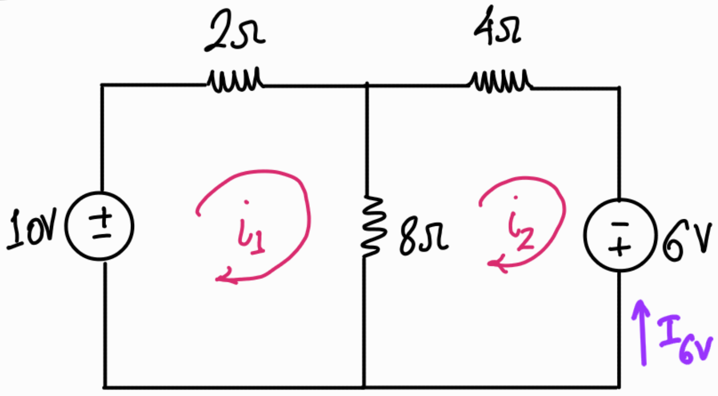
Problem 1



Determine current absorbed by the 6V source.

KVL @ 1 —

$-10 + 10i_1 - 8i_2 = 0$

$\Rightarrow 5i_1 - 4i_2 = 5$ — (i)

KVL @ 2 —

$-8i_1 + 12i_2 = 6$

$\Rightarrow -4i_1 + 6i_2 = 3$ — (ii)

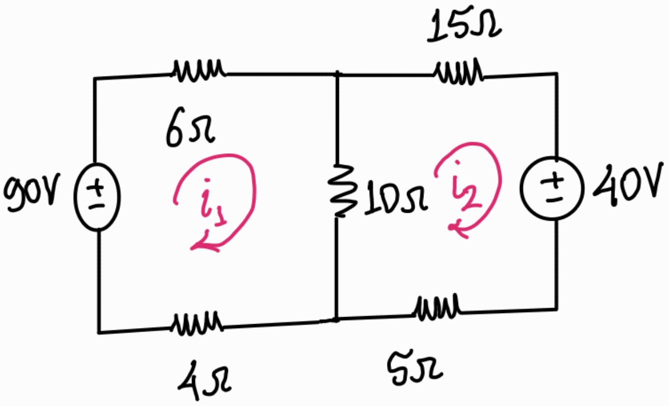
Solving (i) & (ii)

$i_1 = 3A$

$i_2 = 2.5A$

$\therefore I_{6V} = -i_2 = -2.5A$

Problem 2



Calculate current through the 10Ω resistor.

KVL @ 1 —

$20i_1 - 10i_2 = 90$

$\Rightarrow 2i_1 - i_2 = 9$ — (i)

KVL @ 2 —

$-10i_1 + 30i_2 = -40$

$\Rightarrow -i_1 + 3i_2 = -4$ — (ii)

Solving (i) & (ii) —

$i_1 = 4.6A$

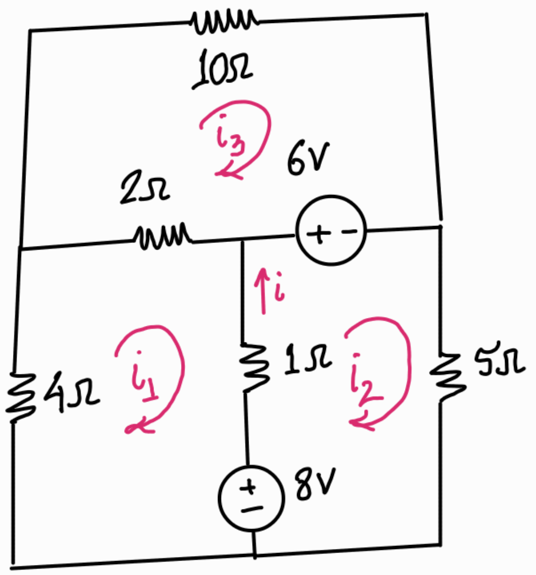
$i_2 = 0.2A$

no assigned direction

$\therefore I_{10\Omega} = \pm(i_1 - i_2)$

$= \pm 4.4A$

Problem 3



Calculate current i

KVL @ 1 —

$7i_1 - i_2 - 2i_3 = -8$ — (i)

KVL @ 2 —

$-i_1 + 6i_2 = 2$ — (ii)

KVL @ 3 —

$-2i_1 + 12i_3 = 6$

$\Rightarrow -i_1 + 6i_3 = 3$ — (iii)

