## Problem 32.39



A cylindrical conductor with a circular cross section has a radius $a$ and a resistivity $\rho$ and carries a constant current $I$. (Take the current to be coming out of the page when the cross-sectional view of the conductor is in the plane of the page.)

Review | Constants

### Part A

What is the magnitude of the electric-field vector $\vec{E}$ at a point just inside the wire at a distance $a$ from the axis?

**Express your answer in terms of some or all of the variables $I$, $a$, $\rho$, and constants $\mu_0$, $\epsilon_0$, $\pi$.**

$E =$

Submit Request Answer

### Part B

What is the direction of this electric-field vector $\vec{E}$?

- opposite to the direction of the current
- counterclockwise around the circle
- clockwise around the circle
- in the direction of the current

## Part C

What is the magnitude of the magnetic-field vector $\vec{B}$ at the same point?

**Express your answer in terms of some or all of the variables $I$, $a$, $\rho$, and constants $\mu_0$, $\epsilon_0$, $\pi$.**

$B =$

Submit Request Answer

## Part D

What is the direction of this magnetic-field vector $\vec{B}$?

- opposite to the direction of the current
- in the direction of the current
- clockwise around the circle
- counterclockwise around the circle

Submit Request Answer

## Part E

What is the magnitude of the Poynting vector $\vec{S}$ at the same point?

**Express your answer in terms of some or all of the variables $I$, $a$, $\rho$, and constants $\mu_0$, $\epsilon_0$, $\pi$.**

$S$ =

Submit Request Answer

## Part F

What is the direction of this Poynting vector $\vec{S}$? (The direction of $\vec{S}$ is the direction in which electromagnetic energy flows into or out of the conductor.)

- in the direction of the current
- radially inward
- radially outward
- opposite to the direction of the current

## Part G

Use the results in parts (e) and (f) to find the rate of flow of energy into the volume occupied by a length $l$ of the conductor. (*Hint:* Integrate $\vec{S}$ over the surface of this volume.)

**Express your answer in terms of some or all of the variables $I$, $a$, $\rho$, $l$, and constants $\mu_0$, $\epsilon_0$, $\pi$.**

$P =$

Submit Request Answer

## Part H

Compare your result to the rate of generation of thermal energy in the same volume.

$P/P_R =$

Submit Request Answer

## Problem 32.41 - Enhanced - with Feedback



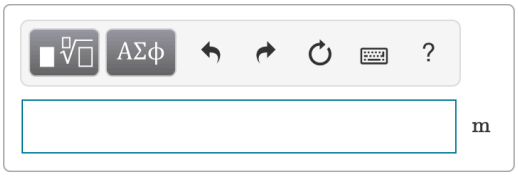
In a certain experiment, a radio transmitter emits sinusoidal electromagnetic waves of frequency 105.0 MHz in opposite directions inside a narrow cavity with reflectors at both ends, causing a standing wave pattern to occur.

Review | Constants

### Part A

How far apart are the nodal planes of the magnetic field?

**Express your answer in meters.**

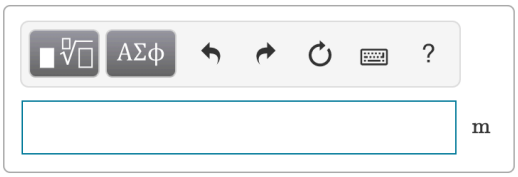



Submit Request Answer

### Part B

If the standing wave pattern is determined to be in its eighth harmonic, how long is the cavity?

**Express your answer in meters.**



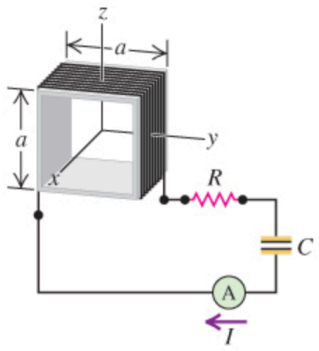
## Problem 32.42



An antenna is created by wrapping a square frame with side length $a$ by a wire $N$ times and then connecting the leads to a resistor $R$ and a capacitor $C$, as shown in (Figure 1). The loop itself has self-inductance $L$. A plane electromagnetic wave with electric field $\vec{E} = E_{\max}\cos(kz - \omega t)\hat{\jmath}$ propagates in the $+z$-direction. The origin is at the center of the frame.

### Figure

1 of 1




Review | Constants

### Part A

What is the magnetic flux through the coil in the direction of the $+x$-axis (*Hint*: The identity $\sin(A+B)+\sin(A-B) = 2\sin A\cos B$ may prove helpful.)

