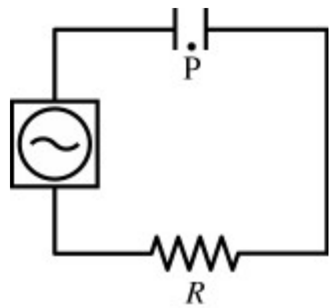
***Physics for Scientists and Engineers, 3e* (Knight)**
Chapter 34 Electromagnetic Fields and Waves

34.1 Conceptual Questions

1) A capacitor is hooked up to a resistor and an AC voltage source as shown in the figure. The output of the source is given by $V(t) = V_0 \sin \omega t$. The plates of the capacitor are disks of radius R. Point P is directly between the two plates, equidistant from them and a distance $R/2$ from the center axis. At point P



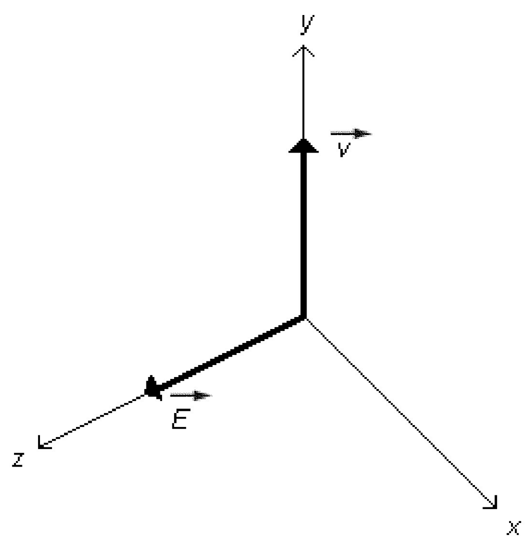
A) there is no magnetic field because there is no charge moving between the plates.
B) there is a constant magnetic field.
C) there is a time-varying magnetic field.
Answer: C
Var: 1

2) In an electromagnetic wave, the electric and magnetic fields are oriented such that they are
A) parallel to one another and perpendicular to the direction of wave propagation.
B) parallel to one another and parallel to the direction of wave propagation.
C) perpendicular to one another and perpendicular to the direction of wave propagation.
D) perpendicular to one another and parallel to the direction of wave propagation.
Answer: C
Var: 1

3) If the magnetic field of an electromagnetic wave is in the $+x$-direction and the electric field of the wave is in the $+y$-direction, the wave is traveling in the
A) xy-plane.
B) $+z$-direction.
C) $-z$-direction.
D) $-x$-direction.
E) $-y$-direction.
Answer: C
Var: 1

4) An electromagnetic wave is propagating towards the west. At a certain moment the direction of the magnetic field vector associated with this wave points vertically up. The direction of the electric field vector of this wave is
A) horizontal and pointing south.
B) vertical and pointing down.
C) horizontal and pointing north.
D) vertical and pointing up.
E) horizontal and pointing east.
Answer: A
Var: 1

5) An electromagnetic wave propagates along the +*y* direction as shown in the figure. If the electric field at the origin is along the +*z* direction, what is the direction of the magnetic field?



A) +*z*
B) -*z*
C) +*y*
D) +*x*
E) -*x*
Answer: D
Var: 1

6) The energy per unit volume in an electromagnetic wave is
A) equally divided between the electric and magnetic fields.
B) mostly in the electric field.
C) mostly in the magnetic field.
D) all in the electric field.
E) all in the magnetic field.
Answer: A
Var: 1

7) If an electromagnetic wave has components $E_y = E_0 \sin(kx - \omega t)$ and $B_z = B_0 \sin(kx - \omega t)$, in what direction is it traveling?
A) $-x$
B) $+x$
C) $+y$
D) $-y$
E) $+z$
Answer: B
Var: 1

8) When an electromagnetic wave falls on a white, perfectly reflecting surface, it exerts a force F on that surface. If the surface is now painted a perfectly absorbing black, what will be the force that the same wave will exert on the surface?
A) $4F$
B) $2F$
C) F
D) $F/2$
E) $F/4$
Answer: D
Var: 1

