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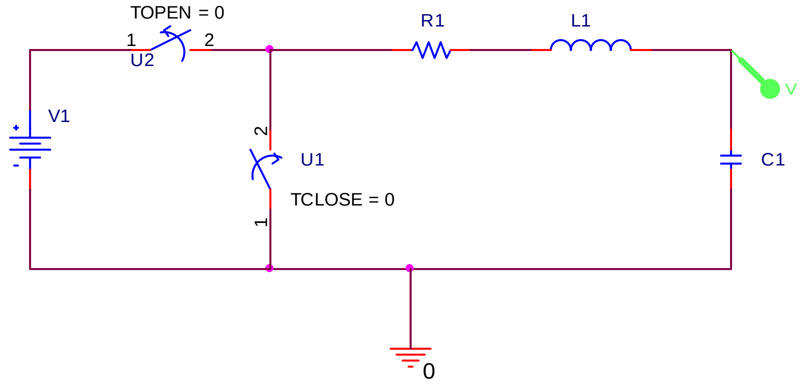
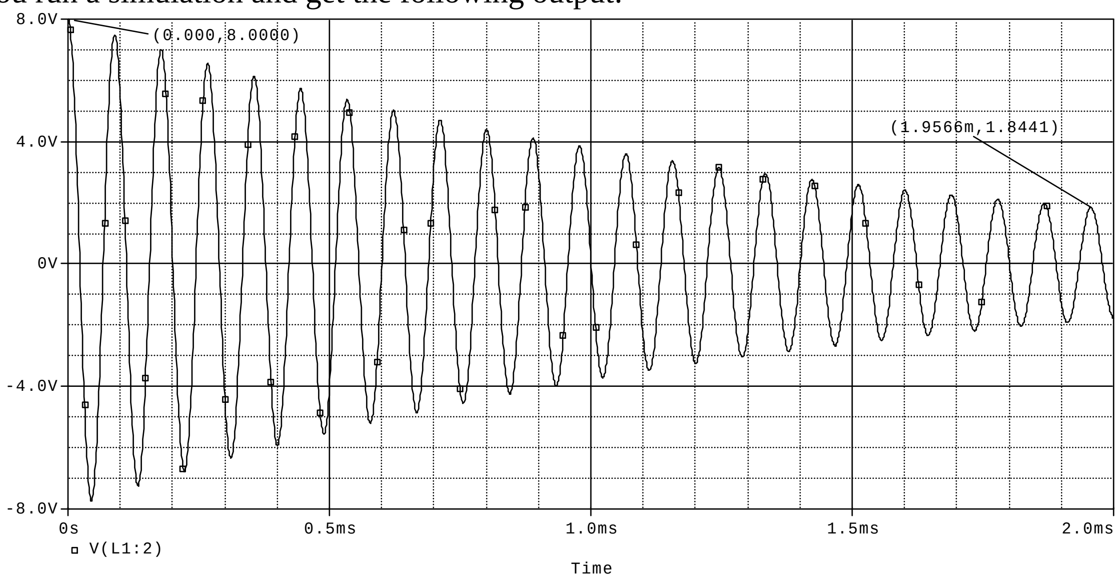
1) Damped Sinusoids (25 points) from Spring 2005

You wire the following circuit in PSpice.



You run a simulation and get the following output:



a) How would you set up the PSpice simulation screen pictured below, to get the output pictured above? (3 points)

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b) Using the output pictured, determine the damping constant, α, of the circuit. (3 points)

c) What is the resonant frequency of the circuit in Hertz? (3 points)

d) Write an expression in the form $v(t) = Ae^{-\alpha t}\cos(\omega_0 t)$ for the output signal. (3 points)

e) Use the general equations for capacitor and inductor behavior (located on the crib sheet for quiz 1), to describe what is happening in this circuit. What is causing the voltage to behave like a damped sinusoid? (5 points)

