ENGR-4300
Spring 2009
Test 2

Name: ____________________________

Section: 1(MR 8:00) 2(TF 2:00) 3(MR 6:00)
(circle one)

Question I (20 points): ___________

Question II (20 points): ___________

Question III (17 points): ___________

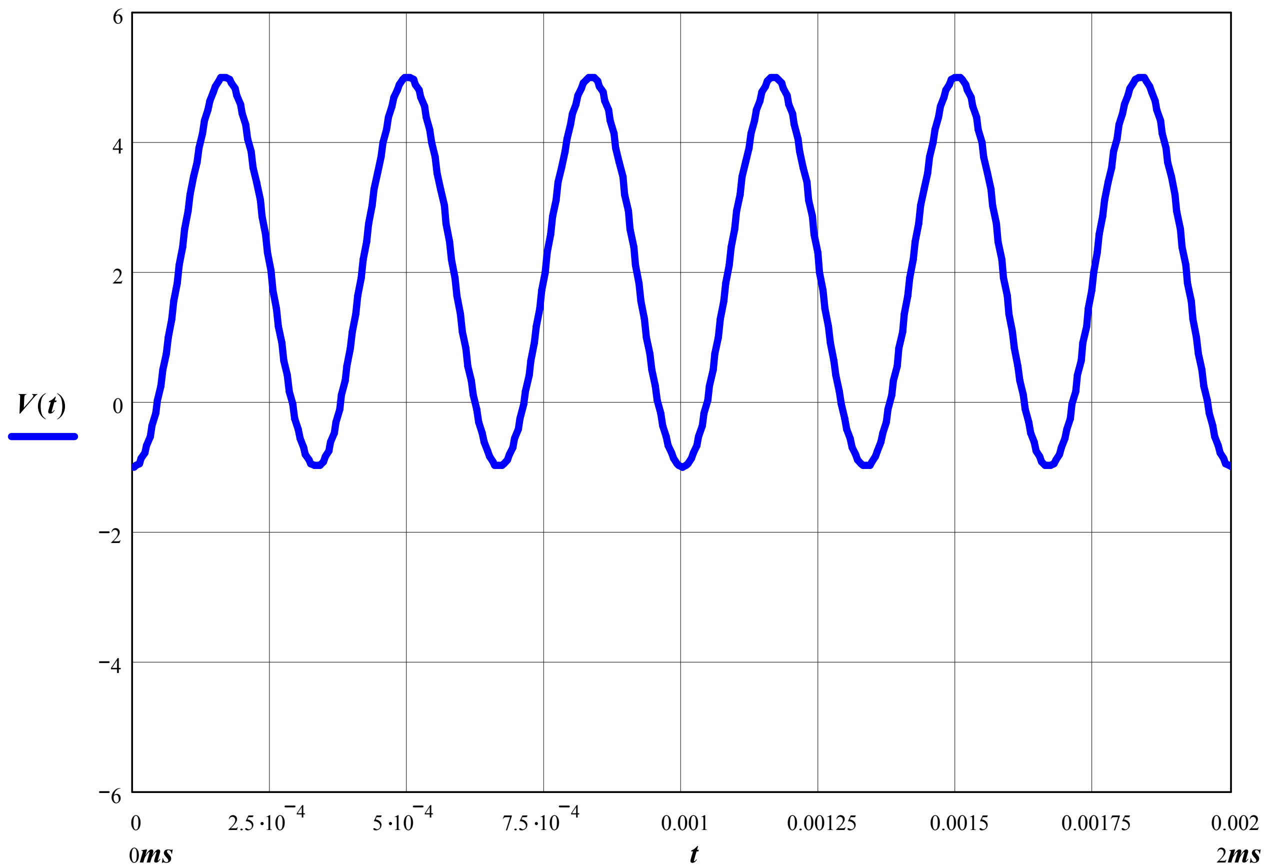
Question IV (20 points): ___________

Question V (23 points): ___________

Total (100 points): ______________

On all questions: SHOW ALL WORK. BEGIN WITH FORMULAS, THEN SUBSTITUTE VALUES AND UNITS. No credit will be given for numbers that appear without justification.

