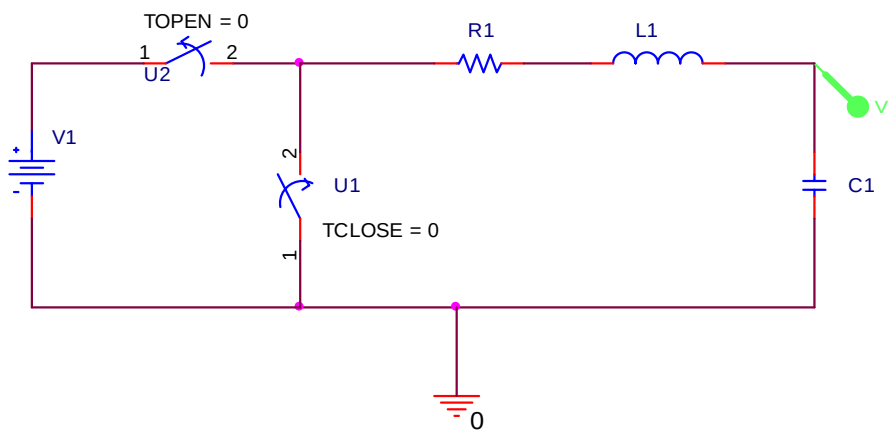
# ENGR4300 Test 2A
# Spring 2005

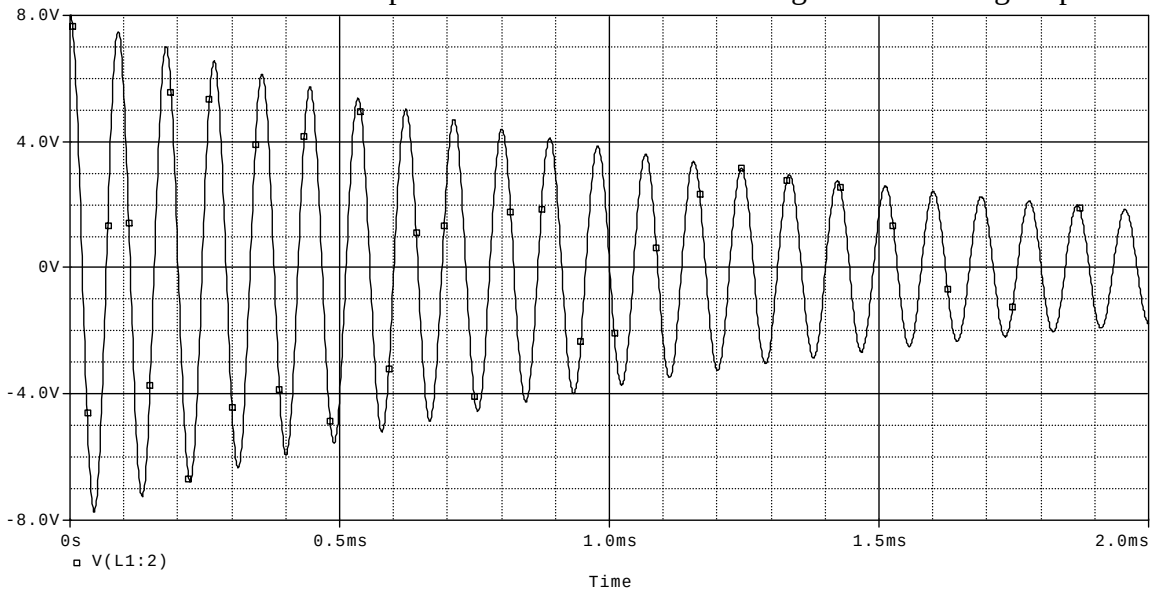
**Name**_____

**Section** _____

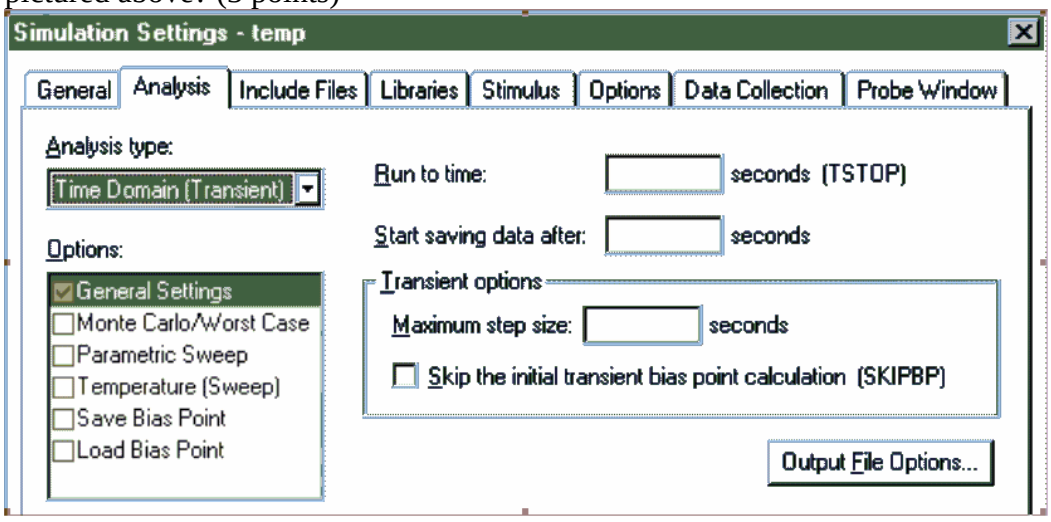
## 1) Damped Sinusoids (25 points)




You wire the circuit above 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)



b) Using the output pictured, determine the damping constant, $\alpha$, 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, inductor, and resistor 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)

