1) Which one of the following lists gives the correct order of the electromagnetic spectrum from *low to high frequencies*?
   A) radio waves, infrared, microwaves, ultraviolet, visible, x–rays, gamma rays
   B) radio waves, microwaves, visible, x–rays, infrared, ultraviolet, gamma rays
   C) radio waves, infrared, x–rays, microwaves, ultraviolet, visible, gamma rays
   D) radio waves, ultraviolet, x–rays, microwaves, infrared, visible, gamma rays
   E) radio waves, microwaves, infrared, visible, ultraviolet, x–rays, gamma rays

2) Which one of the following types of electromagnetic wave travels through space the fastest?
   A) microwaves
   B) radio waves
   C) ultraviolet
   D) infrared
   E) They all travel through space at the same speed.

3) For an electromagnetic wave in free space having an electric field of amplitude E and a magnetic field of amplitude B, the ratio of B/E is equal to
   A) c B) $1/c^2$ C) $\sqrt{c}$ D) $1/c$ E) c^2

4) Which one of the following expressions is the correct representation for the speed of light in vacuum?
   A) $\sqrt{\varepsilon_0 / \mu_0}$ B) $\sqrt{\varepsilon_0 \mu_0}$ C) $1 / \sqrt{\varepsilon_0 \mu_0}$ D) $1 / \varepsilon_0 \mu_0$ E) $\sqrt{\mu_0 / \varepsilon_0}$

5) Which of the following statements about electromagnetic waves in free space are true? (There could be more than one correct choice.)
   A) The electric field carries the same mount of energy as the magnetic field.
   B) The electric field carries more energy than the magnetic field.
   C) The frequency of the electric field is higher than the frequency of the magnetic field.
   D) The electric and magnetic fields have equal amplitudes.
   E) The frequency of the magnetic field is the same as the frequency of the electric field.

6) Except for their color, a perfectly black (absorbing) object is identical to a perfectly white (reflecting) object. If identical light falls on both of these objects, what is true about the momentum they will receive from this light?
   A) The white object will receive twice as much as the black object.
   B) The black object will receive twice as much as the white object.
   C) The black object will receive four times as much as the white object.
   D) The white object will receive four times as much as the black object.
   E) They will both receive the same amount.

7) An FM radio station broadcasts at 96.7 MHz. What is the wavelength of the radio wave used for this broadcast? ($c = 3.0 \times 10^8$ m/s)

8) A certain part of the electromagnetic spectrum ranges from 200 nm to 400 nm. What is the *highest* frequency associated with this portion of the spectrum? ($c = 3.00 \times 10^8$ m/s)

9) A certain part of the electromagnetic spectrum ranges from 200 nm to 400 nm. What is the *lowest* frequency associated with this portion of the spectrum? ($c = 3.00 \times 10^8$ m/s)

10) A radio station broadcasts at a frequency of 80 MHz. How far from the transmitter will this signal travel in 67 ms? ($c = 3.0 \times 10^8$ m/s)

11) If the magnetic field in a traveling electromagnetic wave has a maximum value of 16.5 nT, what is the maximum value of the electric field associated with this wave? ($c = 3.00 \times 10^8$ m/s)

12) A radio transmitter is operating at an average power of 4.00 kW and is radiating uniformly in all directions. What is the average intensity of the signal 8.00 km from the transmitter?

13) Radiation of a single frequency reaches the upper atmosphere of the earth with an intensity of 1350 W/m^2. What is the maximum value of the electric field associated with this radiation? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T • m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N • m^2)

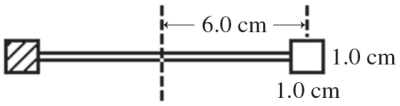
14) What is the maximum value of the magnetic field at a distance of 2.5 m from a light bulb that radiates 100 W of single–frequency sinusoidal electromagnetic waves uniformly in all directions? ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N • m^2, $\mu_0 = 4\pi \times 10^{-7}$ T • m/A, $c = 3.0 \times 10^8$ m/s)

15) The total electromagnetic power emitted by the sun is 3.8×10^{26} W. What is the radiation pressure it exerts on the perfectly absorbing surface of a satellite near the orbit of Mercury, which is 5.8×10^{10} m from the sun? The radiation strikes the surface of the satellite perpendicular to the surface. ($c = 3.0 \times 10^8$ m/s)

16) Light with an average intensity of 683 W/m^2 falls on a black surface and is completely absorbed. What is the radiation pressure that the light exerts on this surface if it strikes perpendicular to the surface? ($c = 3.00 \times 10^8$ m/s)

17) If the average intensity of the sunlight in Miami, Florida, is 1060 W/m^2, what is the average magnitude of the force this light exerts on a 16–m^2 surface of black asphalt that totally absorbs the light? ($c = 3.00 \times 10^8$ m/s)

18) A radiometer has two square vanes (1.0 cm by 1.0 cm), attached to a light horizontal cross arm, and pivoted about a vertical axis through the center, as shown in the figure. The center of each vane is 6.0 cm from the axis. One vane is silvered and it reflects all radiant energy incident upon it. The other vane is blackened and it absorbs all incident radiant energy. Radiant energy, having an intensity of 300 W/m^2, is incident normally upon the front of both vanes. What is the net torque on the vane assembly, about the vertical axis? ($c = 3.0 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T • m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N • m^2)



Answer Key
Testname: CH22_EM_WAVES

1) E
2) E
3) D
4) C
5) A, E
6) A
7) 3.1 m
8) 1.50×10^{15} Hz
9) 7.50×10^{14} Hz
10) 20×10^{6} m
11) 4.95 V/m
12) 4.97 $\mu W/m^2$
13) 1010 V/m
14) 0.10 μT
15) 30 $\mu N/m^2$
16) 2280 nN/m^2
17) 5.65×10^{-5} N
18) 6.0×10^{-12} N • m