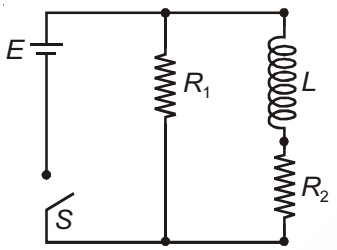
Electromagnetic Induction

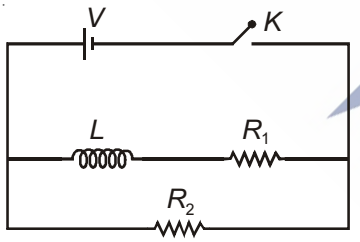
1. An inductor of inductance L = 400 mH and resistors of resistances R_1 = 2 Ω and R_2 = 2 Ω are connected to a battery of emf 12 V as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at t = 0. The potential drop across L as a function of time is **[AIEEE-2009]**



(1) $\frac{12}{t}e^{-3t}$ V (2) $6(1 - e^{-t/0.2})$ V

(3) $12e^{-5t}$ V (4) $6e^{-5t}$ V

2. In the circuit shown below, the key K is closed at t = 0. The current through the battery is **[AIEEE-2010]**



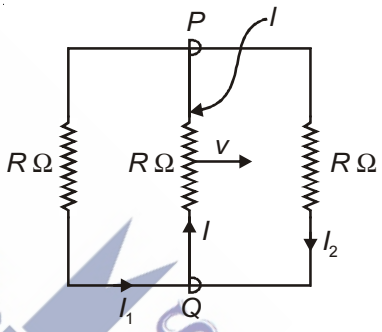
(1) $\frac{V(R_1+R_2)}{R_1R_2}$ at t = 0 and $\frac{V}{R_2}$ at $t = \infty$

(2) $\frac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at t = 0 and $\frac{V}{R_2}$ at $t = \infty$

(3) $\frac{V}{R_2}$ at t = 0 and $\frac{V(R_1+R_2)}{R_1R_2}$ at $t = \infty$

(4) $\frac{V}{R_2}$ at t = 0 and $\frac{VR_1R_2}{\sqrt{R_1^2+R_2^2}}$ at $t = \infty$

3. A rectangular loop has a sliding connector PQ of length l and resistance R Ω and it is moving with a speed v as shown. The set-up is placed in a uniform magnetic field going into the plane of the paper. The three currents I_1, I_2 and I are **[AIEEE-2010]**



(1) $I_1 = I_2 = \frac{Blv}{6R}, I = \frac{Blv}{3R}$

(2) $I_1 = -I_2 = \frac{Blv}{R}, I = \frac{2Blv}{R}$

(3) $I_1 = I_2 = \frac{Blv}{3R}, I = \frac{2Blv}{3R}$

(4) $I_1 = I_2 = I = \frac{Blv}{R}$

4. A horizontal straight wire 20 m long extending from east to west is falling with a speed of 5.0 m/s, at right angles to the horizontal component of the earth's magnetic field 0.30×10^{-4} Wb/m^2. The instantaneous value of the e.m.f. induced in the wire will be **[AIEEE-2011]**

(1) 1.5 mV

(2) 6.0 mV

(3) 3 mV

(4) 4.5 mV

5. A coil is suspended in a uniform magnetic field, with the plane of the coil parallel to the magnetic lines of force. When a current is passed through the coil it starts oscillating; it is very difficult to stop. But if an aluminium plate is placed near to the coil, it stops. This is due to **[AIEEE-2012]**

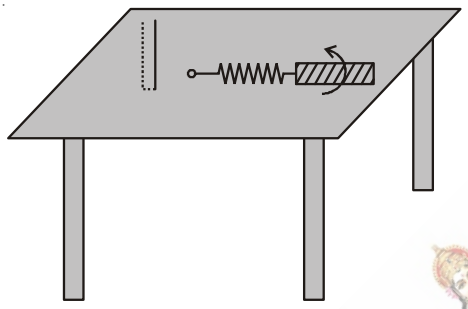
(1) Induction of electrical charge on the plate