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, $\omega_0$, is given by $\omega_0 = \frac{1}{\sqrt{LC}}$ and the decay constant, $\alpha$, is given by $\alpha = \frac{R}{2L}$. In the circuit in this question, 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 value of L1 would make this occur? (2 points)

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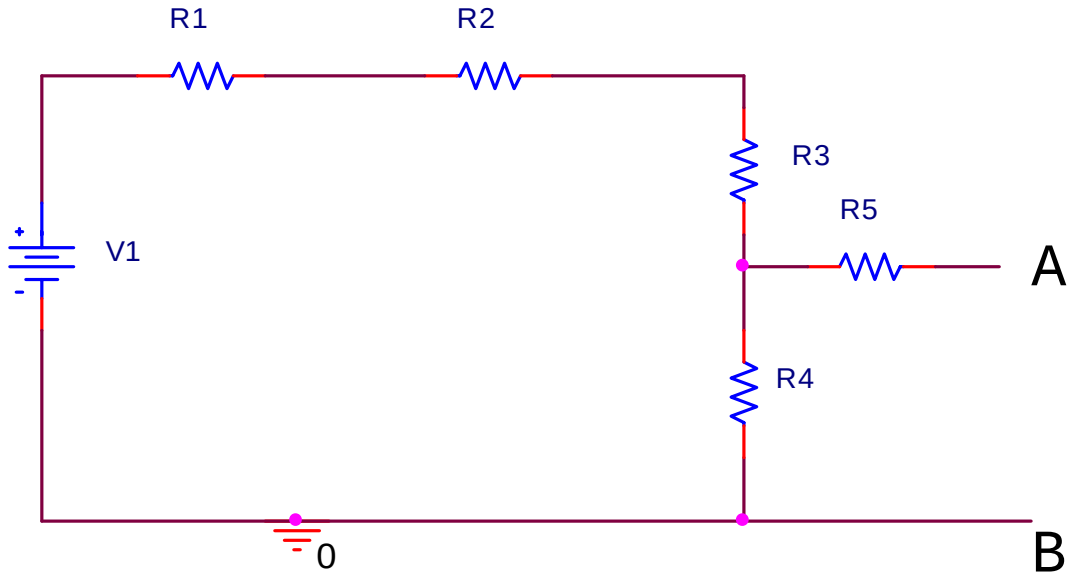
**2) Thevenin Equivalent Sources (25 points)**

