P33.9 Since the separation of the burn marks is $d_{\text{A to A}} = 6\text{ cm} \pm 5\% = \dfrac{\lambda}{2}$, then

$\lambda = 12\text{ cm } \pm 5\%$ and

$$\begin{aligned} v = \lambda f &= (0.12\text{ m } \pm 5\%)\left(2.45 \times 10^9\text{ s}^{-1}\right) \\ &= \boxed{2.9 \times 10^8\text{ m/s } \pm 5\%} \end{aligned}$$

P33.10 $E = E_{\max} \cos\left(kx - \omega t\right)$

$$\frac{\partial E}{\partial x} = -E_{\max} \sin\left(kx - \omega t\right)(k) \quad \rightarrow \quad \frac{\partial^2 E}{\partial x^2} = -E_{\max} \cos\left(kx - \omega t\right)\left(k^2\right)$$

$$\frac{\partial E}{\partial t} = -E_{\max} \sin\left(kx - \omega t\right)(-\omega) \quad \rightarrow \quad \frac{\partial^2 E}{\partial t^2} = -E_{\max} \cos\left(kx - \omega t\right)(-\omega)^2$$

We must show: $\dfrac{\partial^2 E}{\partial x^2} = \mu_0 \in_0 \dfrac{\partial^2 E}{\partial t^2}$

That is, $-\left(k^2\right)E_{\max} \cos\left(kx - \omega t\right) = -\mu_0 \in_0 (-\omega)^2 E_{\max} \cos\left(kx - \omega t\right)$.

But this is true, because $\dfrac{k^2}{\omega^2} = \left(\dfrac{1}{f\lambda}\right)^2 = \dfrac{1}{c^2} = \mu_0 \in_0$.

The proof for the wave of the magnetic field follows precisely the same steps.

P33.11 The amplitudes of the electric and magnetic fields are in the correct ratio so that $E_{\max}/B_{\max} = c$. The ratio of ω to k, however, must also equal the speed of light:

$$\frac{\omega}{k} = \frac{3.00 \times 10^{15}\text{ s}^{-1}}{9.00 \times 10^{6}\text{ m}^{-1}} = 3.33 \times 10^8\text{ m/s}$$

This value is higher than the speed of light in a vacuum, so the wave as described is impossible.

33.14 (a) $$\frac{P}{\text{area}}=\frac{\text{energy}}{\Delta t\cdot\text{area}}=\frac{600\times10^{3}\ \text{Wh}}{(30\ \text{d})(13.0\ \text{m})(9.50\ \text{m})}\left(\frac{1\ \text{d}}{24\ \text{h}}\right)=\boxed{6.75\ \text{W/m}^{2}}$$

(b) The car uses gasoline at the rate of $(55\ \text{mi/h})\left(\frac{\text{gal}}{25\ \text{mi}}\right)$. Its rate of energy conversion is

$$P=44.0\times10^{6}\ \text{J/kg}\left(\frac{2.54\ \text{kg}}{1\ \text{gal}}\right)(55\ \text{mi/h})\left(\frac{\text{gal}}{25\ \text{mi}}\right)\left(\frac{1\ \text{h}}{3\,600\ \text{s}}\right)$$
$$=6.83\times10^{4}\ \text{W}$$

Its power-per-footprint-area is

$$\frac{P}{\text{area}}=\frac{6.83\times10^{4}\ \text{W}}{(2.10\ \text{m})(4.90\ \text{m})}=\boxed{6.64\times10^{3}\ \text{W/m}^{2}}$$

(c) A powerful automobile that is running on sunlight would have to carry on its roof a solar panel huge compared with the size of the car.

(d) Agriculture and forestry for food and fuels, space heating of large and small buildings, water heating, and heating for drying and many other processes are current and potential applications of solar energy.

