Nishant Jindal

R-C Ckt

At $t=0$

→ Capacitor behave as zero resistance wire

At $t \to \infty$

→ Capacitor acts as a open ckt.

→
$$q = q_0(1 - e^{-t/\tau}) \rightarrow \text{Charging}$$
$$q = q_0 e^{-t/\tau} \rightarrow \text{(Discharging)}$$
$$I = I_0 e^{-t/\tau}$$

(**) To find time constant of any R-C Ckt

Trick:→ (Applicable for only one Capacitor in the Ckt)

$$\Rightarrow \tau = (R_{eq}) \cdot C$$

R_{eq} = Equivalent resistance of the Ckt about the Capacitor.

To find 'R_{eq}' accross the Capacitor Short all the battery i.e replaced the battery by zero resistance wire.

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$q = q_0 e^{-t/\tau}$ → (Discharging)

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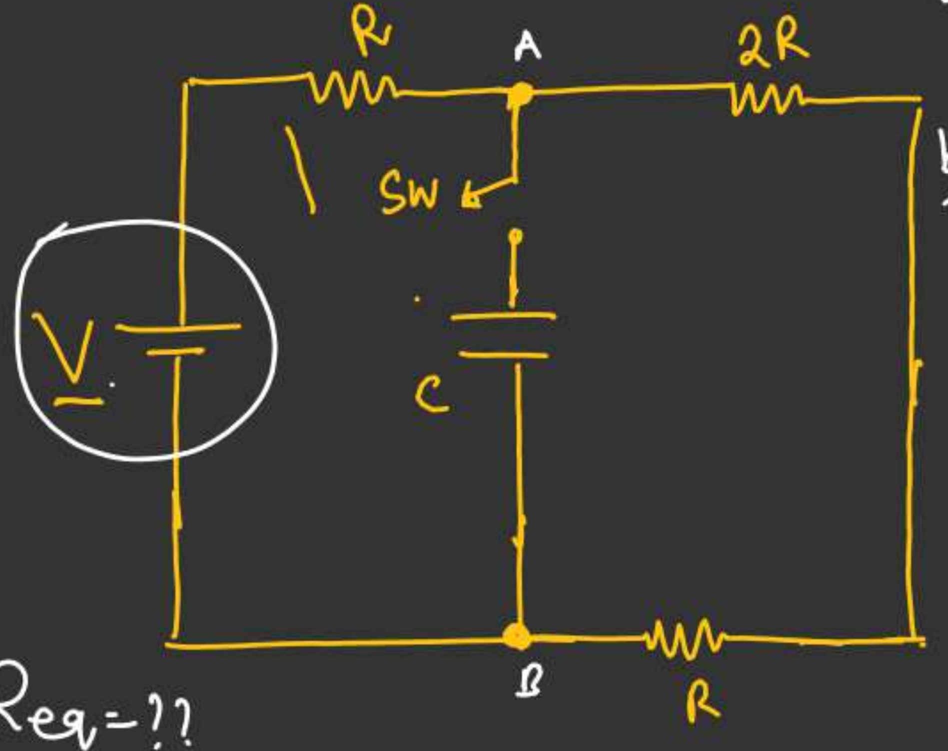
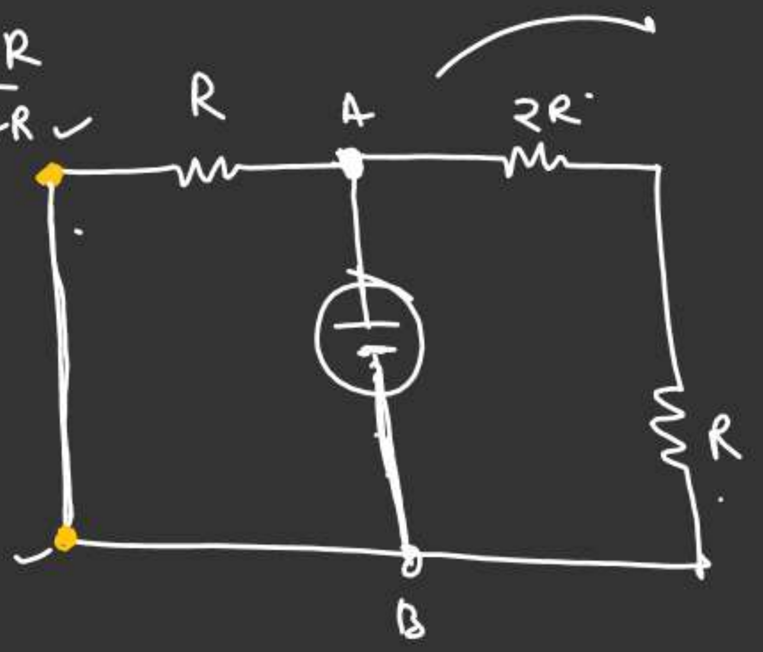
Find τ = ??

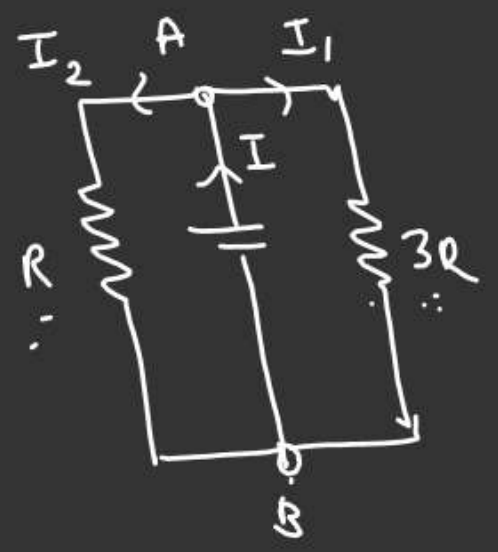


R_{eq} = ??

$(R_{eq})_{AB} = \frac{3R\cdot R}{3R+R}$

$(R_{eq})_{AB} = \left(\frac{3R}{4}\right)$





a) $\boxed{\tau = \frac{3RC}{4}}$

b) If capacitor is uncharged initially. Switch is closed at $t=0$. Find 'q' i.e charge on capacitor as a function of time.