*Part A* You build the circuit pictured below




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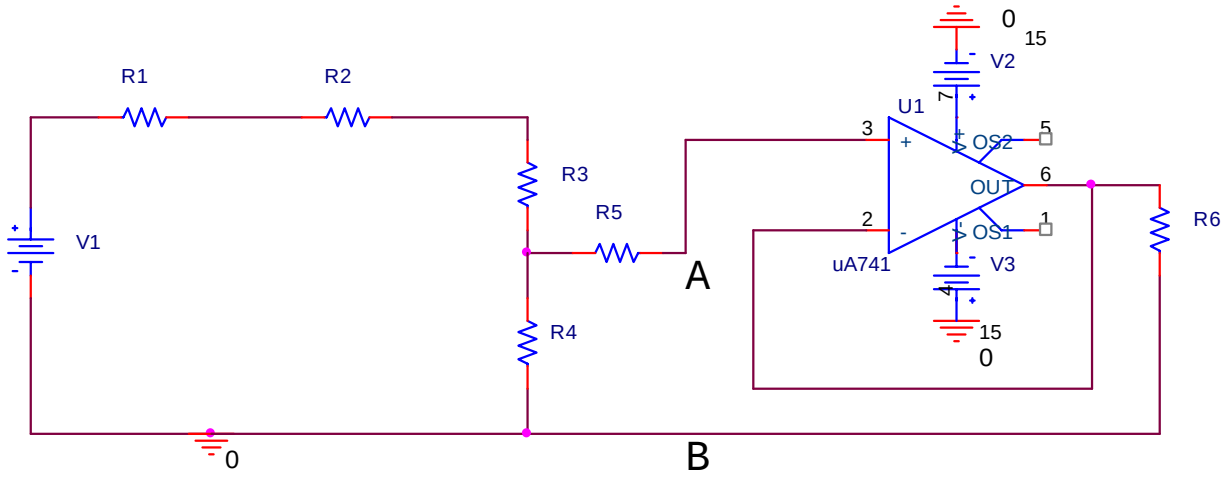
*Part B* You place a voltage follower into this circuit between A and B, as pictured below.




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)

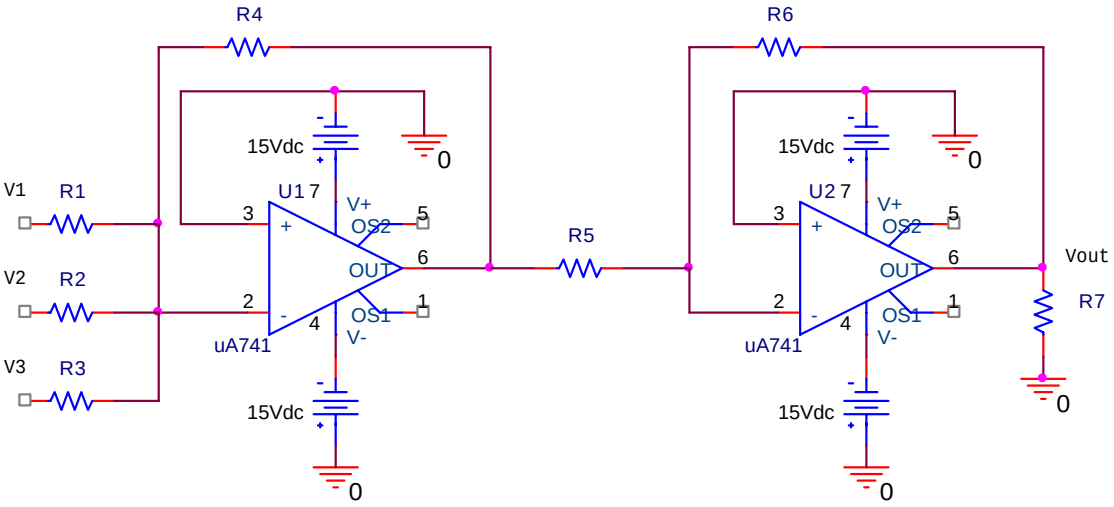
c) What is the current though the load resistor, R6, now? (2 points)