P33.15 (a) $$B_{\max}=\frac{E_{\max}}{c}:\ B_{\max}=\frac{7.00\times10^{5}\ \text{N/C}}{3.00\times10^{8}\ \text{m/s}}=\boxed{2.33\ \text{mT}}$$

(b) $$I=\frac{E_{\max}^{2}}{2\mu_0 c}:$$

$$I=\frac{\left(7.00\times10^{5}\ \text{V/m}\right)^{2}}{2\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)\left(3.00\times10^{8}\ \text{m/s}\right)}=6.50\times10^{8}\ \text{W/m}^{2}$$
$$=\boxed{650\ \text{MW/m}^{2}}$$

(c) $$I=\frac{P}{A}:\quad P=IA=\left(6.50\times10^{8}\ \text{W/m}^{2}\right)\left[\frac{\pi}{4}\left(1.00\times10^{-3}\ \text{m}\right)^{2}\right]=\boxed{511\ \text{W}}$$

P33.16 The energy put into the water in each container by electromagnetic radiation can be written as $\Delta E = eP\Delta t = eIA\Delta t$, where e is the percentage absorption efficiency. This energy has the same effect as heat in raising the temperature of the water:

$$eIA\Delta t = mc\Delta T = \rho Vc\Delta T$$

$$\Delta T = \frac{eI\ell^2\Delta t}{\rho\ell^3 c} = \frac{eI\Delta t}{\rho\ell c}$$

where ℓ is the edge dimension of the container and c the specific heat of water. For the small container,

$$\Delta T = \frac{0.700\left(25.0\times10^3\ \text{W/m}^2\right)(480\ \text{s})}{\left(10^3\ \text{kg/m}^3\right)(0.060\ 0\ \text{m})\left(4\,186\ \text{J/kg}\cdot{}^\circ\text{C}\right)} = \boxed{33.4^\circ\text{C}}$$

For the larger,

$$\Delta T = \frac{0.910\left(25.0\times10^3\ \text{W/m}^2\right)(480\ \text{s})}{\left(10^3\ \text{kg/m}^3\right)(0.120\ \text{m})\left(4\,186\ \text{J/}^\circ\text{C}\right)} = \boxed{21.7^\circ\text{C}}$$

P33.18 (a) The intensity of the broadcast waves is

$$I = \frac{B_{\max}^2 c}{2\mu_0} = \frac{P}{4\pi r^2}$$

solving,

$$B_{\max} = \sqrt{\left(\frac{P}{4\pi r^2}\right)\left(\frac{2\mu_0}{c}\right)} = \sqrt{\left(\frac{P}{2\pi r^2}\right)\left(\frac{\mu_0}{c}\right)}$$

$$= \sqrt{\frac{\left(10.0\times10^3\ \text{W}\right)\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)}{2\pi\left(5.00\times10^3\ \text{m}\right)^2\left(3.00\times10^8\ \text{m/s}\right)}} = \boxed{5.16\times10^{-10}\ \text{T}}$$

(b) Since the magnetic field of the Earth is approximately 5×10^{-5} T, the Earth's field is some 100 000 times stronger.

P33.23 (a) $I = \frac{P}{\pi r^2} = \frac{E_{max}^2}{2\mu_0 c}$, and $r = 1.00 \times 10^{-3}$ m:

$$E_{max} = \sqrt{\frac{2\mu_0 cP}{\pi r^2}}$$
$$= \sqrt{\frac{2\left[4\pi \times 10^{-7} \text{ T}\cdot\text{m/A}\right]\left(3.00\times 10^8 \text{ m/s}\right)\left(15.0\times 10^{-3} \text{ W}\right)}{\pi\left(1.00\times 10^{-3} \text{ m}\right)^2}}$$
$$= 1.90\times 10^8 \text{ J} = \boxed{1.90 \text{ kN/C}}$$

(b) The beam carries power P. The amount of energy ΔE in the length of a beam of length ⌈ is the amount of power that passes a point in time interval $\Delta t = \ell/c$:

$$P = \frac{\Delta E}{\Delta t} = \frac{\Delta E}{\ell/c}$$

or $$\Delta E = \frac{P\ell}{c} = \frac{15.0\times 10^{-3} \text{ W}}{3.00\times 10^8 \text{ m/s}}(1.00 \text{ m}) = \boxed{50.0 \text{ pJ}}.$$

(c) From Equation 33.34 and our result in part (b), the momentum and energy carried a light beam are related by

$$p = \frac{T_{ER}}{c} = \frac{\Delta E}{c} = \frac{50.0\times 10^{-12} \text{ J}}{3.00\times 10^8 \text{ m/s}} = \boxed{1.67\times 10^{-19} \text{ kg}\cdot\text{m/s}}$$

P33.34 From the electromagnetic spectrum chart and accompanying text discussion, the following identifications are made:

Frequency, f	Wavelength, $\lambda = \frac{c}{f}$	Classification
2 Hz = 2×10^0 Hz	150 Mm	Radio
2 KHz = 2×10^3 Hz	150 km	Radio