Question I – Bridges and Damped Sinusoids (20 points)

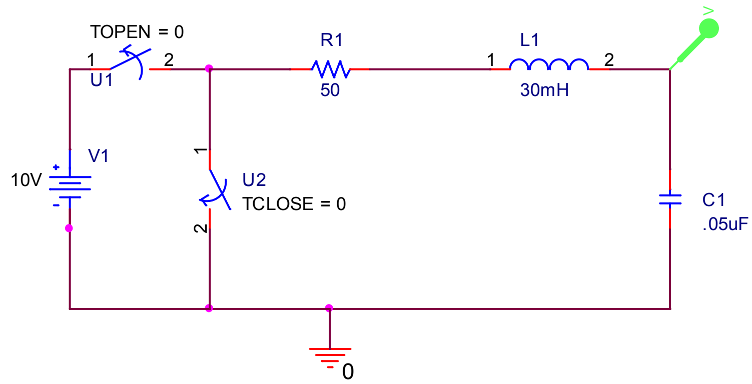


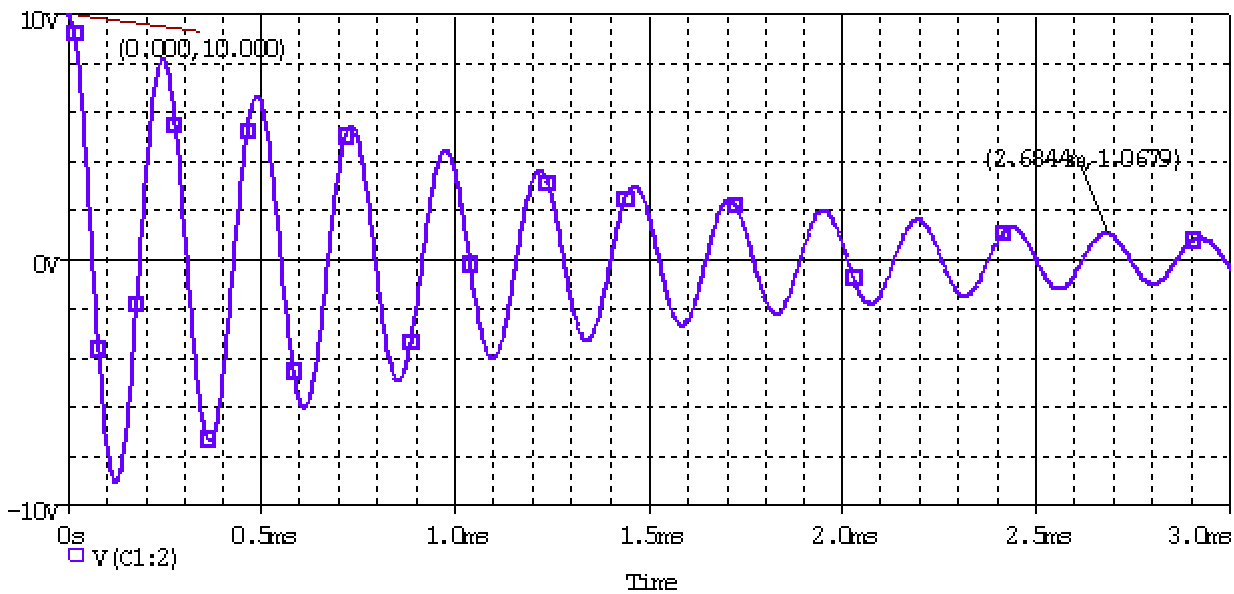
1) (4 pts) Find the ***period and frequency*** of this signal. Include units.

2) (2 pts) What is the value of the DC offset?

3) (4 pts) Write the mathematical expression for this signal and its offset. In general, this is given by $X = X_0 + X_1 \sin(\omega t + \Phi_0)$ which accounts for its frequency, phase shift, and offset. (Phase shift with respect to t=0)

The circuit below gives the simulation output below.



