40-5

$$i_D = \epsilon_0 \frac{d\Phi_E}{dt}$$

$$= \epsilon_0 \frac{d\,EA}{dt} \quad \text{for parallel plates}$$

$$= \epsilon_0 A \frac{dE}{dt}$$

$$= \epsilon_0 A \frac{d(V/d)}{dt} \qquad V = Ed \text{ for parallel plates}$$

$$= \frac{\epsilon_0 A}{d}\frac{dV}{dt}$$

$$= C\frac{dV}{dt} \qquad C = \frac{\epsilon_0 A}{d} \text{ for air gap } \parallel\text{-plate capacitor}$$

$$\text{if } i_D = C\frac{dV}{dt} \Rightarrow \frac{dV}{dt} = \frac{i_D}{C} = \frac{1.0\times10^{-3}\,A}{1.0\times10^{-6}\,F}$$

$$= 1\times10^{3}\ V/s$$

so the voltage across the plates must change at a rate of 1×10^{3} V/s to produce a displacement current of 1.0 mA

40-9

interval (a) $\frac{\Delta E}{\Delta t} = \frac{0.2\,MV/m}{4\,\mu s} = \frac{0.2\times10^{6}\,V/m}{4\times10^{-6}\,s} = 5\times10^{10}\,\frac{V}{m\,s}$

$$\Rightarrow i_D = \epsilon_0 A \frac{dE}{dt} = \epsilon_0 (1.9\,m^2)(5\times10^{10}\,\tfrac{V}{ms}) = 0.84\ A$$

(b) $\frac{\Delta E}{\Delta t} = 0 \Rightarrow i_D = 0$

(c) $\frac{\Delta E}{\Delta t} = \frac{0.4\,MV/m}{5\,\mu s} = 8\times10^{10}\,\frac{V}{ms}$

$$\Rightarrow i_D = 1.3\ A$$

40-13

$$B(r) = \frac{\mu_0 \epsilon_0}{2\pi r}\frac{dE}{dt}$$

$$B(R) = \frac{\mu_0 \epsilon_0}{2\pi R}\frac{d}{dt}\left(\frac{V}{d}\right)$$

$$= \frac{\mu_0 \epsilon_0}{2\pi R d}\frac{dV}{dt}$$

$V = V_0 \sin\omega t$ where $V_0 = 162\ V$, $\omega = 2\pi\nu = 2\pi(60.0\ Hz)$

$$\Rightarrow \frac{dV}{dt} = V_0 \omega \cos\omega t$$

which has a maximum value of $V_0\omega$ when $\cos\omega t =$

$$B(R)_{max} = \frac{\mu_0 \epsilon_0}{2\pi R d} V_0 \omega$$

$$= \frac{\mu_0 \epsilon_0 (162 V) \cancel{2\pi} (60.0 Hz)}{\cancel{2\pi} (32.1 \times 10^{-3} m)(4.80 \times 10^{-3} m)}$$

$$= 7 \times 10^{-10}\ T$$

40-16

a) $Q(t) = \int_0^t i(t')\,dt'$

$= \int_0^t \alpha t'\,dt'$

$Q(t) = \dfrac{\alpha t^2}{2} + \cancel{C}^{\,0}$ ($C=0$ for $Q=0$ at $t=0$)

b) $\int \vec{E}\cdot d\vec{A} = \dfrac{q_{enc}}{\epsilon_0}$

$LHS = E(t)A \qquad RHS = \dfrac{Q(t)}{\epsilon_0}$

Gaussian surface
is cylinder coaxial w/ rod

$2\pi r = \mu_0 i$

$B = \dfrac{\mu_0 i}{2\pi r}$

Gauss' law $\Rightarrow$ $E(t)A = \dfrac{Q(t)}{\epsilon_0}$

$E(t) = \dfrac{\alpha t^2}{2\epsilon_0 \pi R^2}$

c) B field lines are circular & coaxial w/ rod

d) $\oint \vec{B}\cdot d\vec{s} = \mu_0 \epsilon_0 \dfrac{d\Phi_E}{dt}$

$LHS = B2\pi r \qquad LRS = \mu_0 \cancel{\epsilon_0} \dfrac{d}{dt}\left(\dfrac{\alpha t^2}{2\cancel{\epsilon_0}\cancel{\pi}R^2}\cancel{\pi}r^2\right)$

