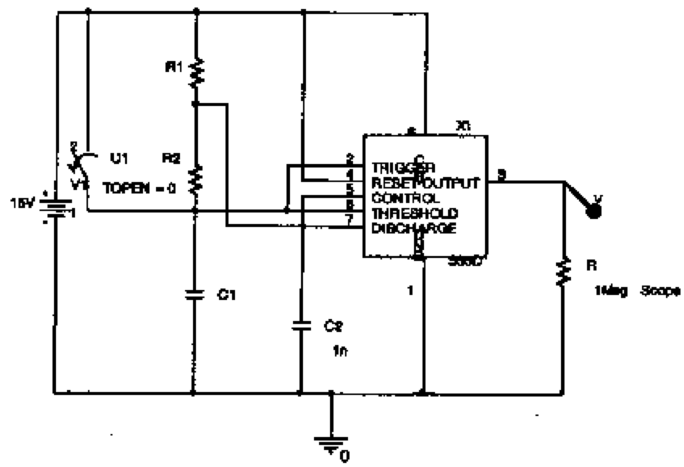
EI TEST 3A Fall 2001 Name Solution Sect 1

Please show all work on all questions for full credit, some explanation of your answer is required.

1 555 Timer Astable Multivibrator (20 points)



a) Design an astable multivibrator, as shown above, using R1, R2, and C1. The output should have a frequency of 5000 Hz, and a duty cycle of 60%. Show all work. (NOTE: It may be nessesary to carry out calculations to the hundredths or thousandths decimal to be accurate) (15 pts)

$f = 5000\,Hz \Rightarrow T = 200\,\mu Sec$

Duty cycle $= 0.6 \Rightarrow T_1 = 0.6T \Rightarrow T_1 = 120\,\mu Sec \Rightarrow T_2 = 80\,\mu Sec$

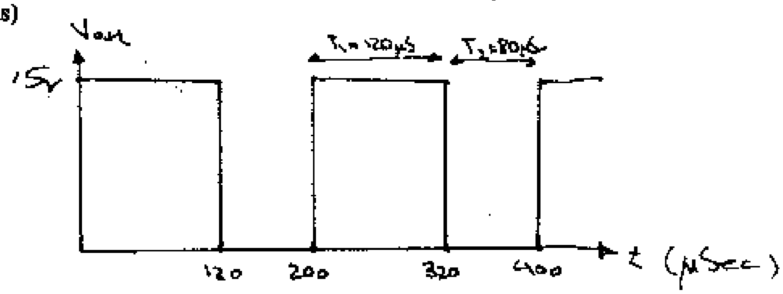
$T_2 = 0.693\, R_2 C_1$ $\boxed{\text{Assume } C_1 = 1\mu F}$

$\Rightarrow R_2 = \frac{T_2}{0.693\, C_1} \Rightarrow \boxed{R_2 = 115\,\Omega}$

$T_1 = 0.693(R_1 + R_2)C_1 \Rightarrow R_1 = \frac{T_1}{0.693\, C_1} - R_2 \approx 58\,\Omega \Rightarrow \boxed{R_1 = 58\,\Omega}$

* The solution to this question is not unique.

b) To scale, draw your 555 output, including values on the X axis (time) for rises and falls of the pulse ie. T1 and T2. Also indicate the amplitudes on the Y axis (volts) (5 pts)



