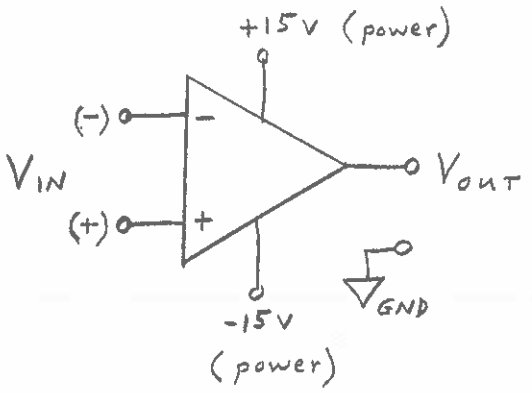
OPERATIONAL AMPLIFIER (OP-AMP)



Input and output voltages are in the range of +10 v to -10 v with respect to ground.

Output voltage V_{OUT} is with respect to ground.

Input voltage is $V_{IN}(+)$ with respect to $V_{IN}(-)$.

Either input can be connected to gnd or to any other voltage between +10 v and -10 v.

For Design Purposes:

Assume input impeadance = ∞ infinity (It's typically = 10 Meg ohm)
Therefore, no current flows into inputs.
Assume gain, V_{OUT}/V_{IN} = ∞ infinity (typically = 1 million)

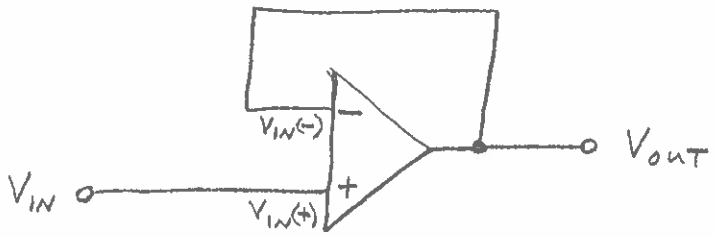
If $V_{IN}(+) > V_{IN}(-)$, then V_{OUT} saturates at +10 v.

If $V_{IN}(+) < V_{IN}(-)$, then V_{OUT} saturates at -10 v.

* { V_{OUT} stays between ±10 v (normal linear operation) only when $V_{IN}(+) = V_{IN}(-)$.

This last condition is obtained by the clever use of feedback components (resistors and capacitors).
Over-all gain of circuit is controlled by feedback components.
For proper operation, gain should be less than 100, and resistors should be between 1K ohm and 1 Meg ohm.

EXAMPLE #1: Unity Gain Buffer:



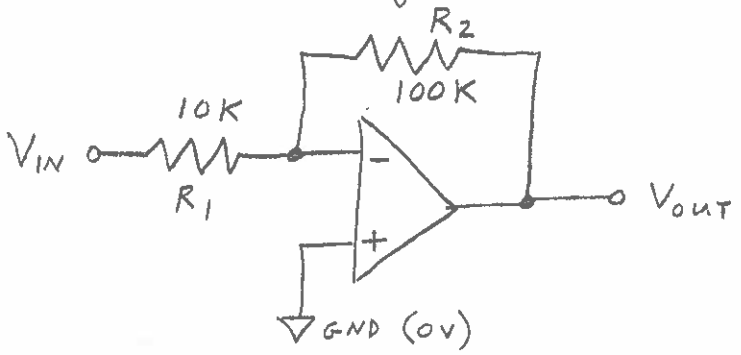
$$Gain = +1$$

$$V_{OUT} = V_{IN}$$

The purpose of this circuit is to monitor a voltage (V_{IN}) from a delicate source without loading it down (without drawing any current) and transferring this voltage to a circuit that draws up to 1 milliamp such as a 1K ohm resistor.

* To understand intuatively how this circuit works, just think what voltage V_{OUT} has to go to in order to make $V_{IN}(-) = V_{IN}(+)$.

EXAMPLE #2: Inverting Amplifier (most common circuit)



$$GAIN = V_{OUT}/V_{IN} = -R_2/R_1 = -10$$

$$V_{OUT} = (-R_2/R_1) * (V_{IN})$$

If +0.5 v is applied at V_{IN},

then $V_{OUT} = -R_2/R_1 * V_{IN} = -10\,V_{IN} = -5\,V$.

* To understand this intuatively, just think what voltage V_{OUT} has to go to in order to make $V_{IN}(-) = V_{IN}(+) = 0v$.

Current through R_1 is $I_1 = V_1/R_1 = 0.5v/10K\Omega = 50\,mAmp$.

Current through R_2 is I_2 .

$I_2 = I_1$ because I_1 has to go somewhere, and it doesn't go into op-amp because input impeadance = ∞ .

Voltage across R_2 is V_2 .

$V_2 = I_2 * R_2 = 50mA * 100K\Omega = 5\,v$ (below 0 v)

or $-5\,v$.