Name_____

SAMPLE FINAL EXAM
ECE 110L
Spring, 2022

READ THROUGH ALL PROBLEMS CAREFULLY.

USE SEPARATE PAGES AS NEEDED TO WORK THE PROBLEMS: ATTACH ALL WORK.

Problem	Points	Score
1	10	
2	10	
3	10	
4	10	
5	10	
6	10	
7	10	
8	10	
9	10	
10	10	
	100	

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Honor Code Acknowledgement

I have adhered to the Duke Community Standard in the completion of this exam.

Signed: _____

- This is a closed-book exam.
- Point values for each problem are indicated.
- Be sure to show all of your work to obtain full credit.
- You must solve the problems SYMBOLICALLY, then numerically.
- Be sure to include UNITS.
- Clearly indicate (e.g., by boxing in) your final answer.
- Please write neatly and legibly. Partial credit will be given, so it is important that all work be clear enough for the graders to follow.
- You MAY use a calculator on this exam.

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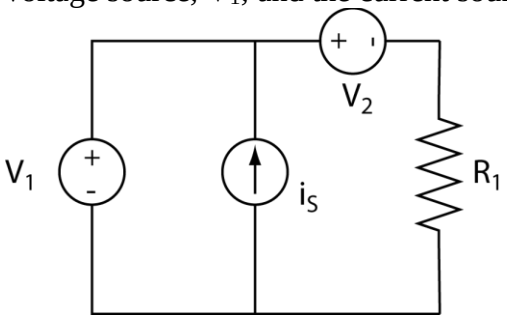
Problem 1 (10 pts)

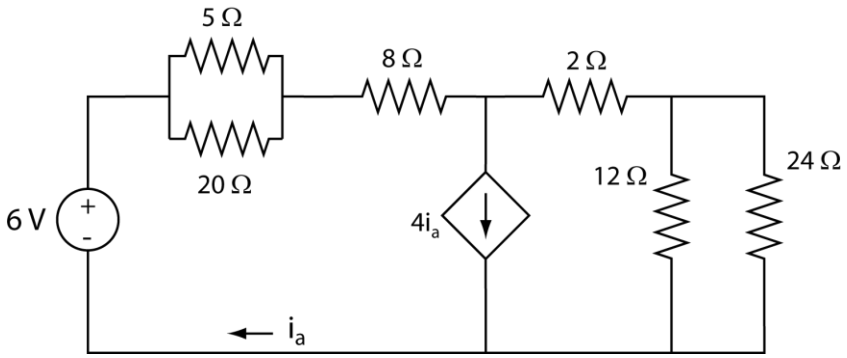
(a) (2 pts) You are measuring the voltage across a voltage source in the lab. When the voltage terminals are open (no load resistor), you measure a voltage of +12 V with your volt meter. Now, you attach a load resistor of $R_L = 120\Omega$ across the terminals, and again measure the voltage. This time, you measure +8 V. What is the internal resistance of the source?

(b) (4 pts) In the circuit below, determine the power dissipated by: the resistor, R_1; the voltage source, V_1; and the current source, i_S.



$V_1 = 10\ V$
$V_2 = 5\ V$
$R_1 = 100\ \Omega$
$i_s = 100\ mA$

(c) (4 pts) In the circuit below, determine the power dissipated in the 12 Ω resistor.



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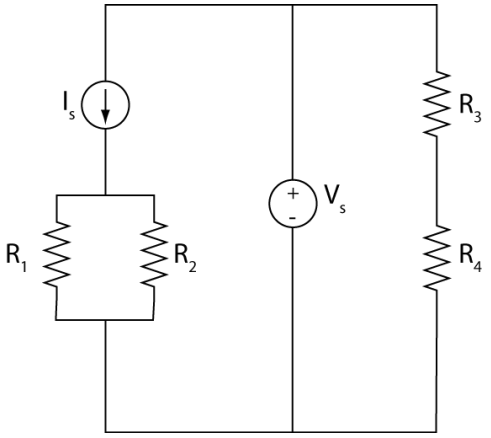
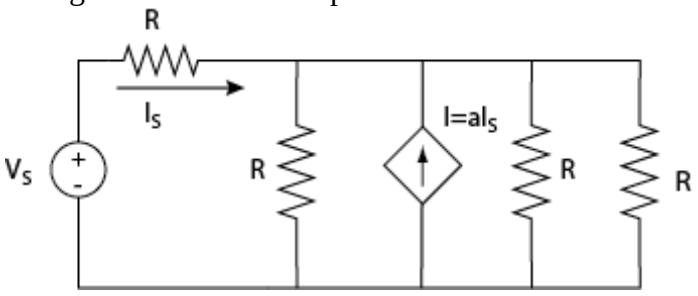
Problem 2 (10 pts)

(a) (5 pts) In the circuit below, determine the power supplied to the circuit by the current source and by the voltage source.



