SPRINT

CRASH COURSE FOR JEE

Class XII

PHYSICS

CONTENTS

CHAPTER 5

Electromagnetic Induction and Alternating Current

MAGNETIC FLUX

$\phi = \vec{B} \cdot \vec{A} = BA\cos\theta$ weber for uniform $\vec{B}$.

$\phi = \int \vec{B} \cdot d\vec{A}$ for non uniform $\vec{B}$.

Faraday's Laws of Electromagnetic Induction

(i) An induced emf is setup whenever the magnetic flux linking that circuit changes.

(ii) The magnitude of the induced emf in any circuit is proportional to the rate of change of the magnetic flux linking the circuit, $\varepsilon \propto \frac{d\phi}{dt}$.

Lenz's Laws

The direction of an induced emf is always such as to oppose the cause producing it.

Law of EMI

$\varepsilon = -\frac{d\phi}{dt}$. The negative sign indicated that the induced emf opposes the change of the flux.

Motional EMF

When a conductor is moved across a magnetic field, an electromotive force (emf) is produced in the conductor. If the conductors forms part of a closed circuit then the emf produced causes an electric current to flow round the circuit. Hence an emf (and thus a current) is induced in the conductor as a result of its movement across the magnetic field. This is known as motional emf.

EMF Induced across a moving Straight Conductor in Uniform Magnetic Field

$E = BLv\sin\theta$ volt where $\left(\text{if } \vec{L} \perp \vec{v} \text{ and } \vec{B}\right)$

B = flux density in wb/m^2;

L = length of the conductor (m);

v = velocity of the conductor (m/s);

θ = angle between direction of motion of conductor & B.

Coil Rotation in Magnetic Field Such that Axis of Rotation is Perpendicular to the Magnetic Field

Instantaneous induced emf. $E = NAB\omega\sin\omega t = E_0\sin\omega t$, where

N = number of turns in the coil; A = area of one turn ;

B = magnetic induction; ω = uniform angular velocity of the coil;

E_0 = maximum induced emf.

Self Induction and Self Inductance

The property of the coil or the circuit due to which it opposes any change of the current coil or the circuit is known as **Self - Inductance**. It's unit is Henry.

Coefficient of Self inductance $L = \frac{\phi_s}{i}$ or $\phi_s = Li$

L depends only on;

(i) Shape of the loop and

(ii) Medium

i = current in the circuit.

ϕ_s = magnetic flux linked with the circuit due to the current i.

self induced emf $e_s = -\frac{d\phi_s}{dt} = -\frac{d}{dt}(Li) = -L\frac{di}{dt}$ (if L is constant)

Mutual Induction

If two electric circuits are such that the magnetic field due to a current in one is partly or wholly linked with the other, the two coils are said to be electromagnetically coupled circuits . Then any change of current in one produces a change of magnetic flux in the other and the latter opposes the change by inducing an emf within itself. This phenomenon is called **Mutual Induction.**

Induced emf in the latter circuit due to a change of current in the former is called **Mutually Induced EMF**.

The circuit in which the current is changed, is called the primary and the other circuit in which the emf is induced is called the secondary.

The co-efficient of mutual induction (mutual inductance) between two electromagnetically coupled circuit is the magnetic flux linked with the secondary per unit current in the primary.

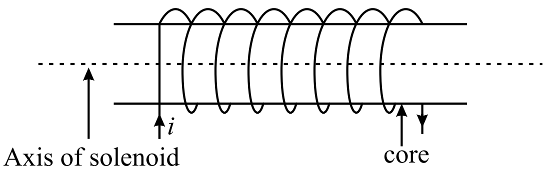
Mutual inductance $= M = \frac{\phi_m}{I_p} = \frac{\text{flux linked with secondary}}{\text{current in the primary}}$

Mutually induced emf $(E_m) = \frac{d\phi_m}{dt} = -\frac{d}{dt}(MI) = -M\frac{dI}{dt}$

M depends on

(1) geometry of loops (2) medium (3) orientation and distance between the loops.

Solenoid



There is a uniform magnetic field along the axis the solenoid (ideal : length >> diameter)

$B = \mu ni$ where;

μ = magnetic permeability of the core material;

n = number of turns in the solenoid per unit length;

i = current in the solenoid;

Self inductance of a solenoid $L = \mu n^2 Al$;

A = area of cross section of solenoid.

Super Conducting Loop in Magnetic Field

$R = 0$; $\varepsilon = 0$. Therefore ϕ_{total} = constant. Thus through a superconducting loop flux never changes.

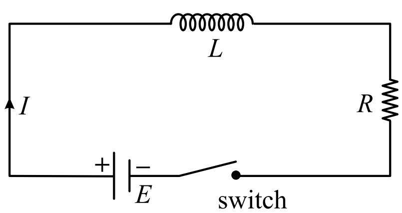
Energy Stored in an Inductor:

$$U = \frac{1}{2} LI^2.$$

Energy of interaction of two loops $U = I_1\phi_2 = I_2\phi_1 = MI_1I_2$, where M is mutual inductance.

Growth of a Current in an L–R Circuit

$I = \frac{E}{R}(1 - e^{-Rt/L})$. [If initial current = 0]

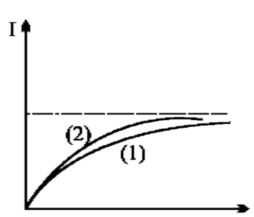


$\frac{L}{R}$ = time constant of the circuit.

$$I_0 = \frac{E}{R}.$$

(i) L behaves as open circuit at $t = 0$ [$i = 0$]

(ii) L behaves as short circuit at $t = \infty$.

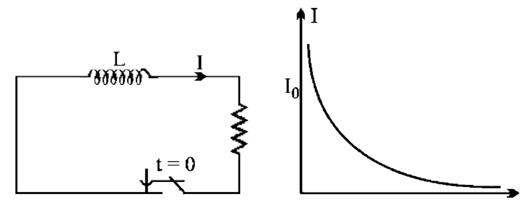


Curve (1) $\longrightarrow \frac{L}{R}$ Large

Curve (2) $\longrightarrow \frac{L}{R}$ Small

Decay of Current

Initial current through the inductor = I_0; Current at any instant $i = I_0 e^{-Rt/L}$



ALTERNATING CURRENT

Instantaneous, RMS and Average Values

(i) Instantaneous value of alternating current
$I = I_0 \sin\omega t$ or $I = I_0 \cos\omega t$

(ii) Peak value of a.c. = I_0

(iii) Alternating emf. = $E = E_0 \sin\omega t$ or $E = E_0 \cos\omega t$

(iv) Mean or average value of a.c.

$$I_m \text{ or } I_a = \frac{2I_0}{\pi} = 0.637 I_0 \text{ for half cycle}$$

= 0 for full cycle.