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f) The differential equation that governs the behavior of a damped sinusoid is given by $\frac{d^2V}{dt^2} + 2\alpha\frac{dV}{dt} + \omega_0^2 V = 0$. In a simple RLC circuit like the one in this question, the angular resonant frequency of the circuit, ω_0, is given by $\omega_0 = \frac{1}{\sqrt{LC}}$ and the decay constant, α, is given by $\alpha = \frac{R}{2L}$. In the circuit above, the value of the resistor, R1, is 30 ohms. What are the values of the capacitor, C1, and the inductor, L1? (6 points)

g) You want the damping constant of the circuit to be double what it is now. What new value of L1 would choose to make this occur? (2 points)

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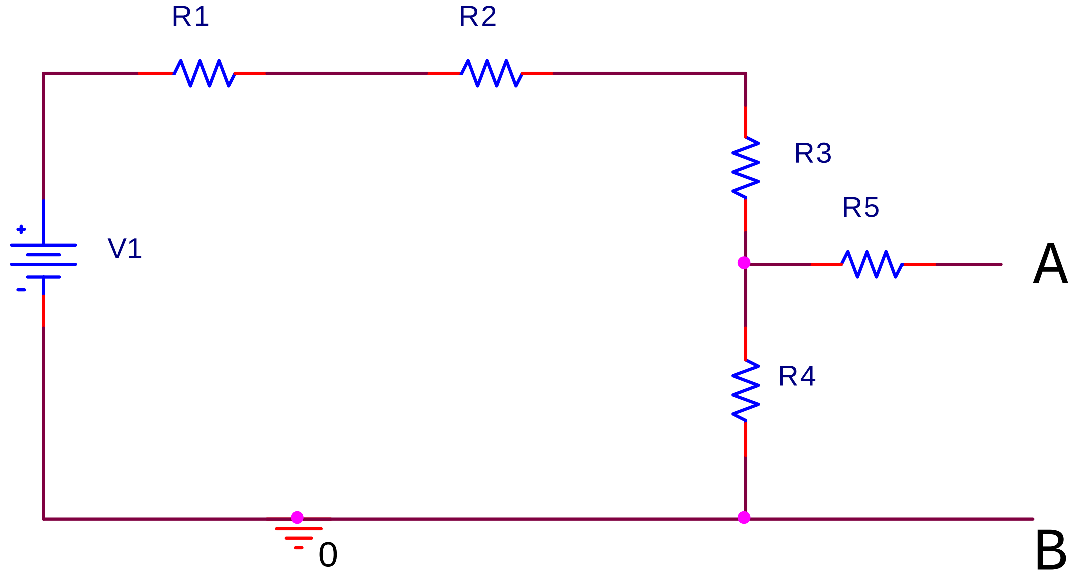
2) Thevenin Equivalent Sources (25 points) from Spring 2005

Part A You build the circuit pictured below



Test A:
Given: R1=30 ohms, R2=2K ohms, R3 = 3K ohms, R4=2K ohms and R5=1K ohms.
Given: V1=6V

a) Find the Thevenin Equivalent voltage, Vth, of this circuit between point A and point B. (6 points)

b) Find the Thevenin Equivalent Resistance, Rth, of this circuit between point A and point B. (6 points)

c) Redraw the Thevenin equivalent model of the circuit (2 points).

d) If you place a 2K ohm load on the circuit, what will the output voltage be between A and B? (2 points)

e) What is the current through the 2K ohm load resistor from d? (2 points)

