PHYSICS

Study Material for NEET preparation

Prepared by Career Point Kota Experts

CAREER POINT

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Features of The Product

This study material is especially designed for NEET aspirants. The entire study material is arranged in such a way so that the learning process progresses gradually from the basic to advanced stages. This easy-to-grasp material enables students to apply the fundamentals they have learned and boost their confidence to tackle the problems asked in the NEET and other medical competitive examinations.

Key Features of the Chapter

Theory & Concepts

Theory provides all the basic concepts in clear and precise manner. It comprises all the related and required diagrams, tables, graphs, real life examples, info graphics, conceptual questions that makes it more comprehensive. It also highlights tips and tricks, facts, notes, misconceptions, key points, and problem solving tactics.

ELECTRO MAGNETIC INDUCTION

KEY CONCEPT

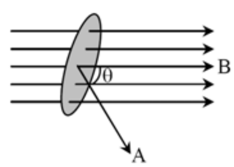
1. Magnetic Flux

(a) The number of lines of flux passing through an area held perpendicular to the field is equal to the magnetic flux linked with that plane.

(b) Mathematically, magnetic flux is the product of the field and the area of the plane. i.e.

$$\phi = \vec{B}.\vec{A} = BA\cos\theta$$

is the angle between Magnetic induction and area vector (area vector is perpendicular to the plane of the area).



(c) This is a scalar quantity.

(d) Unit : MKS - weber or Tesla-m^2
or N-m /amp.
CGS - Maxwell or Gauss-cm^2
1 weber (wb) = 1 Tesla-m^2
$= 1 \times 10^8$ Maxwell $= 10^8$ Gauss-cm^2

Note: **(i) weber** $= \dfrac{\text{newton}}{\text{amp.m}} \times m^2 = \dfrac{\text{newton .m}}{\text{amp}}$

$= \dfrac{\text{joule}}{\text{amp}} = \dfrac{\text{volt} \times \text{coul}}{\text{amp}}$

$= \dfrac{\text{volt} \times \text{amp .sec}}{\text{amp}}$ **= volt.sec.**

(ii) weber $= \dfrac{\text{volt} \times \text{coul}}{\text{amp}}$ **= ohm-coul.**

(iii) weber = volt-sec

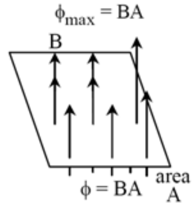
$= \dfrac{\text{volt}}{\text{amp / sec}} \times$ **amp = henry-amp.**

(e) Dimension : [$ML^2 T^{-2} A^{-1}$]

(f) Net flux leaving a surface $= \phi = \oint \vec{B}.d\vec{s}$

(g) If = 0 i.e. area is held perpendicular to the Magnetic lines of force, then flux from the surface is maximum.

$\phi_{max} = BA$



(h) If $\theta = 90^o$ i.e. area is held parallel to lines of force, then flux from the surface is zero. i.e. $\phi = BA\cos 90^o = 0$

(i) Net flux linked with a closed surface is zero. i.e.

$$\phi = \oint \vec{B}.d\vec{s} = 0$$

WHY ? This is because
Magnetic lines of force are closed curves. So the number of lines entering a closed surface is equal to the number of lines leaving the surface. Hence net flux = 0.

(j) Flux linked with a surface depends on the following quantities :
(i) Intensity of magnetic field B.
(ii) Area of the surface A.
(iii) Orientation of surface relative to magnetic field.

Ex.1 At certain location in the northern hemisphere, the earth's magnetic field has a magnitude of 42 μT and points down ward at 57^o to vertical. The flux through a horizontal surface of area 2.5 m^2 will be-
(given cos $33^o = 0.839$, cos $57^o = 0.545$)
(1) 42×10^{-6} Wb (2) 42×10^{-6} Wb/m^2
(3) 57×10^{-6} Wb (4) 57×10^{-6} Wb/m^2

Sol. (3) The flux through the area is
$\phi = BA\cos 57^o = 42 \times 10^{-6} \times 2.5 \times 0.545$
$= 57 \times 10^{-6}$ Wb.