(v) R.m.s. value of ac $I_{rms} = I_0/\sqrt{2} = 0.707 I_0$.

Phase Difference

(i) If the emf leads the current by $\pi/2$, the reactance is called purely inductive.

(ii) If the emf lags behind the current by $\pi/2$, the reactance is called purely capacitive.

(iii) If the emf is in phase with the current, the circuit is called purely resistive.

Sign Convension

Sign for phase difference (ϕ) between I and E for series LCR circuit:

ϕ is positive, when $X_L > X_C$

ϕ is negative, when $X_L < X_C$

ϕ is zero, when $X_L = X_C$

Resonance

(i) The LCR circuit is said to be resonance when

$X_L = X_C$ i.e., when $\omega L = \frac{1}{\omega C}$ and $\omega = \omega_0 = \frac{1}{\sqrt{LC}}$ is called resonance frequency.

(ii) At series resonant frequency, $\omega_0 = \frac{1}{\sqrt{LC}}$, we have:

(*a*) $Z = R$ = minimum value of impedance.

(*b*) $I_0 = E_0/R$ = maximum value of peak current.

(*c*) $\phi = 0$ i.e., I and E are in phase with each other.

(*d*) V_L is equal and opposite to V_C.

(*e*) Potential drop across C and L together is zero.

(*f*) $E = V_R$

JEE Main Corner

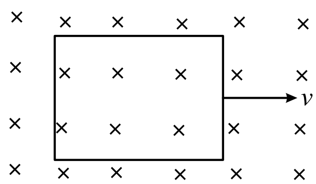
Magnetic Flux, faraday's laws of emi and Lenz's law

1. A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with bigger loop is

(*a*) 9.1×10^{-11} weber (*b*) 6×10^{-11} weber

(*c*) 3.3×10^{-11} weber (*d*) 6.6×10^{-9} weber

2. A square frame of wire of side l and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A uniform and constant magnetic field B exists perpendicular to the plane of the loop in figure. The current induced in the loop is



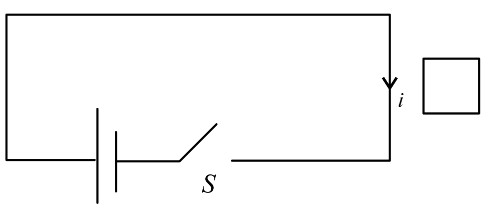
(*a*) $2Blv/R$ anticlockwise

(*b*) Blv/R anticlockwise

(*c*) Blv/R clockwise

(*d*) Zero

3. Consider the conducting square loop shown in figure. If the switch is closed and after some time it is opened again, the closed loop will show



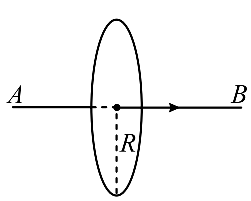
(*a*) A clockwise current-pulse.

(*b*) An anticlockwise current-pulse.

(*c*) An anticlockwise current-pulse and then a clockwise current-pulse.

(*d*) A clockwise current-pulse and then an anticlockwise current-pulse.

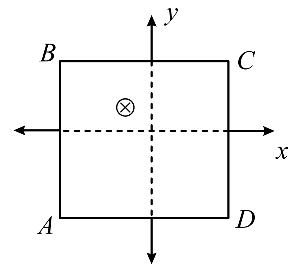
4. A long conductor AB lies along the axis of a circular loop of radius R. If the current in the conductor AB varies at the rate of I ampere/second, then the induced emf in the loop is:



(*a*) $\frac{\mu_0 IR}{2}$ (*b*) $\frac{\mu_0 IR}{4}$

(*c*) $\frac{\mu_0 \pi IR}{2}$ (*d*) Zero

5. A square coil $ABCD$ is placed in x-y plane with its centre at origin. A long straight wire, passing through origin, carries a current in negative z-direction. Current in this wire increases with time. The induced current in the coil is



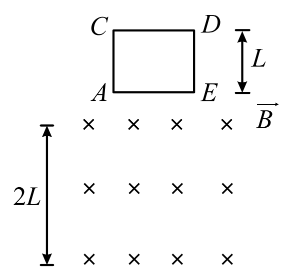
(*a*) Clockwise

(*b*) Anticlockwise

(*c*) Zero

(*d*) Alternating

6. A square coil $ACDE$ with its plane vertical is released from rest in a horizontal uniform magnetic field $\vec{B}$ of length $2L$. The acceleration of the coil is



(*a*) Less than g for all the time till the loop crosses the magnetic field completely.

(*b*) Less than g when it enters the field and greater than g when it comes out of the field.

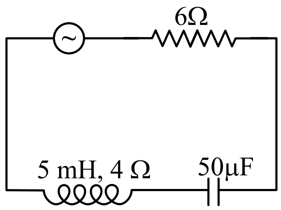
(*c*) g all the time.

(*d*) Less than g when it enters and comes out of the field but equal to g when it is within the field.

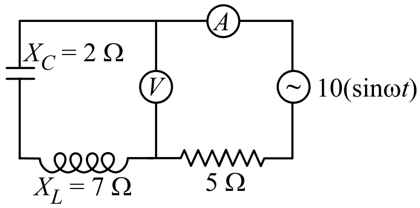
7. The instantaneous flux associated with a closed circuit of 10 Ω resistance is indicated by the following relation $\phi = 6t^2 - 5t + 1$. Then the value in amperes of the induced current at $t = 0.25$ sec will be

(*a*) 1.2 (*b*) 0.8

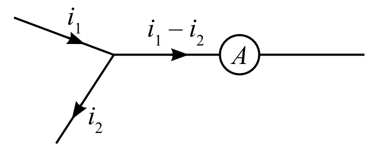
(*c*) 6 (*d*) 0.2



56. In the figure shown hot wire voltmeter and hot wire ammeter are ideal. Find the reading of voltmeter in volts.



57. Two alternating currents i_1 and i_2 are given by $i_1 = 4 \sin\left(314t + \frac{\pi}{6}\right)$ and $i_2 = 2 \sin\left(314t - \frac{\pi}{3}\right)$. Then what will be the reading of hotwire ammeter in mA (upto nearest integer)?