(2) Shielding of magnetic lines of force as aluminium is a paramagnetic material

(3) Electromagnetic induction in the aluminium plate giving rise to electromagnetic damping

(4) Development of air current when the plate is placed

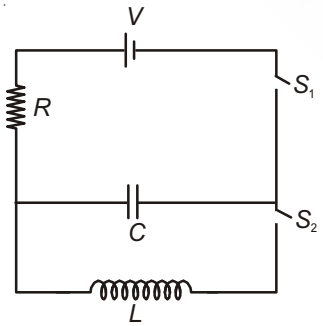
6. A metallic rod of length l is tied to a string of length $2l$ and made to rotate with angular speed ω on a horizontal table with one end of the string fixed. If there is a vertical magnetic field B in the region, the e.m.f. induced across the ends of the rod is **[JEE (Main)-2013]**



(1) $\frac{2B\omega l^2}{2}$ (2) $\frac{3B\omega l^2}{2}$

(3) $\frac{4B\omega l^2}{2}$ (4) $\frac{5B\omega l^2}{2}$

7. In an LCR circuit as shown below both switches are open initially. Now switch S_1 is closed, S_2 kept open (q is charge on the capacitor and $\tau = RC$ is Capacitive time constant). Which of the following statement is correct ? **[JEE (Main)-2013]**



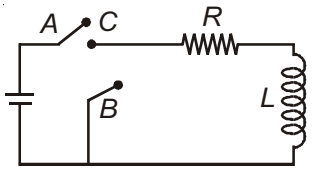
(1) Work done by the battery is half of the energy dissipated in the resistor

(2) At $t = \tau$, $q = CV/2$

(3) At $t = 2\tau$, $q = CV(1 - e^{-2})$

(4) At $t = \frac{\tau}{2}$, $q = CV(1 - e^{-1})$

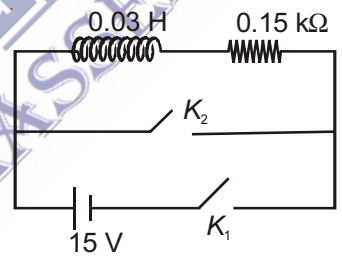
8. In the circuit shown here, the point 'C' is kept connected to point 'A' till the current flowing through the circuit becomes constant. Afterward, suddenly, point 'C' is disconnected from point 'A' and connected to point 'B' at time $t = 0$. Ratio of the voltage across resistance and the inductor at $t = L/R$ will be equal to **[JEE (Main)-2014]**



(1) $\frac{e}{1-e}$ (2) 1

(3) –1 (4) $\frac{1-e}{e}$

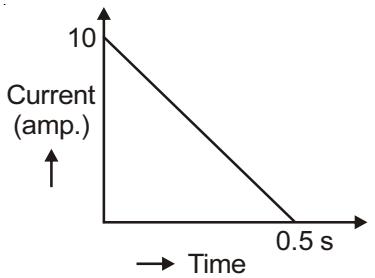
9. An inductor (L = 0.03 H) and a resistor (R = 0.15 kΩ) are connected in series to a battery of 15 V EMF in a circuit shown below. The key K_1 has been kept closed for a long time. Then at $t = 0$, K_1 is opened and key K_2 is closed simultaneously. At t = 1 ms, the current in the circuit will be ($e^5 \cong 150$) **[JEE (Main)-2015]**



(1) 100 mA (2) 67 mA

(3) 6.7 mA (4) 0.67 mA

10. In a coil of resistance 100 Ω, a current is induced by changing the magnetic flux through it as shown in the figure. The magnitude of change in flux through the coil is **[JEE (Main)-2017]**