34.2 Problems

1) Given that the wavelengths of visible light range from 400 nm to 700 nm, what is the highest frequency of visible light? ($c = 3.0 \times 10^8$ m/s)
A) 3.1×10^8 Hz
B) 7.5×10^{14} Hz
C) 2.3×10^{20} Hz
D) 4.3×10^{14} Hz
E) 5.0×10^8 Hz
Answer: B
Var: 1

2) The magnitude of the electric field at a point P for a certain electromagnetic wave is 570 N/C. What is the magnitude of the magnetic field for that wave at P? ($c = 3.0 \times 10^8$ m/s)
A) 2.91 μT
B) 1.90 μT
C) 1.10 μT
D) 1.41 μT
E) 2.41 μT
Answer: B
Var: 1

3) The magnitude of the magnetic field at point P for a certain electromagnetic wave is 2.12 μT. What is the magnitude of the electric field for that wave at P? ($c = 3.0 \times 10^8$ m/s)
A) 636 N/C
B) 745 N/C
C) 5.23 μN/C
D) 6.36 μN/C
E) 7.45 μN/C
Answer: A
Var: 1

4) If the electric field and magnetic field of an electromagnetic wave are given by $E = E_0 \sin(kx - \omega t)$ and $B = B_0 \sin(kx - \omega t)$, and if the value of E_0 is 51 μV/m, what is the value of B_0? ($c = 3.0 \times 10^8$ m/s)
A) 1.7×10^{14} T
B) 1.7×10^{3} T
C) 1.7×10^{-14} T
D) 1.7×10^{4} T
E) 1.7×10^{-13} T
Answer: E
Var: 1

5) A planar electromagnetic wave is propagating in the $+x$ direction. At a certain point P and at a given instant, the electric field of the wave is given by $\vec{E} = (0.082 \text{ V/m}) \hat{\boldsymbol{i}}$. What is the magnetic vector of the wave at the point P at that instant? ($c = 3.0 \times 10^8$ m/s)
A) 0.27 nT $\hat{\boldsymbol{k}}$
B) -0.27 nT $\hat{\boldsymbol{k}}$
C) 0.27 nT $\hat{\boldsymbol{j}}$
D) 6.8 nT $\hat{\boldsymbol{k}}$
E) -6.8 nT $\hat{\boldsymbol{j}}$
Answer: A
Var: 1

6) If the z-component of the magnetic field of an electromagnetic wave traveling in the $+x$ direction through vacuum obeys the equation $B_z(x, t) = (1.25 \text{ μT}) \cos[(3800 \text{ m}^{-1})x - (1.14 \times 10^{-12} \text{ rad/s})t]$, what is the largest that the y component of the electric field can be? ($c = 3.0 \times 10^8$ m/s)
A) 375 N/C
B) 4.17×10^{-15} N/C
C) 3.75×10^{8} N/C
D) 4.17×10^{-9} N/C
E) 1.25×10^{6} N/C
Answer: A
Var: 1

7) The y component of the electric field of an electromagnetic wave traveling in the $+x$ direction through vacuum obeys the equation $E_y = (375 \text{ N/C}) \cos[kx - (2.20 \times 10^{14} \text{ rad/s})t]$. What is the wavelength of this electromagnetic wave? ($c = 3.0 \times 10^8$ m/s)
A) 0.272 μm
B) 1.36 μm
C) 2.72 μm
D) 8.57 μm
E) 17.1 μm
Answer: D
Var: 1

8) The y-component of the electric field of an electromagnetic wave traveling in the $+x$ direction through vacuum obeys the equation $E_y = (375 \text{ N/C}) \cos[kx - (2.20 \times 10^{14} \text{ rad/s})t]$. ($c = 3.0 \times 10^8$ m/s)
(a) What is the largest that the x-component of the wave can be?
(b) What is the largest that the z-component of the wave can be?
Answer: (a) zero (b) 1.25 μT
Var: 1

9) A planar electromagnetic wave is propagating in the $+x$ direction. At a certain point P and at a given instant, the electric field of the wave is given by $\vec{E} = (0.082 \text{ V/m}) \hat{\boldsymbol{j}}$. What is the Poynting vector at the point P at that instant? ($c = 3.0 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 18 $\mu W/m^2 \hat{\boldsymbol{i}}$
B) -18 $\mu W/m^2 \hat{\boldsymbol{i}}$
C) 9.0 $\mu W/m^2 \hat{\boldsymbol{i}}$
D) -9.0 $\mu W/m^2 \hat{\boldsymbol{i}}$
E) -18 $\mu W/m^2 \hat{\boldsymbol{k}}$
Answer: A
Var: 1