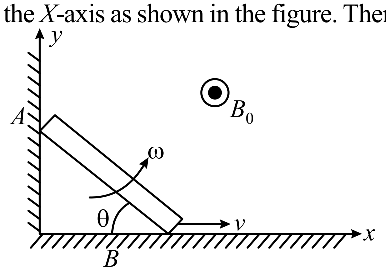


58. In a series *LCR* circuit connected to AC source, the power factor is 1. The angular frequency is 100π rad/s. The inductance is 4H and the resistance is 100Ω. Then the capacitance of the capacitor is _______ nF (Take $\pi^2 = 10$).

JEE Advanced Corner

Multiple Correct Type Questions

1. A thin conducting rod of length *l* is moved such that its end *B* moves along the *X*-axis while end *A* moves along the *Y*-axis. A uniform magnetic field $B = B_0\hat{k}$ exists in the region. At some instant, velocity of end *B* is *v* and the rod makes an angle of θ = 60º with the *X*-axis as shown in the figure. Then, at this instant



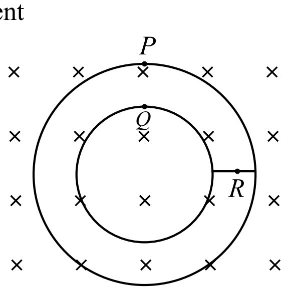
(*a*) Angular speed of rod *AB* is $\omega = \frac{2v}{\sqrt{3}l}$

(*b*) Angular speed of rod *AB* is $\omega = \frac{\sqrt{3}v}{2l}$

(*c*) E.M.F. induced in rod *AB* is $Blv\sqrt{3}$

(*d*) E.M.F. induced in rod *AB* is $Blv/2\sqrt{3}$

2. Figure shows plane figure made of a conductor located in a magnetic field along the inward normal to the plane of the figure. The magnetic field starts diminishing. Then the induced current



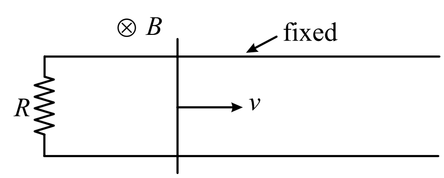
(*a*) At point *P* is clockwise.

(*b*) At point *Q* is anticlockwise.

(*c*) At point *Q* is clockwise.

(*d*) At point *R* is zero.

3. A resistance *R* is connected between the two ends of the parallel smooth conducting rails. A conducting rod lies on these fixed horizontal rails and a uniform constant magnetic field *B* exists perpendicular to the plane of the rails as shown in the figure. If the rod is given a velocity *v* and released as shown in figure, it will stop after some time, which options are correct?



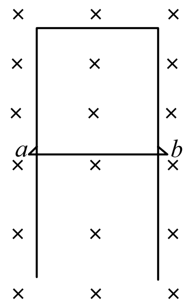
(*a*) The total work done by magnetic field is negative.

(*b*) The total work done by magnetic field is positive.

(*c*) The total work done by magnetic field is zero.

(*d*) Loss in kinetic energy of conducting rod is equal to heat generated in *R*.

4. A copper wire *ab* of length *l*, resistance *r* and mass *m* starts sliding at $t = 0$ down a smooth, vertical, thick pair of connected conducting rails as shown in figure. A uniform magnetic field *B* exists in the space in a direction perpendicular to the plane of the rails. Which options are correct?



(*a*) The magnitude and direction of the induced current in the wire when speed of the wire v is $\frac{vB\ell}{r}$, b to a. (in wire ab)

(*b*) The downward acceleration of the wire at this instant is $g - \frac{B^2\ell^2}{mr}v$.

(*c*) The velocity of the wire as a function of time is $v_m(1 - e^{-gt/v_m})$ where $v_m = \frac{mgr}{B^2\ell^2}$.

(*d*) The displacement of the wire as a function of time is $v_m t - \frac{v_m{}^2}{g}(1 - e^{-gt/v_m})$ where $v_m = \frac{mgr}{B^2\ell^2}$.

5. A pure inductance of 1 henry is connected across a 110 V, 70 Hz source. Then correct option/s are
(Use $\pi = 22/7$)

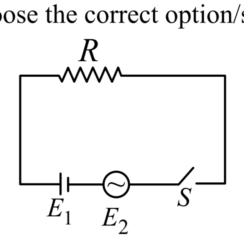
(*a*) Reactance of the circuit is 440 Ω.

(*b*) Current of the circuit is 0.25 A.

(*c*) Reactance of the circuit is 880 Ω.

(*d*) Current of the circuit is 0.5 A.

6. In the circuit shown in the figure $R = 50\Omega$, $E_1 = 25\sqrt{3}$ volt and $E_2 = 25\sqrt{6}\sin(\omega t)$ volt, where $\omega = 100\ \pi s^{-1}$. The switch is closed at $t = 0$, remains closed for 14 minutes and then it is opened. Choose the correct option/s.



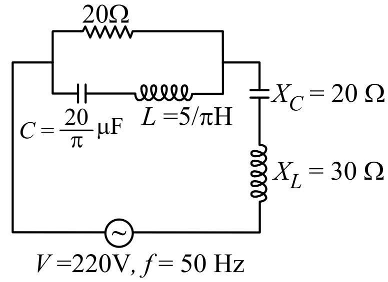
(*a*) The amount of heat produced in the resistor is 63000 J.

(*b*) The amount of heat produced in the resistor is 7000 J.

(*c*) If total amount of heat produced is used to heat 3 kg of water at 20°C, the final temperature of water will be 25°C.

(*d*) The value of direct current, that will produce same amount of heat in same time through same resistor, will be $\sqrt{1.5}$ A.

7. The circuit below is

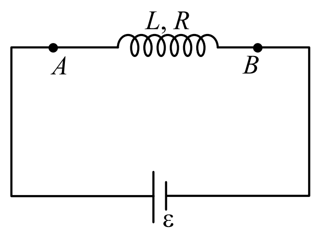


(*a*) Purely resistive (*b*) Purely inductive

(*c*) Purely capacitive (*d*) Zero power factor

Comprehension Based Questions

Comprehension (Q. 8 to 10): An inductor having self inductance L with its coil resistance R is connected across a battery of emf ε. When the circuit is in steady state at $t = 0$ an iron rod is inserted into the inductor due to which its inductance becomes $nL(n > 1)$.



