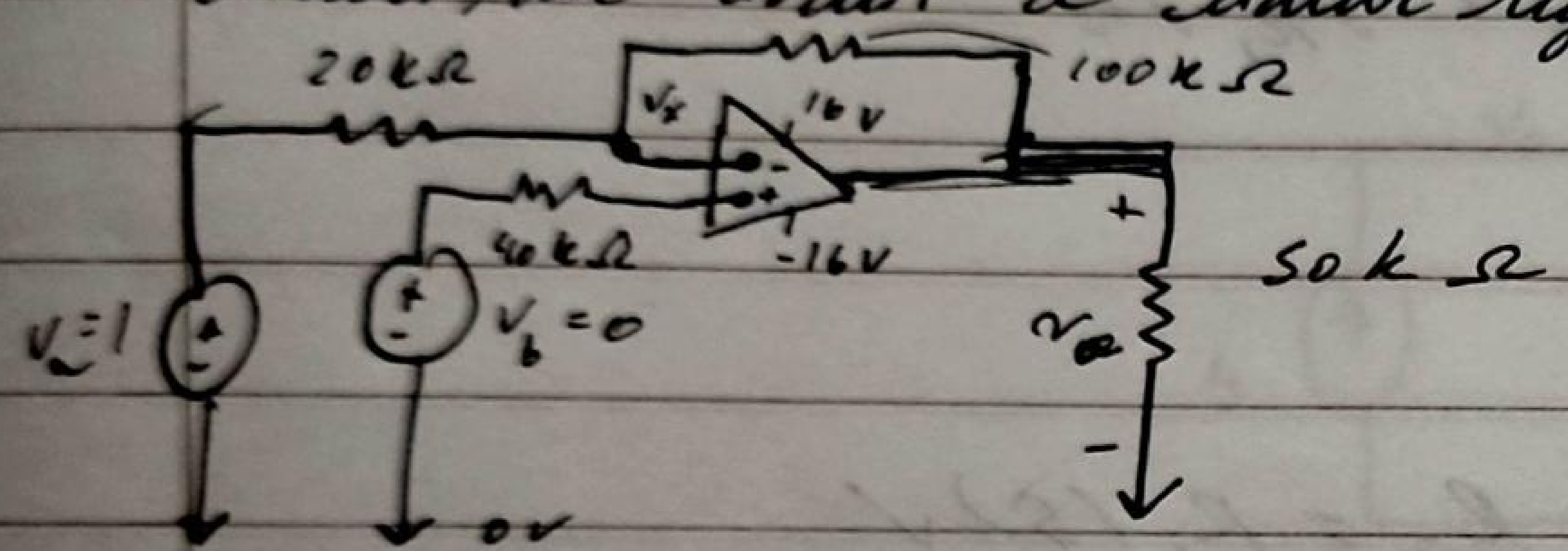
Engr 0&S

Homework 6

1. Consider Op Amplifier, Compute V_o given $V_a = 1V$, $V_b = 0V$; assume, the Circuit a linear region.



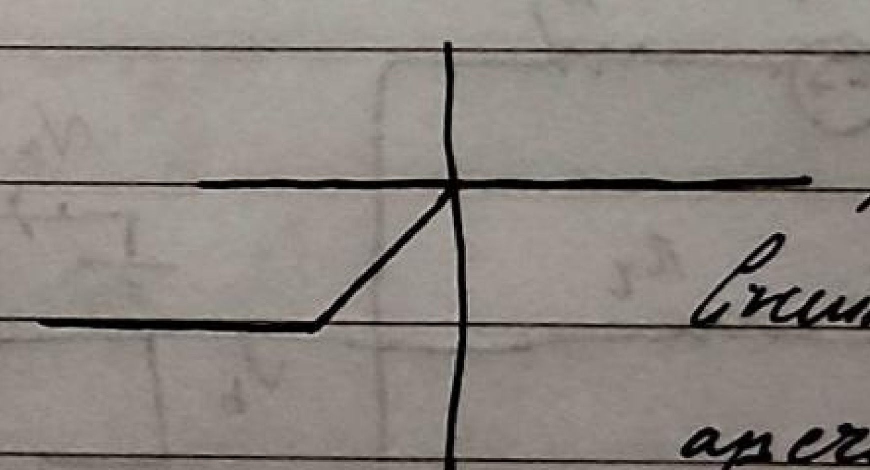
i. Consider $\frac{V_s - V_x}{1k} = \frac{V_x - V_o}{10K}$

