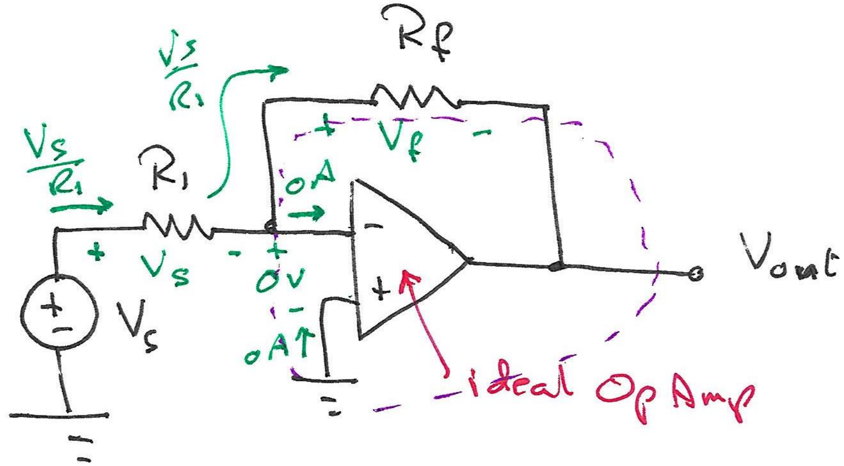
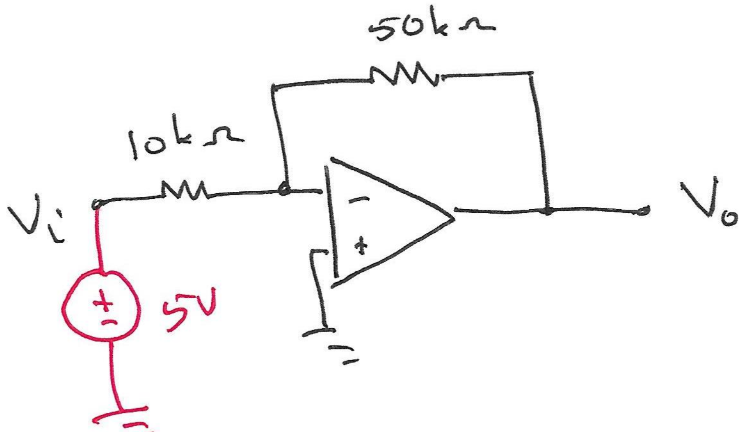


