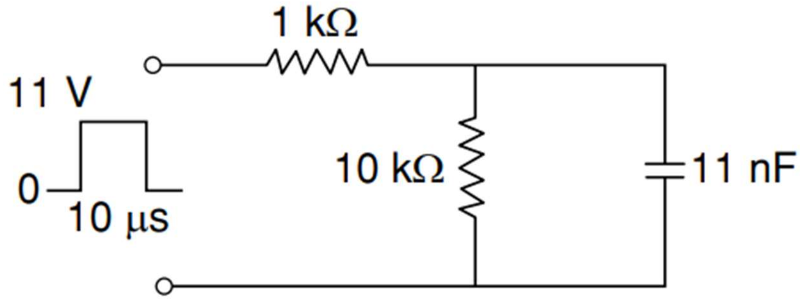
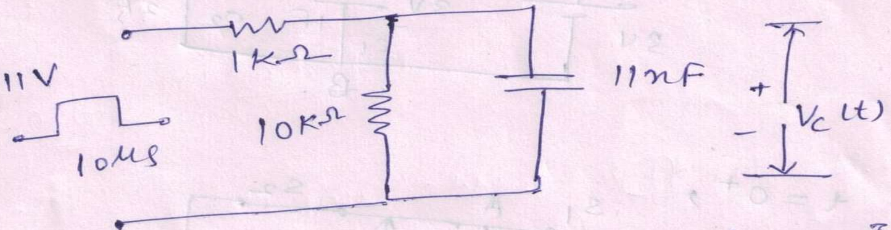
Tutorial - 4

1. An 11 V pulse of 10 µs duration is applied to the circuit shown in the figure. Assuming that the capacitor is completely discharged prior to applying the pulse, the peak value of the capacitor voltage is -



Consider the figure below.



$v_c(0) = 0V.$

(I.V = Initial Value
F.V = Final Value.)

If the input is $11u(t)$,

$v_c(t) = I.V + (F.V - I.V)(1 - e^{-t/\tau})$,

where, $F.V = 11 \times \frac{10}{11} = 10V$,

and $\tau = \frac{10}{11} \times 10^3 \times 11 \times 10^{-9} = \underline{\underline{10 \mu s}}$.

$v_c(t) = 10(1 - e^{-t/\tau})$. —— (1)

When we apply a pulse of $10\mu s$,

$v_c(t)$ as given in (1) is true

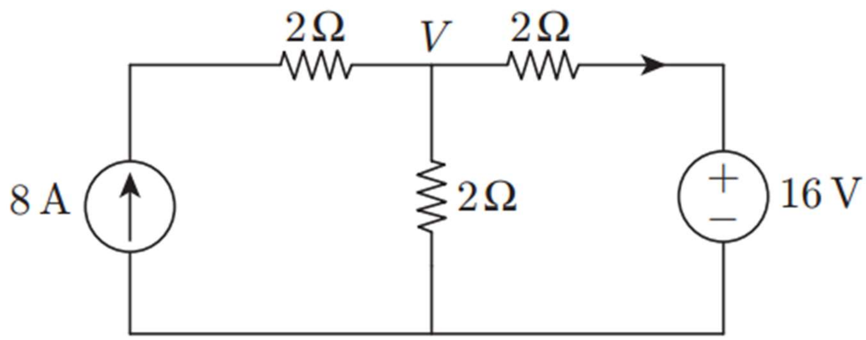
under condition $0 < t < 10\mu s$.

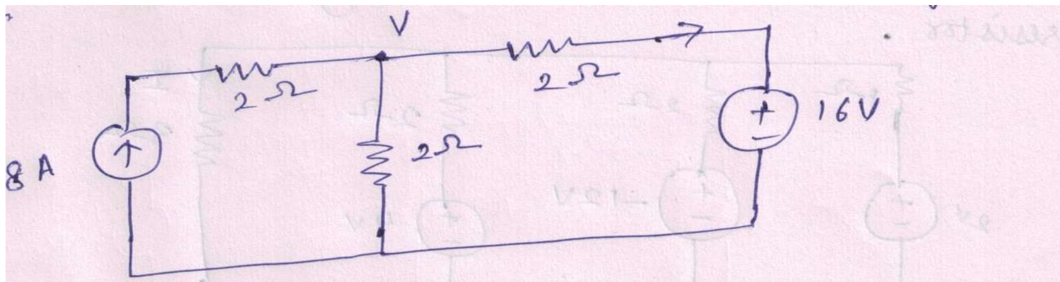
$\therefore$ peak value of $v_c(t)$ occurs at

$t = 10\mu s$.

Peak value $= 10(1 - e^{-1}) = \underline{\underline{6.32 V}}$.