2. Faraday's Laws of Electromagnetic Induction

(a) Whenever the number of magnetic lines of force or magnetic flux passing through a circuit changes an emf is produced in the circuit called induced emf.

(b) If the circuit is closed a current flows through it called induced current.

(c) The induced emf is given by rate of change of magnetic flux linked with the circuit i.e.

$$e = \frac{d\phi}{dt} \quad \text{or} \quad e = \frac{d(N\phi)}{dt}$$

where e = induced emf
N = Total number of turns.

(d) emf is induced in the circuit only till there is a change in the flux linked with it.

(e) From $e = \dfrac{d\phi}{dt}$, we can say that 1 Volt $= \dfrac{1wb}{sec}$

3. Lenz's Law

(a) This gives the direction of induced emf.

(b) According to this law, the direction of induced emf or current in the coil in such a way such as to oppose the change that produces it.

(c) From Lenz's law and Faraday's Law, induced emf is given by $e = -\dfrac{d\phi}{dt}$, Where minus sign is to show that emf opposes the change of flux linked with it.

(d) This law is based upon Law of conservation of energy.

In Chapter Examples

To clarify the application of theory & concept accurately & correctly, there is number of solved in-chapter questions follpowng each topic. It proves practically very effective to understand and correct application of related theory.

Ex.3 A rectangular coil of size 10 cm × 20 cm has 60 turns. It is rotating in magnetic field 0.5 Wb/m^2 with a rate of 1800 revolutions per minutes. The maximum induced e.m.f. across the ends of the coil is-

(1) 111 V (2) 112 V (3) 113 V (4) 114 V

Sol. (4) Given, area = $10 \times 20\ cm^2 = 200 \times 10^{-4}\ m^2$

B = 0.5 T

N = 60

$\omega = 2\pi \times 1800/60$

$\because e = -\frac{d(N\phi)}{dt} = -N\frac{d}{dt}(BA\cos\omega t)$

$= NBA\omega \sin\omega t$

$\therefore e_{max} = NAB\omega$

$= 60 \times 2 \times 10^{-2} \times 0.5 \times 2\pi \times 1800/60$

= 113 volt.

Ex.4 A closed coil of copper whose area is 1m x 1m is free to rotate about an axis. The coil is placed perpendicular to a magnetic field of 0.10 Wb/m^2. It is rotated through 180° in 0.01 second. The induced e.m.f. and induced current in the coil will respectively be-

(The resistance of the coil is 2.0 Ω)

(1) 20 V, 10A (2) 10 V, 20 A

(3) 10 V, 10 A (4) 20 V, 20 A

Sol. (1) The change is flux linked with the coil on rotating it through 180° is

$= nAB - (-nAB) = 2nAB$

$\therefore$ induced e.m.f. $= -\frac{d\phi}{dt}$

$= 2nAB/dt$ (numerically) $= \frac{2 \times 1 \times 0.1}{0.01} = 20$ V

The coil is closed and has a resistance of 2.0 Ω. Therefore i = 20/2 = 10A.

Points To Remember

This part contain important Theories, concepts, formulas of chapter at one place in short manner, So that student can revise all these in short time.

POINTS TO REMEMBER

1. The unit of magnetic flux ϕ is weber. Since $B = \phi/A$, so the unit of magnetic field is also expressed as 'weber/meter^2'. That is why the magnetic field induction B is also called the 'magnetic flux density'. As we have read, the unit of B is also newton /(ampere-meter).
2. C.G.S. unit of flux is Maxwell. 1 weber = 10^8 Maxwell.
3. 1 weber/m^2 = 1 Tesla.
4. If a plane is parallel to the magnetic field, then no flux-line will pass through it and the magnetic flux linked with that plane will be zero.
5. Magnetic flux can change in a number of ways, Some of them are-
   (i) If a coil with plane area A be kept perpendicular to a magnetic field B, then the magnetic flux linked with the coil will be $\phi_1 = BA$.
   (ii) If the coil is suddenly withdrawn from the magnetic field, then the magnetic flux linked with the coil will become $\phi_2 = 0$. Hence, the change in flux
   $\Delta\phi = \phi_2 - \phi_1 = 0 - BA = -BA$
   (iii) If the coil be rotated through 90° in the magnetic field, then also the magnetic flux linked with the coil will become zero and the change in flux will again be BA.
   (iv) If the coil be rotated through 180° (half-turn), then the magnetic flux will become - BA and the change in flux will be $\Delta\phi = (-BA - BA) = -2BA$.
6. The use of the conducting copper ring for the coil in the dead-beat galvanometer closely follows the Lenz's law, as the induced current in the ring opposes the relative motion of the coil with respect to the magnetic field, and due to which the current is induced.
7. In a motor, (a) the current at start is I = E/R; (b) the current at full speed is, I = (E – e)/R; (c) the current at switch off is, I = – e/R, where e = back e.m.f., R = armature resistance, E = e.m.f. of battery.