Solving (i), (ii) & (iii) —

$i_1 = -1.026\,A$

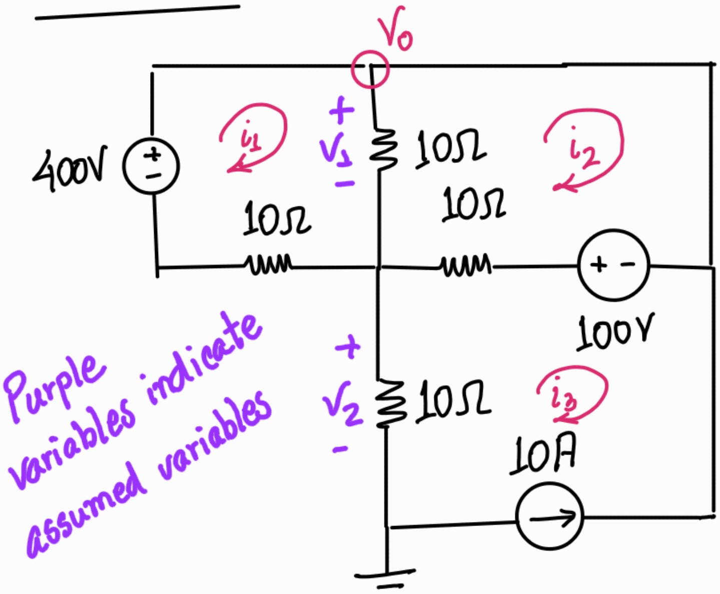
$i_2 = 0.162\,A$

$i_3 = 0.329\,A$

Here, $i = i_2 - i_1$

$= 1.188\,A$

Problem 4



Apply mesh analysis to find v_o

Here, $i_3 = -10A$

KVL @ 1 —

$$20i_1 - 10i_2 = 400$$

$$\Rightarrow 2i_1 - i_2 = 40 \quad \text{— (i)}$$

KVL @ 2 —

$$-10i_1 + 20i_2 - 10\times10 = -100$$

$$\Rightarrow -i_1 + 2i_2 = 0 \quad \text{— (ii)}$$

Solving (i) & (ii) —

$$i_1 = 26.67A$$

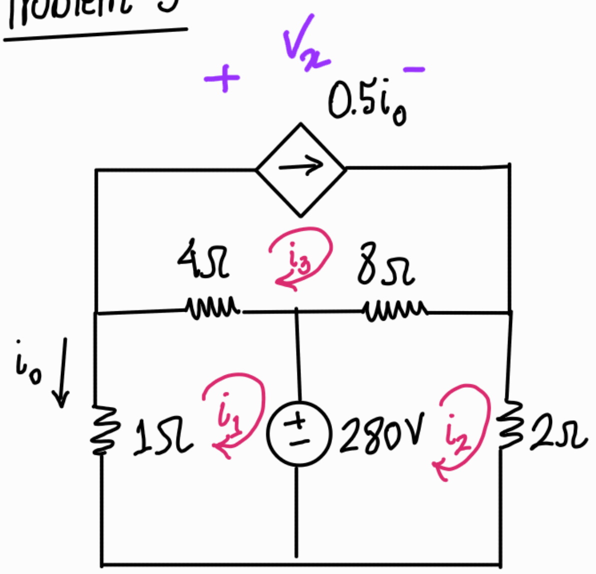
$$i_2 = 13.33A$$

$$V_o = V_1 + V_2$$

$$= (i_1 - i_2)\times 10 + (-i_3)\times 10$$

$$= 233.4V$$

Problem 5



Find i_0 and the voltage across the $0.5i_0$ source

$i_0 = -i_1$ —— (1)

Here, $i_3 = 0.5\,i_0 \Rightarrow 2i_3 = -i_1 \Rightarrow i_1 + 2i_3 = 0$ — (i)

KVL @ 1 ——

$5i_1 - 4i_3 = -280$ —— (ii)

KVL @ 2 ——

$10\,i_2 - 8\,i_3 = 280$

$\Rightarrow 5i_2 - 4i_3 = 140$ —— (iii)

Solving (i) (ii) & (iii) ——

$i_1 = -40A$

$i_2 = 44A$

$i_3 = 20A$

KVL @ 3 ——

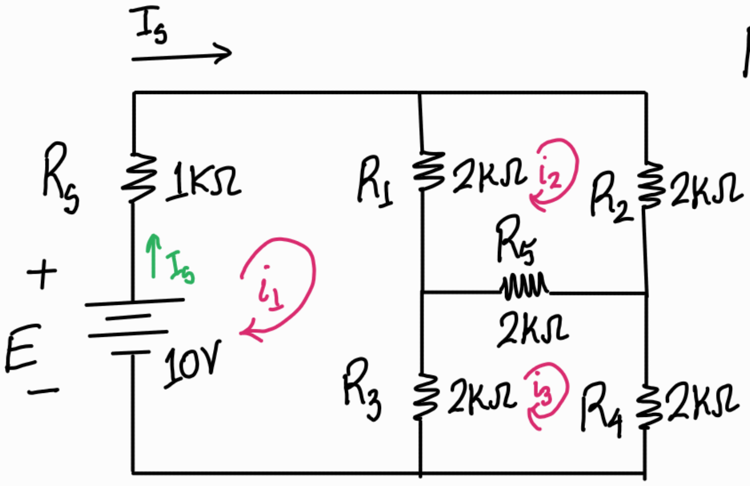
$V_x + (i_3 - i_2) \times 8 + (i_3 - i_1) \times 4 = 0$

$\Rightarrow V_x = -48V$

But since polarity isn't given, $V_{0.5i_0} = \pm 48V$

and $i_0 = -i_1 = 40A$

Problem 6



Find I_S.

KVL @ 1 —

$5i_1 - 2i_2 - 2i_3 = 10$ — (i)

KVL @ 2 —

$-2i_1 + 6i_2 - 2i_3 = 0$

$\Rightarrow -i_1 + 3i_2 - i_3 = 0$ — (ii)

KVL @ 3 —

$-2i_1 - 2i_2 + 6i_3 = 0$

$\Rightarrow -i_1 - i_2 + 3i_3 = 0$ — (iii)

Solving (i), (ii) & (iii) —

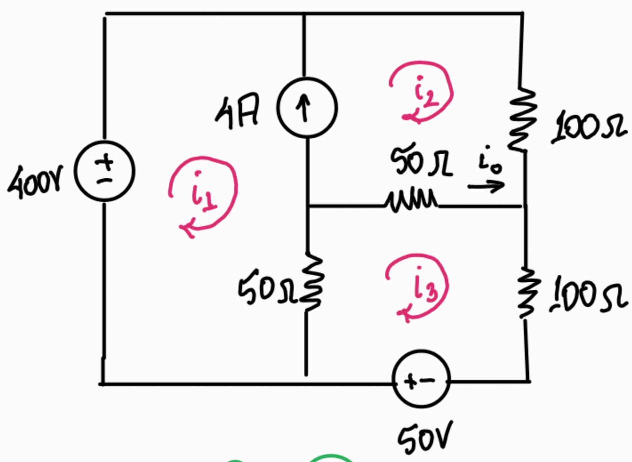
$i_1 = 3.33\ mA$

$i_2 = 1.67\ mA$

$i_3 = 1.67\ mA$

$\therefore i_S = i_1 = 3.33\ mA$

Problem 7



Current relation @ supermesh 1 & 2 —

$-i_1 + i_2 = 4$ — (i)

KVL @ supermesh 1 & 2 —

$50i_1 + 150i_2 - 100i_3 = 400$

$\Rightarrow i_1 + 3i_2 - 2i_3 = 8$ — (ii)

