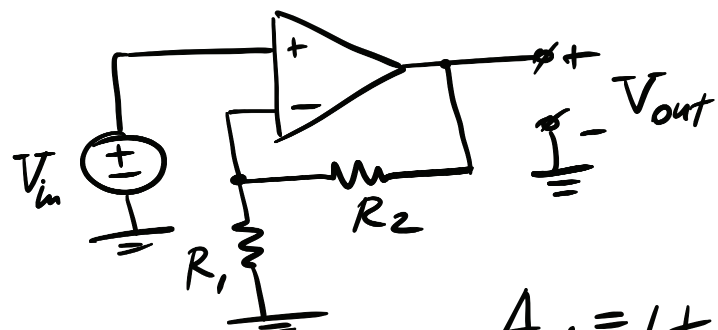
EE 005 Circuits and Electronics

HOMEWORK 4

SOLUTIONS

Problem 1

Design a non-inverting amplifier that will boost the input voltage of V_{in} = 200 mV to V_{out} = 3.3 V.



$$A_v = 1 + \frac{R_2}{R_1} = \frac{V_{out}}{V_{in}} = \frac{3.3V}{200mV} = 16.5\ \frac{V}{V}$$

So that, $\frac{R_2}{R_1} = 15.5$

Choosing $R_1 = 1k \Rightarrow R_2 = 15.5k$

Problem 2

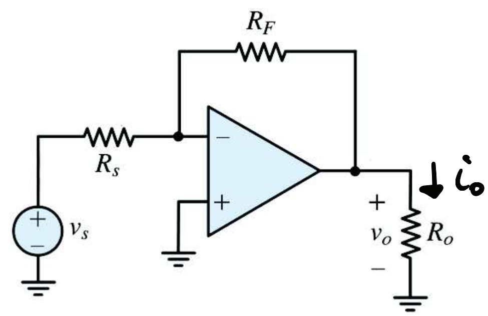


Figure P2

Determine the output ~~current~~ voltage v_o and current i_o in the circuit of **Figure P2**. Assume R_s = 1.7 kΩ, R_F = 5.1 kΩ, R_o = 2 kΩ, v_s = 5 V. Make sure to show the direction of current i_o.

$$V_o = -\frac{R_F}{R_S} V_S = -\frac{5.1k}{1.7k} \times 5V = -15V$$

$$i_o = \frac{V_o}{R_o} = -\frac{15V}{2k} = -7.5\,mA$$

Problem 3

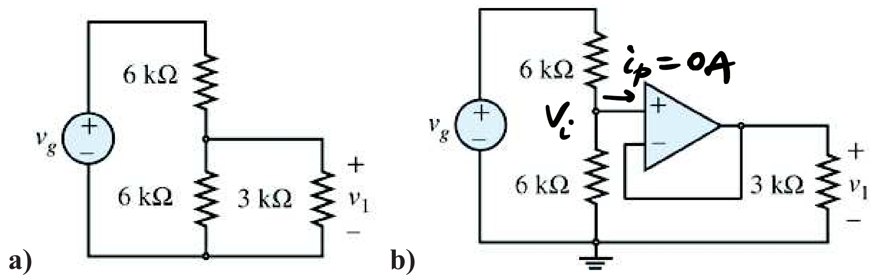


Figure P3

Find v_1 in the circuits of **Figure P3 a)** and **b)**. In **Figure P3 a)** the resistor 3 kΩ "loads" the output; that is, v_1 is changed by attaching the 3 kΩ in parallel with the lower 6 kΩ resistor. However, in **Figure P3 b)** the voltage (isolation) buffer holds v_1 to $v_g/2$, regardless of the presence of the 3 kΩ resistor and its value!

Δ $\boxed{a)}$ $$V_1 = \frac{(6k \| 3k)}{6k + (6k \| 3k)} V_g = \frac{2k}{6k + 2k} V_g = \frac{1}{4} V_g$$

voltage divider

$\boxed{b}$ $$V_1 = V_i = \frac{6k}{6k + 6k} V_g = \frac{1}{2} V_g$$

voltage buffer

$i_p = 0A$, so we can use voltage divider

Problem 4

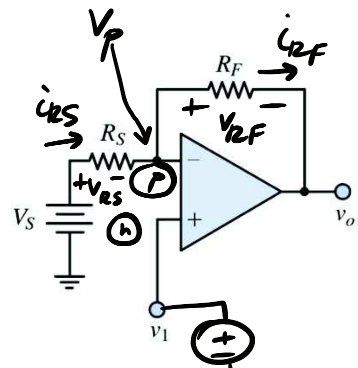


Figure P4

In the op-amp circuit of **Figure P4** the voltage v_1 is applied to the non-inverting terminal of the op-amp. Assuming V_S, R_S and R_F are provided, determine the resulting output voltage v_o. Will the output change if we attach to the output any non-zero resistor R_L.

Δ

$$V_p = V_n = V_1$$

Since $i_p = i_n = 0 \Rightarrow i_{RS} - i_{RF} = 0$

$$i_{RS} = \frac{V_{RS}}{R_S} = \frac{V_S - V_p}{R_S} = \frac{V_S - V_1}{R_S}$$

$$i_{RF} = \frac{V_{RF}}{R_F} = \frac{V_p - V_o}{R_F} = \frac{V_1 - V_o}{R_F}$$

$$\frac{V_S - V_1}{R_S} - \frac{V_1 - V_o}{R_F} = 0$$

$$\frac{V_S}{R_S} - \left(\frac{1}{R_S} + \frac{1}{R_F}\right)V_1 + \frac{V_o}{R_F} = 0$$

$$\boxed{V_o = -\frac{R_F}{R_S}V_S + \frac{R_S + R_F}{R_S}V_1}$$

Observe, if $V_1 = 0V$, then $V_o = -\frac{R_F}{R_S}V_S$ as expected.