Solved Examples

To understand the concept application, in end of the each chapter there is suffiecient number of solved examples.

SOLVED EXAMPLES

Ex.1 A loop of wire is placed in a magnetic field $\vec{B} = 0.02\hat{i}$ tesla. Then the flux through the loop is its area vector is $\vec{A} = 30\hat{i} + 16\hat{j} + 23\hat{k}$ cm^2, is .

(1) 60μW (2) 32μ Wb
(3) 46μ Wb (4) 138μ Wb

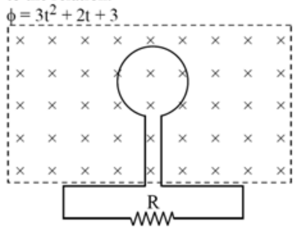
Sol.(1) $\phi = \vec{B} . \vec{A}$

$= (0.02\hat{i}) . (30\hat{i} + 16\hat{j} + 23\hat{k}) \times 10^{-4}$

$= 0.6 \times 10^{-4}$ Wb $= 60\mu$ Wb

Ex. 2 The magnetic flux passing perpendicular to the plane of the coil and directed into the paper is varying according to the relation.

$\phi = 3t^2 + 2t + 3$



Where ϕ is in milliwebers and t is in seconds. Then the magnitude of emf induced in the loop when t = 2 second is-

(1) 31 mV (2) 19 mV (3) 14 mV (4) 6 mV

Sol.(3) The induced emf

$E = -d\phi/dt = -\frac{d}{dt}(3t^2 + 2t + 3) \times 10^{-3}$

(because given flux is in mWb).

Thus $E = (-6t - 2) \times 10^{-3}$

at t = 2 sec,

$E = (-6 \times 2 - 2) \times 10^{-3} = -14$ mV.

Ex.4 A gramophone disc of brass of diameter 30 cm rotates horizontally at the rate of 100/3 revolutions per minute. If the vertical component of the earth's magnetic field be 0.01 weber / $meter^2$, then the emf induced between the centre and the rim of the disc will be-

(1) 7.065×10^{-4} V (2) 3.9×10^{-4} V
(3) 2.32×10^{-4} V (4) none of the above.

Sol. (2) Magnetic flux passing through the disc is $\phi = BA$

$= 0.01 \frac{weber}{meter^2} \times 3.14 \times (15 \times 10^{-2}\ meter)^2$

$= 7.065 \times 10^{-4}$ weber.

The line joining the centre and the circumference of the disc cuts 7.065×10^{-4} weber flux in one round. So, the rate of cutting flux (i.e. induced emf)

= flux x number of revolutions per second

$= 7.065 \times 10^{-4} \times \frac{100}{60 \times 3} = 3.9 \times 10^{-4}$ volt.

Ex.5 A closed coil consists of 500 turns on a rectangular frame of area 4.0 cm^2 and has a resistance of 50 ohm. The coil is kept with its plane perpendicular to a uniform magnetic field of 0.2 weber/$meter^2$. The amount of charge flowing through the coil if it is turned over (rotated through 180°) will be -

(1) 1.6×10^{-19} C (2) 1.6×10^{-9} C
(3) 1.6×10^{-3} C (4) 1.6×10^{-2} C

Sol. (3) The magnetic flux passing through each turn of a coil of area A, perpendicular to a magnetic field B is given by

$\phi_1 = BA.$

The magnetic flux through it on rotating it through 180° will be

$\phi_2 = -BA.$(– sign is put because now the flux lines enters the coils through the outer face)

∴ change in magnetic flux

Practice Exercises

Exercise Level -1 : It contains TOPIC WISE single objective correct (SCQ) type concept building questions.

