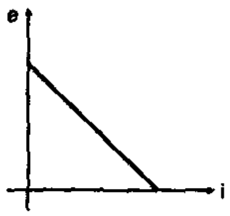
DPP – 4 (EMI)

Video Solution on Website :- https://physicsaholics.com/home/courseDetails/104

Video Solution on YouTube:- https://youtu.be/xAhvcTRPmxg

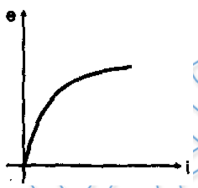
Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/65

Q 1. In an L-R circuit connected to a battery of constant emf E switch s is closed at time t = 0. If e denotes the induced emf across inductor and i the current in the circuit at any time t. Then which of the following graphs shows the variation of e with i?

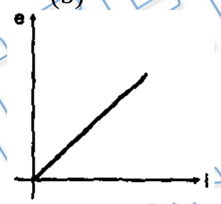


(a)

(b)

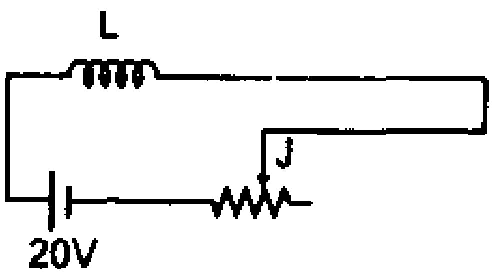


(c)



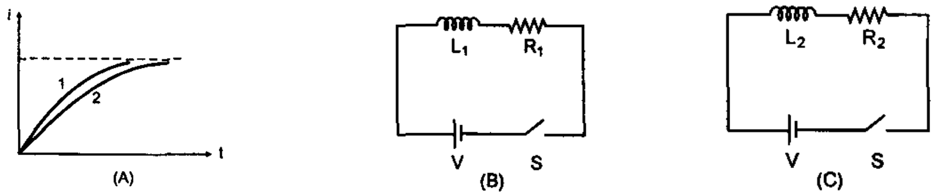
(d)

Q 2. In the circuit shown in figure the jockey J is being pulled towards right so that the resistance in the circuit is increasing. Its value at some instant is 5 Ω. The current in the circuit at this instant will be:



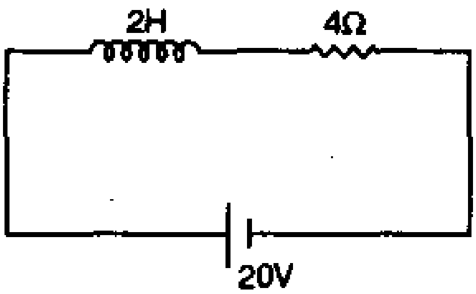
(a) 4 A
(b) less than 4 A
(c) more than 4 A
(d) may be less than or more than 4 A depending on the value of L

Q 3. Current growth in two L-R circuits (B) and (C) is as shown in figure (A). Let L_1, L_2, R_1 and R_2 be the corresponding values in two circuits. Then:



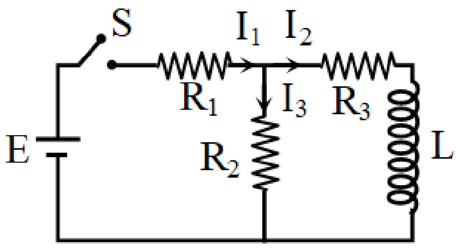
(a) $R_1 > R_2$ (b) $R_1 = R_2$ (c) $L_1 > L_2$ (d) $L_1 < L_2$

Q 4. In the L-R circuit shown in figure, potential difference across the resistance at some instant is 4 V. Then:



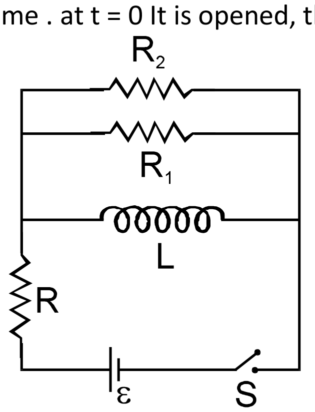
(a) current is increasing at a rate of 8 A/s at this instant
(b) power supplied by the battery at this instant is 20 W
(c) power stored in the magnetic field at this instant is 16 W
(d) current in the circuit at this instant is 1 A

Q 5. In the figure circuit, if E = 10V, R_1 = 2 ohm, R_2 = 3 ohm, R_3 = 6 ohm and L = 5 henry. The current I_1 just after pressing the switch S is



(a) (10/4) ampere
(b) (10/5) ampere
(c) (10/12) ampere
(d) (10/6) ampere

Q 6. Switch S is closed for a long time . at t = 0 It is opened, then:



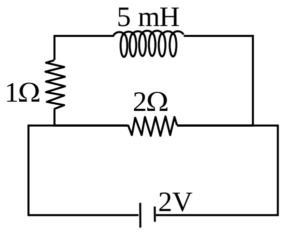
(a) total heat produced in resistor R after opening the switch is $\frac{1}{2}\frac{L\varepsilon^2}{R^2}$

(b) total heat produced in resistor R_2 after opening the switch is $\frac{1}{2}\frac{L\varepsilon^2}{R^2}\left(\frac{R_1}{R_1+R_2}\right)$

(c) heat produced in resistor R_1 after opening the switch is $\frac{1}{2}\frac{R_2 L\varepsilon^2}{(R_1+R_2)R^2}$

(d) Current through R_1 just after opening the switch is $\frac{\varepsilon}{R}\cdot\left(\frac{R_1}{R_1+R_2}\right)$

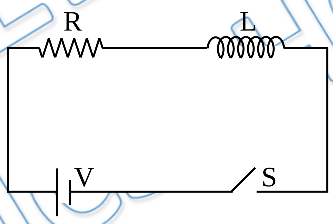
Q 7. When induced emf in inductor coil is 50% of its maximum value then stored energy in inductor coil in the given circuit will be-



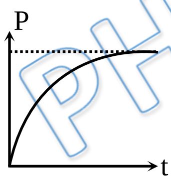
(a) 2.5 mJ (b) 5 mJ
(c) 15 mJ (d) 20 mJ

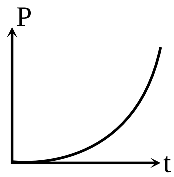
Passage (Q.8 to Q.10)

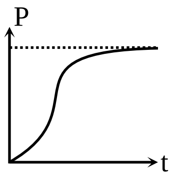
A resistor and inductor are connected in series through a battery. The switch S is closed at time t = 0.

