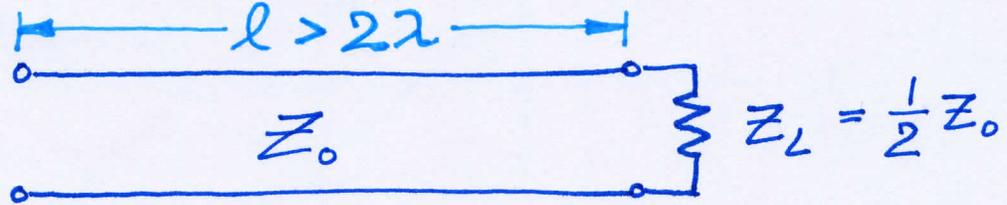


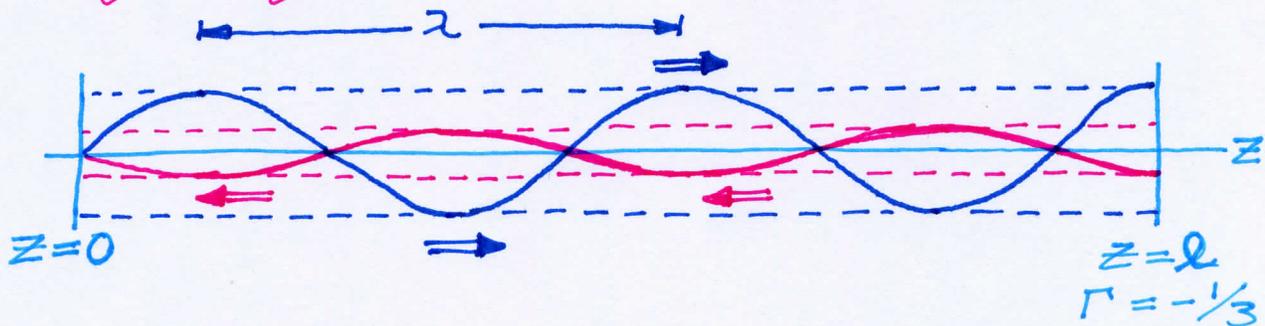
Exam - 01 - Solution

Q1

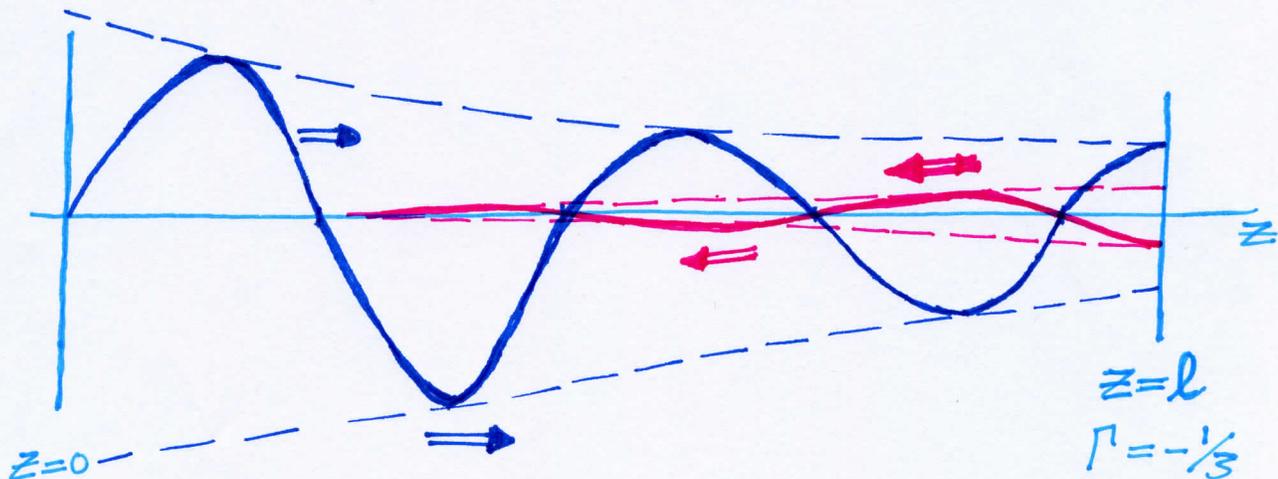
Transmission line, $l > 2\lambda$, $Z_L = \frac{1}{2} Z_0$.

