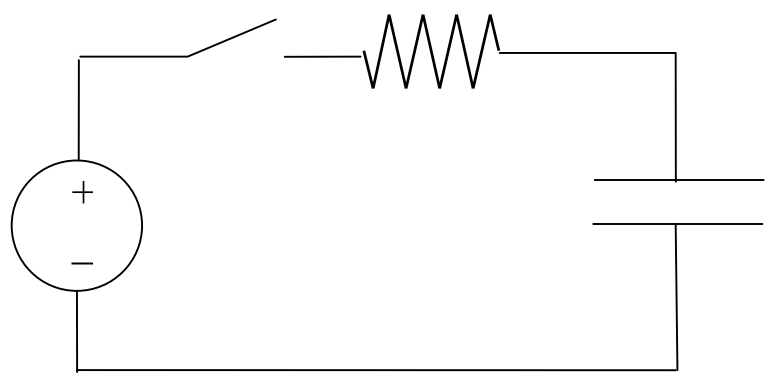
University of California, Berkeley
EE42
Fall 2004

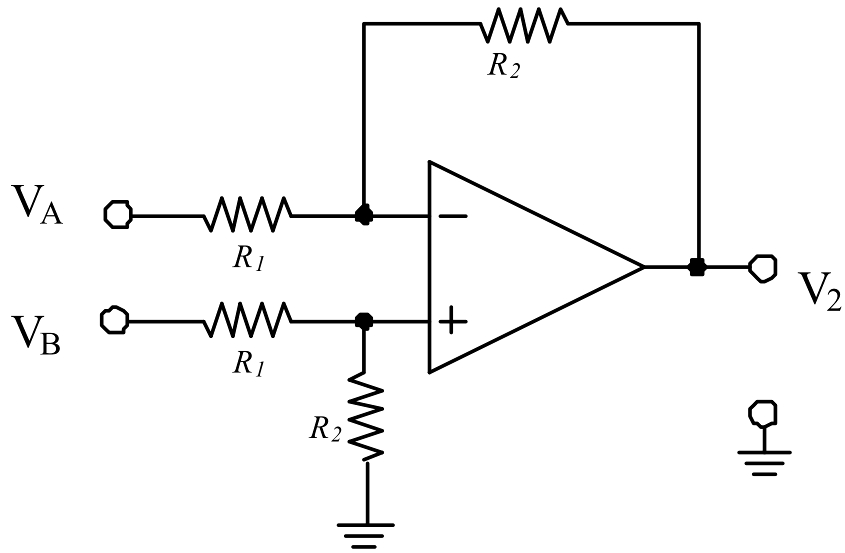
Problem Set 6

Due Thursday October 28, 5:00pm, box in Cory 240
(Note that the due date is delayed by a day.)

1) When a capacitor is charged, it stores energy. If you charge a capacitor from a fixed voltage source and a resistor, however, some of the energy is lost (turned into heat) in the resistor. Show that half of the energy provided by the source is lost in the resistor for the following circuit, and half ends up stored in the capacitor *no matter what the resistance of the resistor is*. This is part of an interesting question, about whether it must take power to calculate (since switching and charging up wires is a major power consumption of conventional logic circuits.) (hint: This can be done by calculating the voltage and current across the resistor and capacitor and integrating with respect to time. Since a perfect capacitor does not lose any energy, the instantaneous stored power is $I_C(t)*V_C(t)$, where $I_R(t)*V_R(t)$ instantaneous power for the resistor gives the power lost to heating up the resistor)



2) Given the following circuit:



Assuming that the amplifier has infinite input resistance and zero output resistance show that the voltage V_2 equals K (V_B-V_A) if A is very large? What is K? (Hint: depends only on R_1, R_2.)

3) Use a truth table to prove DeMorgan's Theorem:

$$A + B = \overline{(\overline{A} \cdot \overline{B})}$$

Hint: Simply construct a table with 4 columns: A, B, left hand side of above and right hand side.

There need be only 4 rows, one for each possible combination of A and B.

4) You are working out the logic for a burglar alarm for your apartment. You have switches on the door and on each of three windows. The switch on the door is closed when the door is opened; the switch on a particular window is closed when the corresponding window is open. Using a battery and resistors you construct a circuit at each switch that generates a "high" of 1.5V (which we will call logical **1**) whenever the respective switch is open and a "low" of 0V (logical **0**) when a switch is closed. Let's define logical variables **D, W1, W2**, and **W3** to represent the conditions of the door and windows. (For example **D = 0** when the door is opened.) You also have a key switch to arm or disarm the alarm. Call this key function "**K**". It is closed (**K=0**) when the alarm system is turned on. Construct a truth table which gives the alarm condition as a function of **D, W1, W2, W3,** and **K**. Let's call the alarm function "**A**".

(a) Write out the truth table for **A** in terms of **D, K, W1, W2** and **W3**. This table of course has 32 rows, considering all possible binary values for the five input variables.
(b) Identify the row or rows in the truth table which produce the desired logical result (alarm variable is high when key switch is closed and one or more of the windows or door is open).
(c) Express this result as a logical expression. **A**= ?