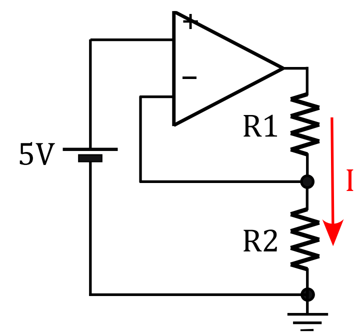
PHY 336 HW2 **Due: October 28/21 at the beginning of class**

For each of the problems, show all your work. If it is not obvious what you are doing, briefly explain what steps you are taking to arrive at the solution.

Problem 1

A non-inverting amplifier is made with an op-amp that is powered with ± 15V. The op-amp can be considered ideal, so that the usual rules of the op-amp apply.



The input voltage is fixed to 5V, thus at the output of the op-amp we will have $\left(1+\frac{R_1}{R_2}\right)5V$.

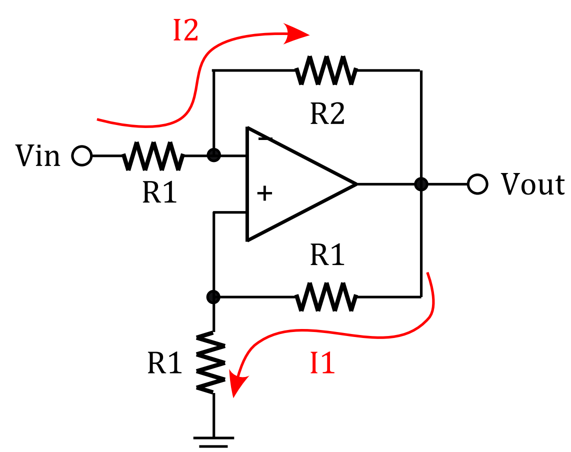
a) Briefly explain why the current does not split up at the node between R_1 and R_2, i.e. why the current I through R_2 is the same as through R_1.

b) How does the current I change if R_2 is doubled and R_1 remains unchanged?

c) How does the current I change if R_1 is doubled and R_2 remains unchanged?

Problem 2 (A modified version of 6.11 #3 p. 273, second edition only)

Consider the circuit shown which is built from four resistors and an op-amp.



a) What is the voltage at the non-inverting op-amp input ($V+$)? Express your result in terms of In terms of V_{out}, R_1 and R_2.

b) What is the input current to the circuit (current I_2 in the diagram). Express your result in terms of V_{in}, V_{out}, R_1 and R_2.

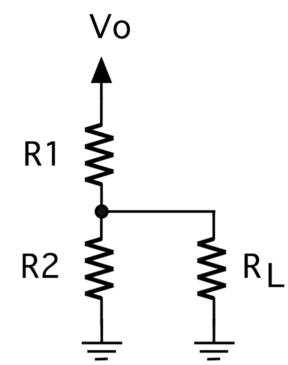
c) What is the voltage at the inverting op-amp input ($V-$)? Express your result in terms of V_{in}, V_{out}, R_1 and R_2.

c) By demanding that $V+ = V-$, show that the output voltage of the circuit is

$$V_{out} = \frac{2R_2}{R_2 - R_1} V_{in}$$

Problem 3

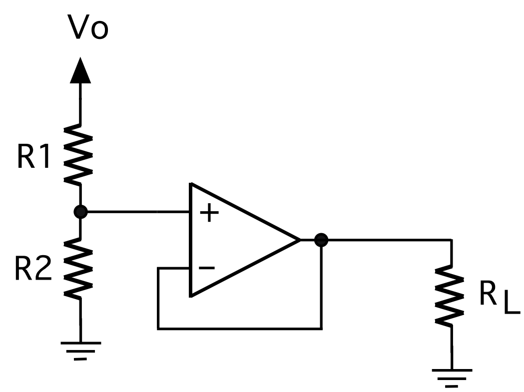
A load resistor R_L is connected to a voltage divider made of two resistors R1 and R2 as shown.



a) Find an expression for the voltage drop across the load resistor.

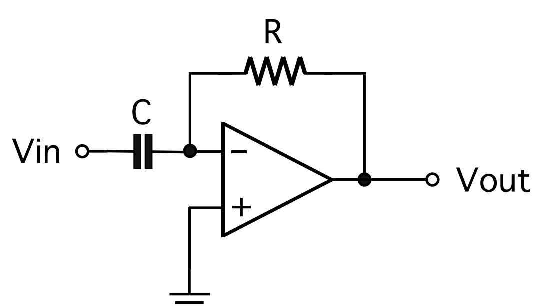
b) Let Vo = 10V, R1 = R2 = 10kΩ and R_L = 5kΩ. What happens to the voltage drop across the 5-kΩ load resistor if its value suddenly decreases to 2 kΩ? Justify you answer with a calculation.

c) Now you add a voltage follower between the load resistor and the voltage divider as shown. Determine the voltage across the 5-kΩ load resistor. What happens to the voltage across the 5-kΩ resistor if it suddenly decreases to 3 kΩ? Explain why this is different than in part b).



Problem 4

a) Derive an expression for V_{out} as a function of V_{in}, R and C. Follow the same steps that we have taken in class with the integrator circuit (i.e. the circuit that had the capacitor in the feedback branch).



b) Suppose the square wave signal shown below is connected to the input of the circuit. Carefully draw a graph of the output voltage as a function of time. Use the attached sheet to construct your drawing. Be as quantitative as possible, using R = 2kΩ and C = 50μF, and assume the op-amp is powered with ±12V.

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