In general

$$\boxed{q = q_0\left(1 - e^{-t/\tau}\right)}$$

q_0 = maximum charge on the capacitor. (i.e at the time of steady state)

$$\boxed{q_0 = CV}$$

→ Potential difference across the capacitor at the time of steady state

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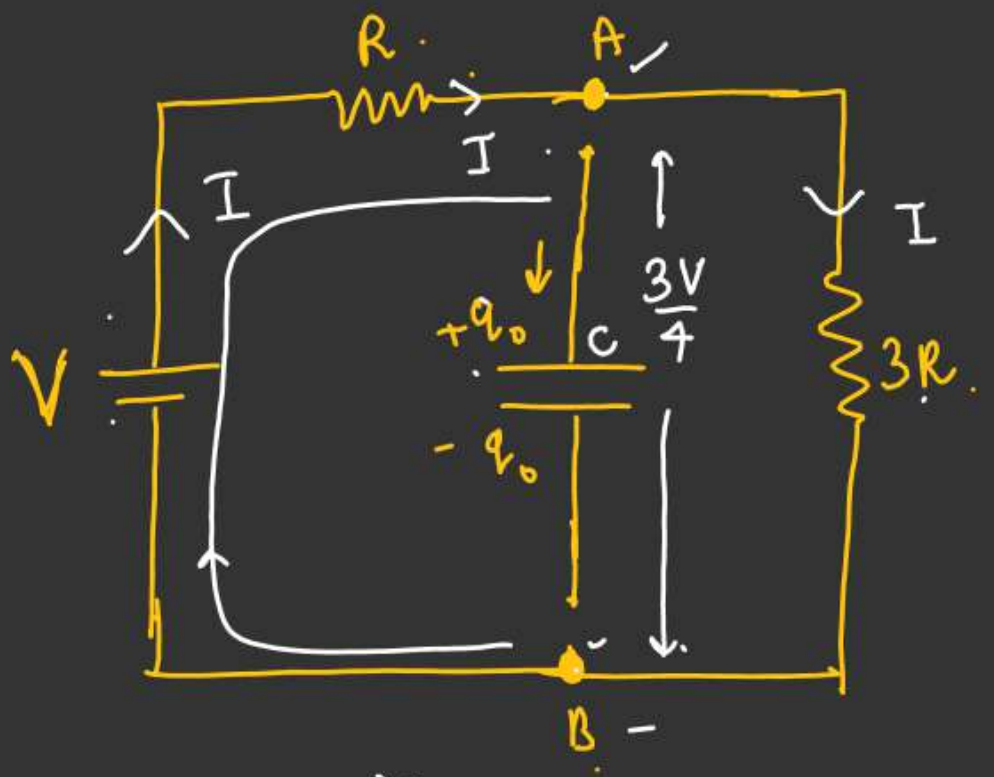
q_{max} (At the time of steady state)

#



$$q_0 = \left(\frac{3CV}{4}\right)$$

$q \to f(t)$

$$q = q_0\left(1 - e^{-t/\tau}\right)$$

$$\boxed{q = \frac{3CV}{4}\left(1 - e^{-\frac{4t}{3RC}}\right)}$$

$$I = \left(\frac{V}{4R}\right)$$

$$V_B + V - IR = V_A$$

$$V_A - V_B = V - IR$$

$$= V - \frac{V}{4R} \times R$$

$$= V - \frac{V}{4} = \left(3V/4\right)$$

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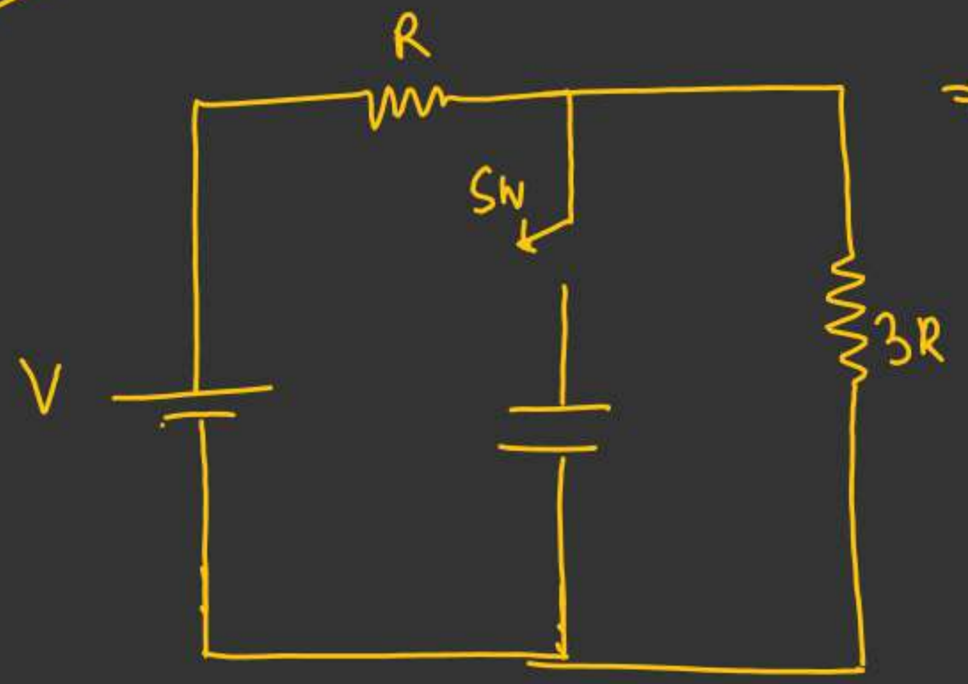
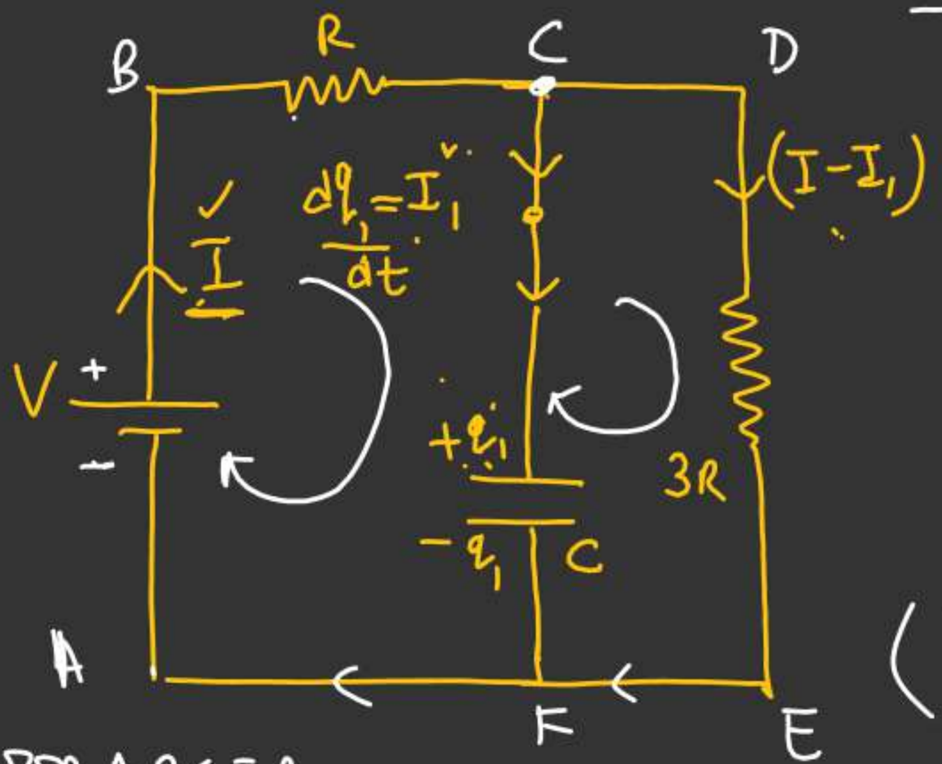
Normal Method.