**Express your answer in terms of the variables $a$, $E_{\max}$, $\omega$, $k$, and $t$.**

$\Phi_B$ =

Submit | Request Answer

### Part B

What is the emf generated in the coil?

**Express your answer in terms of the variables $N$, $a$, $E_{\max}$, $\omega$, $k$, and $t$.**

$\mathcal{E}$ =

## Part C

The electromagnetic wave has frequency 4.00 $\mathrm{MHz}$ and intensity 100 $\mathrm{W/m^2}$. The coil has $N$ = 50 windings and side length $a$ = 10.0 $\mathrm{cm}$. It follows that its self-inductance is $L$ = 78.0 $\mu\mathrm{H}$. If the resistance in the circuit is $R$ = 100 $\Omega$, what value of the capacitance $C$ results in the resonance frequency of the $L$-$R$-$C$ circuit being equal to the frequency of the wave?

**Express your answer with the appropriate units.**

$C$ = Value Units

Submit Request Answer

## Part D

What rms value of the current $I_{\mathrm{rms}}$ flows in that case?

**Express your answer with the appropriate units.**

$I_{\mathrm{rms}}$ = Value Units

## Exercise 32.4 - Enhanced - with Feedback



Consider each of the electric- and magnetic-field orientations.

Review | Constants

### Part A

What is the direction of propagation of the wave if $\vec{E} = E\hat{i},\ \vec{B} = -B\hat{j}$.

**Express the direction of the propagation vector, $\vec{P}$, as a unit vector. Its three components should be entered in order (x,y,z) separated by commas. For example, if the wave propagates only in the -*x* direction, enter `-1,0,0`.**

Submit Request Answer

### Part B

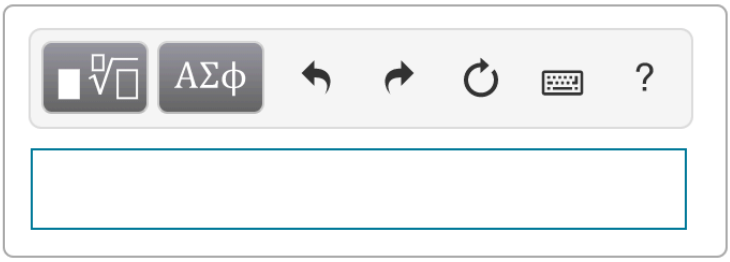
What is the direction of propagation of the wave if $\vec{E} = E\hat{j},\ \vec{B} = B\hat{i}$.

**Express the direction of the propagation vector, $\vec{P}$, as a unit vector. Its three components should be entered in order (x,y,z) separated by commas. For example, if the wave propagates only in the -*x* direction, enter `-1,0,0`.**

## Part C

What is the direction of propagation of the wave if $\vec{E} = -E\hat{k},\ \vec{B} = -B\hat{i}$.

**Express the direction of the propagation vector, $\vec{P}$, as a unit vector. Its three components should be entered in order (x,y,z) separated by commas. For example, if the wave propagates only in the -*x* direction, enter `-1,0,0`.**

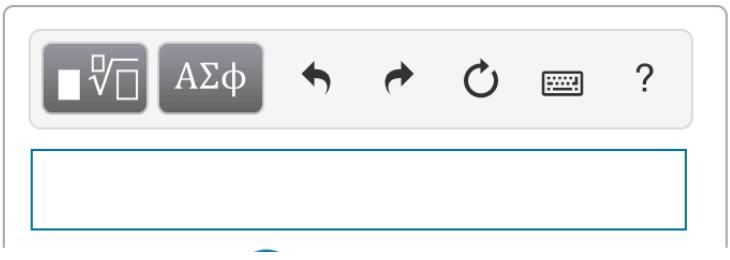



Submit Request Answer

## Part D

What is the direction of propagation of the wave if $\vec{E} = E\hat{i},\ \vec{B} = -B\hat{k}$.

**Express the direction of the propagation vector, $\vec{P}$, as a unit vector. Its three components should be entered in order (x,y,z) separated by commas. For example, if the wave propagates only in the -*x* direction, enter `-1,0,0`.**



## Exercise 32.10 - Enhanced - with Feedback



The electric field of a sinusoidal electromagnetic wave obeys the equation $E = (375\ \text{V/m})\cos[(1.99 \times 10^7\ \text{rad/m})x + (5.97 \times 10^{15}\ \text{rad/s})t]$.

Review | Constants

### Part A

What is the speed of the wave?

