(20 marks) Q(1):

(a) (10 marks) For the circuit shown in Fig.1.a, find the equivalent capacitance between terminals **a** and **b**.

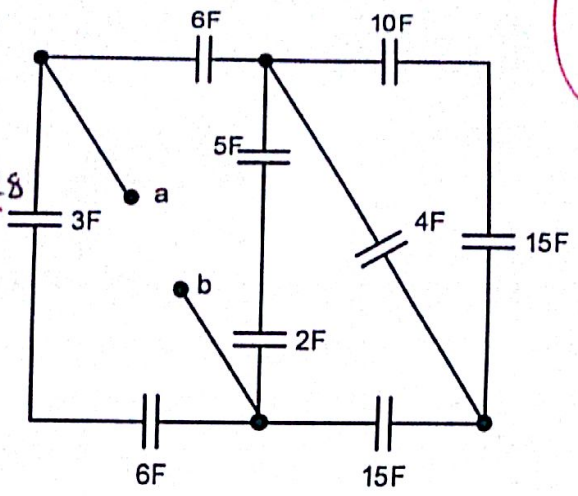
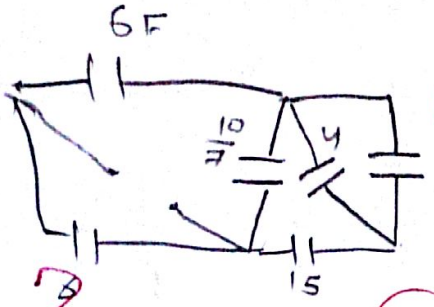


Fig. 1.a

3 series with 6 = $\frac{3\times6}{9} = \frac{18}{9} = 2$

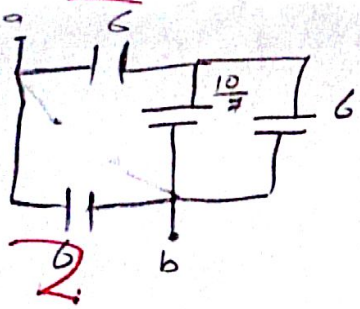
5 series with 2 = $\frac{5\times2}{7} = \frac{10}{7} = 1.428$

10 series with 15 = $\frac{10\times15}{25} = 6$



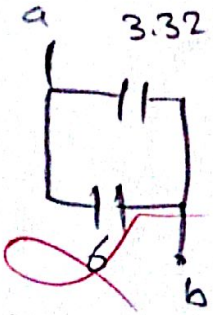
6 + 4 = 10

10 series with 15 = 6



$6 + \frac{10}{7} = \frac{52}{7}$

$\frac{52}{7}$ series with 6 = $\frac{\frac{52}{7}\cdot6}{6+\frac{52}{7}} = \frac{312}{94} = 3.32$



$C_{eq} = 3.32 + 6 = 9.32$ F

(10 marks) For the circuit shown in Fig.1.b, find the equivalent inductance between terminals a and b.

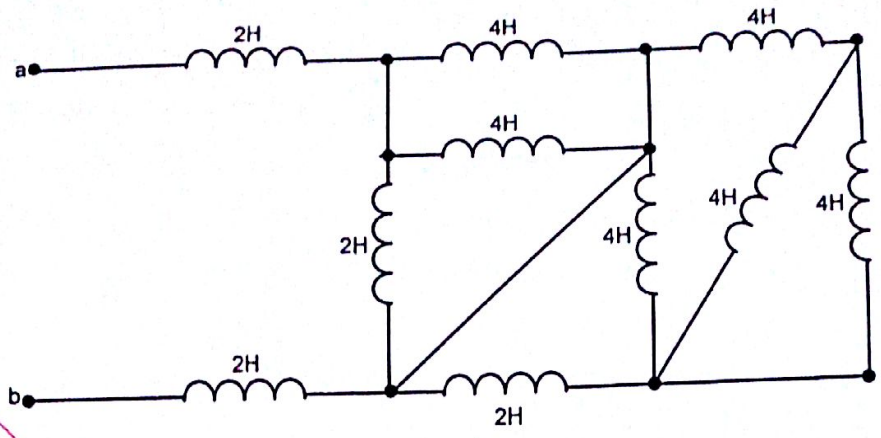
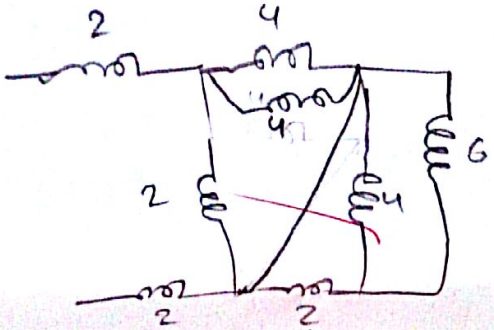


Fig.1.b

10

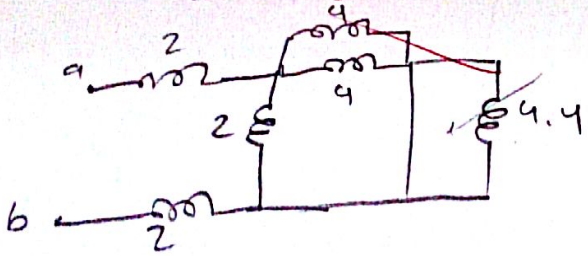
$4 // 4 = 2$

$2 + 4 = 6$



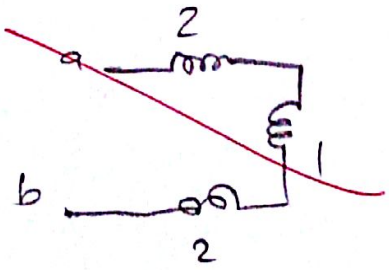
$6 // 4 = \frac{6 \times 4}{10} = 2.4$

$2.4 + 2 = 4.4$



$4 // 4 // 2 = \frac{1}{\frac{1}{4} + \frac{1}{4} + \frac{1}{2}}$

$= 1$



$L_{eq} = 2 + 1 + 2 = 5\,H$

(25 marks) Q(2): For the circuit shown in Fig. 2.

(a) **(15 marks)** Find the Thévenin equivalent circuit for the circuit seen by the variable resistor **R**.

(b) **(10 marks)** What value of **R** that will absorb maximum power from the other parts of the circuit, find this **maximum power**?

$R_L = R_{Th}$

$P_{max} = \frac{V_{Th}^2}{4R_L}$

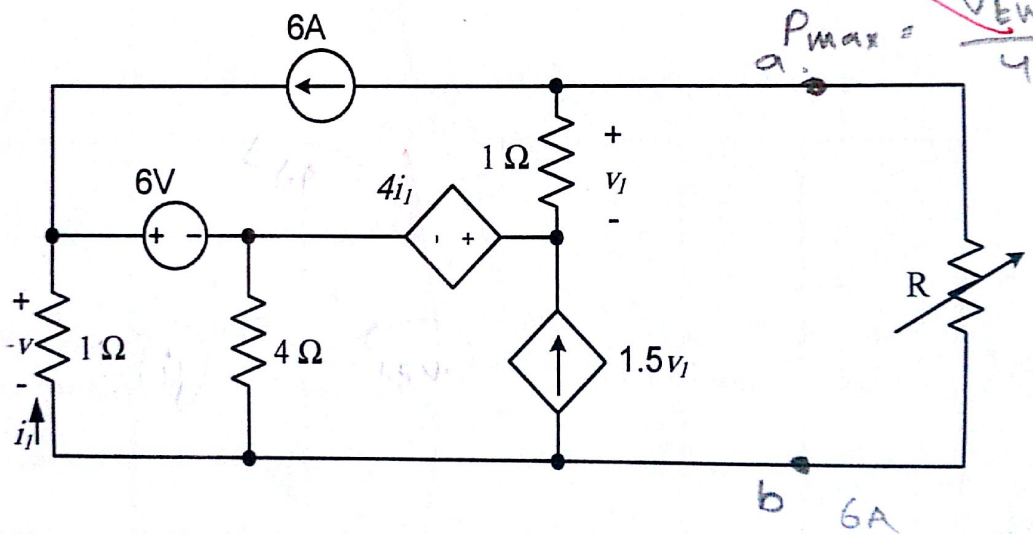
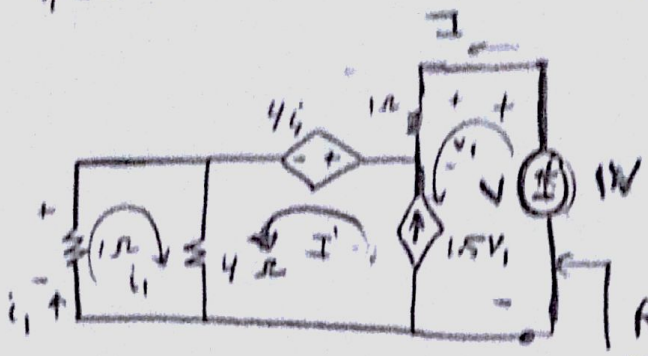


Fig. 2

(a)

$V_1 = I$

Fig. 2



$R_{th} = \frac{1}{I}$

$-1 + I + 4i_1 + 4I' + 4i_1 = 0 \Rightarrow \boxed{I + 4I' + 8i_1 = 1}$ --(1)

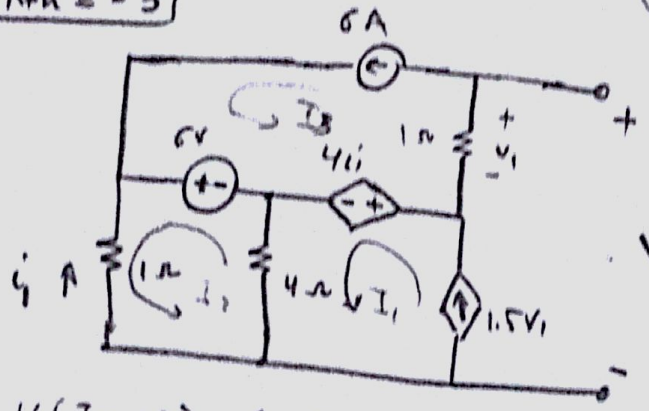
$i_1 + 4i_1 + 4I' = 0 \Rightarrow \boxed{0 + 4I' + 5i_1 = 0}$ --(2)

$I' - I = 1.5V_1 \Rightarrow I' - I = 1.5I \Rightarrow \boxed{-2.5I + I' + 0 = 0}$ --(3)

$I = -\frac{1}{5}$, $I' = -\frac{1}{4}$, $i_1 = \frac{2}{5}$

$\Rightarrow \boxed{R_{th} = -5}$

7.5



$V_1 = -6$

$I_1 = 1.5V_1 \Rightarrow I_1 = -$

$4(I_2 + 9) - 6 + I_2 = 0 \Rightarrow 4I_2 + 36 - 6 + I_2 = 0$

$\Rightarrow 5I_2 = -30 \Rightarrow \boxed{I_2 = -6}$, $\boxed{i_1 = 6}$

7.5

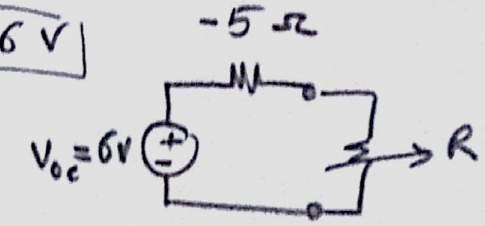
$V_{oc} = V_1 + 4i_1 + 4(I_1 - I_2)$

$\boxed{V_{oc}} = -6 + 4\times6 + 4(-9+6) = -6 + 24 - 12 = \boxed{6\ V}$

4/7

(b) If it exist then it will be $-5\ \Omega$

$P = \frac{V_R^2}{-5} = \frac{(3)^2}{-5} = -1.8$ watt.



(30 marks) Q(3): For the circuit shown in Fig. 3.

1. **(8 marks)** Write the required Nodal equations.
2. **(7 marks)** Draw the dual circuit, show the numerical values of the different elements.
3. **(15 marks)** If the circuit is in steady-state where $v(t) = 5V$ and $i(t) = 2A$, then find V_c, i_L, and i_x.

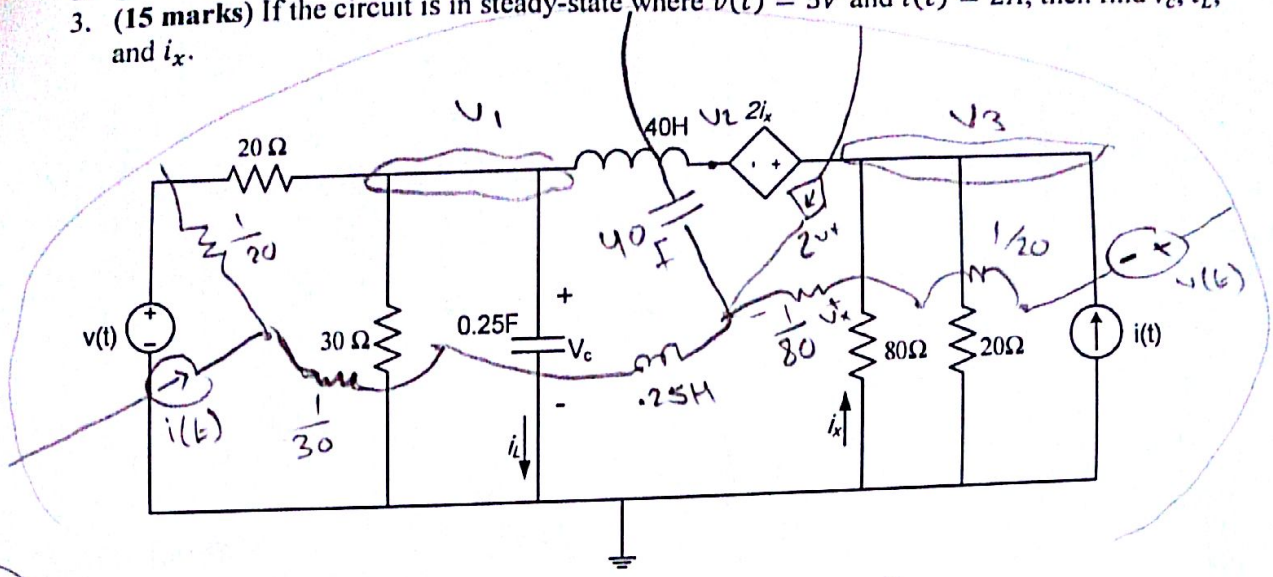


Fig. 3

1

@ node 1: $\frac{V_1 - V_t}{20} + \frac{V_1}{30} + .25\frac{dV_1}{dt} + \frac{1}{40}\int_{t_0}^{t}(V_1 - V_2)dv = 0 + i_L(t_0)$

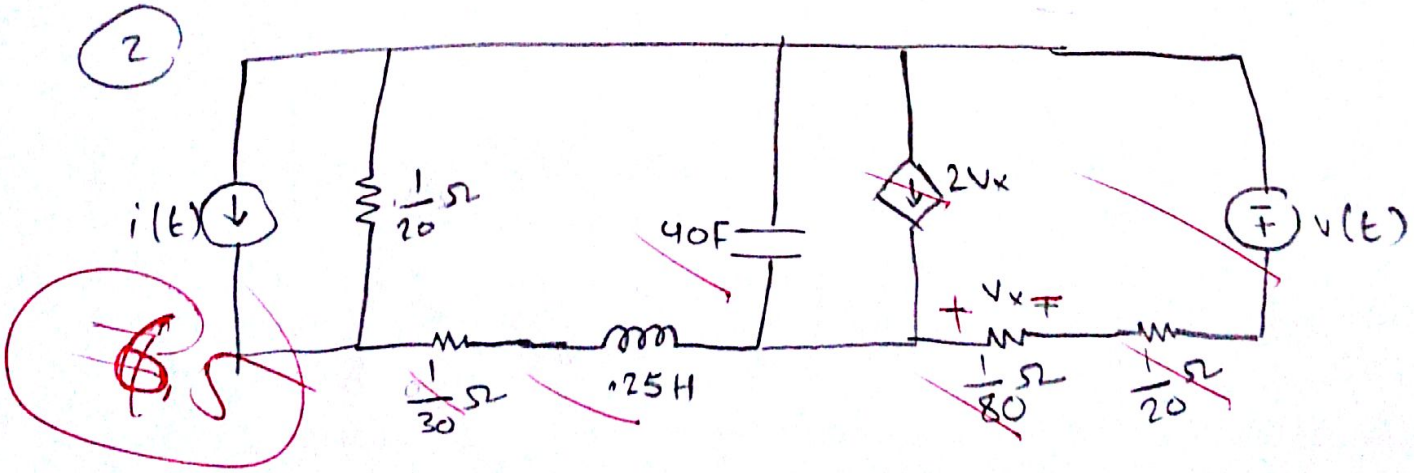
@ Super node(2-3): $\frac{i}{40}\int_{t_0}^{t}(V_2 - V_1)dv + \frac{V_3}{80} + \frac{V_3}{20} = i(t) + i_L(t_0)$

$i_x = \frac{-V_3}{80}$

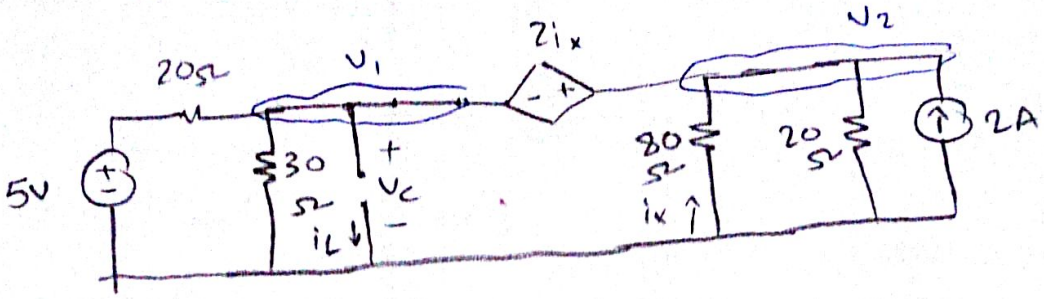
$V_3 - V_2 = 2\left(\frac{-V_3}{80}\right)$

7

2



(3)



(5) → $i_L = 0$

@Supernode (1-2) : $\frac{V_1 - 5}{20} + \frac{V_1}{30} + \frac{V_2}{80} + \frac{V_2}{20} = 2$

$\frac{1}{12} V_1 + \frac{1}{16} V_2 = 2 + \frac{1}{4} = 2.25$ ... (1)

$i_x = -\frac{V_2}{80}$

$V_2 - V_1 = 2\left(\frac{-V_2}{80}\right)$

$-V_1 + \frac{41}{40} V_2 = 0$ ... (2)

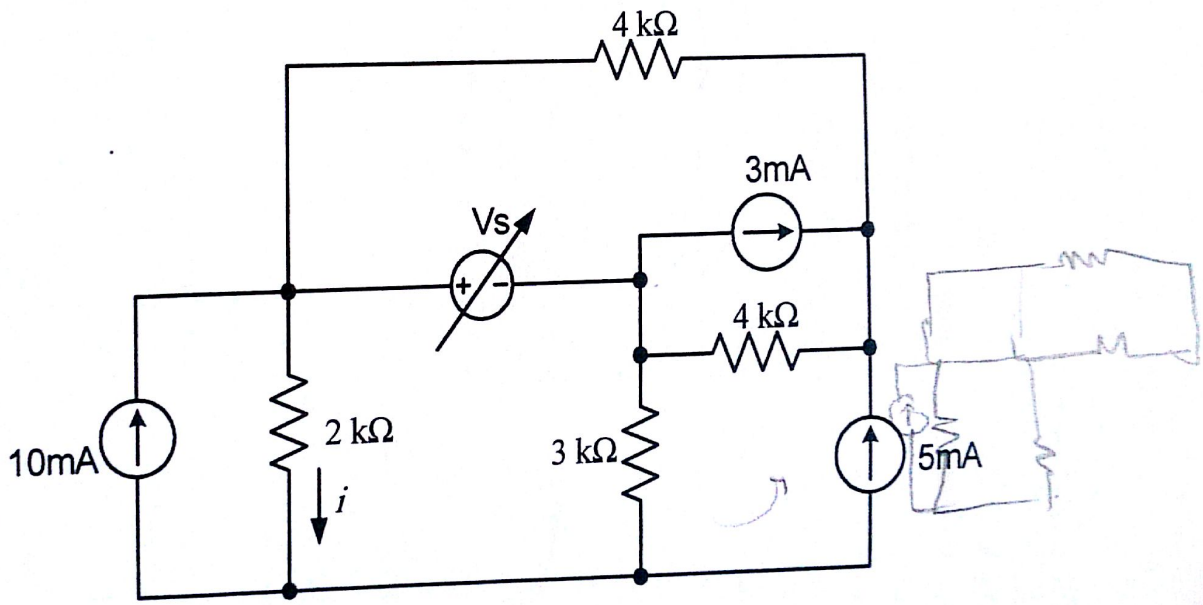
$V_1 = 15.6\ V$

$V_2 = 15.2\ V$

(3) $V_1 = V_c = \cancel{V_{30}} = \frac{V_1}{30} = 0.52\ V$

(5) $i_x = \frac{-V_2}{80} = -.19\ A$

(25 marks) Q(4): The variable dc voltage source V_s in the circuit shown in Fig.4 is adjusted so that i is zero, find the value of V_s.



(25 marks) Q(4): The ... that i is zero, find the value of V_s.

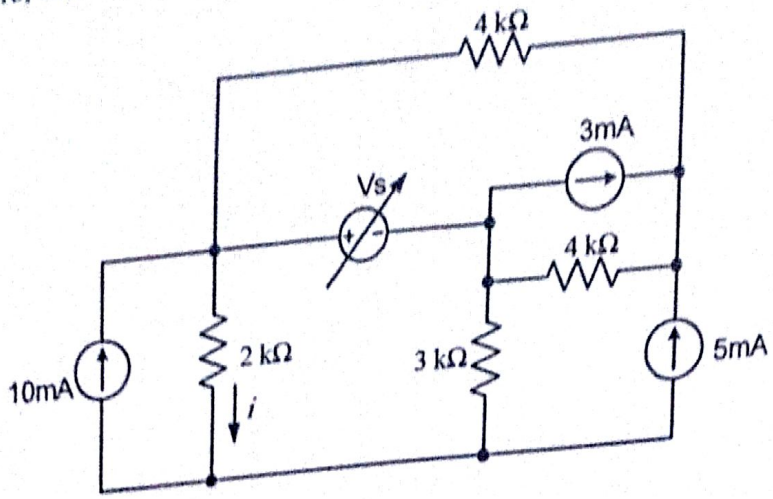
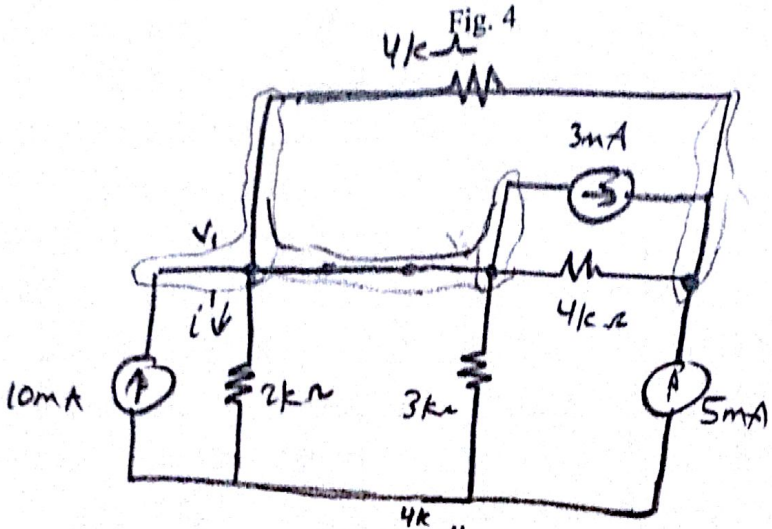
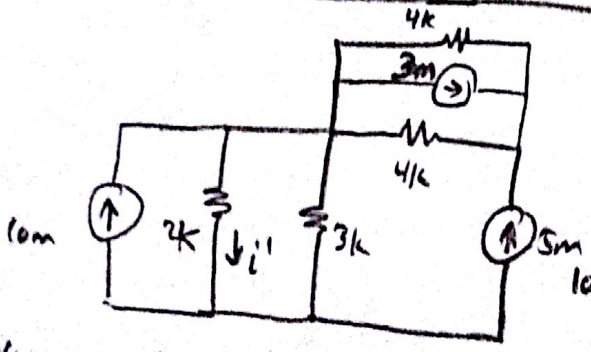
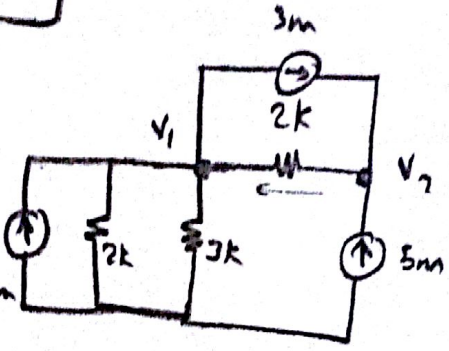


Fig. 4







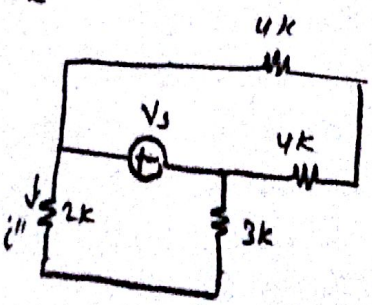
@ Node 1: $\frac{V_1}{2k} + \frac{V_1}{3k} + \frac{V_1 - V_2}{2k} + 3m = 10m \Rightarrow \frac{V_1}{1k} + \frac{V_1}{3k} - \frac{V_2}{2k} = 7m$

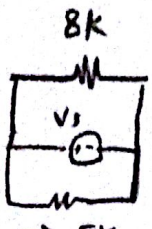
$V_1 + \frac{V_1}{3} - V_2 = 7 \Rightarrow \boxed{\frac{4}{3}V_1 - V_2 = 7}$ — (1)

@ Node 2: $\frac{V_2 - V_1}{2k} = 8m \Rightarrow \boxed{-V_1 + V_2 = 16}$ — (2)

$\Rightarrow i' = \frac{V_1}{2k} = \frac{69}{2k} = 34.5\,mA$

$V_1 = 69$, $V_2 = 85$





$i'' = \frac{V_3}{5k} = \frac{V_3}{5}\,m$

Good luck

7/7

$\Rightarrow i' + i'' = 0 \Rightarrow 34.5 + \frac{V_3}{5} = 0 \Rightarrow \frac{V_3}{5} = -34.5 \Rightarrow \boxed{V_3 = -172.5\,V}$