$$\Rightarrow \Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{\frac{1}{2} Z_0 - Z_0}{\frac{1}{2} Z_0 + Z_0} = \frac{-\frac{1}{2}}{\frac{3}{2}} = -\frac{1}{3} = \underline{\underline{33.3\%}}$$

(a) Forward-propagating wave & Backward-propagating wave

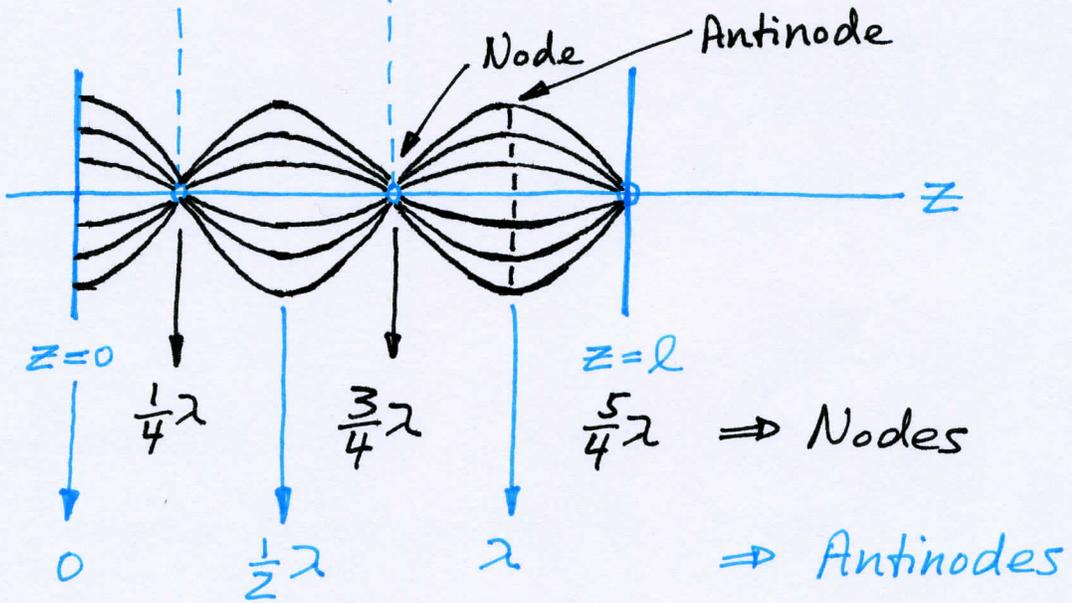
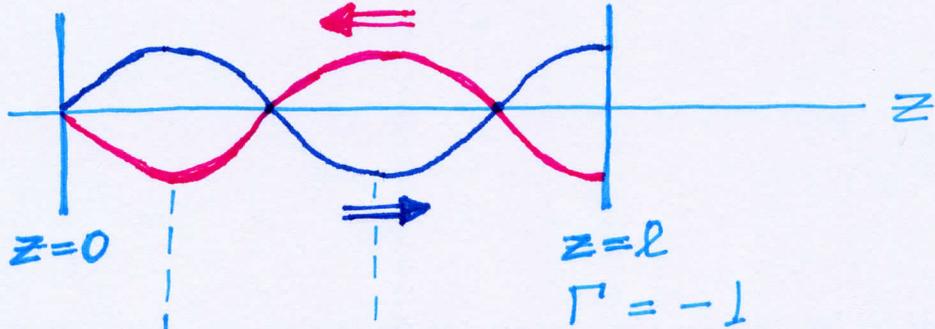