At $t=0$, Switch is Closed.



$\Rightarrow$

At $t=t$.



K.V.L in the Closed loop ABCFA

$$V - IR - \frac{q_1}{c} = 0 \quad (1)$$

KVL in the loop. BDEAB

$$V - IR - (I-I_1)3R$$

$$V - IR - 3IR + 3I_1R$$

$$V + 3I_1R = 4IR$$

$$IR = \left(\frac{V+3I_1R}{4}\right) \quad (2)$$

$$I = \frac{V}{4R} + 3I_1$$

From (1) & (2)

$$V - \left(\frac{V+3I_1R}{4}\right) - \frac{q_1}{c} = 0$$

$$\left(V - \frac{V}{4}\right) - \frac{3R}{4}I_1 - \frac{q_1}{c} = 0$$

$$\frac{3V}{4} - \frac{3R}{4}\left(\frac{dq_1}{dt}\right) - \frac{q_1}{c} = 0$$

$$\left(\frac{3V}{4} - \frac{q_1}{c}\right) = \frac{3R}{4}\left(\frac{dq_1}{dt}\right)$$

$$\frac{3V - 4q_1}{4C} = \frac{3R}{4}\left(\frac{dq_1}{dt}\right)$$

$$(3CV - 4q_1) = 3RC\left(\frac{dq_1}{dt}\right)$$

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$$\int \frac{dx}{a+bx} = \frac{\ln(a+bx)}{b}$$

$$(3CV-4q_1) = 3RC\frac{dq_1}{dt}$$

$$\int_0^{q_1} \frac{dq_1}{\underbrace{3CV}_{a}\underbrace{-4q_1}_{b=-4}} = \frac{1}{3RC}\int_0^t dt$$

$$\frac{\ln[3CV-4q_1]_0^{q_1}}{(-4)} = \frac{1}{3RC}t$$

$$\ln\left[\frac{3CV-4q_1}{3CV}\right] = \frac{-4}{3RC}t$$

$$3CV-4q_1 = 3CVe^{\frac{-4t}{3RC}}$$

$$4q_1 = 3CV\left(1-e^{-\frac{4t}{3RC}}\right)$$

$$q_1 = \left(\frac{3CV}{4}\right)\left(1-e^{-\frac{4t}{3RC}}\right)$$

$$q_1 = \frac{3CV}{4}\left(1-e^{-\frac{t}{(3RC/4)}}\right)$$

$$\boxed{q = q_0(1-e^{-t/\tau})}$$

$$\left(q_0 = \frac{3CV}{4}\right)\left(\tau = \frac{3RC}{4}\right)$$

$$I_1 = \frac{dq_1}{dt}$$

$$q_1 = \frac{3CV}{4} - \frac{3CV}{4}e^{\frac{-4t}{3RC}}$$

$$\frac{dq_1}{dt} = -\frac{\cancel{3C}V}{\cancel{4}}e^{\left(-\frac{4t}{3RC}\right)}\left(\frac{-4}{3RC}\right)$$

$$\boxed{I_1 = \frac{V}{R}e^{\frac{-4t}{3RC}}}$$ *

$I_1 \to f(t)$ in Capacitor

$I \to f(t)$

$$I = \frac{V}{4R} + 3I_1$$

$$\boxed{I = \frac{V}{4R} + \frac{3V}{R}e^{\frac{-4t}{3RC}}}$$ *

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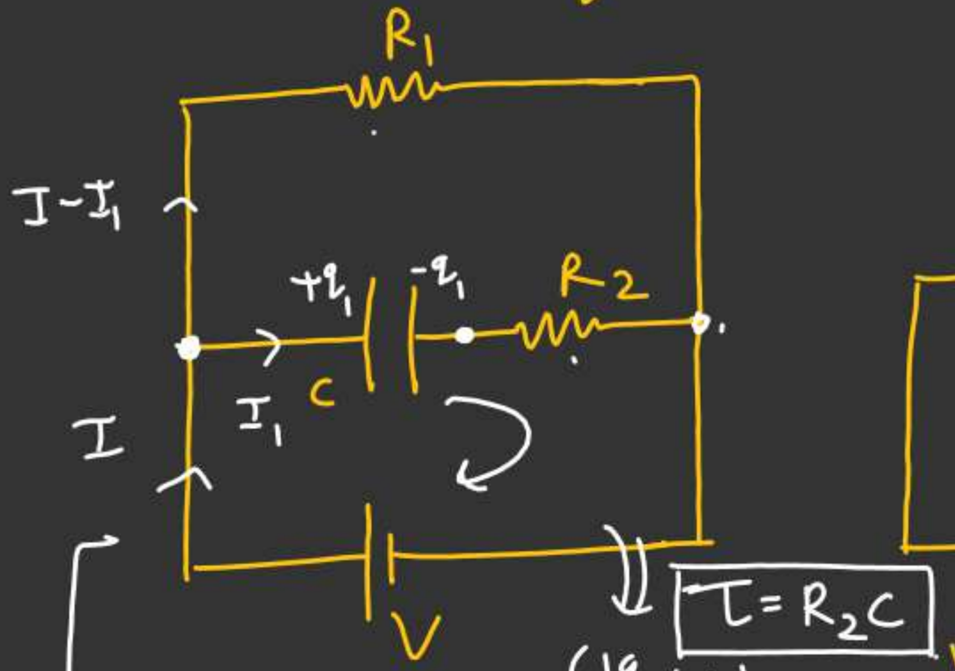
** . Find $\tau = ?$

