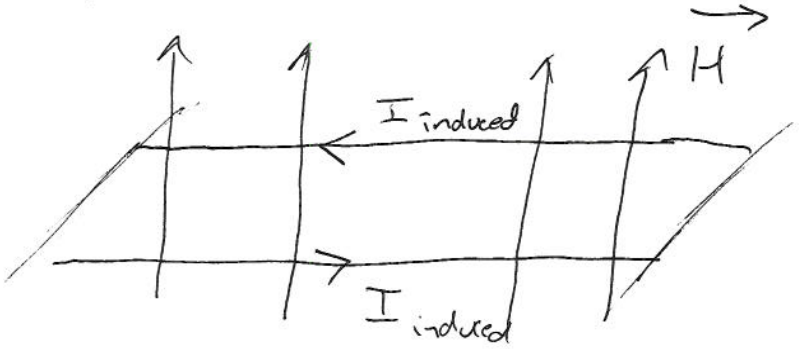
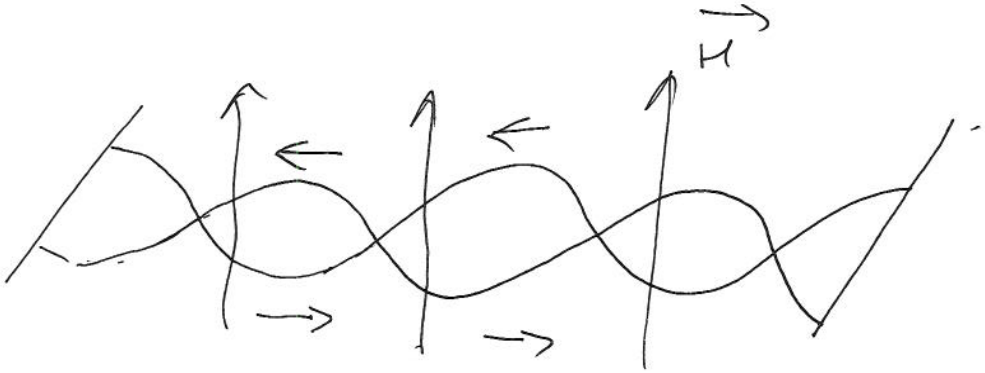
Q 7.1

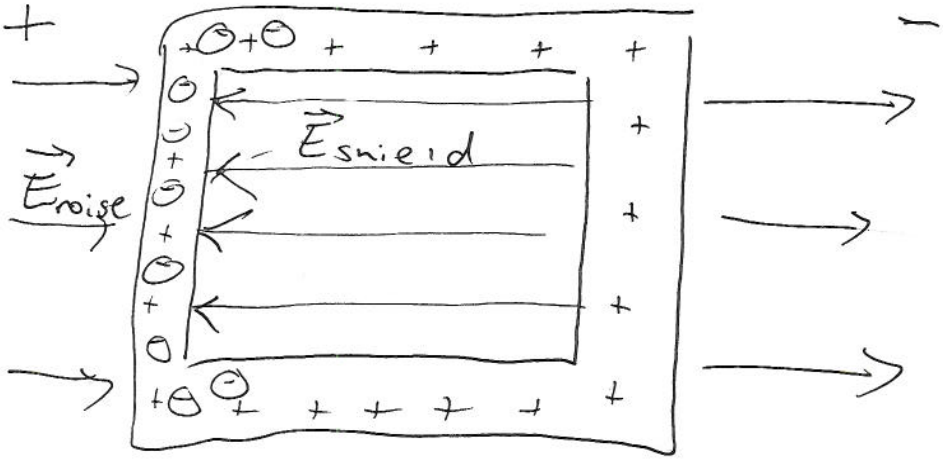
Twisting the wire pair alternates exposure (sign) w.r.t. the noise source.



vs.



Capacitive shielding attenuates the noise



⊖ is mobile and will move opposite $\vec{E}_{noise}$

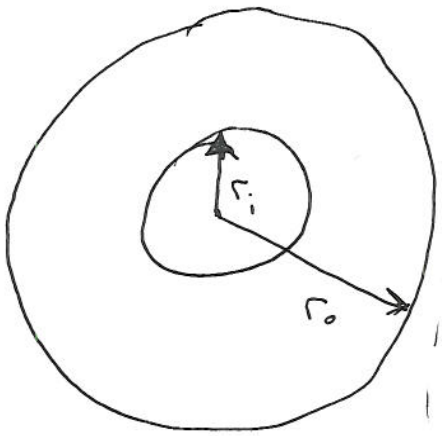
Q 7.2

$$\delta = \frac{1}{\sqrt{\pi \nu \mu \sigma}}$$

$$= \frac{1}{\text{sqrt}(\pi \cdot 10^4\ \text{Hz} \cdot \mu \cdot 4\ \text{S/m})}$$

$$= 2.5\text{m}$$

Q 7.3



$$\oint_S \vec{D} \cdot d\vec{A} = Q$$

$$\frac{\epsilon}{\ell} \int_s \vec{E} \cdot d\vec{A} = Q' \quad \left(Q' = \frac{Q}{\ell}\right)$$

