ECSE 2010
Electric Circuits
Exam 3
Spring 2004

Name Solutions - Dr

Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

Problem No.	Pts.	Score
1	20pts	X/20
2	20pts	X/20
3	20pts	X/20
4	20pts	X/20
5	20pts	X/20
Total	100pts	X/100

Please Note:

* Place all your answers in the spaces provided.
* You MUST show your work to receive any credit.

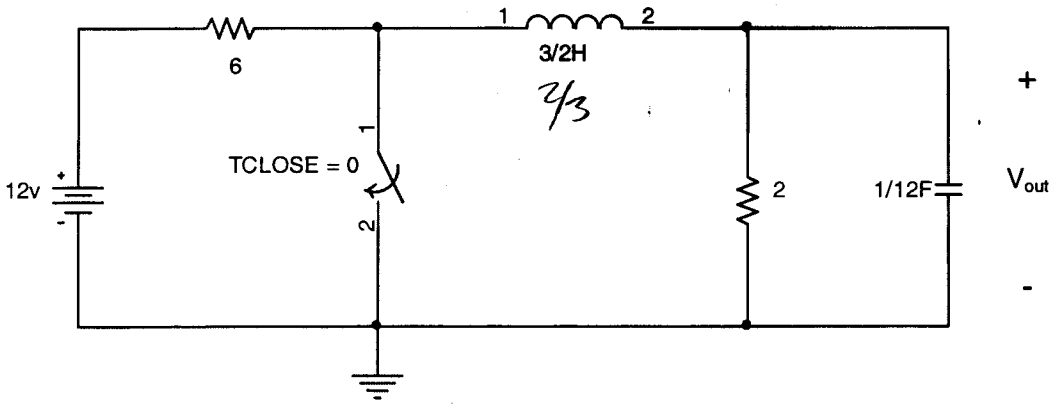
Problem 1 (20pts)

Name Solutions

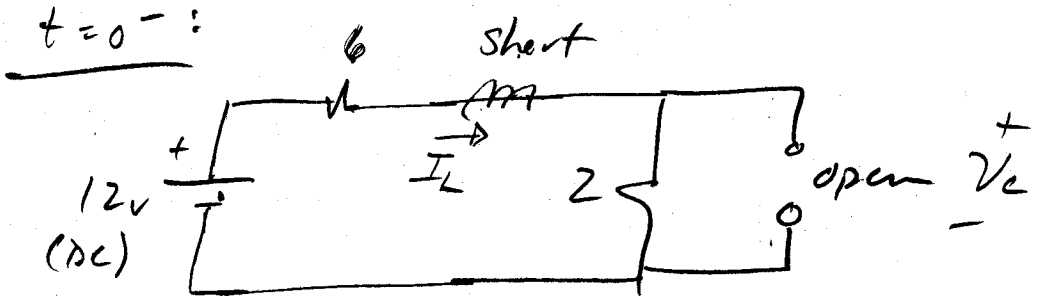
Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

a.) Find $I_L(0^-)$ and $V_c(0^-)$ in the circuit shown. ~~(4pts)~~ (10pts)



$t = 0^-$:



$$V_c(0^-) = 12v \frac{2}{2+6} = 3v$$

$$I_L(0^-) = \frac{3v}{2} = 1.5A$$

$I_L(0^-)$	1.5 Amps
$V_c(0^-)$	3 Volts

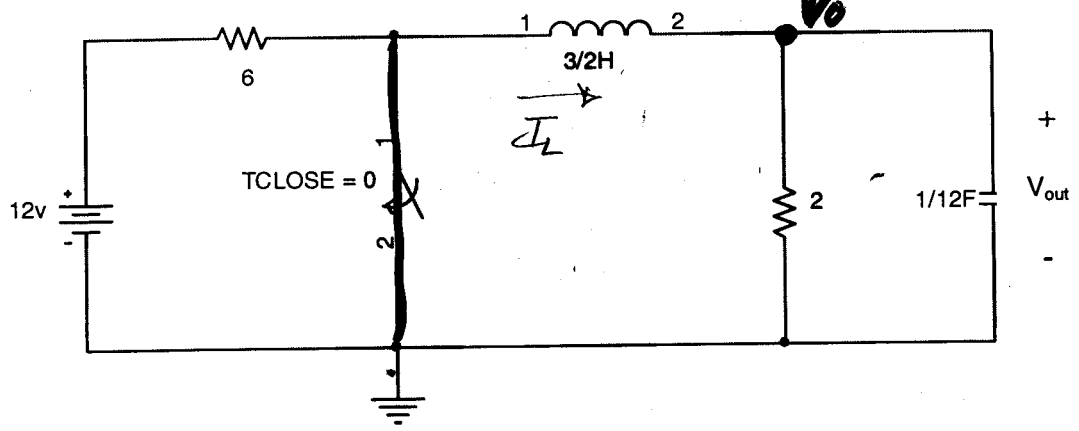
Problem 1 (cont)

Name Solutions - JM

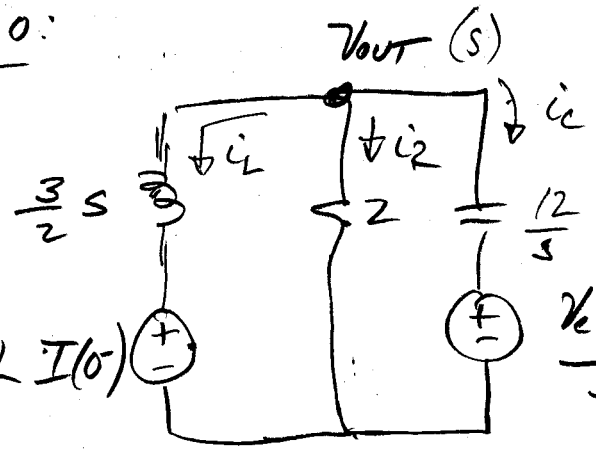
Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

b.) Find $V_{out}(s)$ for t>0 (same circuit as in part a). (~~10 pts~~) (5 pts)



$t > 0$:



$i_L + i_R + i_C = 0$

$(1.5)(1.5) = LI(0^-)$

$\downarrow$

2.25

$$\frac{V_{OUT} - 2.25}{\frac{3}{2}s} + \frac{V_{OUT}}{2} + \frac{V_{OUT} - \frac{3}{s}}{\frac{12}{s}} = 0$$

$$V_o\left[\frac{2}{3s} + \frac{1}{2} + \frac{s}{12}\right] =$$

$$\left[\frac{4.5}{3s} + \frac{1}{4}\right] \longrightarrow V_o = \frac{3(s+6)}{(s^2+6s+8)}$$

$V_{out}(s)$	$\frac{3(s+6)}{s^2+6s+8} = \frac{3(s+6)}{(s+2)(s+4)}$

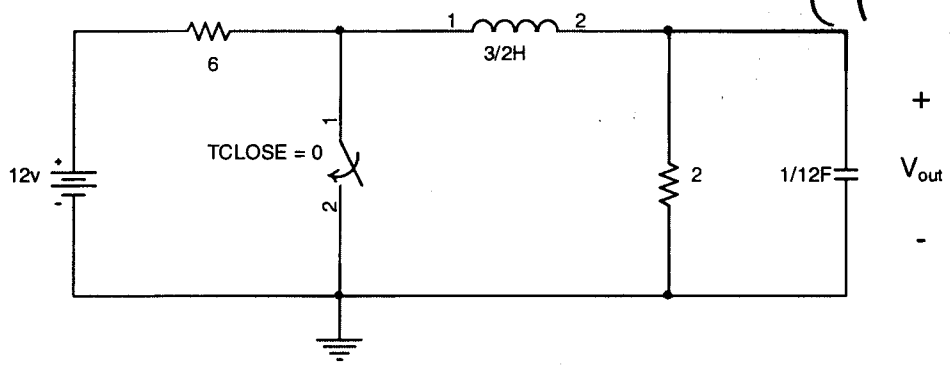
Problem 1 (cont)