**Express your answer with the appropriate units.**

$v$ = Value Units

Submit Request Answer

### Part B

What is the amplitude of the electric field of this wave?

**Express your answer with the appropriate units.**

$E_{\text{max}}$ = Value Units

## Part C

What is the amplitude of the magnetic field of this wave?

**Express your answer in teslas.**

$B_{\max}$ = T

Submit Request Answer

## Part D

What is the frequency of the wave?

**Express your answer with the appropriate units.**

$f$ = *Value* *Units*

Submit Request Answer

## Part E

What is the wavelength of the wave?

**Express your answer with the appropriate units.**

$\lambda =$ Value Units

Submit Request Answer

## Part F

What is the period of the wave?

**Express your answer with the appropriate units.**

$T =$ Value Units

Submit Request Answer

## Exercise 32.18



The energy flow to the earth from sunlight is about $1.40\ \mathrm{kW/m^2}$.

Review | Constants

### Part A

Find the maximum value of the electric field for a sinusoidal wave of this intensity.

**Express your answer in newtons per coulomb.**

$E_{\max}$ = N/C

Submit Request Answer

### Part B

Find the maximum value of the magnetic field for a sinusoidal wave of this intensity.

**Express your answer in teslas.**

$B_{\max}$ = T

## Part C

The distance from the earth to the sun is about $1.50 \times 10^{11}$ m. Find the total power radiated by the sun.

**Express your answer in watts.**

$P_{\text{sun}} =$ W

Submit Request Answer

## Exercise 32.19



A point source emits monochromatic electromagnetic waves into air uniformly in all directions. You measure the amplitude $E_{\text{max}}$ of the electric field at several distances from the source. After graphing your results as $E_{\text{max}}$ versus $1/r$ you find that the data lie close to a straight line that has slope 40.0 $\text{N} \cdot \text{m/C}$.

Review | Constants

### Part A

What is the average power output of the source?

**Express your answer with the appropriate units.**

$P_{\text{average}}$ = *Value* *Units*

Submit Request Answer

A sinusoidal electromagnetic wave emitted by a mobile phone has a wavelength of 36.1 $\mathrm{cm}$ and an electric-field amplitude of $5.50\times10^{-2}\ \mathrm{V/m}$ at a distance of 210 $\mathrm{m}$ from the phone.

Review | Constants

## Part A

Calculate the frequency of the wave.

**Express your answer with the appropriate units.**

$f$ = Value Units

Submit Request Answer

## Part B

Calculate the magnetic-field amplitude.

**Express your answer with the appropriate units.**

$B_{\max}$ = Value Units

## Part C

Find the intensity of the wave.

**Express your answer with the appropriate units.**

$I =$ *Value* *Units*

Submit Request Answer

## Exercise 32.22 - Enhanced - with Feedback



Public television station KQED in San Francisco broadcasts a sinusoidal radio signal at a power of 777 $\mathrm{kW}$. Assume that the wave spreads out uniformly into a hemisphere above the ground.

Review | Constants

### Part A

At a home 4.00 $\mathrm{km}$ away from the antenna, what average pressure does this wave exert on a totally reflecting surface?

**Express your answer in pascals.**

$P_{av}$ = Pa

Submit Request Answer

### Part B

At a home 4.00 $\mathrm{km}$ away from the antenna, what are the amplitudes of the electric and magnetic fields of the wave?

**Express the electric field amplitude in newtons per coulomb. Express the magnetic field amplitude in teslas. Enter your answers numerically separated by a comma.**

$E_{\max}, B_{\max}$ = N/C, T

## Part C

At a home 4.00 $\mathrm{km}$ away from the antenna, what is the average density of the energy this wave carries?

**Express your answer in joules per meter cubed.**

$u_{av}$ = $\mathrm{J/m^3}$

Submit Request Answer

## Part D

For the energy density in part (c), what percentage is due to the electric field?

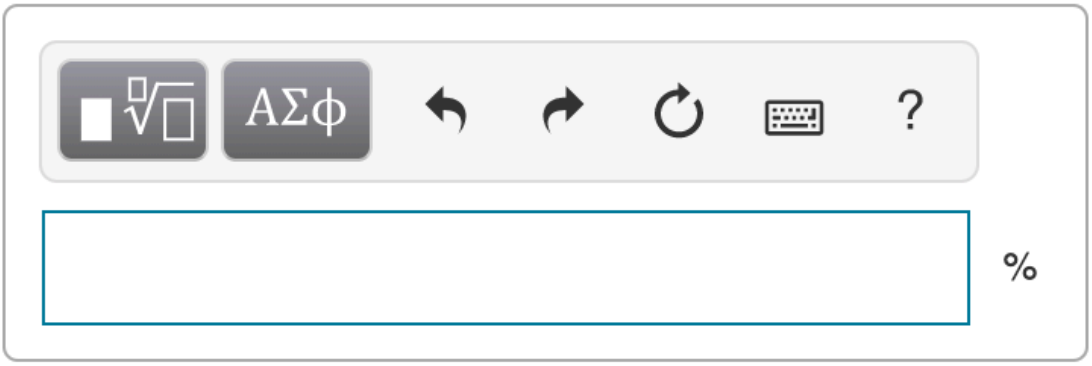
**Express your answer as a percentage.**

