## **Phys122 HW10**

2

a

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

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

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

$$u = \epsilon_0 \varepsilon^2 \cos^2(kx - \omega t)$$

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

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

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

$$u \geq \frac{1}{T}\epsilon_0 \varepsilon^2$$

b

$$\mathbf{S} = \frac{1}{\mu} {}_{0} (\mathbf{E} \times \mathbf{B})$$

$$\mathbf{S} = \frac{1}{\mu} {}_{0} (\varepsilon \cos(kx - \omega t) \hat{j} \times \frac{\varepsilon}{c} \cos(kx - \omega t) \hat{k})$$

$$\mathbf{S} = \frac{1}{\mu_{0}c} \varepsilon^{2} \cos^{2}(kx - \omega t) \hat{i}$$

$$c^{2} = \frac{1}{\mu_{0}\epsilon_{0}} \rightarrow c\epsilon_{0} = \frac{1}{\mu_{0}c}$$

$$\therefore \mathbf{S} = \epsilon_{0} c\varepsilon^{2} \cos^{2}(kx - \omega t) \hat{i}$$

$$\langle \mathbf{S} \rangle = \frac{1}{T} \int_{0}^{T} \mathbf{S} dt$$

$$\therefore \langle \mathbf{S} \rangle = \frac{c\epsilon_{0}\varepsilon^{2}}{2} \hat{i}$$

C

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

O

i

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

ii

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

e

ì

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

ii

$$\langle u
angle/c=rac{rac{J}{m^3}}{m/s}=rac{Js}{m^4} \ \langle u
angle c=rac{J}{m^3}rac{m}{s}=rac{J}{m^2s} \ J=rac{kgm^2}{s^2} \ \langle u
angle c=rac{kg}{s^3},\langle u
angle/c=rac{kg}{m^2s} \ \langle \Pi
angle=rac{kg}{m^2s} ext{ from question f iii} \ \therefore \langle \Pi
angle=\langle u
angle/c$$

f

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

j

$$egin{aligned} 1360 &= rac{c\epsilon_0 arepsilon^2}{2} \hat{i} \ dots &arepsilon &= \sqrt{rac{2*1360}{(3.0 imes 10^8)(8.85 imes 10^{-12})}} = 1012.17 rac{V}{m} \ dots &rac{arepsilon}{c} &= rac{1012.17}{3.0 imes 10^8} = 3.37 imes 10^{-6} T \end{aligned}$$

ш

$$egin{array}{l} 1360 = \langle u 
angle c 
ightarrow \langle u 
angle = rac{1360}{c} \ dots \cdot \langle u 
angle = 4.53 imes 10^{-6} rac{J}{m^3} \end{array}$$

Ш

$$\langle \Pi 
angle = \langle u 
angle / c = rac{4.53 imes 10^{-6}}{3.0 imes 10^{8}} \ dots \langle \Pi 
angle = 1.51 imes 10^{-14} rac{kg}{m^2 s}$$

iv

$$egin{aligned} 1mi^2 &= 2.59 imes 10^6 m^2 \ F &= A\epsilon_0 arepsilon^2 ext{ from d} \ dots &: F &= (2.59 imes 10^6)(8.85 imes 10^{-12})(1012.17)^2 = 23.48 N \end{aligned}$$

4

a

$$I=rac{W}{m^2}
ightarrow I=rac{L}{A} \ \therefore I=rac{L}{4\pi R^2}$$

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

$$egin{aligned} F &= Grac{m_1m_2}{R^2} - rac{IA}{c} = 0 \ Grac{M
horac{4}{3}\pi r^3}{R^2} &= rac{Lr^2}{4R^2c} \ dots &: r &= rac{3L}{16cMG
ho\pi} \ \end{aligned}$$
 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

$$\oint ec{B} \cdot dec{s} = \mu_0 I_{enc} + \mu_0 arepsilon_0 rac{d\Phi_E}{dt}$$
 $\Phi_E = \oint ec{E} \cdot dec{a}$ 
 $\Phi_E = ec{E} \oint dec{a}$ 
 $\Phi_E = E_0 \sin(\omega t) \hat{i} (2\pi R^2)$ 
 $rac{d\Phi_E}{dt} = E_0 \cos(\omega t) (2\pi R^2) \hat{i}$ 
 $ec{B} \oint dec{s} = \mu_0 (I_{enc} + arepsilon_0 E_0 \cos(\omega t) (2\pi R^2) \hat{i})$ 
 $ec{B} \oint dec{s} = \mu_0 arepsilon_0 E_0 \cos(\omega t) (2\pi R^2) \hat{i}$ 
 $ec{B} 2\pi R = \mu_0 arepsilon_0 E_0 \cos(\omega t) (2\pi R^2) \hat{i}$ 
 $ec{B} = \mu_0 arepsilon_0 E_0 R \cos(\omega t) Counter Clockwise$ 

b

$$ec{B}2\pi(2R)=\mu_0arepsilon_0E_0\cos(\omega t)(2\pi(2R)^2)$$
  $ec{B}=2\mu_0arepsilon_0E_0R\cos(\omega t)$  Counter Clockwise