EI TEST 3A Fall 2001 **Name____________________ Sect________**

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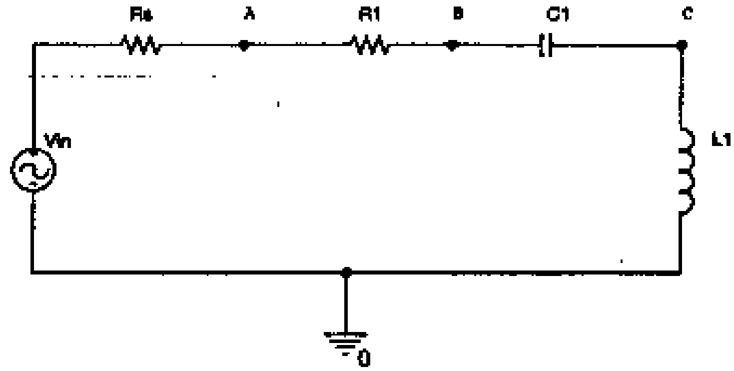
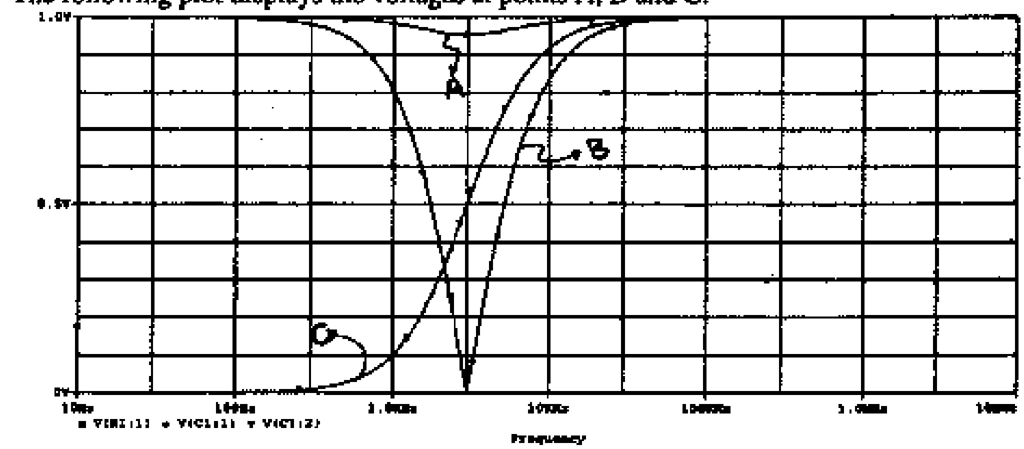
2. Inductance Measurement (20 points)

In the circuit below, Vin = 1v, Rs = 50Ω, R1 = 1kΩ, C1 = 0.1μF and L1 is unknown.



The following plot displays the voltages at points A, B and C.



a) Determine which plot goes with which point. (6 points)

b) Find the resonance frequency f_0 from the plot. Notice that the x-axis has logarithmic scale.(6 points)

$$\boxed{f_0 \approx 3\,\text{kHz}}$$

c) Solve for the unknown inductance. (8 points)

$$\omega_0 = 2\pi f_0 = \frac{1}{\sqrt{LC}} \Rightarrow L = \frac{1}{(2\pi f_0)^2 C} = \frac{1}{(2\pi \times 3000)^2 \times 0.1 \times 10^{-6}}$$

