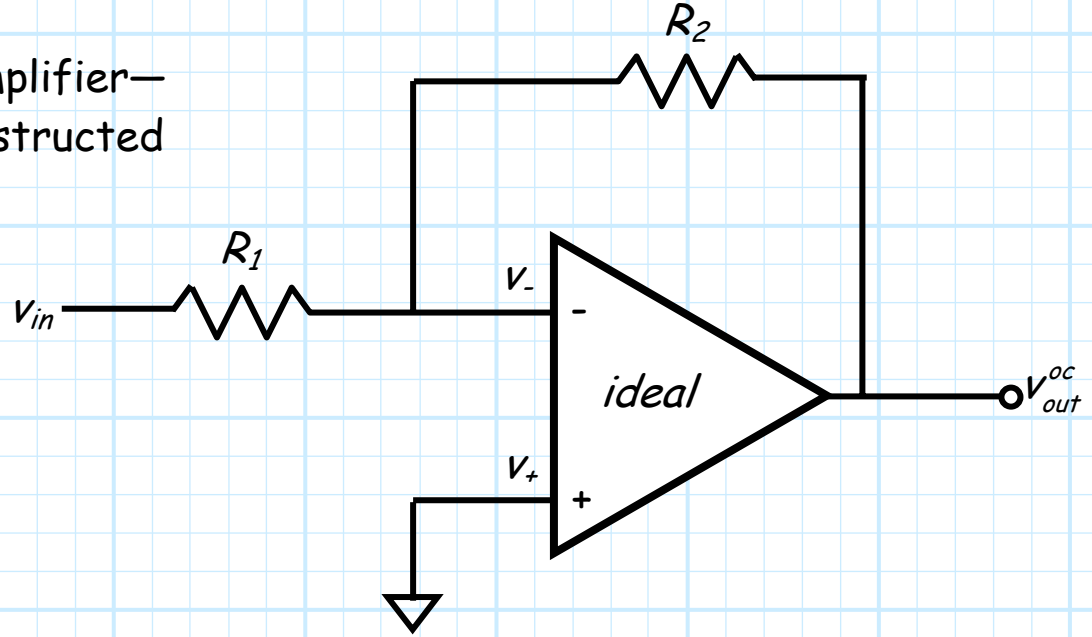
Closed-Loop and Open-Loop Gain

Consider the inverting amplifier—a **feedback** amplifier constructed with an op-amp:



The **open-circuit** voltage gain of this amplifier:

$$A_{vo} = \frac{-R_2}{R_1}$$

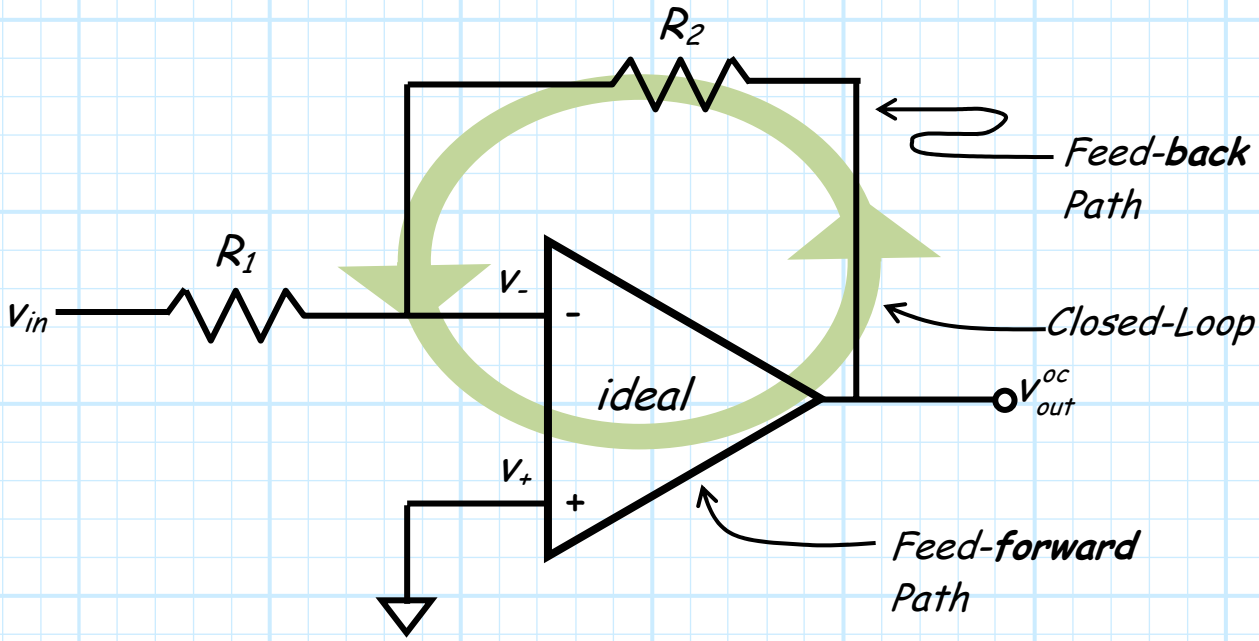
is also referred to by engineers the **closed loop gain** of the **feedback amplifier**.

