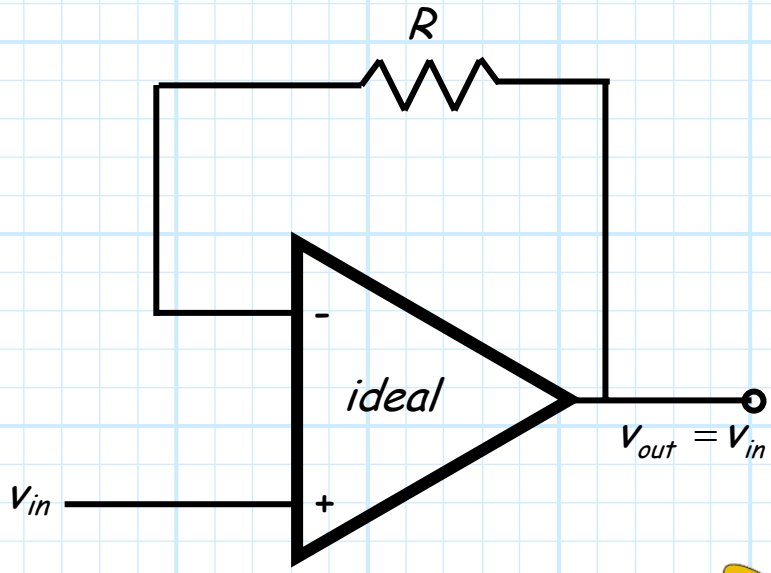
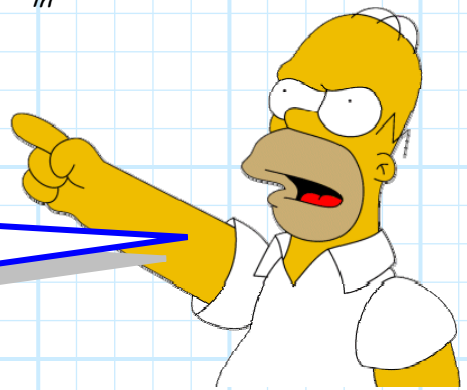
The Voltage Follower

The **voltage follower** has a open-circuit voltage gain $A_{vo} = 1$—with the result that $v_{out} = v_{in}$!



Q: *Pfft! The output voltage is* ***equal*** *to the input voltage?!*

Why *even bother?*



A: To see **why** the voltage follower is **important**, consider the following example.

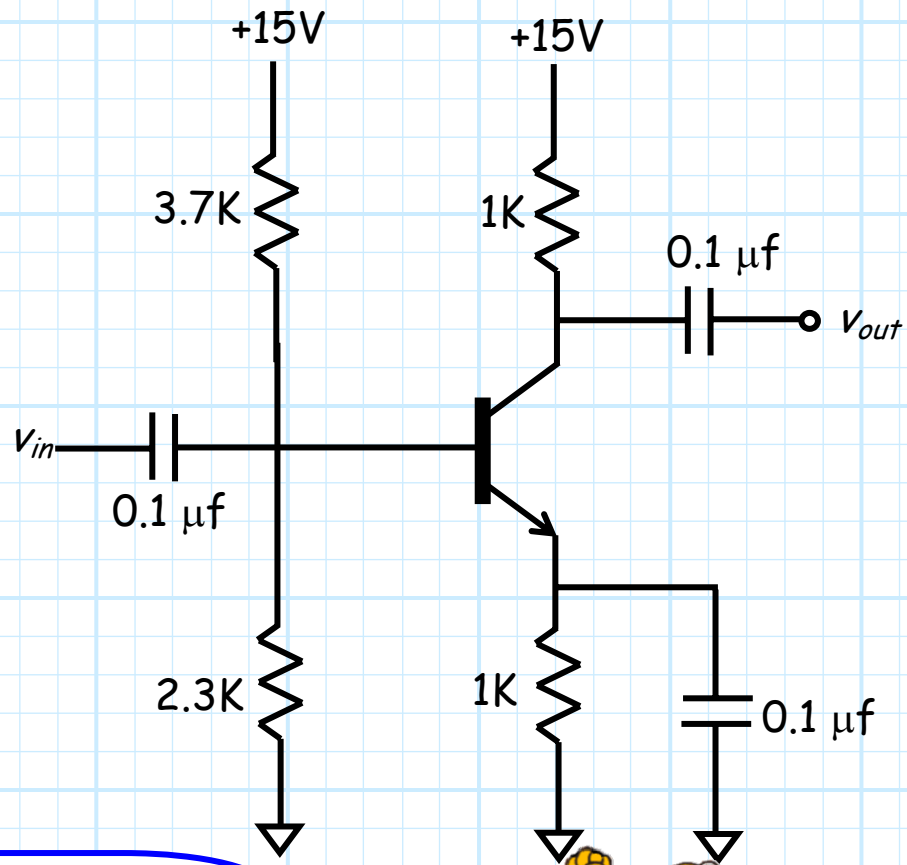
What a great amp…

Say **you** have toiled for hours to design and build the following **audio amplifier**:

A_{vo} = -200 (midband)

R_{out} = 1 K

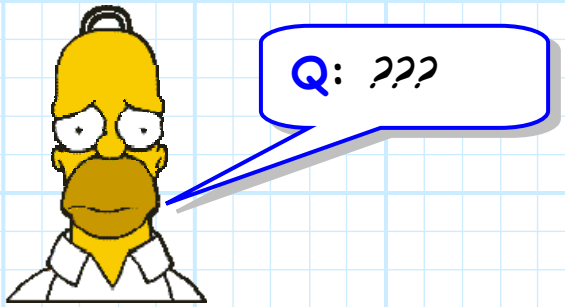
R_i = 370 Ω



Q: $A_{vo} = -200$ *! With this much gain we'll be shakin the windows—right?*

...or, maybe not

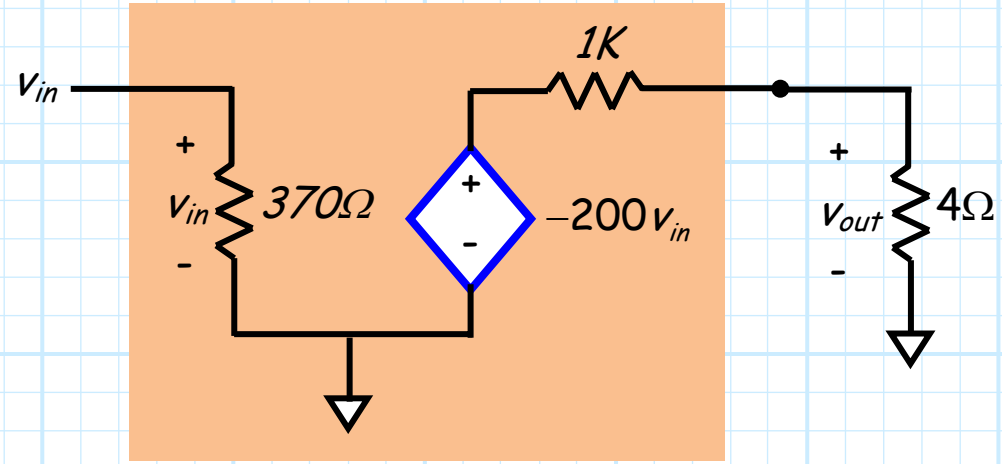
A: Actually, if we connected this amplifier **directly** to a speaker, **nothing** would happen—**silence**!



A: The reason for this is that the **resistance** of most **speakers** is **very small** (4 Ω-8 Ω).

What's the problem then?

We can use the linear equivalent **circuit model** of the audio amplifier to **analyze** the result:



$$v_{out} = -200\,v_{in}\left(\frac{4}{4+1000}\right) = -0.8\,v_{in}$$

The **output** of this amplifier is even **smaller** than its **input**!

The **problem**, of course, is **not** that the open-circuit voltage **gain** is too small—after all, it's –200!

