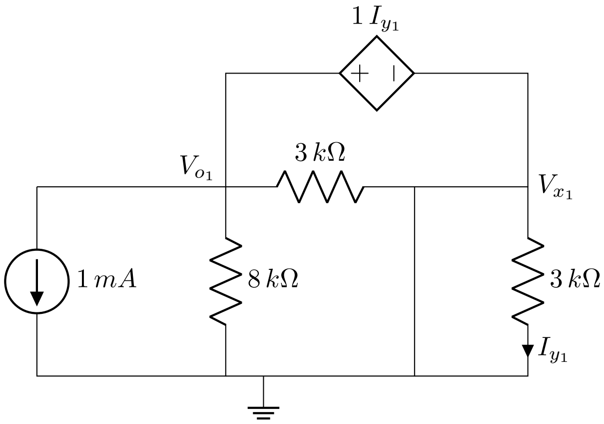
Question 1:

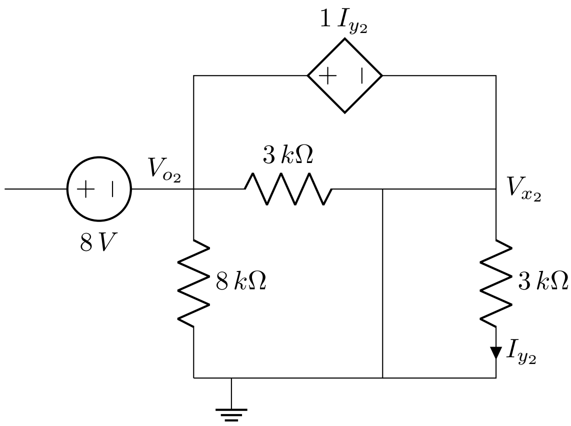
When **1 mA** active:



$$V_{x_1} = 0$$

$$\therefore V_{o_1} = 1 \times I_{y_1} = 1 \times \frac{V_{x_1}}{3} = 0$$

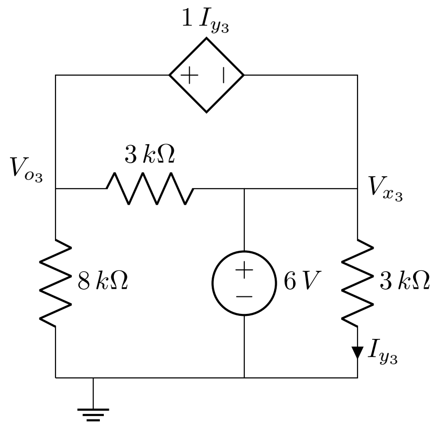
When **8 V** is active:



$$V_{x_2} = 0$$

$$\therefore V_{o_2} = 1 \times I_{y_2} = 1 \times \frac{V_{x_2}}{3} = 0$$

When **6 V** is active:



$$V_{x_3} = 6\,V$$

$$V_{o_3} = V_{x_3} + 1 \times \frac{6}{3} = 8\,V$$

$$\therefore V_o = V_{o_1} + V_{o_2} + V_{o_3} = 8\,V$$

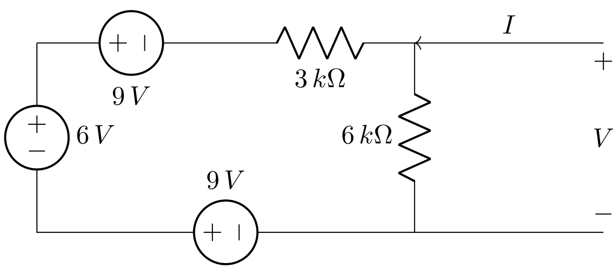
Question 2:

Circuit 1: KCL at 'V' node,

$$I = 2 + \frac{V-8}{2}$$

$$\Rightarrow I = \frac{V}{2} - 2$$

Circuit 2: Source transformed & reduced circuit:



KVL in the left loop (let loop current I_1),

$$-6 + 9 + 3I_1 + 6(I_1 + I) - 9 = 0$$

KCL at ‘V’,

$$I_1 = \frac{V}{6} - I$$

So,

$$3\left(\frac{V}{6} - I\right) + 6\left(\frac{V}{6} - I + I\right) - 9 = -3$$

$$\Rightarrow I = \frac{V}{2} - 2$$

Question 3:
(a) For $t < 0$:

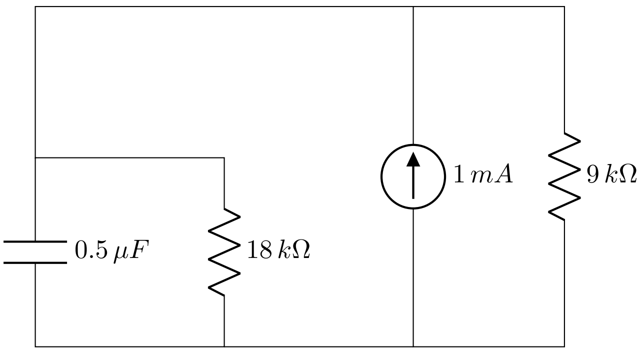


Figure 1: $t < 0$

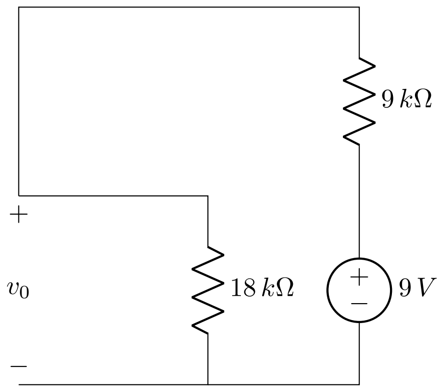
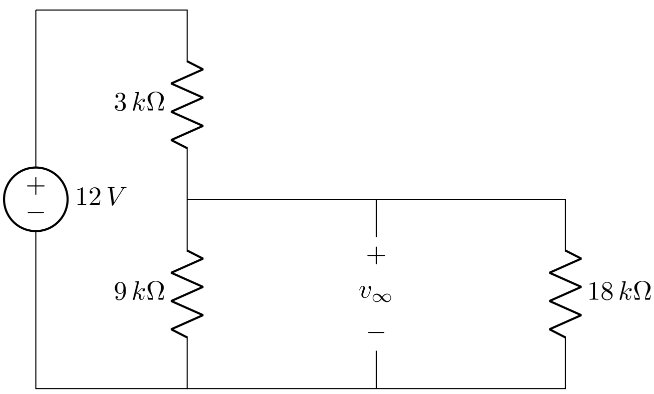


Figure 2: Reduced circuit

$$\therefore v_o = 9 \times \frac{18}{18+9} = 6\,V$$

For $t > 0$:



$$\therefore v_\infty = 12 \times \frac{9||18}{3 + (9||18)} = 8\,V$$

Figure 3: $t > 0$

$$\tau = 0.5 \times (3||9)||18 = 1\,ms$$

(i) $\therefore v(t) = v_\infty + [v_0 - v_\infty]e^{-\dfrac{t-0}{1}} = 8 + [6-8]e^{-\dfrac{t}{1}} = 8 + -2e^{-t}\,V$, where t is in ms.

(ii) $i(t) = C\dfrac{dv(t)}{dt} = 0.5 \times (-\dfrac{1}{1}) \times -2e^{-t} = 1e^{-t}\,mA$, where t is in ms.

(iii) Energy gained by the capacitor $= \dfrac{1}{2} \times 0.5[6^2 - 8^2] = 7\,\mu J$

(b) (i) Transient duration $= 5\tau = 15\,ms$

(ii) Voltage after switching $= v_\infty = -12\,V$
Voltage before switching $= v_0 = -12 - 4 = -16\,V$

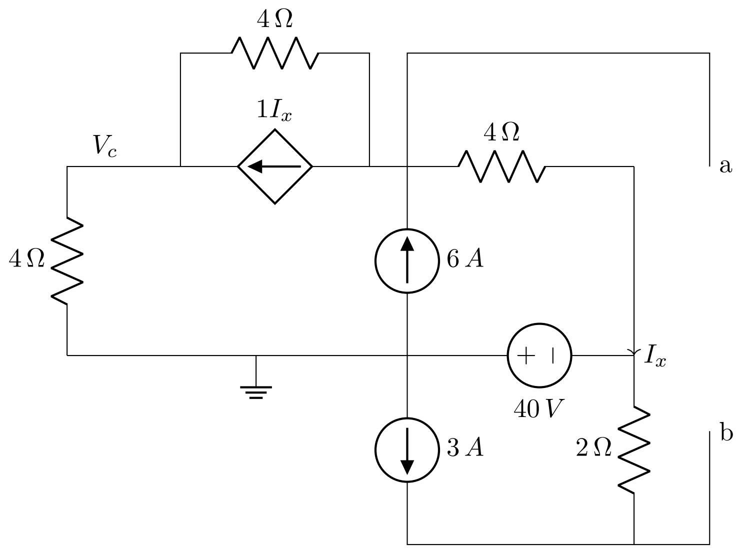
(iii) Opening the capacitor to find v_∞,

$$v_\infty = -\frac{R}{4+R} \times 16 = -12 \Rightarrow R = 12$$

$$\therefore C = \frac{3}{12||4} = 1.0\,\mu F$$

Question 4:

$\boldsymbol{V_{Th}}$ **:**



KCL at ‘b’,

$$-3 + \frac{V_b - (-40)}{2} = 0 \Rightarrow V_b = -34\,V$$

KCL at ‘a’,

$$\frac{V_a-(-40)}{4}-6+1\times\frac{V_a-(-40)}{4}+\frac{V_a-V_c}{4}=0$$

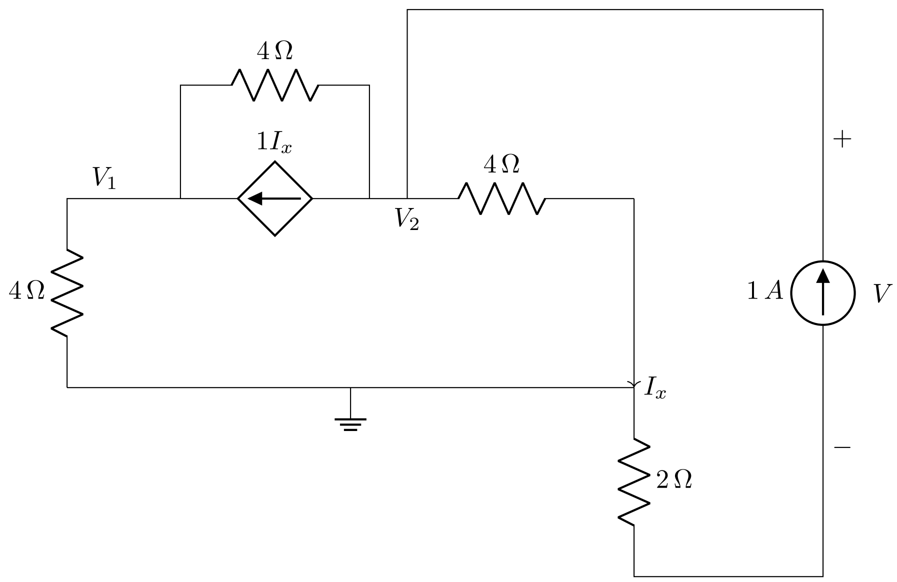
KCL at ‘c’,

$$1\times\frac{V_a-(-40)}{4}+\frac{V_a-V_c}{4}=\frac{V_c-0}{4}$$

Solving, $V_a=-18\,V$, $V_c=2\,V$

$\therefore V_{Th}=V_{ab}=V_a-V_b=16\,V$

$\boldsymbol{R_{Th}}$ **:**



KCL at ‘V_1’,

$$\frac{V_1-0}{4}+\frac{V_1-V_2}{4}-1\times\frac{V_2-0}{4}=0$$

KCL at ‘V_2’,

$$\frac{V_2-V_1}{4}+1\times\frac{V_2-0}{4}-1+\frac{V_2-0}{4}=0$$

Solving, $V_1=2\,V$, $V_2=2\,V$. Now, applying KVL, we see,

$$-V_2+V+(-1)\times 2=0$$

$$\Rightarrow V=4\,V$$

$$\therefore R_{Th}=\frac{V}{1}=4\,\Omega$$

$$\therefore P_{max}=\frac{V_{Th}^2}{4R_{Th}}=\frac{16^2}{4\times 4}=16\,W$$