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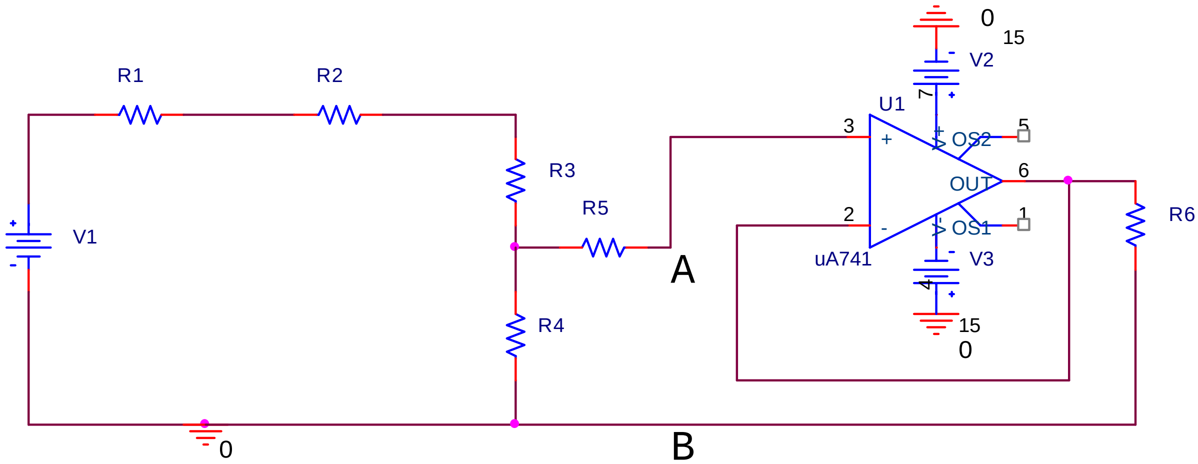
Part B You place a voltage follower into this circuit between A and B, as pictured below.



Test A:
Given: R1=30 ohms, R2=2K ohms, R3 = 3K ohms, R4=2K ohms and R5=1K ohms.
Given: V1=6V
Given: R6 is the load of 2K ohms

a) What does the voltage follower do in this circuit? (2 points)

b) What is the voltage output between A and B for this circuit now? (3 points)

c) What is the current though the load resistor, R6? (2 points)

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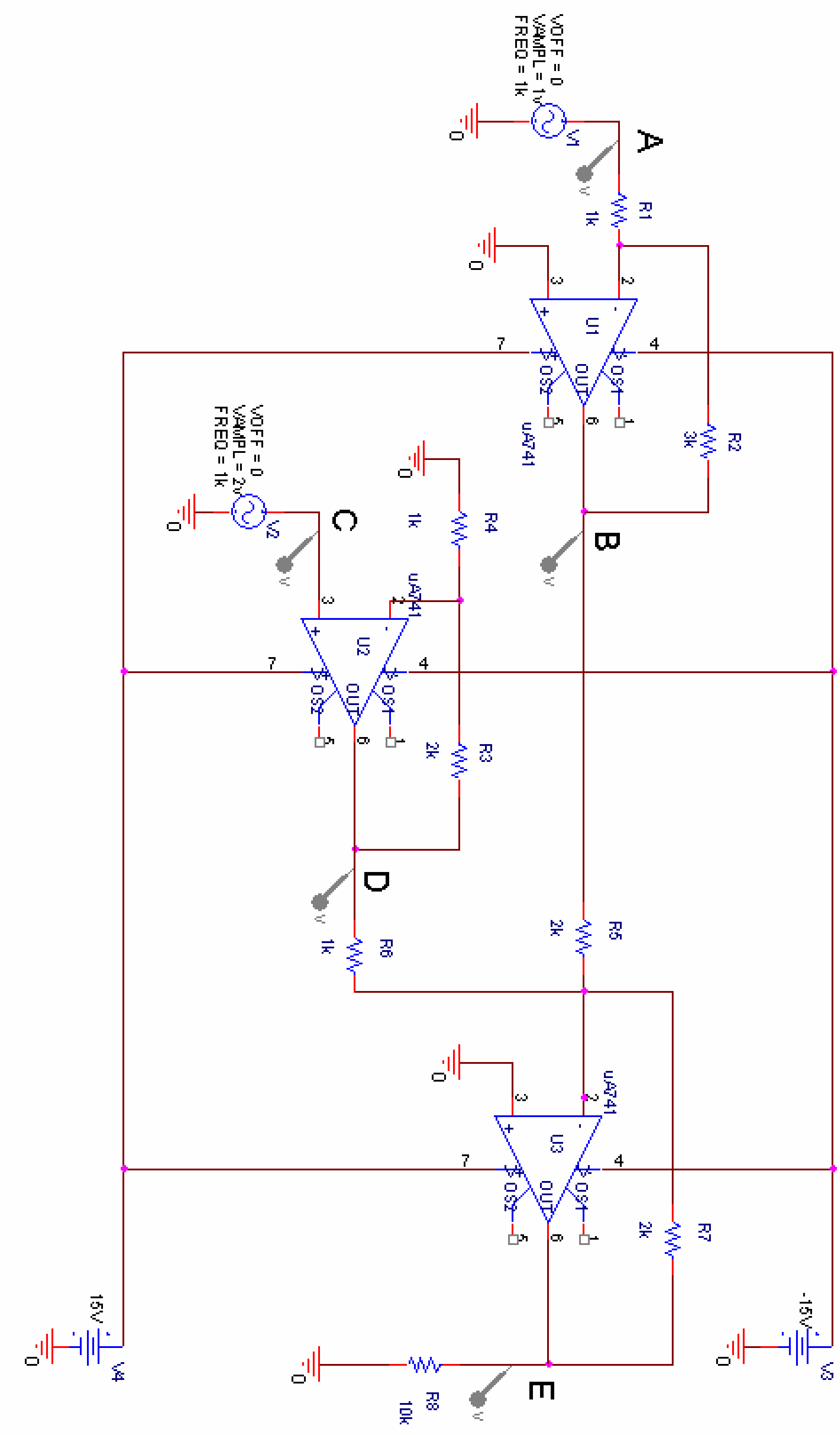
Question 3 – Op Amp Applications (25 points) from Fall 2005