$$\Rightarrow \boxed{L = 28\,\text{mH}}$$

EI TEST 3A Fall 2001 Name__________________ Sect________

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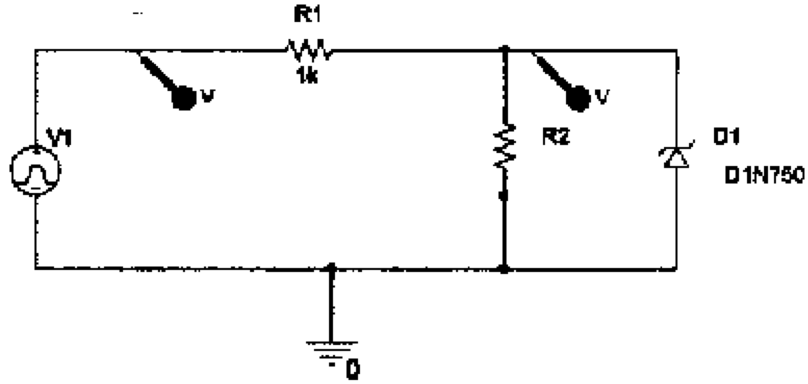
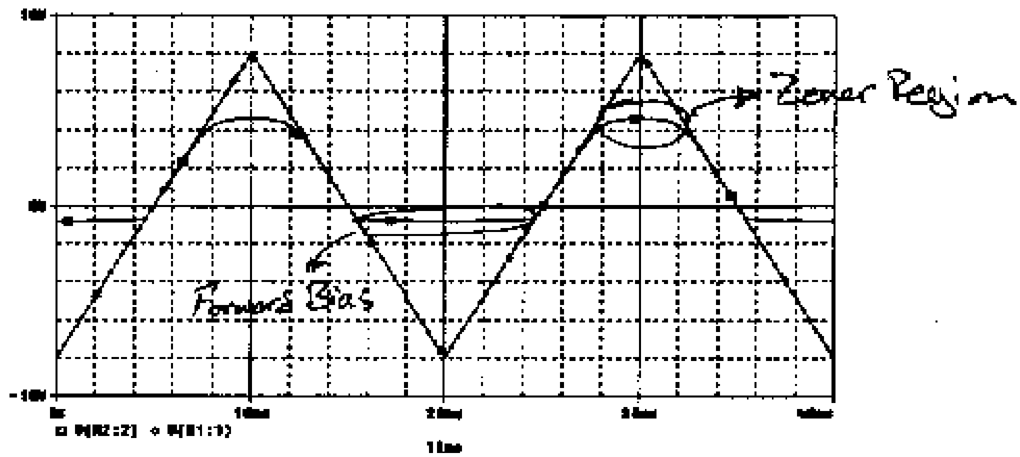
3. Voltage Regulator (20 points)

A zener diode is used to in the circuit below to produce the following output.





a. Circle an area on the plot where the zener diode is functioning in the forward bias region. (3 points)

b. Circle an area on the plot where the zener diode is functioning in the zener region. (3 points)

c. What is the approximate value of the zener voltage (V_z) of the diode? (5 points)

$V_z \approx 4.5v$

d. Assuming the value of the resistor R2 is 20k, what is the current through the resistor, R2, when the diode is functioning in the zener region? (6 points)

$$I_{R_2} = \frac{V_{R_2}}{R_2} = \frac{V_Z}{R_2} = \frac{4.5v}{20k\Omega} = 225\ \mu A$$

e. Why is this circuit called a voltage regulator? (3 points)

Since, when the diode is in Zener region, the output is constant.

EI TEST 3A   Fall 2001   Name________________ Sect________

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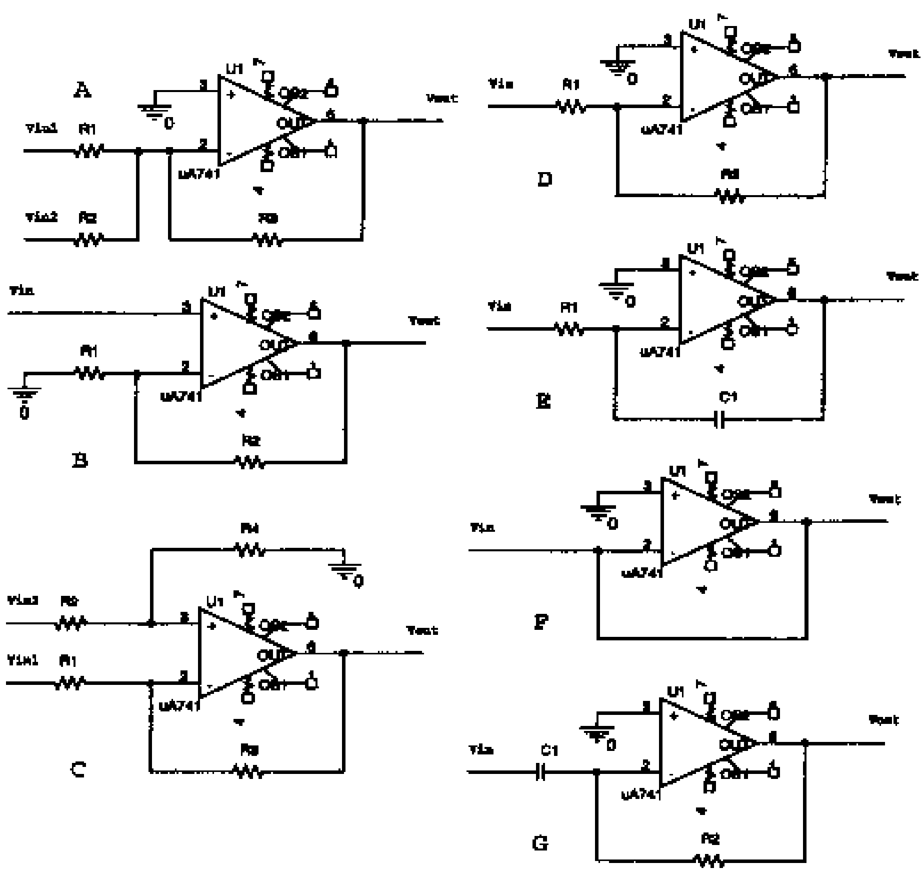
4. Op-Amp Configurations (20 points)

