ECSE 2010
Electric Circuits
Final Exam
Fall 2005

Name ________________________

Section Number (please circle one)

1	2	3
MR	MR	MR
10-12	**12-2**	**4-6**
Kraft	Millard	Parsa

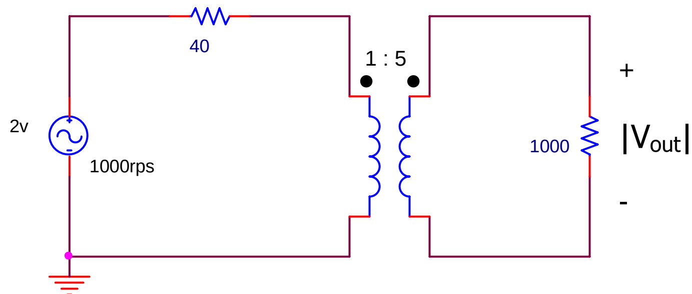
Please Note:

- Place all your answers in the spaces provided.
- You MUST show your work to receive any credit.
- Assume all resistances are in ohms, if not otherwise indicated.

Problem No.	Pts.	Score
1	20pts	
2	20pts	
3	20pts	
4	30pts	
5	20pts	
6	20pts	
7	20pts	
Total	150pts	

Problem 1 (20pts)

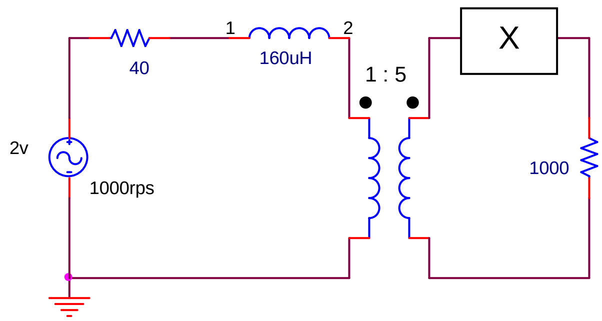
a) Find $|V_{out}|$ in the circuit shown. (10pts)



$|V_{out}|$	

Problem 1 (cont)

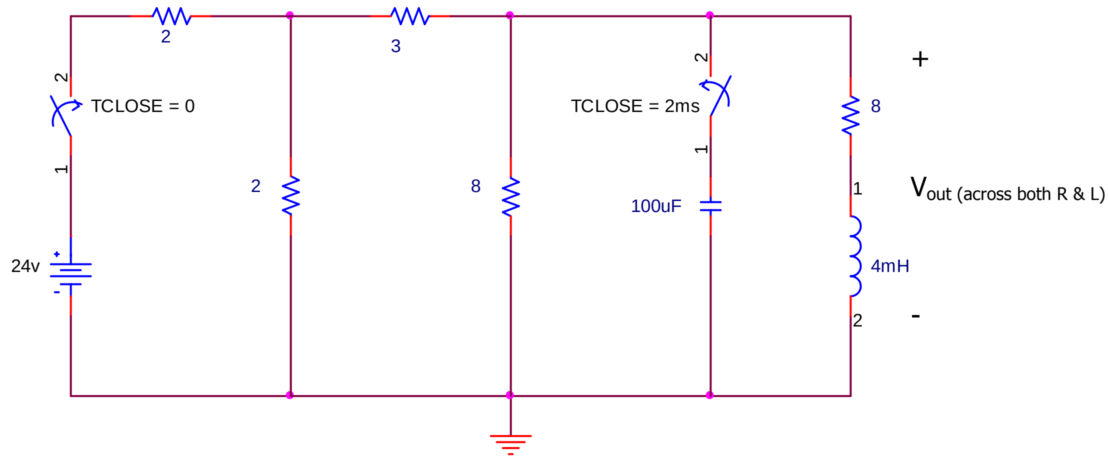
b) Find a component X (both the component type and value) that would maximize the power delivered to the 1000 ohm resistor in the circuit shown. (10pts)