$= \mu_0 \dfrac{\alpha r^2}{2R^2}\dfrac{d}{dt}(t^2)$

$= \mu_0 \dfrac{\alpha t r^2}{R^2}$

$\Rightarrow B2\pi \cancel{r} = \mu_0 \dfrac{\alpha t r^{\cancel{2}}}{R^2} \Rightarrow B(r,t) = \mu_0 \dfrac{\alpha t r}{2\pi R^2} \quad r<R$

e) in the rod $\oint \vec{B}\cdot d\vec{s} = \mu_0 i \Rightarrow B(r)2\pi\cancel{r} = \mu_0 \dfrac{\alpha t}{\cancel{\pi}R^2}\cancel{\pi} r^{\cancel{2}}$

$B(r) = \mu_0 \dfrac{\alpha t r}{2\pi R^2}$

$i = \dfrac{i_{TOTAL}}{TOTAL\ AREA} \times$

41-3

a) $\lambda \nu = c \Rightarrow \nu = \frac{c}{\lambda} = \frac{3.0 \times 10^8 \, m/s}{0.067 \times 10^{-15} \, m}$

$= 4.5 \times 10^{24} \, Hz$

b) $\lambda = \frac{c}{\nu} = \frac{3.0 \times 10^8 \, m/s}{30 \, Hz} = 1.0 \times 10^7 \, m$

41-7 $\frac{E_m}{B_m} = c \Rightarrow B_m = \frac{E_m}{c}$

$= \frac{321 \times 10^{-6} \, V/m}{3.0 \times 10^8 \, m/s}$

$= 1.07 \times 10^{-12} \, T$

41-8

a) $B_y = -B_0 \sin k(x - ct)$ $B_x = 0$ $B_z = 0$

$\vec{E} \times \vec{B}$ must be in +x direction

$B_0 = \frac{E_0}{c}$

dir'n of propagation

E field along z axis

$= \frac{2.34 \times 10^{-4} \, V/m}{3.0 \times 10^8 \, m/s}$

$= 7.8 \times 10^{-13} \, T$

b) $k = \frac{2\pi}{\lambda} \Rightarrow \lambda = \frac{2\pi}{k} = \frac{2\pi}{9.72 \times 10^6 \, m^{-1}} = 6.46 \times 10^{-7} \, m$

41-17 a) $I_2 = 1.50 \, I_1$ I_1 is intensity at original position

$I_2 = \frac{I_0}{4\pi r_2^2}$ $I_1 = \frac{I_0}{4\pi r_1^2}$ & $r_1 = r_2 + 162$

$\frac{I_2}{I_1} = \frac{\cancel{I_0}}{\cancel{4\pi} r_2^2} \frac{\cancel{4\pi} r_1^2}{\cancel{I_0}} = \frac{r_1^2}{r_2^2} = 1.50$

$r_1 = \sqrt{1.50} \, r_2 = r_2 + 162$

$(\sqrt{1.50} - 1) \, r_2 = 162$

$r_2 = 721 \, m$

$\Rightarrow r_1 = 883 \, m$

b) NO. To find the power output we would need either the initial or the final intensity.

41-20

$$\text{intensity} = \frac{1}{2\mu_0} E_m B_m$$

$$= \frac{1}{2\mu_0} E_m \frac{E_m}{c}$$

$$\Rightarrow \quad E_m = \sqrt{c\, I\, 2\mu_0}$$

$$= 1021 \text{ V/m}$$

$$B_m = 3.4 \times 10^{-6} \text{ T}$$