(1) 200 Wb

(2) 225 Wb

(3) 250 Wb

(4) 275 Wb

11. A conducting circular loop made of a thin wire, has area 3.5×10^{-3} m^2 and resistance 10 Ω. It is placed perpendicular to a time dependent magnetic field $B(t) = (0.4T)\sin(50\pi t)$. The field is uniform in space. Then the net charge flowing through the loop during t = 0 s and t = 10 ms is close to

[JEE (Main)-2019]

(1) 7 mC (2) 0.14 mC

(3) 6 mC (4) 14 mC

12. A solid metal cube of edge length 2 cm is moving in a positive y-direction at a constant speed of 6 m/s. There is a uniform magnetic field of 0.1 T in the positive z-direction. The potential difference between the two faces of the cube perpendicular to the x-axis, is **[JEE (Main)-2019]**

(1) 12 mV (2) 2 mV

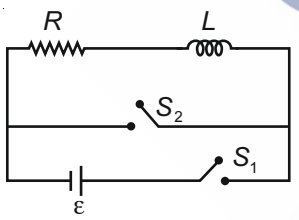
(3) 6 mV (4) 1 mV

13. The self induced emf of a coil is 25 volts. When the current in it is changed at uniform rate from 10 A to 25 A in 1 s, the change in the energy of the inductance is **[JEE (Main)-2019]**

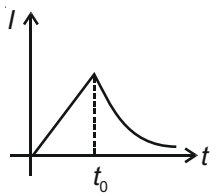
(1) 437.5 J (2) 740 J

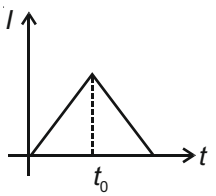
(3) 637.5 J (4) 540 J

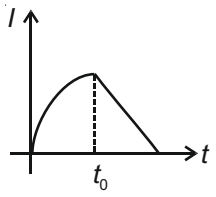
14. In the circuit shown,

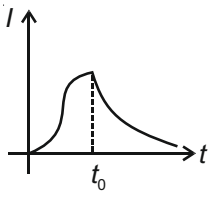


the switch S_1 is closed at time t = 0 and the switch S_2 is kept open. At some later time(t_0), the switch S_1 is opened and S_2 is closed. The behaviour of the current I as a function of time 't' is given by **[JEE (Main)-2019]**

(1)


(2)


(3)


(4)


15. There are two long co-axial solenoids of same length l. The inner and outer coils have radii r_1 and r_2 and number of turns per unit length n_1 and n_2, respectively. The ratio of mutual inductance to the self inductance of the inner-coil is

[JEE (Main)-2019]

(1) $\frac{n_2}{n_1}\cdot\frac{r_2^2}{r_1^2}$ (2) $\frac{n_2}{n_1}$

(3) $\frac{n_2}{n_1}\cdot\frac{r_1}{r_2}$ (4) $\frac{n_1}{n_2}$

16. A copper wire is wound on a wooden frame, whose shape is that of an equilateral triangle. If the linear dimension of each side of the frame is increased by a factor of 3, keeping the number of turns of the coil per unit length of the frame the same, then the self inductance of the coil **[JEE (Main)-2019]**

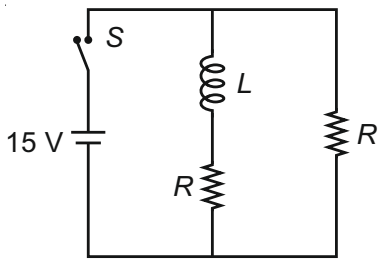
(1) Increases by a factor of 3

(2) Decreases by a factor of $9\sqrt{3}$

(3) Decreases by a factor of 9

(4) Increases by a factor of 27

17. In the figure shown, a circuit contains two identical resistors with resistance R = 5 Ω and an inductance with L = 2 mH. An ideal battery of 15 V is connected in the circuit. What will be the current through the battery long after the switch is closed? **[JEE (Main)-2019]**