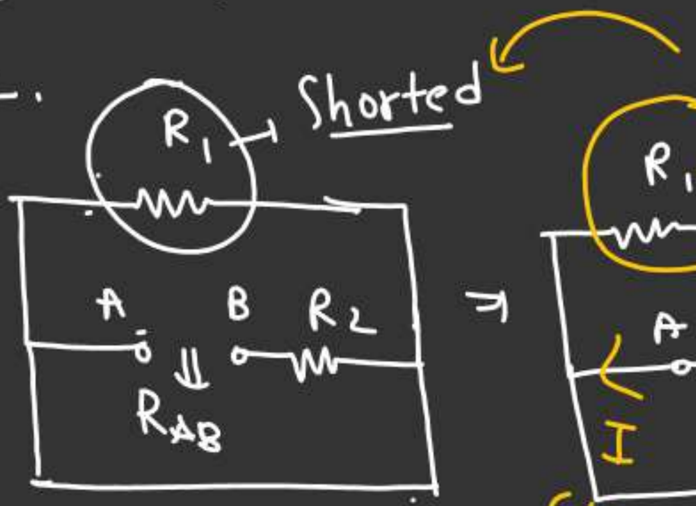
a)



$\boxed{\tau = R_2 C}$

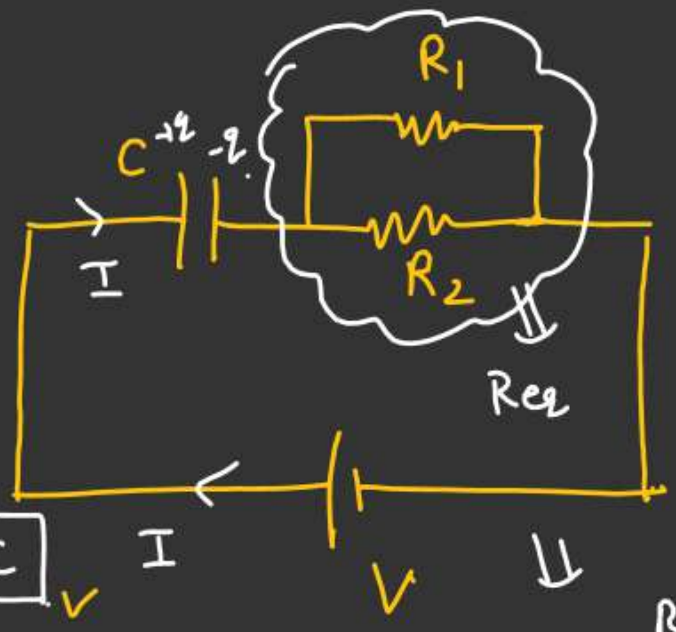
$$V - \frac{q_1}{c} - I_1 R_2 = 0 \quad (dq_1/dt)$$

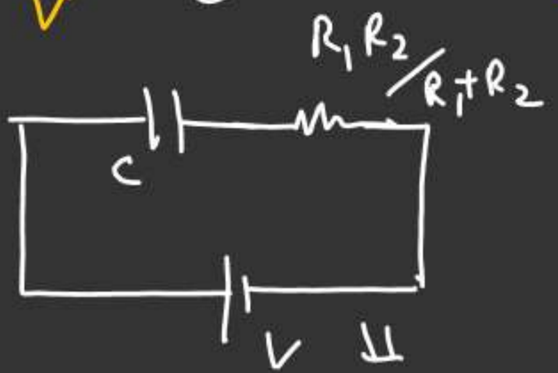
Trick



$(R_{eq})_{AB} = R_2$

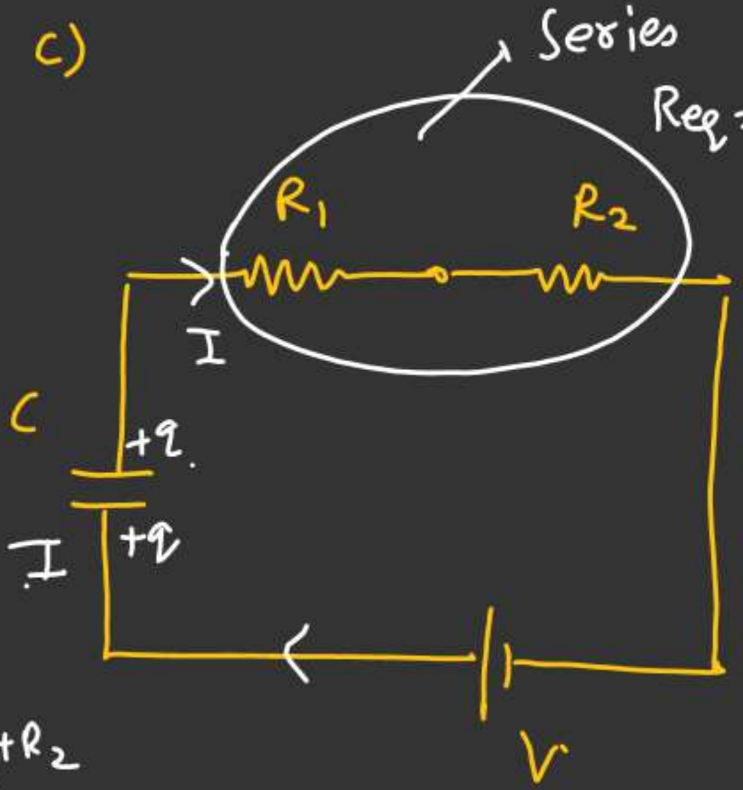
b)





$$\tau = \frac{R_1 R_2 C}{R_1 + R_2}$$

c)