X-type	
Value	

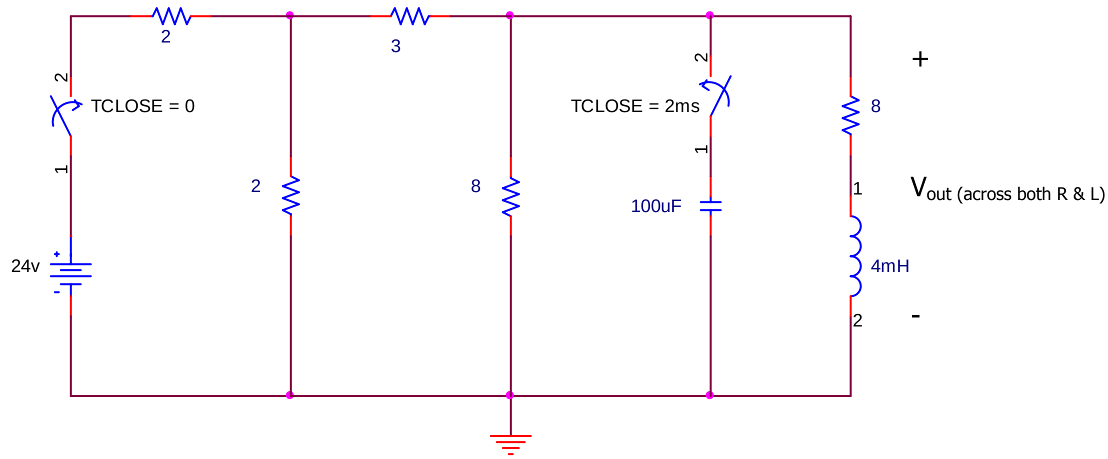
<u>Problem 2</u> (20pts)

a.) Draw the circuit in the s-domain for t ≥ 2ms. (5pts)



Problem 2 (cont)

b.) Find $V_{out}(s)$ in the circuit shown for t > 2ms. (5pts)



$V_{out}(s)$	

Problem 2 (cont)

c.) Find V_{out} (t) for $0 \leq t < 2ms$ (using the circuit shown in parts a & b). (5pts)

$V_{out}(t<2ms)$	

d.) Sketch V_{out} (t) for $t \geq 0$ (using the circuit shown in parts a & b). Show all pertinent points in time, including the appropriate time constants and voltage values (5pts)

Problem 3 (20pts)

The following three loads are connected across a $120V_{rms}$ 60Hz AC generator:

Load #1 has 800 VA and has a pf_1 = .707 **lagging**
Load #2 has 250 Watts and has a pf_1 = .5 **lagging**
Load #3 has -420 VARS and has a pf_1 = 0 **leading**

a) Determine the total apparent power of the three loads. (5pts)

$\|S\|_{total}$ =

b) Determine the power factor of the combined loads. (5pts)

$pf_{combination}$ =

Problem 3 (cont)

c) Determine the capacitance that will be necessary in order to make the overall pf = 1.0, assuming that the voltage across the load is to be kept at $120V_{rms}$. (5pts)