(1) 7.5 A (2) 3 A

(3) 6 A (4) 5.5 A

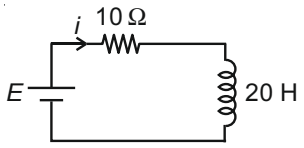
18. Let l, r, c and ν represent inductance, resistance, capacitance and voltage, respectively. The dimension of $\frac{1}{rcv}$ in SI units will be

[JEE (Main)-2019]

(1) [A^{-1}] (2) [LA^{-2}]

(3) [LT^2] (4) [LTA]

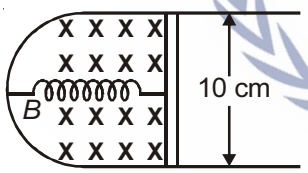
19. A 20 henry inductor coil is connected to a 10 ohm resistance in series as shown in figure. The time at which rate of dissipation of energy (Joule's heat) across resistance is equal to the rate at which magnetic energy is stored in the inductor, is **[JEE (Main)-2019]**



(1) $\frac{2}{\ln 2}$ (2) $2 \ln 2$

(3) $\ln 2$ (4) $\frac{1}{2}\ln 2$

20. A thin strip 10 cm long is on a U shaped wire of negligible resistance and it is connected to a spring of spring constant 0.5 Nm^{-1}(see figure). The assembly is kept in a uniform magnetic field of 0.1 T. If the strip is pulled from its equilibrium position and released, the number of oscillations it performs before its amplitude decreases by a factor of e is N. If the mass of the strip is 50 grams, its resistance 10 Ω and air drag negligible, N will be close to **[JEE (Main)-2019]**



(1) 1000 (2) 5000

(3) 50000 (4) 10000

21. The total number of turns and cross-section area in a solenoid is fixed. However, its length L is varied by adjusting the separation between windings. The inductance of solenoid will be proportional to **[JEE (Main)-2019]**

(1) $1/L$ (2) L

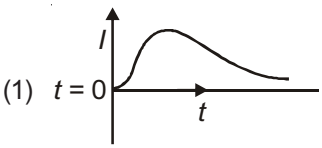
(3) $1/L^2$ (4) L^2

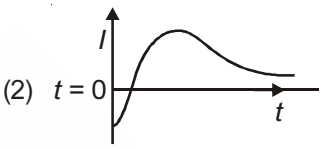
22. Two coils 'P' and 'Q' are separated by some distance. When a current of 3 A flows through coil 'P', a magnetic flux of 10^{-3} Wb passes through Q. No current is passed through 'Q'. When no current passes through 'P' and a current of 2 A passes through 'Q', the flux through 'P' is **[JEE (Main)-2019]**

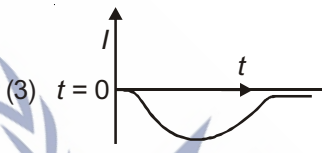
(1) 6.67×10^{-3} Wb (2) 6.67×10^{-4} Wb

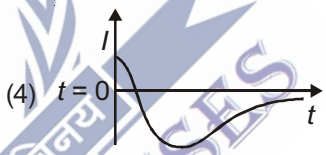
(3) 3.67×10^{-3} Wb (4) 3.67×10^{-4} Wb

23. A very long solenoid of radius R is carrying current $I(t) = kte^{-\alpha t}$ ($k > 0$), as a function of time ($t \geq 0$). Counter clockwise current is taken to be positive. A circular conducting coil of radius $2R$ is placed in the equatorial plane of the solenoid and concentric with the solenoid. The current induced in the outer coil is correctly depicted, as a function of time, by **[JEE (Main)-2019]**

(1) 

(2) 

(3) 

(4) 