$\hookrightarrow \frac{1-0}{20} = \frac{0 - V_o}{100}$

$\hookrightarrow \frac{1}{20} = \frac{V_o}{-100}$

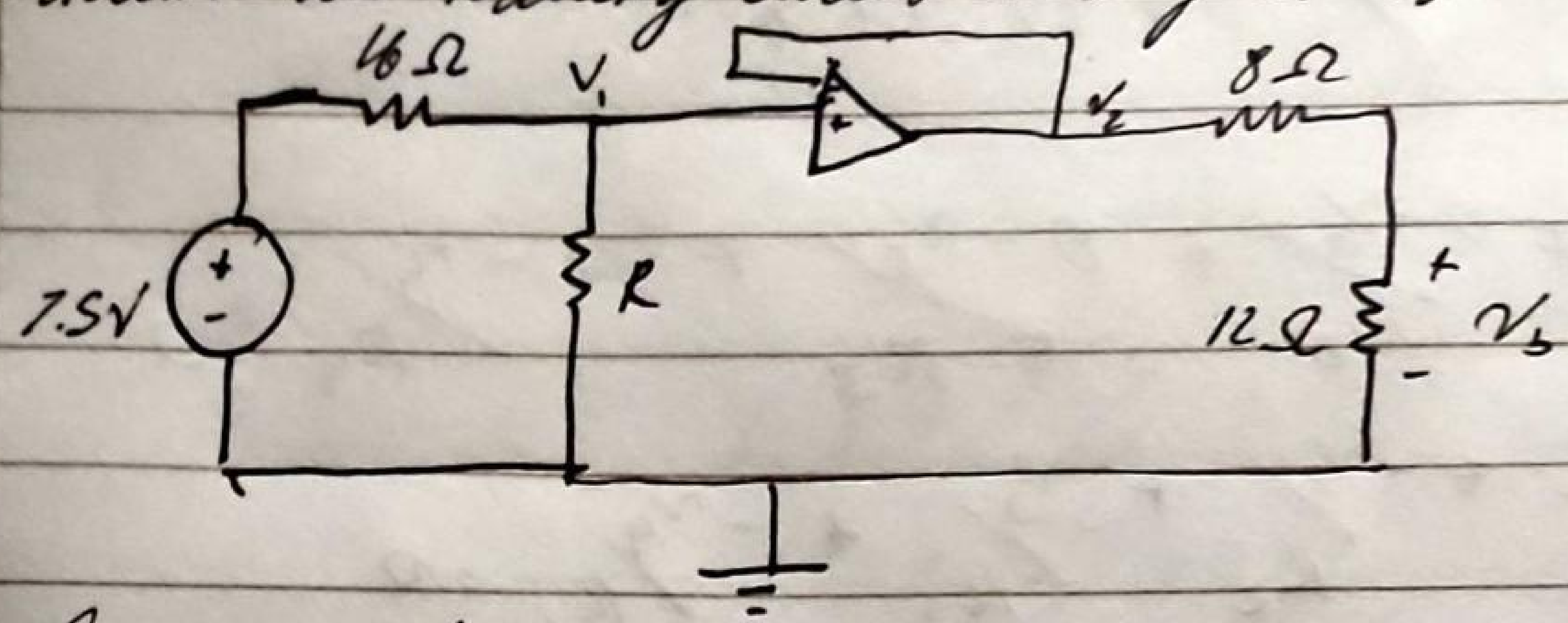
$\hookrightarrow V_o = -\frac{100}{20} = -5V$ ✓