Exercise Level -2: It contains single objective type good quality questions on all the concepts of the chapter in mixed manner.

EXERCISE # 2

Q.1 The coefficient of mutual inductance of two circuits A and B is 3 mH and their respective resistances are 10 ohm and 4 ohm. How much current should change in 0.02 second in the circuit A. So that the induced current in B should be 0.006 ampere-

(1) 0.24 amp (2) 1.6 amp
(3) 0.18 amp (4) 0.16 amp

Q.2 The coefficient of self inductance is 5 mH. If the emf of the cell in the circuit is 1.1 volt and at any instant the rate of increase of current is 6 ampere/second, then at that instant, the resultant e.m.f. in the circuit will be-

(1) 1.13 V (2) 0.13 V (3) 1.07 V (4) 1.4 V

Q.3 The phase difference between the flux linkage and the induced e.m.f. in a rotating coil in a uniform magnetic field is-

(1) π (2) π/2 (3) π/4 (4) π/6

Q.4 A dynamo is sometimes said to generate electricity. It actually acts as a source of-

(1) charge (2) magnetism
(3) e.m.f. (4) energy

Q.5 In a step-down transformer the number of turns in-

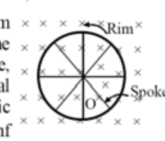
(1) primary are less
(2) primary are more
(3) primary and secondary are equal
(4) primary are infinite

Q.11 A closed coil of copper whose area is 1m × 1m is free to rotate about an axis. The coil is placed perpendicular to a magnetic field of 0.10 Wb/m^2. It is rotated through 180° in 0.01 second. The induced e.m.f. and induced current in the coil will respectively be-

(The resistance of the coil is 2.0 Ω)

(1) 20 V, 10A (2) 10 V, 20 A
(3) 10 V, 10 A (4) 20 V, 20 A

Q.12 A bicycle wheel of radius 0.5 m has 32 spokes. It is rotating at the rate of 120 revolutions per minute, perpendicular to the horizontal component of earth's magnetic field $B_H = 4 \times 10^{-5}$ Tesla. The emf induced between the rim and the centre of the wheel will be-



(1) 6.28×10^{-5} V (2) 4.8×10^{-5} V
(3) 6.0×10^{-5} V (4) 1.6×10^{-5} V

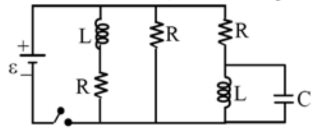
Q.13 The current in a coil varies with respect to time t as $I = 3t^2 + 2t$. If the inductance of coil be 10 mH, the value of induced e.m.f. at t = 2s will be-

(1) 0.14 V (2) 0.12 V (3) 0.11 V (4) 0.13 V

Q.14 If circular coil with N_1 turns is changed in to a coil of N_2 turns. What will be the ratio of self inductances in

Exercise Level -3 : It contains previous years NEET exam quesiotns from 2005 to upto to present year.

Q.48 Figure shows a circuit that contains three identical resistors with resistance R = 9.0 Ω each, two identical inductors with inductance L = 2.0 mH each, and an ideal battery with emf ε = 18 V. The current 'I' through the battery just after the switch closed is,…….. **[NEET-2017]**



(1) 0 ampere (2) 2 mA
(3) 0.2 A (4) 4 A

(1) 1.5 A (2) 1 A (3) 2 A (4) 0.25 A

Q.55 The magnetic flux linked to a circular coil of radius R is:

$\phi = 2t^3 + 4t^2 + 2t + 5$ Wb

The magnitude of induced emf in the coil at t = 5 s is: **[Re-NEET-2022]**

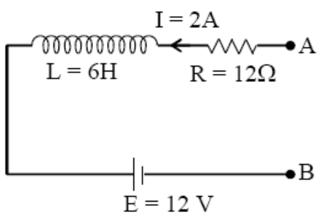
(1) 192 V (2) 108 V (3) 197 V (4) 150 V

Q.56 The magnetic energy stored in an inductor of inductance 4 μH carrying a current of 2 A is : **[NEET-2023]**

(1) 8 μJ (2) 4 μJ (3) 4 mJ (4) 8 mJ

Exercise Level -4 : It contains previous years JEE Mains exam quesiotns from 2005 to upto to present year.

