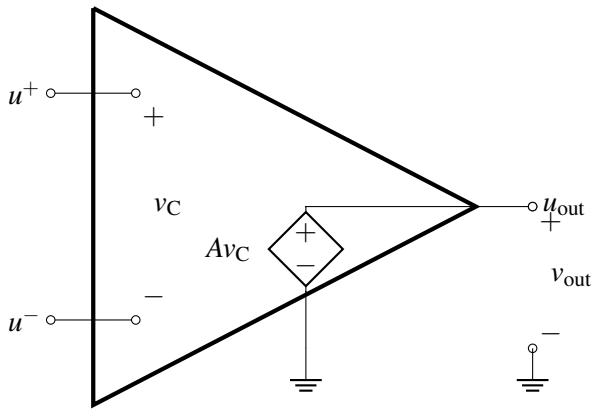
EECS 16A Designing Information Devices and Systems I
Summer 2020 Discussion 4D

1. Op-Amp Rules and Negative Feedback Rule

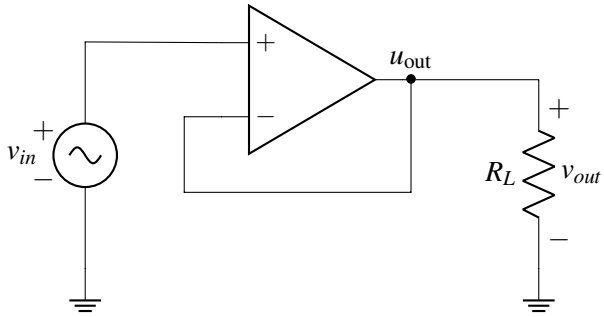
Here is an equivalent circuit of an op-amp (where we are assuming that $V_{SS} = -V_{DD}$) for reference:



(a) What are the currents flowing into the positive and negative terminals of the op-amp (i.e., what are I^+ and I^-)? Based on this answer, what are some of the advantages of using an op-amp in your circuit designs?

(b) Suppose we add a resistor of value R_L between u_{out} and ground. What is the value of v_{out}? Does your answer depend on R_L? In other words, how does R_L affect Av_C? What are the implications of this with respect to using op-amps in circuit design?

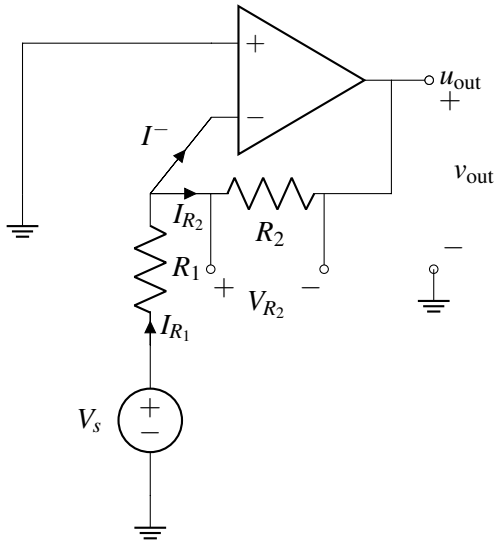
For the rest of the problem, consider the following op-amp circuit in negative feedback:



(c) Assuming that this is an ideal op-amp, what is v_{out}?

(d) Draw the equivalent circuit for this op-amp and calculate v_{out} in terms of A, v_{in}, and R_L for the circuit in negative feedback. Does v_{out} depend on R_L? What is v_{out} in the limit as $A \to \infty$?

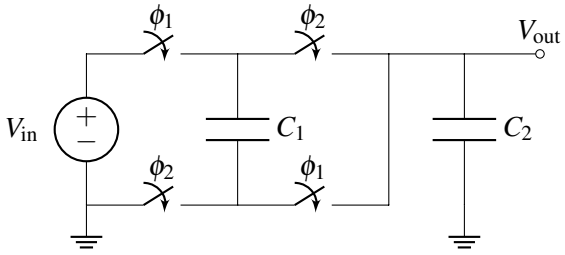
2. An Inverting Amplifier



(a) Calculate v_{out} as a function of V_s and R_1 and R_2.

3. Charge Sharing

Consider the circuit shown below. In phase ϕ_1, the switches labeled ϕ_1 are on while the switches labeled ϕ_2 are off. In phase ϕ_2, the switches labeled ϕ_2 are on while the switches labeled ϕ_1 are off.



(a) Draw the polarity of the voltage (using + and − signs) across the two capacitors C_1 and C_2. (It doesn't matter which terminal you label + or −; just remember to keep these consistent through phase 1 and 2!)

(b) Redraw the circuit in phase ϕ_1 and phase ϕ_2. Keep your polarity from part (a) in mind.

(c) Find V_{out} in phase ϕ_2 as a function of V_{in}, C_1, and C_2.

(d) How will the charges be distributed in phase ϕ_2 if we assume $C_1 \gg C_2$?