(b) For a lossy T-line, the amplitude decreases



(c) $Z_L = 0 \Rightarrow \Gamma = -1 = -100\%$

$l = \frac{5}{4} \lambda$

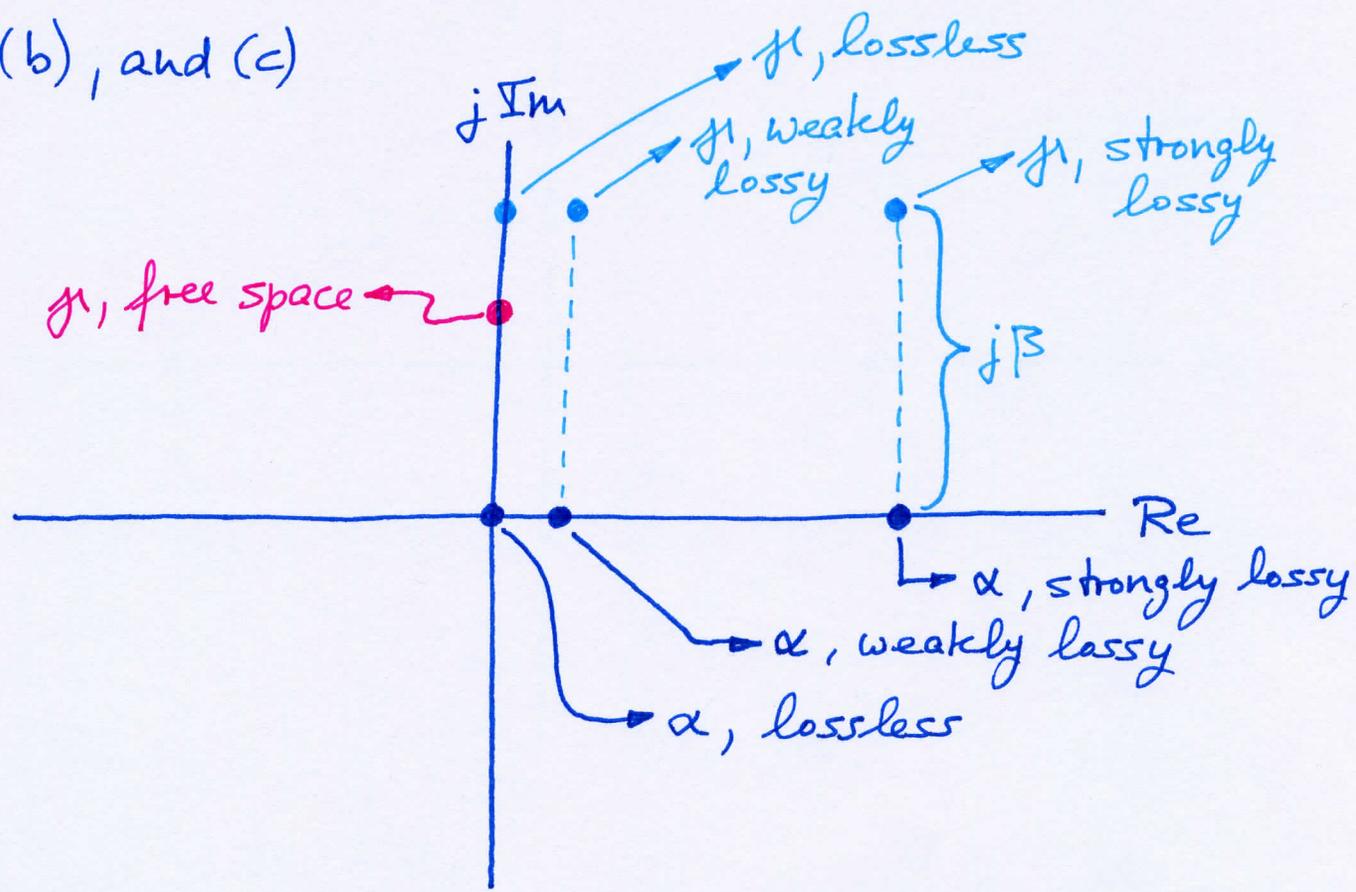


Q2

3

Complex plane with axes Re and jIm

(a), (b), and (c)