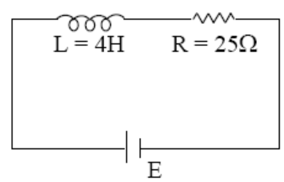
Q.44



As per the given figure, if $\frac{dI}{dT} = -1$ A/s then the value of V_{AB} at this instant will be ______V. **[JEE Main 2023]**

Q.45 A square loop of side 2.0 cm is placed inside a long solenoid that has 50 turns per centimetre and carries a sinusoidally varying current of amplitude 2.5 A and angular frequency 700 rad s^{-1}. The central axes of the loop and solenoid coincide. The amplitude of the emf induced in the loop is $x \times 10^{-4}$ V. The value of x is ________. (Take, $\pi = \frac{22}{7}$) **[JEE Main 2023]**

Q.46 In the given figure, an inductor and resistor are connected in series with a battery of emf E volt. $\frac{E^a}{2b}$ J/s represents the maximum rate at which the energy is stored in the magnetic field (inductor). The numerical value of $\frac{b}{a}$ will be ______. **[JEE Main 2023]**



Answer key

Above mentioned all exercises provided with answer key

ANSWER KEY

EXERCISE-1

Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	2	4	1	1	4	3	3	4	4	4	1	4	4	3	4	1	2	3	2	1
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	4	1	1	3	1	2	2	2	2	4	3	2	2	2	3	4	1	1	3	4
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	1	3	4	1	1	1	4	3	4	2	2	2	3	3	3	3	4	1	4	3
Q.No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78		
Ans.	3	2	1	3	2	2	2	1	2	1	3	1	1	2	3	1	2	2		

Revision Plan

We emphasis that every student should prepare his/her own revision plan. For this purpose there is Revision Plan Section in each chapter which student should prepare while going thorugh the study material. This will be useful at the time of final revision before final exam for quick & effective revision.

Revision Plan

Prepare Your Revision plan today!

After attempting Exercise Sheet, please fill below table as per the instruction given.

A. Write Question Number (QN) which you are unable to solve at your own in **column A**.

B. After discussing the Questions written in **column A** with faculty, strike off them in the manner so that you can see at the time question number during Revision, to solve such questions again.

C. Write down the Question Number you feel are important or good in the **column B**.

EXERCISE	COLUMN A	COLUMN B
	Questions unable to solve in first attempt	Good or Important questions
Exercise-1		
Exercise-2		
Exercise-3		
Exercise-4		

Online Solutions

Self explanatory and detailed soltuion of all excercises mentioned above are available on Career Point website **www.careerpoint.ac.in**

ELECTRO MAGNETIC INDUCTION

EXERCISE-1

Answer Key & Solution

Question Number	Solution	Question Number	Solution	Question Number	Solution	Question Number	Solution
1	Click Here	21	Click Here	41	Click Here	61	Click Here
2	Click Here	22	Click Here	42	Click Here	62	Click Here
3	Click Here	23	Click Here	43	Click Here	63	Click Here
4	Click Here	24	Click Here	44	Click Here	64	Click Here
5	Click Here	25	Click Here	45	Click Here	65	Click Here
6	Click Here	26	Click Here	46	Click Here	66	Click Here
7	Click Here	27	Click Here	47	Click Here	67	Click Here
8	Click Here	28	Click Here	48	Click Here	68	Click Here
9	Click Here	29	Click Here	49	Click Here	69	Click Here
10	Click Here	30	Click Here	50	Click Here	70	Click Here
11	Click Here	31	Click Here	51	Click Here	71	Click Here
12	Click Here	32	Click Here	52	Click Here	72	Click Here
13	Click Here	33	Click Here	53	Click Here	73	Click Here
14	Click Here	34	Click Here	54	Click Here	74	Click Here
15	Click Here	35	Click Here	55	Click Here	75	Click Here
16	Click Here	36	Click Here	56	Click Here	76	Click Here
17	Click Here	37	Click Here	57	Click Here	77	Click Here
18	Click Here	38	Click Here	58	Click Here	78	Click Here
19	Click Here	39	Click Here	59	Click Here		
20	Click Here	40	Click Here	60	Click Here		

