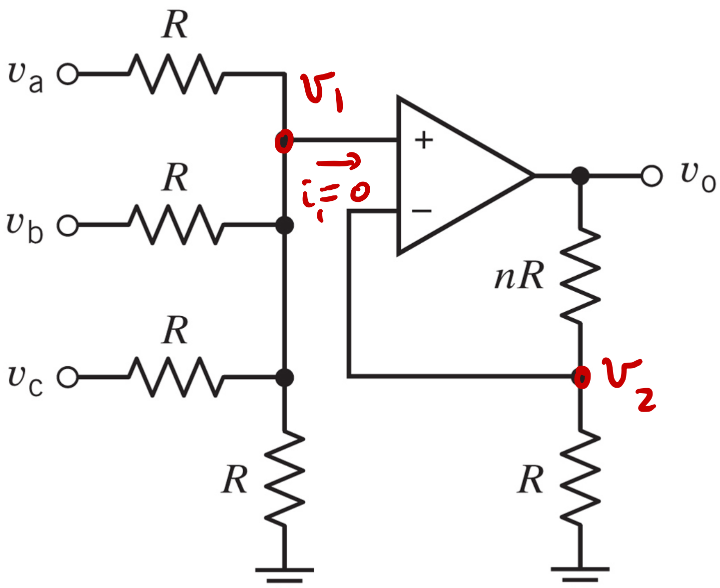
Voltage Summer



From

$v_1 = v_2$

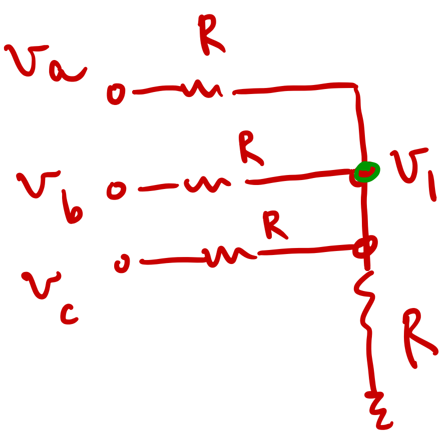
KCL: $\frac{v_o - v_2}{nR} + \frac{0 - v_2}{R} = 0$

$\Rightarrow v_o = v_2(n+1)$

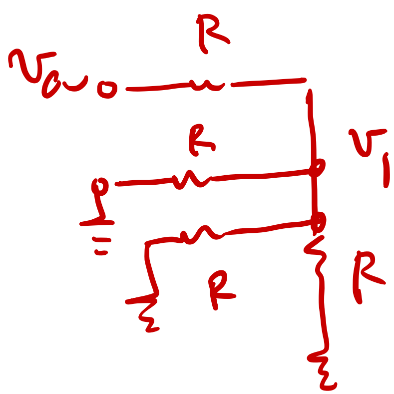
$= v_1(n+1)$

KCL @ v_1

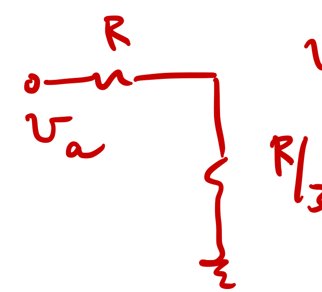
$\frac{v_a - v_1}{R} + \frac{v_b - v_1}{R} + \frac{v_c - v_1}{R} = \frac{v_1}{R}$



Use superposition: $v_1 = v_a \frac{R/3}{R+R/3} + v_b \frac{R/3}{R+R/3} + v_c \frac{R/3}{R+R/3}$



