associated with a plane electromagnetic wave is given by $E_x = 0, E_y = 0, E_z = E_0 \sin k(x - ct)$, where $E_0 = 2.34 \times 10^{-4}$ V/m and $k = 9.72 \times 10^6$ m^{-1}. The wave is propagating in the $+x$ direction.

(a) Write expressions for the components of the magnetic field of the wave.

(b) Find the wavelength of the wave.

(c) What is the wave's frequency and what kind of radiation is it? (See Ch. 39 for a hint.)

38P13: A plane electromagnetic wave, with wavelength 3.18 m, travels in free space in the $+x$ direction with its electric vector $\vec{\mathbf{E}}$, of amplitude 288 V/m, directed along the y axis.

(a) What is the frequency of the wave?

(b) What is the direction and amplitude of the magnetic field associated with the wave?

(c) If $E = E_m \sin(kx - \omega t)$, what are the values of k and ω?

(d) Find the intensity of the wave

(e) If the wave falls on a perfectly absorbing sheet of area 1.85 m^2, at what rate would momentum be delivered to the sheet and what is the radiation pressure exerted on the sheet?

38E42: A small spaceship whose mass, with occupant, is 1500 kg is drifting in outer space, where the gravitational field is negligible. If the astronaut turns on a 10.0-kW laser beam, what speed would the ship attain in one day because of the reaction force associated with the momentum carried away by the beam?