ELECTRO MAGNETIC INDUCTION

NEET SYLLABUS

1. *Faraday's law of electromagnetic induction.*

2. *Lenz's law.*

3. *Induced emf.*

4. *Self and mutual inductance.*

Revision Plan

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After attempting Exercise Sheet, please fill below table as per the instruction given.

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B. After discussing the Questions written in **column A** with faculty, strike off them in the manner so that you can see at the time question number during Revision, to solve such questions again.

C. Write down the Question Number you feel are important or good in the **column B**.

EXERCISE	COLUMN A	COLUMN B
	Questions unable to solve in first attempt	Good or Important questions
Exercise-1		
Exercise-2		
Exercise-3		
Exercise-4		

Revision Strategy:

Whenever you wish to revision this chapter, follow the following steps-

Step-1: Review your theory notes.

Step-2: Solve Questions of column A

Step-3: Solve Questions of Column B

Step-4: Solve questions from other Question Bank, Problem book etc.

ELECTRO MAGNETIC INDUCTION

KEY CONCEPT

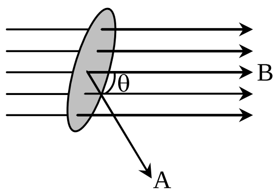
1. Magnetic Flux

(a) The number of lines of flux passing through an area held perpendicular to the field is equal to the magnetic flux linked with that plane.

(b) Mathematically, magnetic flux is the product of the field and the area of the plane. i.e.

$$\phi = \vec{B}.\vec{A} = BA\cos\theta$$

is the angle between Magnetic induction and area vector (area vector is perpendicular to the plane of the area).



(c) This is a scalar quantity.

(d) Unit : MKS - weber or Tesla-m^2

or N-m /amp.

CGS - Maxwell or Gauss-cm^2

1 weber (wb) = 1 Tesla-m^2

$= 1 \times 10^8$ Maxwell $= 10^8$ Gauss-cm^2

Note: **(i) weber** $= \dfrac{\textbf{newton}}{\textbf{amp.m}} \times \textbf{m}^2 = \dfrac{\textbf{newton .m}}{\textbf{amp}}$

$= \dfrac{\textbf{joule}}{\textbf{amp}} = \dfrac{\textbf{volt} \times \textbf{coul}}{\textbf{amp}}$

$= \dfrac{\textbf{volt} \times \textbf{amp .sec}}{\textbf{amp}}$ **= volt.sec.**

(ii) weber $= \dfrac{\textbf{volt} \times \textbf{coul}}{\textbf{amp}}$ **= ohm-coul.**

(iii) weber = volt-sec

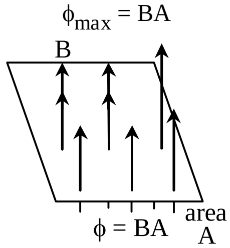
$= \dfrac{\textbf{volt}}{\textbf{amp / sec}}$ **× amp = henry-amp.**

(e) Dimension : [$ML^2\,T^{-2}\,A^{-1}$]

(f) Net flux leaving a surface $= \phi = \oint \vec{B}.d\vec{s}$

(g) If = 0 i.e. area is held perpendicular to the Magnetic lines of force, then flux from the surface is maximum.

$\phi_{max} = BA$



(h) If θ = 90º i.e. area is held parallel to lines of force, then flux from the surface is zero. i.e. $\phi = BA\cos 90º = 0$

(i) Net flux linked with a closed surface is zero. i.e.

$$\phi = \oint \vec{B}.d\vec{s} = 0$$

WHY ? This is because

Magnetic lines of force are closed curves. So the number of lines entering a closed surface is equal to the number of lines leaving the surface. Hence net flux = 0.