10) The magnitude of the Poynting vector of a planar electromagnetic wave has an average value of 0.724 W/m^2. What is the maximum value of the magnetic field in the wave? ($c = 3.0 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 77.9 nT
B) 55.1 nT
C) 38.9 nT
D) 108 nT
E) 156 nT
Answer: A
Var: 1

11) The magnitude of the Poynting vector of a planar electromagnetic wave has an average value of 0.939 W/m^2. The wave is incident upon a rectangular area, 1.5 m by 2.0 m, at right angles. How much total electromagnetic energy falls on the area during 1.0 minute? ($c = 3.0 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 170 J
B) 210 J
C) 250 J
D) 300 J
E) 340 J
Answer: A
Var: 1

12) The magnetic field of an electromagnetic wave has a peak value of 5.0×10^{-10} T. What is the intensity of the wave? ($c = 3.0 \times 10^8$ m/s, $c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 1.0×10^{-13} W/m^2
B) 1.5×10^{-5} W/m^2
C) 3.0×10^{-5} W/m^2
D) 2.0×10^{-13} W/m^2
E) 7.5×10^{5} W/m^2
Answer: C
Var: 1

13) A sinusoidal electromagnetic wave in vacuum delivers energy at an average rate of 5.00 μW/m^2. What are the amplitudes of the electric and magnetic fields of this wave? ($c = 3.0 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
Answer: E_{max} = 0.0614 V/m, B_{max} = 0.205 nT
Var: 1

14) If the intensity of an electromagnetic wave is 80 MW/m^2, what is the amplitude of the magnetic field of this wave? ($c = 3.0 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 0.82 mT
B) 0.33 μT
C) 10 T
D) 14 T
E) 0.58 mT
Answer: A
Var: 1

15) A laser with a power of 1.0 mW has a beam radius of 1.0 mm. What is the peak value of the electric field in that beam? (c = 3.0 x 10^8 m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 490 V/m
B) 840 V/m
C) 65 V/m
D) 120 V/m
E) 22 V/m
Answer: A
Var: 1

16) If a beam of electromagnetic radiation has an intensity of 120 W/m^2, what is the maximum value of the electric field? (c = 3.0 x 10^8 m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 1.5 kV/m
B) 1.0 μT
C) 1.0 μV/m
D) 0.30 kV/m
E) 0.0032 V/m
Answer: D
Var: 1

17) Near the earth the intensity of radiation from the sun is 1.35 kW/m^2. What volume of space in this region contains 1.0 J of electromagnetic energy? (c = 3.0 x 10^8 m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 4.5 x 10^{-6} m^3
B) 3300 m^3
C) 7.4 x 10^{-4} m^3
D) 1400 m^3
E) 220,000 m^3
Answer: E
Var: 1

18) An electromagnetic wave has a peak electric field of 3.0 kV/m. What is the intensity of the wave? (c = 3.0 x 10^8 m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 24 kW/m^2
B) 12 kW/m^2
C) 8.0 kW/m^2
D) 4.0 kW/m^2
Answer: B
Var: 1

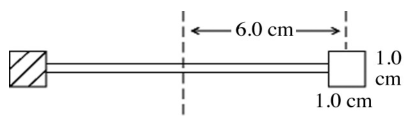
19) An 800-kHz radio signal is detected at a point 4.5 km distant from a transmitter tower. The electric field amplitude of the signal at that point is 0.63 V/m. Assume that the signal power is radiated uniformly in all directions and that radio waves incident upon the ground are completely absorbed. What is the magnetic field amplitude of the signal at that point? (c = 3.0 x 10^8 m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, ε_0 = 8.85 × 10^{-12} $C^2/N \cdot m^2$)
A) 2.1 nT
B) 1.7 nT
C) 1.3 nT
D) 2.5 nT
E) 2.9 nT
Answer: A
Var: 1