%

## Part E

For the energy density in part (c), what percentage is due to the magnetic field?

**Express your answer as a percentage.**

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Request Answer

## Exercise 32.24 - Enhanced - with Feedback



In the 25 $\text{ft}$ Space Simulator facility at NASA's Jet Propulsion Laboratory, a bank of overhead arc lamps can produce light of intensity 2500 $\text{W/m}^2$ at the floor of the facility. (This simulates the intensity of sunlight near the planet Venus.)

Review | Constants

### Part A

Find the average radiation pressure (in pascals and in atmospheres) on a totally absorbing section of the floor.

**Enter your answers in pascals and in atmospheres separated by a comma.**

$P_{\text{ab,Pa}}, P_{\text{ab,atm}}$ = 8.3×10$^{-6}$,8.2×10$^{-11}$ Pa, atm

Submit | Previous Answers

**Correct**

Term 1: Correct answer is shown. Your answer $8.33 \cdot 10^{-6}$ = *8.33×10$^{-6}$* Pa, atm was either rounded differently or used a different number of significant figures than required for this part.

Term 2: Correct answer is shown. Your answer $8.22 \cdot 10^{-11}$ = *8.22×10$^{-11}$* Pa, atm was either rounded differently or used a different number of significant figures than required for this part.

### Part B

Find the average radiation pressure (in pascals and in atmospheres) on a totally reflecting section of the floor.

**Enter your answers in pascals and in atmospheres separated by a comma.**

$P_{\text{re,Pa}}, P_{\text{re,atm}}$ = Pa, atm

## Part C

Find the average momentum density (momentum per unit volume) in the light at the floor.

**Express your answer in kilograms per square meter second.**

$\frac{dp}{dV} =$ [ ] $\mathrm{kg/m^2 \cdot s}$

Submit Request Answer

## Exercise 32.25 - Enhanced - with Solution



He-Ne lasers are often used in physics demonstrations. They produce light of wavelength 633 $\mathrm{nm}$ and a power of 0.550 $\mathrm{mW}$ spread over a cylindrical beam 1.25 $\mathrm{mm}$ in diameter (although these quantities can vary).

For related problem-solving tips and strategies, you may want to view a Video Tutor Solution of Energy in a nonsinusoidal wave.

Review | Constants

### Part A

What is the intensity of this laser beam?

**Express your answer in watts per meter squared.**

$I =$ $\mathrm{W/m^2}$

Submit Request Answer

### Part B

What is the maximum value of the electric field?

**Express your answer in volts per meter.**

$E_{\mathrm{max}} =$ $\mathrm{V/m}$

## Part C

What is the maximum value of the magnetic field?

**Express your answer in microteslas.**

$B_{\text{max}} =$ $\mu\text{T}$

Submit Request Answer

## Part D

What is the average energy density in the laser beam?

**Express your answer in joules per meter cubed.**

$u_{\text{av}} =$ $\text{J/m}^3$

Submit Request Answer

## Exercise 32.27 - Enhanced - with Solution



The microwaves in a certain microwave oven have a wavelength of 12.2 cm.

For related problem-solving tips and strategies, you may want to view a Video Tutor Solution of Standing waves in a cavity.

Review | Constants

### Part A

How wide must this oven be so that it will contain five antinodal planes of the electric field along its width in the standing wave pattern?

**Express your answer in centimeters.**

$L =$ cm

Submit Request Answer

### Part B

What is the frequency of these microwaves?

**Express your answer in hertz.**

$f =$ Hz

## Problem 32.45



Interplanetary space contains many small particles referred to as *interplanetary dust*. Radiation pressure from the sun sets a lower limit on the size of such dust particles. To see the origin of this limit, consider a spherical dust particle of radius $R$ and mass density $\rho$.

Review | Constants

### Part A

Write an expression for the gravitational force exerted on this particle by the sun (mass $M$) when the particle is a distance $r$ from the sun.