2 MHz = 2×10^6 Hz	150 m	Radio
2 GHz = 2×10^9 Hz	15 cm	Microwave
2 THz = 2×10^{12} Hz	150 μm	Infrared
2 PHz = 2×10^{15} Hz	150 nm	Ultraviolet
2 EHz = 2×10^{18} Hz	150 pm	X-ray
2 ZHz = 2×10^{21} Hz	150 fm	Gamma ray
2 YHz = 2×10^{24} Hz	150 am	Gamma ray

Wavelength, λ	Frequency, $f = \frac{c}{\lambda}$	Classification
2 km = 2×10^3 m	1.5×10^5 Hz	Radio
2 m = 2×10^0 m	1.5×10^8 Hz	Radio
2 mm = 2×10^{-3} m	1.5×10^{11} Hz	Microwave
2 μm = 2×10^{-6} m	1.5×10^{14} Hz	Infrared
2 nm = 2×10^{-9} m	1.5×10^{17} Hz	Ultraviolet/X-ray
2 pm = 2×10^{-12} m	1.5×10^{20} Hz	X-ray/Gamma ray
2 fm = 2×10^{-15} m	1.5×10^{23} Hz	Gamma ray
2 am = 2×10^{-18} m	1.5×10^{26} Hz	Gamma ray

P33.36 The angular frequency of the wave is

$$\omega = 2\pi f = 2\pi\left(3.00\times 10^{9}\ \text{s}^{-1}\right) = 1.88\times 10^{10}\ \text{s}^{-1}$$

and the wave number is

$$k = \frac{2\pi}{\lambda} = \frac{\omega}{c} = 2\pi\left(\frac{3.00\times 10^{9}\ \text{s}^{-1}}{3.00\times 10^{8}\ \text{m/s}}\right) = 20.0\pi\ \text{m}^{-1} = 62.8\ \text{m}^{-1}$$

Also,

$$B_{\text{max}} = \frac{E}{c} = \frac{300\ \text{V/m}}{3.00\times 10^{8}\ \text{m/s}} = 1.00\ \mu\text{T}$$

Then,

$$\boxed{E = 300\cos\left(62.8x - 1.88\times 10^{10}t\right)}$$

$$\boxed{B = 1.00\cos\left(62.8x - 1.88\times 10^{10}t\right)}$$

where E is in volts per meter (V/m), B is in microtesla (μT), x is in meters, and t is in seconds.

P33.38 (a) The power incident on the mirror is:

$$P_I = IA = \left(1\ 370\ \text{W/m}^2\right)\left[\pi(100\ \text{m})^2\right] = 4.30\times 10^{7}\ \text{W}.$$

The power reflected through the atmosphere is

$$P_R = 0.746\left(4.30\times 10^{7}\ \text{W}\right) = \boxed{3.21\times 10^{7}\ \text{W}}$$

(b) $$S = \frac{P_R}{A} = \frac{3.21\times 10^{7}\ \text{W}}{\pi\left(4.00\times 10^{3}\ \text{m}\right)^2} = \boxed{0.639\ \text{W/m}^2}$$

(c) Noon sunshine in St. Petersburg produces this power-per-area on a horizontal surface:

$$\frac{P_N}{A} = 0.746\left(1\ 370\ \text{W/m}^2\right)\sin 7.00° = 125\ \text{W/m}^2$$

The radiation intensity received from the mirror is

$\left(\frac{0.639\ \text{W/m}^2}{125\ \text{W/m}^2}\right)100\% = \boxed{0.513\%}$ of that from the noon Sun in

January.

P33.39 Suppose you cover a 1.7 m × 0.3 m section of beach blanket. Suppose the elevation angle of the Sun is 60°. Then the effective target area you fill in the Sun's light is

$$A = (1.7\ \text{m})(0.3\ \text{m})\cos 30° = 0.4\ \text{m}^2$$

Now $I = \frac{P}{A} = \frac{\Delta E}{A\Delta t}$, so

$$\Delta E = IA\Delta t = (0.5)\left[(0.6)\left(1\,370\ \text{W/m}^2\right)\right]\left(0.4\ \text{m}^2\right)(3\,600\ \text{s})$$
$$\boxed{\sim 10^6\ \text{J}}$$

