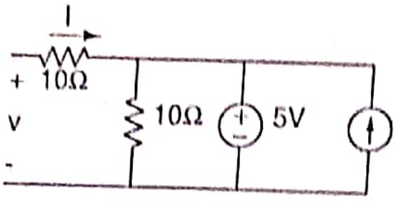
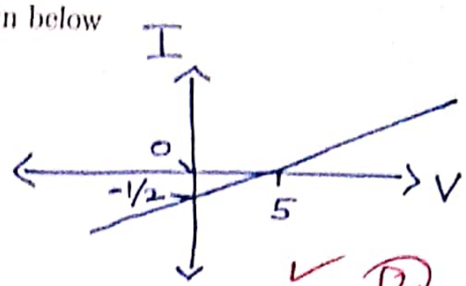
1. Plot the I-V characteristic of the circuit shown below (2)





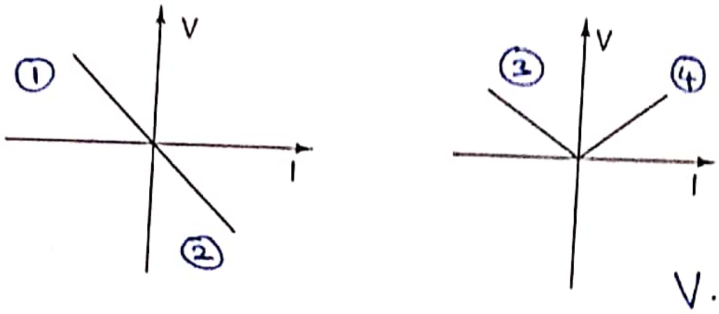
(straight line)

KVL: $V - 10I - 5 = 0 \Rightarrow V = 10I + 5$

$\Rightarrow I = (V-5)/10$

✓ 2

2. The V-I characteristics of two devices are shown below. Mark the regions where the device absorbs/delivers power. Give reasons (2)



2 ✓

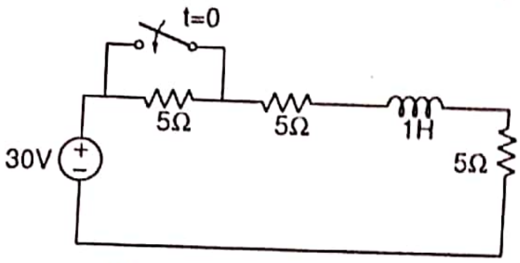
1, 2, 3 : delivers power

4 : absorbs power

$V \cdot I > 0 \Rightarrow$ absorbs power

$V \cdot I < 0 \Rightarrow$ delivers power

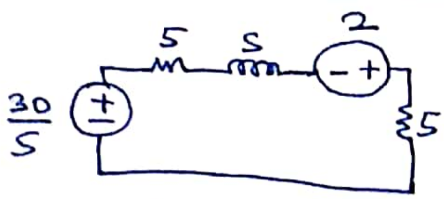
3. Find i) $v_L(0^+)$, ii) $i_L(0^+)$, iii) $v_L(\infty)$ and iv) $i_L(\infty)$. 4 (4)



ii) $i_L(0^+) = i_L(0^-) = \dfrac{30}{5+5+5} = 2\,A$ ✓

iv) $i_L(\infty) = \dfrac{30}{5+5} = 3\,A$ ✓

iii) $v_L(\infty) = 0\,V$ ✓ $\left(\because \dfrac{di_L}{dt} = 0 \text{ @ } t = \infty\right)$



$t > 0$

$I(s) = \dfrac{\frac{30}{s} + 2}{10 + s}$

$V_L(s) = sI(s) - 2 = \dfrac{10}{s+10}$

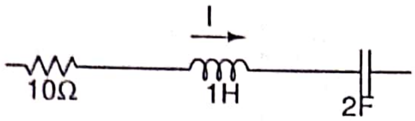
i) $V_L(0^+) = \lim_{s \to \infty} sV_L(s) = \lim_{s \to \infty} \dfrac{10s}{s+10} = 10$ ✓

3

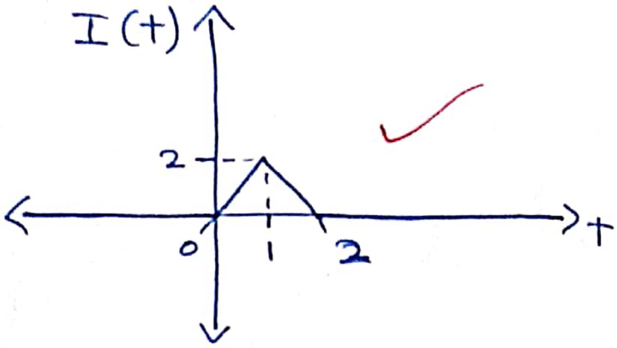
4. In the figure below, $I(t) = 2t(u(t) - u(t-1)) + (4-2t)(u(t-1) - u(t-2))$. Plot

(a) $I(t)$, $v_C(t)$ and $v_L(t)$

(b) The power absorbed/delivered by the inductor as a function of time. (4)

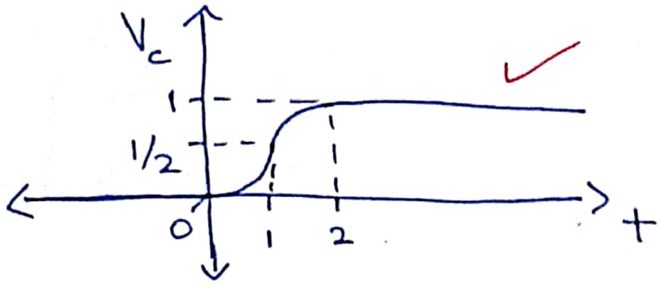


a)