Name Solutions

Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

c.) Find $V_{out}(t)$ for $t \geq 0$ (same circuit as in parts a & b). (~~6~~ 5 pts)



$$\frac{3(s+6)}{s^2+6s+8} \rightarrow \frac{A}{(s+4)} + \frac{B}{(s+2)}$$

$$A = \frac{(s+4)\,3(s+6)}{(s+4)(s+2)}\Bigg|_{s=-4} = \frac{3(-4+6)}{-4+2} = \frac{3\cdot 2}{-2} = -3$$

$$B = \frac{(s+2)\,3(s+6)}{(s+2)(s+4)}\Bigg|_{s=-2} = \frac{3(-2+6)}{-2+4} = \frac{12}{2} = 6$$

$V_{out}(t)$	$6e^{-2t} - 3e^{-4t}$

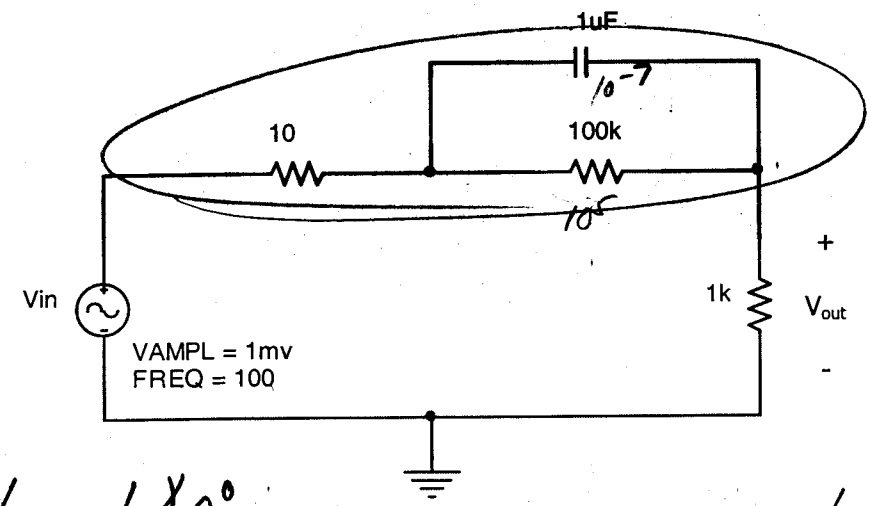
Problem 2

Name Solutions

Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

a.) Find V_{out} (t) in the circuit shown if V_{in} (t) = 1mV cos(**200**πt). (10pts)



$\approx -j16K$

almost all Capacitive!

$V_{in} = 1\angle 0°$

$\omega = 200\pi$ rps

$Z_c = \frac{1}{j(200\pi)(.1uF)} = -j\frac{1}{624}\times 10$

$= -j16K$

$$V_{out}(j\omega) = \frac{1K}{1K + 10 + (Z_c \,||\, 100K)} V_{in}(j\omega)$$

$(Z_c \,||\, 100K) \approx -j16K$

$$V_{out}(j\omega) = \frac{1K}{1010 + (-j16K)} = \frac{1K\angle 0°}{16K\angle -86.4°} 1mV$$

$V_{out} \approx 62.5\,\mu V \angle +86.4°$

→ 0V

$V_{out}(t)$	$62.5\,\mu V \cos(200\pi t + 86.4°)$

≈ 0V!

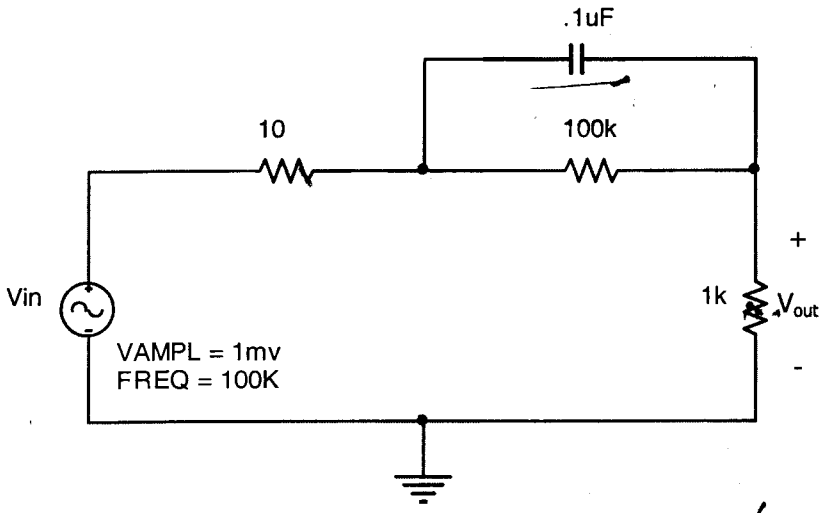
Problem 2 (cont)