$\alpha, \text{ lossless} \Rightarrow \alpha = \underline{\underline{0}}$

$\alpha, \text{ weakly lossy} \Rightarrow \alpha \text{ small}$

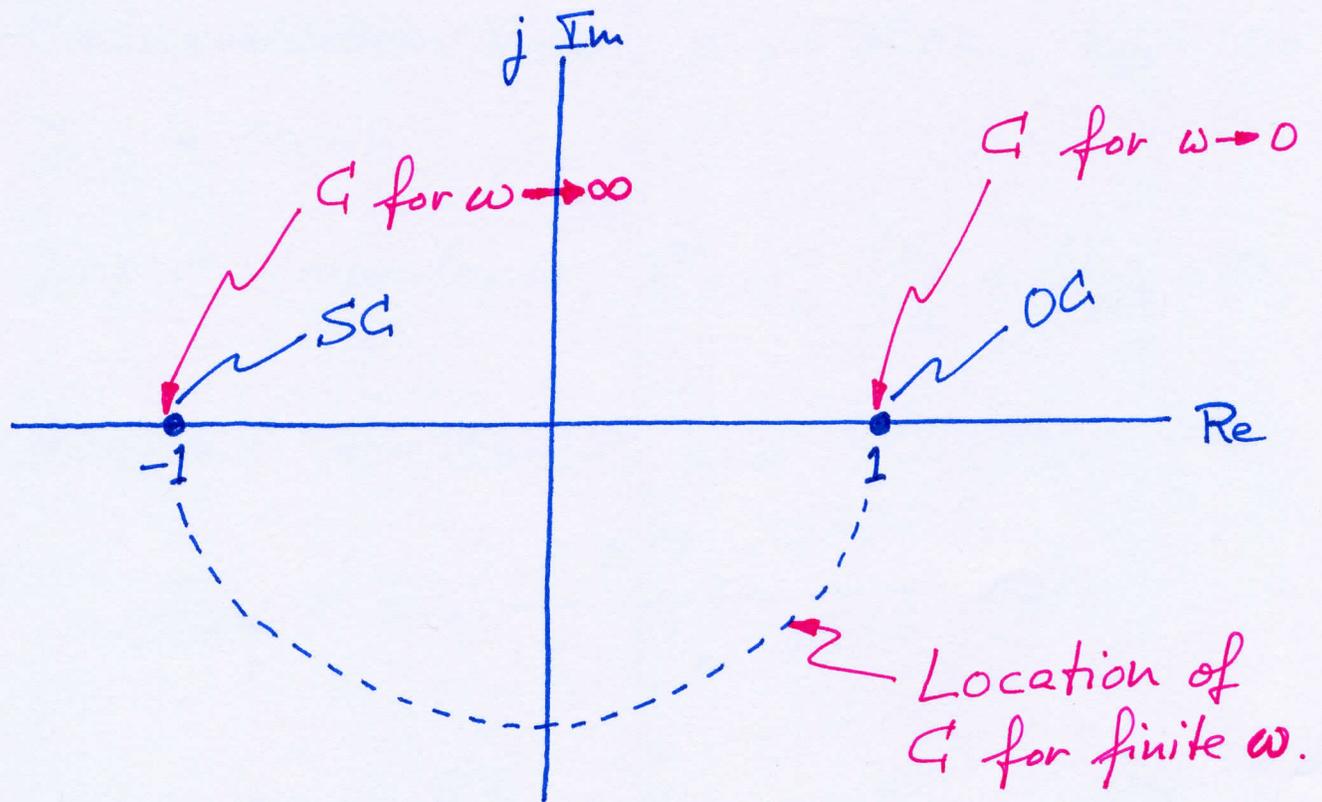
$\alpha, \text{ strongly lossy} \Rightarrow \alpha \text{ large}$

$\mu = \alpha + j\beta$. For sinusoidal wave, β is a constant.

