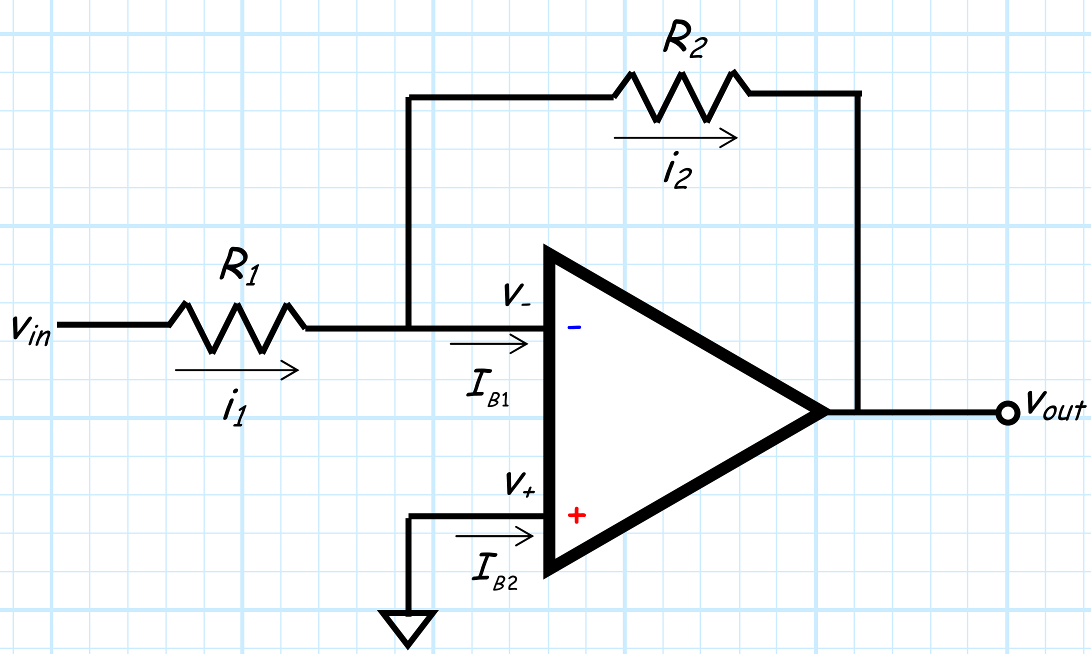
Example: The Input Bias Current

Q: *How do **input bias currents** I_{B1} and I_{B2} affect amplifier operation?*

A: Consider **both** inverting and non-inverting configurations.

Inverting Configuration



KCL is now a bit more tricky!

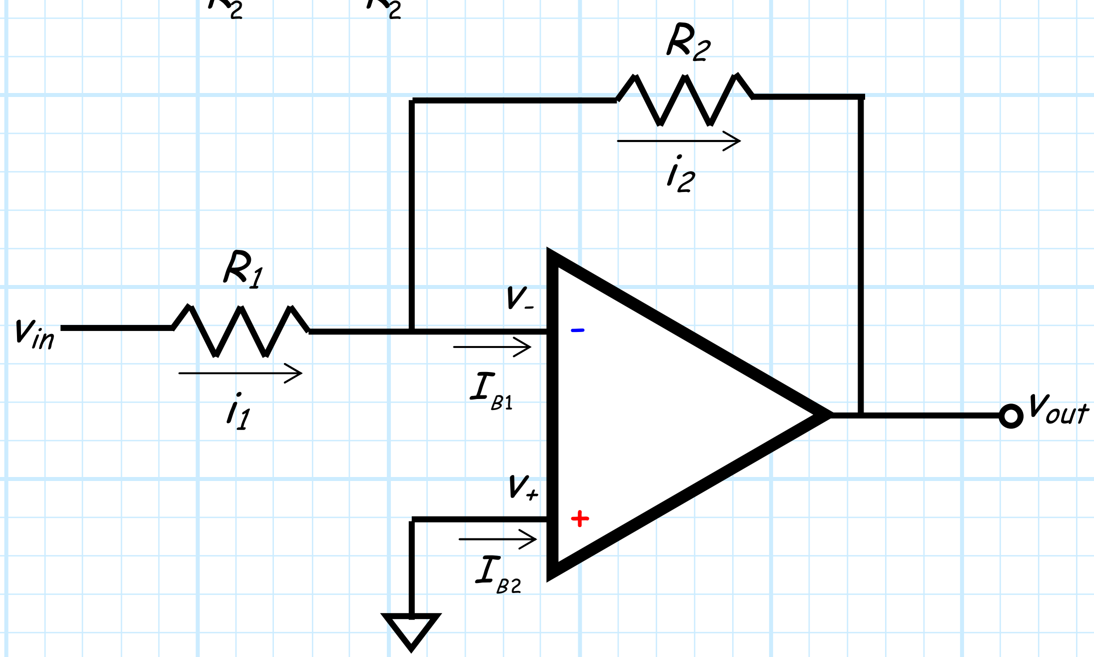
In this case, we apply **KCL** and we find:

$$i_1 = i_2 + I_{B1}$$

However, we still find $v_- \simeq v_+ = 0$ (**neglecting** the input offset voltage) by virtue of the virtual short.

