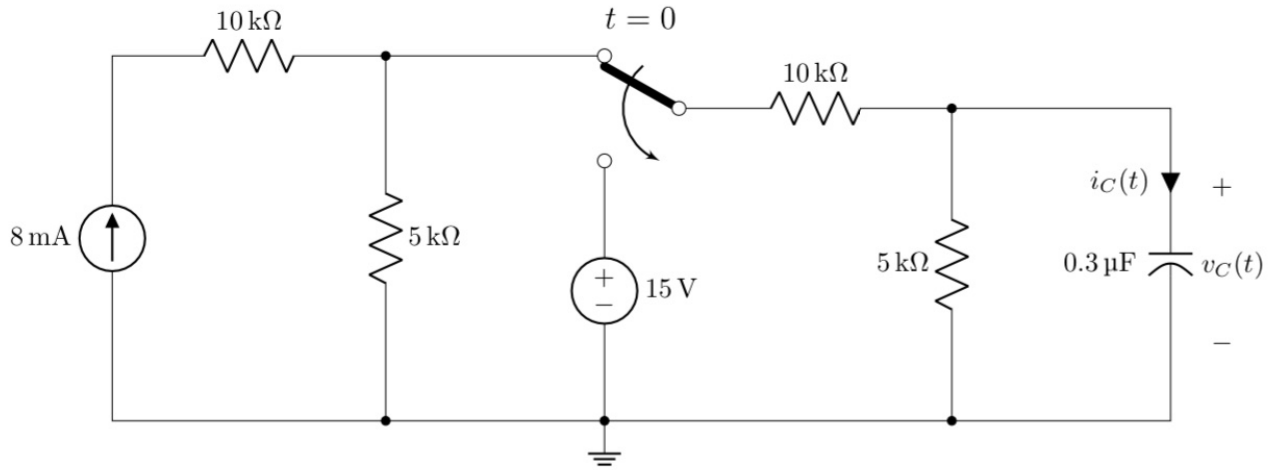
■ Question 1 of 4 *[CO3] [16 marks]*

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

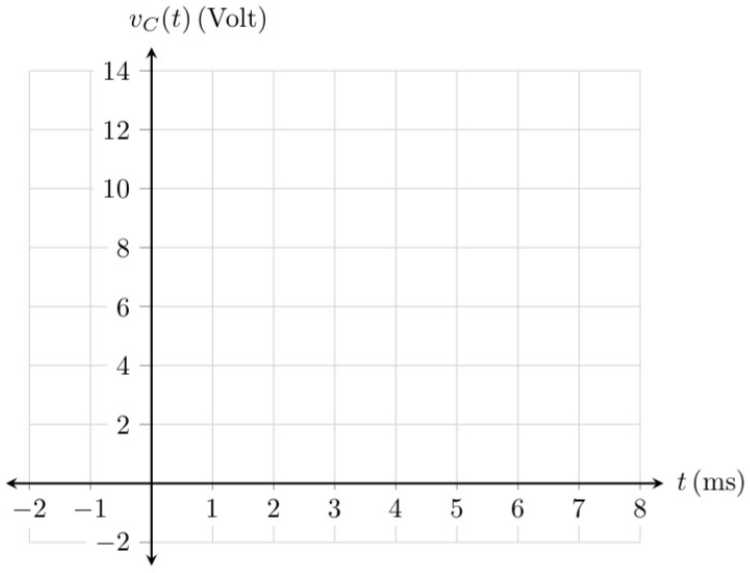


Analyze the Transient Behavior to answer the following questions–

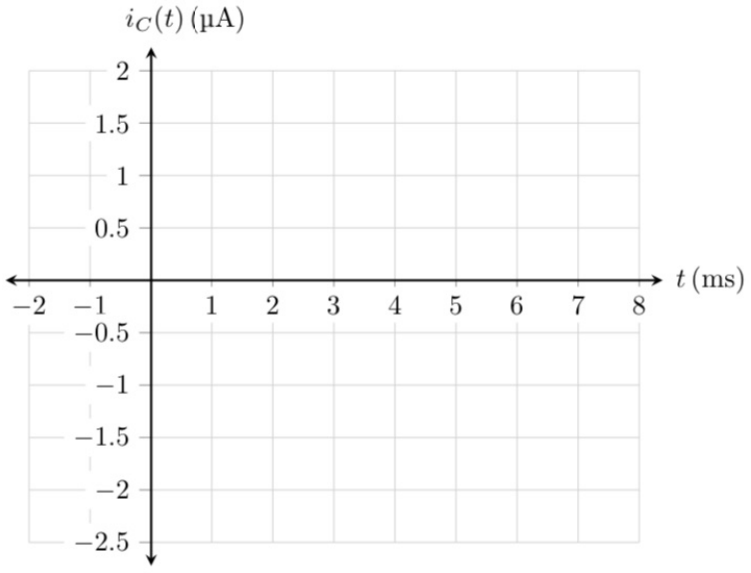
(a) ***[10 marks]*** Determine the voltage response of the capacitor $v_C(t)$ as a function of time for $t > 0$.