### 3) Op Amp Applications – Digital to Analog Conversion (25 points)

One family of digital logic we'll learn about later in the course uses signals that switch discretely between zero and +5V, corresponding to logic levels of 0 (low) and 1 (high), respectively. Here is a chart of the binary numbers from 1 to 16, their decimal equivalents, and corresponding voltage inputs:

| Decimal Value | Binary Value | | | | Corresponding Voltage Inputs | | | |
|---|---|---|---|---|---|---|---|---|
| | x2^3 | x2^2 | x2^1 | x2^0 | Va | Vb | Vc | Vd |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 |
| 2 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 |
| 3 | 0 | 0 | 1 | 1 | 0 | 0 | 5 | 5 |
| 4 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 0 |
| 5 | 0 | 1 | 0 | 1 | 0 | 5 | 0 | 5 |
| 6 | 0 | 1 | 1 | 0 | 0 | 5 | 5 | 0 |
| 7 | 0 | 1 | 1 | 1 | 0 | 5 | 5 | 5 |
| 8 | 1 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 1 | 5 | 0 | 0 | 5 |
| 10 | 1 | 0 | 1 | 0 | 5 | 0 | 5 | 0 |
| 11 | 1 | 0 | 1 | 1 | 5 | 0 | 5 | 5 |
| 12 | 1 | 1 | 0 | 0 | 5 | 5 | 0 | 0 |
| 13 | 1 | 1 | 0 | 1 | 5 | 5 | 0 | 5 |
| 14 | 1 | 1 | 1 | 0 | 5 | 5 | 5 | 0 |
| 15 | 1 | 1 | 1 | 1 | 5 | 5 | 5 | 5 |

The following op amp circuit is configured as a digital to analog (D/A) converter. Our D/A converter shown here is a three bit converter: logic voltages at V1, V2, and V3 generate an output voltage at Vout. V1 is the lowest order bit corresponding to Vd (in the chart), V2 corresponds to Vc, and V3 corresponds to Vb.




Component values for the circuit shown are as follows: R4 = 5k, R5 = 20k, R6 = 10k, R7 = 10Meg ohms. Values R1, R2, and R3 will be determined by you in part b of this question.

a. Given the D/A circuit on the previous page, about what is the maximum voltage rounded to the nearest 0.5 volts (e.g. 1.0V, 1.5V, 2.0V,…) that the circuit should generate at Vout when it is acting correctly as a D/A converter? Describe your reasoning for this answer and show all equations or calculations used to arrive at this answer. (3 points)

b. The D/A should generate output voltages between 0V for a binary input of 000 to the full scale value you determined in part A when a binary input of 111 is present with a proportional increase in voltage as the binary value increases from 000 to 111. Determine the resistor values R1, R2, and R3 that achieve this in the circuit. (12 points)

R1 =

R2 =

R3 =

c. Show the output voltage at Vout will give the correct decimal value for the following two binary input combinations: ( 7 points).