P33.43 The mirror intercepts power

$$P = I_1 A_1 = \left(1.00\times10^3\ \text{W/m}^2\right)\left[\pi(0.500\ \text{m})^2\right] = 785\ \text{W}.$$

(a) In the image, $I_2 = \frac{P}{A_2}$, so

$$I_2 = \frac{785\ \text{W}}{\pi(0.020\,0\ \text{m})^2} = \boxed{625\ \text{kW/m}^2}$$

(b) $I_2 = \frac{E_{\text{max}}^2}{2\mu_0 c}$, so

$$\begin{aligned} E_{\text{max}} &= \sqrt{2\mu_0 c I_2} \\ &= \sqrt{2\left(4\pi\times10^{-7}\ \text{T}\cdot\text{m/A}\right)\left(3.00\times10^8\ \text{m/s}\right)\left(6.25\times10^5\ \text{W/m}^2\right)} \\ &= \boxed{21.7\ \text{kN/C}} \end{aligned}$$

(c) $B_{\max} = \frac{E_{\max}}{c} = \boxed{72.4\ \mu\text{T}}$

(d) We obtain the time interval from

$$0.400(P\Delta t) = mc\Delta T$$

solving,

$$\Delta t = \frac{mc\Delta T}{0.400P} = \frac{(1.00\text{ kg})(4\,186\text{ J/kg}\cdot{}^\circ\text{C})(100^\circ\text{C} - 20.0^\circ\text{C})}{0.400(785\text{ W})}$$

$$= 1.07 \times 10^3\text{ s} = \boxed{17.8\text{ min}}$$

P33.45 (a) At steady state, $P_{\text{in}} = P_{\text{out}}$ and the power radiated out is $P_{\text{out}} = e\sigma AT^4$. Thus,

$$T = \left[\frac{P_{\text{out}}}{e\sigma A}\right]^{1/4} = \left[\frac{900\text{ W/m}^2}{0.700(5.67 \times 10^{-8}\text{ W/m}^2\cdot\text{K}^4)}\right]^{1/4}$$

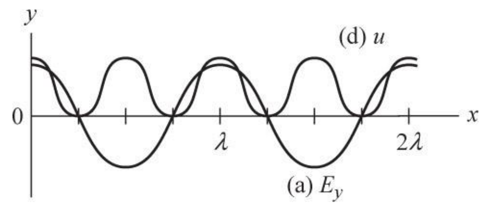
$$= \boxed{388\text{ K}} = 115^\circ\text{C}$$

(b) The box of horizontal area *A* presents projected area *A* sin 50.0° perpendicular to the sunlight. Then by the same reasoning,

$$0.900(1\,000\text{ W/m}^2)A\sin 50.0^\circ$$
$$= 0.700(5.67 \times 10^{-8}\text{ W/m}^2\cdot\text{K}^4)AT^4$$

or $$T = \left[\frac{(900\text{ W/m}^2)\sin 50.0^\circ}{0.700(5.67 \times 10^{-8}\text{ W/m}^2\cdot\text{K}^4)}\right]^{1/4} = \boxed{363\text{ K}} = 90.0^\circ\text{C}$$

P33.46 (a) See ANS. FIG. P33.46



ANS. FIG. P33.46

(b) $u_E = \frac{1}{2}\epsilon_0 E^2 = \boxed{\frac{1}{2}\epsilon_0 E_{\max}^2 \cos^2(kx)}$

(c) $u_B = \frac{1}{2\mu_0}B^2 = \boxed{\frac{1}{2\mu_0}B_{\max}^2 \cos^2(kx)}$

(d) Note that

$$u_B = \frac{1}{2\mu_0}\frac{E_{\max}^2}{c^2}\cos^2(kx) = \frac{1}{2\mu_0}\frac{E_{\max}^2}{(1/\mu_0\epsilon_0)}\cos^2(kx)$$
$$= \frac{1}{2}\epsilon_0 E_{\max}^2 \cos^2(kx) = u_E$$

Therefore, $u = u_E + u_B = \boxed{\epsilon_0 E_{\max}^2 \cos^2(kx)}$.