$$V_f = R_f \frac{V_s}{R_1}$$

$$-V_{out} - V_f + 0 = 0$$

$$V_{out} = -V_f = -\frac{R_f}{R_1} V_s$$

Amplifier with gain magnitude of $\frac{R_f}{R_1}$

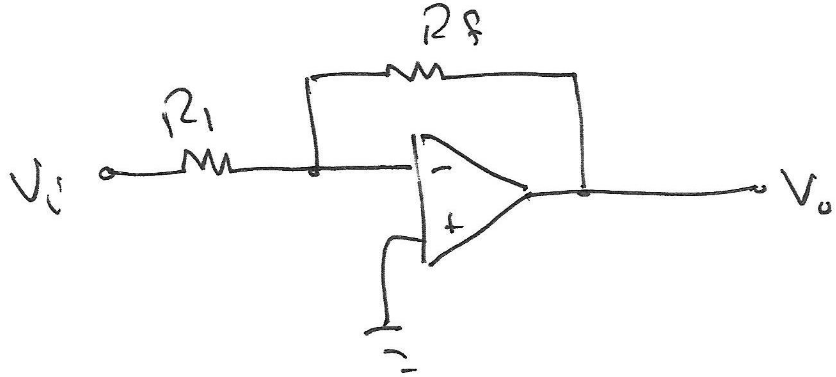


$$V_o = -\frac{50k\Omega}{10k\Omega} \cdot V_i$$

$$= -5 V_i$$

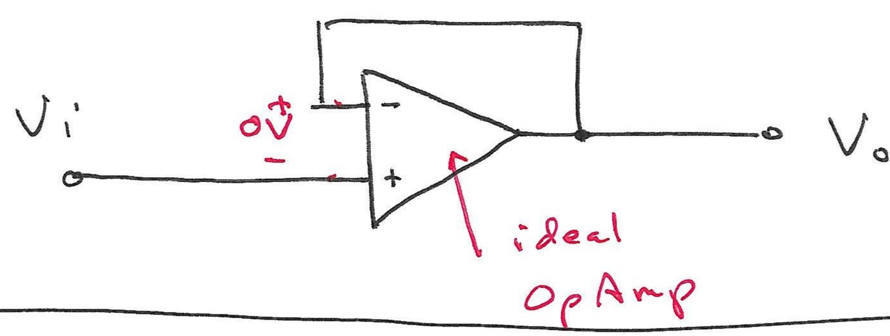
$$V_o = -5(5) = -25V$$

Inverting Amplifier

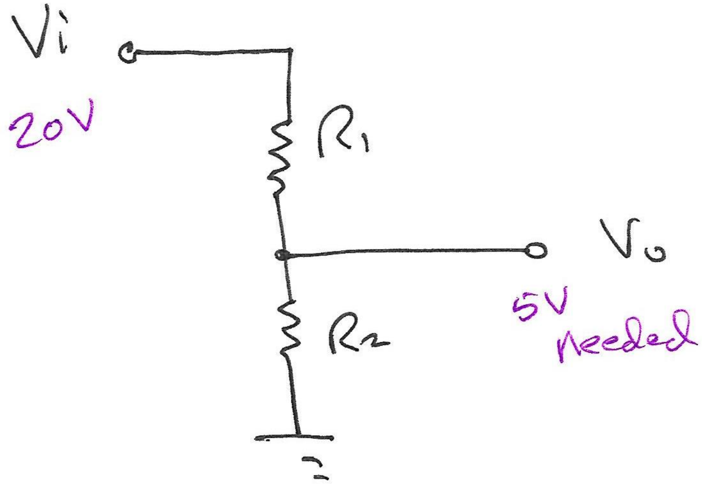


$$V_o = -\frac{R_f}{R_1} V_i$$

Buffer



$$V_o = V_i$$

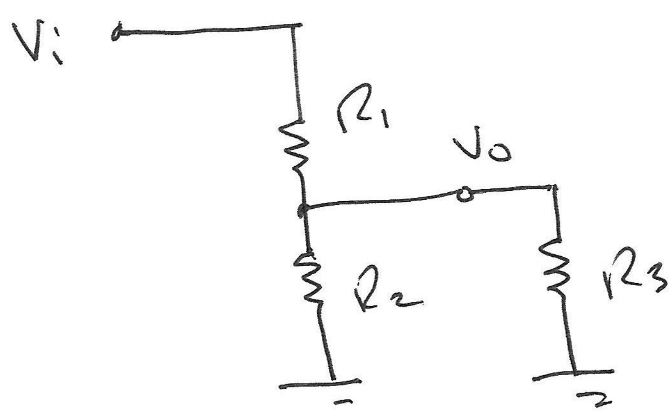


$$V_o = \frac{R_2}{R_1 + R_2} V_i$$

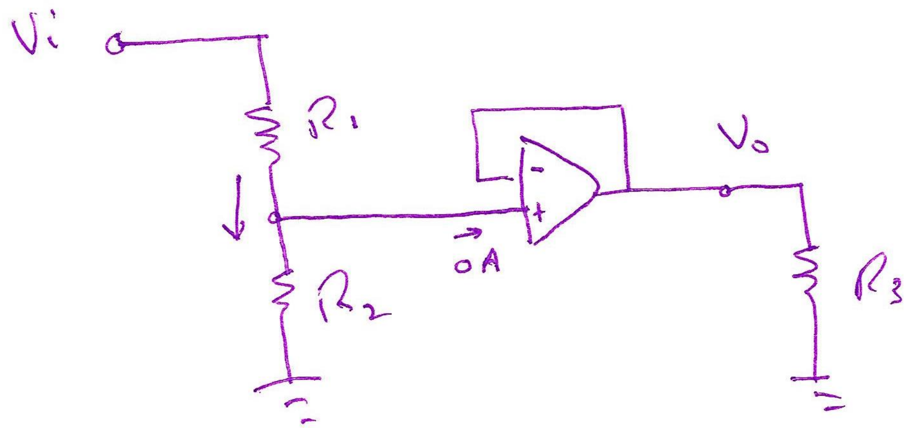
Choose $R_1 = 3R_2$

$$V_o = \frac{1}{4} V_i$$

Connect a load.