20) An 800-kHz radio signal is detected at a point 8.5 km distant from a transmitter tower. The electric field amplitude of the signal at that point is 0.90 V/m. Assume that the signal power is radiated uniformly in all directions and that radio waves incident upon the ground are completely absorbed. What is the average electromagnetic energy density at that point? (c = 3.0 x 10^8 m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, ε_0 = 8.85 × 10^{-12} $C^2/N \cdot m^2$)
A) 3.6 pJ/m^3
B) 5.1 pJ/m^3
C) 7.2 pJ/m^3
D) 10 pJ/m^3
E) 14 pJ/m^3
Answer: A
Var: 1

21) An 800-kHz radio signal is detected at a point 2.7 km distant from a transmitter tower. The electric field amplitude of the signal at that point is 0.36 V/m. Assume that the signal power is radiated uniformly in all directions and that radio waves incident upon the ground are completely absorbed. What is the intensity of the radio signal at that point? (c = 3.00 × 10^8 m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, ε_0 = 8.85 × 10^{-12} $C^2/N \cdot m^2$)
A) 170 μW/m^2
B) 240 μW/m^2
C) 340 μW/m^2
D) 120 μW/m^2
E) 86 μW/m^2
Answer: A
Var: 1

22) An 800-kHz radio signal is detected at a point 9.1 km distant from a transmitter tower. The electric field amplitude of the signal at that point is 0.440 V/m. Assume that the signal power is radiated uniformly in all directions and that radio waves incident upon the ground are completely absorbed. What is the average total power radiated by the transmitter? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 0.27 MW
B) 0.32 MW
C) 0.38 MW
D) 0.45 MW
E) 0.50 MW
Answer: A
Var: 1

23) A radiometer has two square vanes (each measuring 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. An electromagnetic wave with an intensity of 0.30 kW/m^2 is incident normally upon the vanes. What is the electromagnetic power absorbed by the blackened vane? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)



A) 0.030 W
B) 0.040 W
C) 0.050 W
D) 0.060 W
E) 0.090 W
Answer: A
Var: 1

24) A microwave oven operates with sinusoidal microwaves at a frequency of 2400 MHz. The height of the oven cavity is 25 cm and the base measures 30 cm by 30 cm. Assume that microwave energy is generated uniformly on the upper surface of the cavity and propagates directly downward toward the base. The base is lined with a material that completely absorbs microwave energy. The total microwave energy content of the cavity is 0.50 µJ. What is the amplitude of the electric field? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 1600 V/m
B) 1900 V/m
C) 2200 V/m
D) 2500 V/m
E) 2800 V/m
Answer: C
Var: 1

25) A microwave oven operates with sinusoidal microwaves at a frequency of 2400 MHz. The height of the oven cavity is 25 cm and the base measures 30 cm by 30 cm. Assume that microwave energy is generated uniformly on the upper surface of the cavity and propagates directly downward toward the base. The base is lined with a material that completely absorbs microwave energy. The total microwave energy content of the cavity is 0.50 μJ. What is the power output of the oven? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 0.50 kW
B) 0.55 kW
C) 0.60 kW
D) 0.65 kW
E) 0.70 kW
Answer: C
Var: 1

26) A microwave oven operates with sinusoidal microwaves at a frequency of 2400 MHz. The height of the oven cavity is 25 cm and the base measures 30 cm by 30 cm. Assume that microwave energy is generated uniformly on the upper surface of the cavity and propagates directly downward toward the base. The base is lined with a material that completely absorbs microwave energy. The total microwave energy content of the cavity is 0.50 μJ. What is the intensity of the microwave beam? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 5.2 kW/m^2
B) 5.7 kW/m^2
C) 6.2 kW/m^2
D) 6.7 kW/m^2
E) 7.2 kW/m^2
Answer: D
Var: 1

27) A 7.5×10^{14} Hz laser emits a 7.7-μs pulse, 5.0 mm in diameter, with a beam energy density of 0.51 J/m^3. What is the amplitude of the electric field of the emitted waves? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 340 kV/m
B) 480 kV/m
C) 240 kV/m
D) 150 kV/m
E) 120 kV/m
Answer: A
Var: 1

