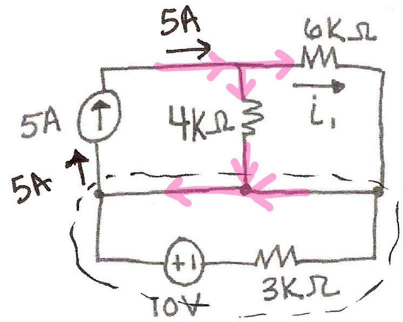
1.

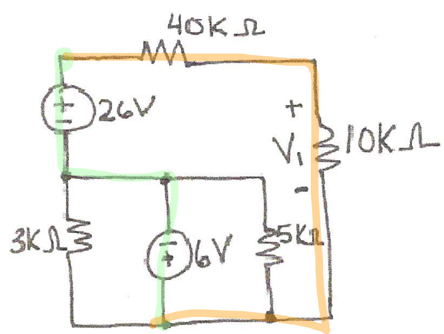


Calculate i_1.

all of this current combines which then goes out - so 5A into parralel R's so splits current by current divider: (current in) (opposite branch R)

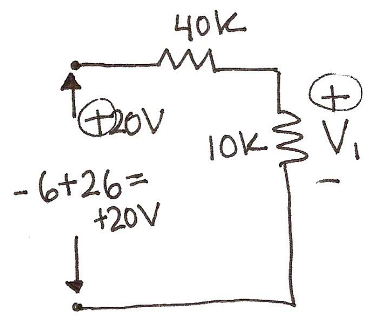
$$i_1 = \frac{5(4k)}{\underbrace{10k}_{\text{total R in both branches}}} = \boxed{2A}$$

2.



Calculate V_1.

$\Longrightarrow$

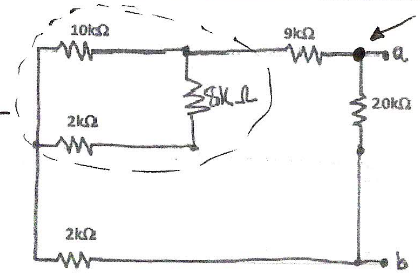


Voltage divider:
~~Vat~~ voltage across R's in series
·signs closest are the same so + answer

$$V_1 = \frac{20(1\cancel{0}K)}{5\cancel{0}\cancel{K}} = \boxed{4V}$$

3. Find the total resistance between terminals **a** and **b**.

parallel



splits so parrallel

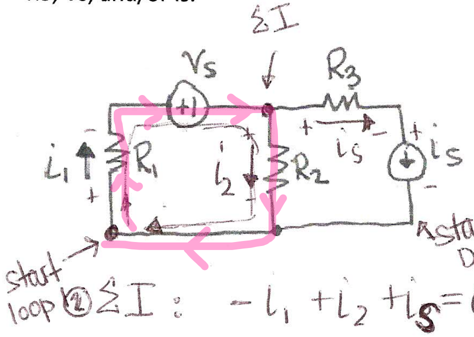
$$R_{eq} = [9K + (8K+2k) \| 10K + 2k] \| 20K$$

$$R_{eq} = \left[9K + \frac{1}{\frac{1}{10k} + \frac{1}{10k}} + 2K\right] \| 20K = [11K + 5k] \| 20K$$

$$R_{eq} = 16k \| 20k = \frac{1}{\frac{(20k)}{(20k)}\frac{1}{16k} + \frac{1}{20k}\frac{(16k)}{(16k)}} = \frac{16k(20k)}{20k + 16k}$$

$$R_{eq} \cong \boxed{8.9K\Omega}$$

4. Derive an expression for i_1 in the circuit below containing not more than circuit parameters R1, R2, R3, Vs, and/or is.



Known values: R_1, R_2, R_3, V_s, i_s

Don't want to take a V-loop across i source

② ΣI: $-i_1 + i_2 + i_s = 0$

① V-loop: $-i_1 R_1 - V_s - i_2 R_2 = 0$

from ② $i_1 = i_2 + i_s$ plug into ①

$-(i_2 + i_s)R_1 - V_s - i_2 R_2 = 0$

$-i_2(R_1 + R_2) = i_s R_1 + V_s$

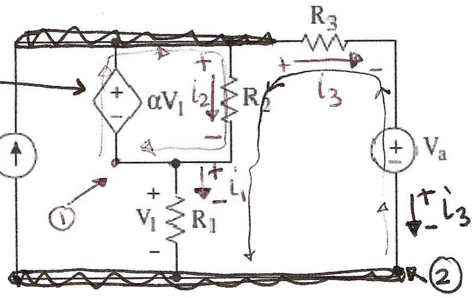
$$i_2 = -\frac{(i_s R_1 + V_s)}{R_1 + R_2}$$

$$\therefore \quad i_1 = \frac{-(i_s R_1 + V_s)}{(R_1 + R_2)} + \frac{i_s(R_1 + R_2)}{R_1 + R_2}$$

$$\boxed{i_1 = \frac{i_s R_2 - V_s}{(R_1 + R_2)}}$$

5.

unknown current in this branch. Do not sum current connected here.