(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.

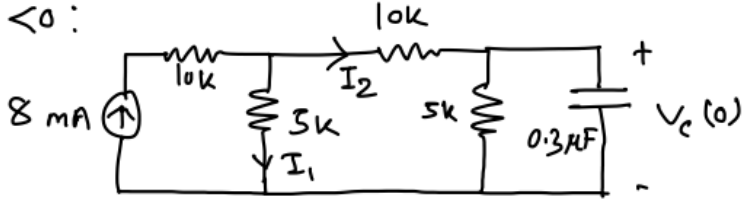


Grid for $v_C(t)$



Grid for $i_C(t)$

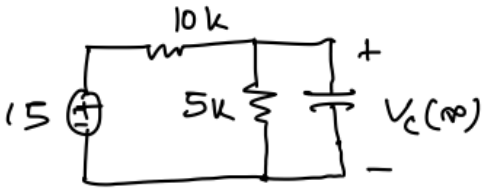
(a) $t<0$:



$$I_2 = 8 \times \frac{5}{5+10+5} = 2 \text{ mA}$$

$$\therefore V_c(0) = I_2 \times 5k = 10V$$

$t>0$:



$$V_c(\infty) = 15 \times \frac{5}{10+5} = 5\text{ V}$$

$$\tau = (10 \| 15) \times 0.3\mu$$
$$= \frac{10}{3} \times 10^3 \times 0.3 \times 10^{-6}$$
$$= 1 \text{ ms}$$

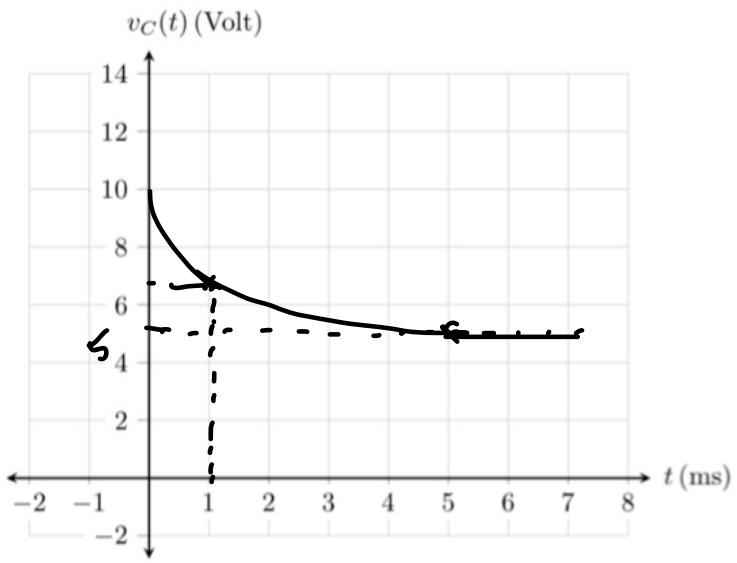
$$\therefore V_c(t) = 5 + (10-5)e^{-t/\tau}$$