Therefore, from KVL and Ohm's Law:

$$i_1 = \frac{v_{in} - v_-}{R_1} = \frac{v_{in}}{R_1} \quad \text{and} \quad i_2 = \frac{v_- - v_{out}}{R_2} = \frac{-v_{out}}{R_2}$$



Combining these results:

$$\frac{v_{in}}{R_1} = \frac{-v_{out}}{R_2} + I_{B1}$$

The output voltage is thus:

$$v_{out} = -\left(\frac{R_2}{R_1}\right) v_{in} + R_2 I_{B1}$$

Should we make R_1 really small?

Note again that if $I_{B1} = 0$, the result reduces to the expected **inverting amplifier** equation:

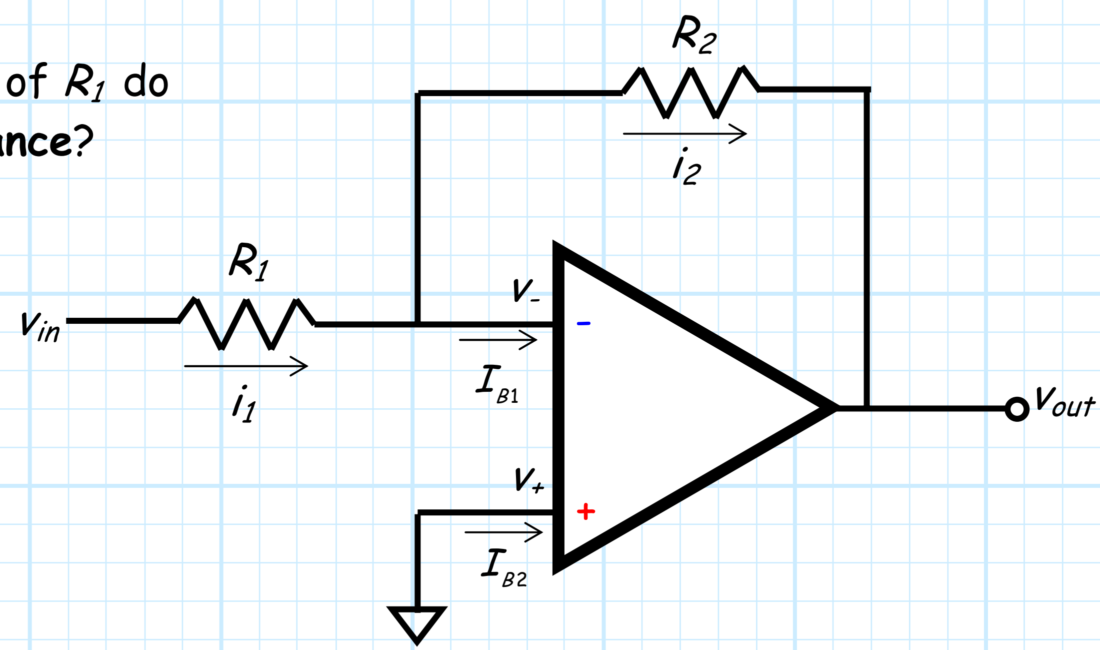
$$v_{out} = -\left(\frac{R_2}{R_1}\right) v_{in}$$

The second term in the above expression ($I_{B1} R_1$) therefore represents another **output offset voltage**!

It appears that we should keep the value of R_1 **small** to minimize the output offset voltage.