(e) $E_\lambda = \int_0^\lambda uA\, dx$

$$E_\lambda = \int_0^\lambda \epsilon_0 E_{\max}^2 \cos^2(kx) A\, dx = \int_0^\lambda \epsilon_0 E_{\max}^2 A\left[\frac{1}{2} + \frac{1}{2}\cos(2kx)\right] A\, dx$$
$$= \frac{1}{2}\epsilon_0 E_{\max}^2 A\, x\Big|_0^\lambda + \frac{\epsilon_0 E_{\max}^2}{4k} A \sin(2kx)\Big|_0^\lambda$$
$$= \frac{1}{2}\epsilon_0 E_{\max}^2 A\lambda + \frac{\epsilon_0 E_{\max}^2}{4k} A\left[\sin(4\pi) - \sin(0)\right]$$
$$= \boxed{\frac{1}{2}\epsilon_0 E_{\max}^2 \lambda A}$$

(f) $P = \frac{E_\lambda}{T} = \frac{1}{2}\frac{\epsilon_0 E_{\max}^2 \lambda A}{(1/f)} = \frac{1}{2}\epsilon_0 E_{\max}^2 (\lambda f) A = \boxed{\frac{1}{2}\epsilon_0 c E_{\max}^2 A}$

(g) $$I = \frac{P}{A} = \frac{\frac{1}{2}\epsilon_0 c E_{\max}^2 A}{A} = \boxed{\frac{1}{2}\epsilon_0 c E_{\max}^2}$$

(h) From part (g), we have

$$\frac{1}{2}\epsilon_0 c E_{\max}^2 = \frac{\mu_0}{\mu_0}\frac{\epsilon_0 c E_{\max}^2}{2} = \left(\mu_0 \epsilon_0\right)\frac{cE_{\max}^2}{2\mu_0} = \frac{1}{c^2}\frac{cE_{\max}^2}{2\mu_0} = \frac{E_{\max}^2}{2\mu_0 c}$$

$$\boxed{\text{The result in part (g) agrees with } I = \frac{E_{\max}^2}{2\mu_0 c} \text{ in Equation 33.27.}}$$

***P33.47** **Conceptualize** Imagine exposing the system to sunlight. The right-hand plate in Figure P33.47 is black, and will therefore absorb all the light incident upon it. The left-hand plate is perfectly reflecting, so it experiences twice as much force as the right-hand plate. As a result, the system will rotate clockwise when viewed from above. Because the radiation pressure is small in magnitude, we assume that the rotation during the time interval during which the plates have light incident upon them is sufficiently small that we can treat the plates as being perpendicular to the sunlight throughout the process.

CategorizeThe system is analyzed using the *rigid object under a net torque model*.

AnalyzeWe can write the force on one plate using Equation 9.3:

$$F = \frac{dp}{dt} \qquad (1)$$

In Equation (1) substitute for the radiation momentum p from Equation 33.34:

$$F_{\text{black}} = \frac{d}{dt}\left(\frac{T_{\text{ER}}}{c}\right) = \frac{1}{c}\left(\frac{dT_{\text{ER}}}{dt}\right) = \frac{1}{c}\left(Power\right)_{\text{avg}} \qquad (2)$$

where we have identified this result as the force on the black plate.

Now use Equation 16.38 to express the power in terms of the intensity of the light striking the plates:

$$F_{\text{black}} = \frac{1}{c} I_s A_p \qquad (3)$$

where A_p is the area on one plate. Based on the discussion in Section 33.5, the force on the reflecting plate must be twice as great:

$$F_{\text{reflecting}} = \frac{2}{c} I_s A_p \qquad (4)$$

Now, from the definition of torque, find the net torque on the system:

$$\sum \tau = \left(\frac{1}{c} I_s A_p\right)\left(\frac{\ell}{2}\right) - \left(\frac{2}{c} I_s A_p\right)\left(\frac{\ell}{2}\right) = -\frac{1}{2c} I_s A_p \ell \qquad (5)$$

where we have defined the direction of the torque by looking downward on the system from above. Now apply the rigid object under a net torque model:

$$\sum \tau = I\alpha \qquad (6)$$

Substitute Equation (5) for the left side, $\Delta\omega/\Delta t$ for α on the right side, and evaluate the moment of inertia of the system as the sum of that of a spherical shell, a rod around the middle, and two particles representing the plates:

$$\begin{aligned}
-\frac{1}{2c} I_s A_p \ell &= \left[\tfrac{2}{3} mR^2 + \tfrac{1}{12} m_r \ell^2 + 2m_p \left(\frac{\ell}{2}\right)^2\right] \frac{\Delta\omega}{\Delta t} \\
&= \left[\tfrac{2}{3} mR^2 + \tfrac{1}{12} m_r \ell^2 + 2m_p \left(\frac{\ell}{2}\right)^2\right] \frac{(\omega_f - 0)}{\Delta t} \\
&= \left[\tfrac{2}{3} mR^2 + \tfrac{1}{12} m_r \ell^2 + 2m_p \left(\frac{\ell}{2}\right)^2\right] \frac{\omega_f}{\Delta t} \qquad (7)
\end{aligned}$$

