2. Chapter 9 #4

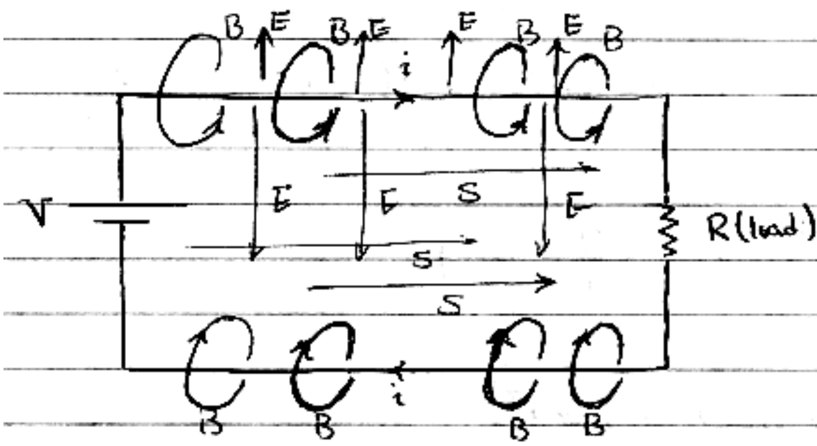
a) from Ch9 #2 we got $c_{coax} = \frac{1}{\sqrt{K}} c_{vacuum} = \frac{3\times10^8 m/s}{\sqrt{2}}$

$$= 2.1\times10^8 \text{ m/s}$$

b) $$Z = \sqrt{\frac{L/\ell}{C/\ell}} = \sqrt{\left[\frac{\mu_0}{2\pi}\ln\left(\frac{d}{a}\right)\right]\left[\frac{\ln(d/a)}{2\pi\varepsilon}\right]} = \sqrt{\frac{\mu_0}{K\varepsilon_0}}\frac{1}{2\pi}\ln\left(\frac{d}{a}\right)$$

$$= \frac{1}{\sqrt{K}}\frac{1}{2\pi}\ln\left(\frac{3\times10^{-3}\cancel{m}}{2\times10^{-4}\cancel{m}}\right)\underbrace{\sqrt{\frac{\mu_0}{\varepsilon_0}}}_{377\Omega} = 115\Omega$$

(H&L, Ch.9, #7)



(H&L, Ch.9; #11)

. 50 KW radio waves , d = 1 mile

$\Rightarrow E_{rms} = ?$

$$S_{rms} = \frac{P}{A} = \frac{50000}{4\pi(1.609\text{km})^2} = 0.0015 \text{ W/m}^2$$

$$\Rightarrow E_{rms} = \sqrt{S_{rms} \cdot Z} = \sqrt{S_{rms} \cdot \sqrt{\frac{\mu_0}{\varepsilon_0}}} = \sqrt{(0.0015)(377)} = \underline{0.759 \text{ V/m}}$$

4. Chapter 9 #13

To see how the current pulse develops, refer to the animation on:
http://physics.usask.ca/~hirose/ep225/animation/em reflection/anim-emreflection.htm

The evolution of the voltage wave for figure 9.40 with $R = 25\Omega$ is shown in the first animation. The discussion of how the current develops follows exactly the discussion in Example 8 on pg. 165 with R replacing the 20Ω resistor in Figure 9.25.

We expect the final current to reduce to

$$i = \frac{V}{R_{total}} = \frac{V}{Z+R} = \frac{10V}{50\Omega + 25\Omega} = \frac{10V}{75\Omega} = 0.133A \text{ for } R = 25\Omega$$

so the voltage drop across the resistor will be:

$$V_R = iR = (0.133A)(25\Omega) = 3.325V$$

once it reaches steady state.

How does this develop?

The current comes out of the source seeing an R+Z of 100Ω. R is due to the internal resistance of the source, Z is due to the impedance of the line.

$$i_{initial} = \frac{10V}{50\Omega + 50\Omega} = 0.1A$$

a voltage pulse of 5V propogates down the transmission line

To figure our how much of this current gets reflected when it reaches R, use eq. 9.38

for $R = 25\Omega$ $\quad \Gamma_I = \frac{Z-R}{R+Z} = \frac{50-25}{50+25} = \frac{1}{3}$

so $\frac{1}{3}$ of the initial 0.1 A gets reflected so

$\frac{0.1A}{3} = 0.033A$ gets reflected

this reflected current pulse moving to the left is now superimposed on the 0.1A current pulse still moving to the right for a total of $0.1A + 0.033A = 0.133A$

When it reaches the source end again there is no reflection because the internal impedance of the source and the impedance of the cable are matched.

$$\Gamma_1 = \frac{50-50}{50+50} = 0!$$

so 1.33A is the steady state current.

For R=50 there is no reflection at the load resistor because the impedance of the cable and the resistance of the load are matched, so $i_{initial} = 0.1A$ is the steady state current.