$R_{eq} = (R_1 + R_2)$

$\tau = (R_1 + R_2) C$

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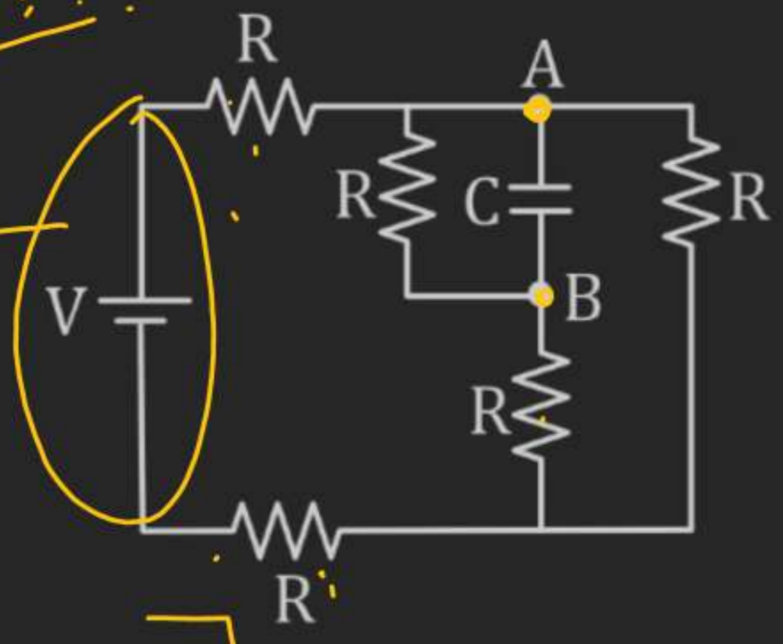
RC ckt

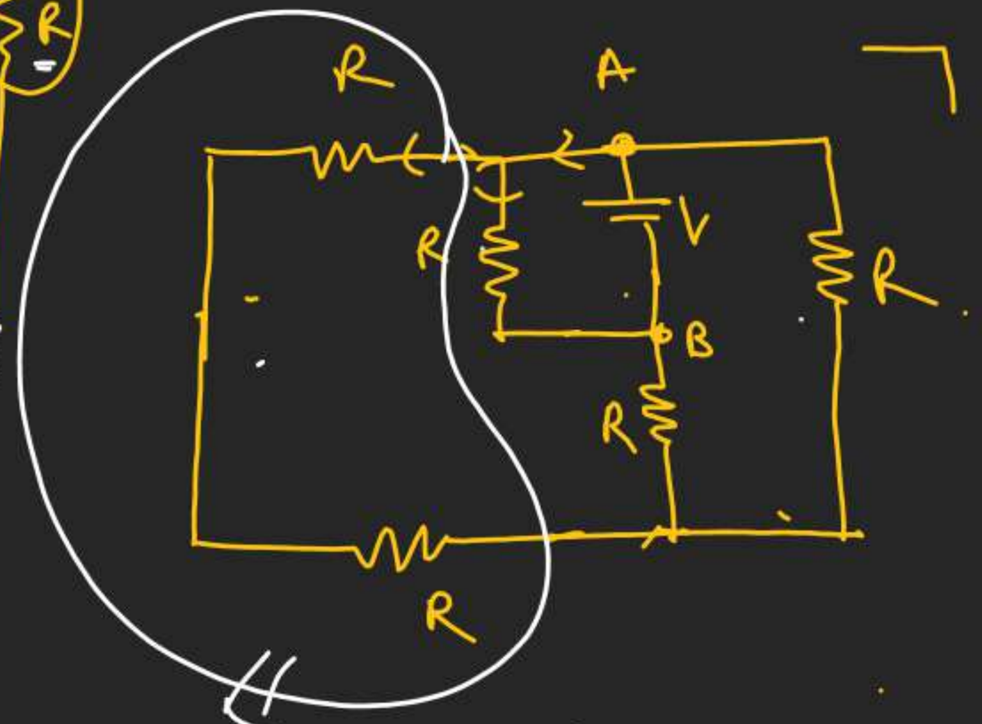
CURRENT ELECTRICITY

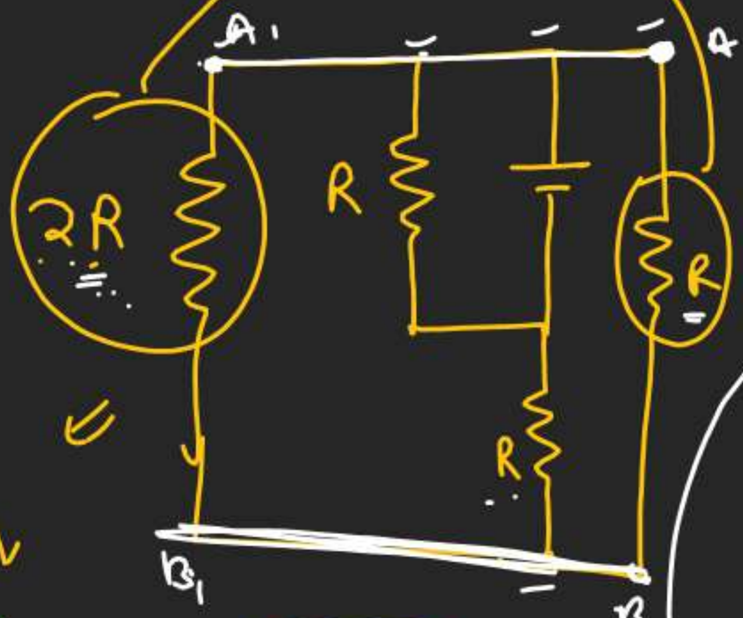
Q.1 Calculate the constant of a circuit as shown in Fig.