2. Determine the power delivered by the 16 V source.

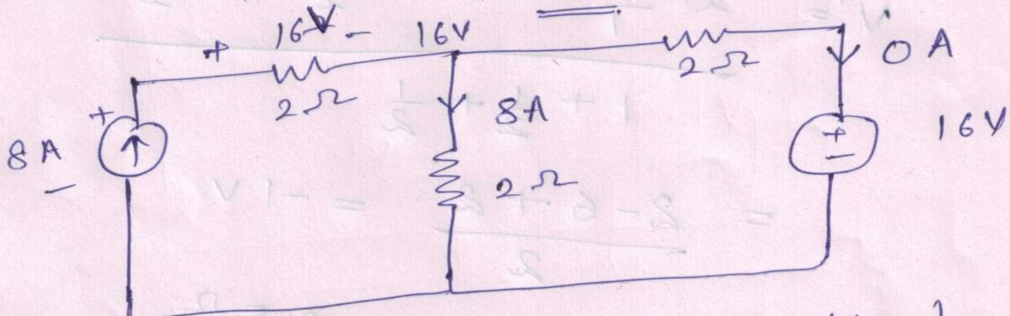




On nodal analysis,

$$\frac{V-16}{2} + \frac{V}{2} - 8 = 0$$

$$\underline{V = 16\ V}$$



$P_{8A} = 32 \times 8 = 256\ W$ (Deliver)

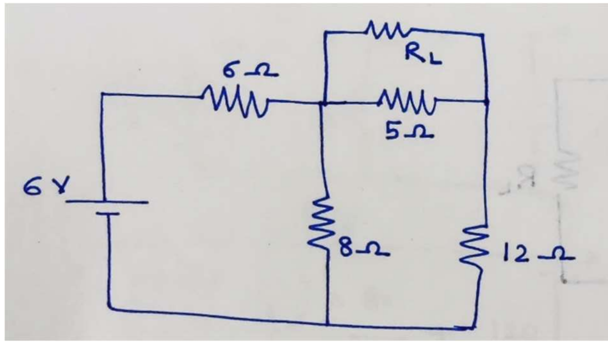
$P_{2\Omega} = 16 \times 8 = 128\ W$ (Absorb)

$P_{2\Omega} = 16 \times 8 = 128\ W$ (Absorb)

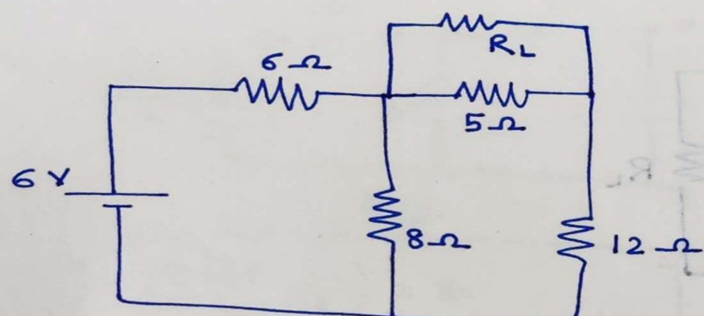
$P_{16V} = 0 \times 16 = 0\ W$

Hence, power delivered by the 16 V source is zero.

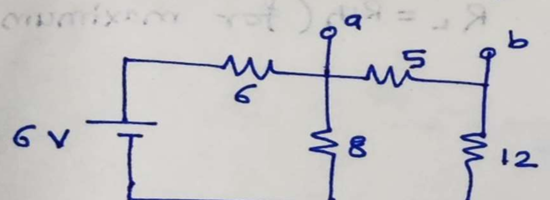
3. Find the Value of R_L in the following circuit for maximum power to be transferred to it. Find the efficiency of the source voltage while delivering the maximum power to R_L.



Solution -



To find value of R_L, for maximum power,



$R_{Th} = 3.77\ \Omega$

$V_{Th} = 0.83$ volts

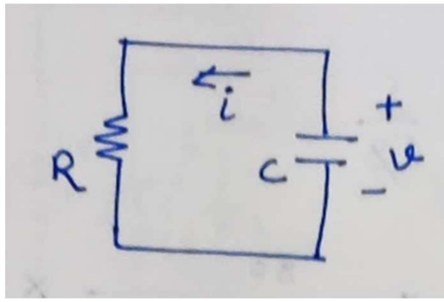
∴ For maximum power transfer,

$R_L = 3.77\ \Omega$

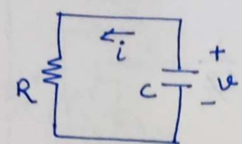
$$P_{max} = \frac{0.83^2}{4 \times 3.77} = 0.0456 \text{ watts.}$$