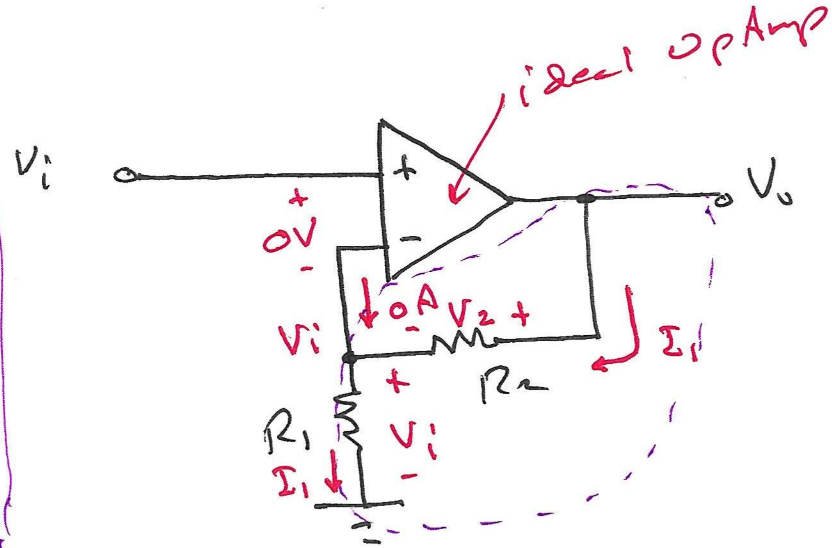


$$V_o = \frac{R_2 \| R_3}{R_1 + (R_2 \| R_3)} V_i$$



$$V_o = \frac{R_2}{R_1 + R_2} V_i$$

Because the buffer prevents current from flowing through R_3 (i.e., prevents loading)