8. After insertion of rod which of the following quantities will change with time?

1. Potential difference across terminals A and B.
2. Inductance.
3. Rate of heat produced in coil

(*a*) Only 1 (*b*) 1 and 3

(*c*) Only 3 (*d*) 1, 2 and 3

9. After insertion of the rod, current in the circuit

(*a*) Increases with time.

(*b*) Decreases with time.

(*c*) Remains constant with time.

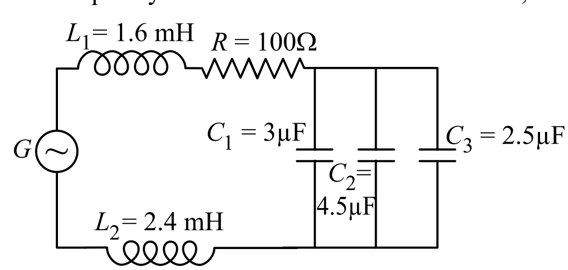
(*d*) First decreases with time then becomes constant.

10. When again circuit is in steady state, the current in it is

(*a*) $I < \varepsilon/R$ (*b*) $I > \varepsilon/R$

(*c*) $I = \varepsilon/R$ (*d*) None of these

Comprehension (Q. 11 to 13): An ac generator G with an adjustable frequency of oscillation is used in the circuit, as shown.



30. A uniform magnetic field exists in region given by $\vec{B} = 3\hat{i} + 4\hat{j} + 5\hat{k}$. A rod of length 5 m is placed along y-axis is moved along x-axis with constant speed 1 m/sec. Then induced e.m.f. in the rod will be

(*a*) zero (*b*) 25 V
(*c*) 20 V (*d*) 15 V

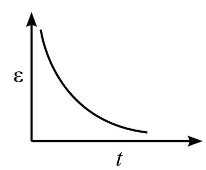
31. A voltage of peak value 283 V varying frequency is applied to a series L-C-R combination in which R = 3Ω; L = 25 mH and C = 400 μF. Then, the frequency (in Hz) of the source at which maximum power is dissipated in the above, is

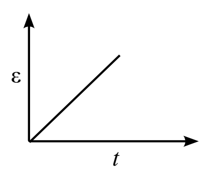
(*a*) 51.5 (*b*) 50.7
(*c*) 51.1 (*d*) 50.3

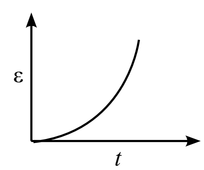
PYQ's (Past Year Questions)

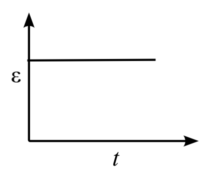
Magnetic Flux and Faraday's Laws of EMI, Lenz's Law

1. A rectangular metallic loop is moving out of a uniform magnetic field region to a field free region with a constant speed. When the loop is partially inside the magnetic field, the plot of magnitude of induced emf (ε) with time (*t*) is given by **[22 Jan, 2025 (Shift-II)]**

(*a*)


(*b*)


(*c*)


(*d*)


2. A square loop of side 10 cm and resistance 0.7Ω is placed vertically in east-west plane. A uniform magnetic field of 0.20 T is set up across the plane in north east direction. The magnetic field is decreased to zero in 1s at a steady rate. Then, magnitude of induced emf is $\sqrt{x} \times 10^{-3}$V. The value of x is ________.

[29 Jan, 2024 (Shift-I)]

3. Match List-I with List-II.

List-I		List-II	
A.	Gauss's law of magnetostatics	I.	$\oint \vec{E} \cdot \vec{da} = \frac{1}{\varepsilon_0} \int \rho dV$
B.	Faraday's law of electro magnetic induction	II.	$\oint \vec{B} \cdot \vec{da} = 0$
C.	Ampere's law	III.	$\oint \vec{E} \cdot \vec{dl} = \frac{-d}{dt} \int \vec{B} \cdot \vec{da}$
D.	Gauss's law of electrostatics	IV.	$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$

Choose the correct answer from the options given below:

[30 Jan, 2024 (Shift-II)]

(*a*) A-I, B-III, C-IV, D-II (*b*) A-III, B-IV, C-I, D-II
(*c*) A-IV, B-II, C-III, D-I (*d*) A-II, B-III, C-IV, D-I

4. A coil is placed perpendicular to a magnetic field of 5000 T. When the field is changed to 3000 T in 2s, an induced emf of 22 V is produced in the coil. If the diameter of the coil is 0.02 m, then the number of turns in the coil is:

[31 Jan, 2024 (Shift-I)]

(*a*) 7 (*b*) 70 (*c*) 35 (*d*) 140

5. The magnetic flux ϕ (in weber) linked with a closed circuit of resistance 8 Ω varies with time (in seconds) as $\phi = 5t^2 - 36t + 1$. The induced current in the circuit at t = 2s is _______ A.

[31 Jan, 2024 (Shift-II)]

6. A coil is placed in magnetic field such that plane of coil is perpendicular to the direction of magnetic field. The magnetic flux through a coil can be changed:

[1 Feb, 2023 (Shift-II)]

A. By changing the magnitude of the magnetic field within the coil.
B. By changing the area of coil within the magnetic field.
C. By changing the angle between the direction of magnetic field and the plane of the coil.
D. By reversing the magnetic field direction abruptly without changing its magnitude.

Choose the most appropriate answer from the options given below:

(*a*) A and B only (*b*) A, B and C only
(*c*) A, B and D only (*d*) A and C only

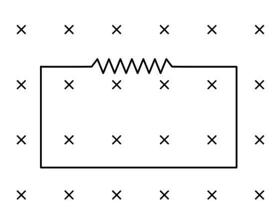
7. The magnetic flux through a coil perpendicular to its plane is varying according to the relation $\phi = (5t^3 + 4t^2 + 2t - 5)$ Weber. If the resistance of the coil is 5Ω, then the induced current through the coil at t = 2s will be,

[26 June, 2022 (Shift-I)]

(*a*) 15.6 A (*b*) 16.6 A
(*c*) 17.6 A (*d*) 18.6 A

8. In the given figure the magnetic flux through the loop increases according to the relation $\phi_B(t) = 10t^2 + 20t$, where ϕ_B is milli-webers and t is in seconds. The magnitude of current through $R = 2\Omega$ resistor at $t = 5$ s is _______ mA

[27 July, 2021 (Shift-II)]