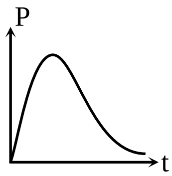


Q 8. The rate of Joule heating (P) in resistor varies with the time 't' is best represented by the graph.

(A)


(B)


(C)


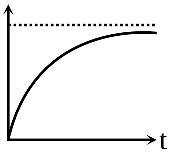
(D)


Q 9. What is the magnitude of current flowing when the rate of increase of magnetic energy in the inductor is maximum –

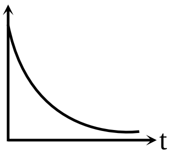
(a) I = V/R (b) I = V/2R
(c) I = V/4R (d) I = (V/R) ln2

Q 10. Which of the following graph best represent rate of change of power dissipated in resistor as a function of time -

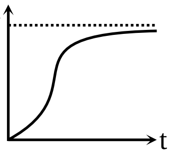
dP/dt

(A) 

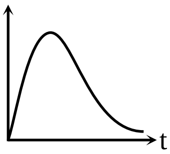
dP/dt

(B) 

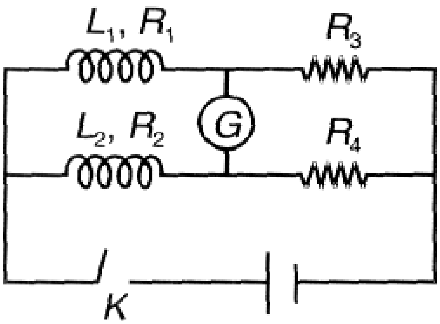
dP/dt

(C) 

dP/dt

(D) 

Q 11. After the key k is closed, galvanometer in the shown arrangement shows zero deflection at all the times if (R_1, and R_2 are resistances of inductors L_1 and L_2)



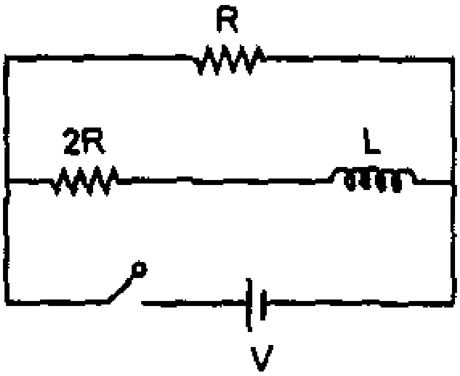
(a) $\frac{R_1}{R_2} = \frac{R_3}{R_4} = \frac{L_1}{L_2}$

(b) $\frac{R_2}{R_1} = \frac{R_3}{R_4} = \frac{L_1}{L_2}$

(c) $\frac{L_1}{L_2} = \frac{R_1}{R_2}$

(d) $\frac{L_1}{L_2} = \frac{R_3}{R_4}$

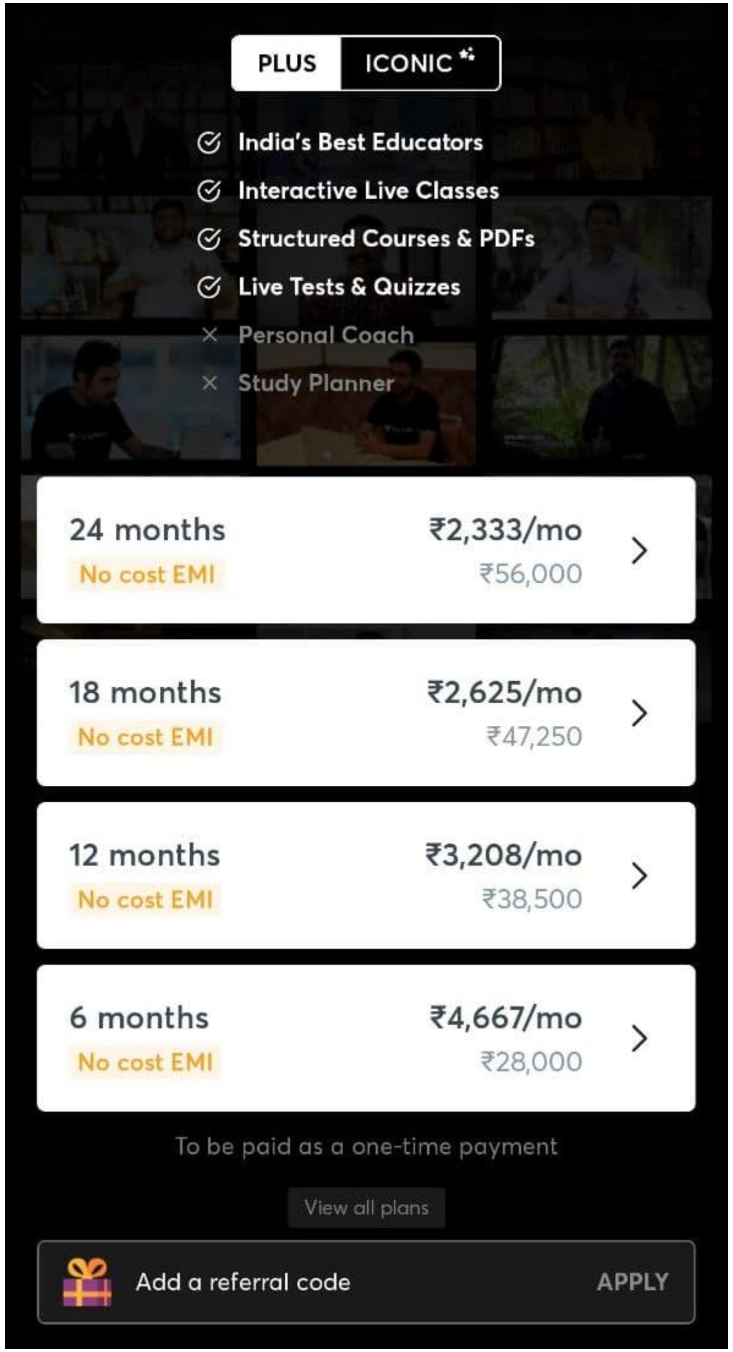
Q 12. The ratio of time constants during current growth and current decay of the circuit shown in figure is:



(a) 1 : 1 (b) 3 : 2 (c) 2 : 3 (d) 1 : 3

Answer Key

Q.1 a	Q.2 c	Q.3 b, d	Q.4 a, b, c, d	Q.5 b
Q.6 b, c	Q.7 a	Q.8 c	Q.9 b	Q.10 d
Q.11 a	Q.12 b			



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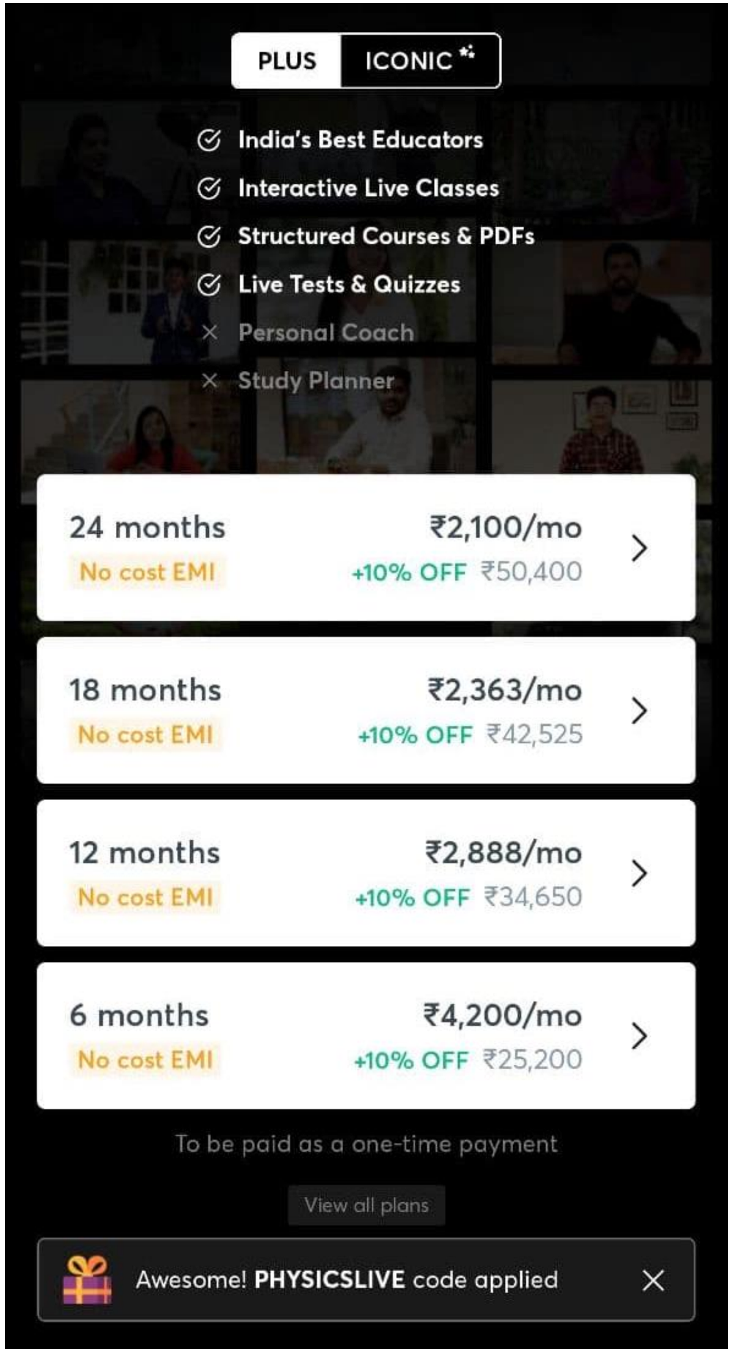
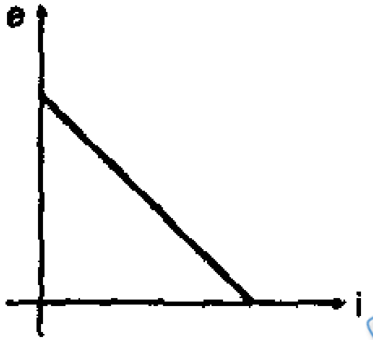


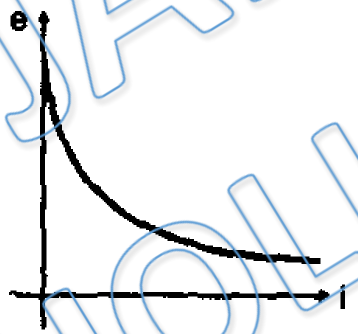
Written Solution

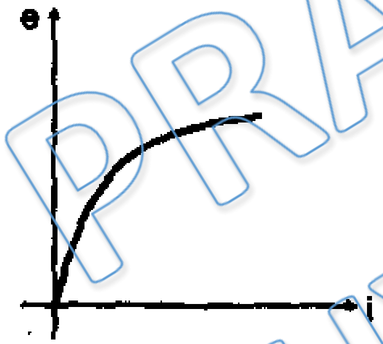
DPP- 4 EMI- Self inductance, RL Circuit, Energy stored in Inductor

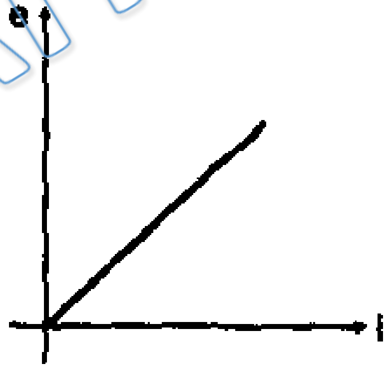
By Physicsaholics Team

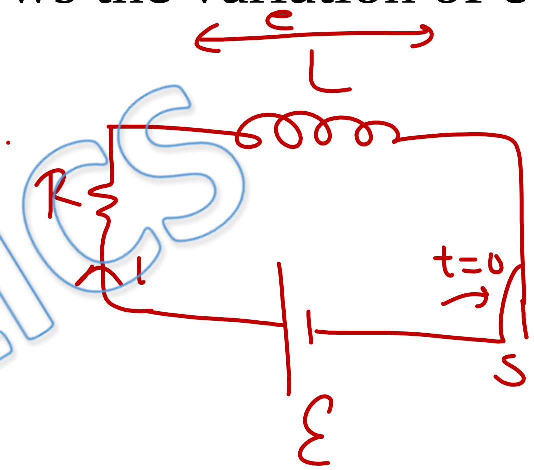
Q.1) In an L-R circuit connected to a battery of constant emf E switch s is closed at time t = 0. If e denotes the induced emf across inductor and i the current in the circuit at any time t. Then which of the following graphs shows the variation of e with i?