ii. Consider linear Circuit Graph



, thus the Circuit indeed is operating in a linear region ✓

2. Circuit the following Circuit and find v_o.



i. Consider Ideal Optm properties

a. $v^+ = v^-$; $R = 29$

ii. Voltage Division from 7.5V

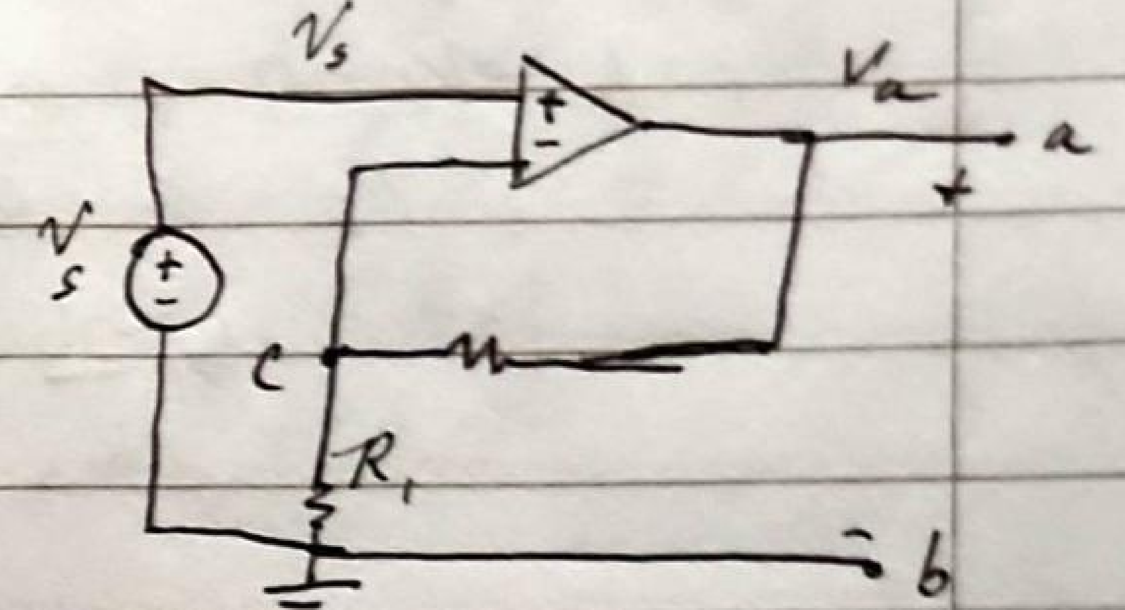
↳ $V_1 = \frac{R(7.5)}{R+16} = 29(7.5)/29+16 = 4.83$ ✓