KVL @ 3 —

$-50i_1 - 50i_2 + 200i_3 = 50$

$\Rightarrow -i_1 - i_2 + 4i_3 = 1$ — (iii)

Solving (i), (ii) & (iii) —

$i_1 = -0.5A$

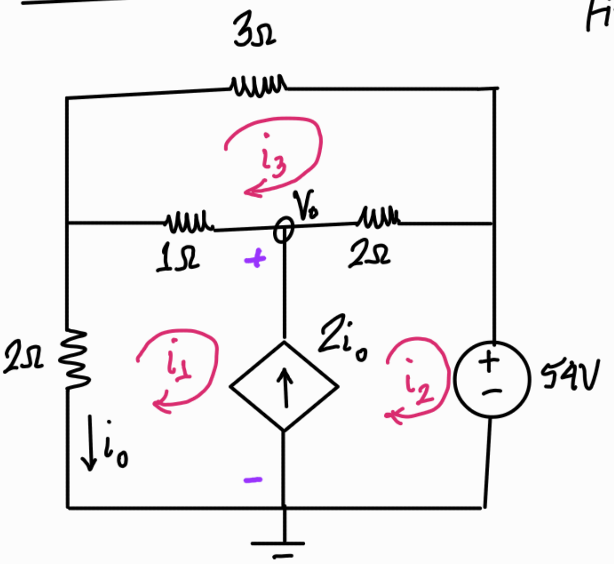
$i_2 = 3.5A$

$i_3 = 1A$

$\therefore i_o = i_3 - i_2 = -2.5A$

Problem 8

Find i_o & v_o using mesh analysis.



Current relationship @ supermesh 1,2 —

$-i_1 + i_2 = 2i_o$ —— (i)

but $i_o = -i_1$

$\therefore$ (i) $\Rightarrow$ $i_1 + i_2 = 0$ —— (ii)

KVL @ supermesh 1,2 —

$3i_1 + 2i_2 - 3i_3 = -54$ —— (iii)

KVL @ 3 —

$-i_1 - 2i_2 + 6i_3 = 0$ —— (iv)

Solving (i), (ii) & (iii) —

$i_1 = -36A$

$i_2 = 36A$

$i_3 = 6A$

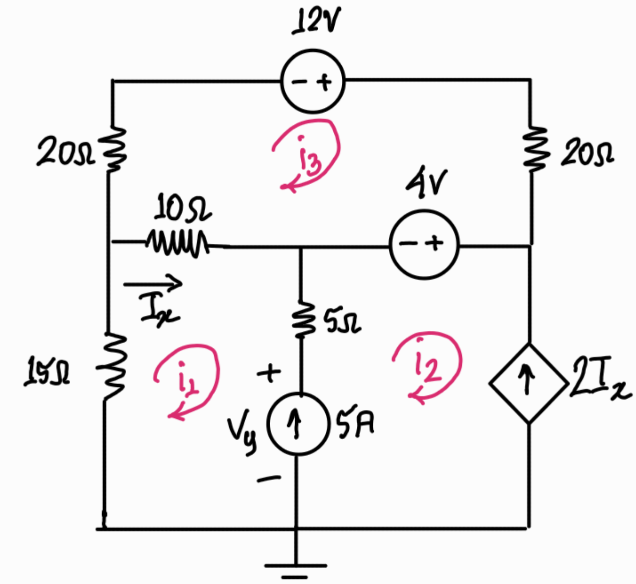
$\therefore i_o = -i_1 = 36A$

KVL @ 1 —

$V_o = -3i_1 + i_3 = 114V$

Problem 9

Find V_y using mesh analysis



@ 2 —

$-i_2 = 2I_x$

but $I_x = i_1 - i_3$

$\therefore -2i_1 - i_2 + 2i_3 = 0$ —— (i)

Current relation @ supermesh 1,2 —

$-i_1 + i_2 = 5$ —— (ii)

KVL @ 3 —

$-10i_1 + 50i_3 = 8$ —— (iii)

Solving (i), (ii) & (iii) —

$i_1 = -1.8A$

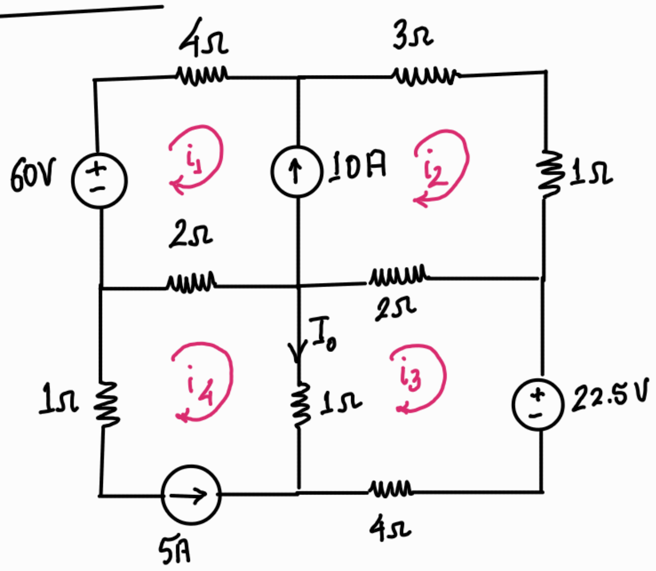
$i_2 = 3.2A$

$i_3 = -0.2A$

KVL @ 1 —

$V_y = -30i_1 + 5i_2 + 10i_3 = 68V$

Problem 10



Find I_o using mesh analysis.

