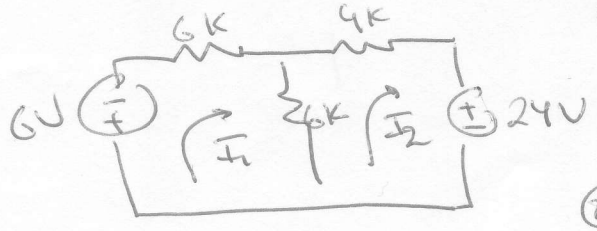
53.



① $+6+6K(I_1)+6K(I_1-I_2)=0$

$12KI_1 - 6KI_2 = -6$

② $6K(I_2-I_1)+4KI_2+24=0$

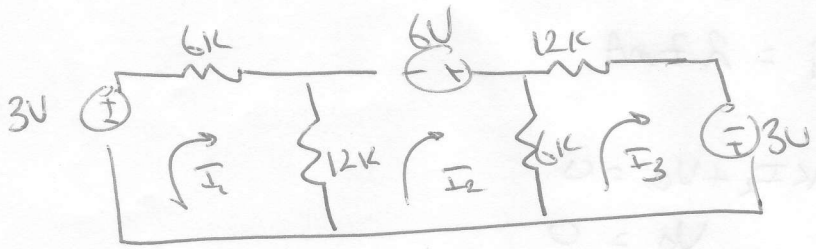
$-6KI_1+10KI_2=-24$

① + 2×② : $14KI_2 = -54$

$I_2 = \frac{-54}{14}\,mA$

$= -\frac{27}{7}\,mA = I_0$

56.



$I_0 = I_2 - I_3$

① $-3+6KI_1+12K(I_1-I_2)=0$

$18KI_1 - 12KI_2 = 3$

② $12K(I_2-I_1)+6+6K(I_2-I_3)=0$

$18KI_2 - 12KI_1 - 6KI_3 = +6$

③ $6K(I_3-I_2)+12KI_3+3=0$

$18KI_3 - 6KI_2 = 3$

① → $I_1 = \frac{3+12KI_2}{18K}$ ③ $I_3 = \frac{3+6KI_2}{18K}$

in ② $18KI_2 - 12K\left(\frac{3+12KI_2}{18K}\right) - 6K\left(\frac{3+6KI_2}{18K}\right) = 6$

$18KI_2 - 2 - 8KI_2 - 1 - 2KI_2 = 6$

$8KI_2 = 9$

$I_2 = \frac{9}{8}\,mA$

in ③ $18K I_3 - 6K I_2 = 3$

$18K I_3 - 6K\left(\frac{9}{8}mA\right) = 3$

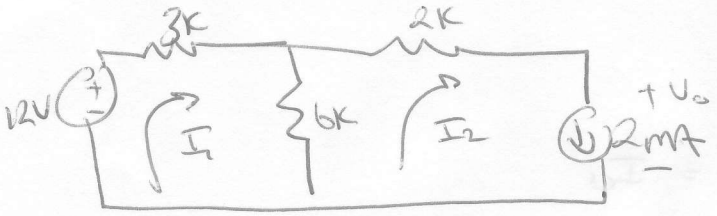
$18K I_3 = 3 + \frac{27}{4}$

$I_3 = 0.54\,mA$

$I_o = I_2 - I_3$

$= 0.58\,mA$

60.



$I_2 = 2mA$

① $-12 + 3K I_1 + 6K(I_1 - I_2) = 0$

$I_1 = 2.7mA$

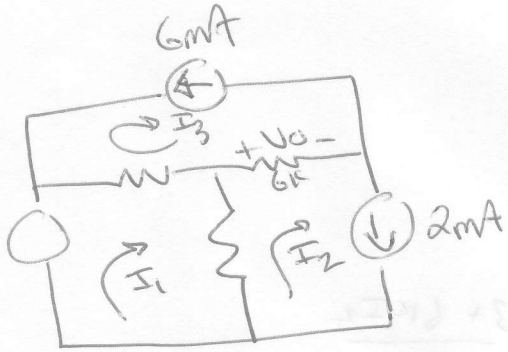
outer loop $-12 + 3K I_1 + 2K I_2 + V_o = 0$

$V_o = 0$

or ② $6K(2mA - I_1) + 2K(2mA) + V_o = 0$

$V_o = 0$

61.

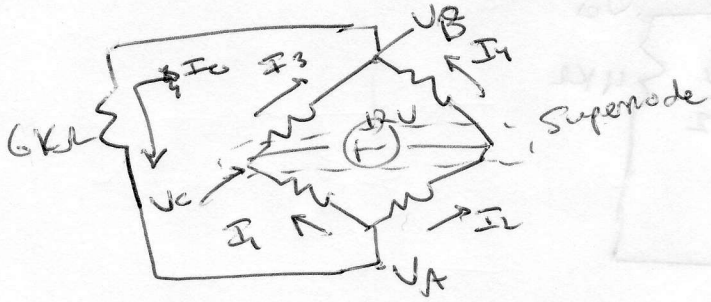


$V_o = 6K(I_2 - I_3)$

$= 6K(2mA - (-6mA))$

$= 48\,V$

30.



$V_C = 12V$

$V_o = V_B - V_A$

Supernode KCL:

$$I_1 + I_2 = I_3 + I_4$$

$$\frac{V_A - V_C}{6K} + \frac{V_A}{6K} = \frac{V_C - V_B}{6K} - \frac{V_B}{6K}$$

$$2V_A + 2V_B - 2V_C = 0 \quad ①$$

@ V_A $\quad I_o = I_1 + I_2$

$$\frac{V_B - V_A}{6K} = \frac{V_A - V_C}{6K} + \frac{V_A}{6K}$$

$$0 = 3V_A - V_B - V_C \quad ②$$

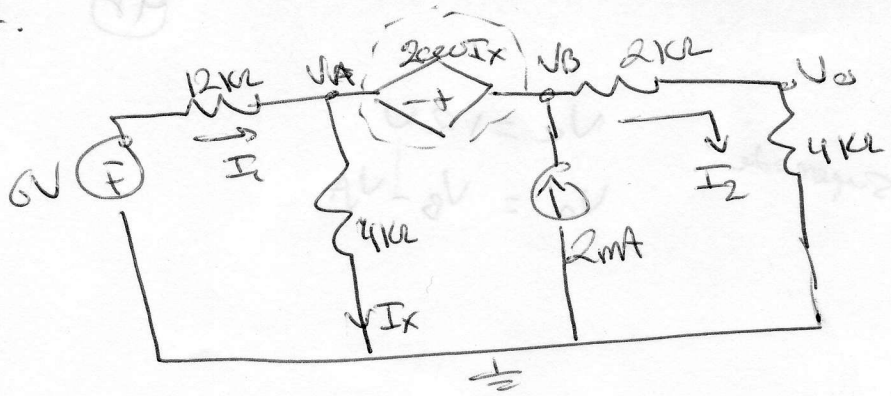
$\therefore$ ① $2V_A + 2V_B = 24$

② $3V_A - V_B = 12$

$V_A = 6V \rightarrow V_B = 6V$

$\Rightarrow V_o = 0$

47.



KCL Supernode

$$2mA + I_1 = I_x + I_2$$

$$2mA + \left(\frac{-6 - V_A}{12K}\right) = \frac{V_A}{4K} + \frac{V_o}{4K}$$

$$1.5 = \frac{7V_A}{12}$$

$$V_A = 2.57V$$

$$\hookrightarrow V_o = V_A$$

$$V_B = 3.86V$$

and $I_2 = 0.6mA$

$$I_2 = \frac{V_o}{4K} = \frac{V_B - V_o}{2K}$$

$$I_x = \frac{V_A}{4K}$$

$$V_B = V_A + 2000I_x$$

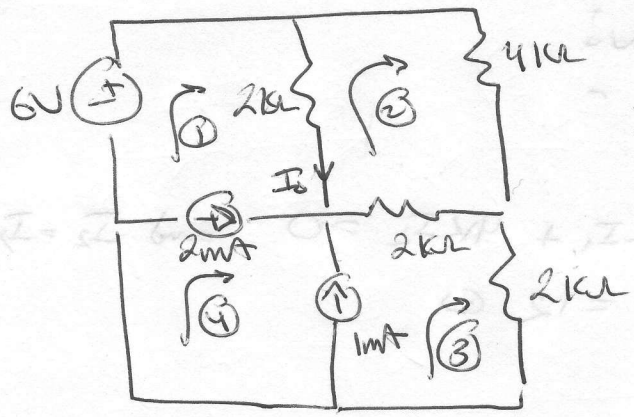
$$= \frac{3V_A}{2}$$

so from I_2: $\frac{V_o}{4K} = \frac{V_B - V_o}{2K}$

$$3V_o = 2V_B$$

$$\hookrightarrow V_o = V_A$$

71



$I_0 = I_1 - I_2$

KVL ~~KCL~~ outer loop:

$$-6 + 4kI_2 + 2kI_3 + 6kI_4 = 0 \quad (1)$$

KVL (2):

$$2k(I_2 - I_1) + 4kI_2 + 2k(I_2 - I_3) = 0$$

$$8kI_2 - 2kI_1 - 2kI_3 = 0 \quad (2)$$

$I_4 - I_1 = 2mA$
$I_3 - I_4 = 1mA$
} $I_3 = 3mA + I_1$ sub in above

(1) $-6 + 4kI_2 + 2k(3mA + I_1) + 6k(2mA + I_1) = 0$

$$8kI_1 + 4kI_2 = -12$$

(2) $8kI_2 - 2kI_1 - 2k(3mA + I_1) = 0$

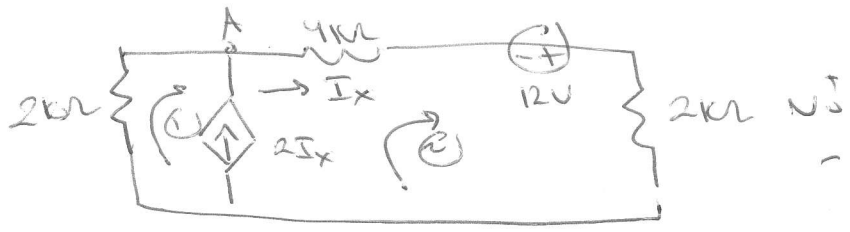
$$8kI_2 - 4kI_1 = 6$$

do (1) + 2×(2) → $I_2 = 0$ → $I_1 = -\frac{3}{2}mA$ → $I_0 = I_1 - I_0$

$$= -\frac{3}{2}mA$$

50

7r



KVL outer loop: $-12 + 2K I_2 + 2K I_1 + 4K I_2 = 0$ and $I_2 = I$

$$2K I_1 + 6K I_x = 12 \quad (1)$$

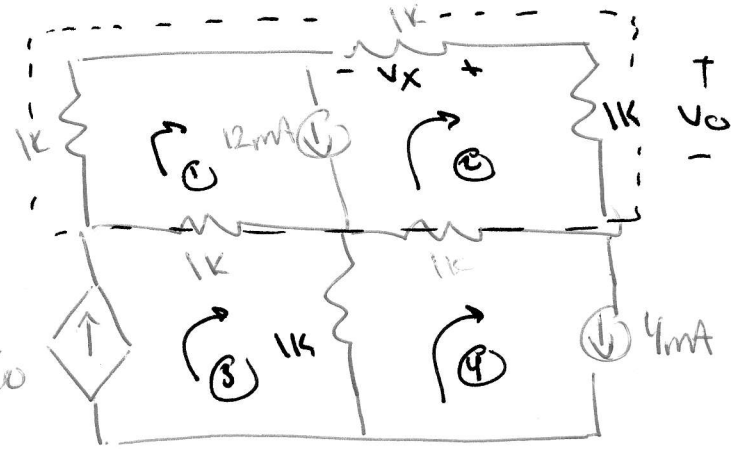
at A: $I_1 + 2I_x = I_x$

$$I_x = -I_1$$

$\therefore$ in (1) $-2K I_x + 6K I_x = 12$

$I_x = 3\,mA \rightarrow V_o = 2K I_x = \underline{6V}$

88.



$V_o = (1K) I_2$

$V_x = -(1K) I_2$

$I_1 - I_2 = 12\,mA$

$I_4 = 4\,mA$

$I_3 = \frac{V_x}{1K} = \frac{-1K\,I_2}{1K} = -I$

$\therefore I_1 + I_3 = 12mA$

KVL in top loop:

$1K\,I_1 - V_x + 1K I_2 + 1K(I_2 - I_4) + 1K(I_1 - I_3) = 0$

$1K(12mA + I_2) - V_x + 1K I_2 + 1K(I_2 - 4\,mA) + 1K(12mA + I_2 + I_2) = 0$

$\hookrightarrow 5K I_2 = V_x - 20$

$I_2 = \frac{V_x - 20}{5K}$ and $I_3 = -I_2 \rightarrow \frac{V_x}{1K} = \frac{20 - V_x}{5K}$

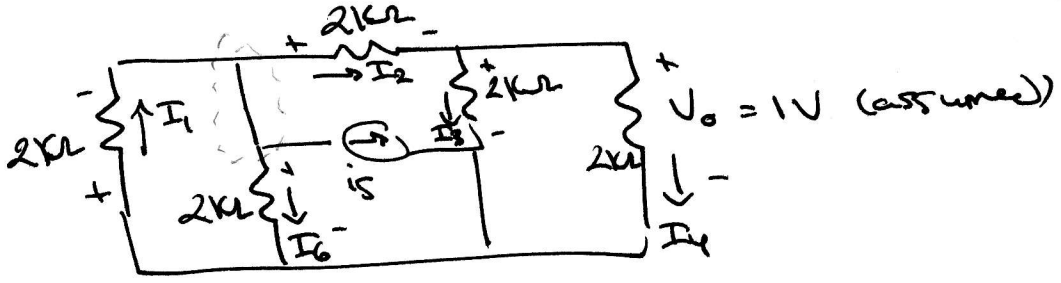
$6V_x = 20$

$V_x = \frac{10}{3}$

$\therefore I_3 = \frac{(\frac{10}{3})}{1K} = 3.3\,mA \rightarrow I_2 = -3.3\,mA$

$\hookrightarrow V_o = \underline{-3.3V}$

1.



$i_4 = \frac{1}{2}$ mA

Right loop: $-V_3 + V_0 = 0 \rightarrow V_3 = V_0 = 1V$

$\hookrightarrow i_3 = \frac{1}{2}$ mA

$i_2 = i_3 + i_4 = 1$ mA

$V_2 = 2V$

Middle loop

$-V_6 + V_2 + V_3 = 0$

$V_6 = 3V$

$\hookrightarrow i_6 = \frac{3}{2}$ mA

outside loop:

$V_1 + V_2 + V_0 = 0$

$V_1 = -3V$

$i_1 = \frac{-3}{2}$ mA

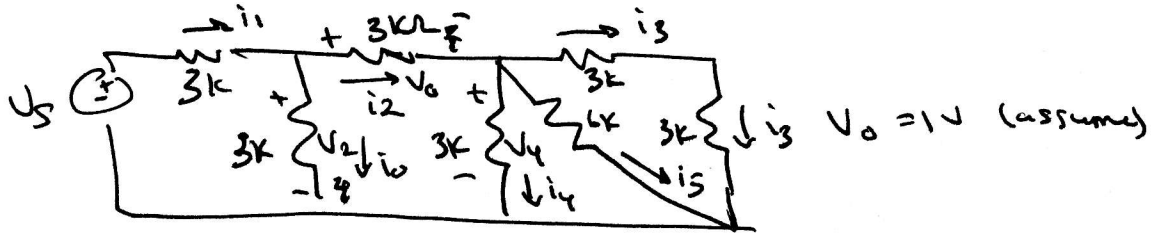
$\therefore i_1 = i_2 + i_6 + i_s$ (supernode)

$i_s = -4$ mA

but i_s, actual $= 2$ mA

so V_0, actual $= \underline{\underline{-3V}}$

5.



$i_3 = \frac{1}{3K} \rightarrow V_4 = (6K)i_3 = 2V$

$\therefore i_4 = \frac{V_4}{3K} = 2i_3$ and $i_5 = \frac{V_4}{6K} = i_3$

$i_2 = i_3 + i_4 + i_5 = 4i_3$

so $V_o = (3K)i_2 = 12K i_3 = 4V$

KVL in middle: $-V_2 + V_o + V_4 = 0$

$V_2 = 6V \rightarrow i_o = \frac{V_2}{3K} = 2mA$

$i_1 = i_o + i_2 = \underset{mA}{2} + \frac{4}{3K} = \frac{10}{3K}\ A$

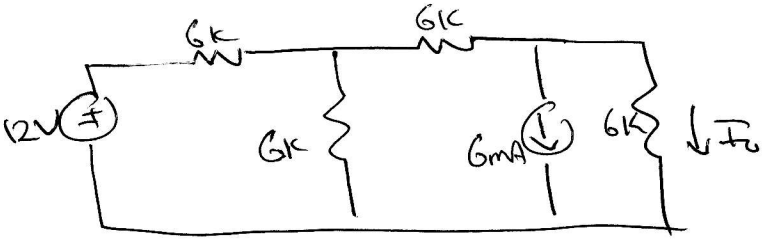
$\rightarrow V_1 = (3K)i_1 = 10V$

KVL on left: $-V_s + V_1 + V_2 = 0$

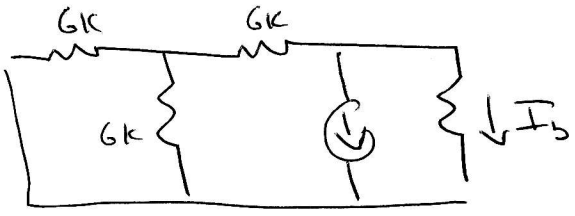
$V_s = 16V$

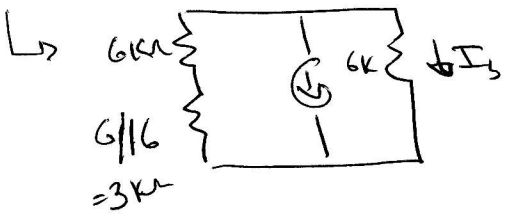
$V_{s,actual} = 8V$ so $V_{o,actual} = \underline{\underline{0.5V}}$

7.



1)





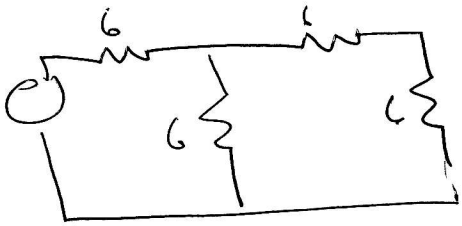
current divisin:

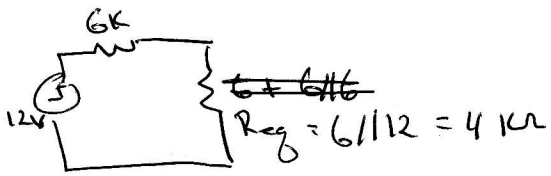
$$I_b = \frac{9k\Omega}{(6+9)k\Omega} \cdot 6mA$$

$$= \frac{-18}{5} mA$$

↑ note sign of current

2)



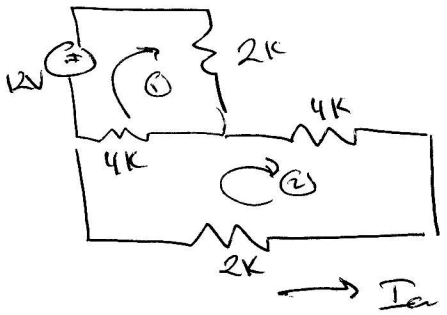


Voltage divider : $V_{eq} = (\frac{4}{10})V_s = 4.8V$

$$I_a = \frac{V_{eq}}{12k\Omega} = 0.4mA$$

$\therefore I_o = I_a + I_b = -3.2\,mA$

11. 1)



$i_2 = -i_a$

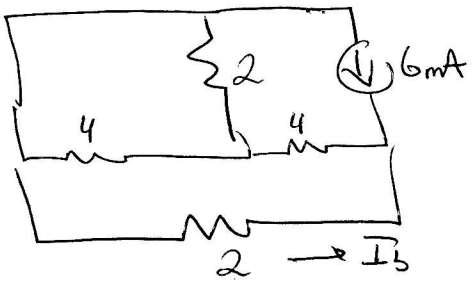
KVL ① $-12 + 2K i_1 + 4K(i_1 - i_2) = 0$

② $4K(i_2 - i_1) + 6K i_2 = 0$

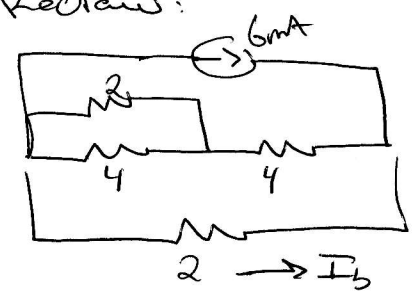
$\therefore i_2 = \frac{12}{11}$ mA

$i_a = -\frac{12}{11}$ mA

2)



Redraw:



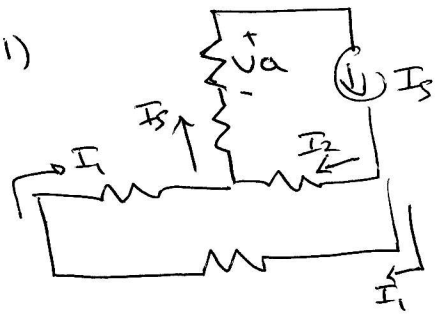
$\Rightarrow$ current division

$I_b = \left[\frac{(2\|4+4)}{(2\|4+4)+2}\right] \cdot 6mA$

$= -\frac{48}{11}$ mA ← note current direction

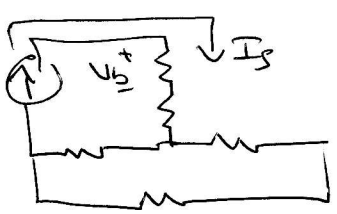
so $I_o = I_a + I_b$

13. 1)



$V_a = -(4mA)(2K\Omega) = -8V$

2)



$V_b = (6mA)(2K\Omega) = 12V$

so $V_o = V_a + V_b = \underline{4V}$