$V_S = 10\ V$
$I_s = 10\ mA$
$R_1 = 1\ k\Omega$
$R_2 = 3\ k\Omega$
$R_3 = 1.5\ k\Omega$
$R_4 = 0.5\ k\Omega$

(b) (5 pts) From the circuit below, find expressions for the power dissipated by the voltage source and the dependent current source.



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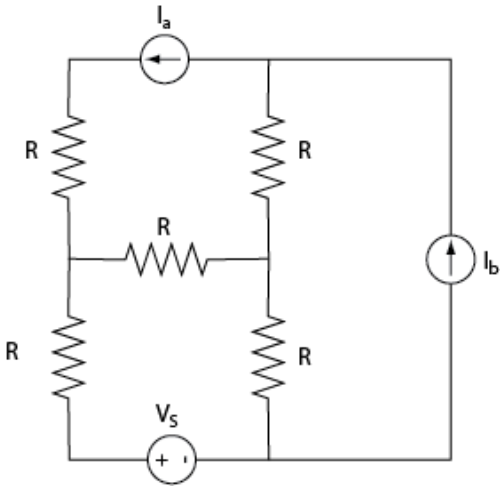
Problem 3 (10 pts)

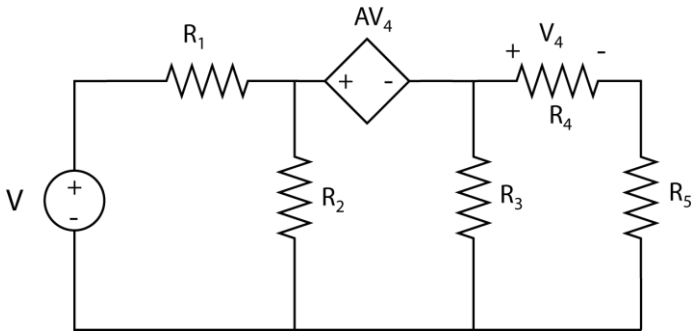


(a) (5 pts) Solve the circuit above using the node voltage method (NVM). Indicate your variables and find expressions for those variables in terms of the circuit parameters given.

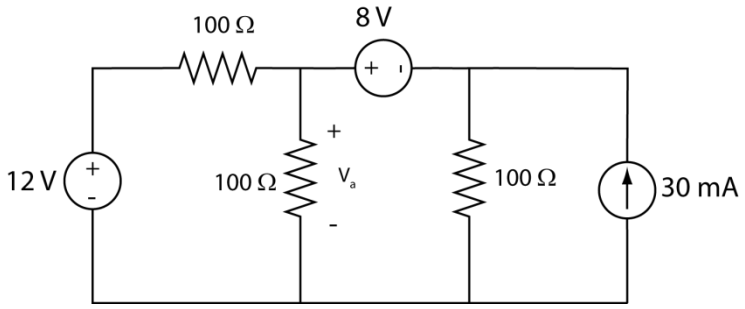
(b) (5 pts) Solve the same circuit as above, but now using the branch current method (BCM).

Problem 4 (10 pts)

(a) (5 pts) In the circuit below, a voltage V is applied to the network as shown. Write down a set of equations that can be used to solve for the voltages and currents everywhere. Use any method you like, but indicate the approach you use and make sure the final equations are clearly indicated. Your unknown quantities should be clearly identified. You do not need to solve the circuit!



(b) (5 pts) Find V_a in the circuit below, using source transformations (not node methods). Show all steps clearly!



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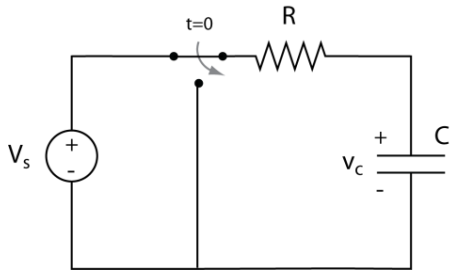
Problem 5 (10 pts)

The switch in the circuit below has been connected to the voltage source for a long time. At t=0, the switch is connected to ground, as indicated.



(a) (2 pts) Write an equation for the current in the circuit valid for $t \geq 0$. You don't need to solve the equation, just show your work.

