Conceptual Questions

24.2 Production of Electromagnetic Waves

1.

The direction of the electric field shown in each part of Figure 24.5 is that produced by the charge distribution in the wire. Justify the direction shown in each part, using the Coulomb force law and the definition of $\mathbf{E} = \mathbf{F}/q$, where q is a positive test charge.

2.

Is the direction of the magnetic field shown in Figure 24.6 (a) consistent with the right-hand rule for current (RHR-2) in the direction shown in the figure?

3.

Why is the direction of the current shown in each part of Figure 24.6 opposite to the electric field produced by the wire's charge separation?

4.

In which situation shown in Figure 24.23 will the electromagnetic wave be more successful in inducing a current in the wire? Explain.

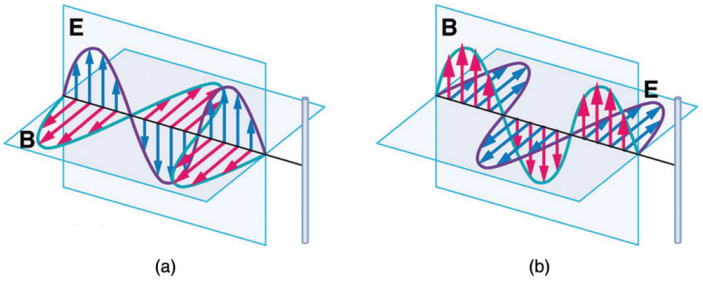

Figure 24.23 Electromagnetic waves approaching long straight wires.

5.

In which situation shown in Figure 24.24 will the electromagnetic wave be more successful in inducing a current in the loop? Explain.

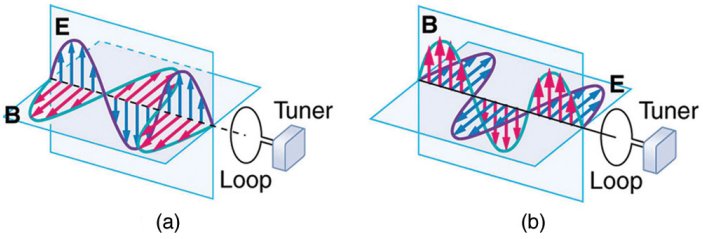

Figure 24.24 Electromagnetic waves approaching a wire loop.

6.

Should the straight wire antenna of a radio be vertical or horizontal to best receive radio waves broadcast by a vertical transmitter antenna? How should a loop antenna be aligned to best receive the signals? (Note that the direction of the loop that produces the best reception can be used to determine the location of the source. It is used for that purpose in tracking tagged animals in nature studies, for example.)

7.

Under what conditions might wires in a DC circuit emit electromagnetic waves?

8.

Give an example of interference of electromagnetic waves.

9.

Figure 24.25 shows the interference pattern of two radio antennas broadcasting the same signal. Explain how this is analogous to the interference pattern for sound produced by two speakers. Could this be used to make a directional antenna system that broadcasts preferentially in certain directions? Explain.

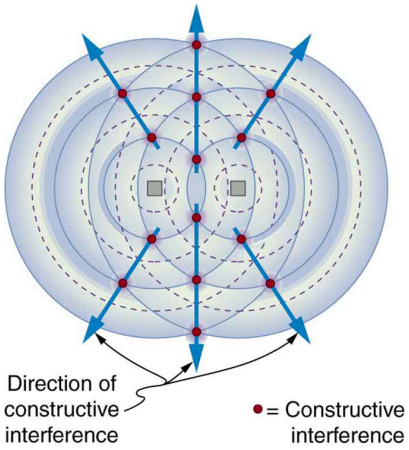

Figure 24.25 An overhead view of two radio broadcast antennas sending the same signal, and the interference pattern they produce.

10.

Can an antenna be any length? Explain your answer.

24.3 The Electromagnetic Spectrum

11.

If you live in a region that has a particular TV station, you can sometimes pick up some of its audio portion on your FM radio receiver. Explain how this is

possible. Does it imply that TV audio is broadcast as FM?

12.

Explain why people who have the lens of their eye removed because of cataracts are able to see low-frequency ultraviolet.

13.

How do fluorescent soap residues make clothing look "brighter and whiter" in outdoor light? Would this be effective in candlelight?

14.

Give an example of resonance in the reception of electromagnetic waves.

15.

Illustrate that the size of details of an object that can be detected with electromagnetic waves is related to their wavelength, by comparing details observable with two different types (for example, radar and visible light or infrared and X-rays).

16.

Why don't buildings block radio waves as completely as they do visible light?

17.

Make a list of some everyday objects and decide whether they are transparent or opaque to each of the types of electromagnetic waves.

18.

Your friend says that more patterns and colors can be seen on the wings of birds if viewed in ultraviolet light. Would you agree with your friend? Explain your answer.

19.

The rate at which information can be transmitted on an electromagnetic wave is proportional to the frequency of the wave. Is this consistent with the fact that laser telephone transmission at visible frequencies carries far more conversations per optical fiber than conventional electronic transmission in a wire? What is the implication for ELF radio communication with submarines?

20.

Give an example of energy carried by an electromagnetic wave.

21.

In an MRI scan, a higher magnetic field requires higher frequency radio waves to resonate with the nuclear type whose density and location is being imaged. What effect does going to a larger magnetic field have on the most efficient antenna to broadcast those radio waves? Does it favor a smaller or larger antenna?

22.

Laser vision correction often uses an excimer laser that produces 193-nm electromagnetic radiation. This wavelength is extremely strongly absorbed by the cornea and ablates it in a manner that reshapes the cornea to correct vision defects. Explain how the strong absorption helps concentrate the energy in a thin layer and thus give greater accuracy in shaping the cornea. Also explain how this strong absorption limits damage to the lens and retina of the eye.