Name Solutions

Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

b.) Find V_{out} (t) in the circuit shown if V_{in} (t) = 1mV cos(**200,000**πt). (10pts)

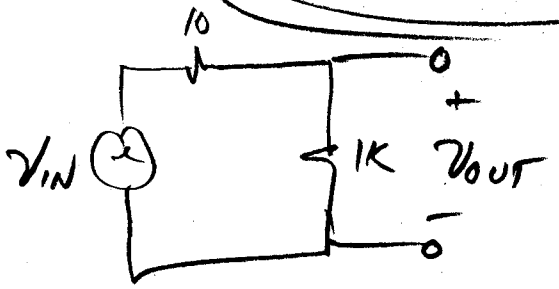


$$Z_C(j200K\pi) = -j\frac{1}{\omega C} = -j\frac{1}{(200K\pi)(.1uF)} = \underline{-j16.}$$

$$Z_p = (100K)\,||\,(-j16) \cong -j16$$

$$V_{OUT} = \frac{1K}{1K + (10 - j16)}V_{IN} = \frac{1K}{1010 - j16}V_{IN}$$

$$V_{OUT} \cong V_{IN} \quad (\text{CAP} \rightarrow \text{short!})$$



$V_{out}(t)$	$1mV\cos(200K\pi t)$

$\sim V_{IN}$!

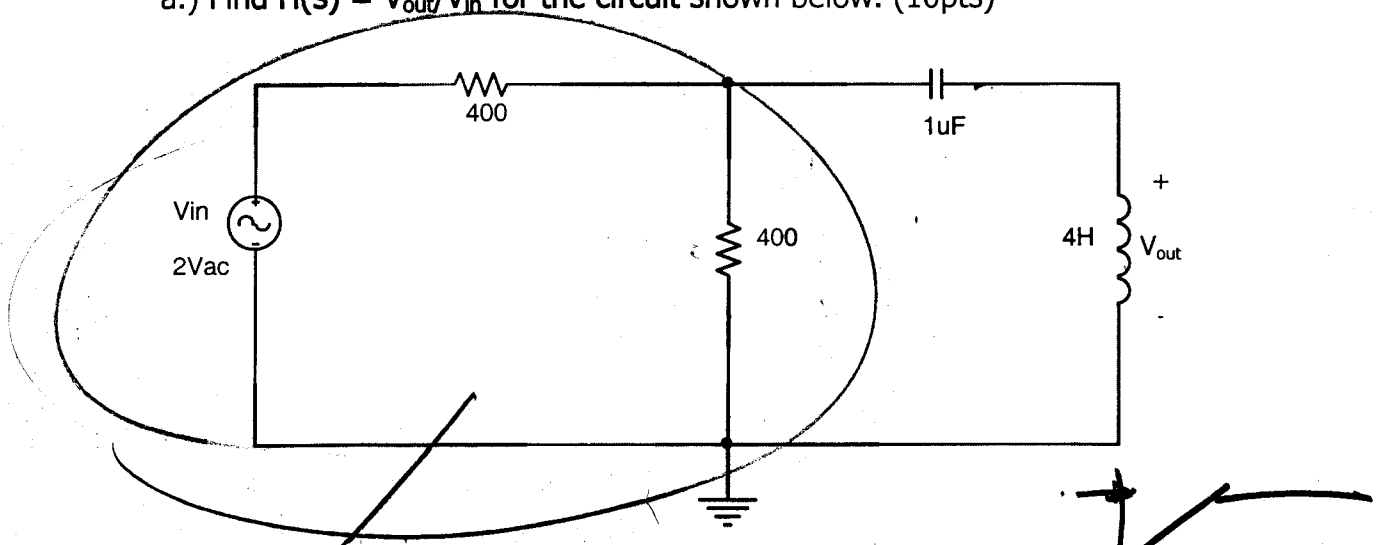
Problem 3 (20pts)