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

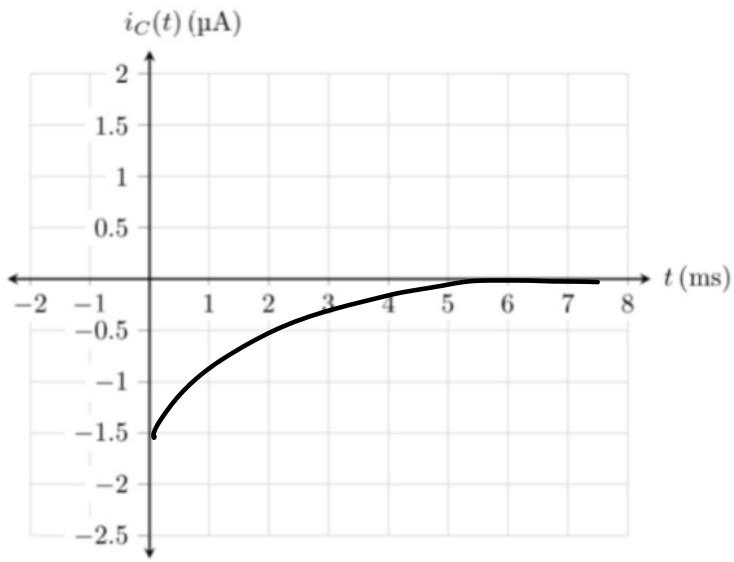
(b) $$i_c(t) = c\frac{d}{dt}V_c(t)$$

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

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



Grid for $v_C(t)$



Grid for $i_C(t)$

■ Question 2 of 4 *[CO3] [10 marks]*

When a voltage $V = 5\,\text{V}$ is applied between terminals a and b of a linear two terminal circuit 'X', the circuit draws a current $I = 2\,\text{A}$ as shown in *Figure 1* below. When the terminals are shorted, 3 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'.