$\Rightarrow$

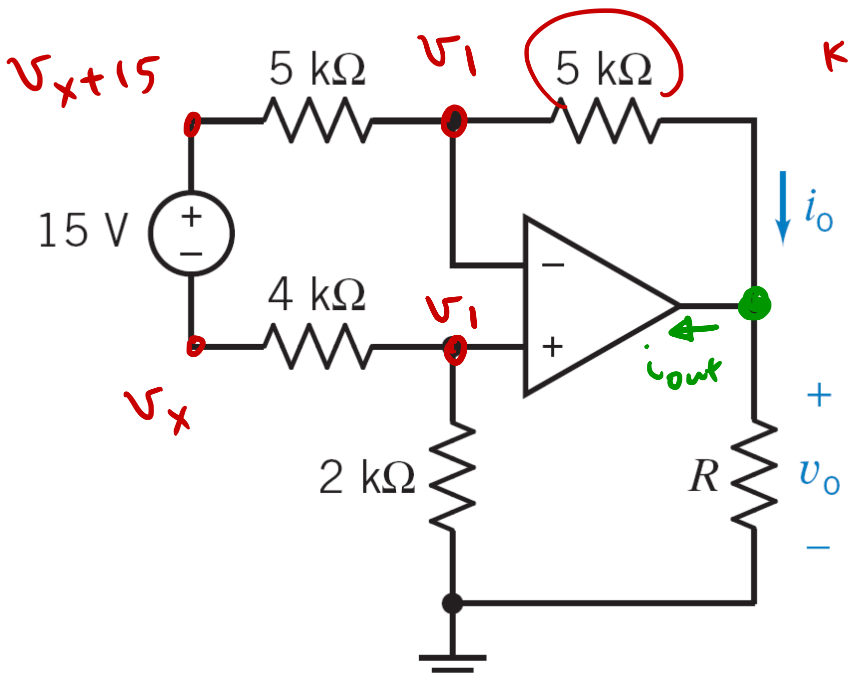


$v_1 = \frac{1}{4}v_a + \frac{1}{4}v_b + \frac{1}{4}v_c$

$\Rightarrow v_o = \left(\frac{1}{4}v_a + \frac{1}{4}v_b + \frac{1}{4}v_c\right)(n+1)$

Example 1

- Find v_o and i_o.



KCL @ v_+: $\frac{v_x - v_1}{4k} + \frac{0 - v_1}{2k} = 0$

$\Rightarrow v_x = 3v_1$

KCL @ v_-: $\frac{v_x + 15 - v_1}{5k} + \frac{v_o - v_1}{5k} = 0$

$\Rightarrow v_o = -v_1 - 15$

@ 15V supernode: $\frac{v_1 - v_x - 15}{5k} + \frac{0 - v_1}{2k} = 0$

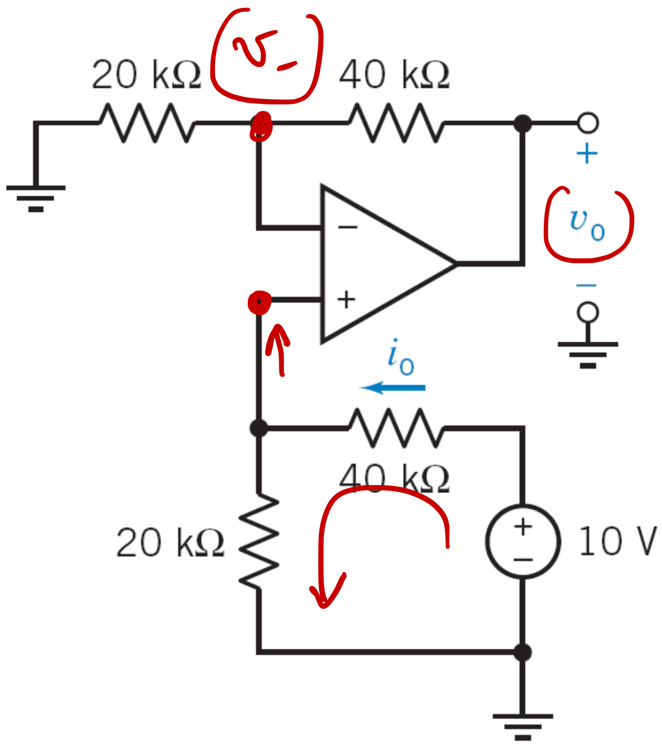
$\Rightarrow v_1 = \frac{-10}{3}$ V, $v_o = -\frac{-10}{3} - 15 = -11.6$ V