@4 —

$i_4 = -5$

KVL @ 3 —

$-2i_2 + 7i_3 - i_4 = -22.5$

$\Rightarrow -2i_2 + 7i_3 = -27.5$ —— (i)

Current relationship @ supermesh 1,2 —

$-i_1 + i_2 = 10$ —— (ii)

KVL @ supermesh 1,2 —

$6i_1 + 6i_2 - 2i_3 - 2i_4 = 60$

$\Rightarrow 3i_1 + 3i_2 - i_3 = 25$ —— (iii)

Solving (i), (ii) & (iii) —

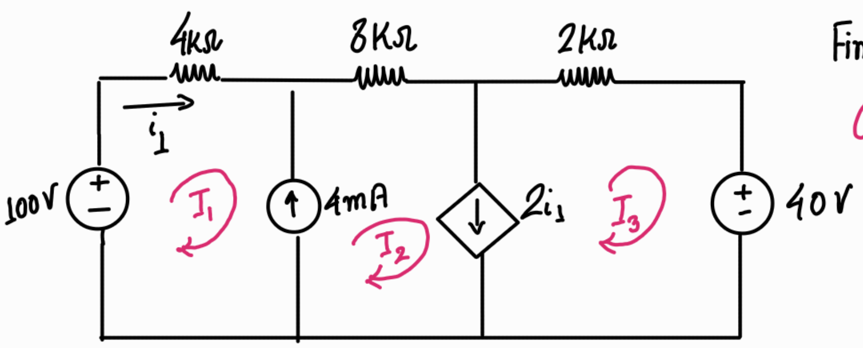
$i_1 = -1.0625\,A$

$i_2 = 8.9375\,A$

$i_3 = -1.375\,A$

here, $I_o = i_4 - i_3 = -3.625\,A$

Problem 11



Find the mesh currents

Current relations @ supermesh 1,2,3 —

$-I_1 + I_2 = 4$ —— (i)

& $I_2 - I_3 = 2i_1$

but $i_1 = I_1$

$\therefore -2I_1 + I_2 - I_3 = 0$ —— (ii)

KVL @ supermesh 1, 2, 3 —

$4I_1 + 8I_2 + 2I_3 + 40 - 100 = 0$

$\Rightarrow 2I_1 + 4I_2 + I_3 = 30$ —— (iii)

Solving (i), (ii), (iii) —

$I_1 = 2mA$

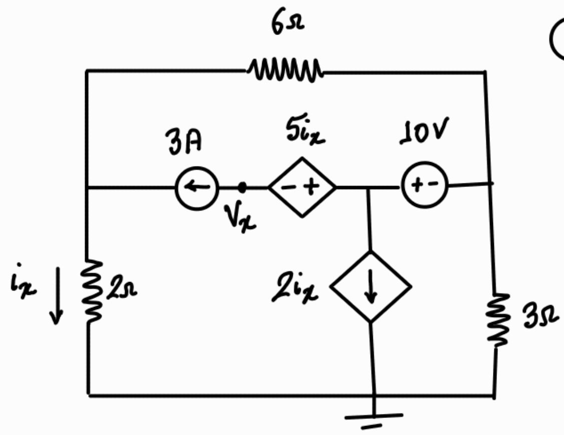
$I_2 = 6mA$

$I_3 = 2mA$

Problem 12

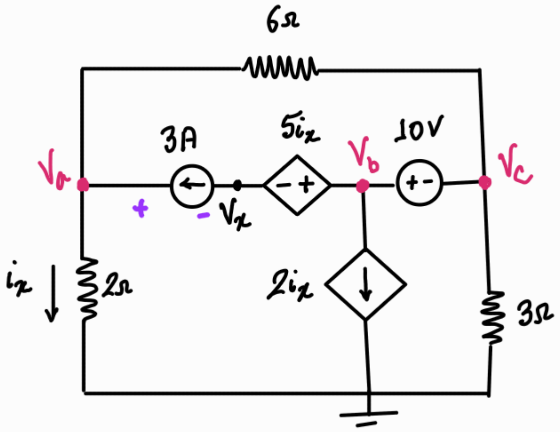
(i) Use nodal analysis to find the voltage across the 3A source & i_x

(ii) Use mesh analysis to find V_x & i_x



Answer —

Nodal analysis —



KCL @ a —

$V_a(2^{-1}+6^{-1}) - V_c(6^{-1}) = 3$ —— (i)

Voltage relationship @ supernode b,c —

$V_b - V_c = 10$ —— (ii)

KCL @ supernode b,c —

$3 + 2i_x + V_c(6^{-1}+3^{-1}) - V_a(6^{-1}) = 0$

but $i_x = V_a \cdot 2^{-1}$

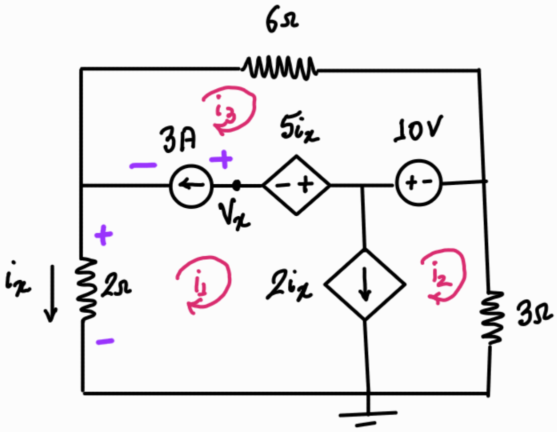
$\therefore 3 + V_a(1-6^{-1}) + V_c(6^{-1}+3^{-1}) = 0$

$\Rightarrow V_a(1-6^{-1}) + V_c(6^{-1}+3^{-1}) = -3$ —— (iii)

Solving (i) (ii) & (iii) —

$V_a = 2.1176\,V$ $V_b = 0.4706\,V$ $V_c = -9.529\,V$

Mesh analysis —



Current relationships @ supermesh 1,2,3 —

$-i_1 + i_3 = 3$ —— (i)

& $i_1 - i_2 = 2i_x$

but $i_x = -i_1$

$\therefore 3i_1 - i_2 = 0$ —— (ii)

KVL @ supermesh 1,2,3 —

$2i_1 + 3i_2 + 6i_3 = 0$ —— (iii)

Solving (i) (ii) & (iii) —

$i_1 = -1.059\,A$ $i_2 = -3.176\,A$ $i_3 = 1.941\,A$

$i_x = \frac{V_a}{2} = 1.059A$

& $V_{3A} = \pm(V_a - V_b + 5i_x)$

$= \pm 6.942V$ (close enough)

and $V_x = -4.824V$ (close enough)

