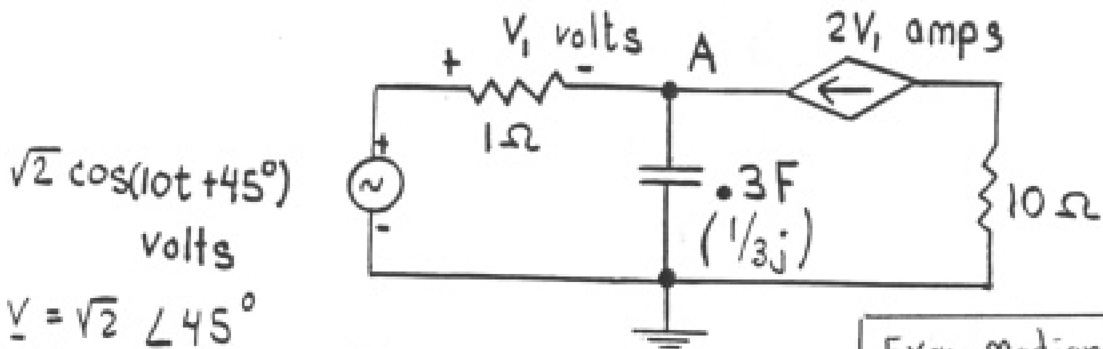
EECS 210 W97 Section #2
Final Exam Solutions

(20 points)
Problem # 1

Winick

Consider the circuit shown below which contains a voltage controlled current source.



$\therefore \underline{V} = \sqrt{2} \angle 45^\circ$

Find the voltage at node A.

Exam Median = 69%	
Exam Mean = 64.7%	
Score	No. of Students
0 - 10	3
11-20	3
21-30	3
31-40	11
41-50	10
51-60	9
61-70	10
71-80	11
81-90	16
91-100	18
	total = 94

$V_A(t) = \boxed{\cos(10t) \text{ volts}}$

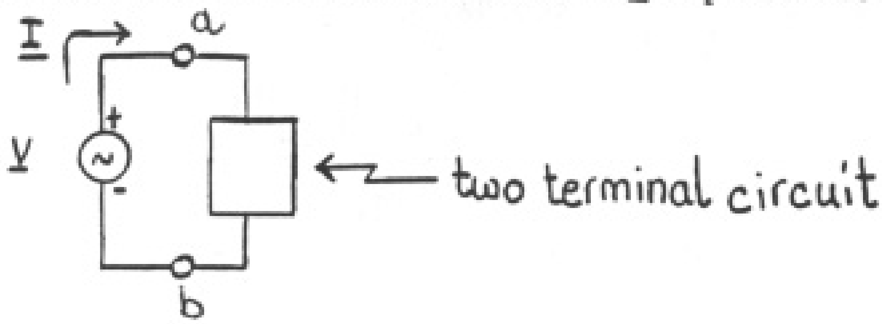
$$\frac{\underline{V} - \underline{V}_A}{1} + (0 - \underline{V}_A)j3 + 2(\underline{V} - \underline{V}_A) = 0$$

$$\therefore \quad \underline{V}_A = \frac{\underline{V}}{1+j} = \underline{V}\,\frac{1}{\sqrt{2}}\angle{-45^\circ}$$

$$= 1\angle 0^\circ$$

(20 points)
Problem # 2

When an arbitrary voltage $\underline{V}$ volts (at ω=100 rad/s) is applied to the two terminal circuit shown below a current $\underline{I}$ amperes flows.



It is experimentally found that the relationship between $\underline{V}$ and $\underline{I}$ is given by

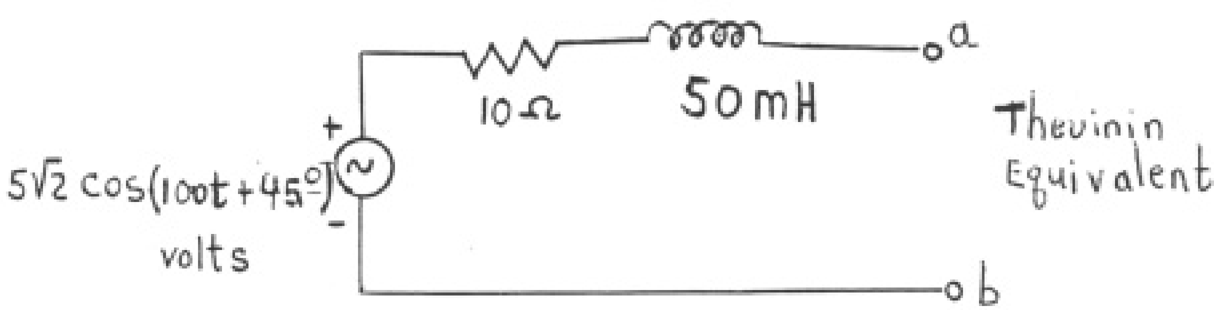
$$\underline{V} = (5 + j5) + \underline{I}(10 + j5)$$

