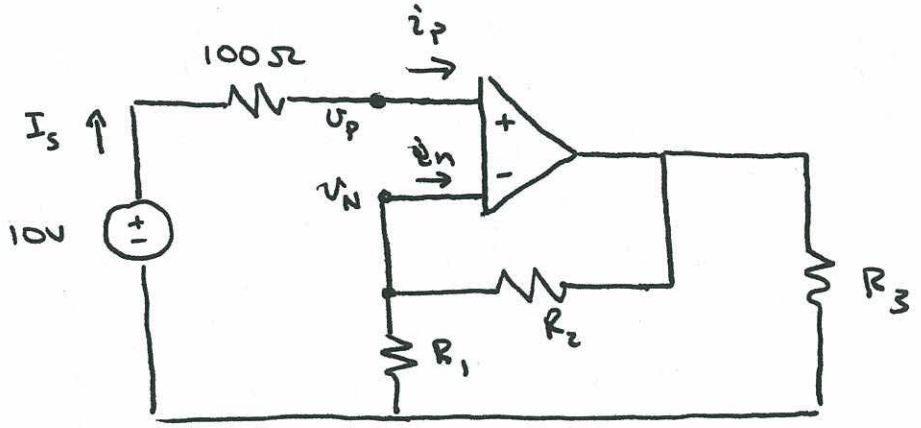
Exercises
chapter 5.1

1.



Op-amp rules for the above circuit:

(1) $v_p = v_N$

(2) $i_p = i_N = 0$

(a) Since $i_p = 0 \Rightarrow \underline{\underline{I_s = 0}}$ (they are in series)

(b) Since $i_s = 0 \Rightarrow$ there is no current through the 100 Ω resistor $\Rightarrow$ no voltage drop across the 100 Ω resistor $\Rightarrow \underline{\underline{v_p = 10V}}$

(c) Since $v_p = v_N$, and from (b):

$$\underline{\underline{v_N = 10V}}$$

Exercises
Chapter 5.2

$K = 10{,}000$

$V^+ = 20V$

$V^- = -10V$

For an op-amp, $V_{out} = K(v_p - v_N)$ but

$$V^- < V_{out} < V^+$$

(a) $v_p - v_N = 1mV \Rightarrow V_{out} = 10{,}000(.001) = \underline{\underline{10V}}$

(b) $v_p - v_N = 2mV \Rightarrow V_{out} = 10{,}000(.002) = \underline{\underline{20V}}$

(c) $v_p - v_N = 4mV \Rightarrow V_{out} = 10{,}000(.004) = 40V$

$\underline{\underline{BUT}} \quad V_{out} < V^+ \Rightarrow \underline{\underline{V_{out} = 20V}}$

(d) $v_p - v_N = -0.2mV \Rightarrow V_{out} = 10{,}000(-0.0002) = \underline{\underline{-2V}}$

(e) $v_p - v_N = -2mV \Rightarrow V_{out} = 10{,}000(-0.002) = -20V$

$\underline{\underline{BUT}} \quad V^- < V_{out} \Rightarrow \underline{\underline{V_{out} = -10V}}$

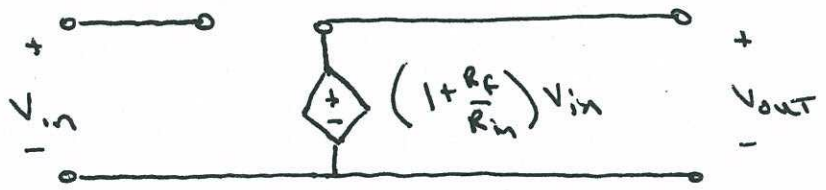
Exercises

Chapter 5.4

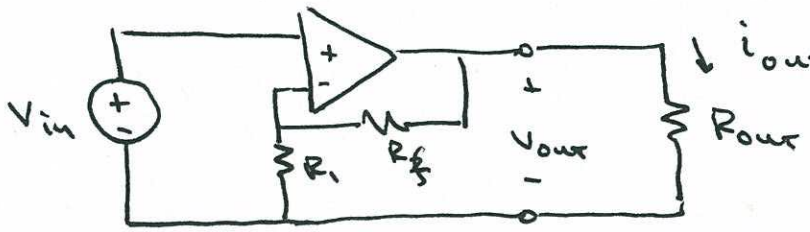
1. The circuit of Example 2 is governed by the relation:

$$V_{out} = \left(1 + \frac{R_f}{R_{in}}\right) V_{in}$$

As a VCVS:

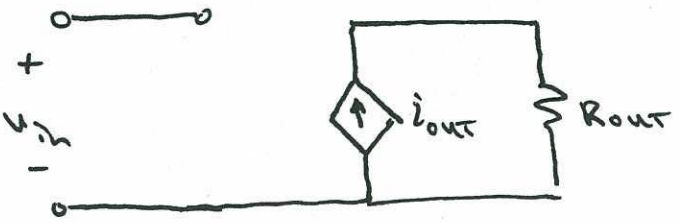


2. Since the circuit of Example 2 sets a voltage we need to have an output resistance to find the current. The circuit becomes:



$$i_{out} = \frac{V_{out}}{R_{out}} = \frac{1}{R_{out}}\left(1 + \frac{R_f}{R_1}\right) V_{in}$$

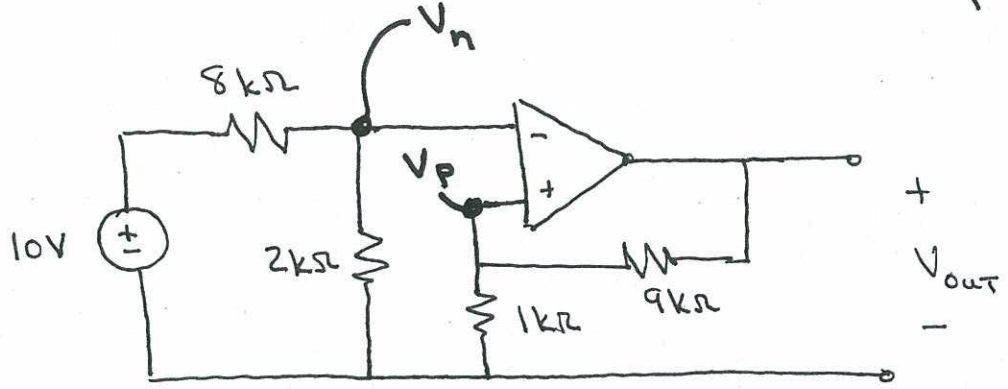
As a voltage controlled current source:



$$i_{out} = \frac{1}{R_{out}}\left(1 + \frac{R_f}{R_1}\right) V_{in}$$

Exercises
chapter 5.4

3.



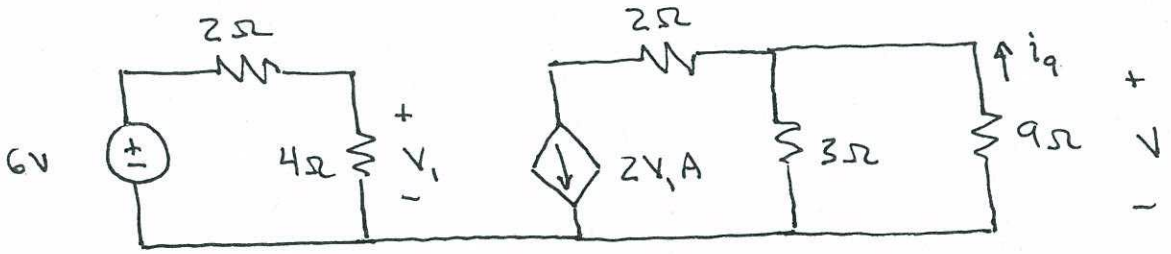
$$V_n = 10V\left[\frac{2k\Omega}{2k\Omega + 8k\Omega}\right] = 2V \quad \text{(voltage divider)}$$

$$V_p = V_n = 2V \quad \text{(op-amp rules)}$$

KCL at non-inverting input: $\dfrac{2V-0}{1k\Omega} = \dfrac{V_{out}-2V}{9k\Omega}$

$$\underline{\underline{V_{out} = 20V}}$$

4.