(b) (3 pts) Now, either solving the equation you've derived in (a), or applying a known solution, write an expression for the voltage across the capacitor, $V_C(t)$ as a function of time.

(c) (3 pts) Write expressions for the energy in the capacitor as a function of time, and the charge on the capacitor as a function of time.

(d) (2 pts) Write an expression for the power dissipated in the capacitor as a function of time.

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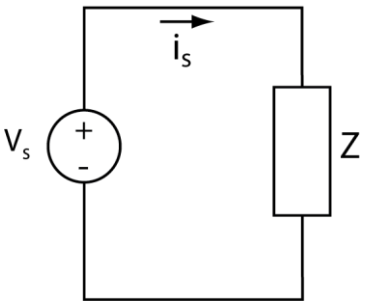
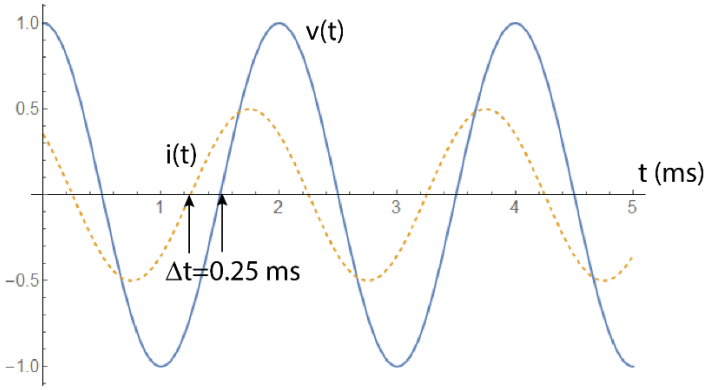
Problem 6 (10 pts)





In the above circuit, a sinusoidal voltage (steady state) is applied to an unknown impedance Z as shown. The source is measured on an oscilloscope, as shown by the solid line in the plot, and found to have a period of 2 ms, with an amplitude of 1 V. The current through the impedance is also measured, as indicated on the plot above, and found to have an amplitude of 0.5 A.

(a) (2 pts) Using the information on the plot, express both the voltage and the current in phasor form ($A \angle\theta$) and rectangular form (a+jb).

(b) (2 pts) What is the value of the impedance?

(c) (1 pts) Is the load capacitive or inductive (justify your answer)?

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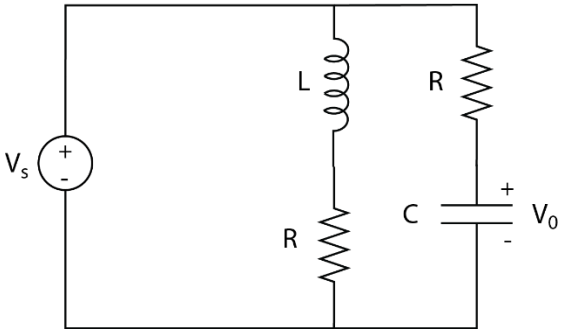

$R = 100\ \Omega$
$L = 10$ mH
$C = 100\ \mu F$
$V_S = 10\ Cos(1000\ t)$ V

Use the circuit above for the following question:

(d) (5 pts) What time dependent voltage appears across the capacitor? Indicate both the magnitude and phase.

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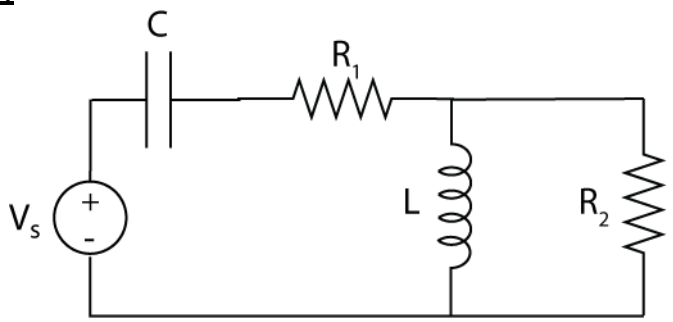
Problem 7 (10 pts)



In the above circuit, $V_S = 10\cos(\omega t)\ V$, $C = 50\ nF$ and $L = 1\ mH$. $R_1 = 100\ \Omega$ and $R_2 = 100\ \Omega$. $\omega = 10^5\ rad/sec$.

(a) (6 pts) Determine the complex current delivered to the circuit at a frequency of $\omega = 10^5\ rad/sec$. Write your answer in phasor form.

(b) (2 pts) Determine the average power delivered to the circuit by the voltage source at the frequency $\omega = 10^5\ rad/sec$. This is equivalent to the power dissipated in the circuit.