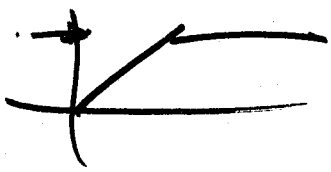
Name Solutions

Section Number (please circle one)

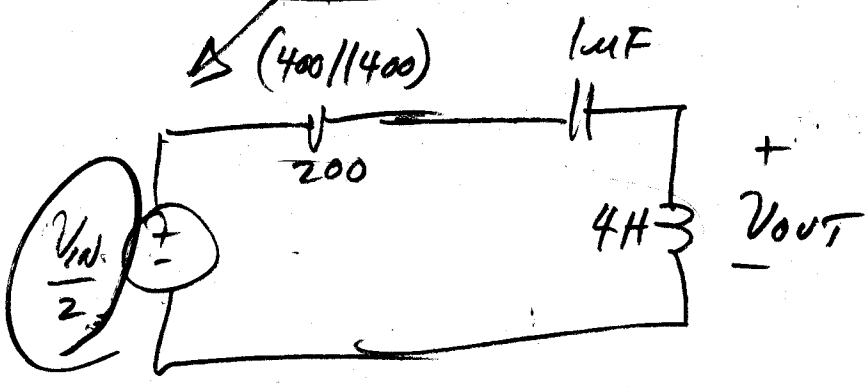
1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

a.) Find H(s) = V_{out}/V_{in} for the circuit shown below. (10pts)





(400||400)



$$V_{OUT} = \frac{sL}{sL + R + \frac{1}{sC}} \left(\frac{V_{IN}}{2}\right) = \frac{\frac{s}{L}}{\frac{s}{L}} \left[\frac{sL}{sL + R + \frac{1}{sC}}\right] \frac{V_{IN}}{2}$$

$$V_{OUT} = \frac{\frac{1}{2}s^2}{s^2 + \frac{R}{L}s + \frac{1}{LC}} V_{IN}$$

H(s)	$\frac{\frac{1}{2}s^2}{s^2 + 50s + (2.5 \times 10^5)}$

$$H(s) = \frac{\frac{1}{2}s^2}{s^2 + \left(\frac{R}{L}\right)s + \left(\frac{1}{LC}\right)} = \frac{\frac{1}{2}s^2}{s^2 + \frac{200}{4} + \frac{1}{(4)(1uF)}}$$

28 rad/s

2 rad^2

Problem 3 (cont)

Name Solutions

Section Number (please circle one)

1	2	3
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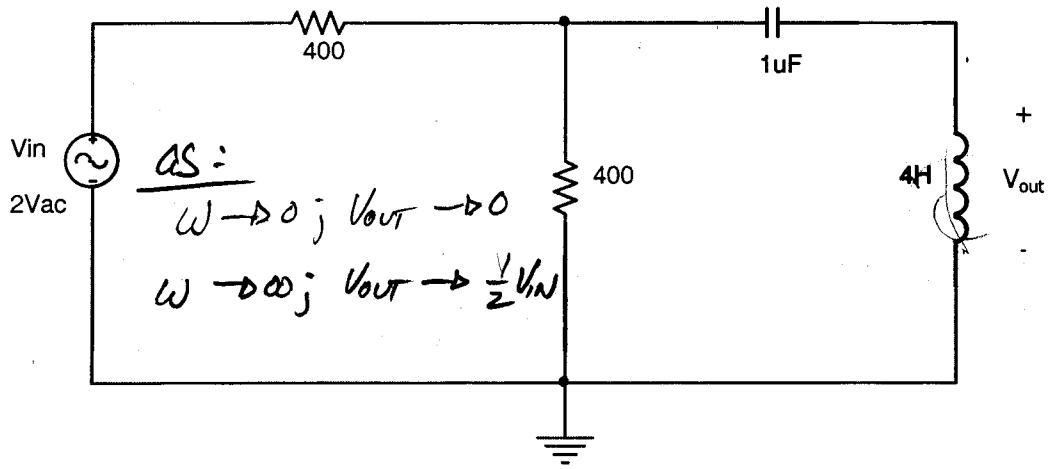
10-12	4-6	2-4