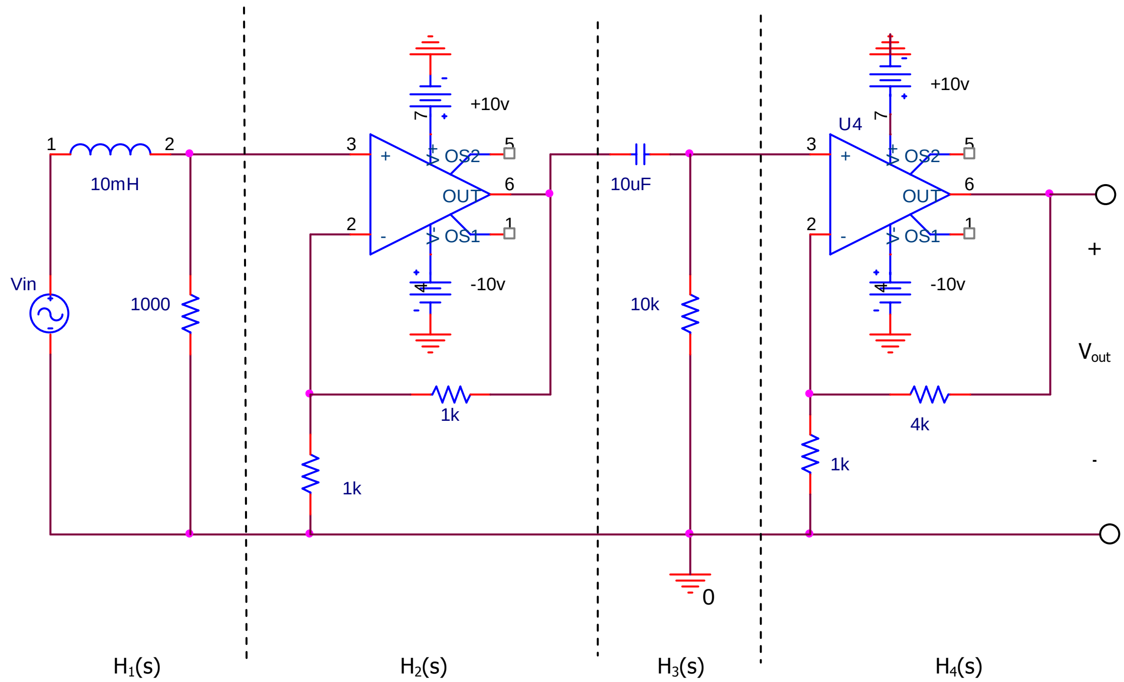
C =

d) Determine the difference in the current drawn from the generator (e.g the difference in the current drawn with and without power factor correction). (5pts)

$I_{difference}$ ($I_{non\text{-}corrected} - I_{corrected}$)	

Problem 4 (30pts)

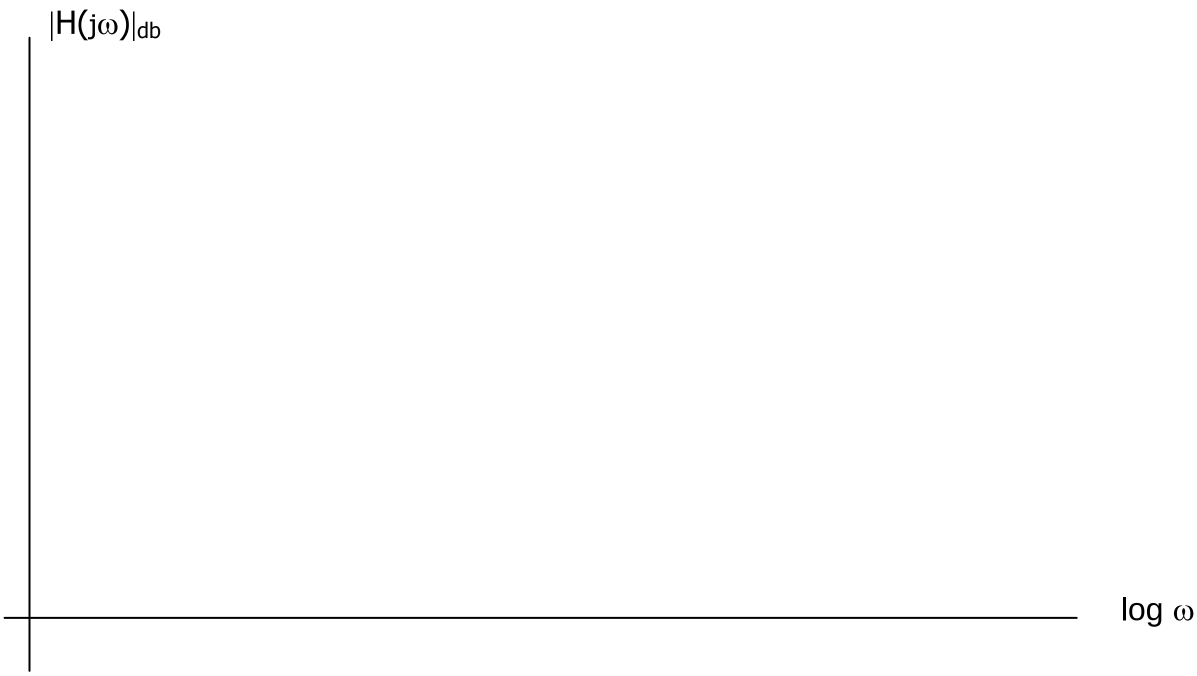
a) Find $H_1(s)$, $H_2(s)$, $H_3(s)$, $H_4(s)$, and the overall transfer function $V_{out}/V_{in} = H(s) = H_1(s)H_2(s)H_3(s)H_4(s)$ for the circuit shown below. (10pts)



$H_1(s)$	
$H_2(s)$	
$H_3(s)$	
$H_4(s)$	
$H(s)$	

Problem 4 (cont)

b) Sketch the asymptotic graphs of $|H(j\omega)|_{db} = |V_{out}/V_{in}|$ and $\angle H(j\omega)$ for the circuit shown in part a on the previous page. Please clearly label your axes as appropriate. (10pts)



