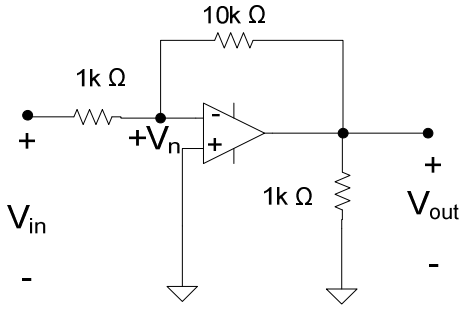
ROSE-HULMAN INSTITUTE OF TECHNOLOGY

ECE203 DC Circuits Spring 2016-2017

Homework Set #20
DUE Tuesday, May 2, 2017

1. For the circuit below, assume the op-amp is ideal.
a. What is the main function of the op-amp circuit below?
b. Find the value of Vn in the circuit if V_{in} = 1V
c. Find the value of Vout in the circuit if V_{in} = 1V
d. Find the Voltage Gain of the circuit, V_{out}/V_{in}
e. Assume that the op-amp supply voltages are V_{cc} = ± 20 V, and the op-amp saturates at the supply voltages, find the maximum range of the input voltage (V_{in}) that will allow the op-amp to operate in its linear range.



a) Inverting amplifier

b) $V_p = 0$ (tied to ground)

$V_n = V_p$ (ideal op amp assumption)

$\boxed{V_n = 0}$

c) KCL at Vn: $\frac{0-1}{1K} + \frac{0-V_{out}}{10K} = 0$

$V_{out} = 10k\left(\frac{-1}{1k}\right)$

$\boxed{V_{out} = -10V}$

d) KCL at Vn: $\frac{0-V_{in}}{1K} + \frac{0-V_{out}}{10K} = 0$

$\frac{V_{out}}{V_{in}} = -\frac{10k}{1k}$

$\boxed{Gain = -10}$

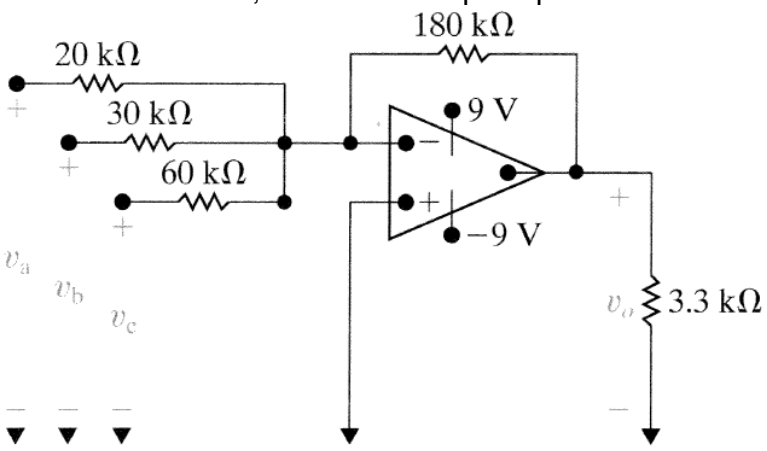
e) $V_{out} = -10\,V_{in}$

$-20 \le V_{out} \le 20$

$-20 \le -10\,V_{in} \le 20$

$\boxed{2 \ge V_{in} \ge -2}$

2. For the circuit below, assume the op-amp is ideal.



a) What circuit configuration is shown in this figure?

b) Find v_o if $v_a = 0.5$ V, $v_b = 1.5$ V, and $v_c = -2.5$ V.

c) The voltages v_a and v_b remain at 0.5 V and 1.5 V, respectively. What are the limits on v_c if the op amp operates within its linear region?

[a] This circuit is an example of an inverting summing amplifier.

[b] $$v_o = -\frac{180}{20}v_a - \frac{180}{30}v_b - \frac{180}{60}v_c = -4.5 - 9 + 7.5 = -6 \text{ V}$$

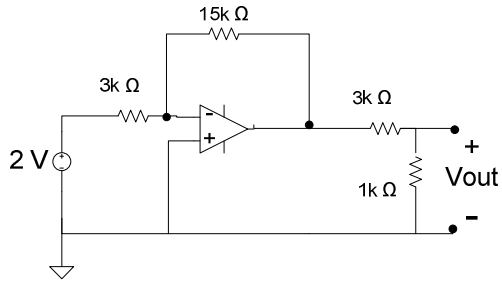
[c] $$v_o = -13.5 - 3v_c = \pm 9$$

$$\therefore \quad v_c = -7.5 \text{ V} \quad \text{when} \quad v_o = 9 \text{ V};$$