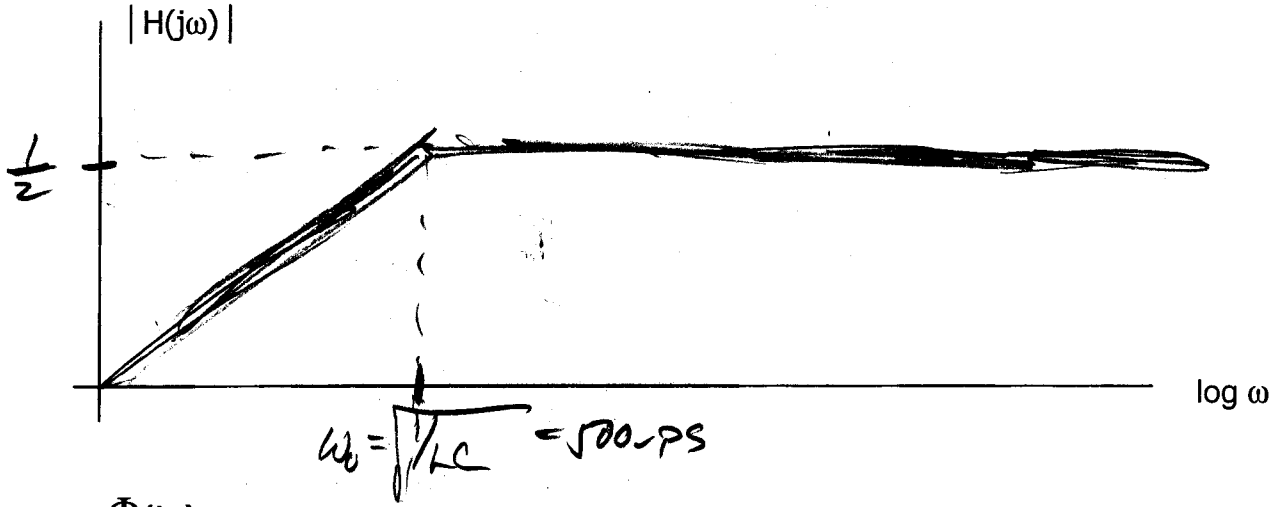
b.) Sketch the asymptotic graphs of $|H(j\omega)|$ and $\Phi(j\omega)$ for the circuit shown. (10pts) (Please be sure to label and mark your axes as appropriate)



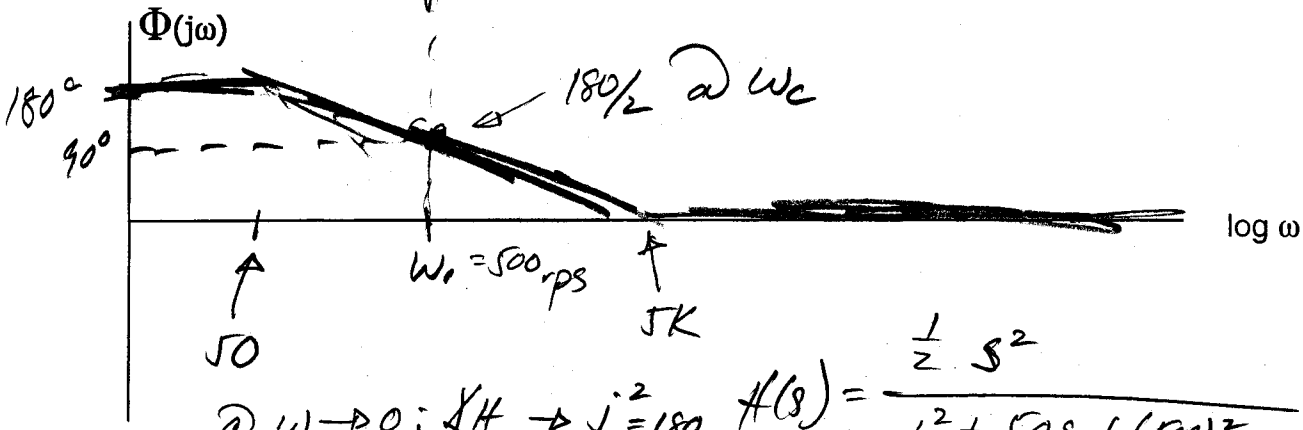
as:

$\omega \to 0$; $V_{OUT} \to 0$

$\omega \to \infty$; $V_{OUT} \to \frac{1}{2} V_{IN}$



$\omega_0 = \sqrt{1/LC} = 500$ rps



@ $\omega \to 0$; $\angle H \to j^2 = 180$

$\omega \to \infty$; $\angle H \to 0^\circ \left(\frac{s^2}{s^2}\right)$

$$H(s) = \frac{\frac{1}{2} s^2}{s^2 + 50s + (500)^2}$$

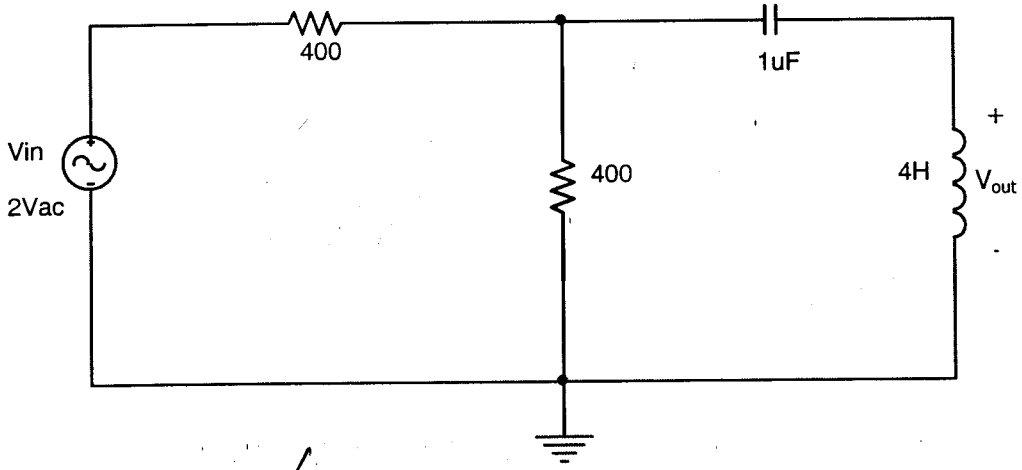
Problem 4 (20pts)

Name Solutions

Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

a.) What frequency (ω_o) of V_{in} would cause the circuit shown below to resonate? (10pts) (Please justify your response)



$$\omega_o = \frac{1}{\sqrt{LC}} = 500$$

ω_o	500

b.) What is the Q of the circuit shown above? (5pts)

Q_{series}

$$Q = \frac{1}{2\zeta} = \frac{\omega_o L}{R_{eq}} = \frac{(500)(4)}{200}$$

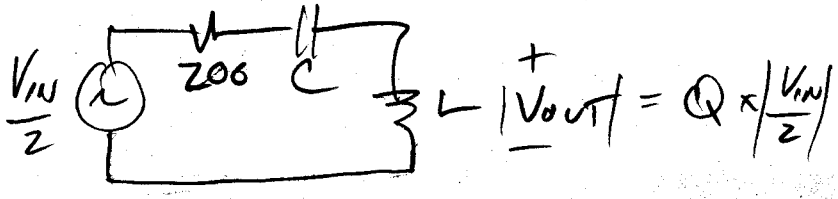
$(400 \,||\, 400)$

Q	10

c.) What is the **magnitude** |**Vout**| of the circuit shown above at ω_o? (5pts)