9. A long solenoid of radius R carries a time(t) dependent current $I(t) = I_0 t(1-t)$. A ring of radius $2R$ is placed cordially 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: **[7 Jan, 2020 (Shift-I)]**

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

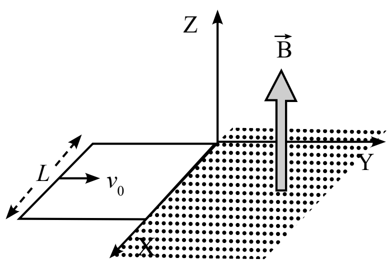
(*b*) At $t = 0.5$ direction of I_R reverses and V_R is zero

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

(*d*) Direction of I_R remains unchanged and V_R is maximum at $t = 0.5$

10. A conducting square loop of side L, mass M and resistance R is moving in the XY plane with its edges parallel to the X and Y axes. The region y ≥ 0 has a uniform magnetic field, $\vec{B} = B_0\hat{k}$ The magnetic field is zero everywhere else. At time t = 0, the loop starts to enter the magnetic field with an initial velocity $v_0\hat{j}$ m/s, as shown in the figure. Considering the quantity $K = \frac{B_0^2 L^2}{RM}$ in appropriate units, ignoring self-inductance of the loop and gravity, which of the following statements is/are correct:

[JEE Adv, 2025]



(*a*) If $v_0 = 1.5KL$, the loop will stop before it enters completely inside the region of magnetic field.

(*b*) When the complete loop is inside the region of magnetic field, the net force acting on the loop is zero.

(*c*) If $v_0 = \frac{KL}{10}$, the loop comes to rest at $t = \left(\frac{1}{K}\right) ln\left(\frac{5}{2}\right)$

(*d*) If $v_0 = 3KL$, the complete loop enters inside the region of magnetic field at time $t = \left(\frac{1}{K}\right) ln\left(\frac{3}{2}\right)$.

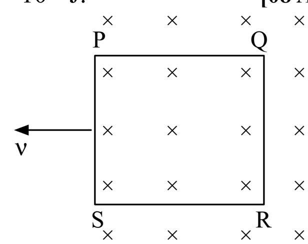
Induced emf in a Moving Rod in Uniform Magnetic Field

11. A horizontal straight wire 5 m long extending from east to west falling freely at right angle to horizontal component of earth's magnetic field 0.60×10^{-4} Wbm^{-2}. The instantaneous value of emf induced in the wire when its velocity is 10 ms^{-1} is ______ × 10^{-3} V. **[29 Jan, 2024 (Shift-II)]**

12. A ceiling fan having 3 blades of length 80 cm each is rotating with an angular velocity of 1200 rpm. The magnetic field of earth in that region is 0.5 G and angle of dip is 30º. The emf induced across the blades is N$\pi \times 10^{-5}$ V. The value of N is __________ . **[30 Jan, 2024 (Shift-I)]**

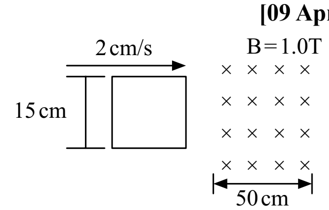
13. A rectangular loop of sides 12 cm and 5 cm, with its sides parallel to the x-axis and y-axis respectively moves with a velocity of 5 cm/s in the positive x axis direction, in a space containing a variable magnetic field in the positive z direction. The field has a gradient of 10^{-3}T/cm along the negative x direction and it is decreasing with time at the rate of 10^{-3} T/s. If the resistance of the loop is 6 mΩ, the power dissipated by the loop as heat is _____ × 10^{-9} W. **[1 Feb, 2024 (Shift-I)]**

14. A square loop PQRS having 10 turns, area 3.6×10^{-3} m^2 and resistance 100 Ω is slowly and uniformly being pulled out of a uniform magnetic field of magnitude $B = 0.5$ T as shown. Work done in pulling the loop out of the field in 1.0 s is _______ × 10^{-6} J. **[08 April, 2024 (Shift-I)]**



15. A square loop of side 15 cm being moved towards right at a constant speed of 2 cm/s as shown in figure. The front edge enters the 50 cm wide magnetic field at t = 0. The value of induced emf in the loop at $t = 10$ s will be:

[09 April, 2024 (Shift-II)]



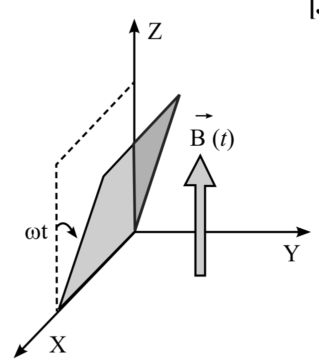
(*a*) 0.3 mV (*b*) 4.5 mV (*c*) zero (*d*) 3 mV

. **16.** A wire of length 1m is moving with a velocity of 8m/s at right angles to a magnetic field of 2T. The magnitude of induced emf, between the ends of wire the will be

[25 Jan, 2023 (Shift-II)]

(*a*) 20 V (*b*) 8 V (*c*) 12 V (*d*) 16 V

17. A conducting square loop initially lies in the XZ plane with its lower edge hinged along the X-axis. Only in the region y ≥ 0, there is a time dependent magnetic field pointing along the z-direction, $\vec{B}(t) = B_0(\cos\omega t)\hat{k}$, where B_0 is a constant. The magnetic field is zero everywhere else. At time $t = 0$, the loop starts rotating with constant angular speed ω about the X axis in the clockwise direction as viewed from the +X axis (as shown in the figure). Ignoring self-inductance of the loop and gravity, which of the following plots correctly represents the induced e.m.f. (V) in the loop as a function of time: **[JEE Adv, 2025]**



Answer Key

JEE Main Corner

1. (*a*)	**2.** (*d*)	**3.** (*d*)	**4.** (*d*)	**5.** (*c*)	**6.** (*d*)	**7.** (*d*)	**8.** (*a*)	**9.** (*b*)	**10.** (*b*)
11. (*a*)	**12.** (*d*)	**13.** (*c*)	**14.** (*b*)	**15.** (*c*)	**16.** (*a*)	**17.** (*c*)	**18.** (*a*)	**19.** (*a*)	**20.** (*b*)
21. (*d*)	**22.** (*d*)	**23.** (*a*)	**24.** (*c*)	**25.** (*a*)	**26.** (*b*)	**27.** (*c*)	**28.** (*d*)	**29.** (*a*)	**30.** (*d*)
31. (*b*)	**32.** (*c*)	**33.** (*d*)	**34.** (*a*)	**35.** (*b*)	**36.** (*b*)	**37.** (*d*)	**38.** (*d*)	**39.** (*c*)	**40.** (*d*)
41. (*a*)	**42.** (*d*)	**43.** (*a*)	**44.** (*d*)	**45.** (*d*)	**46.** (*c*)	**47.** (*a*)	**48.** (*d*)	**49.** (*b*)	**50.** [3]
51. [1]	**52.** [200]	**53.** [3125]	**54.** [100]	**55.** [2]	**56.** [5]	**57.** [3162]	**58.** [2500]		