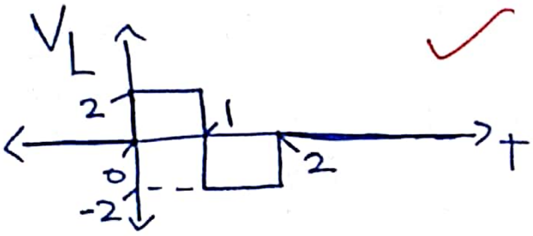
$$V_c(t) = \int_{-\infty}^{t} \frac{i(\tau)}{2} d\tau$$

$$= \frac{t^2}{2}\left[u(t) - u(t-1)\right] + \frac{2-(t-2)^2}{2}\left[u(t-1) - u(t-2)\right] + 2u(t-2)$$



$$V_L(t) = L\frac{dI(t)}{dt}$$

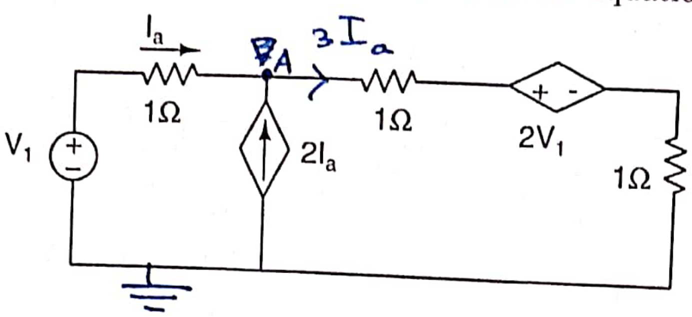
$$= 2\left[u(t) - u(t-1)\right] - 2\left[u(t-1) - u(t-2)\right]$$



b) $P_L = \frac{L}{2}\left[i(t)^2 - i(0)^2\right]$ Plot?

$$= 2t^2\left[u(t) - u(t-1)\right] + 2(t-2)^2\left[u(t-1) - u(t-2)\right]$$

5. Write the nodal equations for the following circuit. Put it in a matrix form. Mark the nodes/supernodes clearly and write the equation at each node/supernode. (4)



A: node

0

$$V_1 - V_A = (1)\,I_a$$

$$V_A - 3I_a - 2V_1 - 3I_a = 0 \Rightarrow -2V_1 + V_a = 6I_A$$

$$\begin{bmatrix} 1 & -1 \\ -2 & 1 \end{bmatrix}\begin{bmatrix} V_1 \\ V_a \end{bmatrix} = \begin{bmatrix} I_a \\ 6I_a \end{bmatrix}$$

$$V_1 = -7I_a$$

Write in terms of V_a, V_b, V_c, V_d.

$$V_A = -8I_a$$

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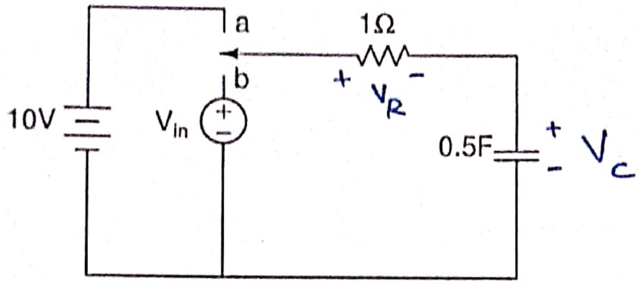
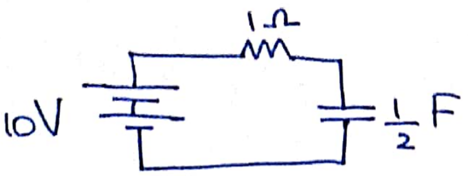
6. In the given network, the switch is in position a for a long time. At $t = 0$ it is switched to position b. $V_{in} = e^{-t}u(t)$. (4)



4

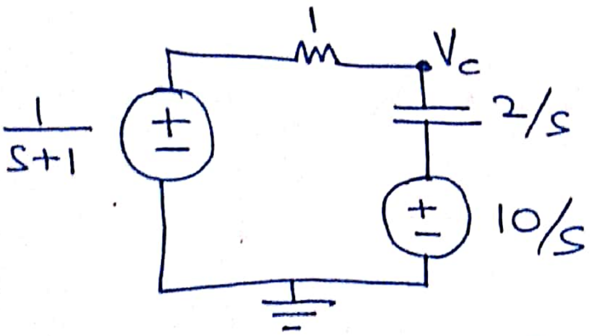
(a) Draw the circuit with switch at positon a and the find the capacitor voltage at $t = 0$.



At $t=0$, $i=0 \Rightarrow V_R = 0$

Hence, $V_c = 10V$

(b) With switch at position b draw the s-domain circuit and determine the voltage across the capacitor as a function of time for $t > 0$.



$$\frac{V_c - 10/s}{2/s} + \frac{V_c - 1/(s+1)}{1} = 0$$

$$\left(\frac{s+2}{2}\right)V_c = \frac{5s+6}{s+1}$$

$$V_c = \frac{2(5s+6)}{(s+1)(s+2)} = \frac{2}{s+1} + \frac{8}{s+2}$$

$$V_c(t) = 2\left(e^{-t} + 4e^{-2t}\right)u(t)$$