Homework #11
Tipler 29-24,38,40,48,50

$\varepsilon_0 = 8.85 \times 10^{-12}$
$\mu_0 = 4\pi \times 10^{-7}$

$|\vec{S}_{av}| = \frac{EB}{\mu_0} = \frac{E^2}{\mu_0 c} = \frac{E^2 c}{\mu_0 \frac{1}{\mu_0 \varepsilon_0}}$
$= \varepsilon_0 E^2 c$
$= \frac{B^2 c}{\mu_0}$

24 $P = (750 \times 10^3)(1000) = 7.5 \times 10^8\ W$

$A = 50 m^2$

$\text{Intensity} = I = \frac{P}{A} = 1.5 \times 10^7\ W/m^2 = \vec{S}_{av} = \frac{1}{2}\varepsilon_0 E_0^2 c = \varepsilon_0 c E_{rms}^2$

$E_{rms} \doteq 7.5 \times 10^4\ V/cm$

$B_{rms} = c E_{rms} = 2.5 \times 10^{-4}\ T$

$\mu = K_m \mu_0$

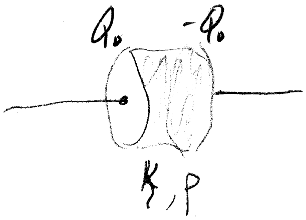
38 $I = 10^{-14}\ W/m^2$
$N = 2000$
$r = 0.01 m$
$K_m = 200$
$\nu = 140\ kHz$

$I = |\vec{S}|_{av} = \frac{1}{2}\frac{B_0^2 c}{\mu_0} \Rightarrow B_0 = 9.156 \times 10^{-15}\ T$

b) $|\mathcal{E}_m| = \left|\frac{d\phi}{dt}\right| = NA \cdot \frac{dB}{dt} = NA\omega K B_0 = (2000)\cdot(\pi (.01)^2)(2\pi \cdot 140 \times 10^3)(200)(9.156 \times 10^{-15} T)$
$= 1.0121 \cdot 10^{-6}\ V$

c) $|\mathcal{E}_e| = E_0 \cdot (2m) = cB_0 \cdot 2m = \underline{5.5 \times 10^{-6}\ V}$

40



a) $I = I_0 e^{-t/RC} = I_0 e^{-t/\kappa\varepsilon_0\rho}$

$Q = Q_0 e^{-t/\kappa\varepsilon_0\rho} \Rightarrow I_0 = +\dfrac{Q_0}{\kappa\varepsilon_0\rho} \qquad I = -\dfrac{dQ}{dt}$

$RC = \left(\rho\dfrac{L}{A}\right)\cdot\left(\kappa\cdot\dfrac{\varepsilon_0 A}{L}\right) = \kappa\varepsilon_0\rho$

Q/A

b) $I_d = \kappa\varepsilon_0\cdot\dfrac{d\Phi_e}{dt} = \kappa\varepsilon_0\cdot\dfrac{d}{dt}(E\cdot A) = \varepsilon_0\kappa\dfrac{d}{dt}\left(\dfrac{\sigma}{\kappa\varepsilon_0}\cdot A\right) = \dfrac{dQ}{dt} = -I$

$I_{total} = I + I_d = 0$?

c) $\oint \vec{B}_c\cdot d\vec{l} = \mu_0 I_c \rightarrow B_c = \dfrac{\mu_0 I\cdot\frac{\pi r^2}{\pi R^2}}{2\pi r} = \dfrac{\mu_0 I r}{2\pi R^2} = \dfrac{\mu_0 r}{2\pi R^2}\cdot I_0 e^{-t/\kappa\varepsilon_0\rho}$

d) $\oint \vec{B}_d\cdot d\vec{l} = \mu_0 I_d \Rightarrow B_d = -B_c$

e) $B_{total} = 0$

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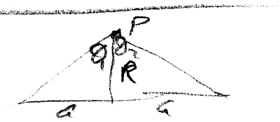
48 eq. 25-12 $\rightarrow B = \dfrac{\mu_0 I}{4\pi R}(\sin\theta_1 + \sin\theta_2)$