JEE Advanced Corner

1. (*a*,*d*)	**2.** (*a*,*c*,*d*)	**3.** (*c*,*d*)	**4.** (*a*,*b*,*c*,*d*)	**5.** (*a*,*b*)	**6.** (*a*,*c*,*d*)	**7.** (*b*,*d*)	**8.** (*c*)	**9.** (*a*)	**10.** (*c*)
11. (*c*)	**12.** (*b*)	**13.** (*d*)	**14.** (*b*)	**15.** (*a*)	**16.** [0.45]	**17.** [5.31]	**18.** [35.00]	**19.** [25.61]	**20.** [6.71]
21. [6.40]	**22.** [119]	**23.** [2]	**24.** [3]	**25.** (*d*)	**26.** (*d*)	**27.** (*a*)	**28.** (*c*)	**29.** (*d*)	**30.** (*b*)
31. (*d*)									

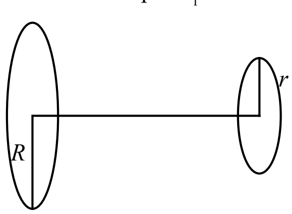
PYQs (Past Year Questions)

1. (*d*)	**2.** [2]	**3.** (*d*)	**4.** (*b*)	**5.** [2]	**6.** (*b*)	**7.** (*a*)	**8.** [60]	**9.** (*b*)	**10.** (*b*,*d*)
11. [3]	**12.** [32]	**13.** [216]	**14.** [3.24]	**15.** (*c*)	**16.** (*d*)	**17.** (*a*)	**18.** (*a*)	**19.** (*a*)	**20.** (*c*)
21. (*b*)	**22.** (*d*)	**23.** [0]	**24.** (*c*)	**25.** (*b*)	**26.** (*d*)	**27.** (*b*)	**28.** (*a*)	**29.** [80]	**30.** (*d*)
31. [2]	**32.** [128]	**33.** (*a*)	**34.** [4]	**35.** (*a*)	**36.** [10]	**37.** (*c*)	**38.** (*c*)	**39.** (*d*)	**40.** [10]
41. (*b*)	**42.** (*b*)	**43.** [25]	**44.** (*c*)	**45.** [144]	**46.** (*a*)	**47.** (*a*)	**48.** [0.63]	**49.** (*a*)	**50.** (*a*)
51. (*a*)	**52.** (*c*)	**53.** (*b*)	**54.** (*a*)	**55.** (*a*)	**56.** (*d*)	**57.** (*d*)	**58.** [1]	**59.** [22]	**60.** (*a*)
61. [3]	**62.** (*d*)	**63.** [1]	**64.** (*a*)	**65.** (*a*)	**66.** [1]	**67.** (*c*)	**68.** (*d*)	**69.** (*d*)	**70.** [50]
71. (*c*)	**72.** (*c*)	**73.** [10]	**74.** (*b*)	**75.** [4]	**76.** (*c*)	**77.** (*c*)	**78.** (*b*)	**79.** (*c*)	**80.** (*c*)
81. (*b*)	**82.** (c)	**83.** (*c*)	**84.** (*d*)	**85.** [250]	**86.** (*c*)	**87.** [900]	**88.** (*a*)	**89.** (*c*)	**90.** (*a*)
91. (*b*)	**92.** [4]	**93.** [400]	**94.** (*c*)	**95.** (*a*)	**96.** [45]	**97.** (*b*)	**98.** (*d*)	**99.** (*c*)	**100.** (*a*)
101. (*a*)									

Explanation

JEE Main Corner

1. (*a*) Let the current in the bigger loop is I_2 and smaller loop in I_1



ϕ_1 be flux due to smaller loop at bigger loop.

ϕ_2 be flux due to bigger loop at smaller loop.

The coefficient of mutual induction b/w loop.

$$M = \frac{\phi_1}{I_1} = \frac{\phi_2}{I_2}$$

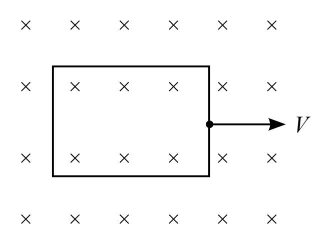
$$\frac{\phi_1}{I_1} = \frac{B_2 A}{I_2} = \frac{\mu_0 R^2 \pi r^2}{2(x^2 + R^2)^{\frac{3}{2}}}$$

$$\phi_1 = \frac{\mu_0 I_1 R^2 (\pi r^2)}{2(x^2 + R^2)^{\frac{3}{2}}}$$

$$\therefore \phi_1 = \frac{\mu_0 \times 2 \times (20 \times 10^{-2})^2}{2[(0.02)^2 + (0.12)^2]^{\frac{3}{2}}} \times \pi \times (0.3 \times 10^{-2})^2$$

$= 9.1 \times 10^{-11}$ wb

2. (*d*) As flux is not changing with Respect to time



$\phi = BA$

$$\varepsilon = \frac{d\phi}{dt} = 0$$

$\varepsilon = 0$

Current = 0

3. (*d*) When the switch in closed current will flow from +ve to –ve terminal. Due to this current a magnetic field will produce. This will cause an induced current in the loop due to Lenz's law. The induced current will be such that it opposes the increase in magnetic flux, so induced current will be in clock wise Direction,

Similarly when the circuit is opened the magnetic field decreases.

Hence induced current will be in –ve Direction.

4. (*d*) Area vector & $\vec{B}$ are $\perp$

Hence $\phi = BA\cos 90°$

$\phi = 0$

Emf = 0

$I = 0$

5. (*c*) Fact based.

6. (*d*) Flux through the loop only changes when it enters and when it leaves the field, when it is fully inside the field or fully outside the field flux doesn't change

Therefor while entering or leaving the field acceleration of loop is less than *g*.