$\tau = ??$

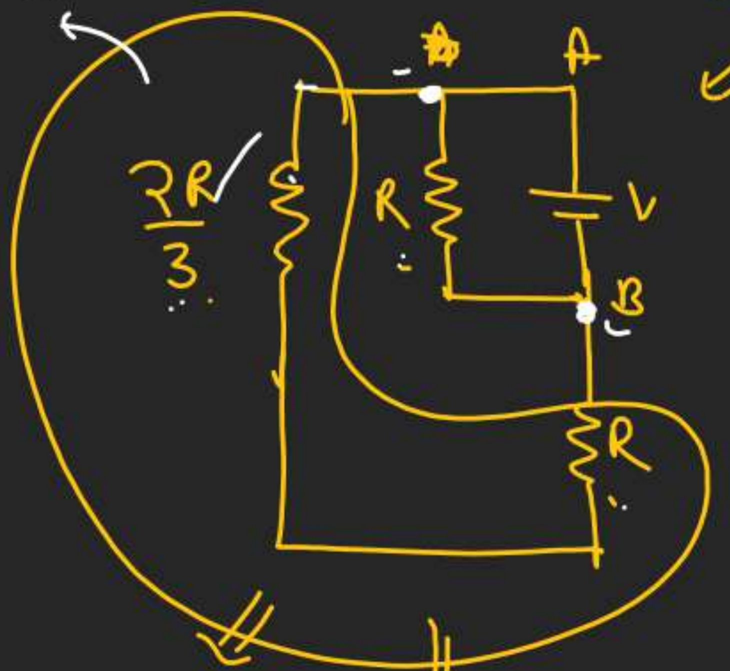


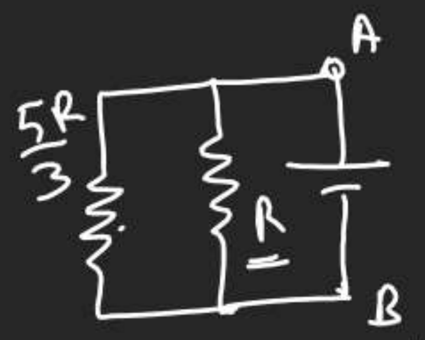
Replace by zero resistance wire





$R_{eq} = \frac{2R}{3}$





$$(R_{eq})_{AB} = \frac{\frac{5R}{3} \cdot R}{\frac{5R}{3} + R} = \left(\frac{5R}{8}\right)$$

$$\tau = \frac{5RC}{8}$$

Nishant Jindal

RC ckt

CURRENT ELECTRICITY

CURRENT ELECTRICITY

Q.2 In the given circuit, with steady current, the potential drop across the capacitor must be **(2001)**

$2V - I2R + V_C - V = 0$

(A) V

(B) $V/2$

(C) $V/3$

(D) $2\,V/3$.

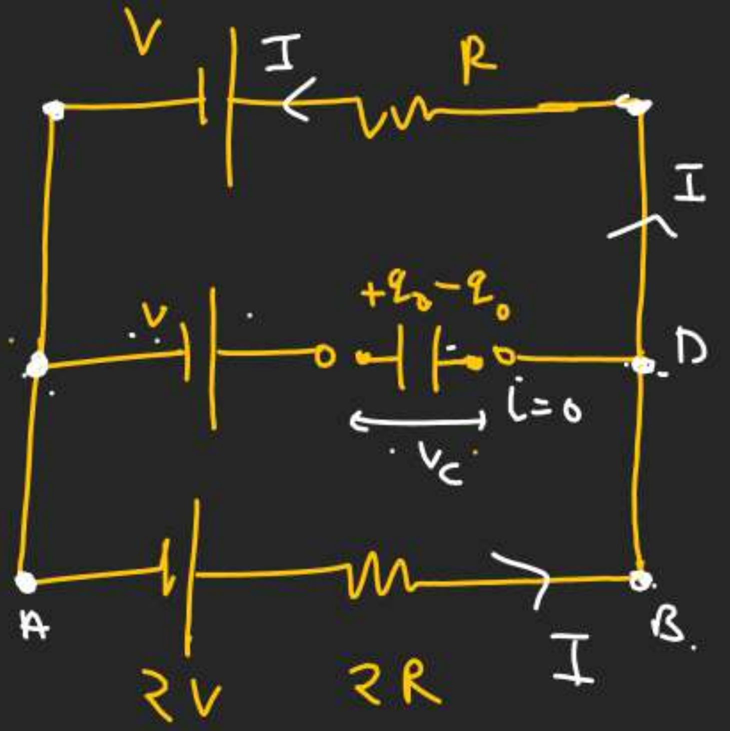
$V_c + V + V_c = V_D$

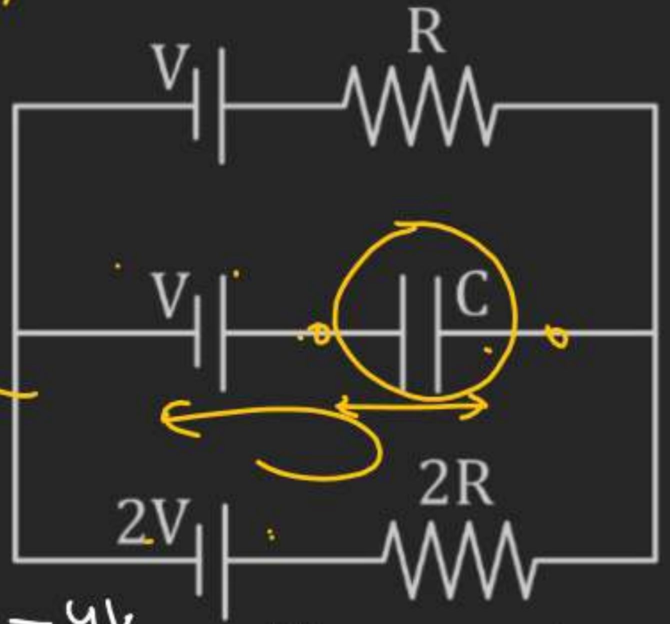
$V + V_c = (V_D - V_c)$

$V_c = [V_D - V_c] - V$

Steady state

At the time of state





$2V - i2R - iR - V = 0$

$V = 3IR$

$I = \left(\frac{V}{3R}\right)$

$V_A + 2V - I2R = V_B$

$V_A - V_B = 2IR - 2V = \left(2R \times \frac{V}{3R} - 2V\right) = \frac{2V - 6V}{3} = -\frac{4V}{3}$

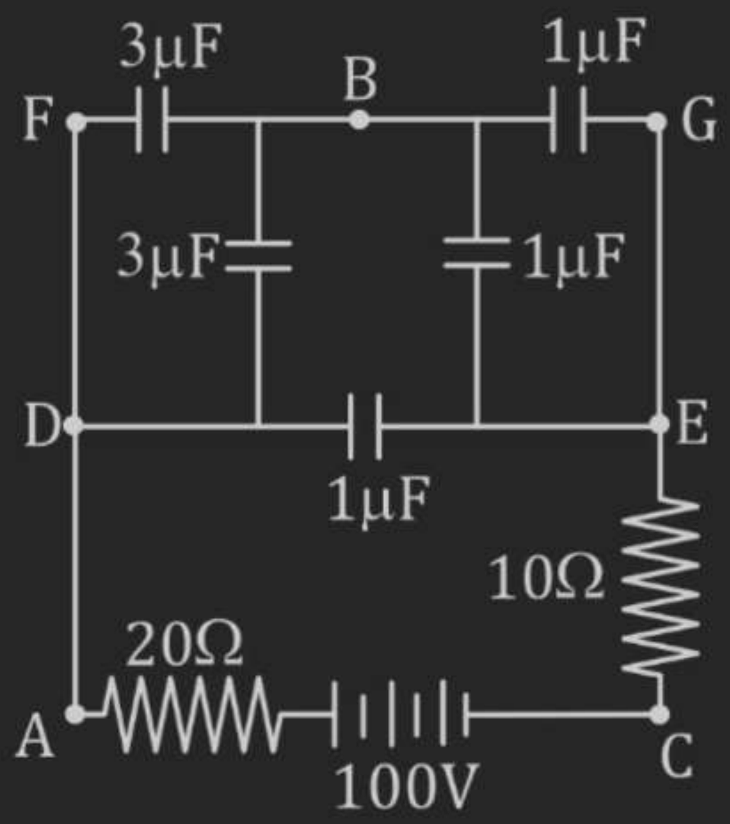
$V_C - V_D = -\frac{4V}{3} \Rightarrow V_D - V_C = 4V/3$

