EXAM 3

1. Short answer questions

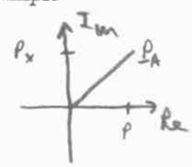
a. Explain the difference between power dissipated, apparent power, and reactive power. Sketch an example showing the relationship between these quantities.

$\underline{P}_A = P + j P_x$

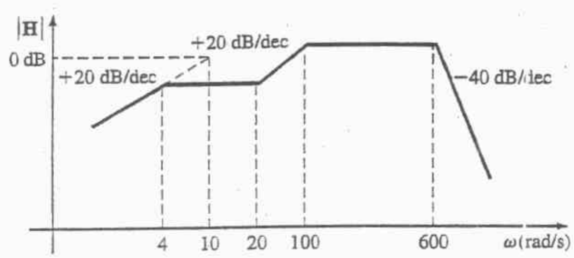
P = power dissipated (W)

$\underline{P}_A$ = apparent power (VA)

P_x = reactive power (VAR)



b. Find the transfer function that would result in the Bode plot shown below.



$$H = 0.1 \frac{j\omega\left(1 + j\,\omega/20\right)}{\left(1+j\omega/4\right)\left(1+j\omega/100\right)\left(1+j\omega/600\right)^2}$$

c. (i) Briefly explain what the frequency response of a circuit is and why we might be interested in knowing it.

The frequency response of a circuit is the output / input vs. frequency; we can find amplitude & phase. It tells us how the output & input signals are related as a function of frequency for a sinusoidal input.
(We will learn that this information can be used to determine the output for an arbitrary input next semester.)

(ii) Briefly explain what resonance means.

The resonant frequency is the natural frequency of the circuit.
At this frequency, V & I are in phase, which happens when the inductive & capacitive effects cancel.

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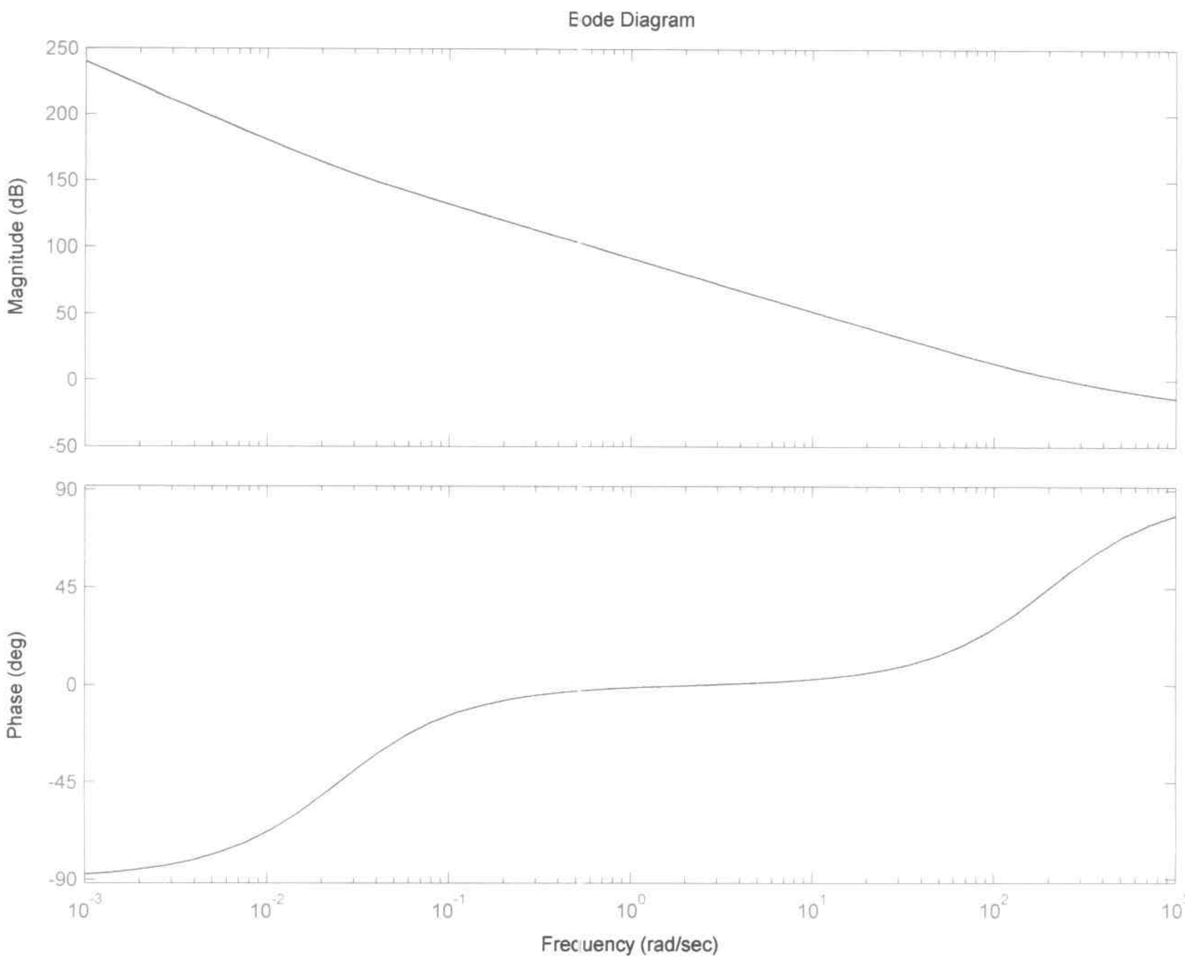
2. Sketch the Bode plot (include both magnitude and phase plots) for the following transfer function.