In free space, $\alpha = 0$. $\beta_{\text{Free space}} < \beta$

$\lambda_{\text{Free space}} > \lambda$

(d)



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

$$\underline{\underline{SC \Rightarrow \Gamma = -1}}$$

$$\underline{\underline{OC \Rightarrow \Gamma = 1}}$$

Capacitor: $Z_L = \frac{1}{j\omega C}$

$$\Gamma = \frac{\frac{1}{j\omega C} - Z_0}{\frac{1}{j\omega C} + Z_0} = \frac{1 - j\omega C Z_0}{1 + j\omega C Z_0}$$

$$\omega \rightarrow 0 \Rightarrow \underline{\underline{\Gamma = 1}}$$

$$\omega \rightarrow \infty \Rightarrow \underline{\underline{\Gamma = -1}}$$

Recall: Complex number = $Re + jIm = |G| e^{j\phi}$

$$\Gamma = \frac{1 - j\omega C Z_0}{1 + j\omega C Z_0} = \frac{|G| e^{-j\theta}}{|G| e^{+j\theta}} = \underline{\underline{e^{-j2\theta}}}$$

Q3

Transmission line $Z_0 = 50\Omega$ $V_{In} = 1.0V$

$$I_{In} = 30mA$$

(a) Input impedance $Z_{In} = \frac{V_{In}}{I_{In}} = \frac{1V}{30mA} = 33.3\Omega$

(b) Assume $\lambda = 30cm$ and $l = 1.5m$

$$Z_{In} = Z_0 \frac{1 + \Gamma e^{-j2\beta l}}{1 - \Gamma e^{-j2\beta l}}$$

where $\beta l = \frac{2\pi}{0.3m} \cdot 1.5m = 10\pi$

and $e^{-j2\beta l} = e^{-j20\pi} = 1$

$$\Rightarrow Z_{In} = Z_0 \frac{1 + \Gamma}{1 - \Gamma}$$

Solve this eqn. for Γ :

$$Z_{In} (1 - \Gamma) = Z_0 (1 + \Gamma)$$

$$Z_{In} - \Gamma Z_{In} = Z_0 + \Gamma Z_0$$

$$Z_{In} - Z_0 = \Gamma (Z_0 + Z_{In})$$

$$\Rightarrow \Gamma = \frac{Z_{In} - Z_0}{Z_{In} + Z_0} = \frac{33.3\Omega - 50\Omega}{33.3\Omega + 50\Omega} = -0.2$$

(c) Load impedance $Z_L = ?$

Recall: $\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$

Solve this eqn. for Z_L :

$$\Gamma Z_L + \Gamma Z_0 = Z_L - Z_0$$

$$\Gamma Z_L - Z_L = -Z_0 - \Gamma Z_0$$

$$Z_L (\Gamma - 1) = -Z_0 (1 + \Gamma)$$

$$Z_L = Z_0 \frac{1 + \Gamma}{1 - \Gamma}$$

$$\Rightarrow Z_L = 50 \Omega \frac{1 - 0.2}{1 + 0.2} = 50 \Omega \frac{0.8}{1.2} = \underline{\underline{33.3 \Omega}}$$

Q4

- (a) Impossible to determine. Load impedance is unknown.
- (b) True. Ideally $G' = 0$ and a lossless transmission line would be obtained.
- (c) True. Vacuum has zero conductivity. Any material will be worse than vacuum in this respect.
- (d) True. When $f \uparrow$ then $\lambda \downarrow$ and $\beta \uparrow$. (Recall: $\beta = \frac{2\pi}{\lambda}$)