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The following questions refer to the circuit on the previous page.

1) What type of op-amp circuit is between points A and B? (1 point)

2) What type of op-amp circuit is between points C and D? (1 point)

3) What type of op-amp circuit is between (B and D) and E? (1 point)

4) Write an expression for the voltage at point B, V_B, in terms of the voltage at A, V_A. Please substitute values. (3 points)

5) Write an expression for the voltage at point D, V_D, in terms of the voltage at C, V_C. Please substitute values. (3 points)

6) Write an expression for the voltage at point E, V_E, in terms of the voltage at B, V_B, and the voltage at D, V_D. Please substitute values. (3 points)

7) Write an expression for the output voltage at E, V_E, in terms of the two input voltages in the circuit, V_A and V_C. (3 points)

8) Identify the signals at points A, B, C, D and E in the PSpice plot below. (10 points)

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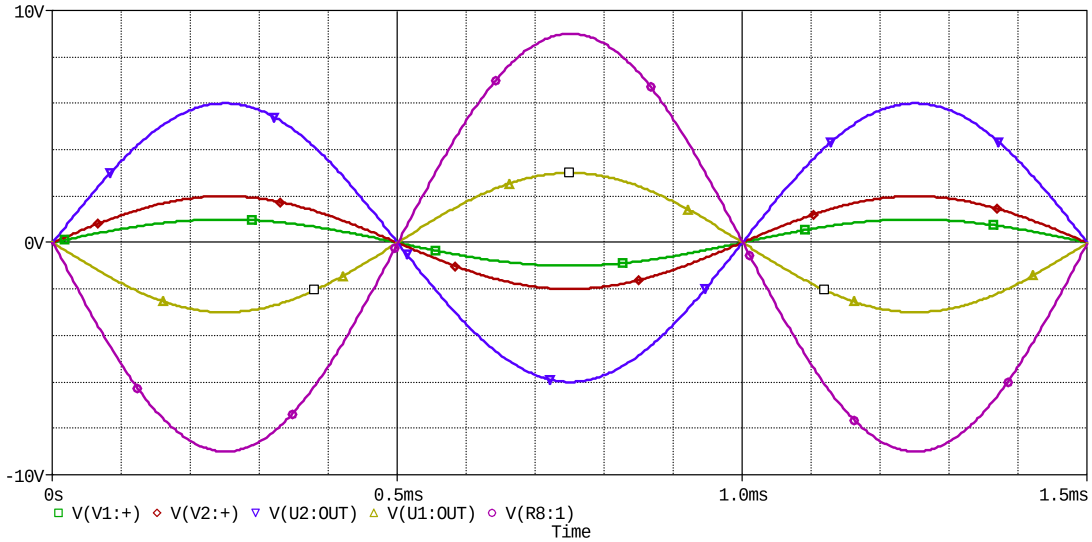