Problem 4 (cont)

c) It is desired to have an output sinusoid with an amplitude of 5v ($|V_{out}|$=5v) for an input V_{in}(t)=**A**cos(1k_{rps}t)volts (for the circuit shown in part a). What must the value of **A** be? (5pts)

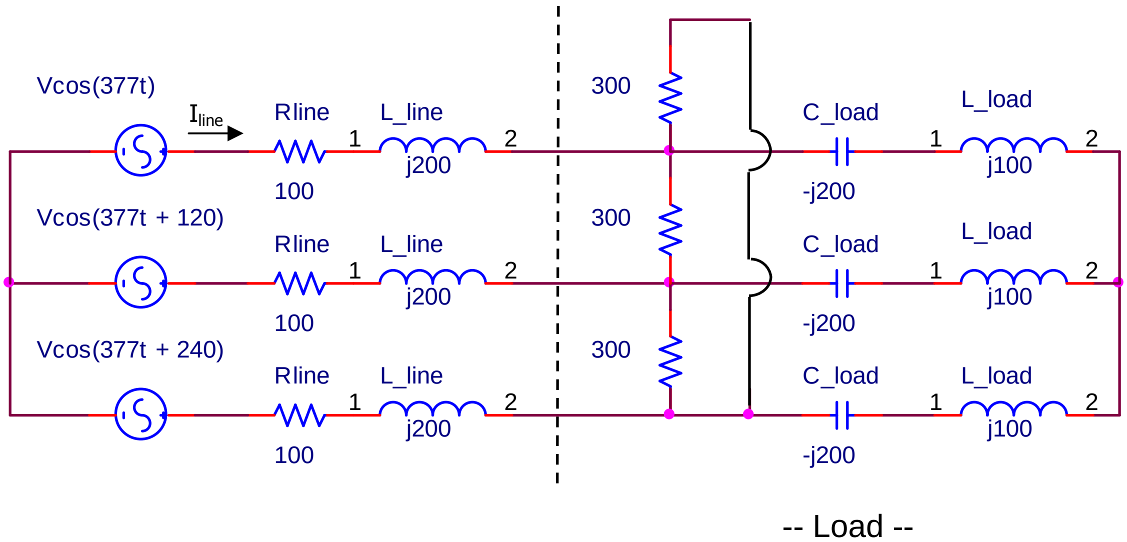
A	

d) What frequency (ω) will change an input that is = 1cos(ωt) into an output = 7.07cos(ωt+90) (using the circuit shown in part a)? Explain and justify your response. (5pts)

ω	

<u>Problem 5</u> (20pts)

a) Given the following 3 phase circuit, what is the equivalent single phase load impedance to the right of the dashed line? (5pts) (Please justify your response)



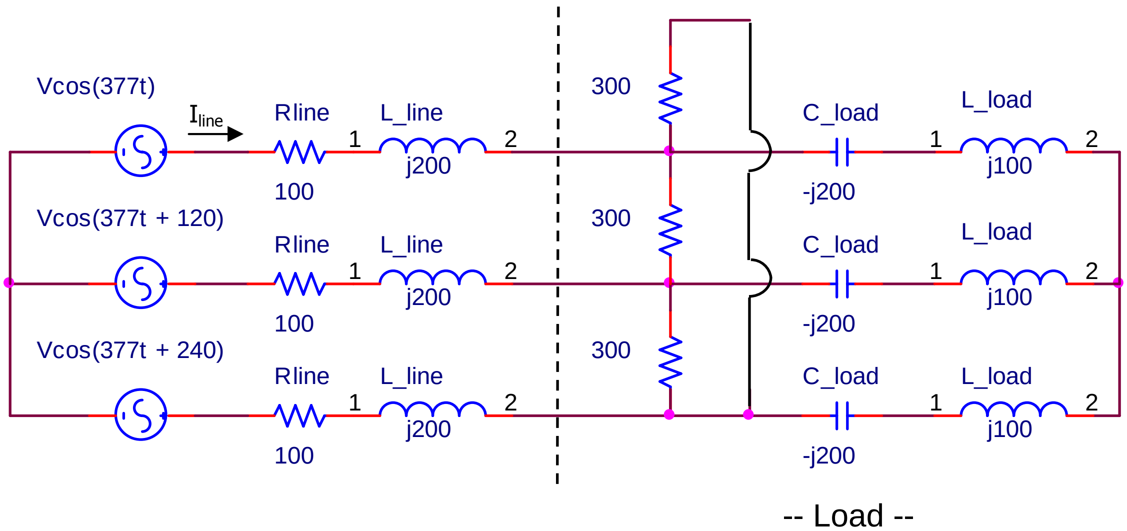
Z_{load}	

b) What is the line current I_{line} (in rms) flowing in each line resistance (R_{line}) associated with the three phases if each of the phase voltages is $V_{\Phi} = 15kV_{rms}$? (5pts)

