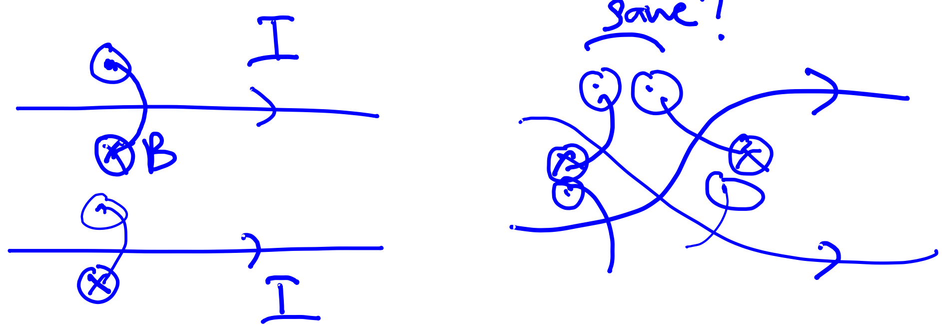
7.1 Why wires twisted?

Shielding: prevent capacitance leakage?

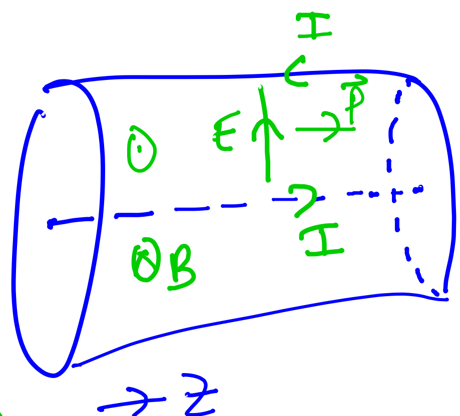


7.2/ $\delta = \frac{1}{\sqrt{\pi f \mu \sigma}} = \frac{1}{\sqrt{\pi \times 10^4 \times 1.26 \times 10^{-6} \times 4}}$ at 10^4 Hz

skin depth

≈ 2.5 m.

7.3/ $\vec{P} = \vec{E} \times \vec{H}$



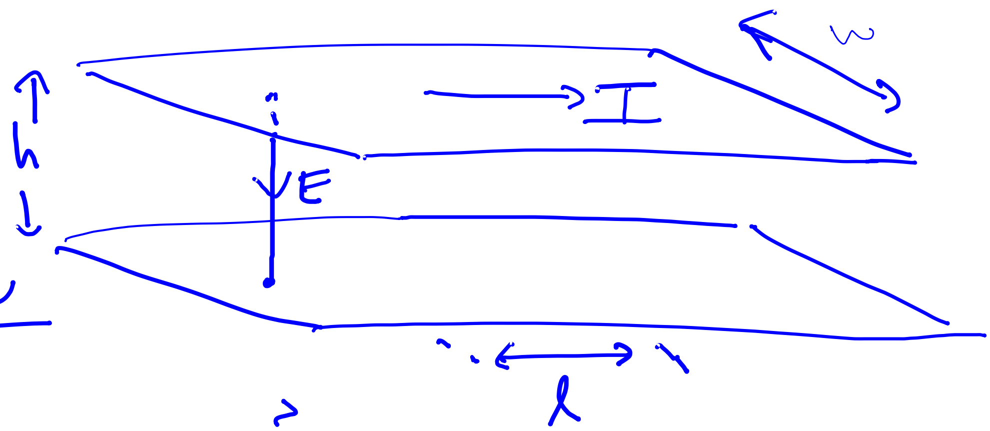
$E = \frac{Q}{2\pi \varepsilon r}$, $H = \frac{I}{2\pi r} \mu$?

$\vec{P} = \frac{Q}{2\pi \varepsilon r} \cdot \frac{I}{2\pi r} \vec{z} = \frac{IQ}{(2\pi)^2 r^2} \frac{\mu}{\varepsilon} \vec{z}$

$P = \int_0^{2\pi} \int_{r_1}^{r_0} \underbrace{d\theta \, r dr}_{\text{from cylindrical coor}} = \frac{IQ}{(2\pi)^2} \frac{\mu}{\varepsilon} 2\pi \int \frac{1}{r^2} r$