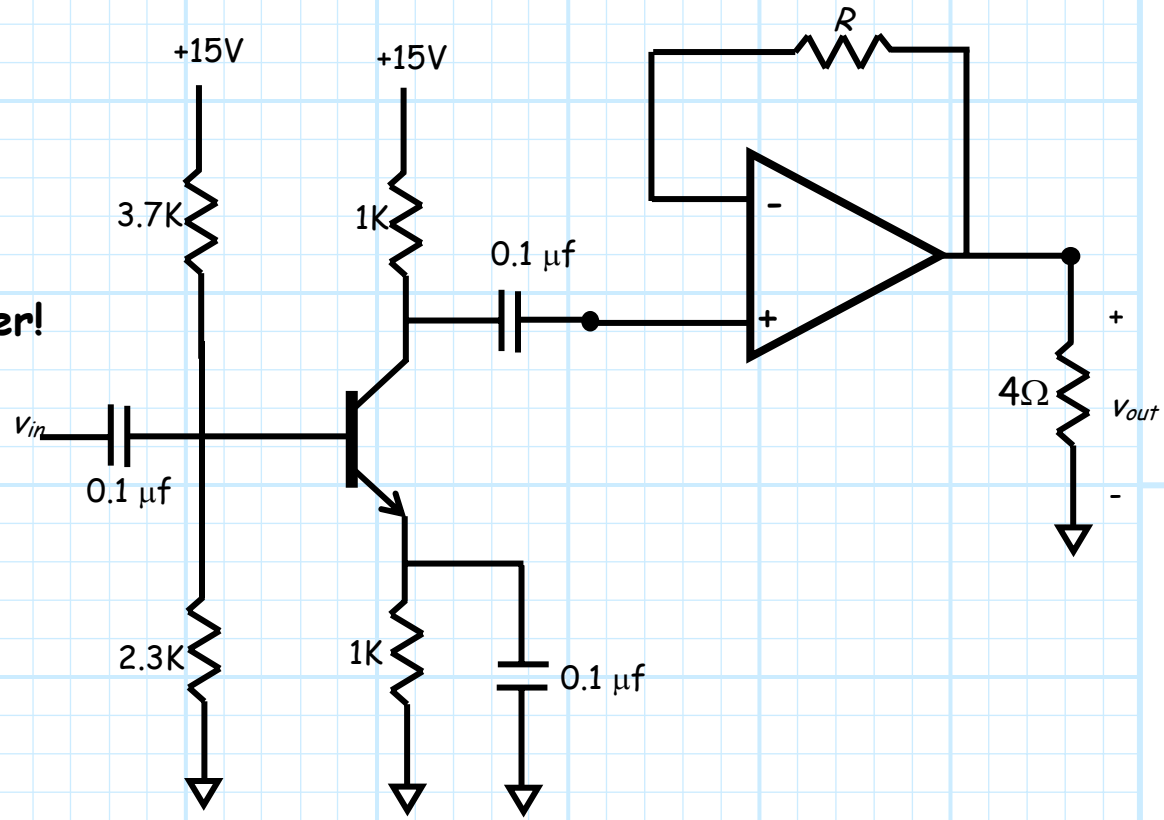
The output resistance is just too large!

The **problem** is that the amplifier **output resistance** (R_{out} = 377Ω) is much **larger** than the **load** resistance R_L= 4 Ω.

Therefore, we have **tremendous loss** due to the resulting **voltage divider**:

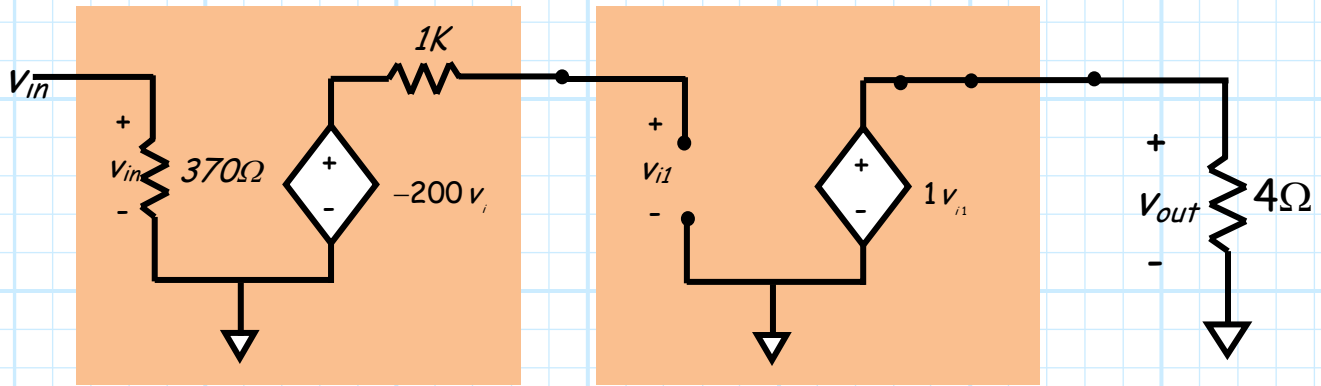
$$\frac{4}{4+1000} \approx 0.004$$

There is a solution to this problem—use a voltage follower!



The voltage follower to the rescue!

Let's again use the **linear equivalent model** to analyze this circuit and find the output voltage v_{out}.



$$v_{out} = -200\,v_{in}\left(\frac{\infty}{1000+\infty}\right)1\left(\frac{4}{0+4}\right) = -200\,v_{in}$$

We've got back our **gain**!

The voltage follower: a useful buffer

Note:

1. **Instead** of 4Ω, the audio amp "sees" a load of ∞, the **input resistance** of the voltage follower—this is **ideal**!

2. **Instead** of 377Ω, the speaker "sees" a source resistance of 0, the **output resistance** of the voltage follower—this too is **ideal**!

Remember, there are **three** characterizing parameters of an amplifier—open circuit voltage gain is just **one** of those three!

The input and output impedance of the voltage follower make it an excellent **"buffer"** between two circuits!