a) Seven circuits (A to G) are shown below. (Connections to power supply are not displayed but assumed).



For each circuit, determine the type (function) of the circuit (1point each) and the mathematical relationship that relates Output and Input voltages (1point each).

A. Adder

$$V_{out} = -R_3\left(\frac{V_{in1}}{R_1} + \frac{V_{in2}}{R_2}\right)$$

B. Non-Inv. Amp.

$$V_{out} = \left(1 + \frac{R_2}{R_1}\right) V_{in}$$

C. Differential Amp

$$V_{out} = \frac{R_3}{R_1}\left(V_{in2} - V_{in1}\right)$$

EI TEST 3A Fall 2001 Name__________________ Sect_______

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D. Inverting Amp.

$$V_{out} = -\frac{R_2}{R_1} V_{in}$$

E. Ideal integrator

$$V_{out} = -\frac{1}{RC}\int V_{in}\, dt$$

F. Voltage follower (buffer)

$$V_{out} = V_{in}$$

G. Ideal differentiator

$$V_{out} = -RC\frac{dV_{in}}{dt}$$

b) Assume that for an ideal differentiator circuit, R = 200Ω, and C = 5μF. If the input voltage is Vin = 5v + 1v Sin(ωt+ϕ), what is the output voltage. (6 points)

$$V_{out} = -RC\frac{dV_{in}}{dt}$$

$$\frac{dV_{in}}{dt} = 0 + (-\omega \times 1v)\cos(\omega t + \phi)$$

$$\Rightarrow V_{out} = -200 \times 5\times10^{-6}\,\omega\cos(\omega t+\phi)$$

$$\Rightarrow \boxed{V_{out} = -0.001\,\omega\cos(\omega t + \phi)}$$

EI TEST 3A Fall 2001 Name___________________ Sect________

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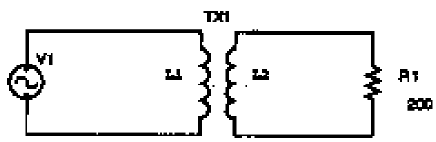
5) Transformer



a) If the L1 coil has 100 turns, and L2 coil has 400 turns what is the voltage across R1? (4 pt)

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = \frac{400}{100} \Rightarrow \boxed{V_2 = V_{R_1} = 4V_1}$$

b) In terms of V1, what is the current in the loop containing L2, and R1?(4pt)

$$I_2 = \frac{V_2}{R_1} = \frac{4V_1}{200} \rightarrow \boxed{I_2 = 20\,mA}$$

c) What is the Impedance Zin of L1? (4 pt)

$$Z_{in} = \frac{R_1}{a^2} = \frac{200\,\Omega}{4^2} \Rightarrow \boxed{Z_{in} = 12.5\,\Omega}$$

d) In the inductors that make up this transformer, which would increase the inductance most? (4 pt)

a.) air core b) wood core (c) iron core) [illegible]

Magnetic Material

e) Which would be the best voltage source to use in this circuit (4pt)

a) 100mv DC b) 5V DC (c) 100mvsin(500t)) (d) 5Vsin(500kt))

Both c and d will be considered correct