$R = 100\Omega$

When the initial current pulse reaches R, R acts as a <u>hard boundary</u> to current since R>Z (note: it is a soft boundary to current) Current pulse get inverted at this boundary according to

negative indicated flipped polarity

$$\Gamma_I = \frac{50\Omega - 100\Omega}{50\Omega + 100\Omega} = -\frac{1}{3}$$

This inverted current is superimposed on the original $i_{initial}$ for a total of:

$$i_{initial} - \frac{1}{3} i_{initial} = 0.066A \text{ total}$$

Again, when it gets to the emf, it is not reflected since the impedances on that end are matched. 0.066A is the steady state current,

in agreement with Ohms law which predicts:

$$I_{ss} = \frac{10V}{50\Omega + 100\Omega} = 0.066A$$

5, Ch9 #15

for current $P = i^2 Z$

the power from the incident current: $P_i = I_i^2 Z$

power from the reflected current: $P_r = I_r^2 Z$

power from the transmitted current that is dissipated by the resistor $(I_i + I_r)^2 R$

by conservation

$$I_i^2 Z = I_r^2 Z + (I_i + I_r)^2 R$$

$$(I_i^2 - I_r^2) Z = (I_i + I_r)^2 R$$

$$\cancel{(I_i + I_r)}(I_i - I_r) Z = (I_i + I_R)^{\cancel{2}} R$$

$$I_i Z - I_r Z = I_i R + I_R R$$

$$I_i (Z - R) = I_R (Z + R) \quad I_R = \frac{(Z-R)}{(Z+R)} I_i$$

(T&L, Ch. 30, #17)

from last problem : $R = 2.3$ cm, $d = 1.1\times10^{-3}$ m , $I_d = \frac{dQ}{dt} = 5A$

$$\Rightarrow \oint \vec{B}\cdot\vec{dl} = (2\pi r)B = \mu_0\varepsilon_0 \frac{dQ}{dt}$$

$$\Rightarrow \phi = \pi r^2 E = \pi r^2 \frac{Q}{\varepsilon_0 \pi R^2}$$

$$\Rightarrow B(2\pi r) = \mu_0 \cancel{\varepsilon_0} \frac{r^2}{\cancel{\varepsilon_0} R^2} \underbrace{\frac{dQ}{dt}}_{I_d}$$

$$\Rightarrow B = \frac{\mu_0 r^{\cancel{2}} I_d}{2\pi \cancel{r} R^2} = \left(\frac{4\pi\times10^{-7}\times5}{2\pi(0.023)^2}\right) r = \boxed{(1.89\times10^{-3}\ T/m)\, r}$$

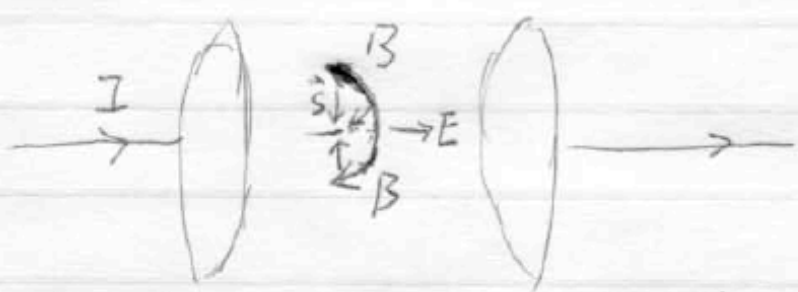
Chapter 30 #46

(a). $I_d = \varepsilon_0 \frac{d\phi_e}{dt} = \varepsilon_0 \frac{d(EA)}{dt} =$

$$E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0}$$

$$\Rightarrow I_d = \varepsilon_0 A \frac{dQ}{dt} \frac{1}{A\varepsilon_0} = \frac{dQ}{dt}$$

<b>.



$\vec{S} = \vec{E}\times\vec{B}$, is radially inward.

<c> $E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0} = \frac{Q}{\pi R^2 \varepsilon_0}$ $\quad \phi_e = EA = Q/\varepsilon_0$

$$B(2\pi R) = \mu_0 \varepsilon_0 \frac{d\phi_e}{dt} = \mu_0 \varepsilon_0 \frac{dQ/dt}{\varepsilon_0} = \mu_0 \, dQ/dt$$

$$\Rightarrow B = \frac{\mu_0}{2\pi R} \frac{dQ}{dt}.$$

$$S = \frac{EB}{\mu_0} = \frac{Q \, dQ/dt}{2\pi^2 R^3 \varepsilon_0}.$$

$$\phi_s = S \times (2\pi R \times d) = \frac{Q \, dQ/dt}{2\pi^2 R^3 \varepsilon_0} 2\pi R \, d = \frac{Q \, dQ/dt}{\pi R^2 \varepsilon_0} d = \frac{Q}{C} \frac{dQ}{dt}$$

the rate of change of the energy stored in the capacitor

$$\frac{d}{dt}\left(\frac{1}{2} \frac{Q^2}{C}\right) = \frac{Q}{C} \frac{dQ}{dt} = \phi_s.$$