7. (*d*) $\phi = 6t^2 - 5t + 1$

$$\text{Emf} = -\frac{d\phi}{dt}$$

$= -(12t - 5)$

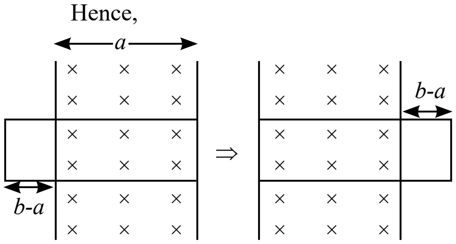
$\Rightarrow \varepsilon_{0.25} = 2\text{Volt}$

$$I = \frac{V}{R} = \frac{2}{10} = 0.2 \text{ Amp}$$

8. (*a*) If bar magnet is falling vertically through the hollow region of long vertical copper tube then the magnetic flux linked with the copper tube (due to 'non-uniform' magnetic field of magnet) changes and eddy currents are generated in the body of the tube by Lenz's law. The eddy currents oppose the falling of the magnet which therefore experiences a retarding force. The retarding force increases with increasing velocity of the magnet and finally equals the weight of the magnet. The magnet then attains a constant final terminal velocity i.e. magnet ultimately falls with zero acceleration in the tube.

9. (*b*) Emf induced in the circuit only when the magnetic flux will change

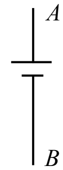
Hence,



total time = time of entry + time of exit

$\Rightarrow a/v + a/v = \left(\frac{2a}{v}\right)$.

10. (*b*) Induced current developed in such a way that it try to oppose the change. Therefor emf generated like



therefore *A* becomes +ve charge.

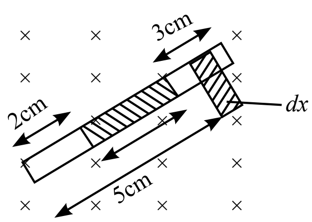
11. (*a*) W = Power × time

$$\Rightarrow \frac{(BV\ell)^2}{R} \times t = \frac{B^2\ell^2V^2}{R} \times t$$

$$v = 1\text{ms}^{-1}\ \frac{B^2\ell^2V^2}{R} \times t = \frac{1^2 \times 1^4}{1 \times 1} = 1\text{ J}$$

12. (*d*) Fact based.

13. (*c*) $\text{Emf} = \int_{0.07}^{0.1} B.\omega.\, x\, dx$

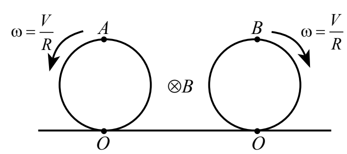


$$= \frac{B\omega}{2}\left[(0.1)^2 - (0.07)^2\right]$$

$$\frac{B\omega}{2}\left[\frac{1}{100} - \frac{49}{10000}\right] \Rightarrow 0.051 \text{ V}$$

14. (*b*) Fact based

15. (*c*)



O is the instantaneous centre of rotation of both the rings.

$$V_O - V_B = \frac{1}{2}B\omega(2R)^2$$

$= 2B\omega R^2$

$= 2VBR$

$V_A - V_O = 2VBR$

So, $V_A - V_B = (V_A - V_O) + (V_O - V_B)$

$= 4VBR$

16. (*a*) Effective length of the rod that create EMF due to *z* component of the field.

$l = 5\sin(53) = 4\text{m}$

Emf = $BVL = 4 \times 2 \times 4 = 32$ V

Emf due to *Y* component of field is *O* because

$$Emf = \frac{d(B.(A))}{dt} = B.\left(\frac{dA}{dt}\right)$$

and $\frac{dA}{dt} = 0 \Rightarrow \text{Emf} = 0$

17. (*c*) $E_{Oa} = \frac{1}{2}Br^2\omega = \frac{1}{2}B\left(\frac{L}{5}\right)^2\omega$

$$E_{ob} = \frac{1}{2}B\left(\frac{4L}{5}\right)^2\omega$$

$$E_{ab} = E_{ob} - E_{oa} = \frac{1}{2}B\omega\left(\frac{16}{25} - \frac{1}{25}\right)L^2$$

$$= \frac{3B\omega L^2}{10}$$

18. (*a*) According to the question

$\frac{dB}{dt}$ = constant = B_0

If $r < R$

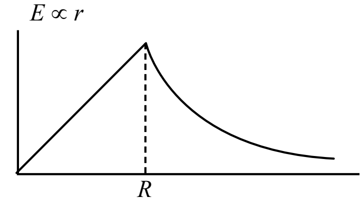
Let at distance *r* the induced electric field is *E*.

$$\text{emf} = \oint E.dr = \left|\frac{-dr}{dt}\right|$$

$$E.2\pi r = \left|\frac{-d[B.\pi r^2]}{dt}\right|$$

$$E = \frac{B_0 r}{2}$$

$E \propto r$



If $r > R$ $E = \frac{B_0R^2}{2r}$

$$E \propto \frac{1}{r}$$

19. (*a*) Induced electric field is anti-clockwise and potential decreases in the direction of electric field so point *P* will be at higher potential than point *Q*.

20. (*b*) As the magnet is moving under gravity the flux link with the copper tube will change because of motion of magnet this will product eddy current in the body of the copper tube and this induced current oppose the fall of the magnet so if it will increase with increase in velocity and after some time net force on the magnet will become zero and then it start moving with constant velocity.

21. (*d*) Consider a small elementary ring of radius r and thickness dr

Flux through the ring $d\phi = B\pi r^2\ dN$,

where $dN = \frac{N}{R}dr$

by integrating we get flux $\phi = \frac{N\pi R^2 B}{3}$

$\varepsilon = \frac{d\phi}{dt}$, whose peak value is $\frac{N\pi R^2 B_0\omega}{3}$