(a) 

(b) 

(c) 

(d) 



$\mathcal{E} - iR - e = 0$

$e = \mathcal{E} - iR$

Constant

St line graph

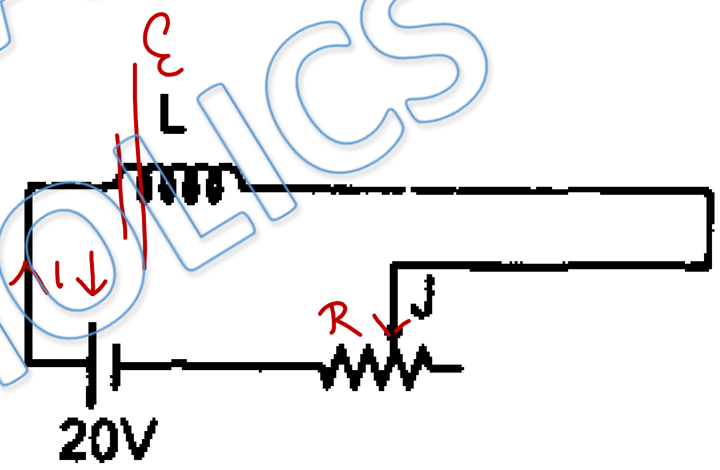
Q.2) In the circuit shown in figure the jockey J is being pulled towards right so that the resistance in the circuit is increasing. Its value at some instant is 5 Ω. The current in the circuit at this instant will be:

$i = \frac{20+\varepsilon}{R}$

at $R = 5$

$i = \frac{20+\varepsilon}{5} = 4 + \frac{\varepsilon}{5}$

$i > 4A$



R↑

(a) 4 A

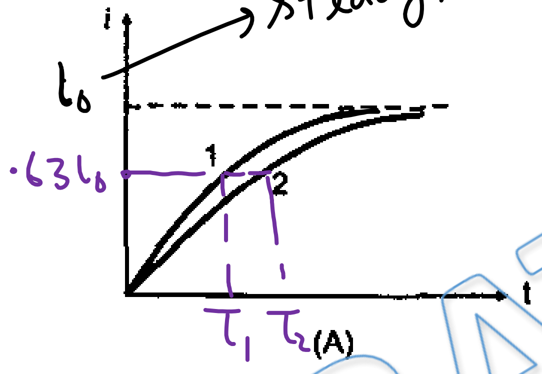
(b) less than 4 A

(c) more than 4 A ✓

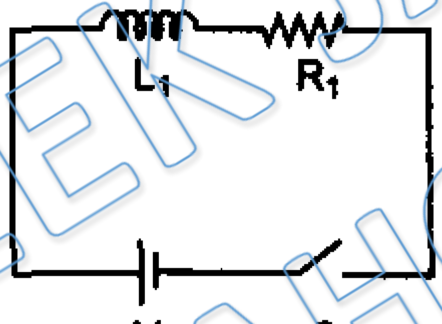
(d) may be less than or more than 4 A depending on the value of L

Q.3) Current growth in two L-R circuits (B) and (C) is as shown in figure (A). Let L_1, L_2, R_1 and R_2 be the corresponding values in two circuits. Then:

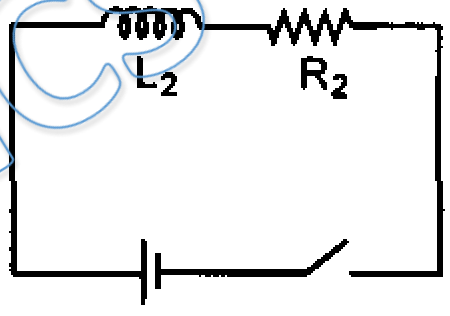
steady state Current $= \frac{V}{R}$ = equal for both $\Rightarrow R_1 = R_2$



(A)



(B)

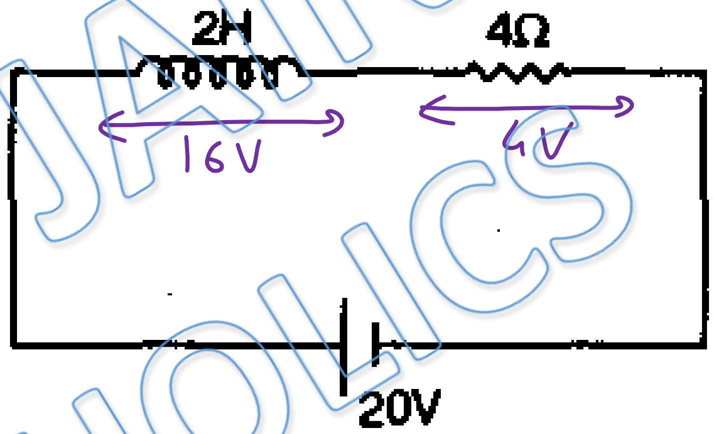


(C)

$\tau_2 > \tau_1 \Rightarrow \frac{L_2}{R_2} > \frac{L_1}{R_1} \Rightarrow L_2 > L_1$

(a) $R_1 > R_2$ (b) $R_1 = R_2$ (c) $L_1 > L_2$ (d) $L_1 < L_2$

Q.4) In the L-R circuit shown in figure, potential difference across the resistance at some instant is 4 V. Then:



$L\frac{di}{dt} = 16 \Rightarrow \frac{di}{dt} = \frac{16}{2} = 8 A/Se$

$V = iR \Rightarrow 4 = i \times 4 \Rightarrow i = 1A$

$P_{batt} = \varepsilon i = 20 \times 1 = 20W$

(a) current is increasing at a rate of 8 A/s at this instant

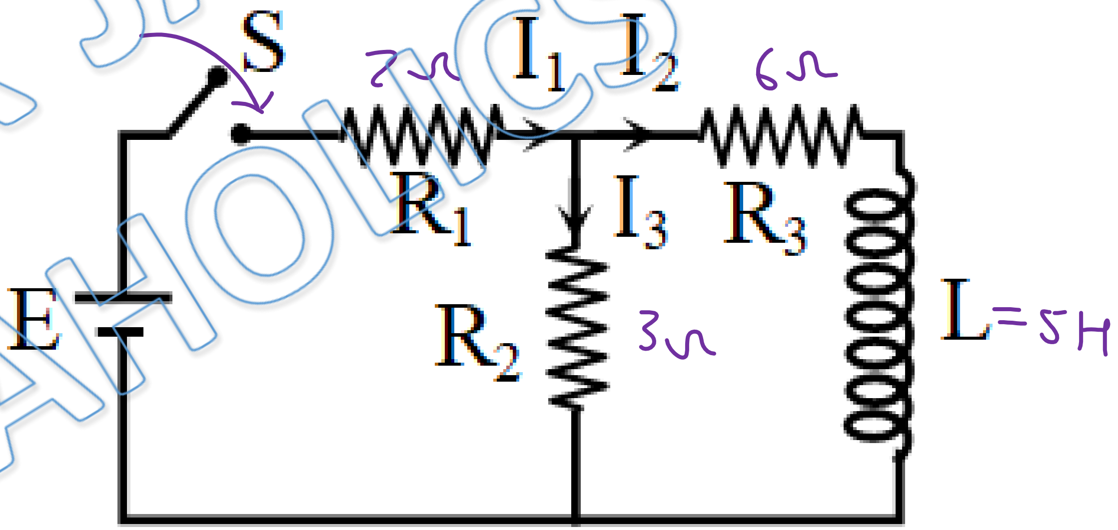
(b) power supplied by the battery at this instant is 20 W

(c) power stored in the magnetic field at this instant is 16 W

(d) current in the circuit at this instant is 1 A

$P_{Inductor} = Vi = 16 \times 1 = 16W$

Q.5) In the figure circuit, if E = 10V, R_1 = 2 ohm, R_2 = 3 ohm, R_3 = 6 ohm and L = 5 henry. The current I_1 just after pressing the switch S is



(a) (10/4) ampere

(b) (10/5) ampere

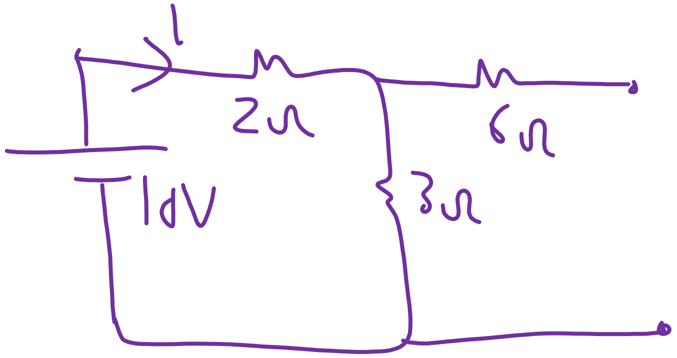
(c) (10/12) ampere

(d) (10/6) ampere

At t=0

$I = \frac{10}{2+3}$

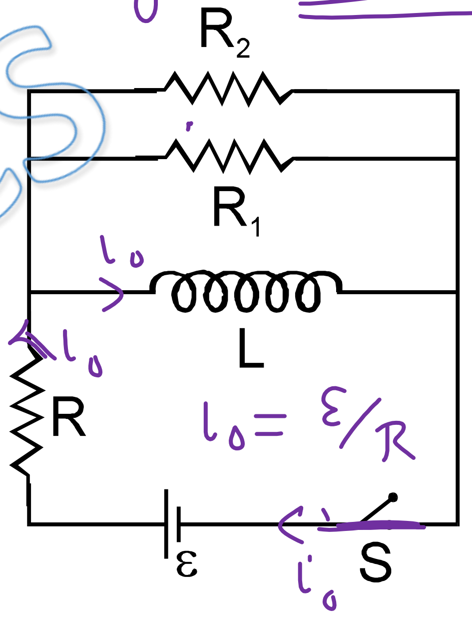
$= \frac{10}{5}$ A



$P = \frac{V^2}{R}$

Q.6) Switch S is closed for a long time. at t = 0 It is opened, then:

just before t=0



(a) total heat produced in resistor R after opening the switch is $\frac{1}{2}\frac{L\varepsilon^2}{R^2}$

just after t=0 → R is out of circuit, no Heat will be generated in R

(b) total heat produced in resistor R_2 after opening the switch is $\frac{1}{2}\frac{L\varepsilon^2}{R^2}\left(\frac{R_1}{R_1+R_2}\right)$

$\frac{\Delta H_1}{\Delta H_2} = \frac{R_2}{R_1}$, $\Delta H_1 + \Delta H_2 = \frac{L\varepsilon^2}{2R^2}$

$i_0 = \varepsilon/R$

(c) heat produced in resistor R_1 after opening the switch is $\frac{1}{2}\frac{R_2 L\varepsilon^2}{(R_1+R_2)R^2}$