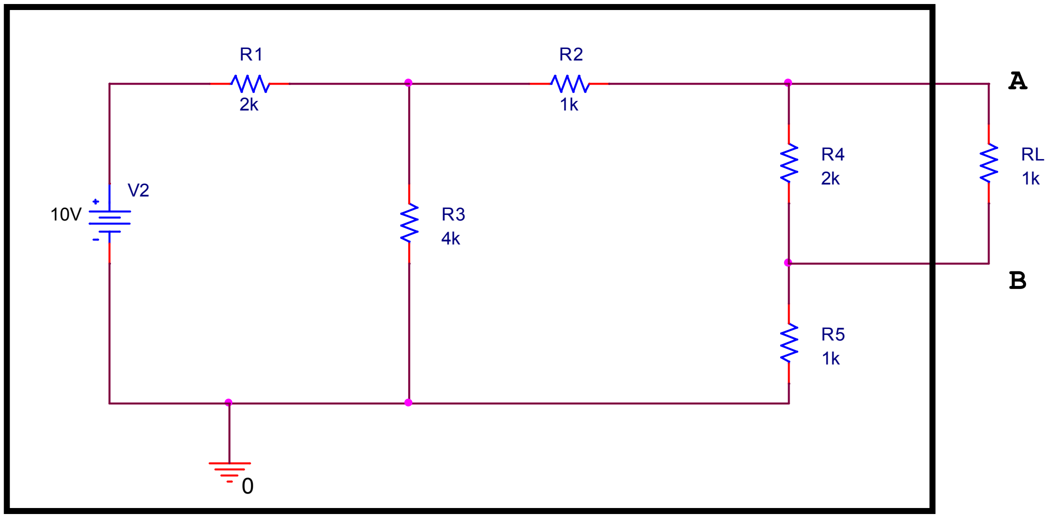


4) (3 pts) Find the damping constant α for this data (***use points labeled for you to three significant figures***).

5) (4 pts) Write the mathematical expression for this data in the form of $v(t)=A \cos(\omega t) e^{-\alpha t}$

6) (3 pt) If the resistor is completely removed from the circuit and replaced with a wire, what will happen to the ***frequency and amplitude*** of the simulated output? ***Why***?

Question II – Thevenin Equivalents (20 points)

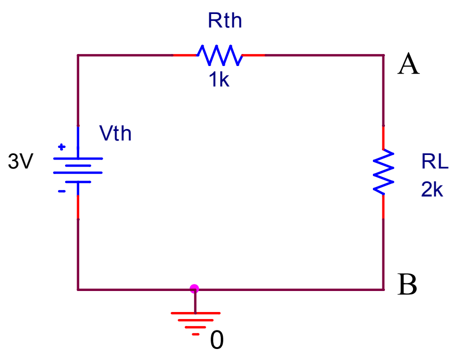


1) (6 pts) Find the Thevenin voltage (Vth) of the circuit inside the rectangle.

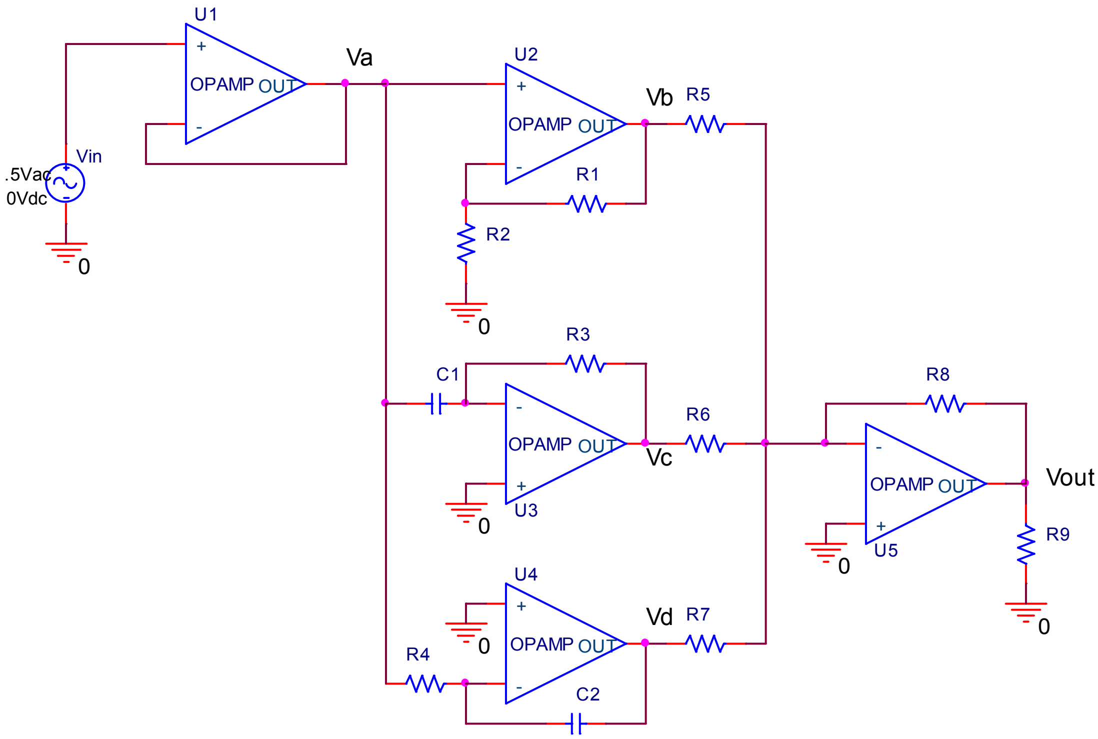
2) (6 pts) Find the Thevenin resistance.