(c) (2 pts) Determine the average power delivered to the circuit at very low frequencies $(\omega \to 0)$ and at very high frequencies $(\omega \to \infty)$.

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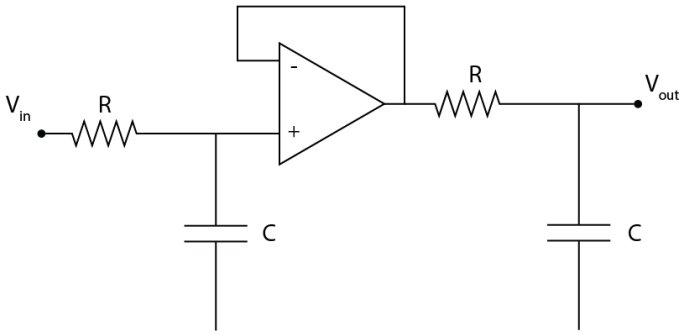
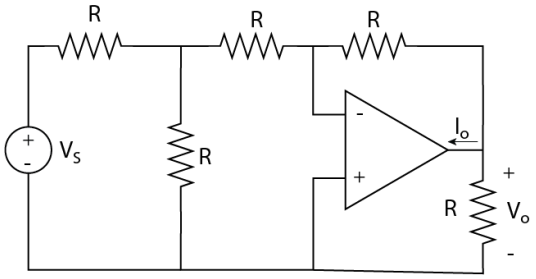
Problem 8 (10 pts)

(a) (5 pts) Find an expression for the transfer function $H(\omega)$ for the circuit below. What is the role of the op-amp in this circuit?

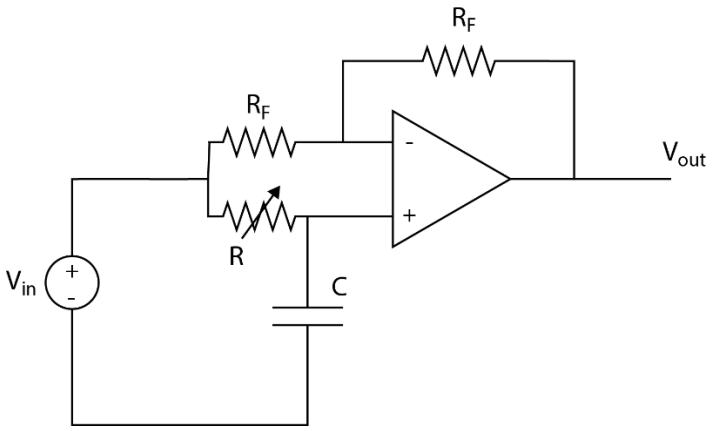


(b) (5 pts) In the circuit below, the voltage source is $V_S = 20\ V$ and the resistors all have value $R = 10\ \Omega$. Find the output current and voltage (I_o and V_o), as indicated in the diagram.



Problem 9 (10 pts)

One of the most important devices in electronics and signal processing is the phase shifter, a device that allows an input signal to be phase shifted with unity gain. Consider the circuit below, in which R is a variable resistor.



(a) (7 pts) Find an expression for the transfer function for this circuit, assuming the input voltage is a sinusoidal signal.

(b) (3 pts) Show that the gain is constant, but the phase shift can be varied as a function of the value of R. What are the minimum and maximum phase shifts possible?

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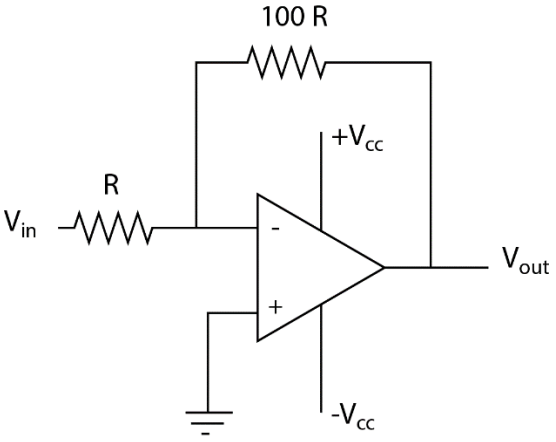
Problem 10 (10 pts)

For the op amp circuit shown below, assume V_{CC}=15 V.



(a) (4 pts) Write an expression for the transfer function of this circuit.

(b) (3 pts) Assume an input signal of $5\ cos(50t)\ mV$. Sketch the output, make sure to label the axes.

(c) (3 pts) Assume an input signal of $25\ cos(50t)\ V$. Sketch the output, make sure to label the axes.