$\Delta H_1 = \frac{R_2}{R_1+R_2}\left(\frac{L\varepsilon^2}{2R^2}\right)$

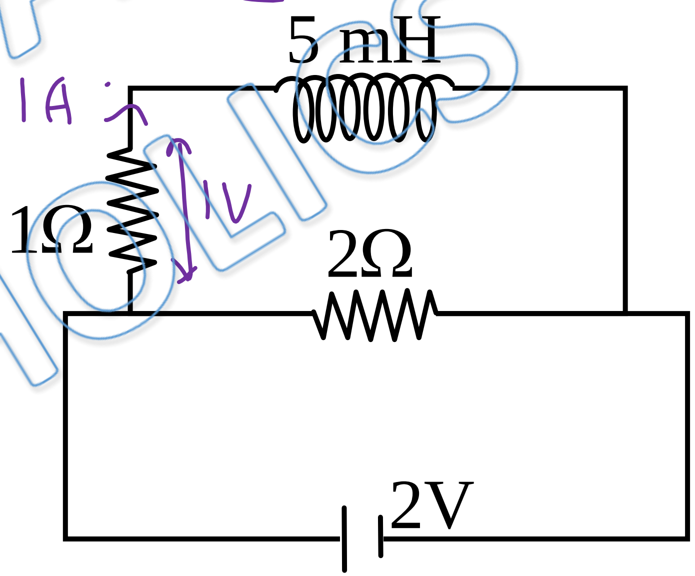
energy of inductor $= \frac{1}{2}L\varepsilon^2/R^2$

(d) Current through R_1 just after opening the switch is $\frac{\varepsilon}{R}\cdot\left(\frac{R_1}{R_1+R_2}\right)$

$\Delta H_2 = \frac{R_1}{R_1+R_2}\left(\frac{L\varepsilon^2}{2R^2}\right)$

$i_1 = \frac{R_2}{R_1+R_2} i_0 = \frac{R_2}{R_1+R_2} \times \varepsilon/R$

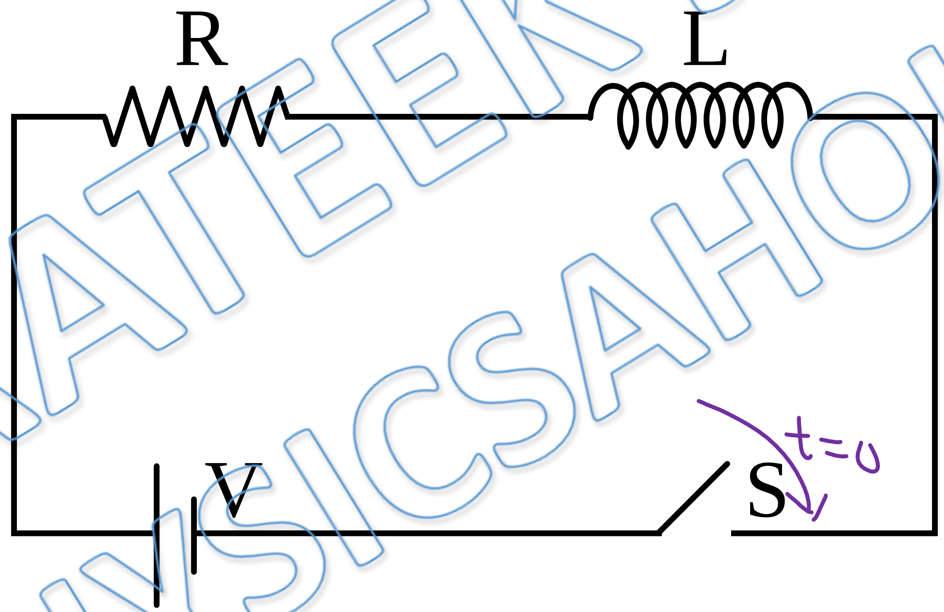
Q.7) When induced emf in inductor coil is 50% of its maximum value then stored energy in inductor coil in the given circuit will be-



(a) 2.5 mJ
(b) 5 mJ
(c) 15 mJ
(d) 20 mJ

Passage II (Question 8 to 10)

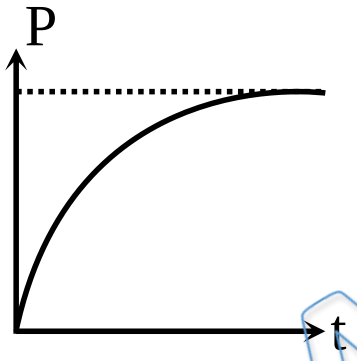
A resistor and inductor are connected in series through a battery. The switch S is closed at time t = 0.



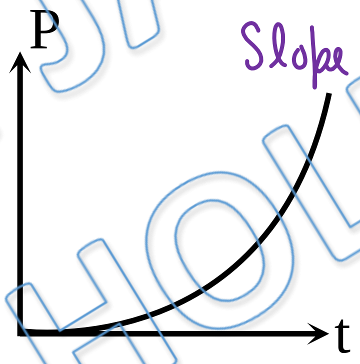
Q.8) The rate of Joule heating (P) in resistor varies with the time 't' is best represented by the graph:

$P = i^2 R = \left[\frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau}\right)\right]^2 R = \frac{\mathcal{E}^2}{R}\left(1 - e^{-Rt/L}\right)^2$

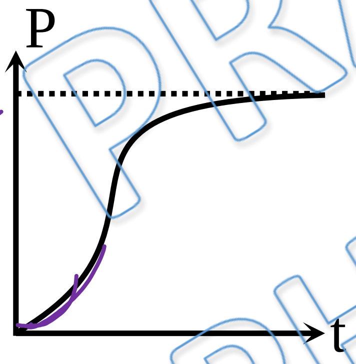
(A)



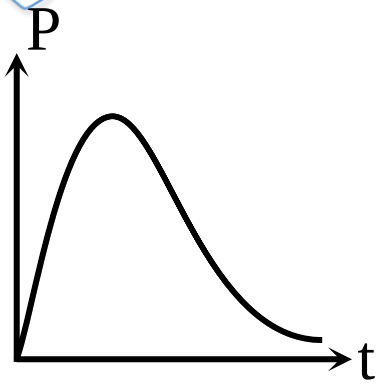
(B)



(C)



(D)



$\text{Slope} = \frac{dP}{dt} = \frac{\mathcal{E}^2}{R} 2\left(1 - e^{-Rt/L}\right)\left(0 + \frac{L}{R} e^{-tR/L}\right)$

