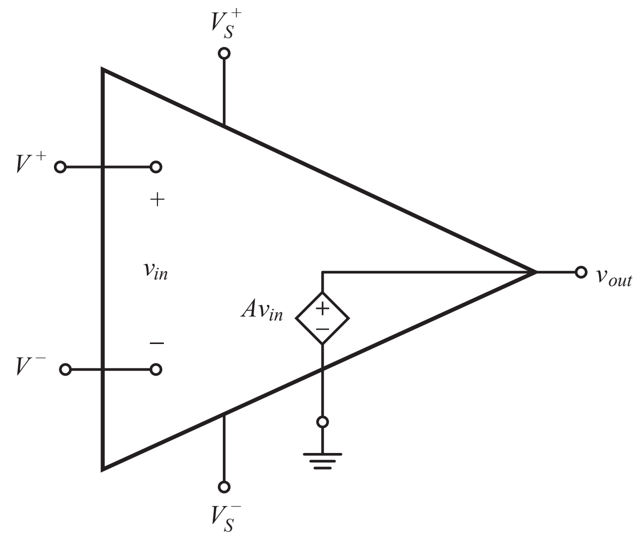
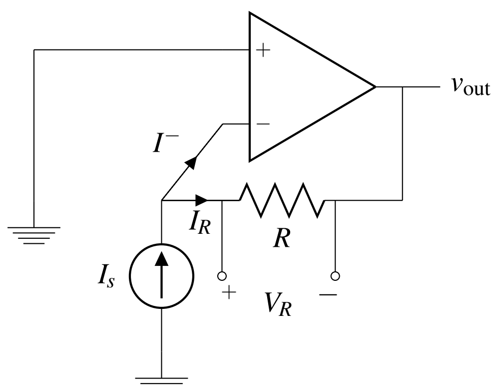
1. A Trans-Impedance Amplifier



Above is a picture of the equivalent circuit of an op-amp. Consider the following circuit with an ideal op amp in negative feedback:

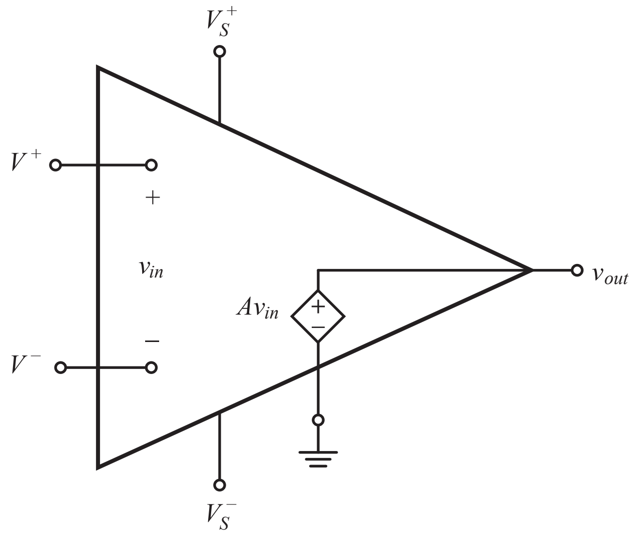


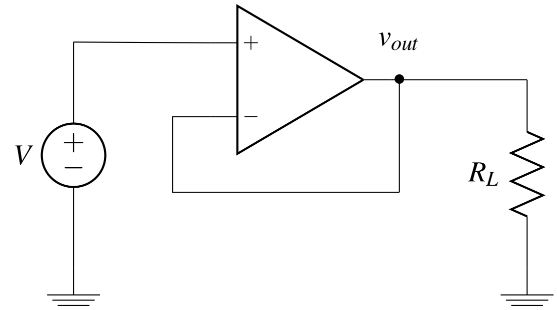
(a) Use the golden rules to calculate v_{out} as a function of I_s and R.

(b) Use the golden rules to implement the same behavior as the above circuit (with a current source), but use instead a voltage source and resistor.

2. Op-Amp Golden Rules

On the left is the picture of the equivalent circuit of an op-amp 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^-? What are some of the advantages of your answer with respect to using an op amp in your circuit designs?

(b) Suppose we add a resistor of value R_L between v_{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_{in}? What are the implications of this with respect to using op amps in circuit design?

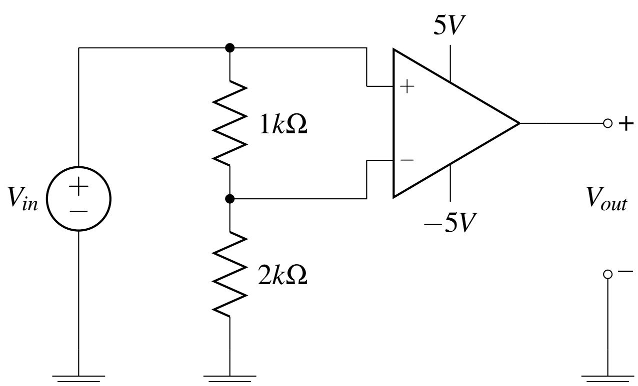
(c) Now consider the circuit on the right. Assuming this is an ideal op amp, what is v_{out}?

(d) Assume for the op-amp that $R_{\text{in}} \to \infty$ and $R_{\text{out}} \to 0$. Draw the equivalent circuit for this op-amp and calculate v_{out} in terms of A, V and R_L. Does v_{out} depend on R_L? What is v_{out} in the limit as $A \to \infty$?

3. Op-amps as Comparators

For each of the circuits shown below, plot V_{out} for V_{in} ranging from -10V to 10V for (a) and from 0V to 10V for (b). Let A = 100 for your plots.

(a)



(b)