Draw an equivalent two terminal circuit which contains only one independent voltage source ($\underline{V}_s$), one resistor (R) and one inductor (L). Specify the values of $\underline{V}_s$, R and L.

$$\therefore \quad \underline{V}_{oc} = (5+j5)$$

$$\underline{I}_{sc} = \frac{-(5+j5)}{10+j5}$$

$$Z_T = \frac{-\underline{V}_{oc}}{\underline{I}_{sc}} = 10+j5$$



(20 points)
Problem # 3 3!

The frequency transfer function, $H(\omega)$, of a filter is given by the Bode plots shown on the next page.

2pts. (a) What kind of filter is this?

$\boxed{\text{bandstop or notch}}$

9pts. (b) If the signal

.316 ✓

$x(t) = 0.1\cos(100t+5^\circ) + 0.1\cos(3100t+53^\circ) + 0.1585\cos(8\times10^5 t+47^\circ)$

is input to this filter, then estimate the filter output $y(t)$ using the Bode plot.

$y(t) = \boxed{\cos(100t) + \cos(3100t) - \sin(8\times10^5 t)}$

$|H(100)| = 20\,dB\ (10)$, $\angle H(100) = \sim -5^\circ\ (5.08^\circ)$

$|H(3100)| = 10\,dB\ (3.16)$, $\angle H(3100) \cong -53^\circ\ (-53.29^\circ)$

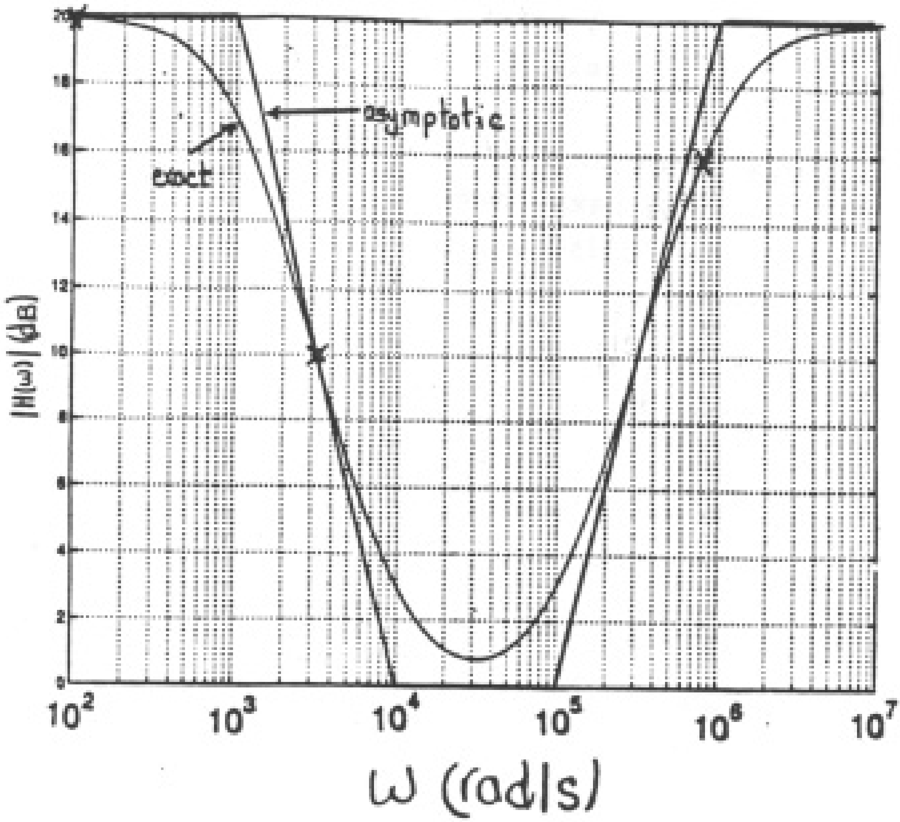
$|H(8\times10^5)| = 16\,dB\ (6.31)$, $\angle H(8\times10^5) \cong 43^\circ\ (43.57^\circ)$