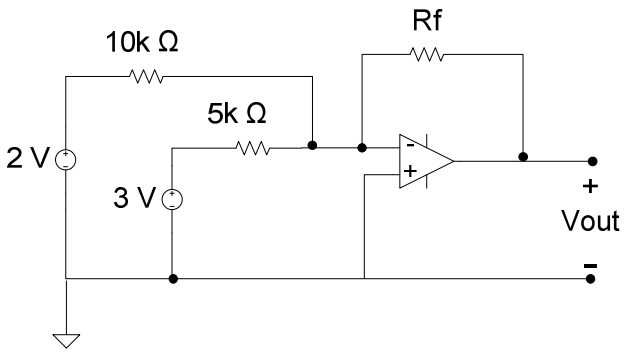
$$v_c = 1.5 \text{ V} \quad \text{when} \quad v_o = -9 \text{ V}$$

$$\therefore \quad -7.5 \text{ V} \leq v_c \leq 1.5 \text{ V}$$

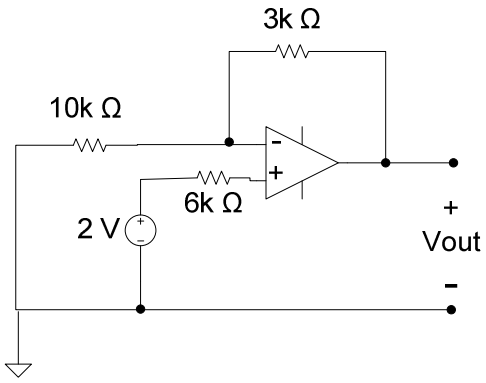
3. For the each circuit below, assume the op-amp is ideal. Find the value of V_{out} and describe what the circuit does.



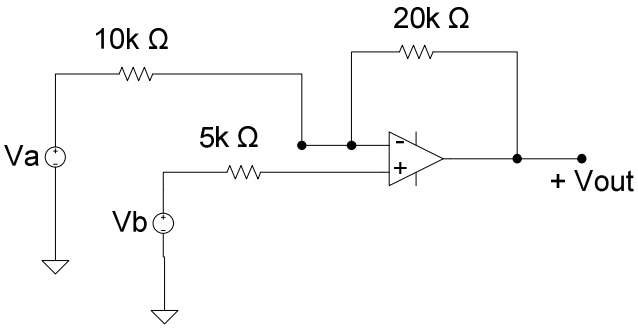
(a)



(b)

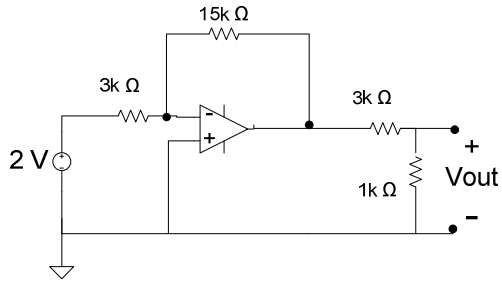


(c)



(d)

a) Inverting Amplifier



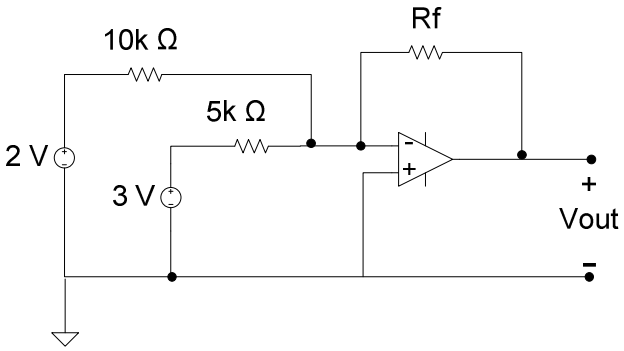
$$\frac{V_x}{2} = \frac{-15k}{3k}$$

$$V_{out} = V_x \frac{1k}{3k+1k}$$

$$V_{out} = -10\left(\frac{1}{4}\right)$$

$$\boxed{V_{out} = -2.5V}$$

b) Summing Amplifier

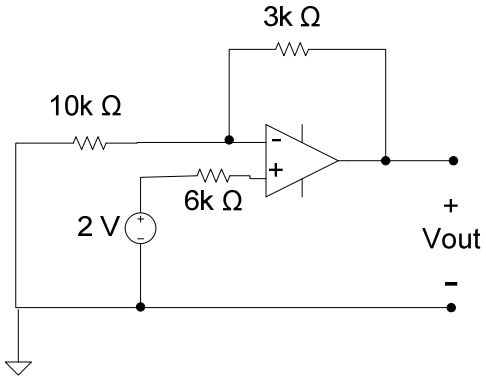


$$V_{out} = -\frac{R_F}{10K}2 - \frac{R_F}{5k}3$$

$$= -\frac{R_F}{1000}(0.2 + 0.6)$$

$$= -\frac{R_F(0.8)}{1000}$$

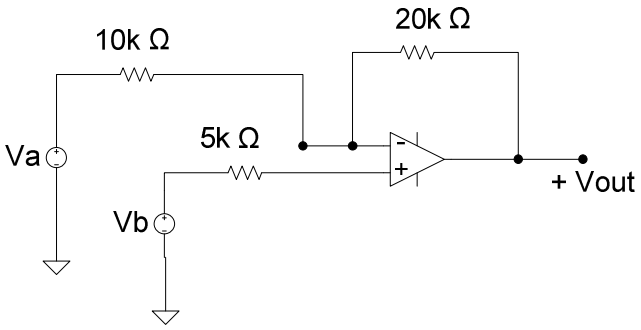
c) Non-Inverting Amplifier



$$\frac{V_o}{2} = \left(1 + \frac{3k}{10k}\right)$$

$$\boxed{V_o = 2.6V}$$

d) Difference Amplifier



using superposition

$$V_o = V_a\left(-\frac{20k}{10k}\right) + V_b\left(1 + \frac{20k}{10k}\right)$$