Phys122 HW10

2

a

$$u = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$$

$$u = \frac{1}{2}\epsilon_0 \varepsilon^2 \cos^2(kx - \omega t) + \frac{1}{2}\frac{1}{\mu_0}(\frac{\varepsilon}{c})^2 \cos^2(kx - \omega t)$$

$$u = \frac{1}{2}\epsilon_0 \varepsilon^2 \cos^2(kx - \omega t) + \frac{1}{2}\epsilon_0 \varepsilon^2 \cos^2(kx - \omega t)$$

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$$u = \frac{1}{T}\int_0^T u dt$$

$$u = \frac{1}{T}\int_0^T \epsilon_0 \varepsilon^2 \cos^2(kx - \omega t) dt$$

$$u = \frac{1}{2}\epsilon_0 \varepsilon^2$$

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b

$$\mathbf{S} = \frac{1}{\mu_0} (\mathbf{E} \times \mathbf{B})$$

$$\mathbf{S} = \frac{1}{\mu_0} (\varepsilon \cos(kx - \omega t) \hat{j} \times \frac{\varepsilon}{c} \cos(kx - \omega t) \hat{k})$$

$$\mathbf{S} = \frac{1}{\mu_0 c} \varepsilon^2 \cos^2(kx - \omega t) \hat{i}$$

$$c^2 = \frac{1}{\mu_0 \epsilon_0} \to c\epsilon_0 = \frac{1}{\mu_0 c}$$

$$\therefore \mathbf{S} = \epsilon_0 c \varepsilon^2 \cos^2(kx - \omega t) \hat{i}$$

$$\langle \mathbf{S} \rangle = \frac{1}{T} \int_0^T \mathbf{S} dt$$

$$\therefore \langle \mathbf{S} \rangle = \frac{c\epsilon_0 \varepsilon^2}{2} \hat{i}$$

C

$$egin{aligned} \Pi &= rac{S}{c^2}
ightarrow &\colon \Pi &= rac{\epsilon_0 arepsilon^2}{c} \cos^2(kx - \omega t) \hat{i} \ \langle \Pi
angle &= rac{1}{T} \int_0^T \Pi dt \ &\colon \langle \Pi
angle &= rac{\epsilon_0 arepsilon^2}{2c} \hat{i} \end{aligned}$$

d

i

$$P_{rad} = rac{\langle S
angle}{c}
ightarrow F = PA = rac{\langle S
angle A}{c} \
dots F = rac{c\epsilon_0 arepsilon^2}{2} \hat{i} rac{A}{c} = rac{A\epsilon_0 arepsilon^2}{2} \hat{i}$$

ii

$$P_{rad} = rac{2\langle S
angle}{c}
ightarrow F = PA = rac{2\langle S
angle A}{c} \ dots F = rac{c\epsilon_0arepsilon^2}{2} \hat{i} rac{2A}{c} = A\epsilon_0arepsilon^2 \hat{i}$$

е

i

$$\langle u
angle c = rac{J}{m^3} rac{m}{s} = rac{J}{m^2 s}$$
 $\langle u
angle / c = rac{J}{m^3} = rac{Js}{m^4}$
 $I = rac{W}{m^2} = rac{J}{m^2 s}$ from question f
 $\therefore I = \langle u
angle c$

ii

$$\langle u \rangle / c = \frac{\frac{J}{m^3}}{m/s} = \frac{Js}{m^4}$$

$$\langle u \rangle c = \frac{J}{m^3} \frac{m}{s} = \frac{J}{m^2 s}$$

$$J = \frac{kgm^2}{s^2}$$

$$\langle u \rangle c = \frac{kg}{s^3}, \langle u \rangle / c = \frac{kg}{m^2 s}$$