I_{line}	

<u>Problem 5</u> (cont)

c) What is the total average real power (in rms) dissipated by the three phases' line resistances (R_{line}) if each of the phase voltages is V_{Φ} = 15kV_{rms}? (5pts)



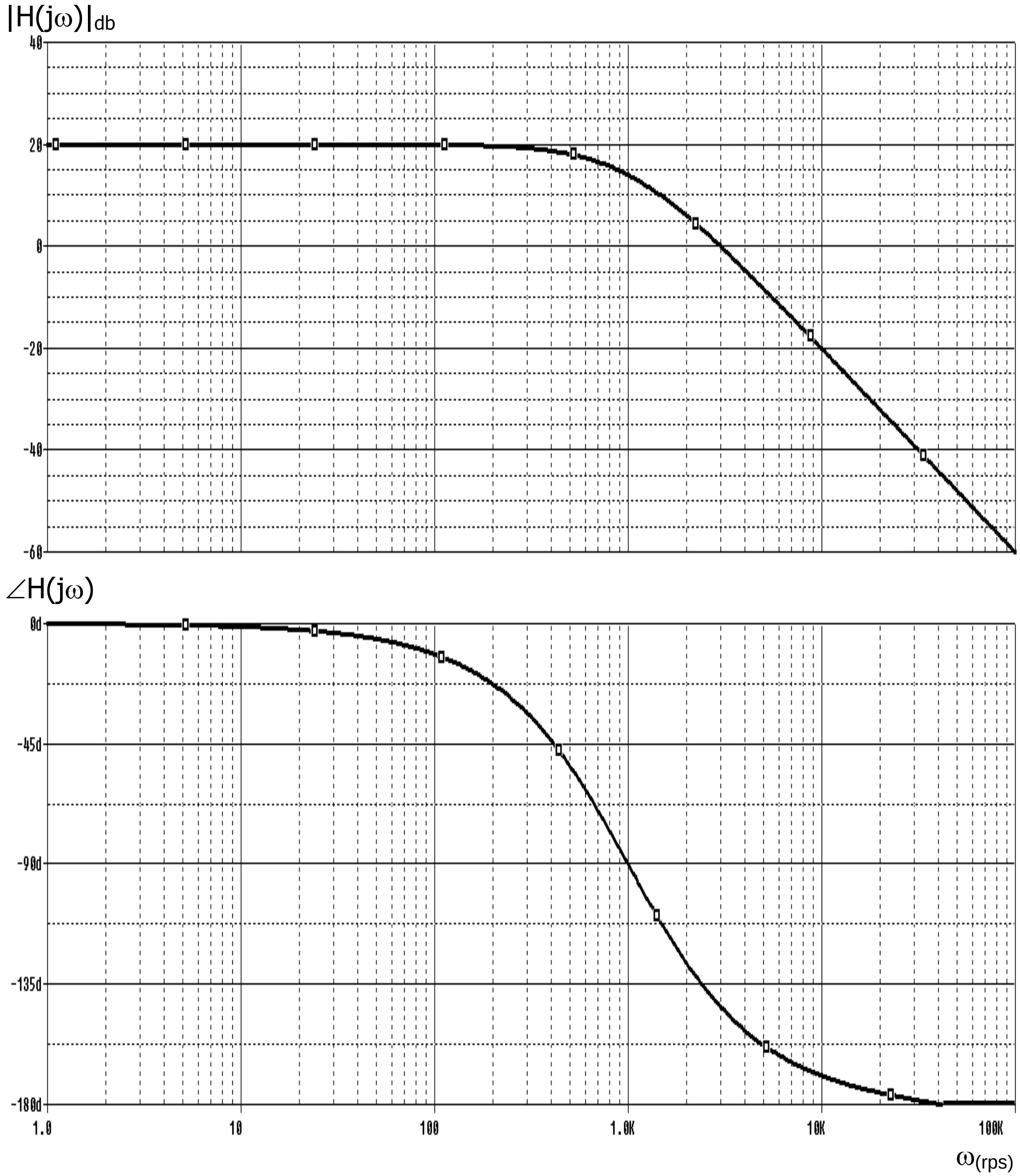
P_{line}	

d) What is the efficiency of the transmission system, defined as: $P_{load\text{-}average}/P_{total}$*100%? (5pts)