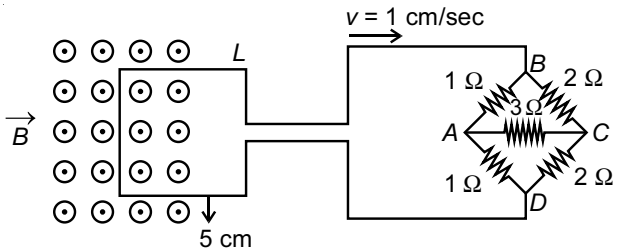
24. A coil of self inductance 10 mH and resistance 0.1 Ω is connected through a switch to a battery of internal resistance 0.9 Ω. After the switch is closed, the time taken for the current to attain 80% of the saturation value is: **[JEE (Main)-2019]**

[Take $\ln 5 = 1.6$]

(1) 0.002 s (2) 0.324 s

(3) 0.103 s (4) 0.016 s

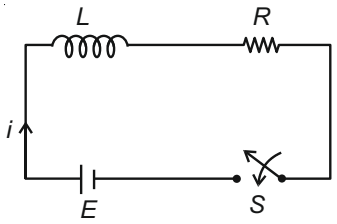
25. The figure shows a square loop L of side 5 cm which is connected to a network of resistances. The whole setup is moving towards right with a constant speed of 1 cm s^{-1}. At some instant, a part of L is in a uniform magnetic field of 1 T, perpendicular to the plane of the loop. If the resistance of L is 1.7 Ω, the current in the loop at that instant will be close to: **[JEE (Main)-2019]**



(1) 170 μA (2) 60 μA

(3) 150 μA (4) 115 μA

26. Consider the *LR* circuit shown in the figure. If the switch *S* is closed at $t = 0$ then the amount of charge that passes through the battery between $t = 0$ and $t = \frac{L}{R}$ is: **[JEE (Main)-2019]**



(1) $\frac{2.7EL}{R^2}$ (2) $\frac{EL}{2.7R^2}$

(3) $\frac{7.3\,EL}{R^2}$ (4) $\frac{EL}{7.3\,R^2}$

27. A long solenoid of radius *R* carries a time (*t*) - dependent current $I(t) = I_0 t(1 - t)$. A ring of radius 2*R* is placed coaxially near its middle. During the time interval $0 \le t \le 1$, the induced current (I_R) and the induced EMF (V_R) in the ring change as **[JEE (Main)-2020]**

(1) Direction of I_R remains unchanged and V_R is zero at $t = 0.25$

(2) Direction of I_R remains unchanged and V_R is maximum at t = 0.5

(3) At $t = 0.5$ direction of I_R reverses and V_R is zero

(4) At $t = 0.25$ direction of I_R reverses and V_R is maximum

28. An emf of 20 V is applied at time $t = 0$ to a circuit containing in series 10 mH inductor and 5 Ω resistor. The ratio of the currents at time $t = \infty$ and at $t = 40$ s is close to **[JEE (Main)-2020]**

(Take $e^2 = 7.389$)

(1) 1.06 (2) 1.15

(3) 1.46 (4) 0.84

29. A planar loop of wire rotates in a uniform magnetic field. Initially, at $t = 0$, the plane of the loop is perpendicular to the magnetic field. If it rotates with a period of 10 s about an axis in its plane then the magnitude of induced emf will be maximum and minimum, respectively at **[JEE (Main)-2020]**

(1) 2.5 s and 7.5 s (2) 5.0 s and 7.5 s

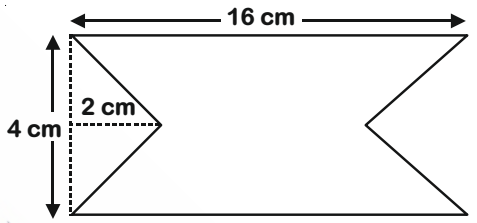
(3) 2.5 s and 5.0 s (4) 5.0 s and 10.0 s

30. The dimension of $\frac{B^2}{2\mu_0}$, where *B* is magnetic field and μ_0 is the magnetic permeability of vaccum, is **[JEE (Main)-2020]**