28) 28)A sinusoidal electromagnetic wave is propagating in vacuum. At a given point *P* and at a particular time, the electric field is in the +*x* direction and the magnetic field is in the -*y* direction.
(a) What is the direction of propagation of the wave?
(b) If the intensity of the wave at point *P* is 0.36 W/m^2, what is the electric field amplitude at that point?
($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
Answer: (a) -*z* direction (b) 16 V/m
Var: 50+

29) A very small source of light that radiates uniformly in all directions produces an electric field amplitude of 2.96 V/m at a point 33.0 m from the source. What is the power output from the source?
($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
Answer: 159 W
Var: 50+

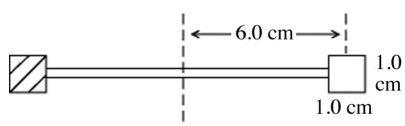
30) The average intensity of the sunlight in Miami, Florida, is 1.04 kW/m^2. For surfaces on which the light is all absorbed, what is the average value of the radiation pressure due to this sunlight in Miami?
($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 2.28 μPa
B) 1.73 μPa
C) 6.93 μPa
D) 3.47 μPa
E) 9.78 μPa
Answer: D
Var: 1

31) The intensity of solar radiation near the earth is 1.4 kW/m^2. What force is exerted by solar radiation impinging normally on a 5.0 m^2 perfectly reflecting panel of an artificial satellite orbiting the earth?
($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 14 kN
B) 94 μN
C) 140 μN
D) 23 μN
E) 47 μN
Answer: E
Var: 1

32) The total electromagnetic power emitted by the sun is 3.8×10^{26} W. What is the radiation pressure on a totally absorbing satellite at the orbit of Mercury, which has an orbital radius of 5.8×10^{10} m?
($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 30 μPa
B) 0.30 μPa
C) 0.030 μPa
D) 300 μPa
E) 3.0 μPa
Answer: A
Var: 1

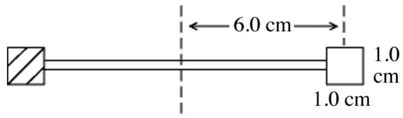
33) A 22.0-kg mirror with a surface area of 1.0 m^2 and a 98% reflectivity is bombarded by light of average intensity 770.0 W/m^2 at an angle of 30.0° to the normal of its surface. If the light has a duration of 0.60 s, how much does the velocity of the mirror change during that time? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 120 nm/s
B) 4.2 nm/s
C) 3.6 nm/s
D) 2.1 nm/s
Answer: A
Var: 50+

34) 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. An electromagnetic wave with an intensity of 0.30 kW/m^2 is incident normally upon the vanes. What is the radiation pressure on the blackened vane? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)



A) 1.0×10^{-10} Pa
B) 1.0×10^{-9} Pa
C) 1.0×10^{-8} Pa
D) 1.0×10^{-7} Pa
E) 1.0×10^{-6} Pa
Answer: E
Var: 1

35) 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. An electromagnetic wave with an intensity of 0.30 kW/m^2 is incident normally upon the vanes. What is the torque due to radiation pressure on the vane assembly about the vertical axis? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)



A) 2.4×10^{-12} N · m
B) 6.0×10^{-12} N · m
C) 1.2×10^{-11} N · m
D) 1.8×10^{-11} N · m
E) 2.4×10^{-11} N · m
Answer: B
Var: 1

36) A microwave oven operates with sinusoidal microwaves at a frequency of 2400 MHz. The height of the oven cavity is 25 cm and the base measures 30 cm by 30 cm. Assume that microwave energy is generated uniformly on the upper surface of the cavity and propagates directly downward toward the base. The base is lined with a material that completely absorbs microwave energy. The total microwave energy content of the cavity is 0.50 μJ. What magnitude force does the microwave beam exert on the base of the oven? ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
A) 1.6 μN
B) 2.0 μN
C) 2.5 μN
D) 3.0 μN
E) 3.5 μN
Answer: B
Var: 1

37) A totally absorbing surface having an area of 7.7 cm^2 faces a small source of sinusoidal electromagnetic radiation that is 2.4 m away. At the surface, the electric field amplitude of the radiation is 84 V/m. ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
(a) What is the radiation pressure exerted on the surface?
(b) What is the total power output of the source, if it is assumed to radiate uniformly in all directions?
Answer: (a) 0.031 μPa (b) 680 W
Var: 1