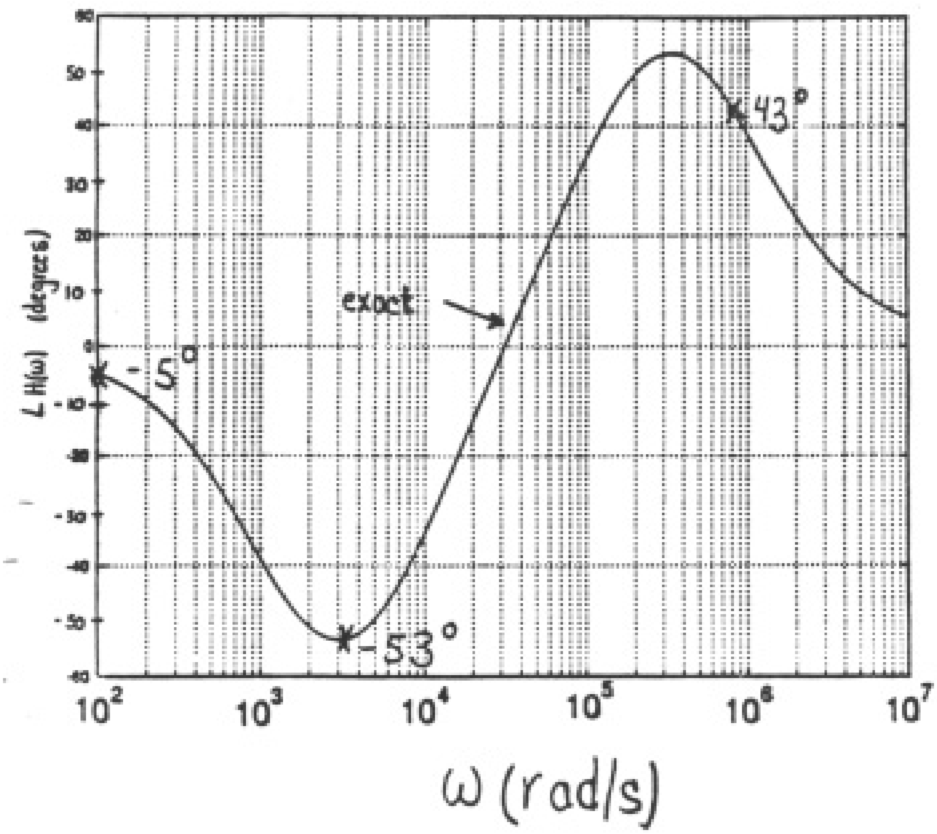
9pts. (c) Find the system transfer function, $H(s)$, from the asymptotic Bode plot.

$H(s) = \boxed{}$

$$10\frac{(1+s/10^4)(1+s/10^5)}{(1+s/10^3)(1+s/10^6)}$$

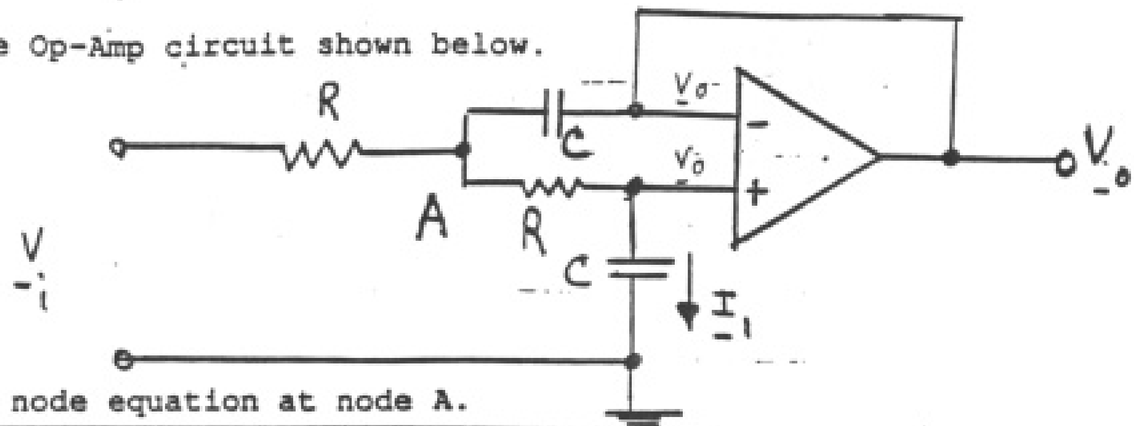
Bode Plots for Problem # 3





(20 points)
Problem # 4

Consider the Op-Amp circuit shown below.