$= \frac{2\mathcal{E}^2 L}{R^2}\left(1 - e^{-Rt/L}\right) e^{-Rt/L}$

$= \frac{2\mathcal{E}^2 L}{R^2}\left(e^{-Rt/L} - e^{-2Rt/L}\right)$

at $t = 0$, Slope $= 0$

at $t \to \infty$, " $= 0$

Slope first ↑ then ↓

Q.9) What is the magnitude of current flowing when the rate of increase of magnetic energy in the inductor is maximum –

Power of inductor $P = Vi = \mathcal{E} e^{-Rt/L} \frac{\mathcal{E}}{R}\left(1 - e^{-Rt/L}\right)$

$P = \frac{\mathcal{E}^2}{R}\left(e^{-Rt/L} - e^{-2Rt/L}\right)$

for $P = P_{max}$, $\frac{dP}{dt} = 0 \Rightarrow \frac{\mathcal{E}^2}{R}\left[-\frac{R}{L} e^{-Rt/L} + \frac{2R}{L} e^{-\frac{2Rt}{L}}\right] = $

(a) I = V/R

(b) I = V/2R

(c) I = V/4R

(d) I = (V/R) ln2

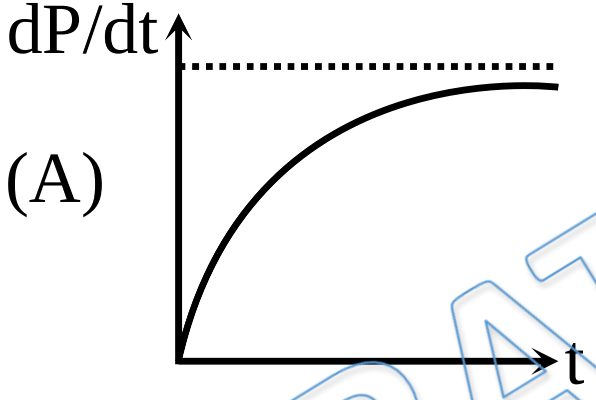
$\Rightarrow 2 e^{-2Rt/L} = e^{-Rt/L}$

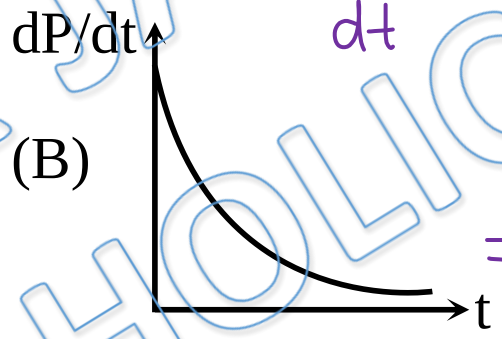
$\Rightarrow e^{Rt/L} = 2 \Rightarrow e^{-Rt/L} = \frac{1}{2}$

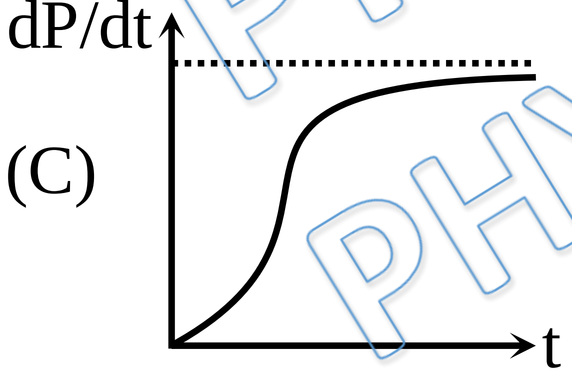
$i = \frac{\mathcal{E}}{R}\left(1 - e^{-Rt/L}\right)$

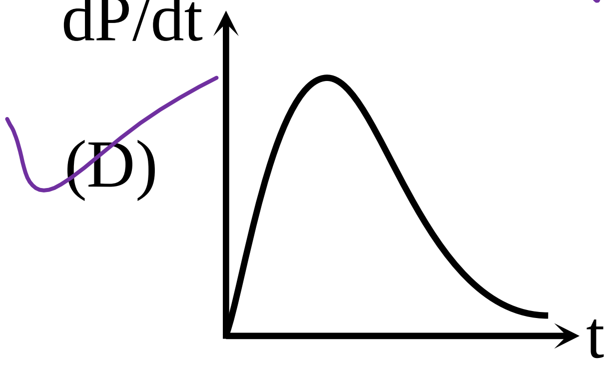
$= \frac{\mathcal{E}}{2R}$

Q.10) Which of the following graph best represent rate of change of power dissipated in resistor as a function of time -









$\frac{dP}{dt}$ = Slope of P–t curve

$= \frac{2\varepsilon^2 L}{R^2}\left(e^{-\frac{Rt}{L}} - 2e^{-\frac{2Rt}{L}}\right)$

$= \frac{2\varepsilon^2 L}{R}\left(1 - e^{-\frac{Rt}{L}}\right)e^{-\frac{Rt}{L}}$

at $t = 0$, $\frac{dP}{dt} = 0$

at $t \to \infty$, $\frac{dP}{dt} = 0$

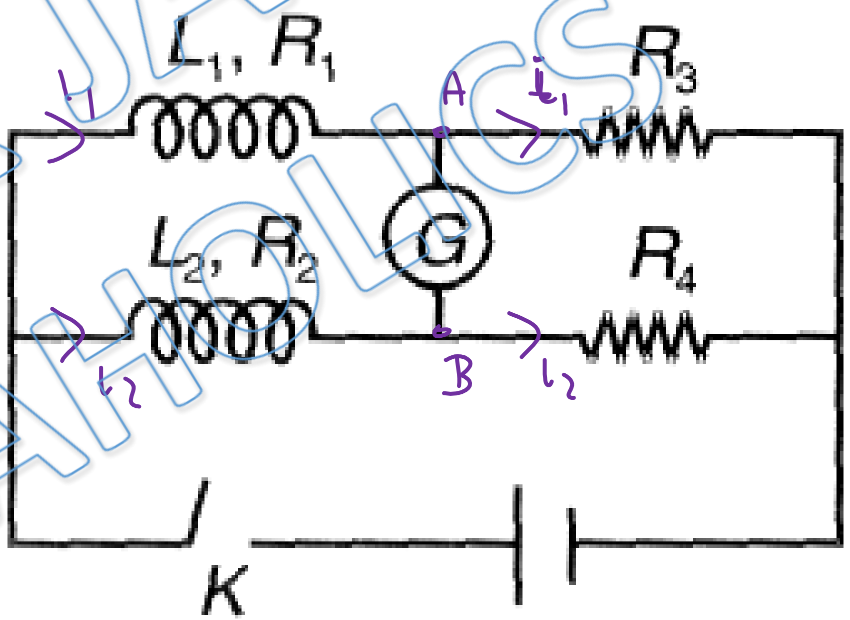
Q.11) After the key k is closed, galvanometer in the shown arrangement shows zero deflection at all the times if (R_1, and R_2 are resistances of inductors L_1 and L_2)

