General Problems

37. If the Sun were to disappear or somehow radically change its output, how long would it take for us on Earth to learn about it?

38. Light is emitted from an ordinary lightbulb filament in wave-train bursts about 10^{-8} s in duration. What is the length in space of such wave trains?

39. (*a*) How long did it take for a message sent from Earth to reach the first astronauts on the Moon? (*b*) How long will it take for a message from Earth to reach the first astronauts who arrive on Mars; assume Mars is at its closest approach to Earth (78×10^6 km)?

40. A radio voice signal from the *Apollo* crew on the Moon (Fig. 22–20) was beamed to a listening crowd from a radio speaker. If you were standing 25 m from the loudspeaker, what was the total time lag between when you heard the sound and when the sound left the Moon?

FIGURE 22–20
Problem 40.

* 41. Cosmic microwave background radiation fills all space with an average energy density of 4×10^{-14} J/m^3. (*a*) Find the rms value of the electric field associated with this radiation. (*b*) How far from a 10-kW radio transmitter emitting uniformly in all directions would you find a comparable value?

* 42. What are E_0 and B_0 2.00 m from a 95-W light source? Assume the bulb emits radiation of a single frequency uniformly in all directions.

* 43. Estimate the rms electric field in the sunlight that hits Mars, knowing that the Earth receives about 1350 W/m^2 and that Mars is 1.52 times farther from the Sun (on average) than is the Earth.

* 44. At a given instant in time, a traveling EM wave is noted to have its maximum magnetic field pointing west and its maximum electric field pointing south. In which direction is the wave traveling? If the rate of energy flow is 560 W/m^2, what are the maximum values for the two fields?

* 45. Estimate how long an AM antenna would have to be if it were (*a*) $\frac{1}{2}\lambda$ or (*b*) $\frac{1}{4}\lambda$. AM radio is roughly 1 MHz (530 kHz to 1.7 MHz).

* 46. How large an emf (rms) will be generated in an antenna that consists of a 380-loop circular coil of wire 2.2 cm in diameter if the EM wave has a frequency of 810 kHz and is transporting energy at an average rate of 1.0×10^{-4} W/m^2 at the antenna? [*Hint*: you can use Eq. 21–5 for a generator, since it could be applied to an observer moving with the coil so that the magnetic field is oscillating with the frequency $f = \omega/2\pi$.]

* 47. The average intensity of a particular TV station's signal is 1.0×10^{-13} W/m^2 when it arrives at a 33-cm-diameter satellite TV antenna. (*a*) Calculate the total energy received by the antenna during 6.0 hours of viewing this station's programs. (*b*) What are the amplitudes of the E and B fields of the EM wave?

* 48. 15 km from a radio station's transmitting antenna, the amplitude of the electric field is 0.12 V/m. What is the average power output of the radio station?

* 49. The variable capacitance of a radio tuner consists of six plates connected together placed alternately between six other plates, also connected together (Fig. 22–21). Each plate is separated from its neighbor by 1.1 mm of air. One set of plates can move so that the area of overlap varies from 1.0 cm^2 to 9.0 cm^2. (*a*) Are these capacitors connected in series or in parallel? (*b*) Determine the range of capacitance values. (*c*) What value of inductor is needed if the radio is to tune AM stations from 550 kHz to 1600 kHz?

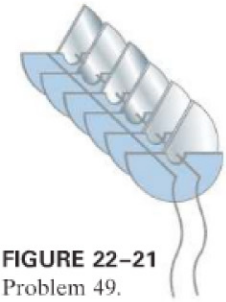

FIGURE 22–21
Problem 49.

* 50. A radio station is allowed to broadcast at an average power not to exceed 25 kW. If an electric field amplitude of 0.020 V/m is considered to be acceptable for receiving the radio transmission, estimate how many kilometers away you might be able to hear this station.

* 51. A point source emits light energy uniformly in all directions at an average rate P_0 with a single frequency f. Show that the peak electric field in the wave is given by

$$E_0 = \sqrt{\frac{\mu_0 c P_0}{2\pi r^2}}.$$

* 52. Suppose a 50-kW radio station emits EM waves uniformly in all directions. (*a*) How much energy per second crosses a 1.0-m^2 area 100 m from the transmitting antenna? (*b*) What is the rms magnitude of the $\vec{\mathbf{E}}$ field at this point, assuming the station is operating at full power? (*c*) What is the voltage induced in a 1.0-m-long vertical car antenna at this distance?

* 53. Repeat Problem 52 for a distance of 100 km from the station.

* 54. What is the maximum power level of the radio station of Problem 52 so as to avoid electrical breakdown of air at a distance of 1.0 m from the antenna? Assume the antenna is a point source. Air breaks down in an electric field of about 3×10^6 V/m. [*Hint*: see Problem 51.]

Answers to Exercises

A: (*a*) 3.8×10^6 Hz; (*b*) 5.5×10^{18} Hz.
B: 45 cm.
C: 3 hours.