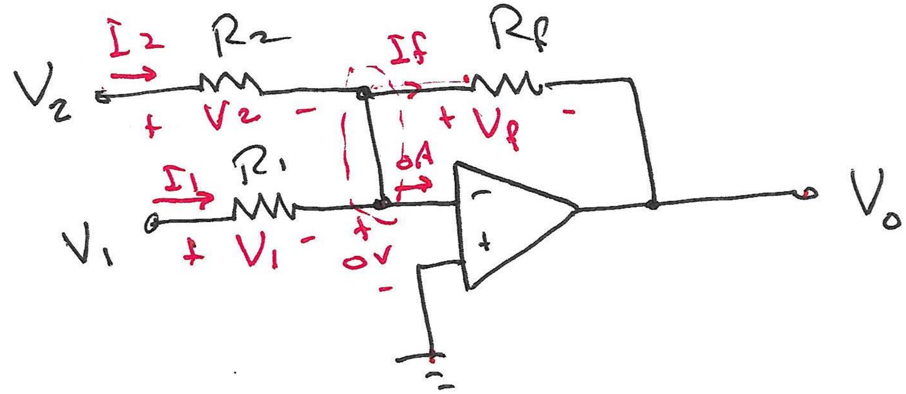
Amplifier

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

$$I_1 = \frac{V_i}{R_1} \qquad V_2 = R_2 I_1 = R_2 \frac{V_i}{R_1}$$

$$-V_o + V_2 + V_i = 0$$

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



$$I_f = I_1 + I_2$$

$$= \frac{V_1}{R_1} + \frac{V_2}{R_2}$$

$$I_1 = \frac{V_1}{R_1}$$

$$I_2 = \frac{V_2}{R_2}$$

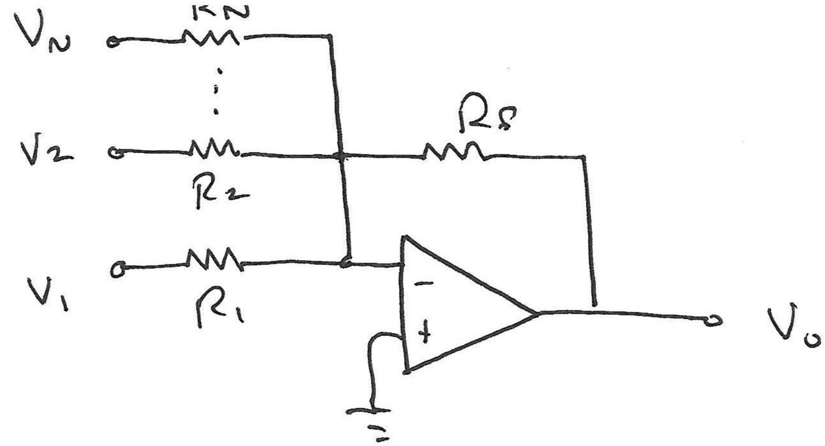
$$V_f = R_f I_f$$

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

Summing Amplifier

$$V_o = -V_f$$

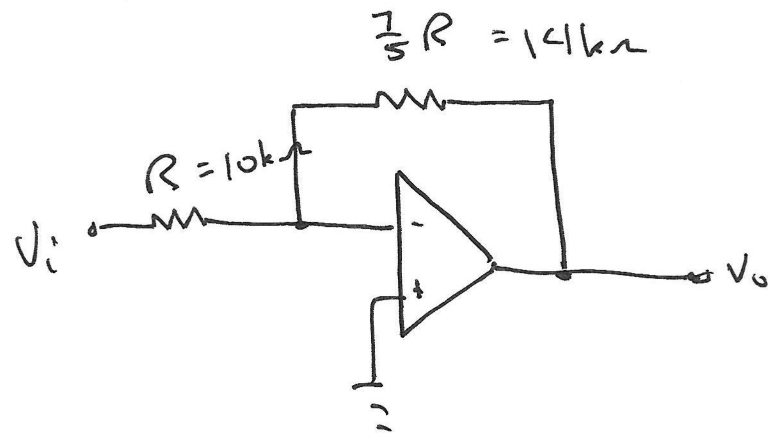
$$V_o = -\frac{R_f}{R_1} V_1 - \frac{R_f}{R_2} V_2$$



Summing Amplifier

$$V_o = -\frac{R_f}{R_1} V_1 - \frac{R_f}{R_2} V_2 - \cdots - \frac{R_f}{R_N} V_N$$

Design a circuit that converts $-5V$ to $+7V$.