(a) Write a node equation at node A.

$$\boxed{\frac{\underline{V}_A - \underline{V}_i}{R} + (\underline{V}_A - \underline{V}_o)sC + \frac{(\underline{V}_A - \underline{V}_o)}{R} = 0} \quad (1)$$

or $(2+RCs)\underline{V}_A = \underline{V}_i + (1+RCs)\underline{V}_o$ (2)

1 pnts.

(b) Express the node voltage at node A in terms of $\underline{V}_o$ by first computing I_1.

$\underline{I}_1 = \underline{V}_o sC$ (3)

$\underline{V}_A - \underline{V}_o = R\underline{I}_1 = \underline{V}_o RCs$ (4)

$\therefore \boxed{\underline{V}_A = (1+RCs)\underline{V}_o}$ (5)

(c) Combine your results of parts (a) and (b) above to show that the system transfer function is given by

$$H(s) = \frac{1}{as^2 + bs + 1} = \frac{1}{(1+RCs)^2}$$

Find the values of a and b in terms of R and C.

$a = \boxed{(RC)^2}$ $\qquad$ $b = \boxed{2RC}$

5pts total (d) For R=1Ω and C=1F, H(s) is given by

$$H(s) = \frac{1}{(1+s)^2}$$

→ 4 pts.

Sketch the asymptotic Bode plot(magnitude only) of this H(s) on page 12. What type of filter is this?

$\boxed{\text{Low Pass}}$ ← 1 pt.

5pts (e) When R=1 Ω and C=1F, the 3 dB cut-off frequency ω_c (i.e., $|H(\omega_c)| = 0.707|H(0)|$) is 0.644 rad/s. Frequency and impedance scaling are used to transform this circuit into a new low-pass filter with C=10 nF and 3 dB cut-off frequency 6440 rad/s. Find the new value for R.

$K_f = 6440/.644 = 10^4$

R = $\boxed{10k\Omega}$

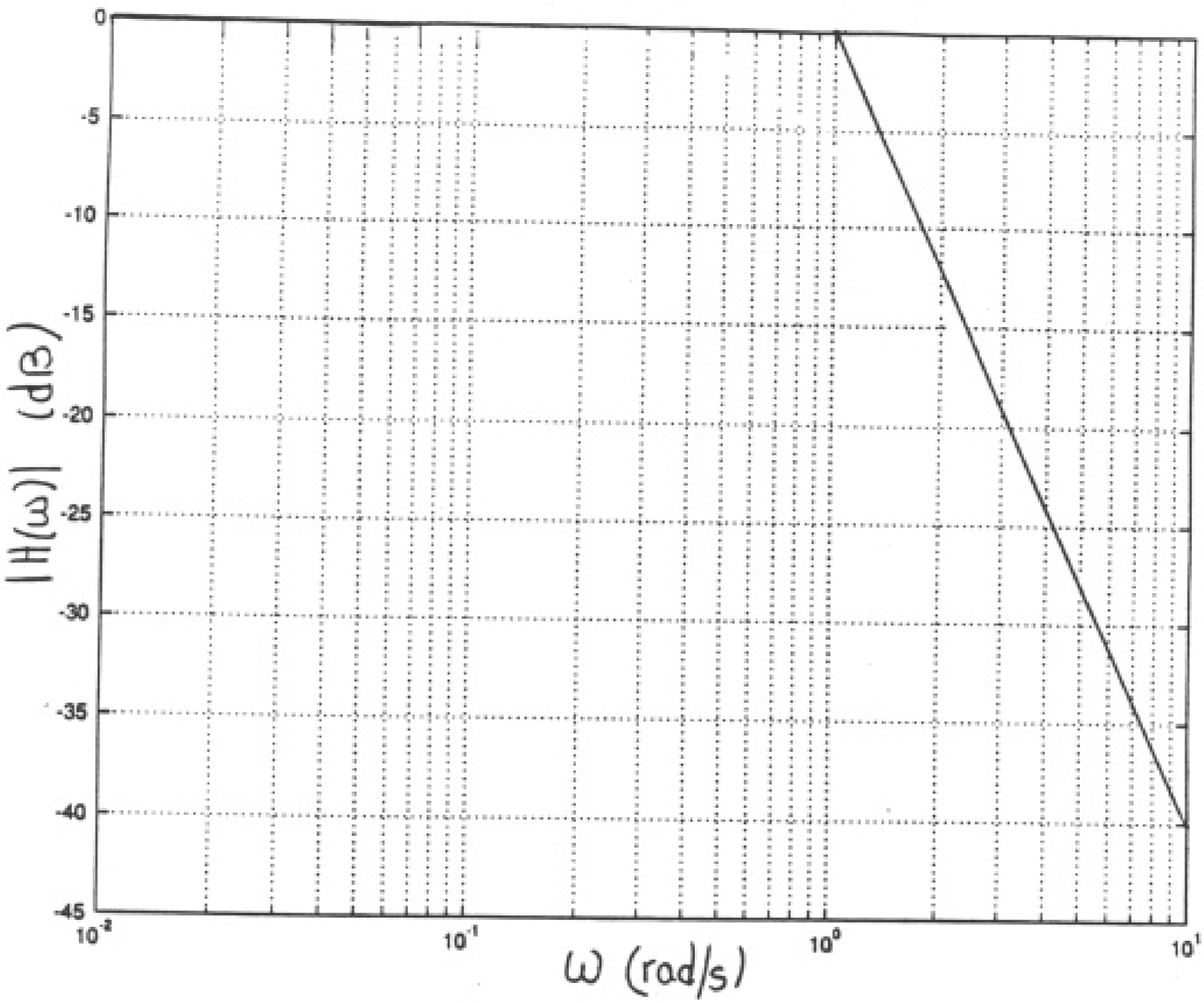
$\underbrace{C^{new}}_{10nF} = \underbrace{C^{old}}_{1F} / K_f \underbrace{K_m}_{10^4} \Longrightarrow K_m = 10^4$