$$E \cdot 2\pi\epsilon r = Q'$$

$$\rightarrow \vec{E} = \frac{Q'}{2\pi\epsilon r} \hat{r}$$

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

$$= \frac{IQ'}{\epsilon (2\pi r)^2} \hat{z}$$

$$\oint \vec{H} \cdot d\vec{\ell} = I$$

$$2\pi r H = I$$

$$\vec{H} = \frac{I}{2\pi r} \hat{\theta}$$

$$P = \int_0^{2\pi} \int_{r_i}^{r_o} |\vec{P}| \, r \, dr \, d\theta$$

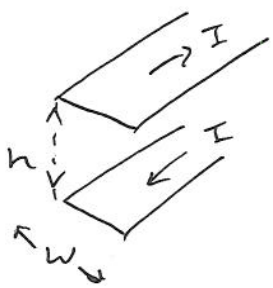
$$= \frac{IQ'}{2\pi\epsilon} \int_{r_i}^{r_o} \frac{1}{r} dr$$

$$= \frac{IQ'}{2\pi\epsilon} \ln\left(\frac{r_o}{r_i}\right)$$

$$= IV$$

Q 7.4

$$C' = \left[\frac{C}{m}\right] = \epsilon \frac{\omega}{h}$$



$$\oint_C \vec{H} \cdot d\vec{r} = I \quad \rightarrow H = \frac{I}{\omega}$$

$$\Phi = \int \vec{B} \cdot d\vec{A} = \frac{\mu}{\omega} \int I \, dA = \frac{\mu}{\omega} \cdot h\ell \cdot I$$

$$L' = \frac{\Phi}{I\ell} = \mu \frac{h}{\omega}$$

$$\therefore Z = \sqrt{\frac{L'}{C'}} = \sqrt{\frac{\mu h^2}{\epsilon \omega^2}} \; //$$

$$\therefore v = \frac{1}{\sqrt{L'C'}} = \frac{1}{\sqrt{\mu \frac{h}{\omega} \cdot \epsilon \frac{\omega}{h}}} = \frac{1}{\sqrt{\mu\epsilon}} \; //$$

Q 7.5

a) For coax: $L = \frac{\mu_0}{2\pi} \ln\left(\frac{r_o}{r_i}\right)$, $C = \frac{2\pi \epsilon_0 \epsilon_r}{\ln(r_o/r_i)}$

$$Z = \sqrt{L/C}$$

$$= \sqrt{\frac{4\pi \cdot 10^{-7}}{2\pi} \ln\left(\frac{1.48}{0.406}\right) \frac{1}{2\pi \cdot 2.26 \cdot 8.854 \cdot 10^{-12}} \ln\left(\frac{1.48}{0.406}\right)}$$

$$= 51.6\,\Omega$$ //

b) $$v = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\mu_0 \epsilon_0 \epsilon_r}} = \frac{1}{\sqrt{4\pi \cdot 10^{-7} \cdot 2.26 \cdot 8.854 \times 10^{-12}}}$$

$$= 2 \cdot 10^8\ m/s$$ //

c) $2 \cdot 10^8\ m/s \cdot 10^{-9}\ s = 0.2\ m$ //

d) $r_o = 30\ mil = 0.762\ mm$

$$51.6 = \sqrt{L/C} = \sqrt{\frac{\mu_0}{2\pi}\left(\ln\left(\frac{0.762\,mm}{r_i}\right)\right)^2 \cdot \frac{1}{2\pi \epsilon_0 \epsilon_r}}$$

$$\Rightarrow r_i = 0.22\ mm$$ //

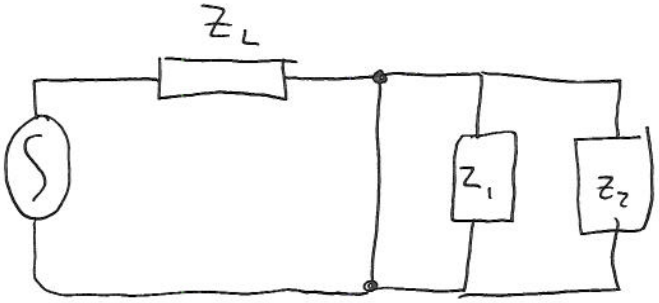
e) $c = \nu \lambda \rightarrow \frac{2 \cdot 10^8\ m/s}{1.48\,mm \cdot 2} = 6.7 \cdot 10^{10}\ Hz$ //

Q 7.6

a) $2 \cdot 10^{8} \frac{m}{s} \cdot 10^{-7} \frac{s}{bit} = 20 \; m/bit$

//

b)



$Z_1 = Z_2 = Z = 51.6\,\Omega$

$\approx 50\,\Omega$

$$\frac{1}{Z_L} = \frac{1}{Z_1} + \frac{1}{Z_2} \rightarrow Z_L = \frac{Z}{2} = 25\,\Omega$$

//

$$R = \left| \frac{Z_L - Z}{Z_L + Z} \right| = \left| \frac{-25}{75} \right| = \frac{1}{3}$$

//