38) A laser beam has a wavelength of 633 nm and a power of 0.500 mW spread uniformly over a circle 1.20 mm in diameter. This beam falls perpendicularly on a perfectly reflecting piece of paper having twice the diameter of the laser beam and a mass of 1.50 mg. ($c = 3.00 \times 10^8$ m/s, $\mu_0 = 4\pi \times 10^{-7}$ T · m/A, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
(a) What are the amplitudes of the electric and magnetic fields in this laser beam?
(b) What acceleration does the laser beam give to the paper?
Answer: (a) 577 N/C, 1.92 μT (b) 2.22 $\mu m/s^2$
Var: 1

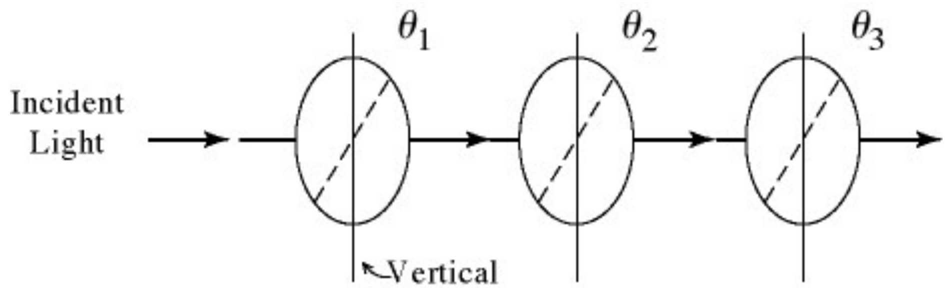
39) Light of intensity I_0 and polarized horizontally passes through three polarizes. The first and third polarizing axes are horizontal, but the second one is oriented 20.0° to the horizontal. In terms of I_0, what is the intensity of the light that passes through the set of polarizers?
A) $0.780 I_0$
B) $0.180 I_0$
C) $0.442 I_0$
D) $0.883 I_0$
Answer: A
Var: 1

40) Polarized light passes through a polarizer. If the electric vector of the polarized light is horizontal what, in terms of the initial intensity I_0, is the intensity of the light that passes through a polarizer if the polarizer is tilted 22.5° from the horizontal?
A) $0.854 I_0$
B) $0.147 I_0$
C) $0.191 I_0$
D) $0.011 I_0$
Answer: A
Var: 1

41) Unpolarized light is incident upon two polarization filters that do not have their transmission axes aligned. If 18% of the light passes through this combination of filters, what is the angle between the transmission axes of the filters?
A) 53°
B) 73°
C) 85°
D) 80°
Answer: A
Var: 31

42) Unpolarized light passes through three polarizing filters. The first one is oriented with a horizontal transmission axis, the second filter has its transmission axis 25.7° from the horizontal, and the third one has a vertical transmission axis. What percent of the light gets through this combination of filters?
A) 7.6%
B) 92.4%
C) 50.0%
D) 0.00%
Answer: A
Var: 1

43) In the figure, the orientation of the transmission axis for each of three polarizing sheets is labeled relative to the vertical direction. A beam of light, polarized in the vertical direction, is incident on the first polarized with an intensity of 1000 W/m^2. What is the intensity of the beam after it has passed through the three polarizing sheets when θ_1 = 30°, θ_2 = 30° and θ_3 =60°?



A) 141 W/m^2
B) 316 W/m^2
C) 433 W/m^2
D) 563 W/m^2
E) 188 W/m^2
Answer: D
Var: 1

44) The following are positioned in sequence: A source of a beam of natural light of intensity I_0; three ideal polarizers *A*, *B*, and *C*; and an observer. Polarizer axis angles are measured clockwise from the vertical, from the perspective of the observer. The axis angle of polarizer *A* is set at 0° (vertical), and the axis angle of polarizer *C* is set at 50°. Polarizer *B* is set so that the beam intensity is zero at the observer. Which of the following pairs of angles are possible axis angle settings of polarizer *B*?
A) 40° and 90°
B) 40° and 130°
C) 40° and 140°
D) 90° and 130°
E) 90° and 140°
Answer: E
Var: 1