$R^{new} = K_m R_{old} \Longrightarrow R^{new} = 10k\Omega$

Work Area For Problem # 4

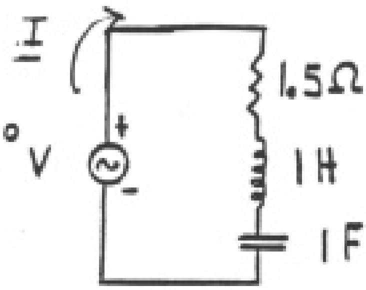
(continued on page 13)

Aysmptotic Bode Plot (Magnitude) for Problem #4



(20 points)
Problem # 5

Consider the circuit shown below.



$\underline{V} = 1.5\sqrt{2}\angle 45^\circ$ V
$\omega = 2$ rad/s

8 pts (a). Compute the power factor seen by the source. Specify whether it is leading or lagging.

pf = $\boxed{.707 \text{ lagging}}$

$\underline{Z} = 1.5 + j2 - .5j = 1.5(1+j)$

$\angle pf = \tan^{-1} \frac{-1.5}{1.5} = -45^\circ$

$\therefore$ pf = .707 lagging

4 pts. (b). Find the (i) apparent power, (ii) complex power, and (iii) real power delivered by the source. Don't forget to include the units.

$\underline{I} = \underline{V}/\underline{Z} = 1.5\sqrt{2}\angle 45^\circ / 1.5\sqrt{2}\angle 45^\circ = 1\angle 0^\circ$ A

apparent power $= \frac{1}{2}|\underline{I}||\underline{V}| = \frac{1}{2}(1)(1.5\sqrt{2}) = \underline{1.5/\sqrt{2} \text{ VA}}$

complex power $= \underline{S} = \frac{1}{2}\underline{V}\,\underline{I}^* = \frac{1}{2}(1.5\sqrt{2}\angle 45^\circ)\,1 = .75\sqrt{2}\angle 45^\circ$
$= \underline{.75(1+j) \text{ VA}}$

real power = $\underline{.75 \text{ W}}$

8 pts. (c). A second load is connected in parallel with the series RLC combination. This load dissipates 1.25 W and has a power factor of 0.9806 lagging. Compute the power factor seen by the source with these two loads connected in parallel. Specify whether it is leading or lagging.

pf = $\boxed{}$

$\underline{S}_2 = 1.25 + jQ_2$

$\angle pf_2 = -\cos^{-1}[.9806] = -11.304^\circ$
$= \tan^{-1}[-Q_2/1.25]$

$\therefore Q_2 = .25$ VAR

$\underline{S}_{tot} = \underline{S}_1 + \underline{S}_2 = P_{tot} + jQ_{tot}$
$= (.75 + j.75) + (1.25 + j.25)$
$= 2 + j1$ VA $\Longrightarrow \angle pf_{tot} = \tan^{-1}(-1/2) = -26.57^\circ$

$pf_{tot} = \underline{.894 \text{ lagging}}$