Efficiency will be 50 %

4. For the following circuit, $v(t) = 10e^{-4t}$, $i(t) = 0.2e^{-4t}$. Find the values of R and C.



Solution –



$v(t) = 10\, e^{-4t}$ V, $i(t) = 0.2 \cdot e^{-4t}$ Amp , $t > 0$

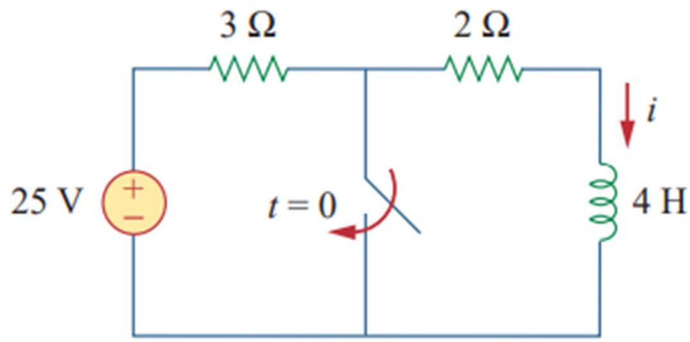
$$R = \frac{10}{0.2} = 50 \text{ ohm}$$

Here, $\tau = 1/4$

$$RC = \frac{1}{4}$$

$$50 \times C = \frac{1}{4} \Rightarrow C = \frac{1}{200} = 0.5 \times 10^{-2} = 5 \text{ mF}$$

5. In the circuit, the switch is closed at t=0 seconds. Find inductor current i(t) for both t<0 and t >0 respectively,

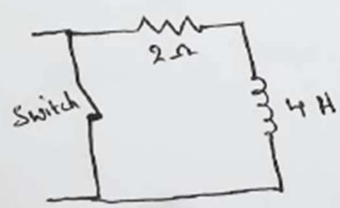


Solution -

⇒ For $t<0$ time, in steady state, inductor acts as short circuit for DC. So, current, i, during $t<0$ is given by,

$$i = \frac{25}{3+2} = 5\ A$$

⇒ At $t=0$ time, switch is closed. So the energy stored in the inductor previously starts discharging. So, for $t>0$, we have an R-L circuit as shown.



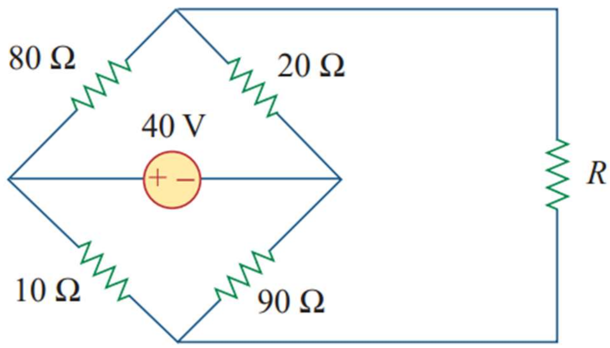
⇒ $i(t) = i(0)\, e^{-t/\tau}$;

$$\tau = \frac{L}{R} = \frac{4}{2} = 2\ ; \quad i(0) = 5\ A\ .$$

⇒ $i(t) = 5e^{-t/2}\ A$.

∴ $$\boxed{\begin{aligned} i &= 5\ A\ ; \quad t<0 \\ i &= 5e^{-t/2}\ A\ ; \quad t>0 \end{aligned}}$$

6. In the circuit, R is the variable load resistance. The value of R (in ohms) at which it absorbs the maximum power from the circuit is 25 ohms. Find maximum power transferred to load resistance R in Watts?



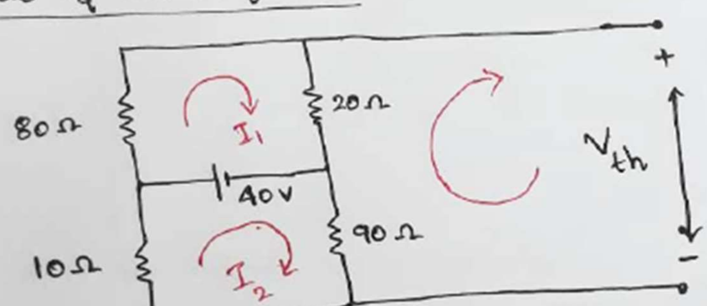
Solution –

⇒ Maximum power transferred to R, $P_{max} = \dfrac{V_{Th}^2}{4R_{Th}}$

∴ $R = R_{th}$, at maximum power transfer instant.

Given $R = R_{th} = 25\ \Omega$. But, we dont know V_{th} ?

Circuit is redrawn below :



→ $(80+20)\,I_1 - 40 = 0$ ⟶ $I_1 = 0.4$

$(10+90)\,I_2 + 40 = 0$ ⟶ $I_2 = -0.4$

$-90\,I_2 - 20I_1 + V_{th} = 0$ ⟶ $V_{th} = -28\ V$

⇒ $P_{max} = \dfrac{V_{th}^2}{4R_{th}} = \dfrac{(28)^2}{4 \times 25} = \dfrac{784}{100} = 7.84$ Watts

⇒ $\boxed{P_{max} = 7.84\ W}$