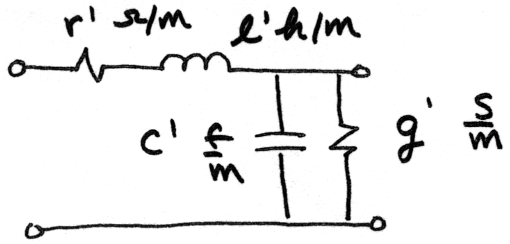
1. (30)

a) If a lossless transmission line is terminated in the characteristic impedance there are no standing waves. True or False.

b) The reflection coefficient is generally a complex number with magnitude less than or equal to 1. True or False.

c) I saw a T shirt that said "186,000 miles per second… its not only a good idea, it's the law!" How does this apply to transmission lines? speed of light is the max. velocity possible

d) For the lumped parameter transmission line shown below label the elements (c', l', r', g') and give the units.



e) Give order of magnitude estimates of the wavelengths (in meters) of the following signals:

Power lines $\lambda = \frac{c}{f} = \frac{3\times10^8}{60} = 5\times10^6$ m

TV signals $\lambda = \frac{c}{10^8} = 3$ m

Cell Phone $\lambda = \frac{c}{10^9} = 0.3$ m

f) The characteristic impedance of the spool of coax cable that we use in the lab is (circle one)

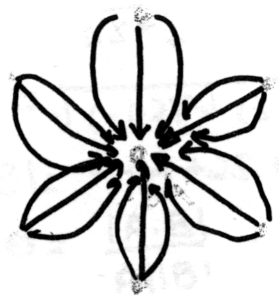
50 Ohms,

75 Ohms

300 Ohms

400 Ohms

(g) We have 6 positive charges of magnitude Q equally spaced on a circle (60 degrees apart). The charge in the center is –6Q. Sketch the electric field lines.



2. (15) Two points are located in a Cartesian Coordinate system. Point A is at (3.5, 7.0, -8.4) and point B is at (-1.2, 3.7, 2.2). Find the vector going from point A to Point B. If we consider the vector OA from the origin to point A and the vector OB from the origin to point B then find the angle between the vectors.

$-4.7\hat{a}_x - 3.3\hat{a}_y + 10.6\hat{a}_z$

$|A| = \sqrt{3.5^2 + 7^2 + (-8.4)^2} = 11.48$

$|B| = \sqrt{(-1.2)^2 + (3.7)^2 + (2.2)^2} = 4.47$

$|A \cdot B| = -4.2 + 25.9 - 18.48 = 3.22$

$\cos\theta = \frac{|A \cdot B|}{|A||B|} = 0.063$

$\theta = 86.4°$

$\cos\theta = \frac{A \cdot B}{|A||B|}$

3. (25)

a) Express $v(t) = 3\cos(\omega t - \pi/4)V$ as a phasor.

$\tilde{V} = 3e^{-j\pi/4}$ V

b) Express $i(x,t) = 4e^{-3x}\sin(\omega t - \pi/6)A$ as a phasor

$= 4e^{-3x}\cos(\frac{\pi}{3} - \omega t + \frac{\pi}{6})$

$= 4e^{-3x} e^{-j2\pi/3}$ A

c) Given the phasor $\vec{E} = -j3\hat{a}_x + j15\hat{a}_y$ at 30 MHz write the expression in the time domain.

$E(t) = 3\cos(2\pi \times 30 \times 10^6 t - \frac{\pi}{2})\hat{a}_x$

$+ 15\cos(2\pi \times 30 \times 10^6 t + \frac{\pi}{2})\hat{a}_y$

d) Given the phasor $I = 3 + j4$ A, ~~with~~ write the time domain expression. at ω_o

$|I| = \sqrt{3^2+4^2} = 5$, $\tan\theta = \frac{4}{3} \Rightarrow \theta = 53.13°$

$i(t) = 5\cos(\omega_o t + 53.13)$ A

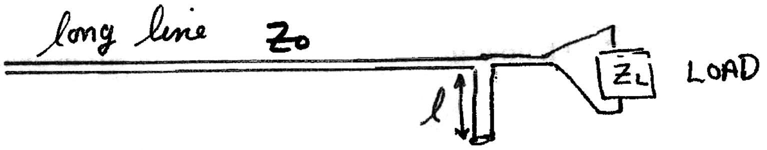
e) For the following expressions determine if the wave is traveling or standing. If it is a traveling indicate the direction and velocity.

i) $\sin(\omega t)\cos(\beta z)$ Standing wave.

ii) $\cos(3\omega t - 5z)$ traveling in +z direction

$v_p = \lambda f = \frac{2\pi}{5} \cdot \frac{3\omega}{2\pi} = \frac{3\omega}{5}$ m/s

4) (15) The following diagram describes a notch filter to block a frequency ω_0 from the load. The wave velocity is v_p. A short transmission line is inserted close to the load. What is the minimum length of the stub line if it is shorted? If it is open circuited?



$$Z_{in_{sc}} - jZ_0 \tan \beta l = 0$$

$$\frac{2\pi}{\lambda} l = \pi \;, \; l = \frac{\lambda}{2}$$

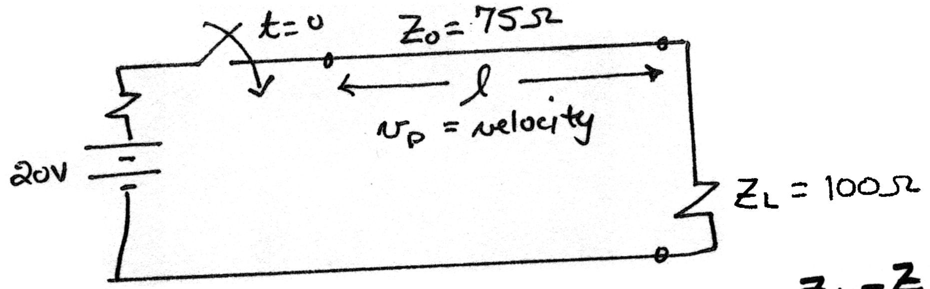
$$\lambda = v_p \cdot \frac{2\pi}{\omega_0} \Rightarrow l = \frac{v_p \pi}{\omega_0}$$

$$Z_{in_{oc}} = -jZ_0 \cot \beta l = 0$$

$$\frac{2\pi}{\lambda} l = \frac{\pi}{2} \;, \; l = \frac{\lambda}{4} = \frac{v_p 2\pi}{4\omega_0} = \frac{v_p \pi}{2\omega_0}$$

5)(15) A transmission line with characteristic impedance of 75 Ohms and a 100 Ohm termination (Load) resistance is connected to a 20 Volt dc source with 10 Ohms internal (source) impedance.

Find the reflection coefficients at the load and the source end.
Find the steady state voltage at the load.
Plot the voltage at the load for 3 transit times. It would be helpful to include a bounce diagram.



$$\frac{Z_g - Z_o}{Z_g} = \frac{10-75}{10+75} = -0.765 \qquad \Gamma_L = \frac{Z_L - Z_o}{Z_L + Z_o} = \frac{100-75}{100+75} = 0.143$$

$$V_{ss} = \frac{100}{110} \times 20 = 18.18$$

$$V^+ = \frac{75}{85} \times 20 = 17.65$$