A closed loop

Q: ***Closed loop?*** *What does that mean?*

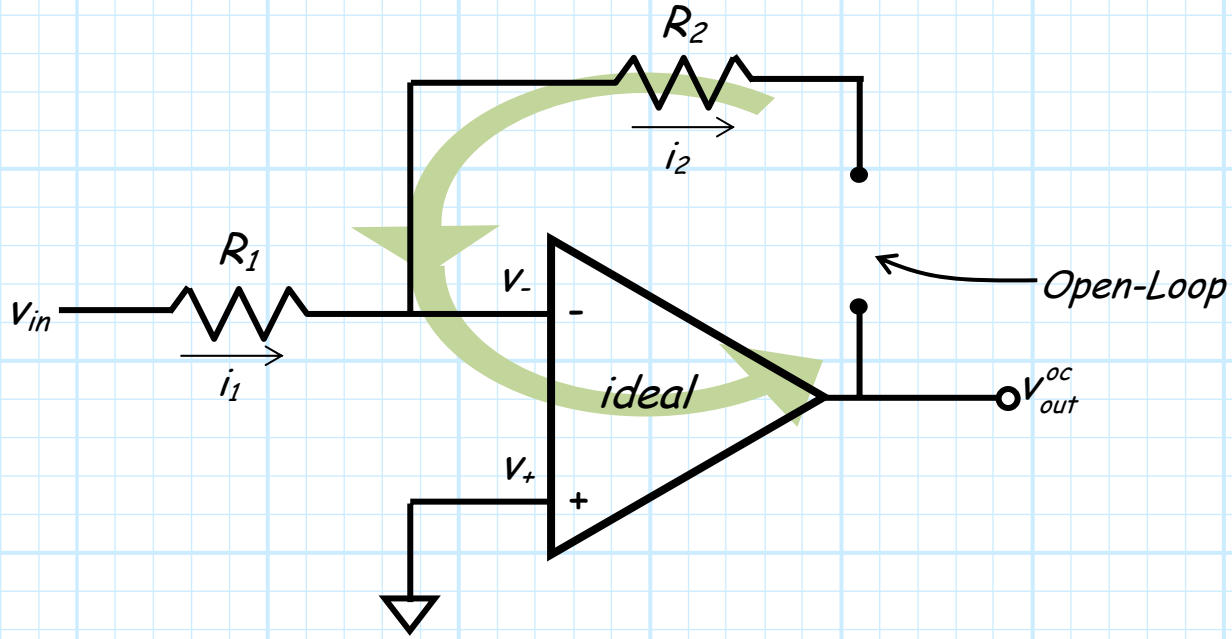
A: The term "closed loop" refers to loop formed by the **feed-forward** path and the **feed-back** (i.e., feedback) path of the amplifier.