$$\langle \Pi \rangle = \frac{kg}{m^2 s} from question fiii$$

$$\therefore \langle \Pi \rangle = \langle u \rangle / c$$

f

$$I=1360rac{W}{m^2}$$

i

$$\begin{array}{l} 1360 = \frac{c\epsilon_0\varepsilon^2}{2}\hat{i} \\ \therefore \varepsilon = \sqrt{\frac{2*1360}{(3.0\times10^8)(8.85\times10^{-12})}} = 1012.17\frac{V}{m} \\ \therefore \frac{\varepsilon}{c} = \frac{1012.17}{3.0\times10^8} = 3.37\times10^{-6}T \end{array}$$

ii

$$\begin{array}{|c|c|c|}\hline 1360 = \langle u \rangle c \rightarrow \langle u \rangle = \frac{1360}{c}\\ \therefore \langle u \rangle = 4.53 \times 10^{-6} \frac{J}{m^3} \end{array}$$

iii

$$\langle \Pi \rangle = \langle u \rangle / c = \frac{4.53 \times 10^{-6}}{3.0 \times 10^{8}}$$
$$\therefore \langle \Pi \rangle = 1.51 \times 10^{-14} \frac{kg}{m^{2}s}$$

iv

$$mi^2=2.59 imes 10^6m^2 \ F=A\epsilon_0arepsilon^2$$
 from d $::F=(2.59 imes 10^6)(8.85 imes 10^{-12})(1012.17)^2=23.48N$

4

a

$$I = \frac{W}{m^2} \rightarrow I = \frac{L}{A}$$

 $\therefore I = \frac{L}{4\pi R^2}$

b

$$F=rac{IA}{c}$$
 $A= ext{Cross Section Area}$
 $A=\pi r^2$
 $F=rac{L\pi r^2}{4\pi R^2 c}$
 $\therefore F=rac{Lr^2}{4R^2 c}$

C

$$F=Grac{m_1m_2}{R^2}-rac{IA}{c}=0$$
 $Grac{M
horac{4}{3}\pi r^3}{R^2}=rac{Lr^2}{4R^2c}$
 $\therefore r=rac{3L}{16cMG
ho\pi}$ meters

d

$$r = \frac{3L}{16cMG\rho\pi} \to r = \frac{(3)(4\times10^{26}W)}{(16\pi)(3\times10^8\frac{m}{s})(2\times10^{30}kg)(6.67\times10^{-11}\frac{Nm^2}{kg^2})(2.5\times10^3\frac{kg}{m^3})}$$
$$\therefore r = 2.386\times10^{-7}\frac{Ws}{N} = 2.386\times10^{-7}\frac{Nm}{s}\frac{s}{N} = 2.386\times10^{-7}m$$

5

a

$$\begin{split} \oint \vec{B} \cdot d\vec{s} &= \mu_0 I_{enc} + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} \\ \Phi_E &= \oint \vec{E} \cdot d\vec{a} \\ \Phi_E &= \vec{E} \oint d\vec{a} \\ \Phi_E &= E_0 \sin(\omega t) \hat{i} (2\pi R^2) \\ \frac{d\Phi_E}{dt} &= \omega E_0 \cos(\omega t) (2\pi R^2) \hat{i} \\ \vec{B} \oint d\vec{s} &= \mu_0 (I_{enc} + \varepsilon_0 \omega E_0 \cos(\omega t) (\pi R^2) \hat{i}) \\ \vec{B} \oint d\vec{s} &= \mu_0 \varepsilon_0 \omega E_0 \cos(\omega t) (\pi R^2) \hat{i} \\ \vec{B} 2\pi R &= \mu_0 \varepsilon_0 \omega E_0 \cos(\omega t) (\pi R^2) \hat{i} \\ \vec{B} &= \frac{\mu_0 \varepsilon_0 \omega E_0 R \cos(\omega t)}{2} \text{ Counter Clockwise} \end{split}$$

b

$$ec{B}2\pi(2R) = \mu_0 \varepsilon_0 \omega E_0 \cos(\omega t) (\pi(R)^2)$$
 $ec{B} = rac{\mu_0 \varepsilon_0 \omega E_0 R \cos(\omega t)}{4}$ Counter Clockwise