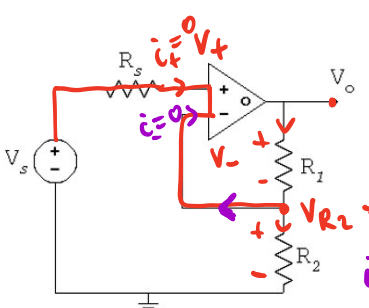
- Example #2: non-inverting amplifier
  - Obtain Vo in the following circuit assuming the ideal op-amp approximation



$V_+ = V_-$

$i_+ = i_- = 0$

$V_o = V_{R_1} + V_{R_2} = V_{R_1} + V_s \quad (=)$

$V_{R_2} = V_- = V_+ = V_s$

$i_{R_1} = i_{R_2} = \frac{V_{R_2}}{R_2} = \frac{V_s}{R_2}$

$(=) \left(\frac{V_s}{R_2}\right) \cdot R_1 + V_s =$

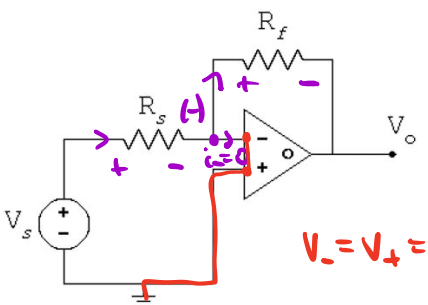
$= V_s \left(1 + \frac{R_1}{R_2}\right) = V_o$

V_o has the same polarity as V_s.

Recall: $i_o \neq 0$ (in general).

Recall: Never do KCL @ ground in op-amp circuit!

- Example #3: inverting amplifier
  - Obtain Vo in the following circuit assuming the ideal op-amp approximations



$V_- = V_+ = 0$

$V_+ = V_-$

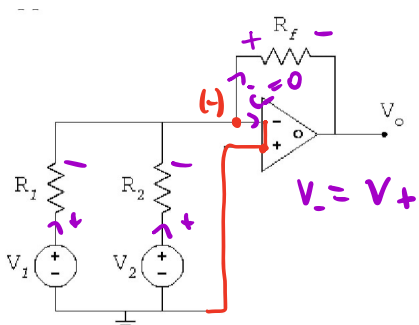
$i_+ = i_- = 0$

KCL @ (-):

$$\frac{V_s - V_-}{R_s} = \frac{V_- - V_o}{R_f} + 0$$

$$\frac{V_s}{R_s} = -\frac{V_o}{R_f} \Rightarrow V_o = -\frac{V_s}{R_s} R_f = -\left(\frac{R_f}{R_s}\right) V_s$$

- Example #4: adder
  - Obtain Vo in the following circuit assuming the ideal op-amp approximation



$V_- = V_+ = 0$

KCL @ (-):

$$\frac{V_1 - V_-}{R_1} + \frac{V_2 - V_-}{R_2} = \frac{V_- - V_o}{R_f}$$

$$V_o = -\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2\right)$$

Find V_o - ?

a) $-\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2\right)$

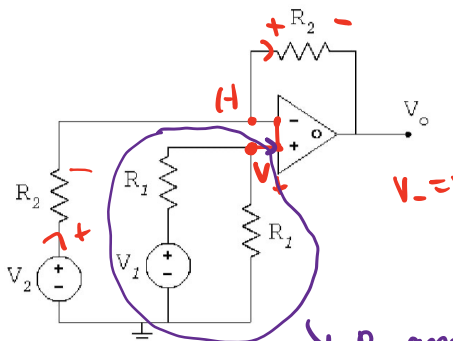
b) $\frac{R_2}{R_1}(V_1 + V_2)$

c) $\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2\right)$

d) 0

Note: could do superposition on V_1 and V_2 to get same circuit as in ex 3.

- Example #5: subtractor
  - Obtain Vo in the following circuit assuming the ideal op-amp approximation



KCL @ (-): $\frac{V_2 - V_-}{R_2} = \frac{V_- - V_o}{R_2}$ ⇒

$V_- = V_+$?

$V_o = 2V_- - V_2 =$?

$= V_1 - V_2$

↘ R_1 and R_1 are in series:

⇓

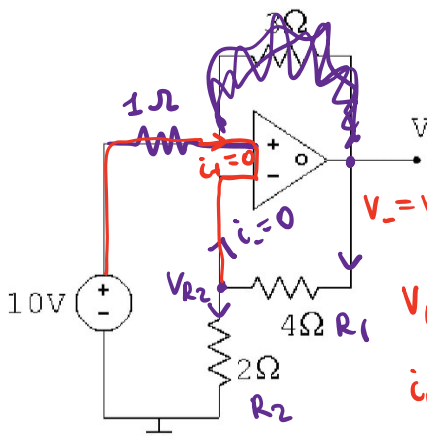
voltage division:

$V_+ = V_1 \left(\frac{R_1}{R_1 + R_1}\right) = \frac{V_1}{2} = V_-$

- Example #6: Obtain Vo in the following circuit assuming the ideal op-amp approximation

$V_+ = V_-$

$i_+ = i_- = 0$



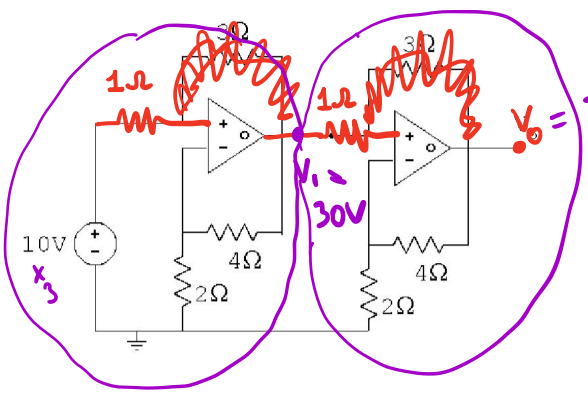
$V_o = V_{R_1} + V_{R_2} = i_{R_1} \cdot R_1 + 10 = 5 \cdot 4 + 10 = 30V$ (?)

$V_- = V_+$

$V_{R2} = V_- = V_+ = 10V$

$i_{R_1} = i_{R_2} = \frac{V_{R2}}{R_2} = \frac{10}{2} = 5A$

- Example #7: Obtain Vo in the following circuit assuming the ideal op-amp approximation



a) 30V
b) −30V
c) 90V
d) −90V