7.1 Twist: the twisting ensures that both cables are, on average, the same distance apart from any source of noise, and thus are affected equally by noise. If you measure the difference between the two wires, the noise will not affect the measurement. A tighter twist is better.

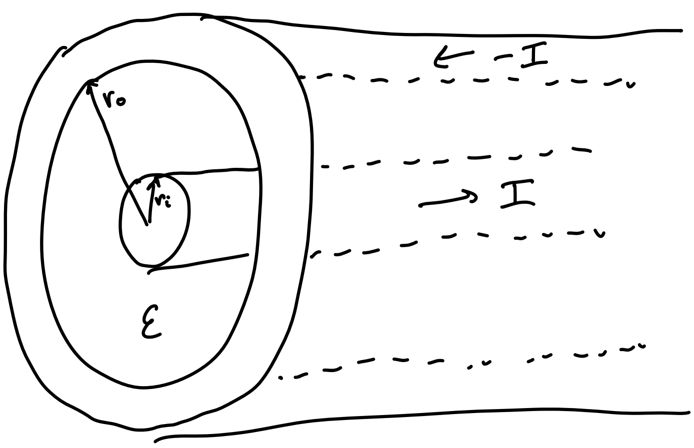
Shield: a conductive barrier around the signal wires will block EM waves from inducing current in the wires.

7.2 $\sigma = 4$ S/m, find skin depth @ $10^4$ Hz

Assume $\mu = 1.257 \times 10^{-6}$ H/m

$$\delta = 1/\sqrt{\pi \nu \mu \sigma} = \boxed{2.52 \text{ m}}$$

7.3




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

$$H = \frac{I}{2\pi r}$$

$$E = \frac{Q}{2\pi \varepsilon r}$$

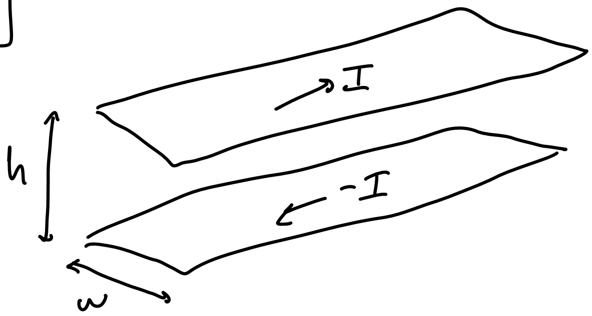
$$P = \int_{r_i}^{r_o} \vec{E} \times \vec{H} \, dr = \int_{r_i}^{r_o} \frac{Q}{2\pi\varepsilon r} \cdot \frac{I}{2\pi r} \, dr = \frac{QI}{4\pi^2 \varepsilon} \int_{r_i}^{r_o} \frac{1}{r^2} \, dr$$

$$= \frac{QI}{4\pi^2 \epsilon}\left(\frac{1}{r_i} - \frac{1}{r_o}\right)$$

$I = I$, $V = \frac{Q}{2\pi\epsilon} \ln \frac{r_o}{r_i}$

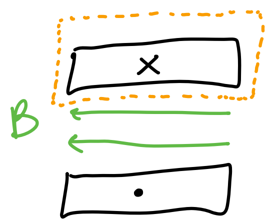
So not quite $P = IV$ ? did something wrong

**7.4**




$$Z = \sqrt{\frac{L}{C}}, \quad v = \frac{1}{\sqrt{LC}}$$

$$C = \frac{\epsilon_0 A}{d} = \frac{\epsilon_0 w \ell}{h} \rightarrow \frac{C}{\ell} = \frac{\epsilon_0 w}{h}$$




$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I$$

$$Bw = \mu_0 I \rightarrow B = \frac{\mu_0 I}{w}$$

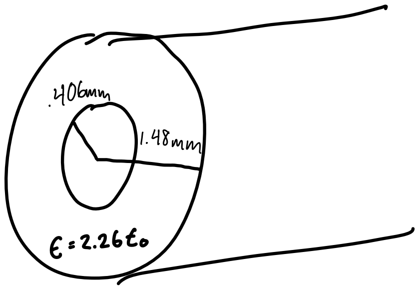
$$\Phi = \int \vec{B} \cdot d\vec{A} = B \cdot \ell \cdot h = \frac{\mu_0 I \ell h}{w}$$

$$L = \frac{\Phi}{I} = \frac{\mu_0 \ell h}{w} \rightarrow \frac{L}{\ell} = \frac{\mu_0 h}{w}$$

$$Z = \sqrt{\frac{L}{C}} = \sqrt{\frac{\mu_0 h}{w} \cdot \frac{h}{\epsilon_0 w}} = \frac{h}{w}\sqrt{\frac{\mu_0}{\epsilon_0}} = \boxed{\frac{h}{w} Z_0}$$

$$v = \frac{1}{\sqrt{LC}} = \sqrt{\frac{w}{\mu_0 h} \cdot \frac{h}{\epsilon_0 w}} = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = \boxed{c}$$

# 7.5




a) $L = \frac{\mu_0}{2\pi} \ln \frac{r_o}{r_i} = 2.59 \times 10^{-7}$ H/m

$C = \frac{2\pi \epsilon}{\ln(r_o/r_i)} = 9.72 \times 10^{-11}$ F/m

$Z = \sqrt{\frac{L}{C}} = 51.7\,\Omega$

b) $v = \sqrt{\frac{1}{LC}} = 1.99 \times 10^8$ m/s

c) $1.99 \times 10^8$ m/s $\cdot$ 1 ns $=$ .199 m

d) $Z = \sqrt{\frac{L}{C}} = \sqrt{\frac{\mu_0}{2\pi} \ln \frac{r_o}{r_i} \cdot \frac{\ln(r_o/r_i)}{2\pi\epsilon}}$

$= \frac{1}{2\pi} \ln \frac{r_o}{r_i} \cdot \frac{1}{\sqrt{2.26}} \cdot Z_0$

$= 39.9 \ln \frac{r_o}{r_i}$

$Z = 39.9 \ln \frac{30\text{mil}}{r_i} = 50\,\Omega$

↳ $r_i = 8.56$ mils

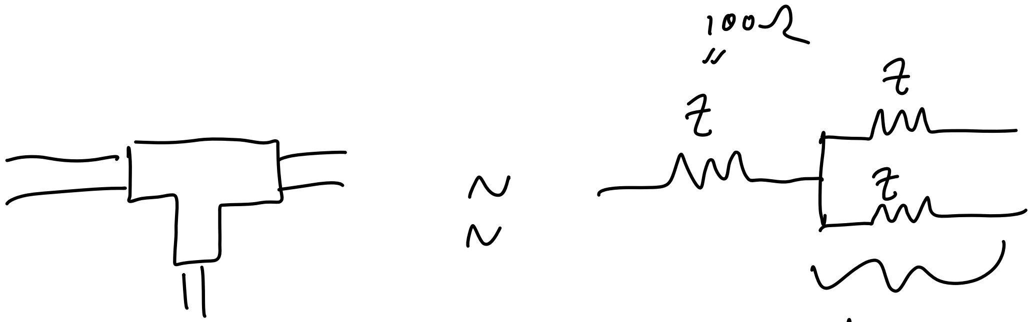
e) $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8 \text{ m/s}}{.001 \text{ m}} = 3 \times 10^{11}$ Hz $=$ 300 GHz

**7.6** $t_{PD} = 4.6$ ns/m

$Z = 100\,\Omega$

a) ?

b)




$\frac{1}{2}Z = 50\,\Omega$

$$R = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$= \frac{50\,\Omega - 100\,\Omega}{50\,\Omega + 100\,\Omega}$$

$$= \frac{-50}{150} = \boxed{-\frac{1}{3}}$$