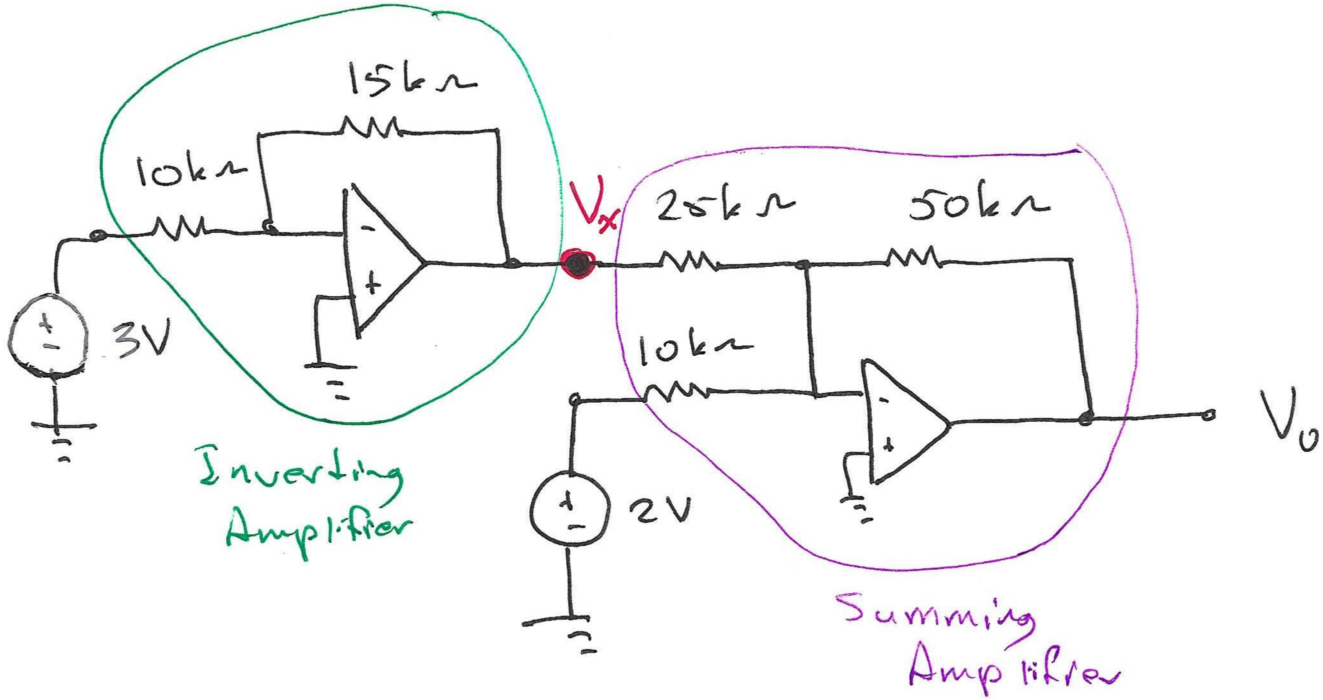


Choose $R = 10k\Omega$

Then $\frac{7}{5}R = 14k\Omega$

$$V_o = -\frac{14k\Omega}{10k\Omega} V_i = -1.4\, V_i$$

for $V_{in} = 5V$, $V_o = -1.4(5) = -7V$



$$V_x = -\frac{15k\Omega}{10k\Omega} 3V = -\frac{9}{2} V = -4.5V$$

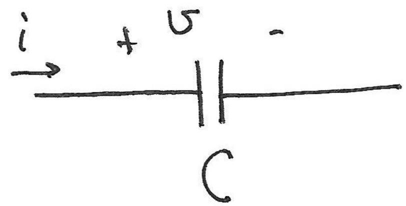
$$V_o = -\frac{50k\Omega}{25k\Omega} V_x - \frac{50k\Omega}{10k\Omega} (2V)$$

$$= -2(-4.5) - 5(2)$$

$$= 9 - 10$$

$$= -1 \ V$$

Capacitor



units of capacitance are farads (F).

