

EE20005 practice set 5-1

Q1

- a) Condition: ideal Op Amp:
1. Infinity input resistance
 2. Infinity loop gain
 3. Zero output resistance

$$r_1 = \infty \Omega, \mu = \infty, r_0 = 0 \Omega.$$

- b) $r_1 \rightarrow \infty, I_1 = I_2 = 0 A$
 c) $v_0 = v^- = v^+ = 0 V$

Q2

- a) $I_1 = I_2 = 0 A$
 b) $v_1 = v_s \cdot \frac{24}{16+24} = 7.5 \times \frac{6}{10} = 4.5 V$
 $v_2 = v^- = v^+ = 4.5 V$
 c) $v_0 = v_2 \cdot \frac{12}{8+12} = 4.5 \times \frac{3}{5} = 2.7 V$
 $I_4 = \frac{v_0}{R_0} = \frac{2.7}{12} = 0.225 A$
 d) $I_3 = I_4 = 0.225 A$

Q3

- a) $I_1 = I_2 = 0 A$
 b) $v^- = v^+ = 0 V$
 c) $I_s = \frac{v_s}{R_1} = \frac{1}{5k} = 0.2 mA$
 $I_F = I_s = 0.2 mA$
 d) $v_o = -I_s \times 25k\Omega = -0.2 mA \times 25k\Omega = -5 V$

Q4

- a) Apply KCL on Node V1:

$$\frac{v_1 - 0.75}{2k} + \frac{v_1 - 0}{4k} + \frac{v_1 - 0}{4k} = 0$$

$$4v_1 - 1.5 = 0$$

$$v_1 = 0.375 V$$

 b) $I_1 = \frac{v_1}{4k\Omega} = \frac{0.375}{4000} = 93.75 \mu A$

$$I_2 = 0 A, I_3 = I_1 = 93.75 \mu A$$

$$\begin{aligned} \text{c) } v_o &= -I_3 \times 10k\Omega = -93.75 \mu A \times 10000\Omega = -0.9375 V \\ i_o &= -(i_3 + \frac{v_o}{2k\Omega}) = -93.75 \mu A - \frac{0.9735 V}{2000 \Omega} = -(93.75 \mu A + 0.4688 mA) \\ i_o &= -0.5625 mA \end{aligned}$$

$$\begin{aligned} \text{d) } i_s &= \frac{-v_1 + 0.75}{2k\Omega} = \frac{0.75 - 0.375}{2000} = 0.1875 mA \\ R_s &= \frac{V_s}{i_s} = \frac{0.75 V}{0.1875 mA} = 4k\Omega \end{aligned}$$

Q5

$$\begin{aligned} \text{a) } v^- &= v^+ = 1 V \\ \text{b) } I_1 &= \frac{3-1}{4k} = \frac{2}{4000} = 0.5 mA \\ I_2 &= 0 A \\ I_3 &= I_1 = 0.5 mA \\ \text{c) } I_3 &= \frac{1-v_o}{10k\Omega} \rightarrow v_o = -10k\Omega \times 0.5 mA + 1 = -5 + 1 = -4 V \end{aligned}$$

Q6

$$\begin{aligned} \text{a) } I_1 &= I_2 = 0 A \\ \text{b) } V^- &= V^+ = V_s = 1 V \\ \text{c) } 1 V &= V_o \times \frac{10k\Omega}{10k\Omega + 10k\Omega} \rightarrow V_o = 2 V \\ \text{Gain} &= \frac{V_o}{V_i} = 2 \\ \text{d) } I_3 &= \frac{V_o}{20k\Omega} = \frac{2}{20000} = 0.1 mA \\ \text{e) } I_3 &= V_o \cdot (20k || 5k)\Omega = 2 \times \frac{1}{4000} = 0.5 mA \\ \text{f) } &\text{As there is no input current, thus the input resistance should be infinity.} \end{aligned}$$

Q7

$$\begin{aligned} \text{a) } V^- &= V^+ = 1 \times \frac{9}{1+9} = 0.9 V \\ \text{b) } I_1 &= 0 A \\ I_3 &= \frac{0.9}{5k\Omega} = 18 \mu A \\ I_2 &= -I_3 = -18 \mu A \\ \text{c) } \frac{V_o - 0.9}{100k\Omega} &= I_2 \rightarrow V_o = 1.8 + 0.9 = 2.7 V \\ I_o &= \frac{V_o}{10k\Omega} - I_2 = 270 \mu A + 18 \mu A = 288 \mu A \end{aligned}$$

Q8

- a) $V^- = V^+ = 0\text{ V}$
b) $I_1 = \frac{2\text{ V}}{10\text{ k}\Omega} = 0.2\text{ mA}$
 $I_2 = \frac{-2\text{ V}}{20\text{ k}\Omega} = -0.1\text{ mA}$
 $I_3 = \frac{-4.5\text{ V}}{30\text{ k}\Omega} = -0.15\text{ mA}$
c) $I_4 = I_1 + I_2 + I_3 = 0.2 - 0.1 - 0.15 = -0.05\text{ mA}$
d) $V_o = -I_4 R_o = -0.05\text{ mA} \times 30\text{ k}\Omega = 1.5\text{ V}$

Q9

- a) $I_1 = \frac{V_1 - 0}{100\text{ k}\Omega} = \frac{1}{100000} = 10\text{ }\mu\text{A}$
 $I_2 = \frac{V_2 - 0}{100\text{ k}\Omega} = \frac{2}{100000} = 20\text{ }\mu\text{A}$
b) $I_3 = -I_2 = -20\text{ }\mu\text{A}$
 $I_4 = I_1 - I_3 = 10 - (-20) = 30\text{ }\mu\text{A}$
c) $\frac{0 - V}{200\text{ k}\Omega} = I_4 \rightarrow V = -30\text{ }\mu\text{A} \times 200\text{ k}\Omega = -6\text{ V}$
 $V_o = \frac{40\text{ k}\Omega}{10\text{ k}\Omega + 40\text{ k}\Omega} \cdot V = \frac{4}{5} \times -6\text{ V} = -4.8\text{ V}$
 $30\text{ }\mu\text{A} + I_o = \frac{-6\text{ V}}{10\text{ k}\Omega + 40\text{ k}\Omega}$
 $I_o = -0.15\text{ mA}$
d) Same