(a) $\frac{R_1}{R_2} = \frac{R_3}{R_4} = \frac{L_1}{L_2}$

(b) $\frac{R_2}{R_1} = \frac{R_3}{R_4} = \frac{L_1}{L_2}$

(c) $\frac{L_1}{L_2} = \frac{R_1}{R_2}$

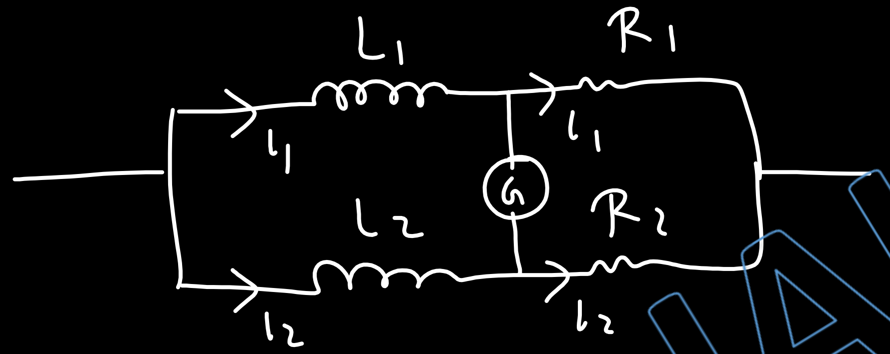
(d) $\frac{L_1}{L_2} = \frac{R_3}{R_4}$



$V_A = V_B$

$L_1 \frac{di_1}{dt} + i_1 R = L_2 \frac{di_2}{dt} + i_2 R$

$i_1 R_3 = i_2 R_4$



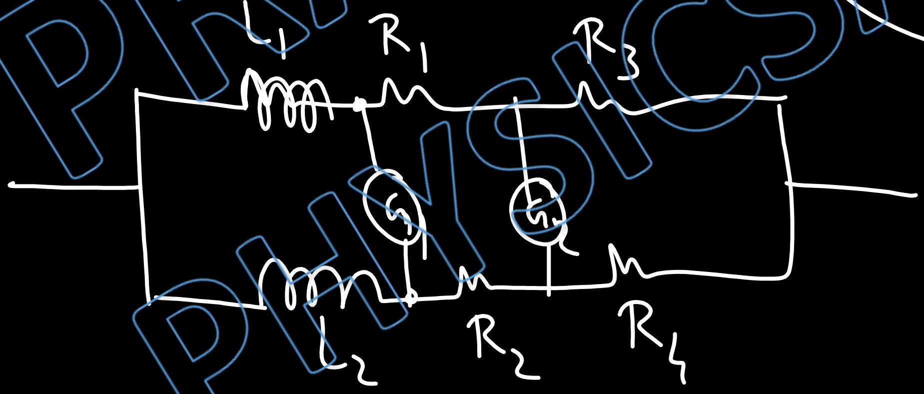
$$L_1 I_1 = L_2 I_2$$

$$I_1 R_1 = I_2 R_2$$

$$\frac{I_1}{I_2} = \frac{L_2}{L_1}$$

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$

$$\frac{L_1}{L_2} = \frac{R_1}{R_2}$$

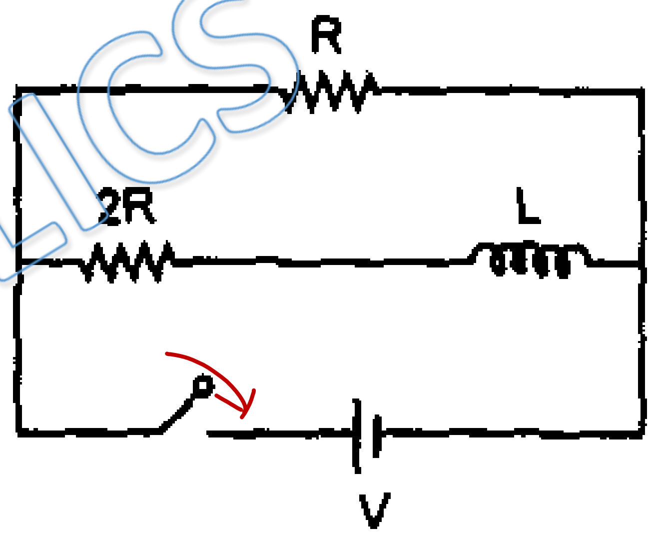


$$\frac{L_1}{L_2} = \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

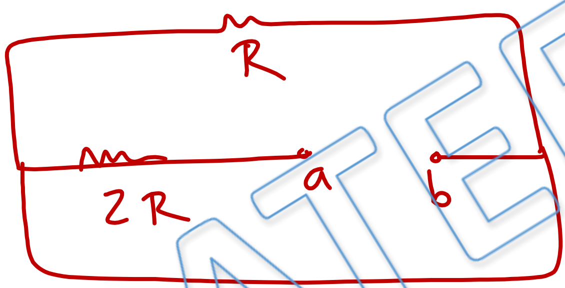
$$G_1 = G_2 = 0$$

Ans. a

Q.12) The ratio of time constants during current growth and current decay of the circuit shown in figure is:



for τ of charging →



$R_{eff} = 2R$.

$\tau_1 = \frac{L}{2R}$

(a) 1 : 1 (b) 3 : 2 (c) 2 : 3 (d) 1 : 3

for τ of discharging

$R_{eff} = 3R$

$\tau_2 = \frac{L}{3R}$

$\frac{\tau_1}{\tau_2} = 3/2$

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