iii. Voltage across V_2

↳ $V_o = V_2 \cdot 12/(12+8)$; $V_2 = V_1 = 4.83$

↳ $V_o = 4.83(12)/12+8 = 2.89V$ ✓

3. Select R_1 & R_2 such that $v_o = 6V_s$



i. Consider $v_+ = v_- = v$

• KCL at node C

$$\frac{0-v_c}{R_1} = \frac{v_c - v_a}{R_2}$$

↳ $\frac{v_c}{R_1} = \frac{v_c}{R_2} - \frac{v_a}{R_2}$

↳ Thus, $v_a/R_2 = v_c/R_2 + v_c/R_1$

↳ $\left(v_c\left(\frac{R_1+R_2}{R_1R_2}\right)\right) = v_a/R_2$ R_2

↳ $v_a = v_c\left(\frac{R_1+R_2}{R_1}\right)$

↳ $v_a = v_c\left(1 + R_2/R_1\right)$

ii. Optm ideal law

↳ $v_c = v_s$; $v_a = v_s\left(1 + R_2/R_1\right)$ →

3 Continued...

↳ Recall $v_a = v_s \, (1 + R_2/R_1)$

iii. Consider $v_0 = v_a - v_b = v_s\,(1 + R_2/R_1) - 0$

↳ $v_0 = (1 + R_2/R_1)v_s \;;\; v_s = 6$

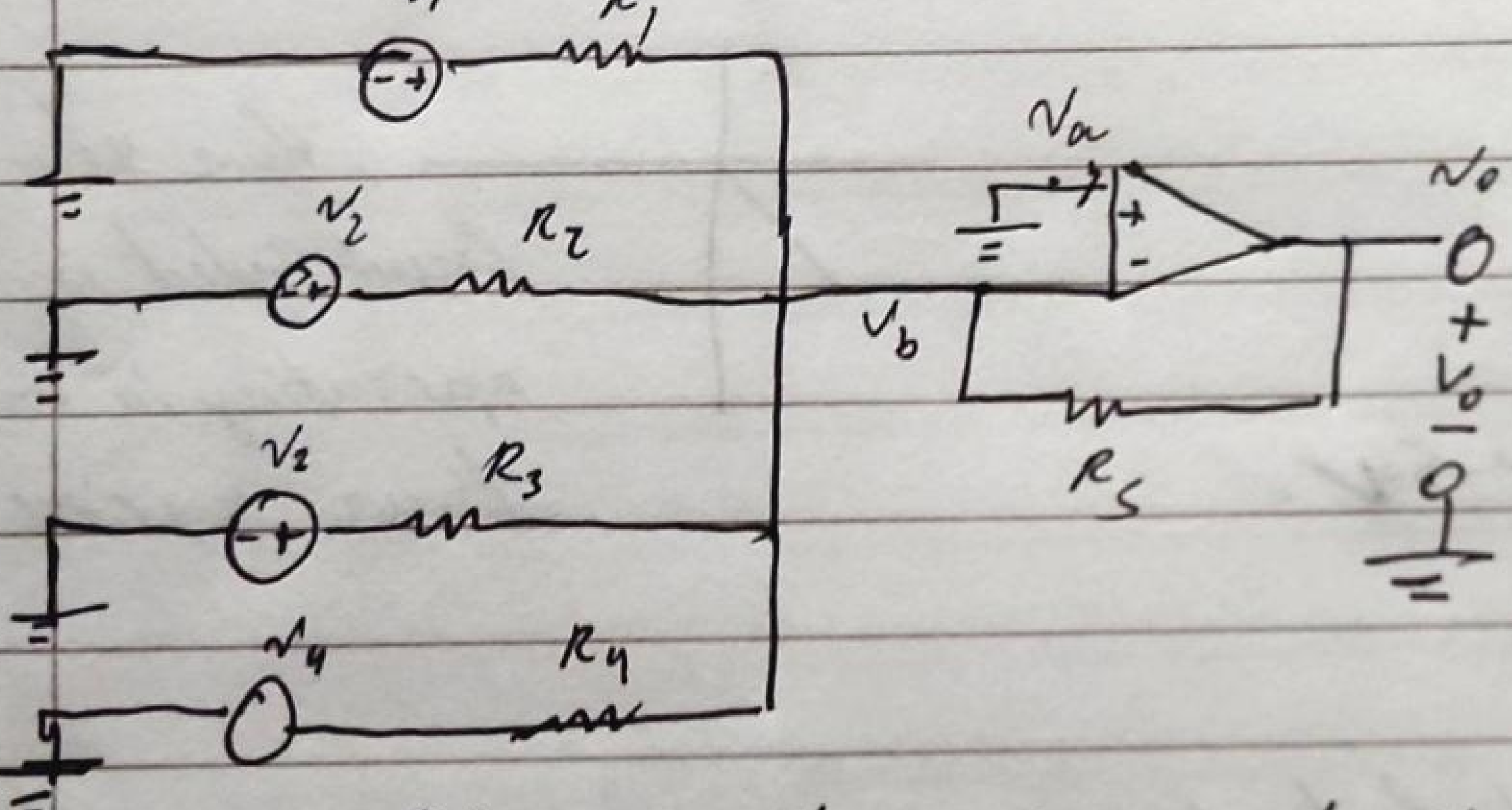
↳ Therefore, $6\,v_s = (1 + R_2/R_1)v_s$

iv. Therefore, $6 = 1 + R_2/R_1$

↳ $R_2/R_1 = 5$ ✓

v. Now Consider $R_2/R_1 = 5 \Rightarrow R_2 = R_1(5)$ ✓

4. Consider the Circuit



a. Determine v_0 in terms of v_1, v_2, v_3, v_4.

1 ↳ Node analysis at v_b

2 ↳ $\dfrac{v_0 - 0}{R_5} + \dfrac{0 - v_1}{R_1} + \dfrac{0 - v_2}{R_2} + \dfrac{0 - v_3}{R_3} + \dfrac{0 - v_4}{R_4} = 0$

↳ $\dfrac{-v_0}{R_5} + \dfrac{-v_1}{R_1} + \dfrac{-v_2}{R_2} + \dfrac{-v_3}{R_3} + \dfrac{-v_4}{R_4} = 0$

↳ $\left(\dfrac{v_0}{R_5} = \dfrac{v_1}{R_1} + \dfrac{v_2}{R_2} + \dfrac{v_3}{R_3} + \dfrac{v_4}{R_4}\right) - R_5$ ✓

↳ Thus, $v_0 = -R_5\left(\dfrac{v_1}{R_1} + \dfrac{v_2}{R_2} + \dfrac{v_3}{R_3} + \dfrac{v_4}{R_4}\right)$