$$H(j\omega) = \frac{-j2.5(200 + j\omega)(2 + j80\omega)^2}{\omega^3}$$

$$= \frac{-\overbrace{(2.5)(200)(2)}^{1000}(1 + j\omega/100)(1 + j\omega/.025)}{(j\omega)^3}$$



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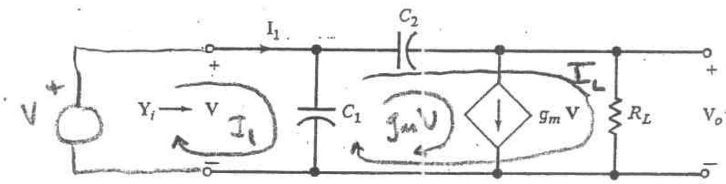
3. The circuit below is a model of a device known as a transistor. Find expressions for the two transfer functions $H = \frac{V_o}{V}$ (voltage gain) and $Z_i = \frac{V}{I_1}$ (input impedance) as a function of frequency ω.



Left loop (follow I_1) $\quad \underline{V} - \frac{1}{j\omega C_1}(\underline{I}_1 - g_m\underline{V} - \underline{I}_L) = 0 \quad (1)$

Right loop (follow I_L) $\quad -\frac{1}{j\omega C_2}(\underline{I}_L + g_m\underline{V}) - R_L\underline{I}_L - \frac{1}{j\omega C_1}(\underline{I}_L + g_m\underline{V} - \underline{I}_1) \quad (2)$

for $\underline{H} = \frac{\underline{V}_o}{\underline{V}} = \frac{R_L\underline{I}_L}{\underline{V}}$, eliminate $\underline{I}_1$ (eg solve (1) for $\underline{I}_1$ & sub into (2)) for an eq. in $\underline{V}$ & $\underline{I}_L$.

for $\underline{Z}_1 = \frac{\underline{V}}{\underline{I}_1}$, eliminate $\underline{I}_L$ (eg. solve (1) for $\underline{I}_L$ & sub into (2)) for an eq. in $\underline{V}$ & $\underline{I}_1$.

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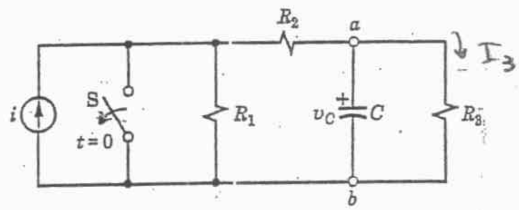
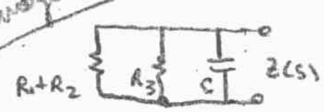
4. In the circuit below, switch S opens at t = 0. Find $v_c(t)$ if $v_c(0) = 0$ (C is initially uncharged). The current source $i(t) = I_0$.



Particular

$$v_{c_p} = R_3 I_3 = R_3 \left(\frac{R_1}{R_1+R_2+R_3} I_0 \right) \quad \text{by current} \div.$$

Homogeneous



=

$$Z(s) = \frac{R_{eq}/sC}{R_{eq} + 1/sC} = \frac{R_{eq}}{1 + sR_{eq}C} \text{ ; use pole for } v$$

where $R_{eq} = \dfrac{(R_1+R_2)R_3}{R_1+R_2+R_3}$ $\quad \Rightarrow s = -1/R_{eq}C$

$$v_{ch} = A e^{-t/R_{eq}C}$$

Complete

$$v_c = v_{ch} + v_{cp} = Ae^{-t/R_{eq}C} + \frac{R_1 R_3}{R_1+R_2+R_3} I_0$$

IC $\quad v_c(0) = 0 = A + \dfrac{R_1R_2}{R_1+R_2+R_3} I_0 \quad$ or $\quad A = -\dfrac{R_1R_2}{R_1+R_2+R_3} I_0$

$$\boxed{v_c(t) = \frac{R_1R_2}{R_1+R_2+R_3} I_0 \left(1 - e^{-t/R_{eq}C}\right) u(t) \text{ V} \quad , \text{ w/ } R_{eq} = \frac{(R_1+R_2)R_3}{R_1+R_2+R_3}}$$