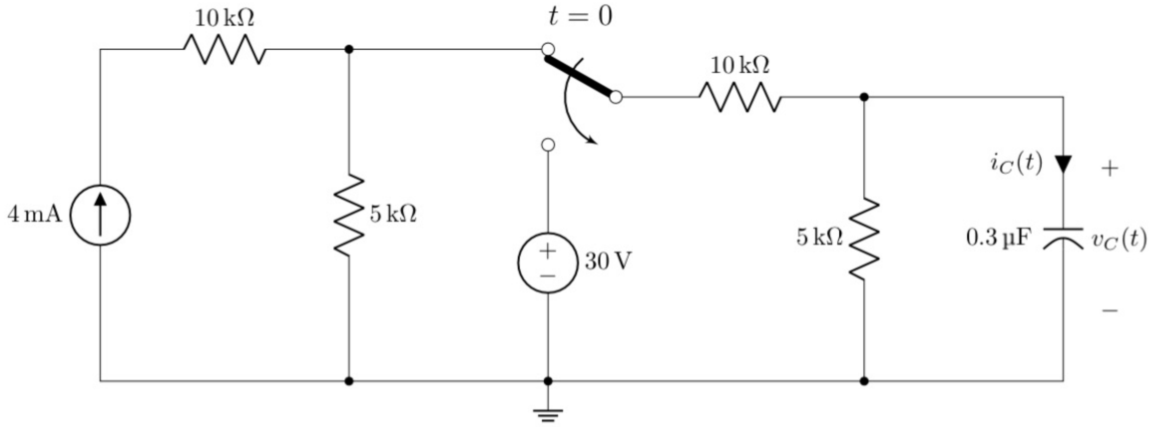
■ Question 1 of 4 *[CO3] [16 marks]*

The switch in the following circuit shifts at $t = 0$.

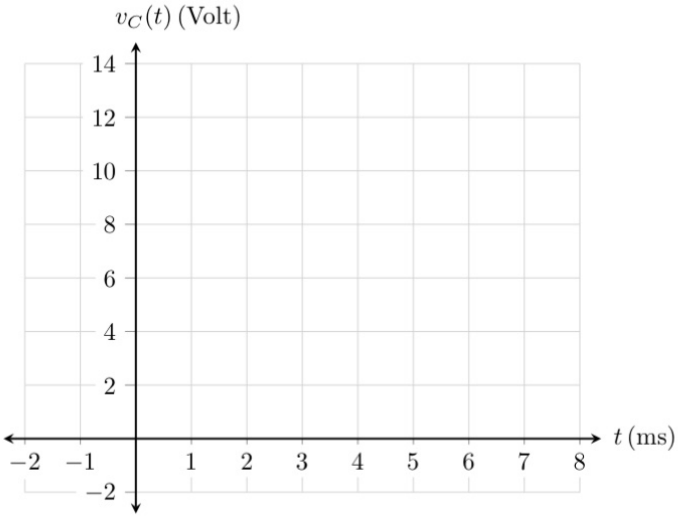


Analyze the Transient Behavior to answer the following questions–

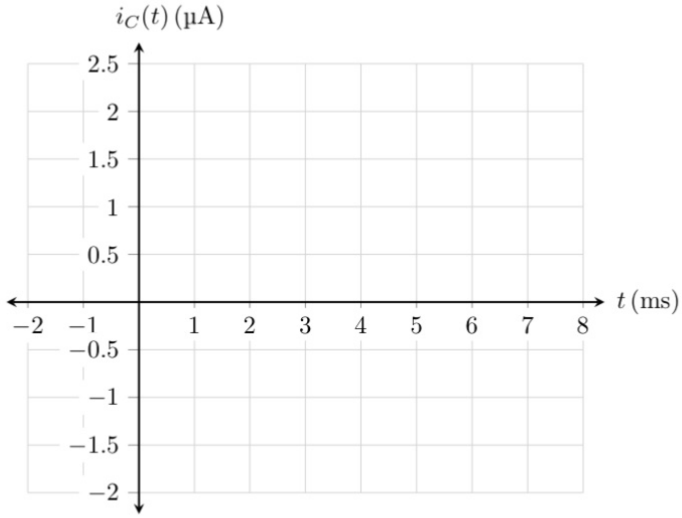
(a) ***[10 marks]*** Determine the voltage response of the capacitor $v_C(t)$ as a function of time for $t > 0$.

(b) ***[3 marks]*** Determine the current $i_C(t)$ through the capacitor for $t > 0$.

(c) ***[3 marks]*** On the grids provided below, approximately draw the $v_C(t)$ and $i_C(t)$ found in (a) and (b) respectively.

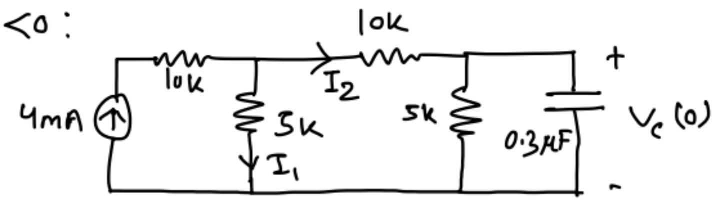


Grid for $v_C(t)$



Grid for $i_C(t)$

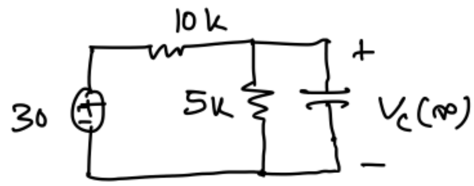
(a) $t<0$:



$$I_2 = 4 \times \frac{5}{5+10+5} = 1\,mA$$

$$\therefore V_c(0) = I_2 \times 5k = 5V$$

$t>0$:



$$V_c(\infty) = 30 \times \frac{5}{10+5} = 10\,V$$

$$\tau = (10 \| 5) \times 0.3\mu = \frac{10}{3} \times 10^3 \times 0.3 \times 10^{-6} = 1\,ms$$

$$\therefore V_c(t) = 10 + (5-10)e^{-t/\tau}$$

$$= 10 - 5e^{-1000t}$$

(b) $$i_c(t) = c\frac{d}{dt}V_c(t)$$

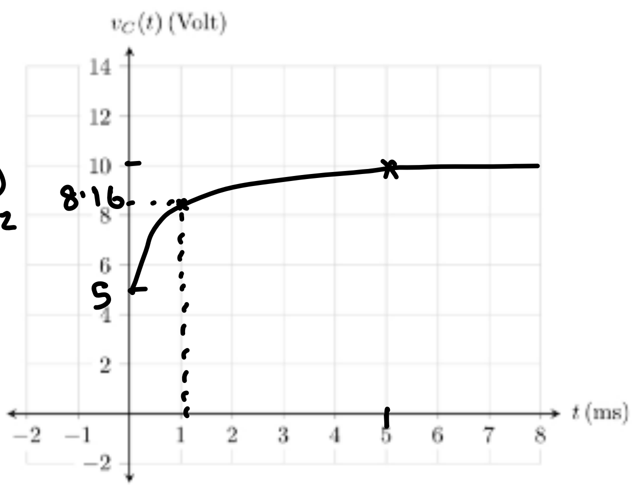
$$= \left(0 - (-1000) \times 5e^{-1000t}\right) \times 0.3 \times 10^{-6}$$

$$= 1.5e^{-1000t}\ mA$$

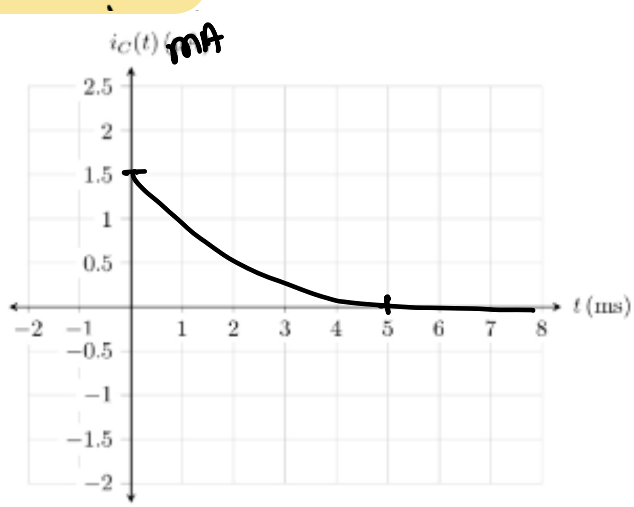
$v(T)$

$= 5+(10-5) \times 0.632$

$= 8.16$



Grid for $v_C(t)$



Grid for $i_C(t)$

■ Question 2 of 4 *[CO3] [10 marks]*

When a voltage $V = 6\,\text{V}$ is applied between terminals a and b of a linear two terminal circuit 'X', the circuit draws a current $I = 4\,\text{A}$ as shown in *Figure 1* below. When the terminals are shorted, $2\,\text{A}$ current flows as shown in *Figure 2*.

(a) ***[2 marks]*** Derive a relationship between I and V.

(b) ***[2 marks]*** Draw the relationship found in (a) on the grid provided below.

(c) ***[6 marks]*** If the circuit in *Figure 3* is an alternative version of the circuit 'X', determine the voltage V' and the resistance R'.

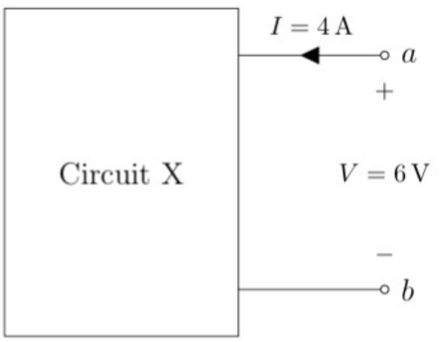


Figure 1

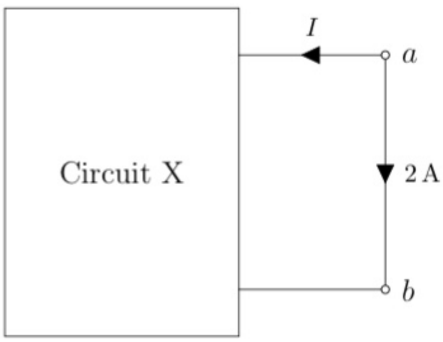


Figure 2

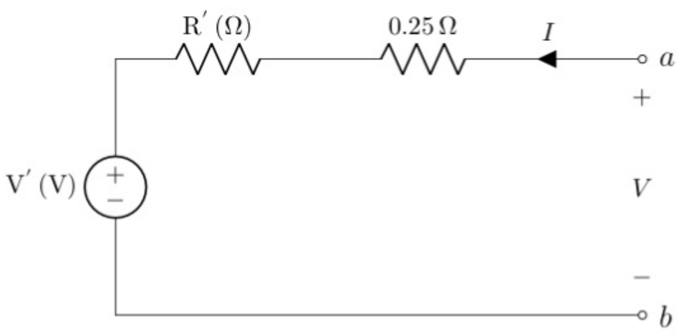
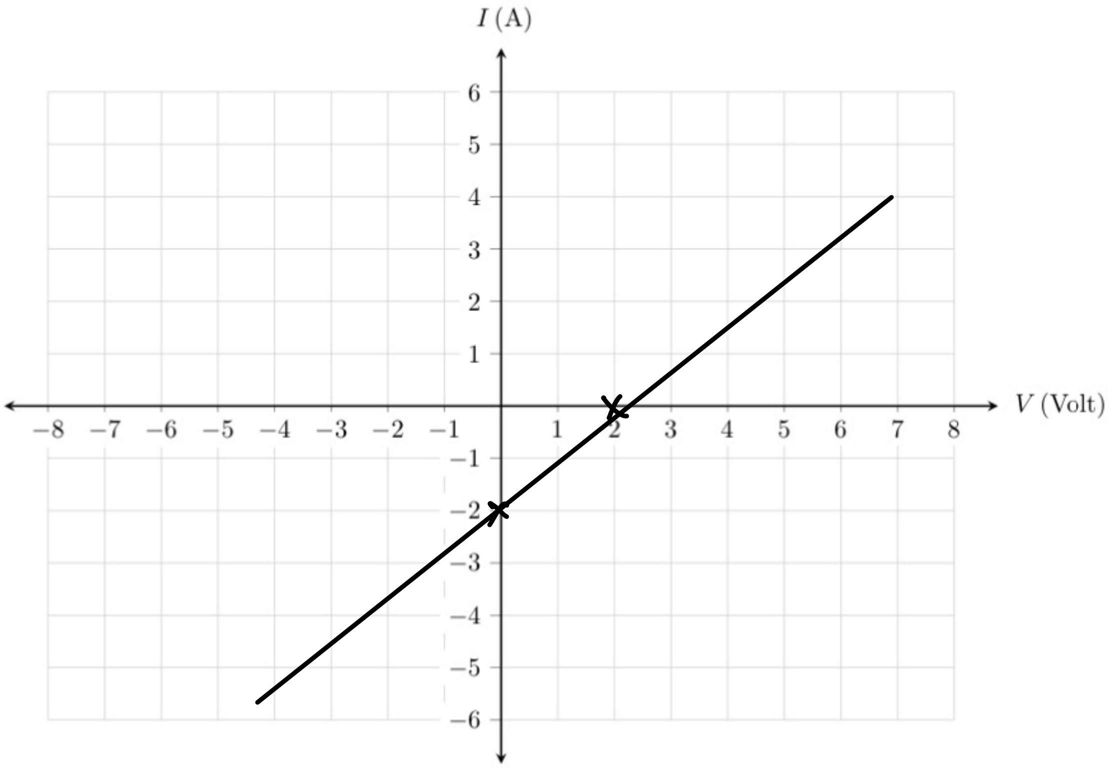


Figure 3



set-A

2

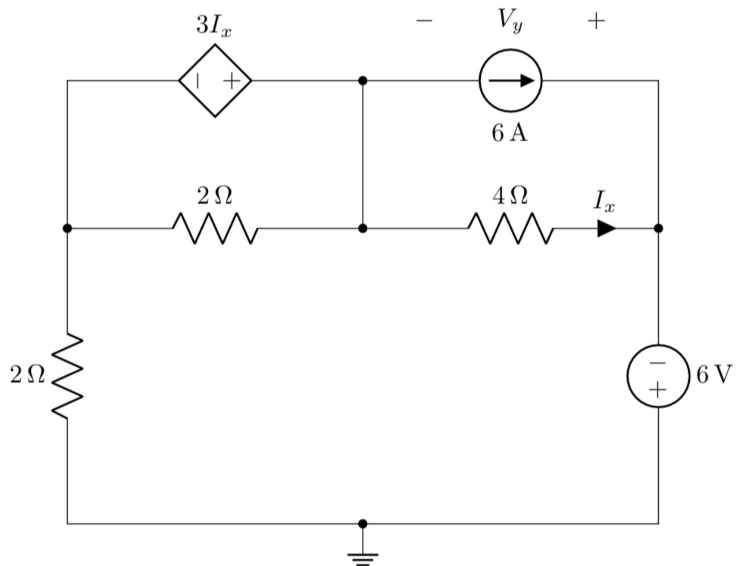
(6, 4)   (0, -2)

eq → $\boxed{I = \cancel{6}\,V - 2}$

$R' = 0.75$

$V' = 2$

■ Question 3 of 4 *[CO2] [16 marks]*

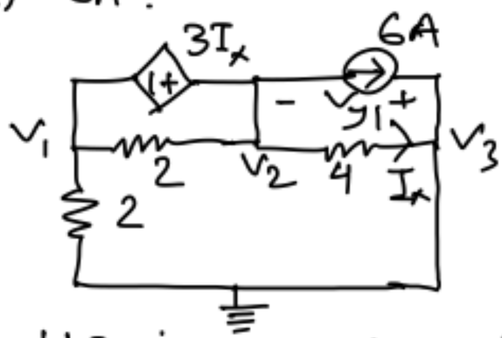


From the above circuit, answer the following questions-

(a) *[13 marks]* Find V_y using **Superposition principle**.
After applying Superposition principle you may use any analysis technique you prefer (Nodal, Mesh, Src Tx etc.).

(b) *[3 marks]* Find the **power consumed/supplied** by the **current source** (with proper ± sign and unit).

(a) 6A :



$1+2$: $v_1 - v_2 = -3\left(\frac{v_2 - v_3}{4}\right)$

$$\Rightarrow v_1 + v_2\left(-1+\frac{3}{4}\right) - \frac{3}{4}v_3 = 0$$

Supernode: $\frac{v_1}{2} + 6 + \frac{v_2 - v_3}{4} = 0$

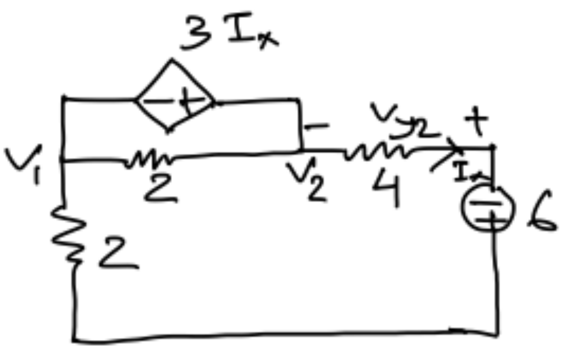
$$\Rightarrow \frac{v_1}{2} + \frac{v_2}{4} - \frac{v_3}{4} = -6$$

3 : $v_3 = 0$

$\therefore$ $v_1 = -4$, $v_2 = -16$

$\therefore$ $v_{y_1} = v_3 - v_2 = 16V$

6V:



$1+2$: $v_1 - v_2 = -3\left(\frac{v_2 - (-6)}{4}\right)$

$$\Rightarrow v_1 + v_2\left(-1+\frac{3}{4}\right) = -\frac{18}{4}$$

Supernode: $\frac{V_1}{2} + \frac{V_2+6}{4} = 0$

$$\Rightarrow \frac{V_1}{2} + \frac{V_2}{4} = -\frac{6}{4}$$

$$\therefore V_1 = -4 \quad , \quad V_2 = 2$$

$$\therefore V_{y2} = -6 - V_2$$

$$= -8\ V$$

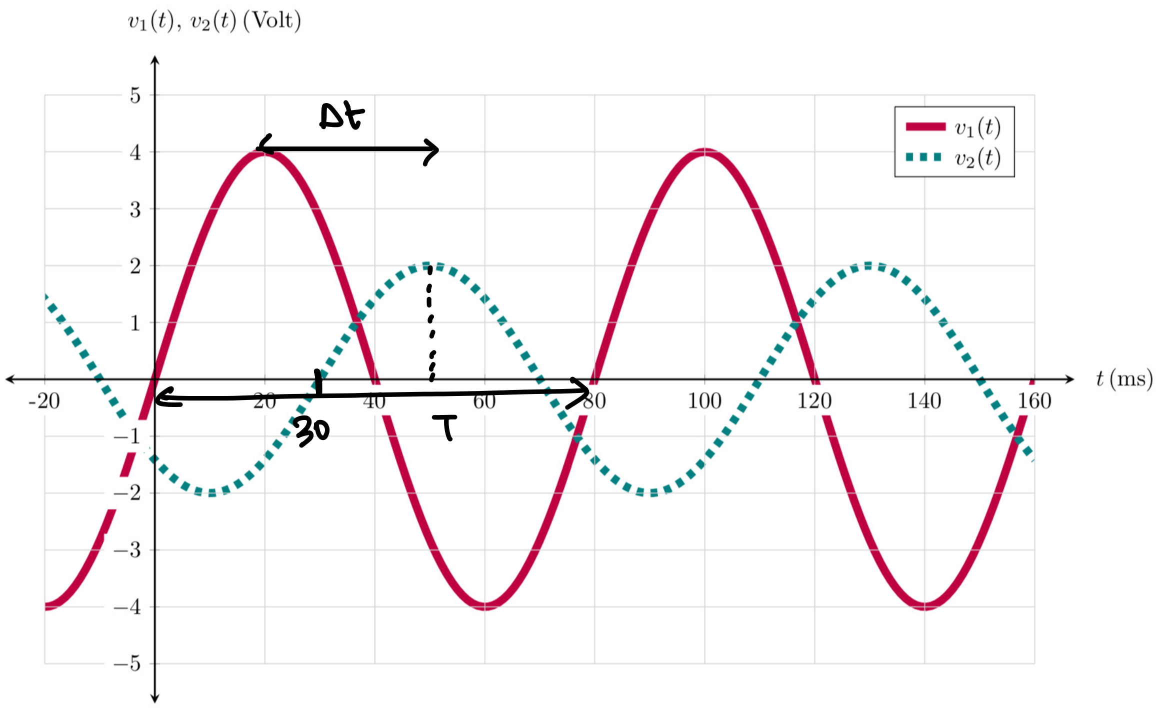
$$\therefore V_y = V_{y1} + V_{y2} = 16 - 8 = 8V$$

(b) $P_{6A} = V_y \times 6 = 8 \times -6 = -48\ W$

~~(Consuming)~~ (supplying)

■ Question 4 of 4 *[CO3] [8 marks]*

Two ac voltage waveforms $v_1(t)$ and $v_2(t)$ from a circuit are plotted below as a function of time t.



(a) *[4 marks]* Determine the phase difference between the two and specify which one is leading.

(b) *[4 marks]* Write analytical expressions for both $v_1(t)$ and $v_2(t)$. From the expressions, verify the fact found in (a).

a) $\Delta t = 50 - 20 = 30ms$

$T = 80ms$

$\omega = \frac{2\pi}{80}$ rad/ms

$\Delta\phi = \omega \times \Delta t = \frac{\cancel{2}\pi}{\cancel{80}_{4}} \times 3\cancel{0} = \frac{3\pi}{4}$ rad.

$v_1(t)$ leads $v_2(t)$ by $\frac{3\pi}{4}$ rad.

b) $v_1(t) = 4\sin\left(\frac{2\pi}{80}t\right)$ V

$\phi_2 = 30ms \times \omega = 30 \times \frac{2\pi}{80} = \frac{3\pi}{4}$

$v_2(t) = 2\sin\left(\frac{2\pi}{80}t - \frac{3\pi}{4}\right)$

phase diff $= 0 - -\frac{3\pi}{4} = \frac{3\pi}{4}$

$v_1(t)$ leads $v_2(t)$ by $\frac{3\pi}{4}$ rad