**Express your answer in terms of $M$, $R$, $r$, $\rho$, and gravitational constant $G$.**

$F_G = \frac{4}{3}GM\rho\pi\left(\frac{R^3}{r^2}\right)$

Submit | Previous Answers

✔ Correct

### Part B

Let $L$ represent the luminosity of the sun, equal to the rate at which it emits energy in electromagnetic radiation. Find the force exerted on the (totally absorbing) particle due to solar radiation pressure. The relevant area is the cross-sectional area of the particle, *not* the total surface area of the particle.

**Express your answer in terms of $L$, $R$, $r$, and speed of light $c$.**

$F =$

## Part C

The mass density of a typical interplanetary dust particle is about $3000\ \mathrm{kg/m^3}$. Find the particle radius $R$ such that the gravitational and radiation forces acting on the particle are equal in magnitude. The luminosity of the sun is $3.9 \times 10^{26}\ \mathrm{W}$.

**Express your answer in meters.**

$R =$ m

## Problem 32.49



When electromagnetic radiation strikes perpendicular to a flat surface, a totally absorbing surface feels radiation pressure $I_0/c$, where $I_0$ is the intensity of incident electromagnetic radiation. A totally reflecting surface feels twice that pressure. More generally, a surface absorbs a proportion $e$ of the incident radiation and reflects a complementary proportion, $1 - e$, where $e$ is the emissivity of the surface. Note that $0 \leq e \leq 1$.

Review | Constants

### Part A

Determine the radiation pressure $p_{\text{rad}}$ in terms of $I_0$ and $e$.

**Express your answer in terms of the variables $I_0$, $e$, and speed of light $c$.**

$p_{\text{rad}} =$

Submit Request Answer

### Part B

Consider cosmic dust particles in outer space at a distance of $1.5 \times 10^{11}$ m from the sun, where $I_{\text{sun}} = 1.4\ \text{kW/m}^2$. We can model these particles as tiny disks with $e = 0.61$ diameter 6.0 $\mu$m and mass $1.0 \times 10^{-10}$ grams, all oriented perpendicular to the sun's rays. What is the force on one of these particles that is exerted by the radiation from the sun?

**Express your answer with the appropriate units.**

$F_{\text{rad}} =$ Value Units

## Part C

What is the ratio of this force to the attractive force of gravity exerted by the sun on the particle?

$\frac{F_{\text{rad}}}{F_{\text{grav}}} =$

Submit

Request Answer

## Part C

Suppose a manufacturing error occurred and the oven was made 6.0 $\mathrm{cm}$ longer than specified in part (a). In this case, what would have to be the frequency of the microwaves for there still to be five antinodal planes of the electric field along the width of the oven?

**Express your answer in hertz.**

$f =$ Hz

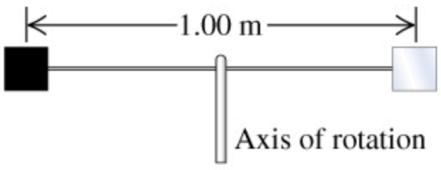
Submit Request Answer

## Problem 32.37



Two square reflectors, each 2.00 $\mathrm{cm}$ on a side and of mass 5.00 $\mathrm{g}$, are located at opposite ends of a thin, extremely light, 1.00 $\mathrm{m}$ rod that can rotate without friction and in a vacuum about an axle perpendicular to it through its center (Figure 1). These reflectors are small enough to be treated as point masses in moment-of-inertia calculations. Both reflectors are illuminated on one face by a sinusoidal light wave having an electric field of amplitude 1.35 $\mathrm{N/C}$ that falls uniformly on both surfaces and always strikes them perpendicular to the plane of their surfaces. One reflector is covered with a perfectly absorbing coating, and the other is covered with a perfectly reflecting coating.

**Figure** 1 of 1




Review | Constants

### Part A

What is the angular acceleration of this device?

**Express your answer in radians per second squared.**

$\alpha =$ ____ $\mathrm{rad/s^2}$

Submit Request Answer

Provide Feedback

Next

## Problem 32.38



A source of sinusoidal electromagnetic waves radiates uniformly in all directions. At a distance of 15.0 $\mathrm{m}$ from this source, the amplitude of the electric field is measured to be 3.60 $\mathrm{N/C}$.

Review | Constants

### Part A

What is the electric-field amplitude at a distance of 30.0 $\mathrm{cm}$ from the source?

**Express your answer with the appropriate units.**

$E_{\mathrm{max}}$ = Value Units

Submit Request Answer

Provide Feedback

Next