$V_C = 4V/3 - V = V/3$

Nishant Jindal

RC ckt H.W.

Q.3 Find the potential difference between the points A and B and between the points B and C in the steady state. (1979)



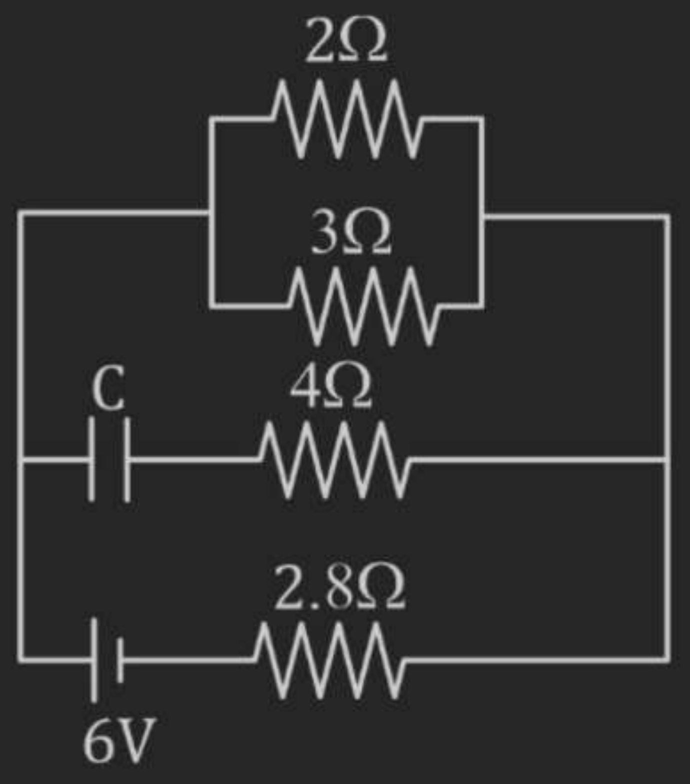
Nishant Jindal

RC ckt

H-W

CURRENT ELECTRICITY

Q.4 Calculate the steady state current in the $2 \mathrm{ohm}$ resistor shown in the circuit in the figure. The internal resistance of the battery is negligible and the capacitance of the condenser C is 0.2 microfarad. **(1982)**

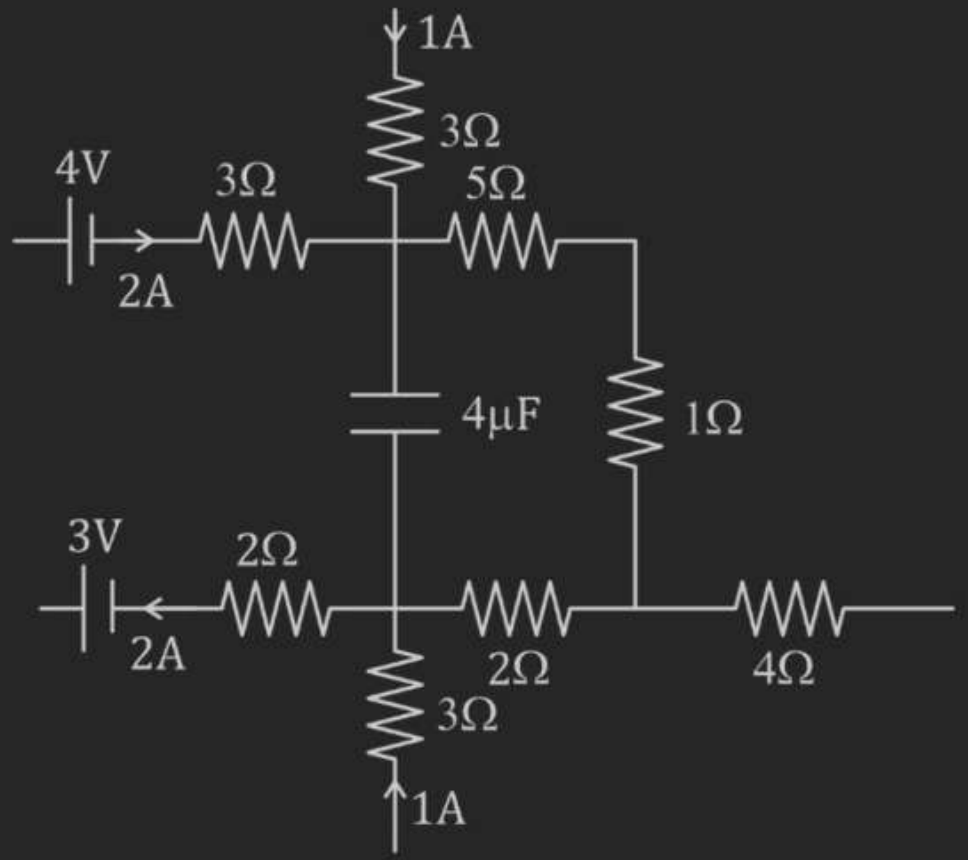


CURRENT ELECTRICITY

H.W

Q.5 A part of circuit in a steady state along with the currents flowing in the branches, the values of resistances etc., is shown in the figure.