In this case, the **feed-forward** path is formed by the **op-amp**, while the **feed-back** path is formed by the feedback **resistor** R_2.



An open loop

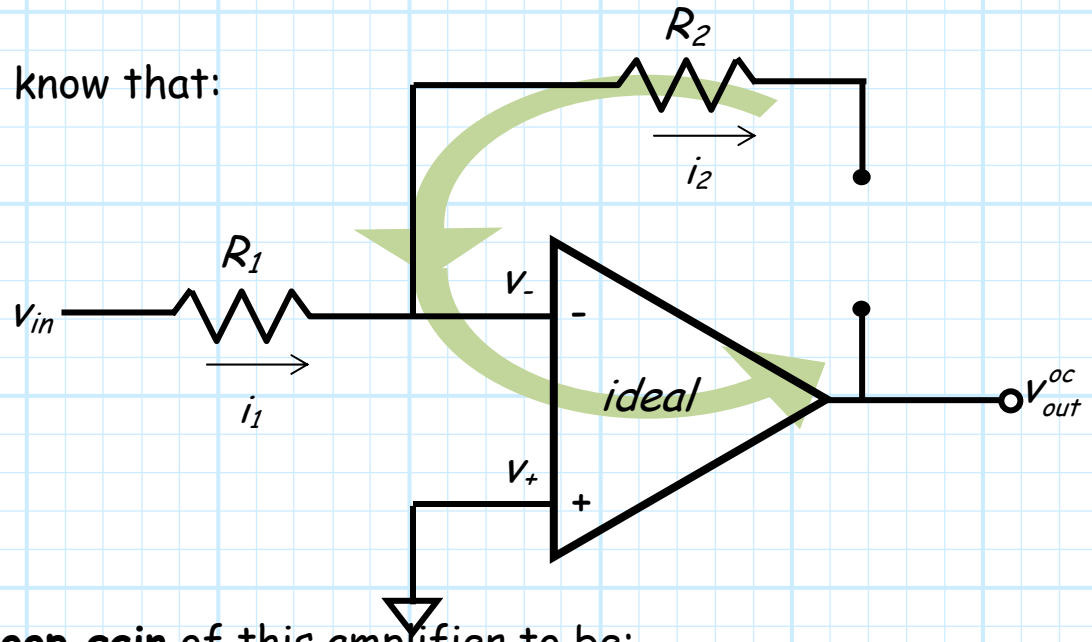
If the loop is **broken**, then we say the loop is "open". The gain (v_o/v_i) for the open loop case is referred to as the **open-loop gain**.



Open and closed loop gains

For example, in the circuit we know that:

$$v_+ = 0$$
$$v_{out}^{oc} = A_{op}\left(v_+ - v_-\right)$$
$$i_1 = i_2 = 0$$
$$v_- = v_{in} - i_1 R_1 = 0$$



Combining, we find the **open-loop gain** of this amplifier to be:

$$A_{open} = \frac{v_{out}^{oc}}{v_{in}} = -A_{op}$$

Once we "close" the loop, we have an amplifier with a **closed-loop** gain:

$$A_{closed} = \frac{v_{out}^{oc}}{v_{in}} = -\frac{R_2}{R_1}$$

which of course is the **open-circuit voltage gain** of this inverting amplifier.

Feedback is a wonderful thing

Note that the **closed**-loop gain ($-R_2/R_1$) does **not** explicitly involve the op-amp gain A_{op}.

* The closed-loop gain is determined by two **resistor** values, which typically are selected to provide **significant** gain ($|A_{vo}| > 1$), albeit not so large that the amplifier is easily **saturated**.

* Conversely, the **open**-loop gain ($-A_{op}$) obviously **does** involve the op-amp gain. Moreover, as in this case, the open-loop gain of a feedback amplifier often **only** involves the op-amp gain!

* As a result, the **op-amp gain** is often alternatively referred to as the **open-loop gain**.

Note that **closing** the feedback loop turns a generally **useless** amplifier (the gain is too high!) into a **very** useful one (the gain is just right)!