(1) $ML^{-1}T^{-2}$ (2) ML^2T^{-2}

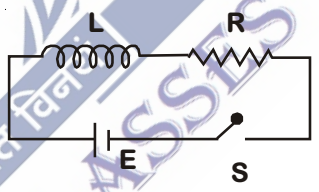
(3) ML^2T^{-1} (4) MLT^{-2}

31. At time $t = 0$ magnetic field of 1000 Gauss is passing perpendicularly through the area defined by the closed loop shown in the figure. If the magnetic field reduces linearly to 500 Gauss, in the next 5 s, then induced EMF in the loop is **[JEE (Main)-2020]**



(1) 48 μV (2) 36 μV

(3) 56 μV (4) 28 μV

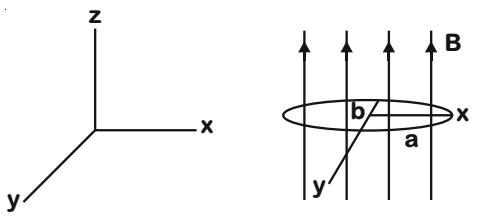
32. 

As shown in the figure, a battery of emf *E* is connected to an inductor *L* and resistance *R* in series. The switch is closed at $t = 0$. The total charge that flows from the battery, between $t = 0$ and $t = t_C$ (t_C is the time constant of the circuit) is **[JEE (Main)-2020]**

(1) $\frac{EL}{R^2}$ (2) $\frac{ER}{eL^2}$

(3) $\frac{EL}{R^2}\left(1-\frac{1}{e}\right)$ (4) $\frac{EL}{eR^2}$

33. An elliptical loop having resistance *R*, of semi major axis *a*, and semi minor axis *b* is placed in a magnetic field as shown in the figure. If the loop is rotated about the *x*-axis with angular frequency ω, the average power loss in the loop due to Joule heating is **[JEE (Main)-2020]**



(1) $\frac{\pi abB\omega}{R}$ (2) $\frac{\pi^2a^2b^2B^2\omega^2}{2R}$

(3) Zero (4) $\frac{\pi^2a^2b^2B^2\omega^2}{R}$

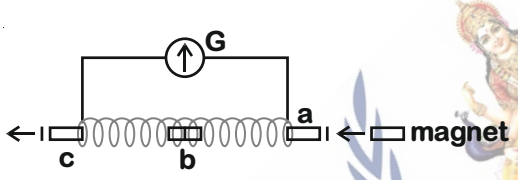
34. A uniform magnetic field B exists in a direction perpendicular to the plane of a square loop made of a metal wire. The wire has a diameter of 4 mm and a total length of 30 cm. The magnetic field changes with time at a steady rate dB/dt = 0.032 Ts^{-1}. The induced current in the loop is close to (Resistivity of the metal wire is 1.23 × 10^{-8} Ωm)

[JEE (Main)-2020]

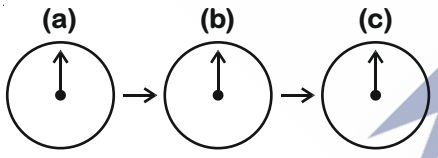
(1) 0.34 A (2) 0.61 A

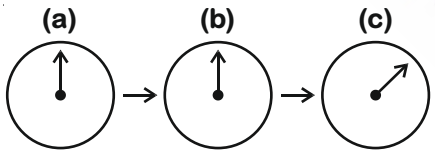
(3) 0.53 A (4) 0.43 A

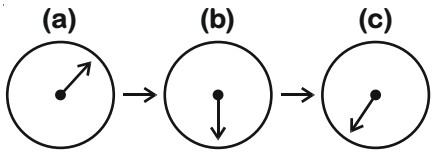
35. A small bar magnet is moved through a coil at constant speed from one end to the other. Which of the following series of observations will be seen on the galvanometer G attached across the coil?

