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# Do not click until you are ready to take the exam

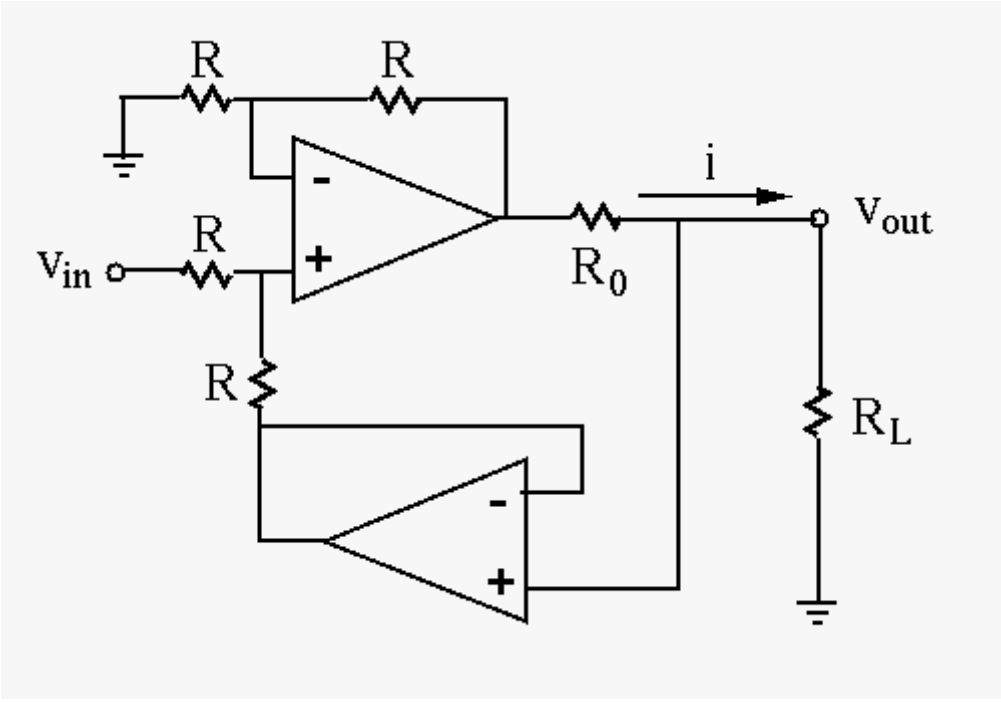
### The Problems

1. **Problem 12 (33 points)**

   The circuit given below is composed of a differential amplifier (top) and a voltage follower (bottom), whick feeds the output $v_{out}$ to the non-inverting input of the differentiator.

   Give the expression of the output current $\underline{i}$, and show that it is uniquely determined by the circuit parameters, independent of the load resistor $R_L$, i.e., the circuit is a current source.

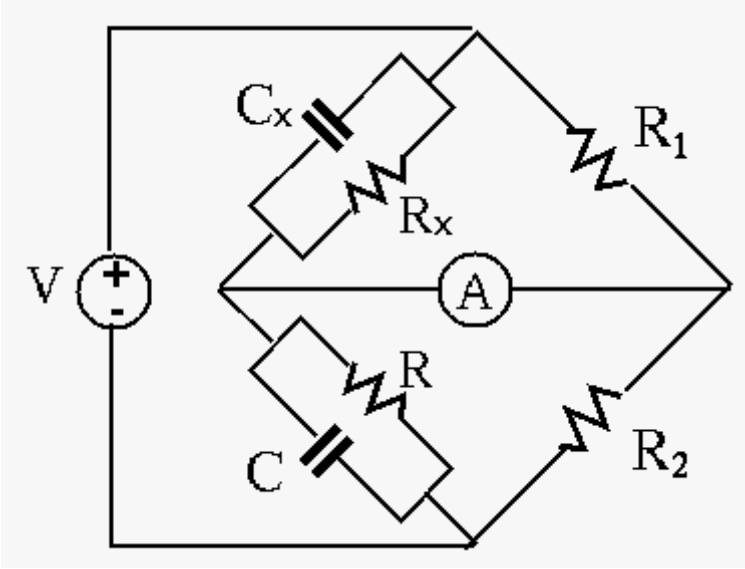
   **Hint:** use virtual ground assumption, label the voltages at both the inverting and non-inverting inputs of the differentiator by $V_1$, and label the output of the differentiator as $V_2$. Apply KCL to the two input nodes.




2. **Problem 2 (33 points)**

   The AC bridge circuit shown below powered by an AC voltage source is used to measure the unknown capacitance $C_x$ and unknown resistance $R_x$. By adjusting $R_1$ or $R_2$, the bridge is balanced, i.e., the

current through the ampmeter is zero, and the values of $C_x$ and $R_x$ can be expressed in terms of the known values of $R$, $C$, $R_1$ and $R_2$. Give these expressions for $C_x$ and $R_x$.




3. **Problem 3 (34 points)**

In the circuit given below, $R_1 = R_2 = 10\,k\Omega$, $R_3 = 20\,k\Omega$, $C = 10\,\mu F$, the current source is $I = 1\,mA$, the voltage source is $V = 10\,V$. The circuit is at steady state before the switch $s$ closes at $t = 0$. Find the current $i(t)$ through $R_3$ and voltage $v_c(t)$ across $C$ for $t > 0$, and sketch them as two functions of time.