NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(Don’t put Student ID Number or any other numbers on this page)

**ECE 111**

**FINAL EXAM**

**Fall 2013**

FOR GRADERS’ USE ONLY.

|  |  |  |
| --- | --- | --- |
| PROBLEM # | GRADE | POINTS |
| 1 |  | 10 |
| 2 |  | 32 |
| 3 |  | 12 |
| 4 |  | 36 |
| 5 |  | 34 |
| 6 |  | 44 |
| 7 |  | 32 |
| 8 |  | 24 |
| TOTAL |  | 224 |

1. (10 points total)

Given simple circuit elements with voltages across and currents through them as shown below, what power are they dissipating?

A. (3 points)

**A**

**+**

**-**

**8V**

**-2 mA**

PA = \_-16mW\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

B. (3 points)

**B**

**+**

**-**

**-1 V**

**1 A**

PB = \_\_+1W\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

C. (3 points)

**C**

**-**

**+**

**1 V**

**3 mA**

PC = \_\_+3mW\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. (1 point) Circle the letter of all of the above elements that are supplying power to the circuit.

**A** B C

2.) (32 points total)

Given the circuit below:



We are going to find the voltage across the 1kΩ resistor on the upper right.

A.) (4 points) The nodes are numbered as for Nodal Analysis. Which one do you pick as the Reference Node? Are any Node Voltages fixed, and therefore do not need to be solved for, but are known? Which one(s)?

**Pick the bottom node as reference, Node 1 is now fixed at 1V.**

B.) (3 points) What is the output voltage (Vo) in terms of the node voltages (V1, V2, V3, V4)?



C) (15 points) Write the equations you’ll need to solve to find the node voltages.

OR 

D.) (10 points) Solve these equations to get the output voltage Vo.









3. (12 Points Total)

Given this circuit containing an Ideal Op-Amp:



A. (4 points) Is this: **Non-Inverting**, Inverting, Comparator, Differential, or Buffer Configuration (CIRCLE ONE.)

B. (8 points if you got the correct results in part A and apply it here, 6 points if you got the wrong result in A and give the corresponding results here, 4 points if you analyze the circuit and get the correct results, 0 points if you analyze the circuit and get the wrong results.) Given part A, what is the output in terms of VS?



4. (36 points total)

Given the circuit below:



A.) (20 points) Use Source Transformations or other technique to find the Thevenin Equivalent of the

circuit, not including the 3k Ω load resistor.

Transform 5V and 2kΩ to 2.5 mA and 2kΩ, 2kΩ//2kΩ=1kΩ, 2.5 mA//1.5 mA=4 mA.

Transform 4 mA and 1kΩ to 4V and 1 kΩ, 1kΩ+1kΩ=2kΩ.

Thevenin equivalent is a 4 V source in series with a 2 kΩ resistor.

B. (4 points) What is the voltage across the load resistor, Vout?

By Voltage Division: 

C. (8 points) What power is being delivered to the load resistor?



D. (4 points) If I put a load resistor with a different resistance on this circuit, is there any way to get more power delivered to the load, and why?

Maximum power is delivered to the load when RL = RS, or 2kΩ. Any resistance less than 3kΩ and greater than or equal to 2kΩ will get more power delivered.

5. (34 points total)

Given the circuit below, in which the switch has been closed for a long time and opens at t=0, answer the following questions:



A. (6 points) If I asked you for the TOTAL response of anything in this circuit (current through or voltage across ANY passive element) and I called it Y(t), what general form would it take?

Y(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

B. (4 points) Which quantity, voltage across or current through which element in this circuit, MUST be continuous across the switch opening, and what is its initial value?

**The current through the inductor is the state variable and must be continuous.**

NOW, I am going to ask you to find the current down through the 10Ω resistor, ir(t).

C. (6 points) What is the final value of ir (i.e., ir(∞))?

 because the circuit is source-free.

D. (2 points) What is ir just after the switch opens (i.e., ir(0+))?





E. (4 points) What is the decay constant, τ? (NOTE: This is for time t≥0.)



F. (6 points) Evaluate the constant(s) and give the formula for ir(t) for t>0:

ir(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

G. (2 points) How long would I have to wait to make sure all transients from the switch have died away?



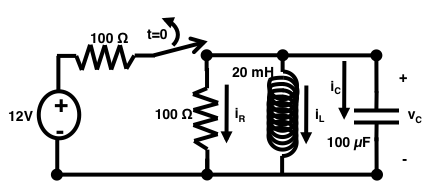
H. (4 points) Sketch ir(t):

ir

**t**

6. (44 points total)

Given the circuit below, in which the switch has been closed for a long time and opens at t=0:



We are going to analyze the circuit to find the voltage across the RLC, vC(t).

A. (6 points) What are the values of the state variables before the switch opens (i.e., at t=0-)? Then what are their values just after the switch opens (i.e., at t= 0+)?

Current through the inductor and voltage across the capacitor are the state variables.

 because L is a short circuit and takes all the current

 because L is a short ckt.

C. (2 points) What is the final value of vC  (i.e., vC(∞))?

 because the circuit is source-free.

D. (12 points) What is the initial value of the derivative, dvC/dt (0+)?



E. (6 points) What are the natural frequency (ω0) and the damping coefficient (α)?

ω0 = \_\_\_\_\_\_\_\_\_\_\_\_

α = \_\_\_\_\_\_\_\_\_

F. (2 points) So, will the circuit be:

CIRCLE ONE: Over-damped, Critically-damped, or Under-damped ?

G. (4 points) Therefore, what will the FORM of vC(t) be?

vC(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

H. (4 points) At this point, without going any further on the math, sketch what you EXPECT the voltage to look like as a function of time. (Use the initial and final values, the initial value of the derivative, and whether it is under-, critically-, or over-damped. Don’t worry about exact values, just the general shape.)

**vc**

**t**

I. (8 points) Evaluate the constants and write an expression for the voltage:



 so



Take Derivative:



or



vC(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. (32 points total)

Given this circuit in the time domain:

10 cos(6283t) V 

where the source is 10 cos(6283t) V.

A. (6 points) On the drawing below, label each component with the corresponding frequency (j) domain quantity:

B. (12 points) If you replace the impedances with a single equivalent impedance, Zeq as in the diagram below, what will that equivalent be?



(HINT: Write it in both rectangular and polar forms.)



C. (2 points) Is this circuit overall inductive or capacitive at this frequency?

CIRCLE ONE: INDUCTIVE **CAPACITIVE**

D. (8 points) Derive an expression for the phasor current through the circuit.

**I = \_\_\_\_****\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

E. (4 points) Now write i(t) in the time domain:

i(t) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8. (24 Points)

Given the circuit below:



We are going to find the voltage across the capacitor  as a function of the input .

First,

1. (6 points) Label the diagram in the frequency domain:



B.) (10 points) Find an expression for the output phasor voltage as a multiple of the input phasor voltage (HINT: You might try Voltage Division.)



C.) (4 points) Using the values R = 240Ω and C = 0.1µF, for what (natural, or radian) frequency is the magnitude of  one-half of the magnitude of the input ? What is that frequency in Hz (cycles/second)?



D.) (4 points) What is the output at low frequency () and at high frequency ()? How would you describe this output (High Pass, Low Pass, Band Pass)?

At low frequency: V=Vs

At high frequency: V=0,

So this is a low pass filter.