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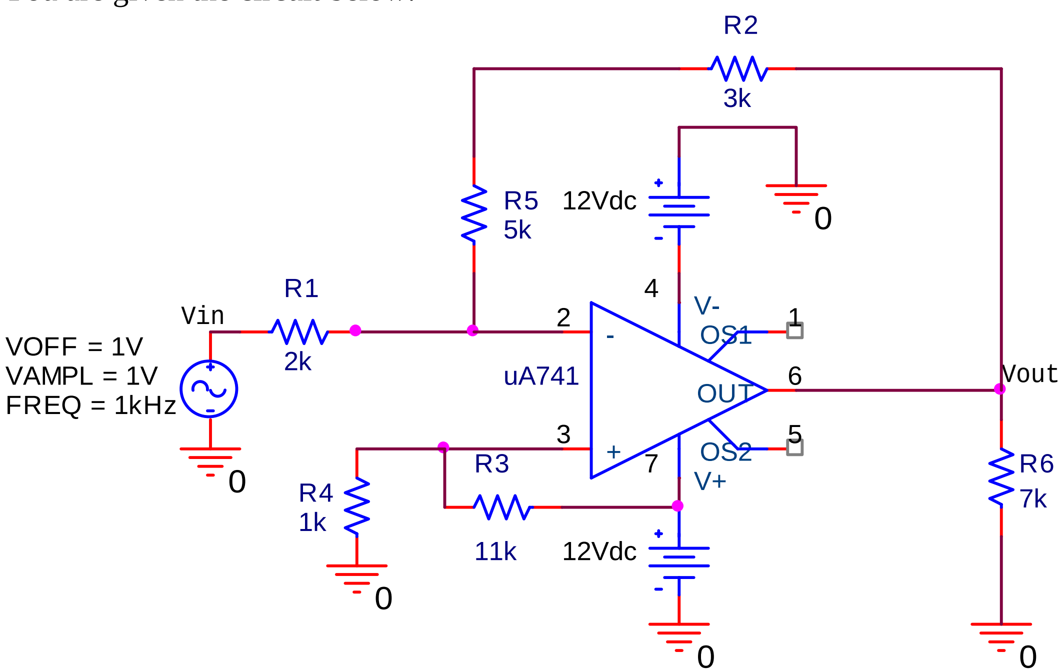
Question 4 – Op Amp Analysis (30 points) From Fall 2005

You are given the circuit below:



1) What are the golden rules of op amp analysis (2 points):

2) Without a feedback connection, can either of these rules be violated for an ideal op amp? If so, which one(s) and why (2 points)?

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3) Use the golden rules of op amp analysis to derive an expression for Vout in terms of Vin and the resistors in the circuit as labeled. Do NOT substitute resistor values until instructed to do so.

a) Draw the circuit corresponding to the inverting terminal of the op-amp (3 points)

b) Based on the circuit in a) write the equation at the inverting terminal of the op amp (Do not substitute values) (3 points)

c) Draw the circuit corresponding to the non-inverting terminal of the op-amp (3 points)

d) Based on the circuit in c) write the equation at the non-inverting terminal of the op amp (Do not substitute values) (3 points)

e) Use these equations to solve for Vout in terms of Vin and resistor values R1-R6. (Do not substitute values.) (7 points)

f) Substitute resistor values into your equation from part e to get Vout in terms of Vin (3 points)

g) For the input signal shown in the circuit schematic, what is the minimum and maximum output voltages generated at Vout? Show your work. (4 points)

