Op-amp rules for the above circuit:

1. \( V_p = V_N \)
2. \( I_p = I_N = 0 \)

(a) Since \( I_p = 0 \) \(\Rightarrow I_s = 0\) (they are in series)

(b) Since \( I_s = 0 \) \(\Rightarrow\) there is no current through the 100 ohm resistor \(\Rightarrow\) no voltage drop across the 100 ohm resistor \(\Rightarrow V_p = 10V\)

(c) Since \( V_p = V_N \), and from (b):

\( V_N = 10V \)
K = 10,000

V^+ = 20V

V^- = -10V

For an op-amp, \( V_{out} = K \left( V_p - V_n \right) \) but

\( V^- < V_{out} < V^+ \)

(a) \( V_p - V_n = 1mV \) \( \Rightarrow \) \( V_{out} = 10,000 \left( .001 \right) = 10V \)

(b) \( V_p - V_n = 2mV \) \( \Rightarrow \) \( V_{out} = 10,000 \left( .002 \right) = 20V \)

(c) \( V_p - V_n = 4mV \) \( \Rightarrow \) \( V_{out} = 10,000 \left( .004 \right) = 40V \)

\[ \text{But} \quad V_{out} < V^+ \Rightarrow V_{out} = 20V \]

(d) \( V_p - V_n = -0.2mV \) \( \Rightarrow \) \( V_{out} = 10,000 \left( -0.0002 \right) = -2V \)

(e) \( V_p - V_n = -2mV \) \( \Rightarrow \) \( V_{out} = 10,000 \left( -0.002 \right) = -20V \)

\[ \text{But} \quad V^- < V_{out} \Rightarrow V_{out} = -10V \]
1. The circuit of Example 2 is governed by the relation:

\[ V_{out} = (1 + \frac{R_f}{R_{in}}) V_{in} \]

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:

\[ i_{out} = \frac{V_{out}}{R_{out}} = \frac{1}{R_{out}} (1 + \frac{R_f}{R_1}) V_{in} \]

As a voltage controlled current source:
3.

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

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

KCL at non-inverting input: \[ \frac{2V-0}{1kΩ} = \frac{V_{out}-2V}{9kΩ} \]

\[ V_{out} = 20V \]

4.

\[ V_1 = 6V \left( \frac{4Ω}{2Ω+4Ω} \right) = 4V \quad \text{(voltage divider)} \]

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

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

\[ V = -i_q (9Ω) \Rightarrow V = -18V \]
The output voltage is $V^+$ if $V_p - V_n > 0$ and $V^-$ if $V_p - V_n < 0$. 