Solve Equation (7) for ω_f:

$$\omega_f = -\frac{I_s \pi r_p^{\,2} \ell}{\left[\frac{4}{3}mR^2 + \left(\frac{1}{6}m_r + m_p\right)\ell^2\right]c}\Delta t$$

Substitute numerical values:

$$\Delta\omega = -\frac{\left(1\,000\text{ W/ m}^2\right)\pi\left(0.020\,0\ m\right)^2\left(1.00\text{ m}\right)}{\left[\begin{array}{l}\frac{4}{3}\left(0.500\text{ kg}\right)\left(0.150\text{ m}\right)^2 \\ \qquad +\left(\dfrac{0.050\,0\text{ kg}}{6}+0.010\,0\text{ kg}\right)\left(1.00\text{ m}\right)^2\end{array}\right]\left(3.00\times 10^8\text{ m/ s}\right)}\left(120\text{ s}\right)$$

$$= \boxed{-1.51\times 10^{-5}\text{ rad/ s}}$$

Finalize Because the system began from rest, this final result is the angular velocity with which the system is turning after the light is removed. The negative sign tells us that the system is rotating clockwise when viewed from above. This is a very small angular velocity, consistent with the fact that radiation pressure on small objects is tiny. On a spacecraft, we can extend the length of the arms, make the plate radius larger, and increase the time interval during which sunlight strikes the plates. In addition, we can replace the black plate with a small object of the same mass, or a plate turned edge-on to the Sun. This would maintain the mass balance of the system, but because the small object would absorb negligible radiation, it would not supply a counter-torque, so that the net torque on the system would be doubled.]

Answer: -1.51×10^{-5} rad/s

P33.51 We are given f = 90.0 MHz and $E_{\max} = 200\text{ mV/m} = 2.00\times 10^{-3}\text{ V/m}$

(a) The wavelength of the wave is $\lambda = \dfrac{c}{f} = \boxed{3.33\text{ m}}$

(b) Its period is $T = \dfrac{1}{f} = 1.11\times 10^{-8}\text{ s} = \boxed{11.1\text{ ns}}$

(c) We obtain the maximum value of the magnetic field from

$$B_{\max} = \frac{E_{\max}}{c} = 6.67 \times 10^{-12}\ \text{T} = \boxed{6.67\ \text{pT}}$$

(d) $$\boxed{\vec{\mathbf{E}} = \left(2.00 \times 10^{-3}\right) \cos 2\pi \left(\frac{x}{3.33} - 90.0 \times 10^{6} t \right) \hat{\mathbf{j}}}$$

$$\boxed{\vec{\mathbf{B}} = \left(6.67 \times 10^{-12}\right) \cos 2\pi \left(\frac{x}{3.33} - 90.0 \times 10^{6} t \right) \hat{\mathbf{k}}}$$

where $\vec{\mathbf{E}}$ is in V/m, $\vec{\mathbf{B}}$ in tesla, x in meters, and t in seconds.

(e) $$I = \frac{E_{\max}^2}{2\mu_0 c} = \frac{\left(2.00 \times 10^{-3}\ \text{V/m}\right)^2}{2\left(4\pi \times 10^{-7}\ \text{T} \cdot \text{m/A}\right)\left(3.00 \times 10^{8}\ \text{m/s}\right)}$$

$$= \boxed{5.31 \times 10^{-9}\ \text{W/m}^2}$$

(f) From Equation 33.33, $I = cu_{\text{avg}}$ so $u_{\text{avg}} = \frac{I}{c} = \boxed{1.77 \times 10^{-17}\ \text{J/m}^3}$

(g) From Equation 33.37, the pressure is

$$P = \frac{2I}{c} = \frac{(2)\left(5.31 \times 10^{-9}\ \text{W/m}^2\right)}{3.00 \times 10^{8}\ \text{m/s}} = \boxed{3.54 \times 10^{-17}\ \text{Pa}}$$