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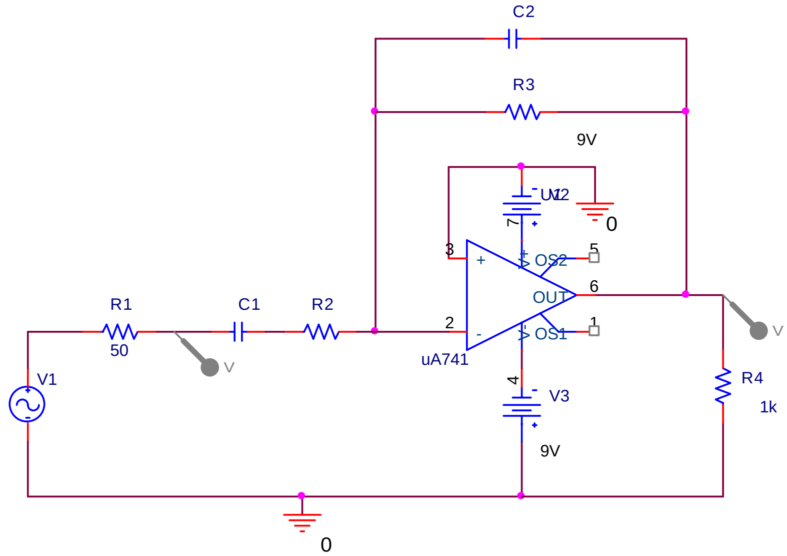
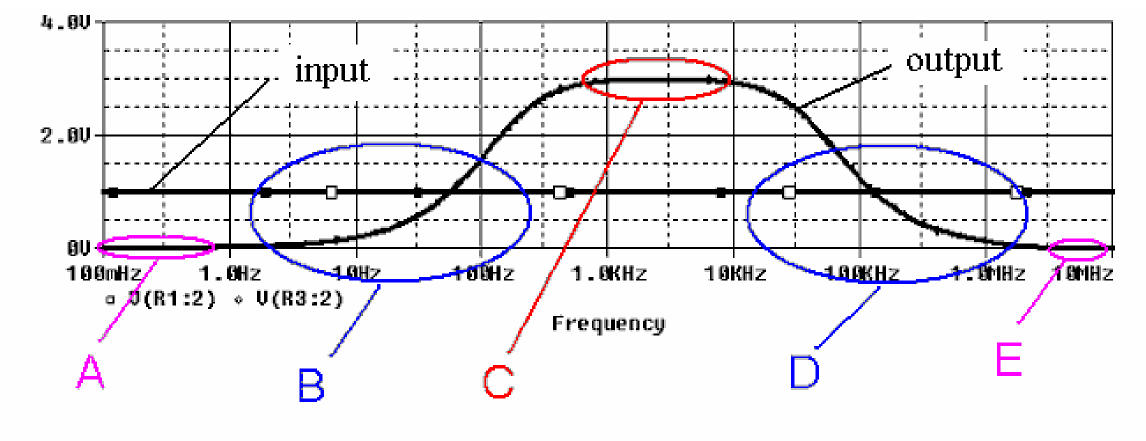
Question 5 -- Op Amp Integrators and Differentiators (25 points) from Spring 2004

Here is a combined differentiator/integrator similar to the one you implemented in experiment 8. Let C1=0.01μF, R2=100K ohms, C2= 0.01 nF, and R3=300K ohms.



a. Below is an AC sweep for the above circuit



i) Identify the input and the output traces.*(2 points) (Test A)*

ii) If you built this circuit in the studio, in which of the circled regions would the output look like the following? *(2 points each) [Total=8 points]*

a reasonable integration of the input?

a reasonable differentiation of the input?

an amplified inversion of the input?

disappear into the noise?

b. What are the general equations for the following: (Give specific values based on the components in the circuit.)

i. The circuit when it is acting as an ideal integrator *(3 points)*

ii. The circuit when it is acting as an ideal differentiator *(3 points)*

iii. The circuit when it is acting as an inverting amplifier *(3 points)*

cA. Sketch the AC sweep of an integrator that integrates between 1K and 4K hertz. Give a ballpark estimate of the corner frequency. Mark 1K, 4K and the corner frequency on the sketch. Justify your decisions. *(6 points)*

cB. Sketch the AC sweep of an differentiator that differentiates between 1K and 4K hertz. Give a ballpark estimate of the corner frequency. Mark 1K, 4K and the corner frequency on the sketch. Justify your decisions. *(6 points)*