$i_o = \frac{v_1 - v_o}{5k} = 1.67$ mA

$i_{out} = i_o + \frac{-v_o}{R}$

Example 2

- Find v_o and i_o.



$$i_o = \frac{10}{20K+40K} = 0.167 \text{ mA}$$

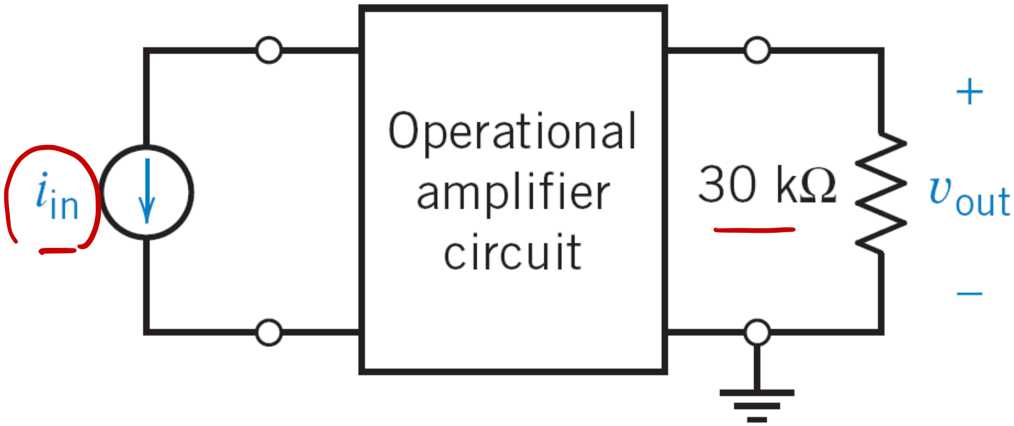
$$V_+ = V_- = 10 \times \frac{20K}{20K+40K} = \frac{10}{3} \text{ V}$$

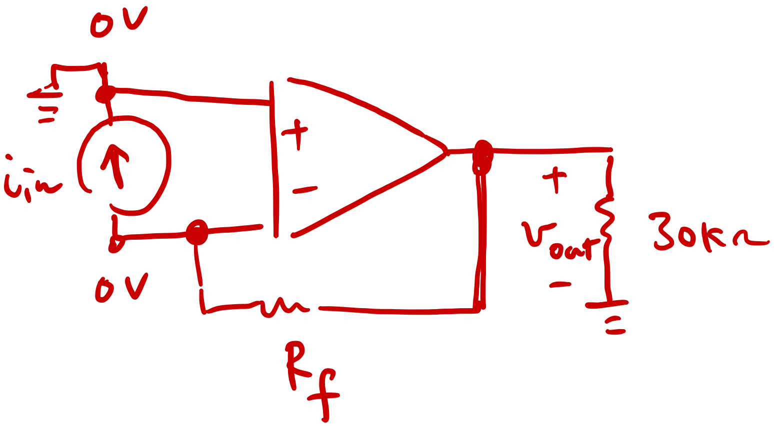
KCL: $$\frac{V_o - V_-}{40K} + \frac{0 - V_-}{20K} = 0$$

$$\Rightarrow V_o = 5 \cdot V_- = 10 \text{ V}$$

Design Example 1

- Design the operational amplifier such that v_{out} = 30 V/mA*i_{in}. $= 30 \times 10^{3}\ V/A \cdot i_{in}$





$$i_{in} = \frac{v_{out} - 0}{R_f} \Rightarrow \frac{v_{out}}{i_{in}} = R_f = 30\ k\Omega$$

Design Example 2

- Design the operational amplifier such that $v_{out} = 5*v_1 + 2*v_2$.