Answer wrong in slide

$i_x = -i_1 = 1.059A$

$V_x = V_{2\Omega} + V_{3A}$

$= 2i_x + V_{3A}$

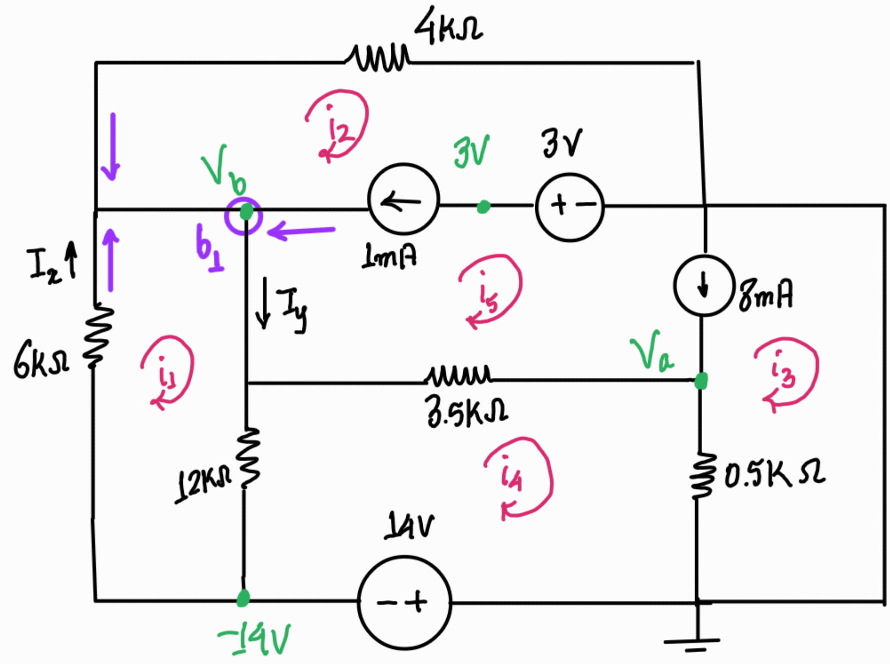
KVL @ 3 —

$6i_3 - 10 + 5i_x + V_{3A} = 0$

$\therefore V_{3A} = -6.941V$ (± because no assigned polarity)

$\therefore V_x = -4823V$

Problem 13



Find I_x & I_y using both nodal and mesh analysis

Mesh analysis —

Current relations @ supermesh 2,5,3 —

$i_2 - i_5 = 1$ — (i)

& $-i_3 + i_5 = 8$ — (ii)

KVL @ supermesh 2,5,3 —

$4i_2 + 0.5i_3 - 4i_4 + 3.5i_5 = 0$ — (iii)

KVL @ 4 —

$-12i_1 - 0.5i_3 + 16i_4 - 3.5i_5 = -14$ — (iv)

KVL @ 1 —

$18i_1 - 12i_4 = 0$ — (v)

from (i) $\rightarrow i_2 = 1 + i_5$

$\therefore$ (ii) $\rightarrow -i_3 + i_5 = 8$ — (1)

Nodal analysis —

KCL @ a —

$V_a(0.5^{-1} + 3.5^{-1}) - V_b(3.5^{-1}) = 8$ — (i)

KCL @ b —

$-V_a(3.5^{-1}) + V_b(4^{-1} + 3.5^{-1} + 6^{-1} + 12^{-1}) = 1 - 14(6^{-1} + 12^{-1})$ — (ii)

Solving (i) & (ii) —

$V_a = 3.25V$

$V_b = -2V$

$\therefore I_x = -\frac{-2-(-14)}{6}$

$= -2mA$

applying KCL @ b_1 —

$I_x + 1 - \frac{V_b}{4} = I_y \Rightarrow -2+1+\frac{2}{4} = I_y$

$\Rightarrow I_y = -0.5\,mA$

Note — Don't do $I_y = \frac{V_b-(-14)}{12}$

(iii) $\rightarrow 0.5 i_3 - 4 i_4 + 7.5 i_5 = -4$ — (2)

(iv) $\rightarrow -12 i_1 - 0.5 i_3 + 16 i_4 - 3.5 i_5 = -14$ — (3)

(v) $\rightarrow 18 i_1 - 12 i_4 = 0$ — (4)

Solving (1), (2), (3) & (4) —

$i_1 = -2mA$

$i_3 = -9.5mA$

$i_4 = -3mA$

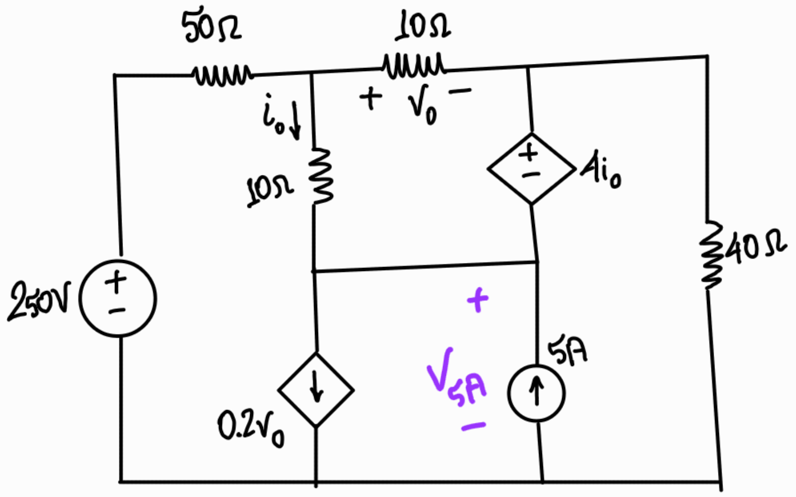
$i_5 = -1.5mA$

$\therefore i_2 = -0.5mA$

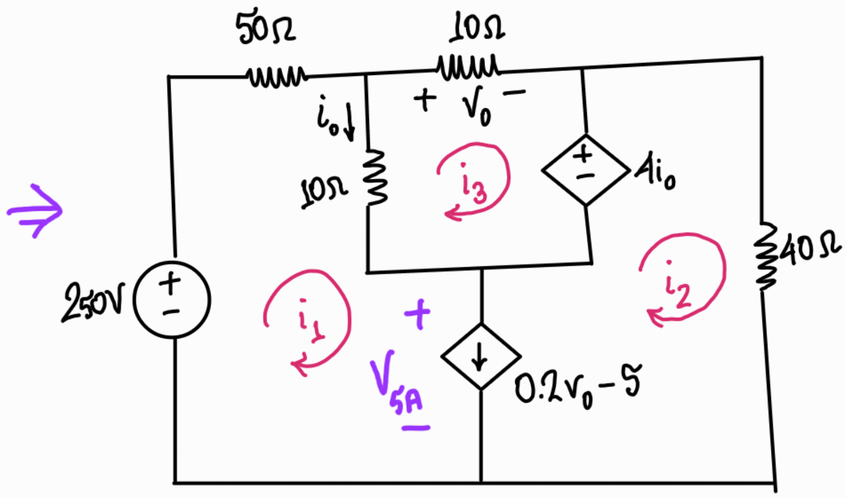
$I_x = i_1 = -2mA$ & $I_y = i_1 - i_5 = -0.5mA$

P.S. — here mesh analysis was not feasible

Problem 14



Use mesh analysis to determine v_o & i_o.
What is voltage across the 5A source?



Current relation @ supermesh 1,2 —

$i_1 - i_2 = 0.2v_o - 5$

but $v_o = 10 i_3$

$\therefore i_1 - i_2 - 2i_3 = -5$ —— (i)

KVL @ supermesh 1,2 —

$60i_1 + 40i_2 - 10i_3 - 4i_o = 250$

but $i_o = i_1 - i_3$

$\therefore 60i_1 + 40i_2 - 10i_3 - 4i_1 + 4i_3 = 250$

$\Rightarrow 56i_1 + 40i_2 - 6i_3 = 250$ —— (ii)

KVL @ 3 —

$-10i_1 + 20i_3 + 4i_o = 0$

but $i_o = i_1 - i_3$

$\therefore -6i_1 + 16i_3 = 0$ —— (iii)

Solving (i) (ii) & (iii) —

$i_1 = 0.7843\text{ A}$
$i_2 = 5.196\text{ A}$
$i_3 = 0.294\text{ A}$

$\therefore i_o = i_1 - i_3 = 0.49\text{ A}$

& $v_o = 10i_3 = 2.94\text{ V}$

KVL @ 1 —

$60i_1 - 10i_3 + V_{5A} = 250$

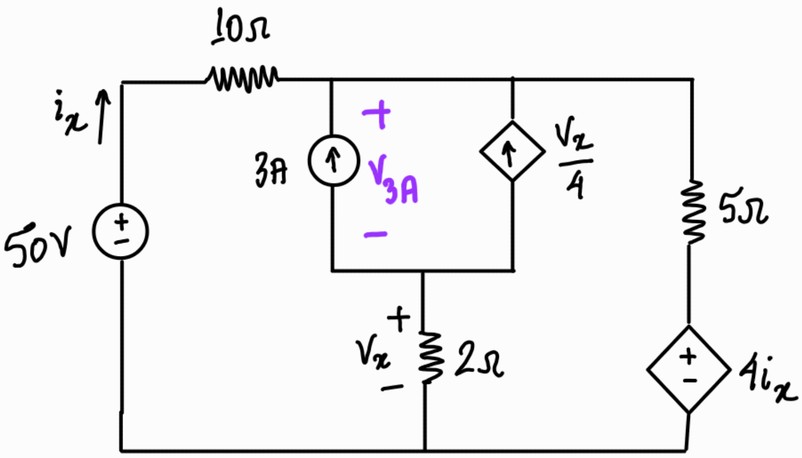
$\therefore V_{5A} = 205.88\text{ V}$

but since polarity isn't defined,

$V_{5A} = \pm 205.88\text{ V}$

P.S. — Do not combine circuits if your manipulation leads you to lose info crucial to solving the actual problem.

Problem 15



Use mesh analysis to determine V_x & i_x. What is the voltage across the 3A source?

Current relation @ supermesh 1,2 —

$$-i_1 + i_2 = 3 + \frac{V_x}{4}$$

but $V_x = (i_1 - i_2) \times 2$

$$\therefore -i_1 + i_2 = 3 + 0.5i_1 - 0.5i_2$$

$$\Rightarrow -1.5i_1 + 1.5i_2 = 3 \quad \text{—— (i)}$$

KVL @ supermesh 1,2 ——

$$10i_1 + 5i_2 + 4i_x = 50$$

but $i_x = i_1$

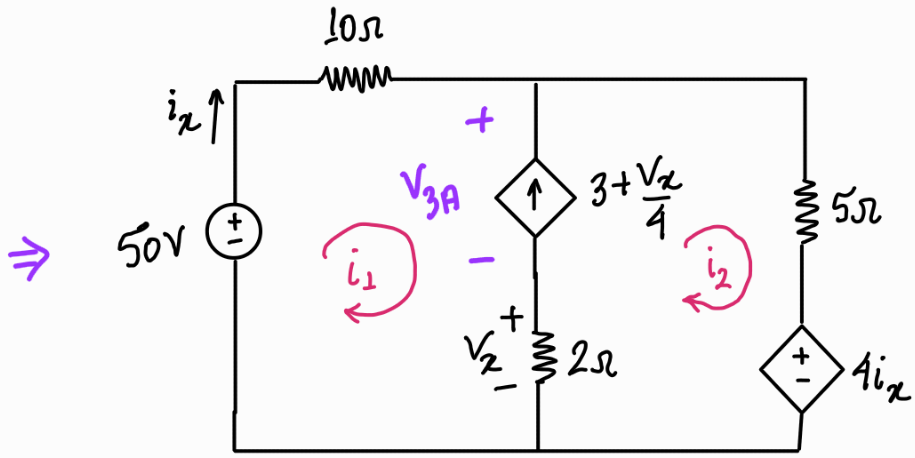
$$\therefore 14i_1 + 5i_2 = 50 \quad \text{—— (ii)}$$

Solving (i) & (ii) —

$i_1 = 2.105\,A$

$i_2 = 4.105\,A$

$\Rightarrow$



$\therefore i_x = i_1 = 2.105\,A$

$V_x = (i_1 - i_2) \times 2 = -4V$

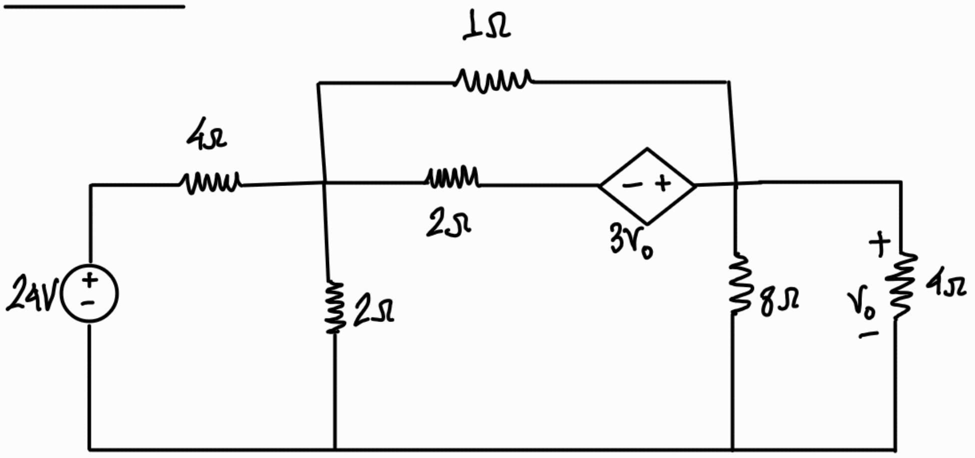
KVL @ 1 ——

$$10i_1 + V_{3A} + V_x = 50$$

$$\Rightarrow V_{3A} = 32.95\ V$$

but since polarity wasn't assigned, $V_{3A} = \pm 32.95V$

Problem 16



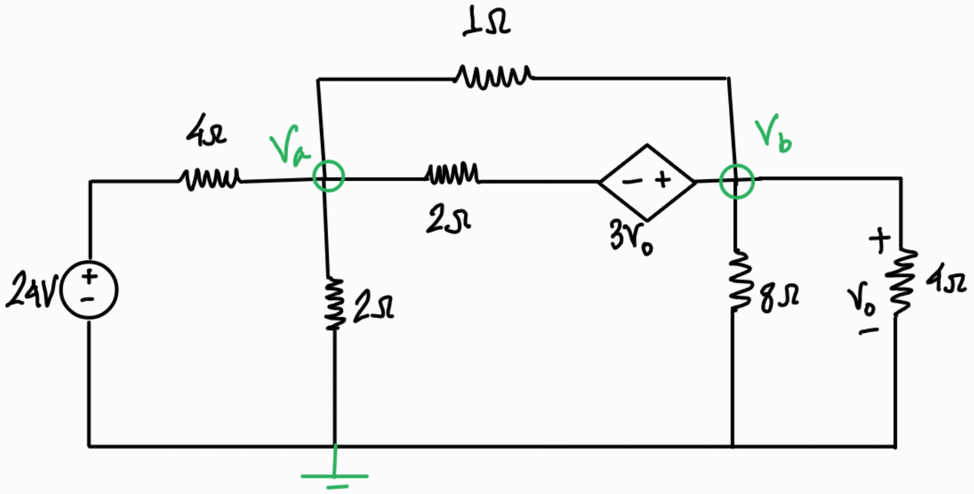
Which method of analysis will be more convenient for solving this ckt? Derive the equations for the convenient method.

number of essential nodes = 3 $\quad \therefore$ nodal equations = $n-1=2$

number of meshes = 4 $\quad \therefore$ mesh equations = $m = 4$

$\therefore$ nodal analysis will be more convenient.

Preparing the ckt for nodal analysis ——



KCL @ a ——

$$\frac{V_a-24}{4}+\frac{V_a-V_b}{1}+\frac{V_a-V_b+3V_o}{2}+\frac{V_a}{2}=0$$

$$\Rightarrow V_a\left(4^{-1}+1^{-1}+2^{-1}+2^{-1}\right)-V_b\left(1^{-1}+2^{-1}\right)+V_o\left(\frac{3}{2}\right)=6$$

but $V_o = V_b$

$$\therefore V_a\left(4^{-1}+1^{-1}+2^{-1}+2^{-1}\right)-V_b\left(1^{-1}+2^{-1}-\frac{3}{2}\right)=6 \quad \text{—— (i)}$$

KCL @ b ——

$$-V_a\left(1^{-1}+2^{-1}\right)+V_b\left(1^{-1}+2^{-1}+8^{-1}+4^{-1}\right)-\frac{3}{2}V_o=0$$

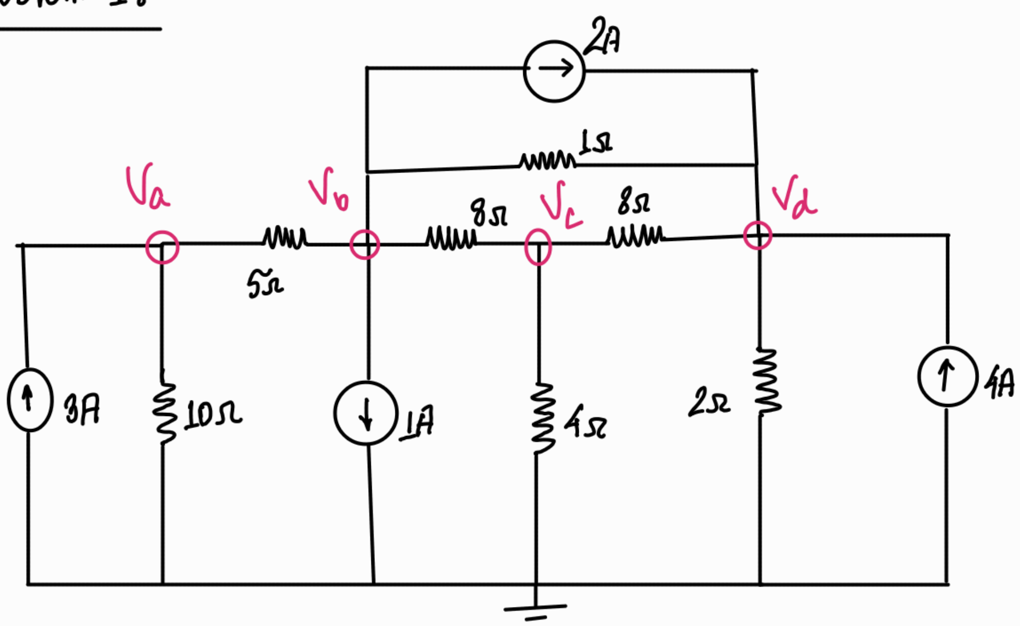
$$\Rightarrow -V_a\left(1^{-1}+2^{-1}\right)+V_b\left(1^{-1}+2^{-1}+4^{-1}+8^{-1}-\frac{3}{2}\right)=0$$

Solving (i) & (ii) ——

$V_a = 2.67\text{V}$

$V_b = 10.67\text{ V}$

Problem 17



Which method of analysis will be more convenient for solving this ckt? Derive the equation for the convenient method.

#essential nodes (except ground) = 4 $\therefore$ # of equations = 4

meshes = 7 $\therefore$ # of equations = 7

$\therefore$ nodal more convenient

But for mesh analysis you will have 3 mesh current values directly. So, even when nodal is more convenient based only on numbers, mesh is also feasible. This isn't true for all cases. So maintain caution.

comment

KCL @ a —

$V_a(10^{-1}+5^{-1}) - V_b(5^{-1}) = 3$ — (i)

KCL @ b —

$-V_a(5^{-1}) + V_b(5^{-1}+8^{-1}+1^{-1}) - V_c(8^{-1}) - V_d(1^{-1}) = -3$ — (ii)

KCL @ c —

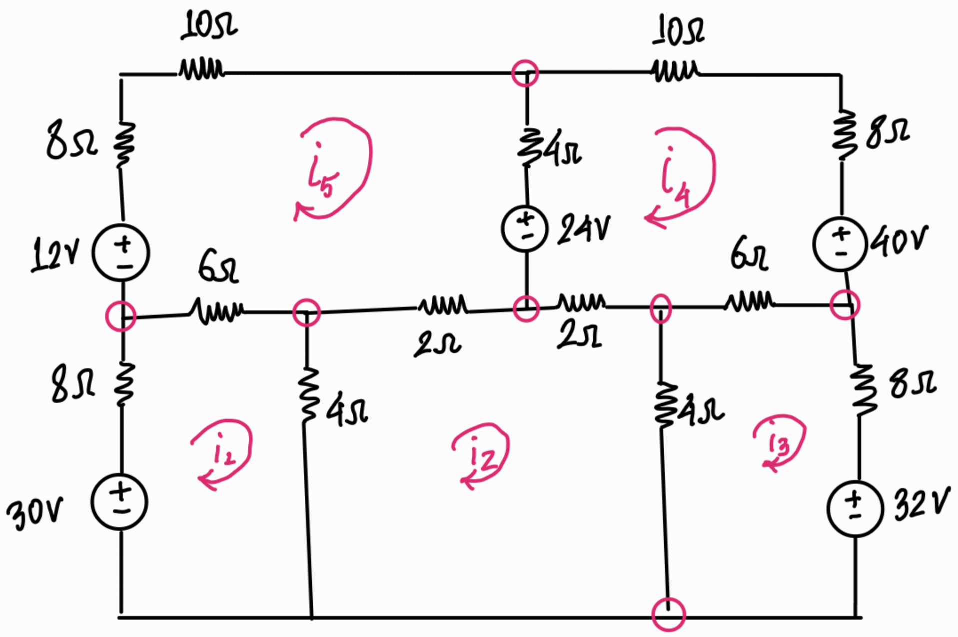
$-V_b(8^{-1}) + V_c(8^{-1}+8^{-1}+4^{-1}) - V_d(8^{-1}) = 0$ — (iii)

KCL @ d —

$-V_b(1^{-1}) - V_c(8^{-1}) + V_d(1^{-1}+8^{-1}+2^{-1}) = 6$ — (iv)

Solving (i), (ii), (iii) & (iv) $\longrightarrow$ $V_a = 13.897\text{V}$, $V_b = 5.845\text{V}$, $V_c = 3.348\text{V}$, $V_d = 7.547\text{V}$

Problem 18



Which method of analysis will be more convenient for solving this ckt? Derive the equations for the convenient method.

essential nodes = 7 $\therefore$ # nodal equations = 6 $\therefore$ mesh analysis will be more convenient.

meshes = 5 $\therefore$ # mesh equations = 5

KVL @ 1 —

$$18i_1 - 4i_2 - 6i_5 = 30 \quad \text{——(i)}$$

KVL @ 2 —

$$-4i_1 + 12i_2 - 4i_3 - 2i_4 - 2i_5 = 0 \quad \text{——(ii)}$$

KVL @ 3 —

$$-4i_2 + 18i_3 - 6i_4 = -32 \quad \text{——(ii)}$$

KVL @ 4 —

$$-2i_2 - 6i_3 + 30i_4 - 4i_5 = -16 \quad \text{——(iv)}$$

KVL @ 5 —

$$-6i_1 - 2i_2 - 4i_4 + 30i_5 = -12 \quad \text{——(v)}$$

Solving (i) (ii), (iii), (iv) & (v) —

$i_1 = 1.468\,A$

$i_2 = -0.476\,A$

$i_3 = -2.233\,A$

$i_4 = -1.049\,A$

$i_5 = -0.278\,A$

Solving wasn't required.
I solved the values to check if the equations were correct and so I have included the values here.