If v and i satisfy the PSC, then

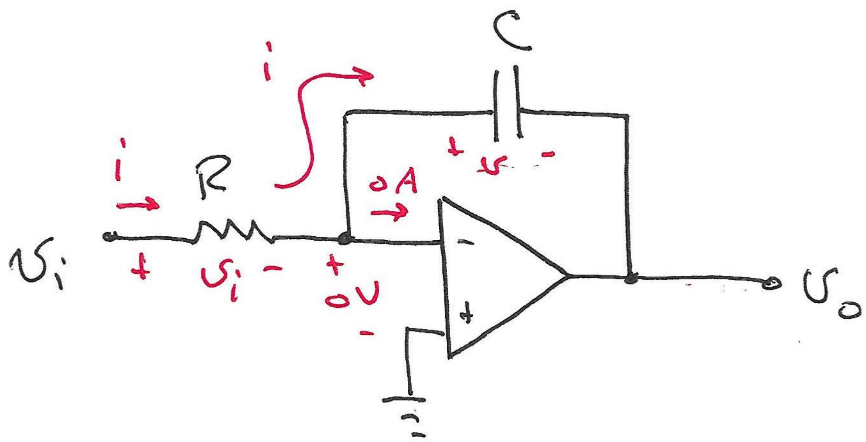
$$i = C\frac{dv}{dt}$$

$$Q = Cv$$

$$\frac{dQ}{dt} = C\frac{dv}{dt}$$

current

$$v = v_0 + \frac{1}{C}\int_0^t i\,dt$$



$$i = \frac{v_i}{R}$$

$$v = v_{initial} + \frac{1}{C}\int_0^t i\,dt$$

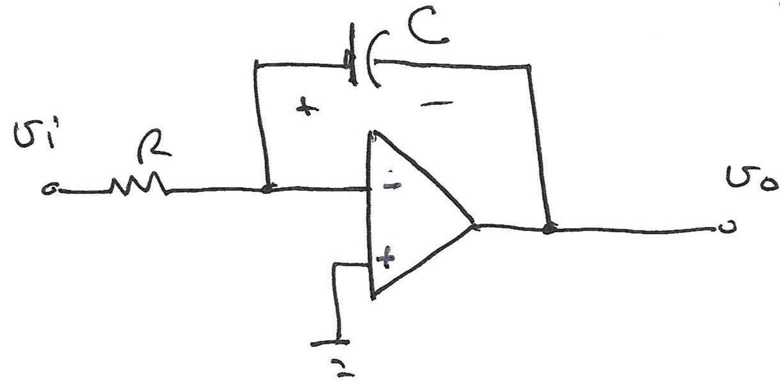
$$\boxed{v = v_{initial} + \frac{1}{RC}\int_0^t v_i\,dt}$$

If the capacitor is <u>not</u> initially charged:

$$v = \frac{1}{RC}\int_0^t v_i\,dt$$

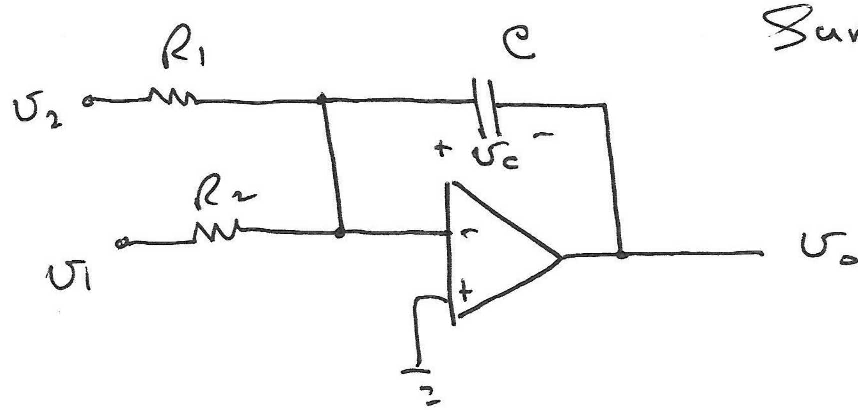
$$\Rightarrow v_o = -\frac{1}{RC}\int_0^t v_i\,dt$$

Integrator

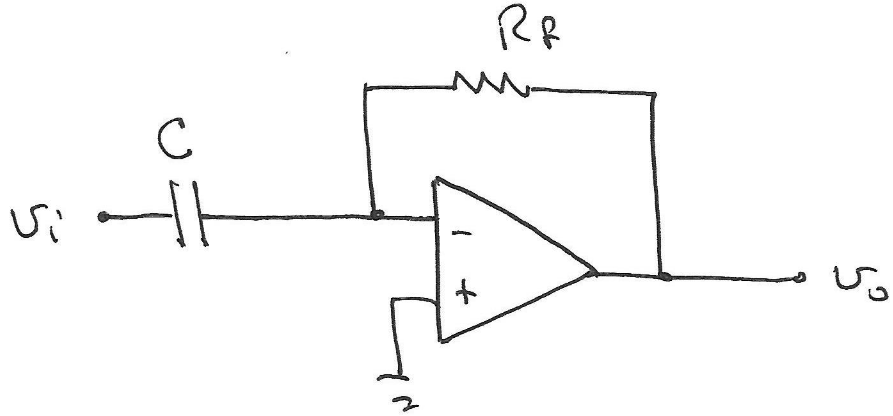


$$v_o = v_{initial} - \frac{1}{RC}\int_0^t v_i\,dt$$

Summing Integrator



$$v_o = v_c(0) - \frac{1}{R_2C}\int_0^t v_1\,dt - \frac{1}{R_1C}\int_0^t v_2\,dt$$



How is v_o related to v_i?

(For next time.)