

Name: _____

1. Determine an expression for the gain $g = \frac{V_{out}}{V_{in}}$ of the non-inverting amplifier shown in Fig. 1. The triangles indicate the ground (0 V) level, relative to which V_{in} and V_{out} are measured.

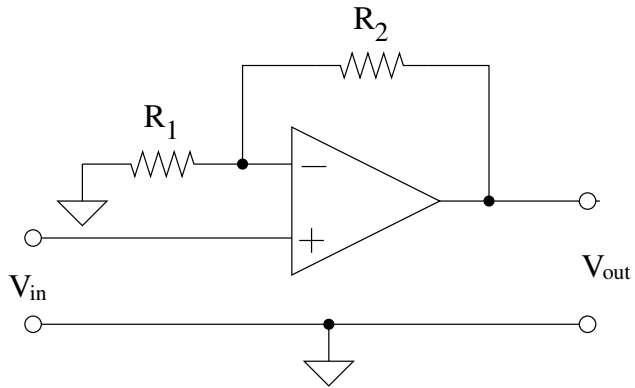


Figure 1: Non-inverting amplifier

2.

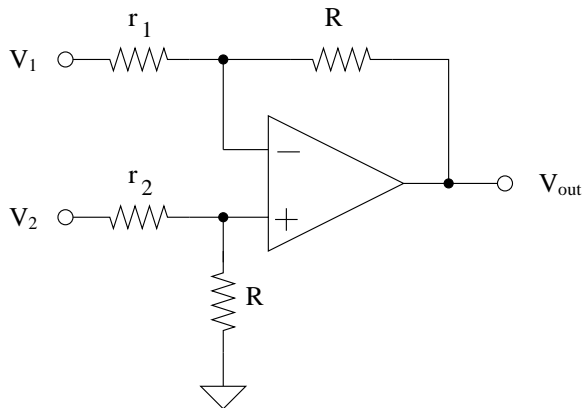


Figure 2: “Making a difference”

For $r_1 = r_2 = r$, the circuit on the left has an output that is the amplified voltage difference of its inputs.

$$V_{out} = \frac{R}{r} (V_2 - V_1)$$

However, measuring differences can be difficult as you will show in this and the next problem.

Show that for $r_1 \neq r_2$

$$V_{out} = \left(\frac{r_1 + R}{r_2 + R} \frac{R}{r_1} \right) V_2 - \frac{R}{r_1} V_1.$$

3. Continuing with the circuit shown in Fig. 2, consider a situation where you were able to pick resistors such that $R = r_1 = r$ holds exactly, so that the resistor values ($= r$) have a standard deviation $\sigma = 0$. In contrast, for r_2 you just took a resistor from the bin, so there is an uncertainty σ_r , *i.e.* $r_2 = r \pm \sigma_r$.

a) Derive an expression for the resulting error term σ_Δ : $V_{out} = \Delta = (V_2 - V_1) \pm \sigma_\Delta$.

b) In lab we use 5% resistors ($\sigma_r/r = 5\%$). If $V_2 = 10$ V, what is the minimum voltage difference $|\Delta| = |V_2 - V_1|$ for which the resulting relative measurement uncertainty is better than 10% ($\sigma_\Delta/|\Delta| < .1$)?