Calculate the energy stored in the capacitor $C(4\mu F)$ **(1986)**



RC ckt

H-W

CURRENT ELECTRICITY

Q.6 In the given circuit (1988)

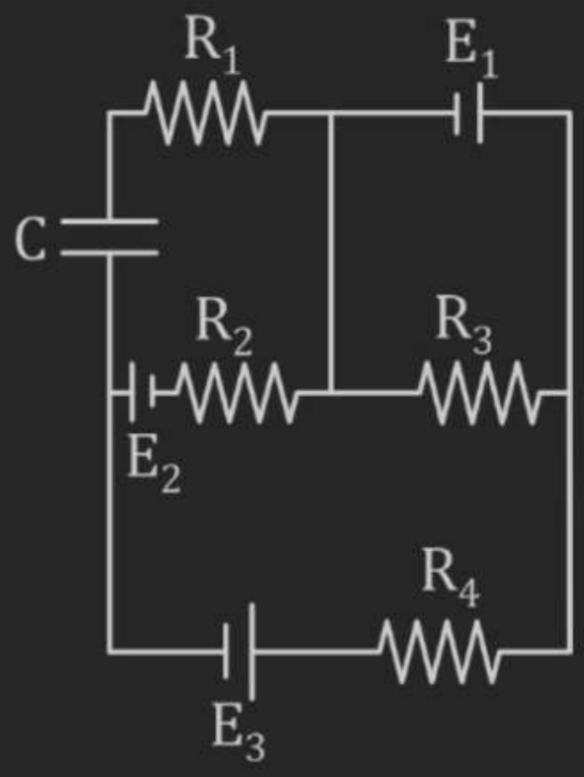
$E_1 = 3E_2 = 2E_3 = 6$ volt

$R_1 = 2R_4 = 6 \text{ ohm}$

$R_3 = 2R_2 = 4 \text{ ohm}$

$C = 5 \mu F.$

Find the current in R_3 and the energy stored in the capacitor.



Nishant Jindal

RC ckt

H-W

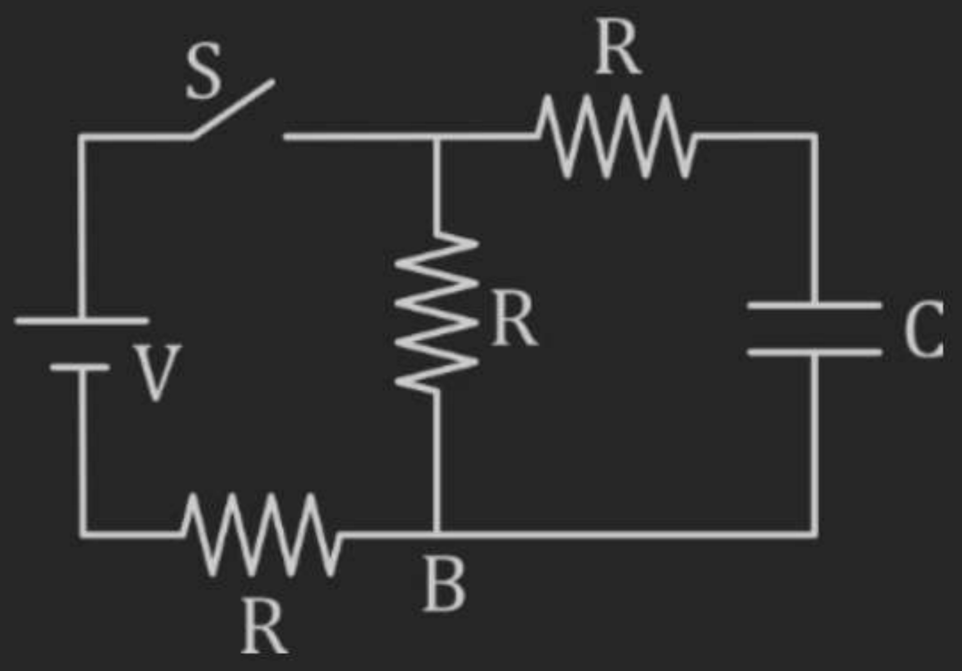
CURRENT ELECTRICITY

Q.7 In the circuit shown in figure, the battery is an ideal one, with emf V. The capacitor is initially uncharged. (1988)

The switch S is closed at time $t = 0$.

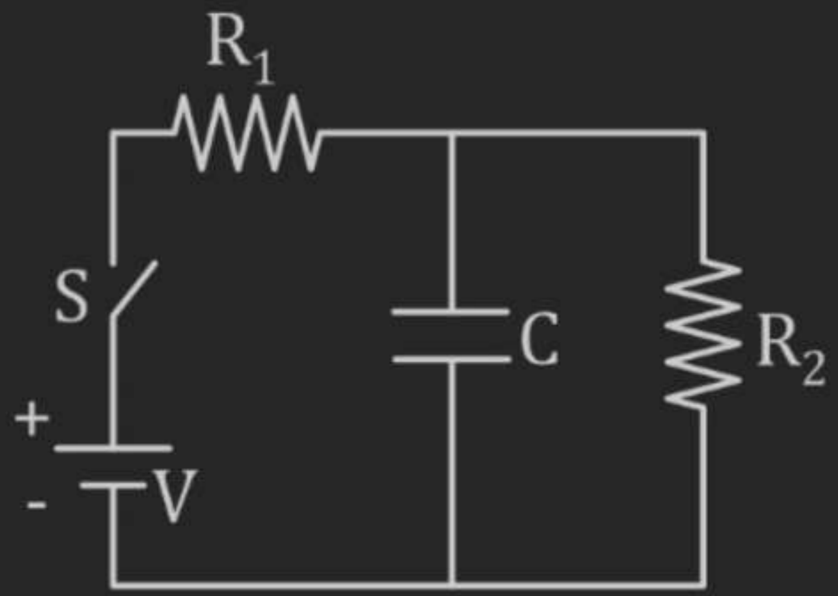
(a) Find the charge Q on the capacitor at time t.

(b) Find the current in AB at time t. What is its limiting value at $t \to \infty$.



H.W

Q.8 In the given circuit, the switch S is closed at time $t = 0$. The charge Q on the capacitor at any instant t is given by $Q(t) = Q_0(1 - e^{-\alpha t})$. Find the value of Q_0 and α in terms of given parameters as shown in the circuit. (2005)



Nishant Jindal

RC ckt

H.W

CURRENT ELECTRICITY

Q.9 In the circuit shown below, the switch S is connected to position P for a long time so that the charge on the capacitor becomes q_1 μC. Then S is switched to position Q. After a long time, the charge on the capacitor is q_2 μC. (2021)

(a) The magnitude of q_1 is _____.

(b) The magnitude of q_2 is ____.