$\sin\theta_1 = \sin\theta_2 = \dfrac{a}{\sqrt{R^2+a^2}}$

a) $B = \dfrac{\mu_0\cdot I}{4\pi R}\cdot 2\cdot\dfrac{a}{\sqrt{R^2+a^2}} = \dfrac{\mu_0 I a}{2\pi R}\dfrac{1}{\sqrt{R^2+a^2}}$

b) $E_x = \dfrac{Q}{4\pi\varepsilon_0}\cdot\dfrac{2a}{(r^2+a^2)^{3/2}} = \dfrac{Q\cdot a}{2\pi\varepsilon_0(r^2+a^2)^{3/2}}$

$E_x\, dA = E_x\cdot 2\pi r\,dr = \dfrac{Qa\, r\,dr}{\varepsilon_0 (r^2+a^2)^{3/2}}$

c) $\Phi_e = \int E_x\, dA = \int_0^R \dfrac{Qa\, r\,dr}{\varepsilon_0 (r^2+a^2)^{3/2}} = \dfrac{Qa}{\varepsilon_0}\underbrace{\int_0^R \dfrac{r\,dr}{(r^2+a^2)^{3/2}}}$

$\hookrightarrow \left.\dfrac{-1}{(r^2+a^2)^{1/2}}\right|_0^R = \dfrac{1}{a} - \dfrac{1}{(R^2+a^2)^{1/2}}$

$\varepsilon_0\Phi_e = Q\left[1 - \dfrac{a}{\sqrt{a^2+R^2}}\right]$

d) $I_d = +\varepsilon_0\dfrac{d\Phi_e}{dt} = \dfrac{dQ}{dt}\left[1 - \dfrac{a}{\sqrt{a^2+R^2}}\right] = (-I)\left(1 - \dfrac{a}{\sqrt{\ }}\right)$

$I + I_d = I\cdot\dfrac{a}{\sqrt{a^2+R^2}}$

e) $\underbrace{\oint \vec{B}\cdot d\vec{l}}_{\hookrightarrow B\cdot 2\pi R} = \mu_0(I + I_d) = \dfrac{\mu_0\cdot I a}{\sqrt{a^2+R^2}} \rightarrow B = \dfrac{\mu_0 I a}{2\pi R}\dfrac{1}{\sqrt{a^2+R^2}}$

50.

a) $\underbrace{\frac{dp}{dt}}_{ma} = \frac{P}{c} = \frac{P_{sun} \cdot A / 4\pi r^2}{c}$ $\longrightarrow$ $a = \frac{P_s A}{4\pi r^2 mc}$

$P_s = 3.8 \times 10^{26}$

$M_{sun} = 2 \times 10^{30}$

$G = 6.67 \times 10^{-11}$

b) Work done by sun $= \int F \cdot dr = m \int a \cdot dr = m \cdot \frac{P_s A}{4\pi mc} \int_{r_0}^{r} \frac{dr}{r^2}$

$$= \frac{P_s A}{4\pi c} \cdot \left(\frac{1}{r_0} - \frac{1}{r}\right)$$

$$\frac{1}{2} m v^2 = \frac{1}{2} m v_0^2 + \frac{P_s A}{4\pi c}\left(\frac{1}{r_0} - \frac{1}{r}\right)$$

$$\boxed{v^2 = v_0^2 + \frac{P_s A}{2\pi mc}\left(\frac{1}{r_0} - \frac{1}{r}\right)}$$

c) $a_{gravity} = -\frac{G M_{sun}}{r^2}$

$$\frac{a_{grav}}{a_{sail}} = \frac{GM/r^2}{P_s A / 4\pi r^2 mc} = \frac{4\pi c \cdot G M_{sun}}{P_s A} = 1322.5 \cdot \frac{m}{A}$$

say $m = 1000$ kg, $A = (100\ m)^2$ $\Longrightarrow$ $\frac{a_{grav}}{a_{sail}} = 132$