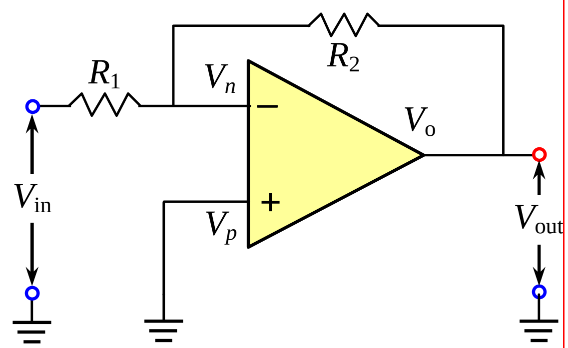
Today, we will:

- Do another example problem – op-amps with GBP effects.
- Begin the pdf module: **Stress, Strain, and Strain Gages**, and do some examples.

Example: Op-amp circuit with GBP effects

Given: Ben amplifies the voltage output of a microphone by a factor of 1000 using an inverting amplifier as sketched, with $\boldsymbol{R_1}$ **= 1.00 kΩ** and $\boldsymbol{R_2}$ **= 1.00 MΩ**. The quality of the amplified music sounds odd to Ben, particularly at high frequencies, but he is clueless as to why this is happening. His friend Ashley took M E 345 and remembers something about GBP effects with op-amps. She looks up the specs for Ben's op-amp: $\mathbf{GBP_{noninverting}}$ **= 0.450 MHz**. She explains to Ben that his op-amp is acting like a first-order low-pass filter, and that is why he is losing some of the high frequencies in his music.



To do:

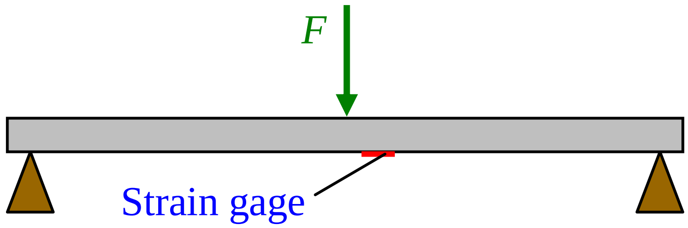
(***a***) Calculate the internal cutoff frequency of this op-amp circuit.

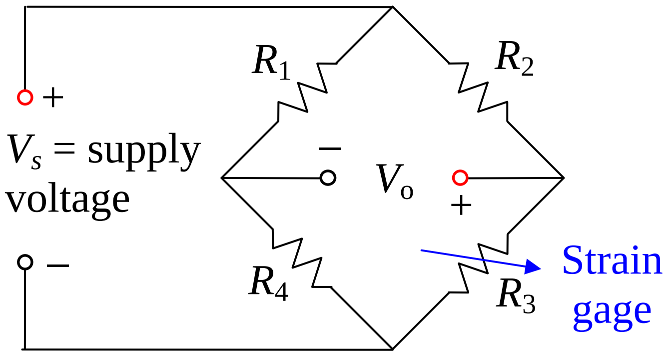
(***b***) Compare the *theoretical* gain and the *actual* gain of this circuit at f = 10,000 Hz.

Solution:

Example: Strain gages

Given: We are measuring the strain on the surface of a beam. The beam's modulus of elasticity is E = 193 GPa. We use one strain gage on the bottom of the beam, as shown; the strain gage factor is S = 2.02. We construct a quarter bridge Wheatstone bridge circuit, with the strain gage on resistor 3, as sketched below. All resistors, including the strain gage itself (when unloaded) are 120 Ω. The supply voltage is 5.00 V DC, and the bridge is initially balanced when there is no load.





(*a*) To do: Will V_o be positive or negative when a downward load is added?

Solution:

Recall from the pdf notes:

$$\frac{V_o}{V_s} \approx \frac{R_{2,\text{initial}} R_{3,\text{initial}}}{\left(R_{2,\text{initial}} + R_{3,\text{initial}}\right)^2} \left(\frac{\delta R_1}{R_{1,\text{initial}}} - \frac{\delta R_2}{R_{2,\text{initial}}} + \frac{\delta R_3}{R_{3,\text{initial}}} - \frac{\delta R_4}{R_{4,\text{initial}}} \right)$$

(***b***) **To do**: For a loading in which V_o = 1.25 mV, calculate the strain ε_a in units of microstrain.

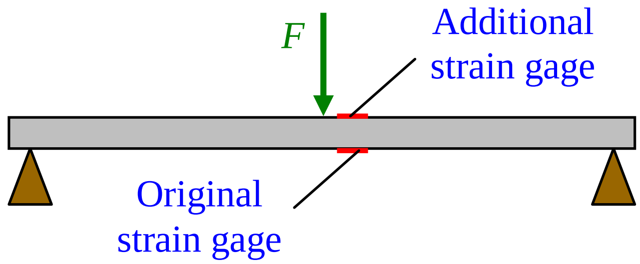
Solution:

(*c*) **To do**: If the material is cold work tool steel with modulus of elasticity E = 193 GPa (at room temperature), calculate the axial stress (in MPa) in the beam under this load.

Solution:

(*d*) **To do**: Suppose we want more sensitivity, so we glue another strain gage on *top* of the beam. Which resistor should we use for this second active strain gage?

Solution:



Again from the pdf notes: $$\frac{V_o}{V_s} \approx \frac{R_{2,\text{initial}} R_{3,\text{initial}}}{\left(R_{2,\text{initial}} + R_{3,\text{initial}}\right)^2} \left(\frac{\delta R_1}{R_{1,\text{initial}}} - \frac{\delta R_2}{R_{2,\text{initial}}} + \frac{\delta R_3}{R_{3,\text{initial}}} - \frac{\delta R_4}{R_{4,\text{initial}}} \right)$$

(*e*) **To do**: For the setup of Part (d) with the same strain as in Part (b), calculate output voltage V_o.

Solution: