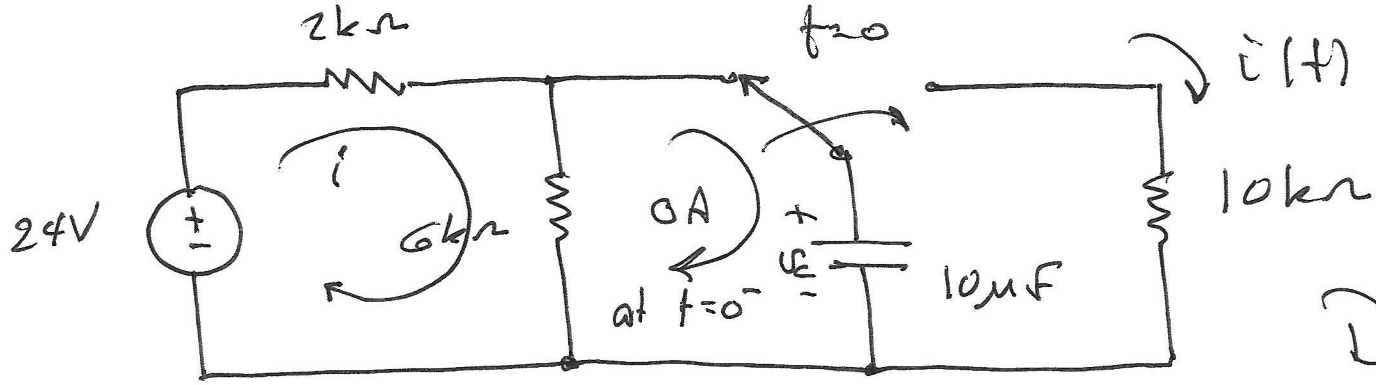
1. RC / RL networks
2. Op Amps
3. Superposition
4. Mesh Analysis / Nodal Analysis

   Thévenin / Norton / Max Power Transfer

   Power Calculation

1.



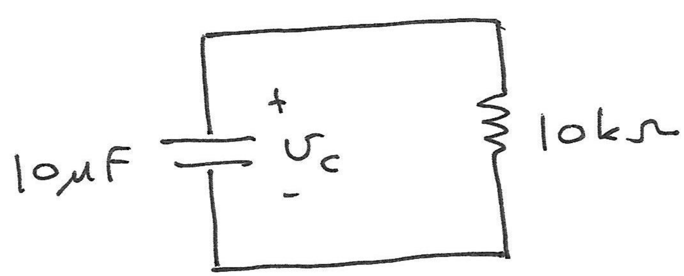
Determine $i(t)$ for $t \geq 0$

The switch has been in the position shown for a long time.

$$i(0^-) = \frac{24V}{8k\Omega} = 3mA$$

$$v_c(0^-) = (6k\Omega)\, i(0^-) = 18V$$

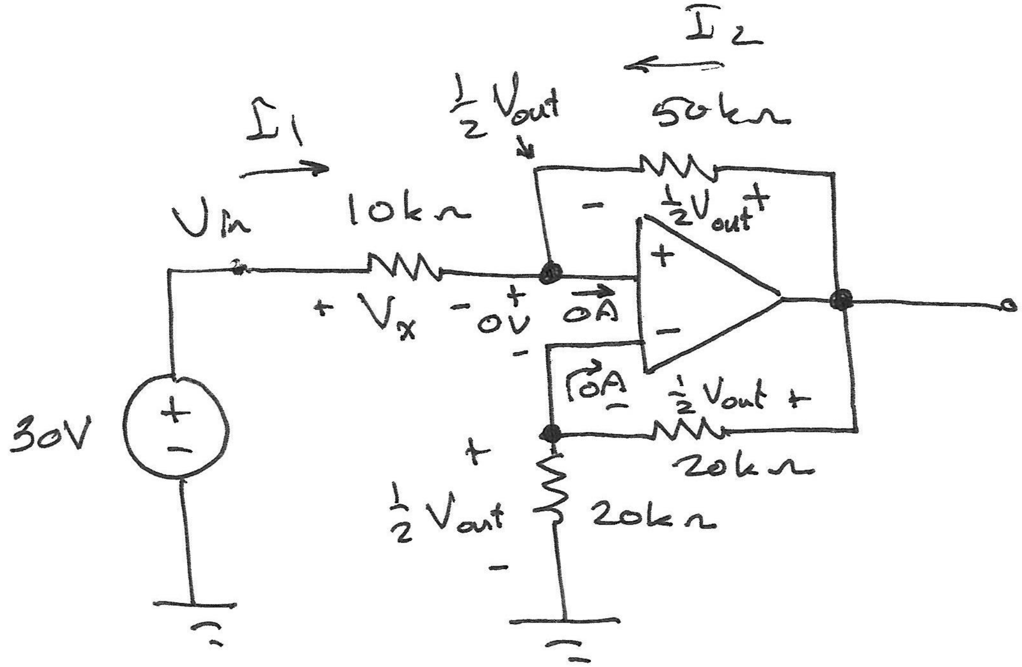
For $t \geq 0$:



$v_c(0) = 18V$

$$v_c(t) = v_c(0)\, e^{-t/\tau} \ V, \ t \geq 0$$

$\tau = RC = 0.1s$ $\Rightarrow$ $v_c(t) = 18 e^{-10t} \ V, \ t \geq 0$



Determine V_{out}.

$$I_1 = \frac{V_x}{10k\Omega} = \frac{30 - \frac{1}{2}V_{out}}{10k\Omega}$$

$$V_x = V_{in} - \frac{1}{2}V_{out}$$
$$= 30 - \frac{1}{2}V_{out}$$

$$I_2 = \frac{\frac{1}{2}V_{out}}{50k\Omega}$$

$$I_1 + I_2 + 0 = 0$$

$$\frac{30 - \frac{1}{2}V_{out}}{10k\Omega} + \frac{\frac{1}{2}V_{out}}{50k\Omega} = 0$$

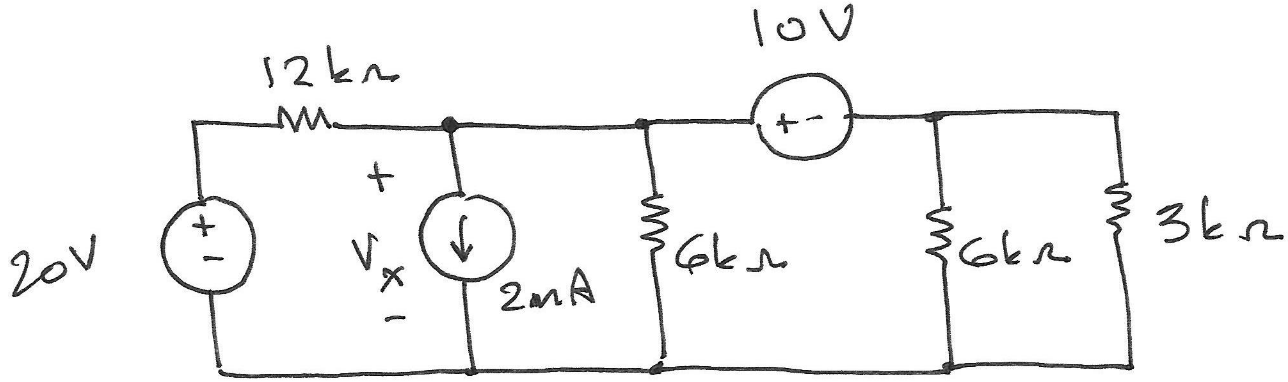
$$5\left(30 - \frac{1}{2}V_{out}\right) + \frac{1}{2}V_{out} = 0$$

$$150 - \frac{5}{2}V_{out} + \frac{1}{2}V_{out} = 0$$

$$150 - 2V_{out} = 0$$

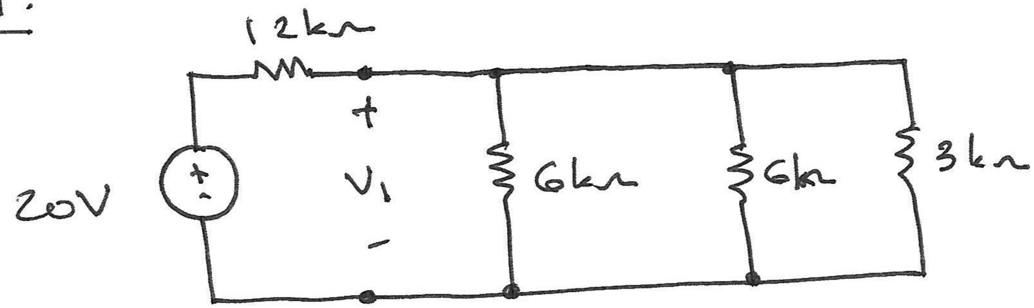
$$V_{out} = 75V$$

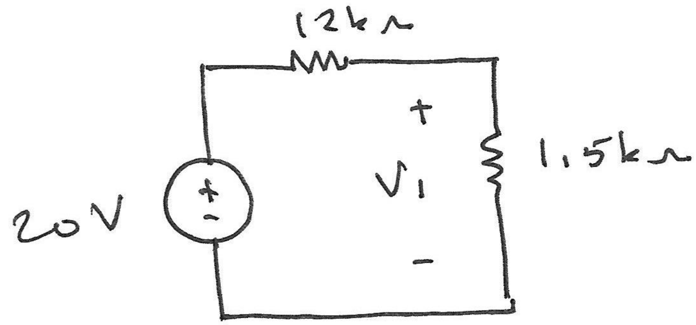
3.



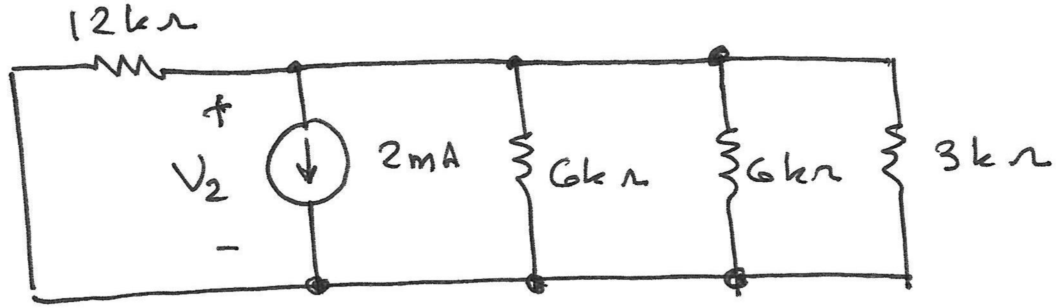
Determine the value of V_x.

Case 1:

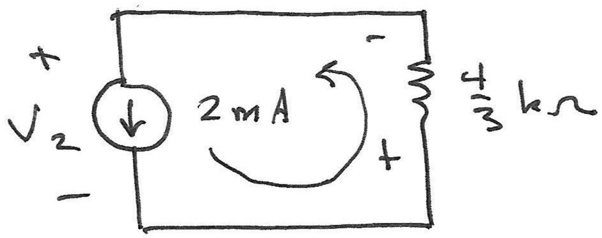




$$V_1 = \frac{1.5}{12+1.5} 20 = \frac{20}{9} V$$



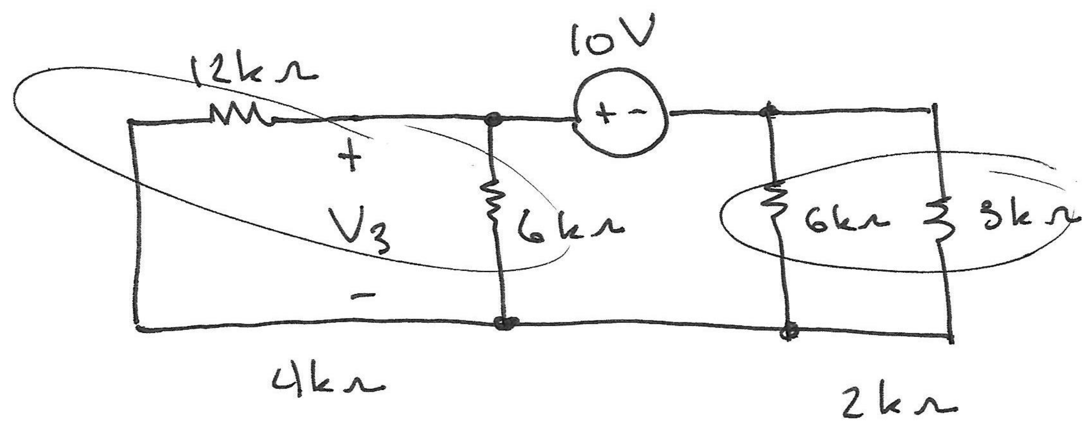
$$12k\Omega \,||\, 1.5k\Omega = \frac{18}{13.5}\,k\Omega = \frac{12}{9}\,k\Omega = \frac{4}{3}\,k\Omega$$

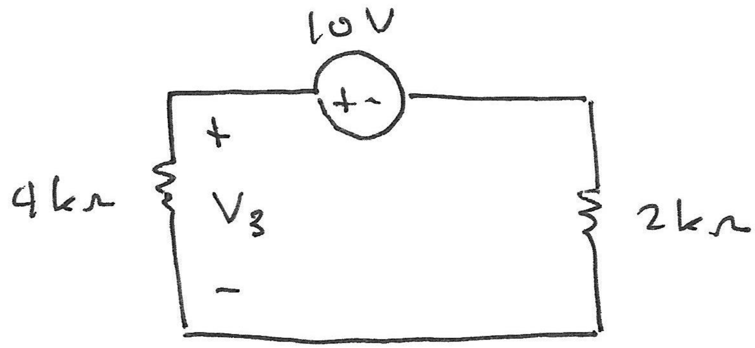


$$V_2 = -\left(\frac{4}{3}\,k\Omega\right)(2mA)$$

$$= -\frac{8}{3}\,V$$

Case 3





$$V_3 = \frac{4}{4+2} \cdot 10V = \frac{20}{3} V$$

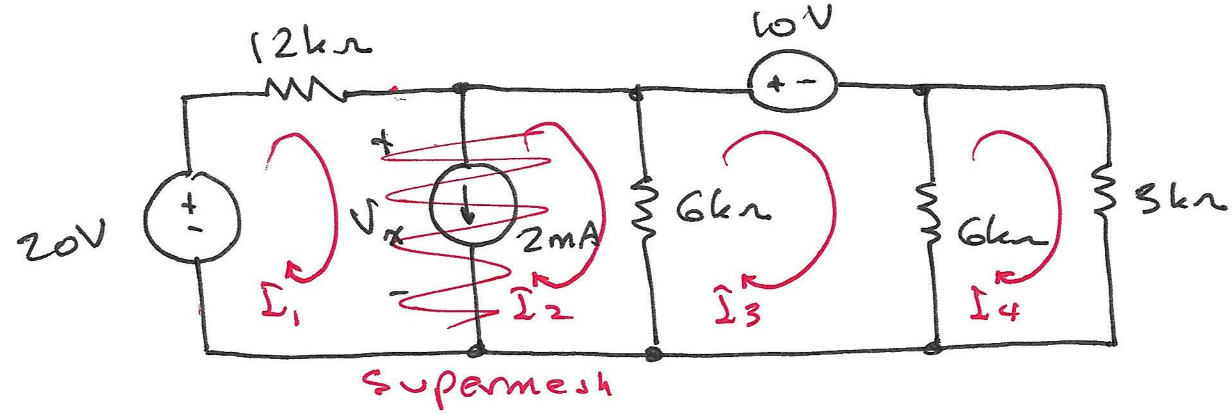
$$V_x = V_1 + V_2 + V_3$$

$$= \frac{20}{9} - \frac{8}{3} + \frac{20}{3}$$

$$= \frac{20 - 24 + 60}{9}$$

$$= \frac{56}{9} V$$

4.



Mesh Analysis

$$I_1 - I_2 = 2mA \quad \text{(constraint)}$$

$$-20 + (12k\Omega)I_1 + (6k\Omega)(I_2 - I_3) = 0 \quad \text{(KVL for supermesh}$$

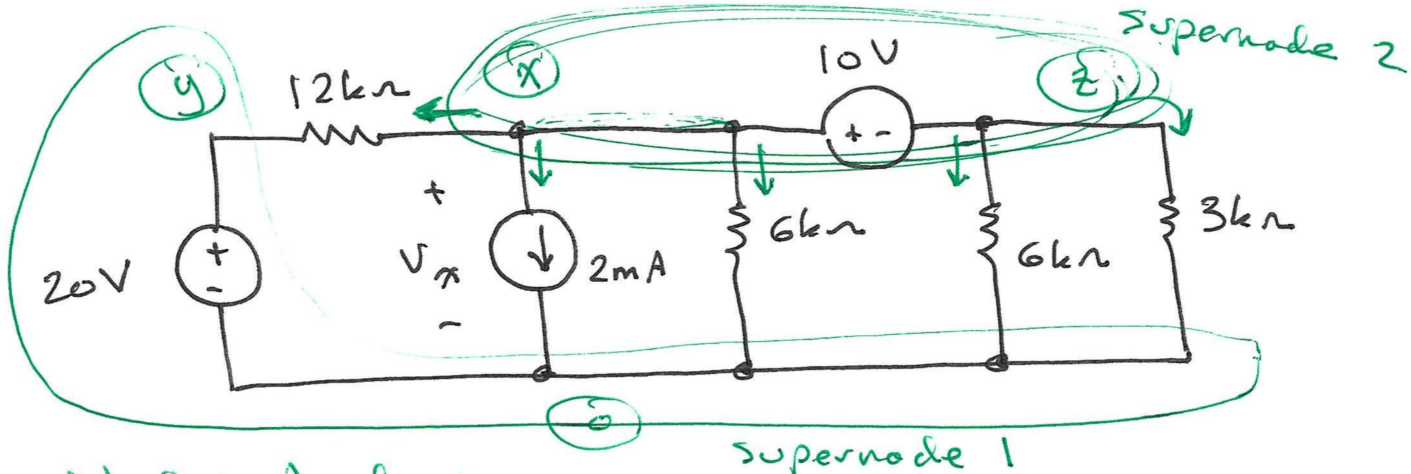
$$(6k\Omega)(I_3 - I_2) + 10 + (6k\Omega)(I_3 - I_4) = 0 \quad \text{(KVL}$$
mesh

$$(6k\Omega)(I_4 - I_3) + (3k\Omega)I_4 = 0 \quad \text{(KVL for mesh 4)}$$

Solve for $I_1, \ldots, I_4$.

Then $V_x = (6k\Omega)(I_2 - I_3) = ?$

or $V_x = 20V - (12k\Omega)I_1 = ?$



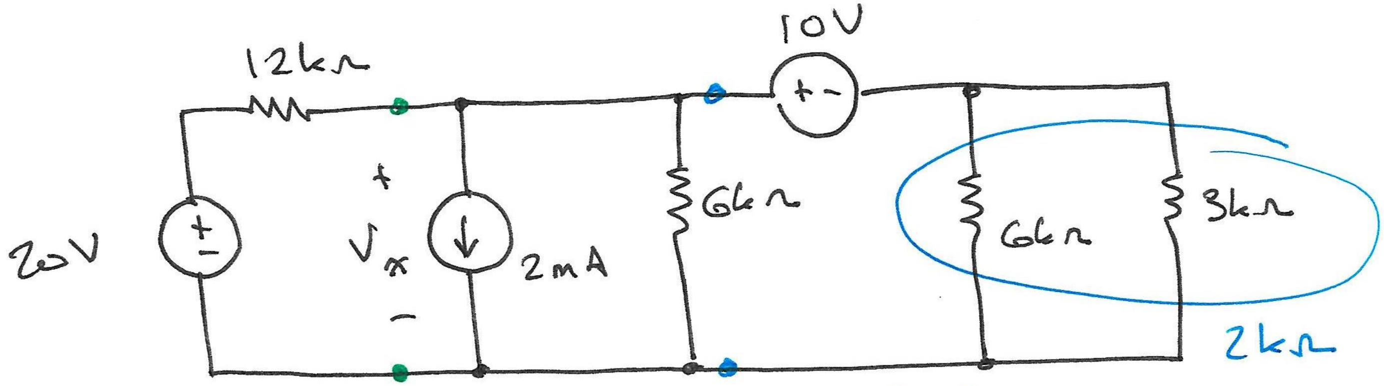
Nodal Analysis

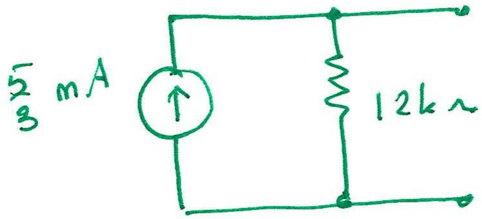
$V_y = 20V$ (constraint) (SN 1)

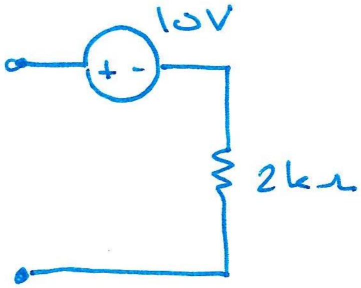
$V_x - V_z = 10V$ (constraint) (SN 2)

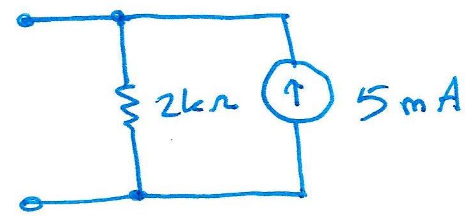
$$\frac{V_x - V_y}{12k\Omega} + 2mA + \frac{V_x}{6k\Omega} + \frac{V_z}{6k\Omega} + \frac{V_z}{3k\Omega} = 0$$ (KCL for S

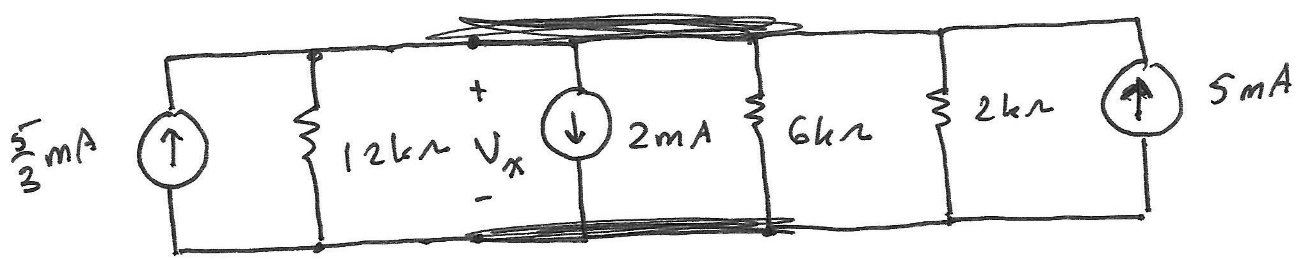
Solve for V_x.







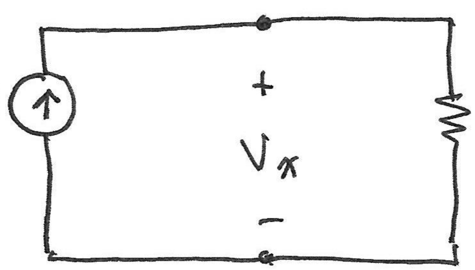




$I_{eq} =$

$\left(\frac{5}{3} - 2 + 5\right) mA$

$= \frac{14}{3}\ mA$



$R_{eq} =$

$12k\Omega \,||\, 6k\Omega \,||\, 2k\Omega$

$= \frac{4}{3}\ k\Omega$

$V_x = R_{eq} I_{eq}$

$= \frac{55}{9}\ V$