3) (4 pts) Draw the Thevenin equivalent circuit with the load (1K ohms).

4) (4 pts) For the following Thevenin equivalent circuit (***not the one above***) find the voltage between A and B with a load of 2K ohms.



Question III – Op-Amp Applications (17 points)



Assume that ±9 **Volt power supplies** have been properly connected to all five op-amps in the circuit above.

1) (5pt) The circuit has 5 op-amps labeled as U1 through U5. State what the op-amp circuit is for each. Choices are: 1. Follower/Buffer, 2. Inverting Amp, 3. Non-inverting Amp, 4. Differentiator, 5. Integrator, 6. Adding (Mixing) Amp, 7. Difference (Differential) Amp, 8. Miller Integrator, 9. Practical Differentiator.

U1 Circuit: ________________ U2 Circuit: ________________ U3 Circuit: ________________

U4 Circuit: ________________ U5 Circuit: ________________

2) (4pt) Determine the values relative to ground, of Va(t), Vb(t), Vc(t) and Vd(t) as functions of Vin(t) with R1 = 20k, R2 = 20k, R3 = 4k, R4 = 3k, R5 = 10k, R6 = 20k, R7 = 30k, R8 = 10k, R9 = 1k, C1 = 100μF and C2 = 68μF.

a) Voltage at point Va(t):

b) Voltage at point Vb(t):

c) Voltage at point Vc(t):

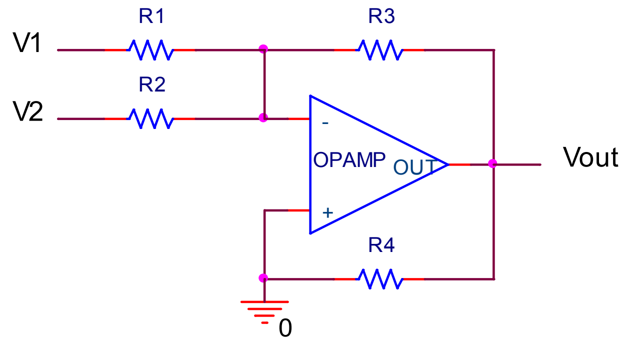
d) Voltage at point Vd(t):

3) (3pt) Determine the output voltage, Vout(t), as a function of Vb(t), Vc(t) and Vd(t).

4) (4pt) Now find Vout(t) as a function of Vin(t).

5) (1pt) What is a practical use for a voltage follower/buffer op-amp?

Question IV – Op-Amp Analysis (20 points)



Assume that **±9 Volt power supplies** have been properly connected to the op-amp in the circuit above.

1) (2pt) What op-amp circuit given on your crib sheet does this circuit most closely represent?

2) (3pt) What feedback connection is necessary before the golden rule concerning the voltages on the two input terminals can be applied?

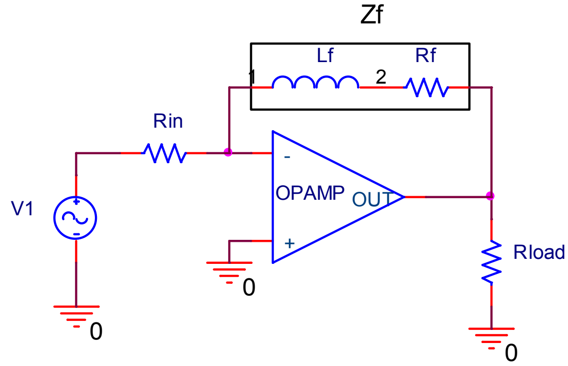
3) (10pt) Using the two golden rules of op-amp analysis, **derive** an expression for Vout in terms of V2 and the appropriate resistor values, ***when V1 has been set to 0Volts***. You must use Ohm's Law and current laws to describe how the op-amp functions by the golden rules.

4) (4pt) Remove R4, set V2 = V1 (short the 2 inputs together), and **derive** the expression for Vout in terms of V1 and the resistors using the rules for op-amp analysis.

5) (1pt) What does R4 model or represent in this circuit?