Efficiency	

Problem 6 (20pts)

a) Given the plots below, find the cutoff frequency ω_{co} of the circuit that would produce the response shown. (5pts)



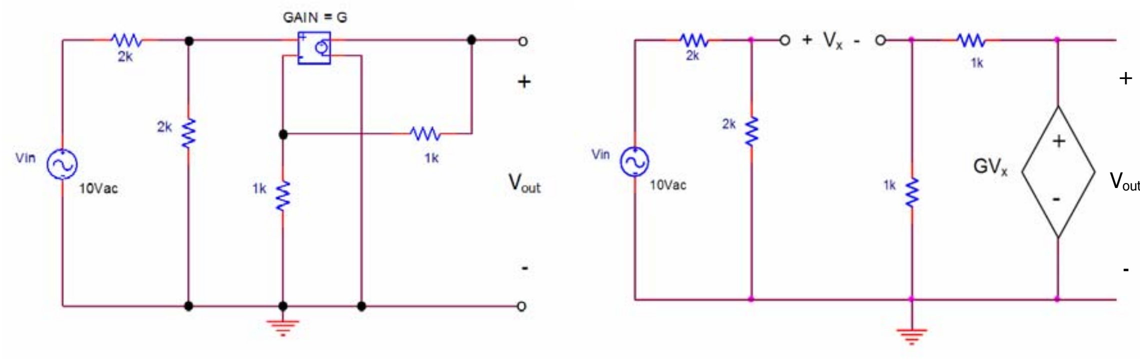
ω_{co} =

Problem 6 (cont)

b) Design a circuit that would produce the Bode Plot given in part (a). Assume that you only have **one** capacitor, **one** inductor, **six** resistors and **two** op-amps available. Please provide values for your component choices and show your circuit schematic. Please specify and provide support for your component choices and circuit topology. (15pts)

Problem 7 (20pts)

a) Find $|V_{out}|$ for the circuit shown as a function of the gain (G) with $|V_{in}| = 10v$. Please note: the two circuits below are identical. (5pts)



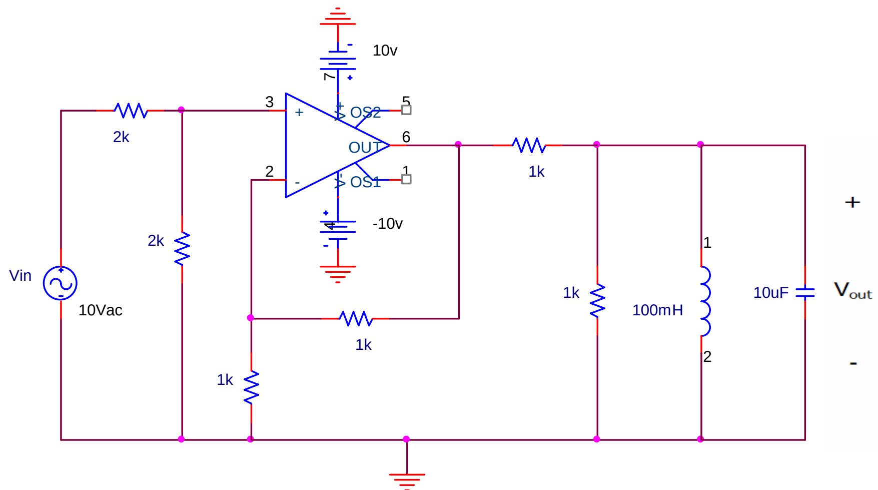
$|V_{out}|$	

b) Find V_{out} (t) in the circuit shown above if the gain G=100,000 and V_{in} (t) = 10cos (1000t + 30). (5pts)

V_{out} (t)	

Problem 7 (cont)

c) Find $H(s) = V_{out}/V_{in}$ for the circuit shown below. Consider how your result could relate to that from part (b). (5pts)



$H(s) = V_{out}/V_{in}$	

d) Find V_{out} if V_{in} = 10cos (1000t) for the circuit shown above if the gain G=100,000. (5pts)