$$= \frac{IQ}{2\pi}\frac{\mu}{\varepsilon}\ln\frac{r_0}{r_1} = IV$$

7.41



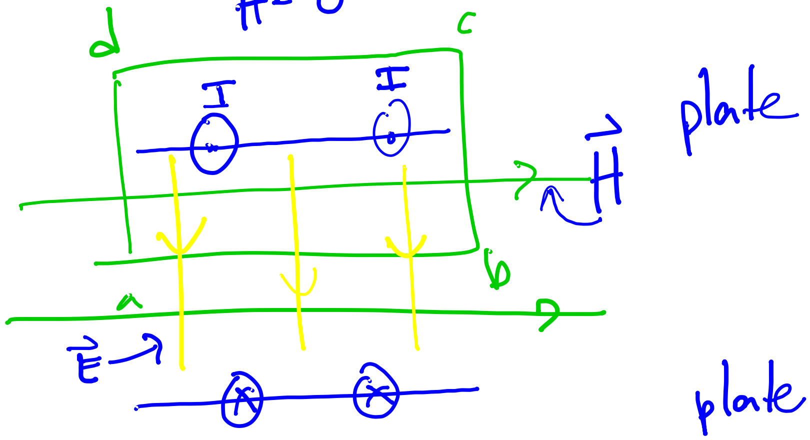
$\nabla \times \vec{H}$

stokes law

$$\int \vec{J}\, d\vec{A} = \oint H\, dl$$

$$I = H \cdot w$$

$$\Rightarrow H = \frac{I}{w}$$



$$\phi = \int B\, dA = \int \mu H\, dA$$

$$= \mu \frac{I}{w}\, l h$$

$$\frac{L}{\text{meter}} = \frac{\phi}{I l} = \mu \frac{h}{w}$$

$$L = \frac{\phi}{I}$$

Capacitance:

from last week, capacitance between two plates

$$C = \frac{\varepsilon A}{\quad} \qquad A = lw$$

$$\frac{C}{\text{per meter}} = \frac{\varepsilon A}{h\,l} = \frac{\varepsilon w}{h}$$

$$\text{Impedance, } Z = \frac{L}{C} = \sqrt{\frac{\mu\, h/w}{\varepsilon\, w/h}} = \sqrt{\frac{\mu h^2}{\varepsilon w^2}}$$

$$v = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\frac{\mu h}{w}\,\frac{\varepsilon w}{h}}} = \frac{1}{\sqrt{\mu\varepsilon}}$$

7.5/ From book $L = \frac{\mu_0}{2\pi} \ln\frac{r_0}{r_1}$

$$C = \frac{2\pi\varepsilon}{\ln\frac{r_0}{r_1}}$$

$$Z = \sqrt{\frac{\quad}{C}} \approx 50\,\Omega$$

$$v = \frac{1}{\sqrt{LC}} \approx 2\times 1^{8}\ \mathrm{ms} \qquad v = \frac{s}{t}$$
$$\approx 0.7c$$

c) clock speed is 1 s

distance : $0.7c \times 1\,\mathrm{ns} = 0.2\,\mathrm{m}$

d) $$Z = \sqrt{\frac{L}{C}} = \left(\frac{\mu_0 \left(\ln \frac{r_0}{r_1}\right)^2}{2\pi \times 2\pi \varepsilon} \right)^{1/2}$$

$$= \sqrt{\frac{\mu_0}{\varepsilon}}\ \frac{\ln \frac{r_0}{r_1}}{2\pi}$$

$$Z \propto \ln \frac{r_0}{r_1}$$

To match capacitance, $\ln \frac{1.48}{0.406} = \ln \frac{30/1000}{r_1}$

$$\therefore r_1 = \frac{30/1000}{1.48/0.406} = \frac{8.23}{1000}\ \mathrm{in}$$
$$\approx 8.23\ \mathrm{mil}$$

e) diameter $= 1.48 \times 2\ \mathrm{mm}$

$v = f\lambda$

$$\Rightarrow f = \frac{v}{\lambda} = \frac{2\times 10^{8}}{1.48\times 2\times 10^{-3}} \approx 67\ \mathrm{GHz}$$

2.6 a) Ethernet is 10 mbit/s $= 10^7$ bit/s

speed is 2×10^8 m/s

1 bit takes 10^{-7} s

in 10^{-7} s, distance travelled is $10^{-7}\times 2\times10^8$

$= 20$ m

64 bytes takes $20\times 64\times 8$

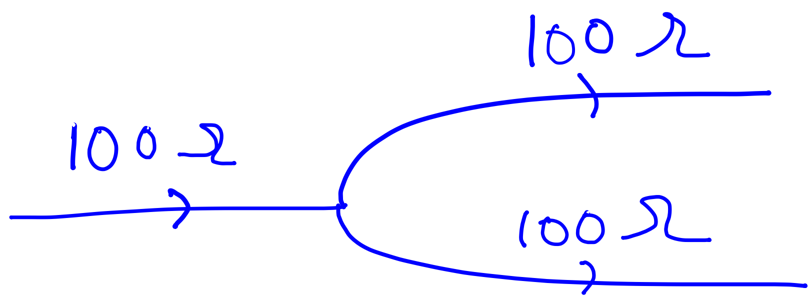
$= 10240$ m ≈ 1 km

b)

load impedence

$$\frac{1}{Z_L} = \frac{1}{Z} + \frac{1}{Z}$$

$$= \frac{2}{Z}$$



$$\Rightarrow Z_L = \frac{Z}{2} = 50\ \Omega$$

$$R = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{50-100}{50+100} = -\frac{1}{3}$$

?!?

$$T = \frac{2Z_L}{Z_L + Z_0} = \frac{2\times 50}{150} = \frac{2}{3}$$