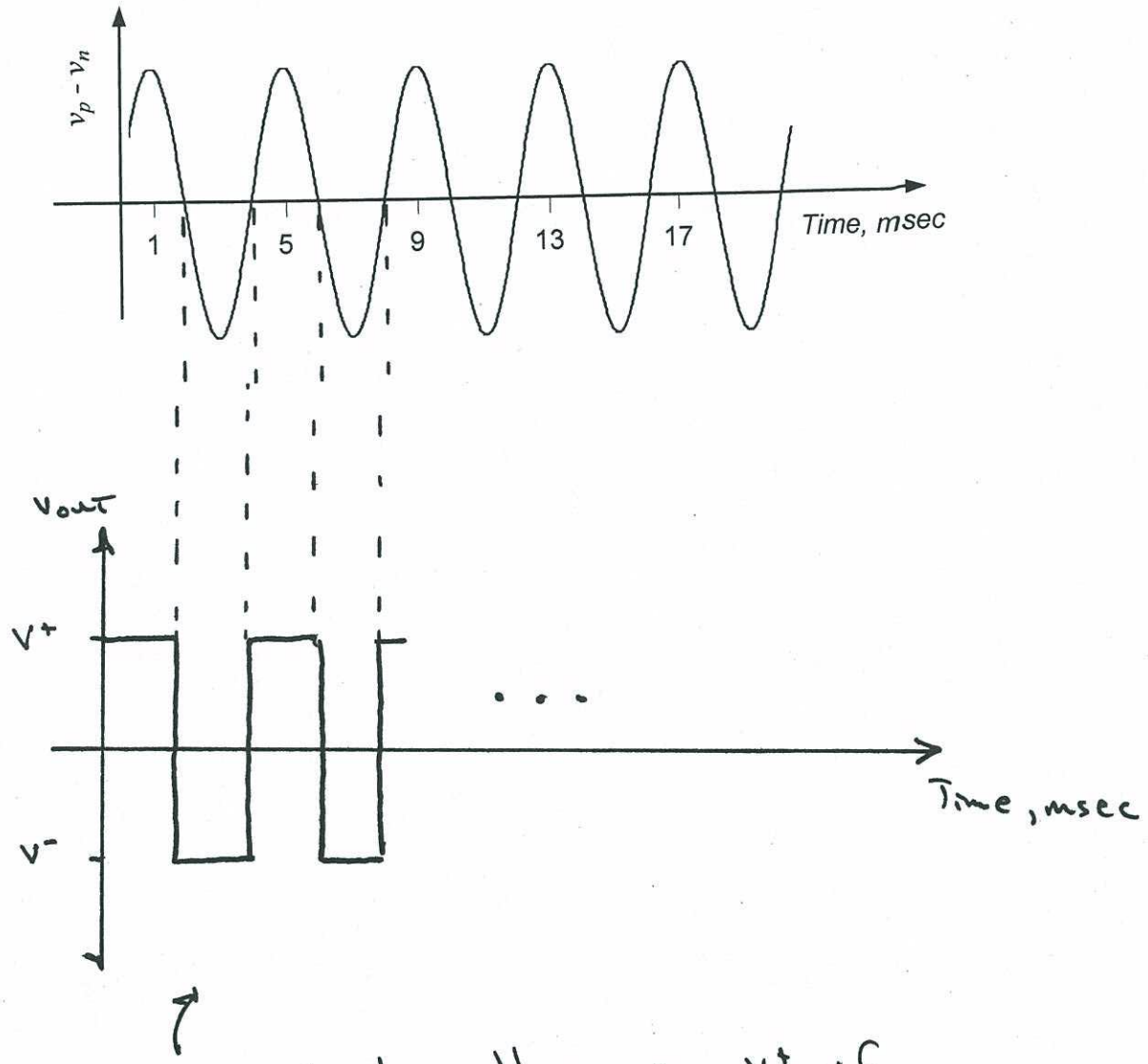
$$V_1 = 6V\left(\frac{4\Omega}{2\Omega + 4\Omega}\right) = 4V \quad \text{(voltage divider)}$$

$$2V_1 = 8A \quad \text{(dependent source current)}$$

$$i_q = 8A\left[\frac{3\Omega}{3\Omega + 9\Omega}\right] = 2A \quad \text{(voltage divider)}$$

$$V = -i_q(9\Omega) \Rightarrow \underline{\underline{V = -18V}}$$

Exercises
Chapter 5.5



The output voltage is V^+ if $v_p - v_n > 0$ and V^- if $v_p - v_n < 0$.