$$|V_{OUT}| = Q\left|\frac{V_{IN}}{2}\right| = 10\left(\frac{2V}{2}\right)$$

|Vout|	10V



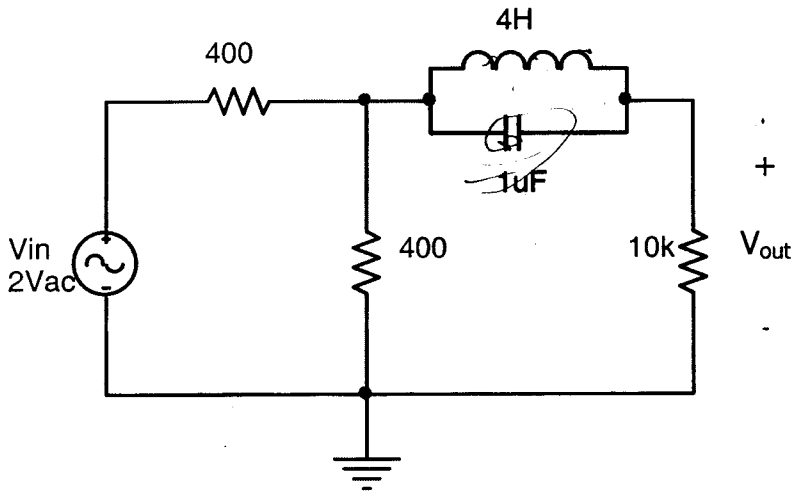
Problem 5 (20pts)

Name Solutions

Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

a.) What kind of frequency response would the circuit shown have? (10pts)



(Please circle one and justify your response in the space provided below)

Bandpass filter	Lowpass filter	Highpass filter	Notch filter

@ ω_0:

resonance will occur between the L & C causing $Z_{eq}(Z_L \| Z_C) \to \infty$.

Therefore, @ ω_0: $V_{out} \to 0$

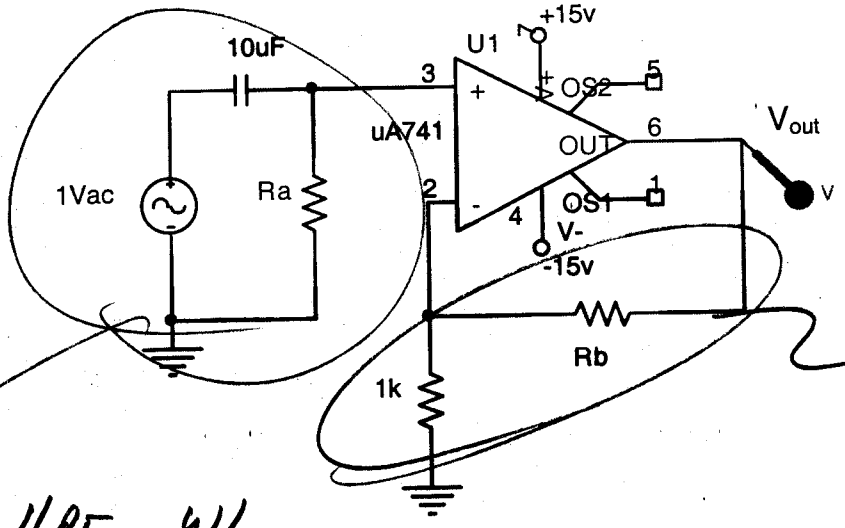
Problem 5 (cont)

Name Solutions

Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4

b.) What values of **Ra** and **Rb** in the following circuit could produce the frequency plots shown on the following page? (10pts)



$A_V = 1 + \frac{R_b}{1K}$

HPF w/ $\omega_c = 100$ rps

$A_{V_{MB_{dB}}} \cong +6dB = 20\log_{10}|A_{V_{MB}}|$; $A_{V_{MB}} = 10^{(6/20)} \approx 2$

$10^{(\frac{6}{20})} =$

$R_b = (2-1)1K = 1K$

$$H(s) = \frac{R_a}{\frac{1}{sC} + R_a} = \frac{s}{s + \frac{1}{R_aC}}$$

ω_c

$$\frac{1}{R_a(10\mu F)} = 100$$

$$R_a = \frac{1}{(100)(10\mu F)} = \frac{1000}{} = 1K$$

Ra	1K
Rb	1K

Problem 5 (cont)

Name Solutions

Section Number (please circle one)

1	2	3
MTR	MWR	MTR
10-12	4-6	2-4