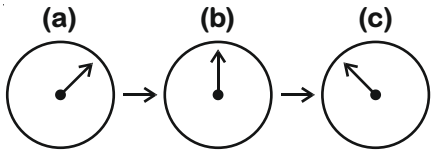


Three positions shown describe : (a) the magnet's entry (b) magnet is completely inside and (c) magnet's exit. **[JEE (Main)-2020]**

(1) 

(2) 

(3) 

(4) 

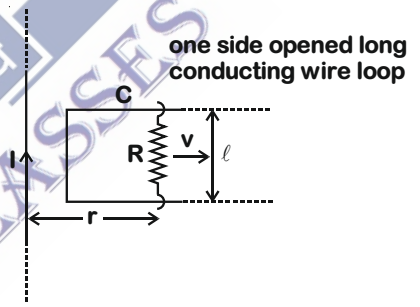
36. A series L-R circuit is connected to a battery of emf V. If the circuit is switched on at t = 0, then the time at which the energy stored in the inductor reaches $\left(\frac{1}{n}\right)$ times of its maximum value, is

[JEE (Main)-2020]

(1) $\frac{L}{R}\ln\left(\frac{\sqrt{n}+1}{\sqrt{n}-1}\right)$ (2) $\frac{L}{R}\ln\left(\frac{\sqrt{n}}{\sqrt{n}-1}\right)$

(3) $\frac{L}{R}\ln\left(\frac{\sqrt{n}}{\sqrt{n}+1}\right)$ (4) $\frac{L}{R}\ln\left(\frac{\sqrt{n}-1}{\sqrt{n}}\right)$

37. An infinitely long, straight wire carrying current I, one side opened rectangular loop and a conductor C with a sliding connector are located in the same plane, as shown, in the figure. The connector has length ℓ and resistance R. It slides to the right with a velocity v. The resistance of the conductor and the self inductance of the loop are negligible. The induced current in the loop, as a function of separation r, between the connector and the straight wire is **[JEE (Main)-2020]**



(1) $\frac{\mu_0}{4\pi}\frac{Iv\ell}{Rr}$ (2) $\frac{\mu_0}{\pi}\frac{Iv\ell}{Rr}$

(3) $\frac{\mu_0}{2\pi}\frac{Iv\ell}{Rr}$ (4) $\frac{2\mu_0}{\pi}\frac{Iv\ell}{Rr}$

38. In a fluorescent lamp choke (a small transformer) 100 V of reverse voltage is produced when the choke current changes uniformly from 0.25 A to 0 in a duration of 0.025 ms. The self inductance of the choke(in mH) is estimated to be _____

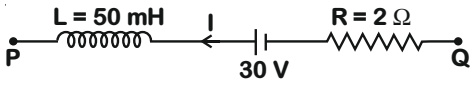
[JEE (Main)-2020]

39. A circular coil of radius 10 cm is placed in a uniform magnetic field of 3.0 × 10^{-5} T with its plane perpendicular to the field initially. It is rotated at constant angular speed about an axis along the diameter of coil and perpendicular to magnetic field so that it undergoes half of rotation in 0.2 s. The maximum value of EMF induced (in μV) in the coil will be close to the integer _____.

[JEE (Main)-2020]

40. Two concentric circular coils, C_1 and C_2 are placed in the XY plane. C_1 has 500 turns, and a radius of 1 cm. C_2 has 200 turns and radius of 20 cm. C_2 carries a time dependent current $I(t) = (5t^2 - 2t + 3)$ A where t is in s. The emf induced in C_1 (in mV), at the instant $t = 1$ s is $\frac{4}{x}$. The value of x is _____ . **[JEE (Main)-2020]**

41. A part of a complete circuit is shown in the figure. At some instant, the value of current I is 1 A and it is decreasing at a rate of 10^2 A s^{-1}. The value of the potential difference $V_P - V_Q$, (in volts) at that instant, is _____. **[JEE (Main)-2020]**



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