V_{out} (t)	

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Laplace Transform Theorems

1. Definition $L\left[f(t)\right]=F(s)=\int_{0-}^{\infty} f(t)e^{-st}dt$
2. Linearity $L\left[k_1 f(t_1)+k_2 f(t_2)\right]=k_1F_1(s)+k_2F_2(s)$
3. Time shift $L\left[f(t-\tau)\right]=e^{-\tau s}F(s)$
4. Frequency Shift $L\left[e^{-at}f(t)\right]=F(s+a)$
5. Scaling Theorem $L\left[f(at)\right]=\frac{1}{a}F\left(\frac{s}{a}\right)$
6. Differentiation Theorem $L\left[\frac{df}{dt}\right]=sF(s)-f(0)$
7. Differentiation Theorem $L\left[\frac{d^2f}{dt^2}\right]=s^2F(s)-sf(0)-\dot{f}(0)$
8. Differentiation Theorem $L\left[\frac{d^nf}{dt^n}\right]=s^nF(s)-\sum_{k=1}^{n}s^{n-k}f^{k-1}(0)$
9. Integration Theorem $L\left[\int f(\tau)d\tau\right]=\frac{F(s)}{s}+\frac{\int^{0+} f(\tau)d\tau}{s}$
10. Final value theorem* $f(\infty)=\lim_{s\to 0} sF(s)$
11. Initial value theorem** $f(0^+)=\lim_{s\to\infty} sF(s)$

* Provided all poles of $F(s)$ have negative real parts with the exception of possibly one pole at the origin.

** Provided $f(t)$ is continuous or has a step discontinuity at $t=0$.

Laplace Transform of Time Functions

1.	$\delta(t)$	1
2.	$u(t)$	$1/s$
3.	$tu(t)$	$1/s^2$
4.	$\frac{1}{2!}t^2u(t)$	$1/s^3$
5.	$\frac{1}{(m-1)!}t^{m-1}u(t)$	$1/(s^m)$
6.	$e^{-at}u(t)$	$1/(s+a)$
7.	$te^{-at}u(t)$	$1/(s+a)^2$
8.	$\frac{1}{(m\text{-}1)!}t^{m-1}e^{-at}u(t)$	$1/(s+a)^m$
9.	$(1-e^{-at})u(t)$	$a/[s(s+a)]$
10.	$\frac{1}{a}\ (at-1+e^{-at})u(t)$	$a/[s^2(s+a)]$
11.	$(1-at)e^{-at}u(t)$	$s/(s+a)^2$
12.	$\sin(\omega t)u(t)$	$\omega/(\mathrm{s}^2+\omega^2)$
13.	$\cos(\omega t)u(t)$	$s/(\mathrm{s}^2+\omega^2)$
14.	$e^{-at}\cos(\omega t)u(t)$	$(s+a)/[(s+a)^2+\omega^2]$
15.	$e^{-at}\sin(\omega t)u(t)$	$\omega/[(s+a)^2+\omega^2]$
16.	$\left\{1-\frac{1}{\sqrt{1-\zeta^2}}e^{-\zeta\omega_n t}\left[\sin(\omega_d t+\theta)\right]\right\}u(t)$	
	$\omega_{\mathrm{d}}=\omega_n\sqrt{1-\zeta^2}\ ;\quad \theta=\cos^{-1}(\zeta)$	
OR	$\left\{1\text{ - }e^{-\zeta\omega_n t}\left[\cos(\omega_d t)+\frac{\zeta}{\sqrt{1-\zeta^2}}\sin(\omega_d t)\right]\right\}$	$\frac{\omega_n^2}{s(s^2+2\zeta\omega_n s+\omega_n^2)}$

Laplace Transform of Time Functions (cont)

17.	$F(s)=\dfrac{Bs+C}{s^2+2\alpha s+\omega_0^2}$ $L^{-1}\left[F(s)\right]=f(t)$ $f(t)=Ae^{-\alpha t}\cos(\omega_d t+\phi)$, where $\omega_d=\sqrt{\omega_o^2-\alpha^2}$, $\phi=\tan^{-1}\left(\dfrac{\alpha B-C}{\omega_d B}\right)$ and $A=\sqrt{B^2+\left(\dfrac{(\alpha B-C)}{\omega_d}\right)^2}=\dfrac{\sqrt{B^2\omega_o^2-2\alpha BC+C^2}}{\omega_d}$