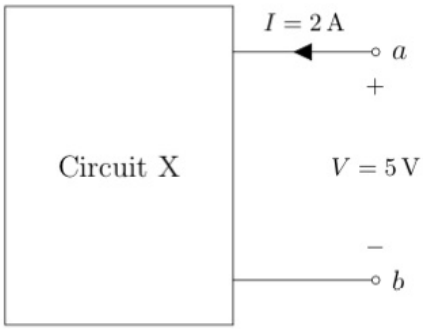


Figure 1

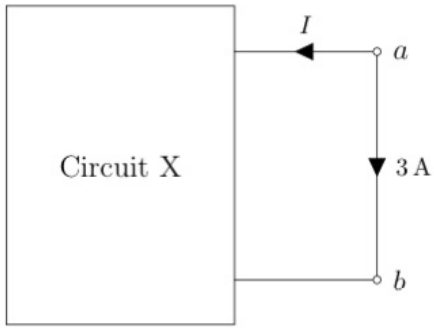


Figure 2

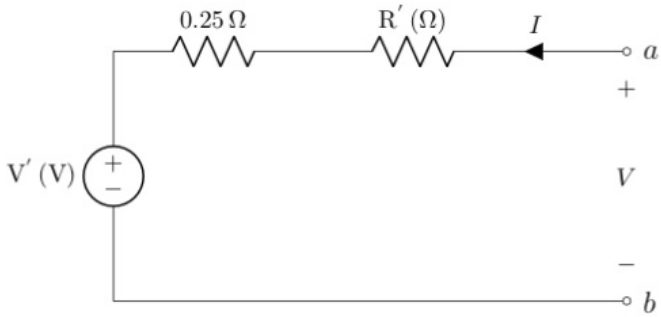
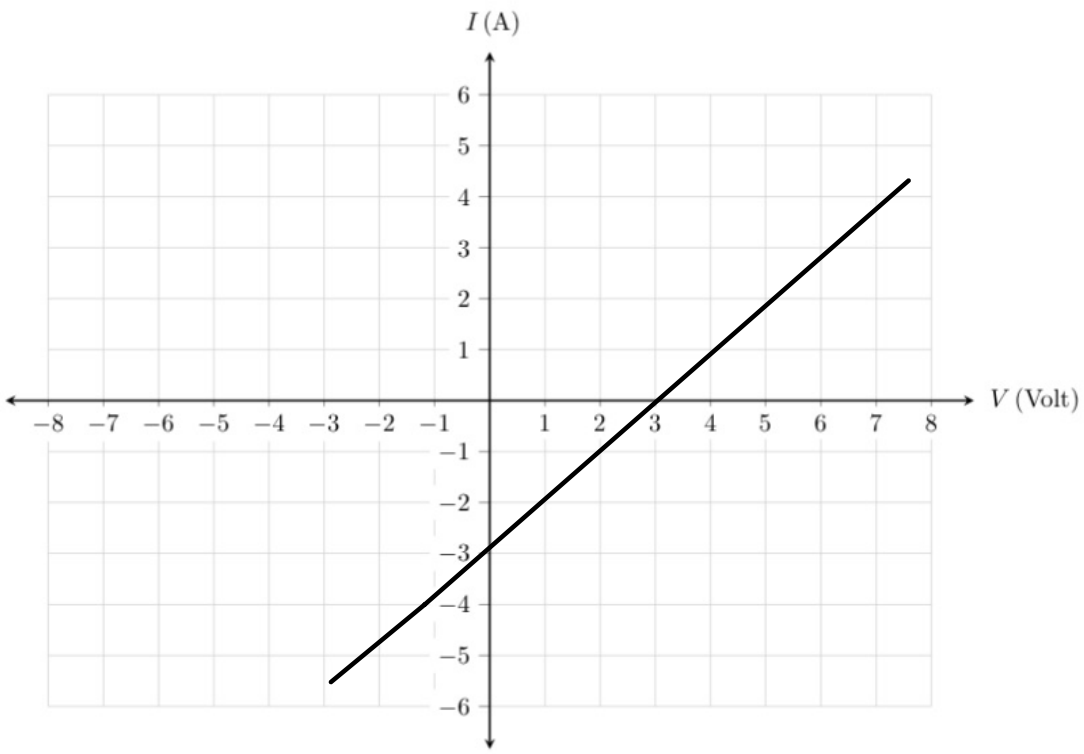
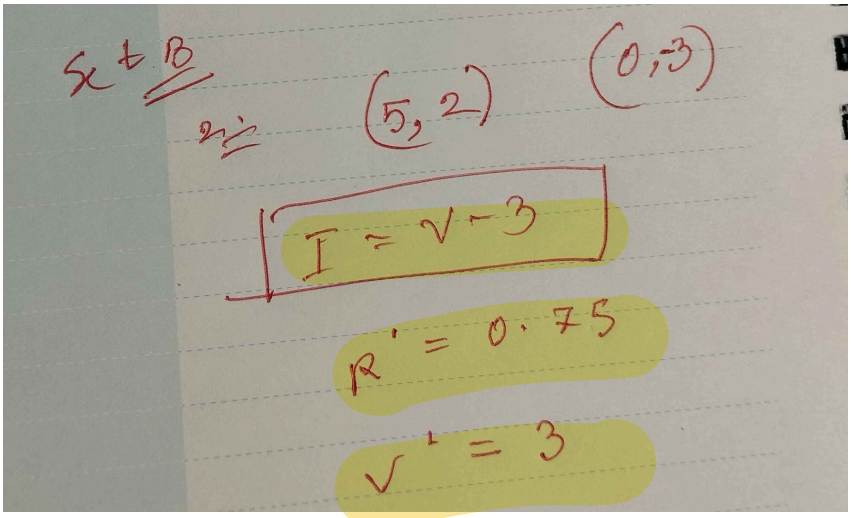
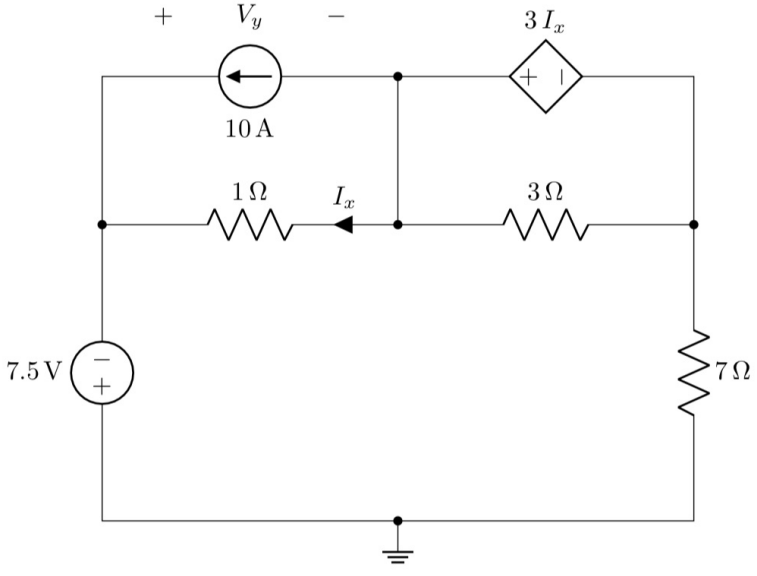