b. Consider $R_5 = 1k\Omega$, ~~since~~

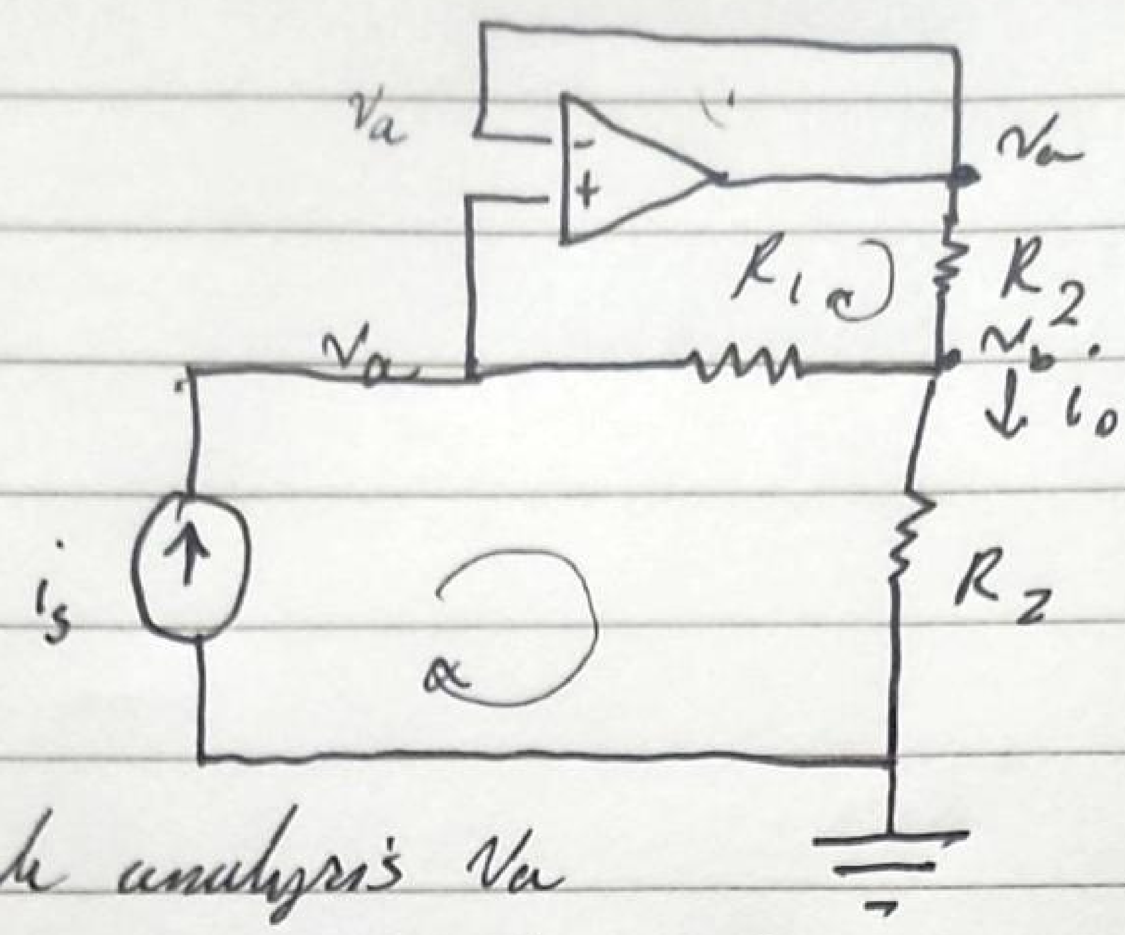
a ↳ Given $v_0 = -\frac{1}{4}(v_1 + v_2 + v_3 + v_4)$

↳ substitution $\Rightarrow -\frac{1}{4}(v_1 + v_2 + v_3 + v_4) = -1k\left(\frac{v_1}{R_1} + \frac{v_2}{R_2} + \frac{v_3}{R_3} + \frac{v_4}{R_4}\right)$

↳ Thus, $R_1 = 4k$, $R_2 = 4k$, $R_3 = 4k$, $R_4 = 4k$

Problem No. 5

a. Consider the non inverting current, show $i_0 = k i_s$ where k is the current gain.



↳ Node analysis V_a

a. ↳ $\frac{V_a - V_b}{R_1} - i_s = 0$

↳ $i_s = \frac{V_a - V_0}{R_1}$

b. Node Equation for Node b

$\frac{V_b - V_a}{R_2} + \frac{V_b}{R_2} + \frac{V_b - V_a}{R_1} = 0 \quad \left[\because i_s = \frac{V_a - V_b}{R_1}\right]$

↳ $\frac{V_b - V_a}{R_2} + i_0 - i_s = 0 \quad \left[\because -i_s = \frac{V_b - V_a}{R_1}\right]$

↳ $\frac{-R_1 i_s}{R_2} + i_0 - i_s = 0 \quad \left[\because V_0 - V_a = -R_1 i_s\right]$

↳ $i_0 = i_s\left[R_1/R_2 + 1\right]$

↳ Thus, $k = R_1/R_2 + 1$ ✓

b. $k = R_1/R_2 + 1$; Consider $R_1 = 11\,k\Omega$

$R_2 = 1\,k\Omega$

↳ $11k\Omega/1k\Omega + 1$

↳ $k = 12$ ✓