Question V – Op-Amp Integrators and Differentiators (23 points)

In the circuit below, Rin = 200Ω, Lf = 200mH and Rf = 200Ω. Assume that power supplies have been properly connected to an ideal op-amp and the output voltage is limited to ±10V



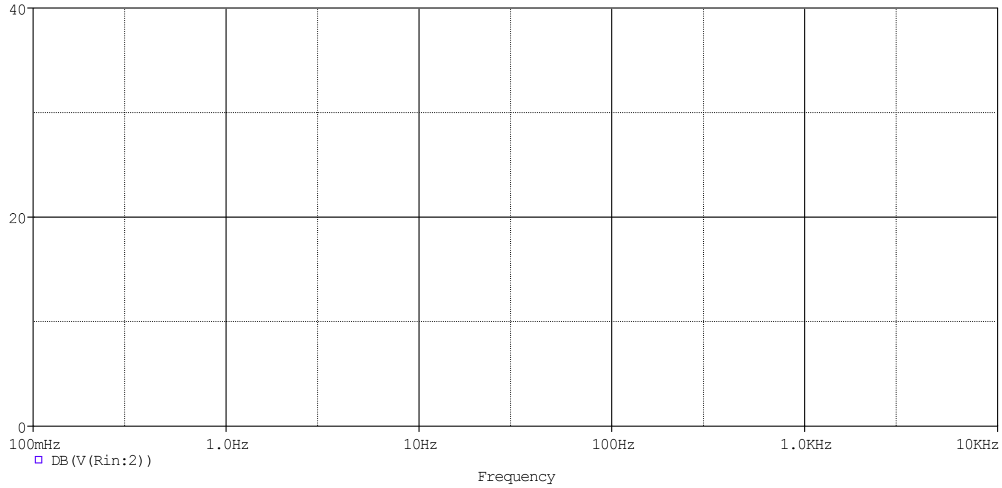
1) (4pt) Find the transfer function H(jω) = Vout(jω)/V1(jω) for this circuit. (Substitute in the values provided for the components.)

2) (2pt) What function is this circuit designed to perform at high frequencies (f ≥ 2kHz)?

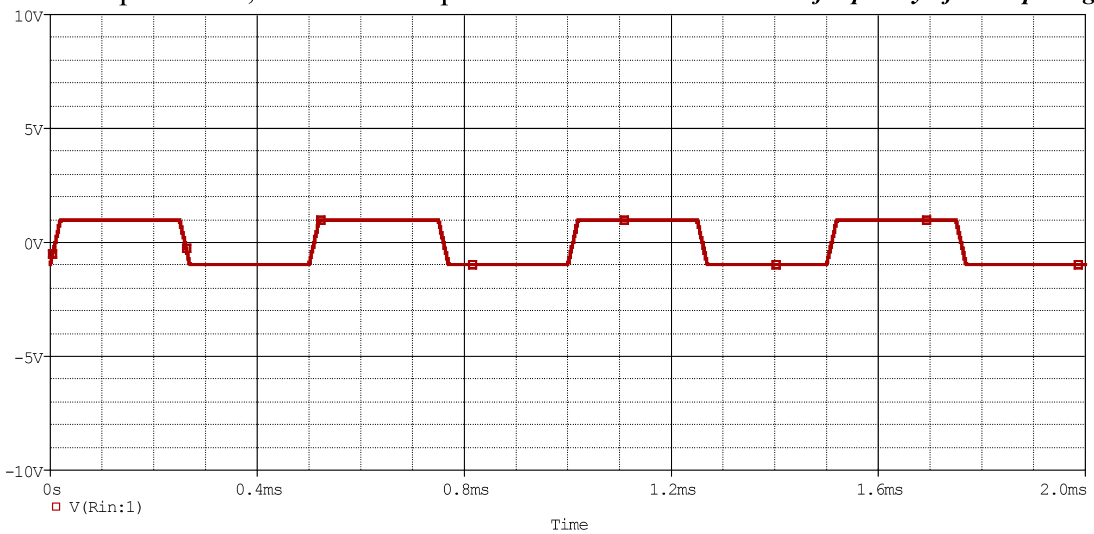
3) (2pt) What function is this circuit designed to perform at low frequencies (f ≤ 10Hz)?

4) (4pt) What is the corner frequency (in Hz) for the circuit where it transitions from its low frequency performance to its high frequency performance?

5) (4pt) Sketch the bode plot of |H(jω)|, 20log(magnitude) vs. log of frequency, of the transfer function from 0.1 to 10kHz. For simplicity assume that the ideal op-amp output voltage is unlimited.



6) (4pt) For the input below, sketch the output on the same axis. ***Note the frequency of the input signal.***



7) (2pt) For the input below, sketch the output on the same axis. ***Note the frequency of the input signal.***