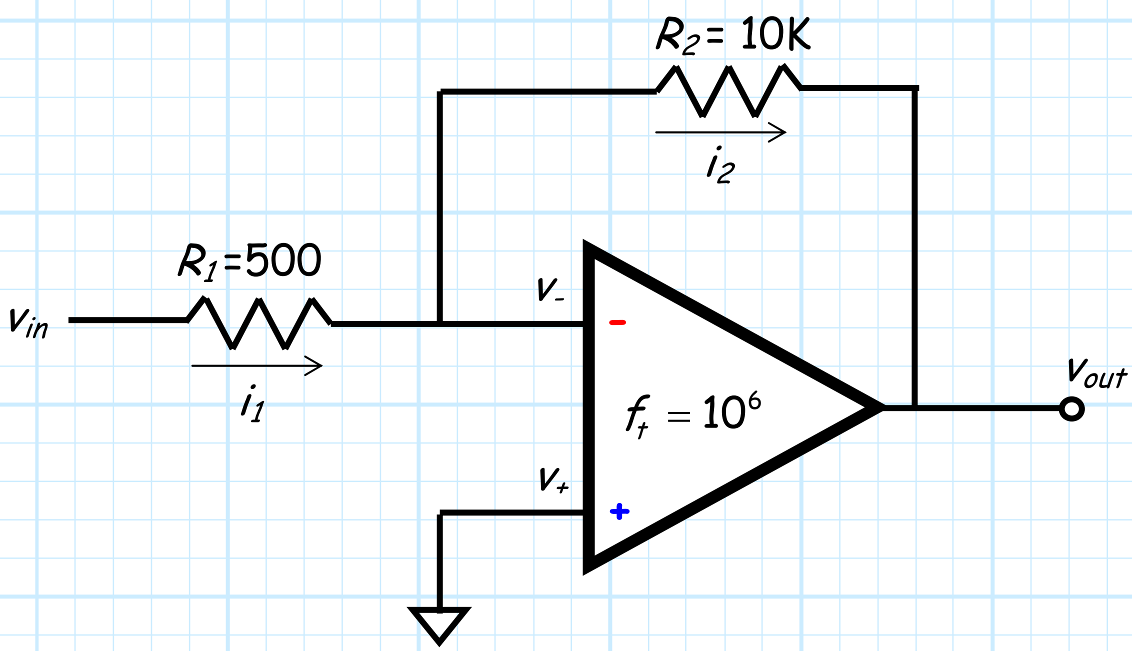
# Example: Amplifier Bandwidth

Say we build the following amplifier in the **lab**:




The **op-amp** in this circuit happens to have a unity-gain bandwidth of **1MHz**.

**Q:** *What is the **3 dB bandwidth** of this amplifier?*

# xy=10^6 and x=20; you figure it out

**A:** We know that the mid-band **gain** of this amplifier is:

$$\left|A_{vo}(\omega_m)\right| = \left|\frac{-R_2}{R_1}\right| = \frac{R_2}{R_1} = \frac{10}{0.5} = \mathbf{20} \qquad (26\text{dB})$$

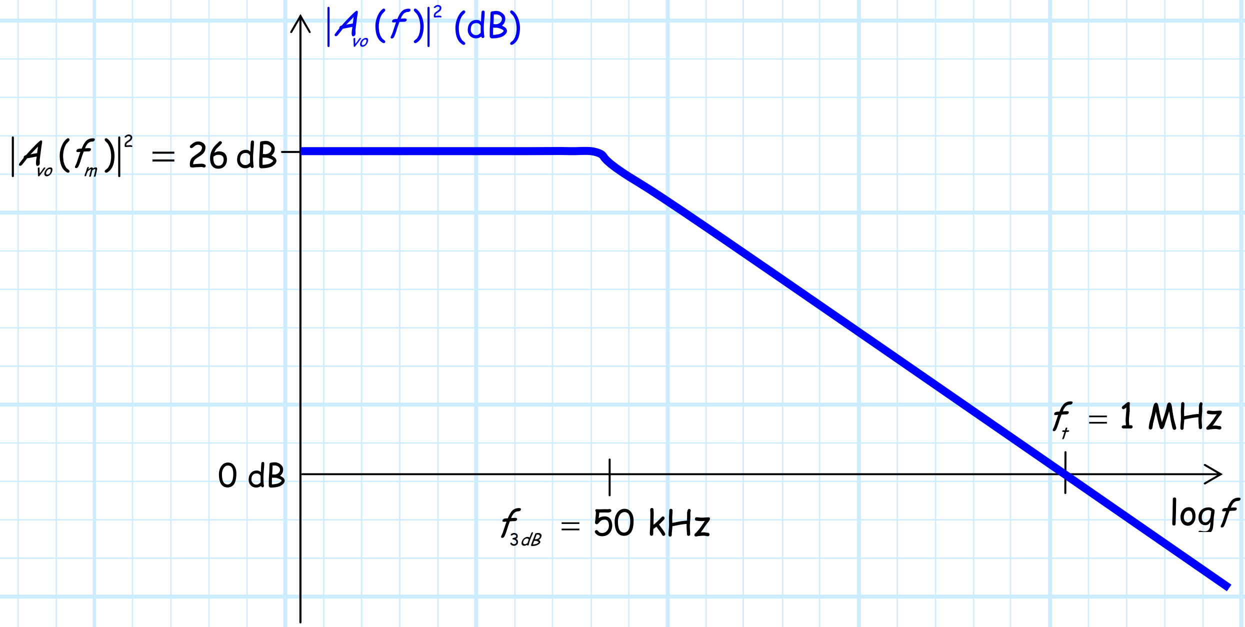
Since we know that $f_t = 10^6$, we can directly determine the amplifier **bandwidth**:

$$f_{3dB} = \frac{f_t}{\left|A_{vo}(f_m)\right|} = \frac{10^6}{20} = 5\text{x}10^4$$

Since the **product** of the amplifier **gain** and **bandwidth** is equal to the **gain-bandwidth product**, we find that the gain-bandwidth product $f_t$ **divided** by the mid-band **gain** equals the amplifier **bandwidth** $f_{3dB}$!

# If I want more bandwidth…

In this case, the amplifier **bandwidth** is $f_{3dB} = 50\,\text{kHz}$.




**Q:** *Is there any way to **increase** the bandwidth of this amplifier to 500 kHz?*

**A:** Sure! But we must **decrease** its mid-band gain.

# …I must accept less gain

The gain-bandwidth product $f_t = 10^6$ is a constant—if we **increase** the bandwidth, we must **decrease** the gain.

Therefore, if we want the amplifier bandwidth to equal 500 kHz, we must **decrease** the mid-band gain to:

$$\left|A_{vo}(f_m)\right| = \frac{f_t}{f_{3dB}} = \frac{10^6}{5\text{x}10^5} = 2 \quad (6\text{dB})$$

A gain of 2—**quite** a decrease!

But this of course **makes sense**.

To **increase** the bandwidth **10 times**, we must **decrease** the gain by a factor of **10**.

# There's no free lunch

Note we **could** accomplish this by simply changing the **feedback resistor** from $R_2 = 10K$ to $R_2 = 1K$.