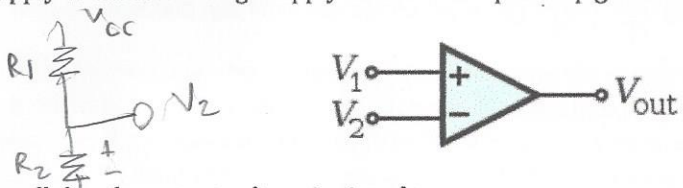
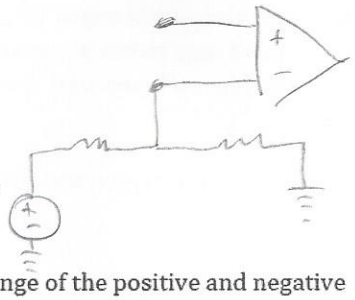
The Comparator

The inverting and non-inverting amplifiers are both configured with a negative feedback loop in order to amplify the input signal by a reasonable gain factor. But what if we simply wanted the output to be high or low? Would we still use a negative feedback loop?

Below is a diagram of the comparator. At first glance, we find that the comparator will saturate to the high voltage supply or the low voltage supply because the open loop gain of the operational amplifier is very large.





Also we recall that the output voltage is given by:

$$V_{out} = A(V_+ - V_-)$$

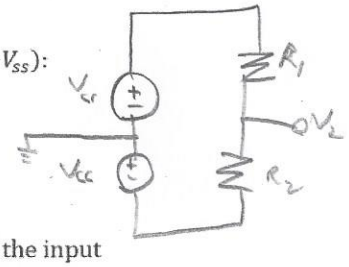
In this case, $V_+ = V_1$ and $V_- = V_2$.

In practice, the output voltage of the operational amplifier is limited by the range of the positive and negative power supply voltages. If the output voltage V_{out} falls into the range outside the supply voltages, we obtain a condition known as *saturation*. In this case, the operational amplifier will simply output the highest or lowest voltage available, which are the values of the high and low supply voltages[2].

It is fairly simple to see that the output voltage would be given by the following ($V_{supply} = V_{cc} = -V_{ss}$):

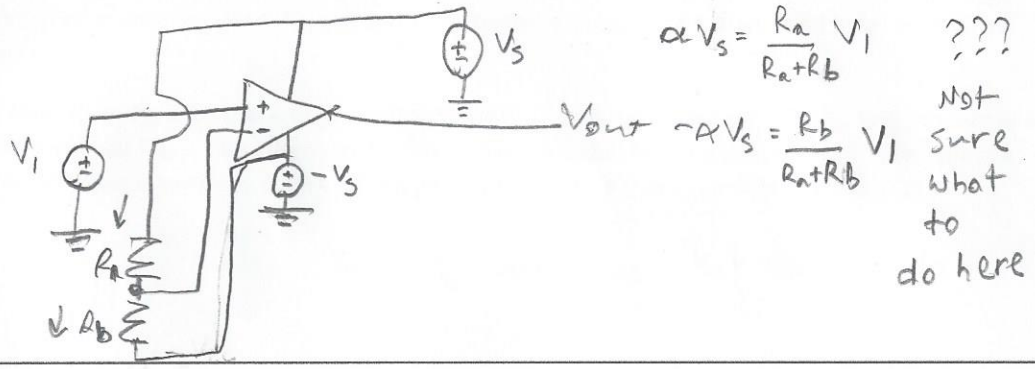
$$V_{out} = V_{supply} \; if \; V_1 > V_2$$

$$V_{out} = -V_{supply} if \; V_1 < V_2$$



Keeping this in mind, suppose we wanted to design a circuit which would output high or V_{supply} if the input voltage $V_1 > \alpha V_{supply}$ (and low or $-V_{supply}$ otherwise), where α is a constant and $-1 < \alpha < 1$. Draw the circuit below using ONLY one comparator, two resistors R_a, and R_b, and supplies V_{cc}, and $V_{ss} = -V_{cc}$. Clearly label the positive and negative supply voltages, the input voltage V_1, and the output voltage V_{out}. Also find a relationship between R_a, R_b, and α.

Score __/5



[2] Not all op-amps are capable of driving the output all the way to the supply voltage. While some op-amps, such as the LMC6482 have a so-called "rail-to-rail" output, an op-amp without this feature may only be able to drive the output to within a volt or two of the supply. In our case, the TLC277 does not have a rail-to-rail output.