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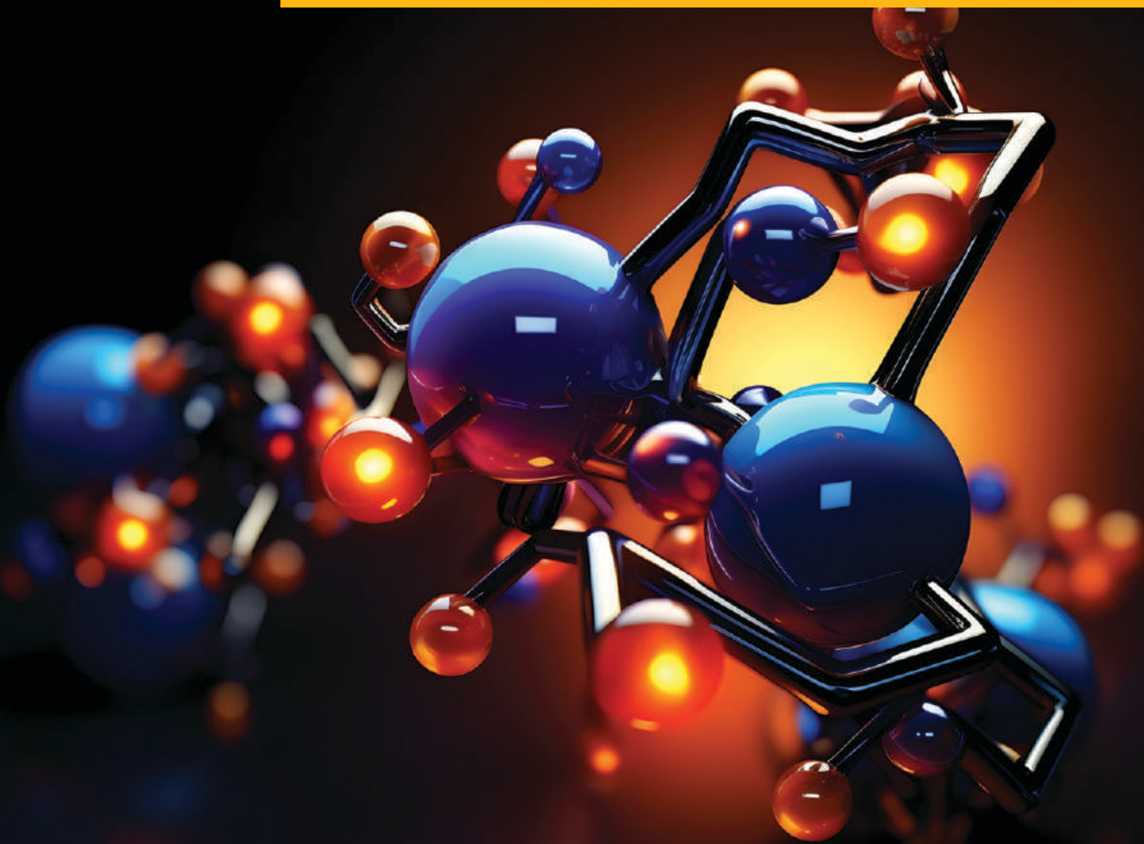

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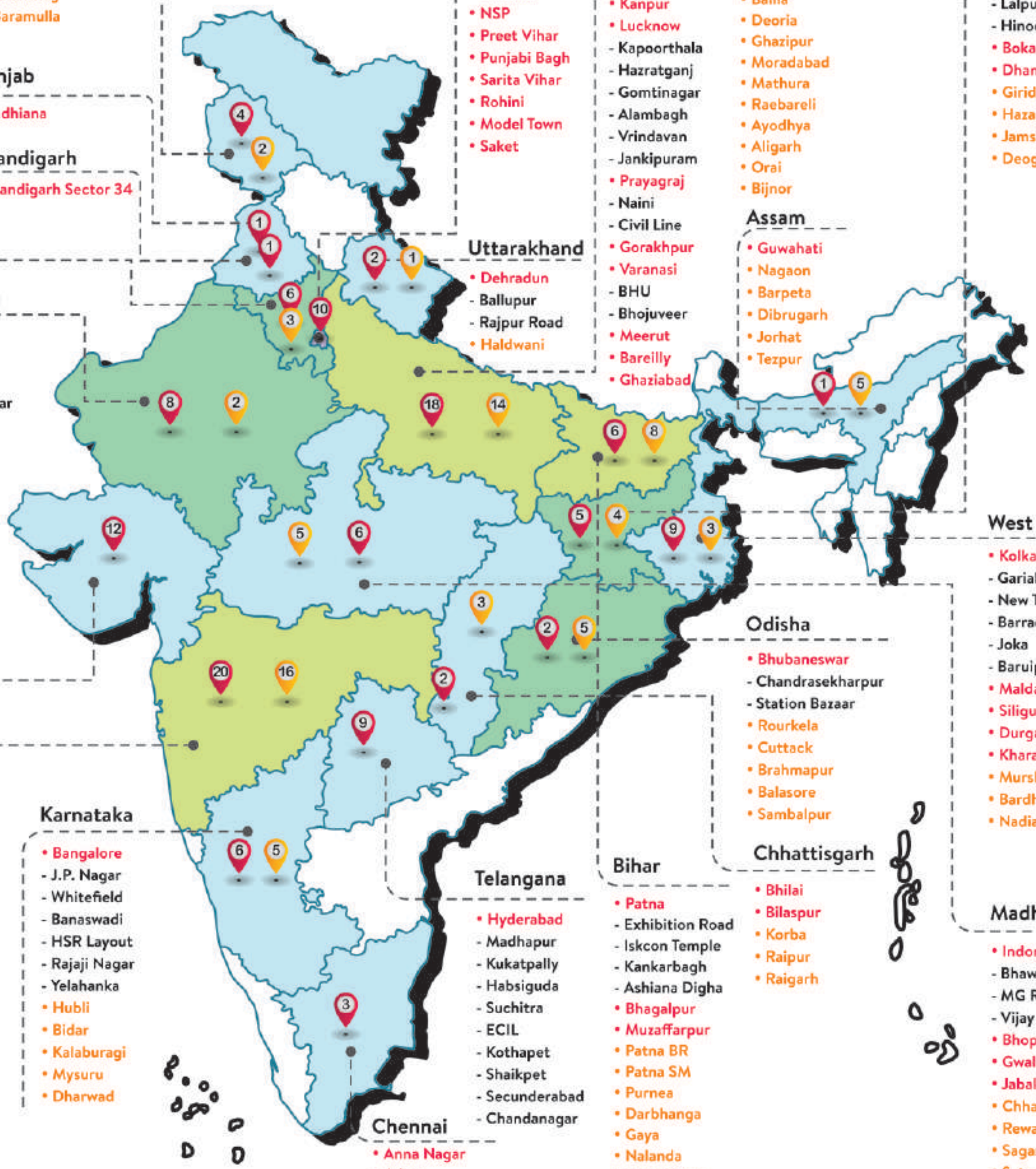

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  - Civil Line
- Gorakhpur
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  - Harmu
  - Lalpur
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- Dhanbad
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- Hazaribagh
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