) Derive the expression for V_1 containing not more than circuit parameters α, R_1, R_2, R_3, V_a, and i_a.

6. Using the circuit shown in Problem #5, derive an expression for the power through R2. The known values are α, i_a, V_a, R_1, R_2 and R_3.

First write an equation for unknown V_1.

$$V_1 = i_1 R_1$$

$$① \quad +\alpha V_1 - i_2 R_2 = 0 \rightarrow i_2 = \frac{\alpha V_1}{R_2}$$

$$② \quad +V_a + i_3 R_3 - \alpha V_1 - i_1 R_1 = 0$$

$$+V_a + i_3 R_3 - \alpha (i_1 R_1) - i_1 R_1 = 0 \rightarrow i_3 = \frac{-V_a + i_1 R_1 (1+\alpha)}{R_3}$$

ΣI at ②:

$$+i_a - i_1 - i_3 = 0$$

$$i_3 = i_a - i_1 \quad \text{(set equal to)}$$

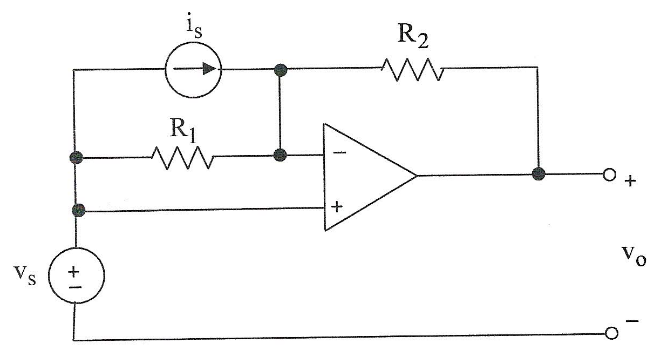
$$(i_a - i_1) = \left[-V_a + i_1 R_1 (1+\alpha)\right] / R_3$$

$$\left(i_a + \frac{V_a}{R_3}\right) = i_1 \frac{R_1}{R_3}(1+\alpha) + i_1 = i_1 \left[1 + \frac{R_1}{R_3}(1+\alpha)\right]$$

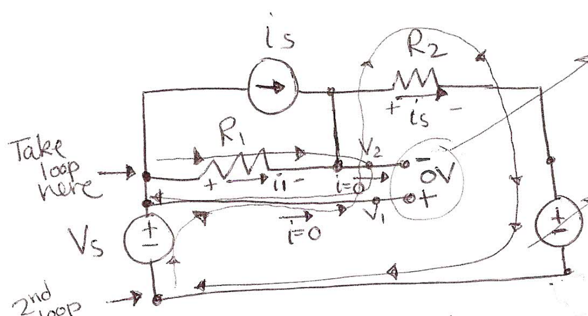
$$\boxed{V_1 = \frac{[R_3 i_a + V_a]}{[R_3 + R_1(1+\alpha)]} \cdot R_1}$$

$$P_{i_2} = i_2^2 \cdot R_2 = \boxed{\left[\frac{\alpha (R_3 i_a + V_a) R_1}{[R_3 + R_1 (1+\alpha)] R_2}\right]^2 \cdot R_2}$$

7. The op-amp operates in the linear mode. Using an appropriate model of the op amp, derive an expression for v_O in terms of not more than V_S, i_s, R_1, and/or R_2. Note that the current source is **not** ideal and has a voltage drop across it.



Redraw:



This is a "virtual" short that means 0V drop so $V_1 = V_2$. Also means <u>no</u> current from V_1 to V_2.

· Taking a loop <u>through</u> V_2 to V_1

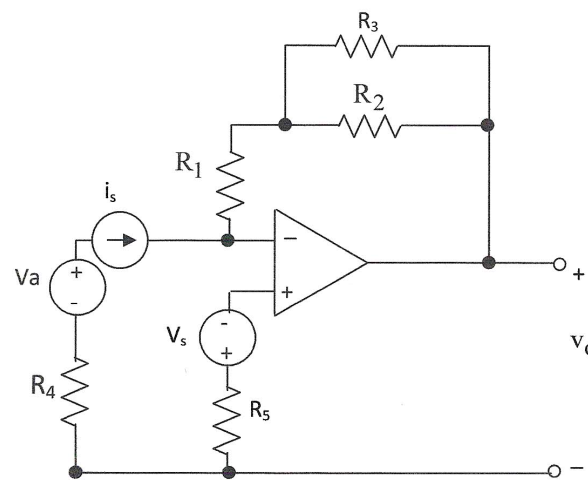
$$-i_1R_1 + 0 = 0 \quad \therefore \quad \underline{i_1 = 0}$$

$\therefore$ i_s flows through R_2.

$$+V_s - 0 - i_sR_2 - V_0 = 0$$

$$\boxed{V_0 = V_s - i_2R_2}$$

8. The op-amp operates in the linear mode. Using an appropriate model of the op amp, derive an expression for v_o in terms of not more than V_a, V_S, i_s, R_1, R_2, R_3, R_4 and R_5. Note that the current source is **not** ideal and has a voltage drop across it.