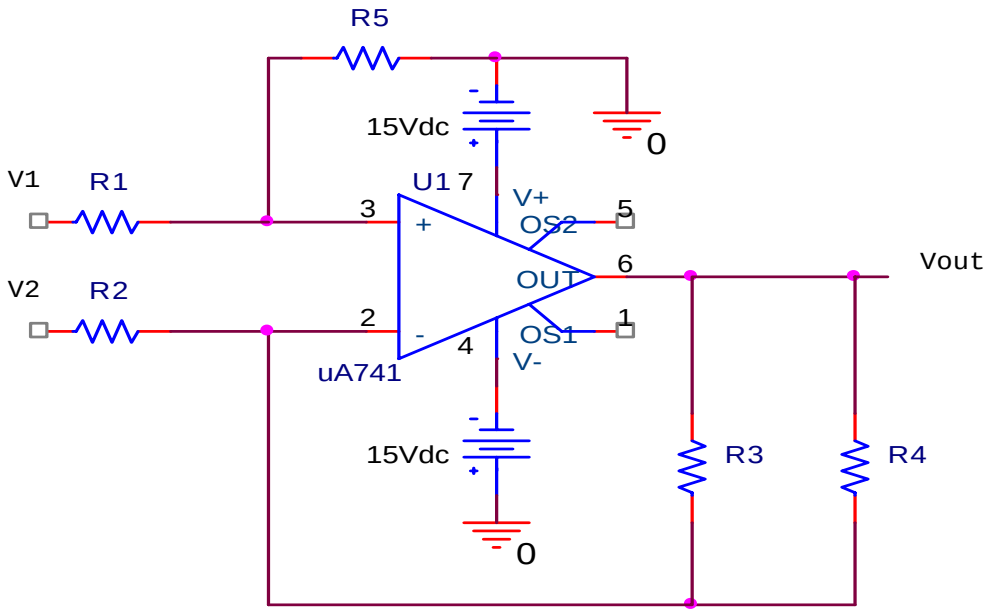
100

011

d. The second op amp (rightmost in the schematic shown) performs two primary functions in this circuit. One of these functions could instead be integrated into the first op amp circuit by using a different selection of resistor values. What function does this op amp perform that *cannot* be integrated with the first op amp? (A one sentence answer is worth 3 points.)

**4) Op Amp Analysis (25 points)**

*Part A* Given the op-amp circuit below:




R1 = R2 = 2k, R3 = R4 = 6k, R5 = 3k

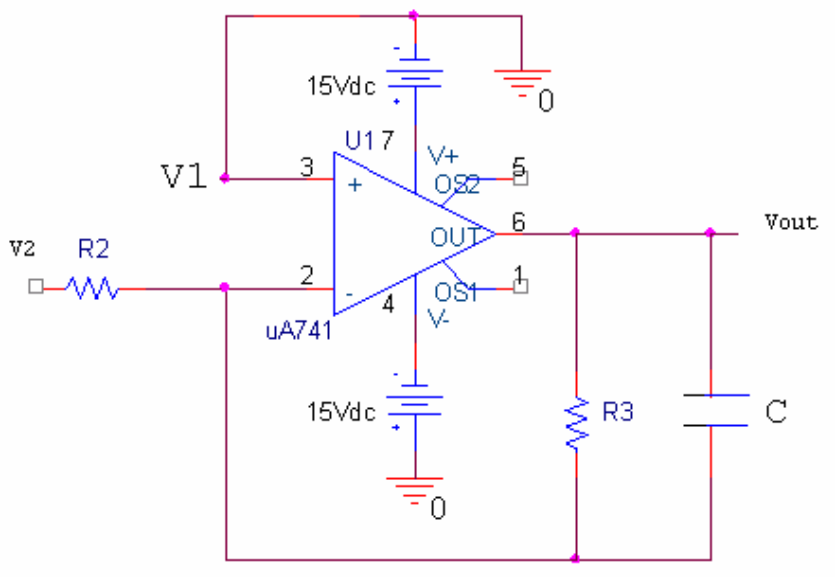
a. What op-amp circuit given on your crib sheet does this circuit most closely represent? (Hint: disregard specific resistor values) (2 points)

b. What are the golden rules of op amp analysis? (2 points)

c. Find an expression for Vout in terms of V1, V2 and resistor values R1, R2, R3, R4, and R5 (do not substitute actual resistor values) (12 points)

d. Substitute resistor values in this equation and write the equation for Vout in terms of V1 and V2 input signals. (3 points)

*Part B* What if R4 is replaced by a 10uF capacitor and V1 is grounded, as shown below?




a. What function is this circuit designed to perform? (2 points)

b. Write the transfer function Vout/V2 for this circuit (2 points)

c. Over about what frequency range is the desired function of the circuit reliably performed? [You can assume that the operation is being performed even when the output amplitude is very small.] (2 points)