Figure 3





■ Question 3 of 4 *[CO3] [16 marks]*

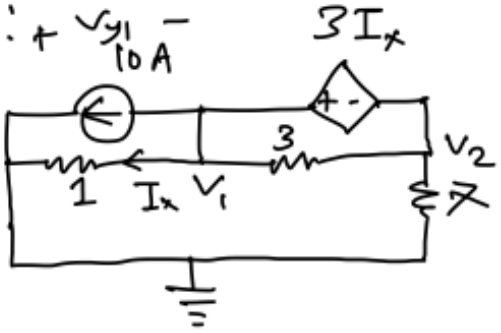


From the above circuit, answer the following questions-

(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) 10A : $+ v_{y1} -$



1 + 2 : $v_1 - v_2 = 3 \times \frac{v_1}{1}$

$\Rightarrow -2v_1 - v_2 = 0$

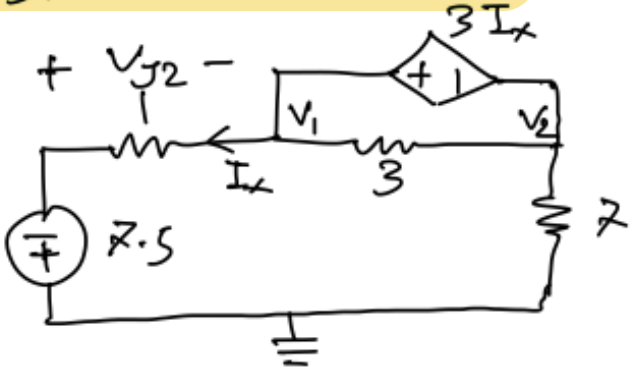
Supernode: $v_1 + 10 + \frac{v_2}{2} = 0$

$\Rightarrow v_1 + \frac{v_2}{2} = -10$

$\therefore v_1 = -14, \quad v_2 = 28$

$\therefore v_{y1} = -v_1 = 14V$

2.5V : $+ v_{y2} -$



1 + 2 : $v_1 - v_2 = 3 \times (v_1 + 2.5)$

$\Rightarrow -2v_1 - v_2 = 22.5$

Supernode: $\frac{v_1 + 2.5}{1} + \frac{v_2}{2} = 0$

$\Rightarrow v_1 + \frac{v_2}{2} = -2.5$

$v_1 = -6, \quad v_2 = -10.5$

$\therefore V_{y2} = -2.5 - V_1 = -1.5\ V$

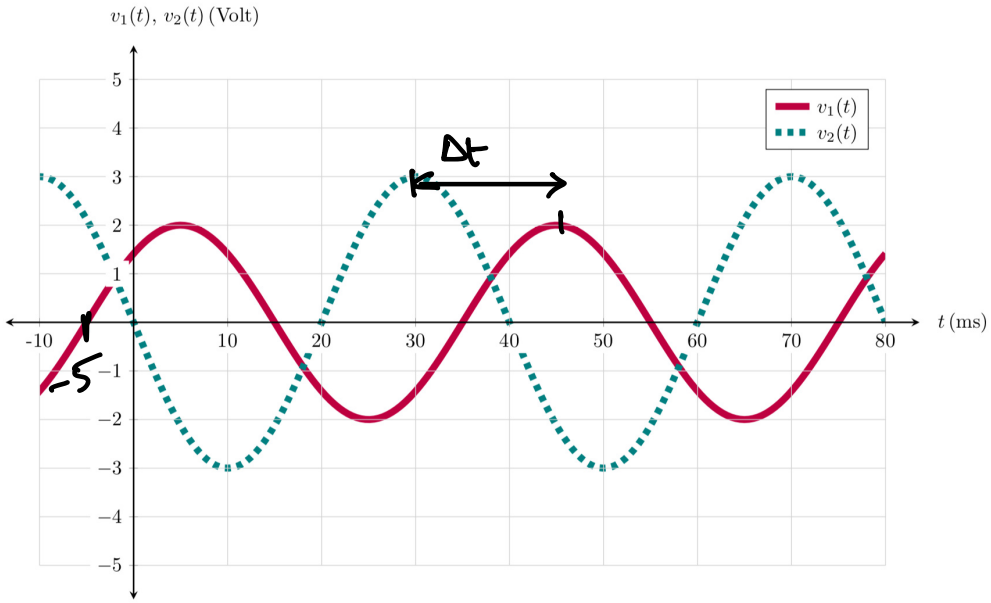
$\therefore V_y = V_{y1} + V_{y2} = 14 - 1.5$

$= 12.5\ V$

(b) $P_{10A} = 10 \times V_y = -125\ W$ (supplying) (~~consuming~~)

■ **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) $\Delta t = 45 - 30 = 15\ ms$

$T = 40\ ms$

$w = \frac{2\pi}{40}\ rad/ms$

$\Delta\phi = \frac{2\pi}{40} \times 15 = \frac{3\pi}{4}\ rad$

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

b) $\phi_1 = \frac{2\pi}{40} \times 5 = \frac{\pi}{4}$

$v_1(t) = 2\sin\left(\frac{2\pi}{40}t + \frac{\pi}{4}\right)$

$v_2(t) = -3\sin\left(\frac{2\pi}{40}t\right)$

$= 3\sin\left(\frac{2\pi}{40}t + \pi\right)$

$\Delta\phi = \pi - \frac{\pi}{4} = \frac{3\pi}{4}$

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