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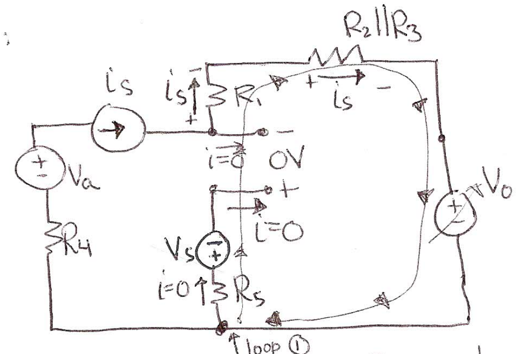


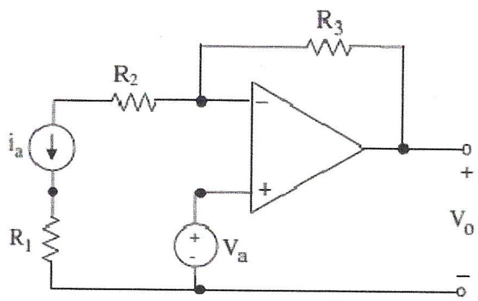
i_s flows through R_1 and $R_2 \| R_3$ because $i=0$ into op-amp.

① $-0 - V_s - 0 - i_s R_1 - i_s R_2 \| R_3 - V_o = 0$

0 V drop across R_5

$$\therefore \boxed{V_o = -V_s - i_s R_1 - \frac{i_s R_2 R_3}{(R_2 + R_3)}}$$

9. The op-amp operates in the linear mode. Using an appropriate model of the op-amp, derive an expression for Vo in terms of not more than i_a, R1, R2, R3, and/or Va. Note that the current source is **not** ideal and has a voltage drop across it.



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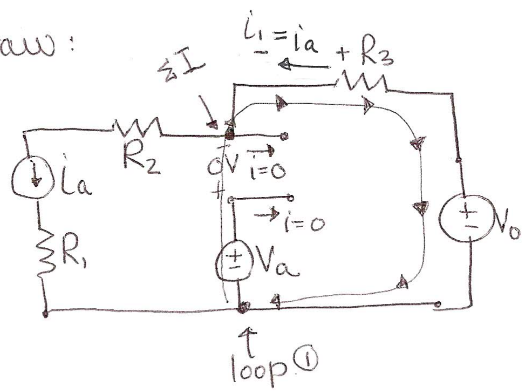
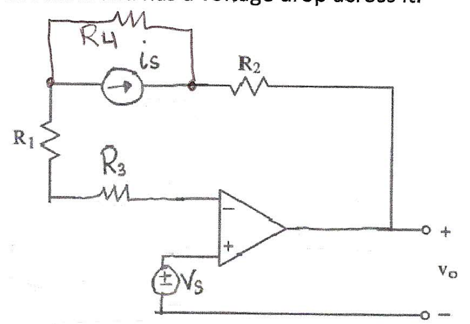


$\Sigma I : +i_a + 0 - i_1 = 0 \quad \therefore \; i_1 = i_a$

V-loop: $+V_a - 0 + i_a R_3 - V_o = 0$

$$\boxed{V_o = V_a + i_a R_3}$$

10. The op-amp operates in the linear mode. Using an appropriate model of the op-amp, derive an expression for Vo in terms of not more than i_a, R1, R2, R3, and/or Va. Note that the current source is **not** ideal and has a voltage drop across it.



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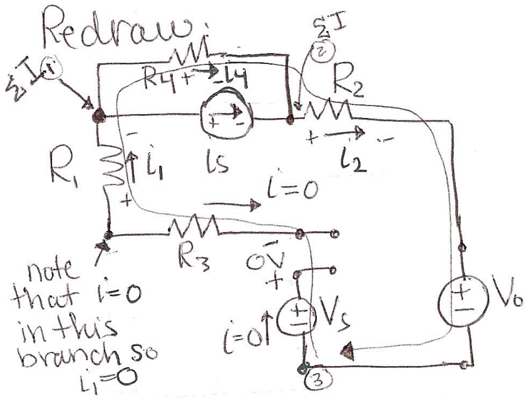

at ① : $\Sigma I = -\underset{0}{i_1} + i_s + i_4 = 0 \quad \therefore i_s = -i_4$

at ② : $\Sigma I \quad -i_s - i_4 + i_2 = 0$

$-i_s - (-i_s) + i_2 = 0 \quad \therefore i_2 = 0$

at ③ V-loop : $+V_s - 0 + 0 - \underset{0}{i_1} R_1 - i_4 R_4 - \underset{0}{i_2} R_2 - V_0 = 0$

$\therefore \boxed{V_0 = V_s + i_s R_4}$