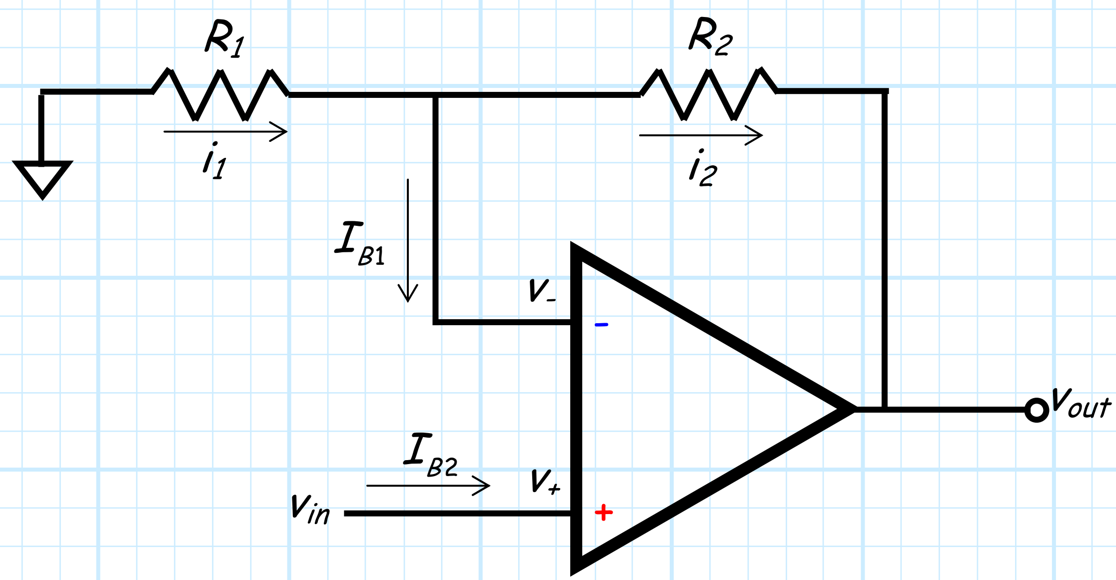
Q: What would a small value of R_1 do to the amplifier **input resistance**?

A:



Please welcome the non-inverting config.

Non-Inverting Configuration



Neglecting the input offset voltage, we can use the **virtual short** to determine that:

$$v_{-} \simeq v_{in}$$

and **KCL** provides the same result as that of the inverting amplifier:

$$i_1 = i_2 + I_{B1}$$

Again, a DC output offset

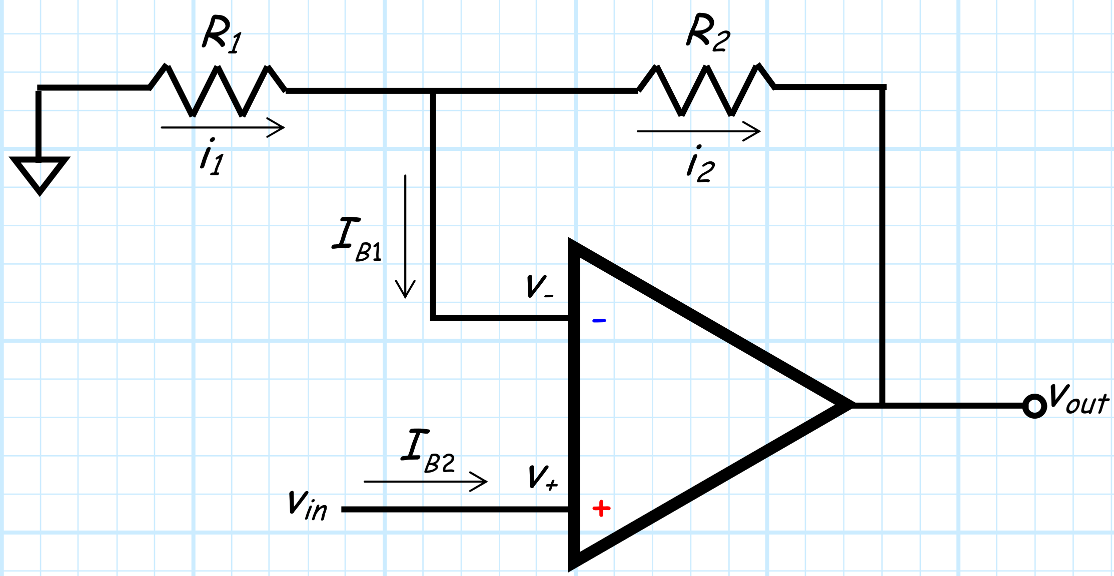
From **KVL and Ohm's Law**:

$$i_1 = \frac{0 - v_-}{R_1} = \frac{-v_{in}}{R_1}$$

and likewise:

$$i_2 = \frac{v_- - v_{out}}{R_2} = \frac{v_{in} - v_{out}}{R_2}$$

Combining, we find:



$$\frac{-v_{in}}{R_1} = \frac{v_{in} - v_{out}}{R_2} + I_{B1}$$

or rearranging:

$$v_{out} = \left(1 + \frac{R_2}{R_1}\right) v_{in} + I_{B1} R_2$$

We have another trick or two up our sleeve

Again, we find that this result is simply the ideal **non-inverting** expression:

$$v_{out} = \left(1 + \frac{R_2}{R_1}\right) v_{in}$$

with an added **output offset voltage** term:

$$I_{B1} R_2$$

In this case, we find that this offset voltage is minimized by making feedback resistor R_2 **small**.

In general, we find that the effects of the input bias currents can be minimized by using **small** resistor values.

However, we will find that there is an **additional strategy** for minimizing the effects of input bias currents!