(j) Flux linked with a surface depends on the following quantities :

(i) Intensity of magnetic field B.

(ii) Area of the surface A.

(iii) Orientation of surface relative to magnetic field.

Ex.1 At certain location in the northern hemisphere, the earth's magnetic field has a magnitude of 42 μT and points down ward at 57º to vertical. The flux through a horizontal surface of area 2.5 m^2 will be-

(given cos 33º = 0.839, cos 57º = 0.545)

(1) 42×10^{-6} Wb (2) 42×10^{-6} Wb/m^2

(3) 57×10^{-6} Wb (4) 57×10^{-6} Wb/m^2

Sol. (3) The flux through the area is

$\phi = BA\cos 57º = 42 \times 10^{-6} \times 2.5 \times 0.545$

$= 57 \times 10^{-6}$ Wb.

2. Faraday's Laws of Electromagnetic Induction

(a) Whenever the number of magnetic lines of force or magnetic flux passing through a circuit changes an emf is produced in the circuit called induced emf.

(b) If the circuit is closed a current flows through it called induced current.

(c) The induced emf is given by rate of change of magnetic flux linked with the circuit i.e.

$$e = \frac{d\phi}{dt} \quad \text{or} \quad e = \frac{d(N\phi)}{dt}$$

where e = induced emf

N = Total number of turns.

(d) emf is induced in the circuit only till there is a change in the flux linked with it.

(e) From $e = \dfrac{d\phi}{dt}$, we can say that 1 Volt $= \dfrac{1wb}{sec}$

3. Lenz's Law

(a) This gives the direction of induced emf.

(b) According to this law, the direction of induced emf or current in the coil in such a way such as to oppose the change that produces it.

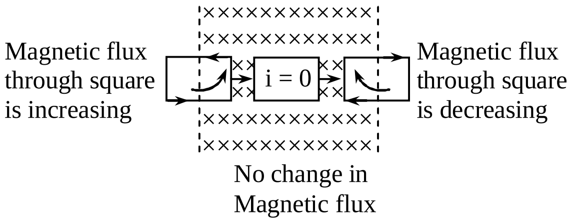
(c) From Lenz's law and Faraday's Law, induced emf is given by $e = -\dfrac{d\phi}{dt}$, Where minus sign is to show that emf opposes the change of flux linked with it.

(d) This law is based upon Law of conservation of energy.

(e) Mechanical energy and Magnetic energy get converted into Electrical of energy in this Phenomenon called electromagnetic induction.

Problems :

(i)

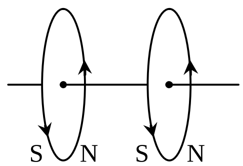


(ii) Case 1 : brought closer $\rightarrow \leftarrow$

$\Rightarrow$ Current in both will decrease

Case 2 : brought apart $\leftarrow \rightarrow$

$\Rightarrow$ Current in both will increase.



(iii) Case 1 : brought closer $\rightarrow \leftarrow$

$\Rightarrow$ Current in both will increase

Case 2 : brought apart $\leftarrow \rightarrow$

$\Rightarrow$ Current in both will decrease

Ex.2 A coil of metal wire is stationary in a non-uniform magnetic field. Is there any induced e.m.f in coil ?

Sol. No, since magnetic flux is not changing.

4. Some General Points

(a) Induced emf is given by $e = -\dfrac{d\phi}{dt}$

$\because$ Sign is given by Lentz's Law.

(b) If magnetic flux linked with a circuit changes from ϕ_1 to ϕ_2 in time 'Δt' then induced emf

E is given by $E = -\dfrac{(\phi_2 - \phi_1)}{\Delta t}$

(c) If circuit is a closed one, then induced current is given by

$$i = \frac{E}{R} = -\frac{(\phi_2 - \phi_1)}{\Delta t\, R} \text{ amp}$$

or $\quad i = -\dfrac{1}{R}\dfrac{d}{dt}(N\phi)$

(d) Value of induced emf does not depend on the resistance of the circuit.

(e) Value of induced current depends on resistance. i.e. $I \propto \dfrac{1}{R}$

(f) If circuit is open or $R = \infty$, then there will be an induced emf but no current flowing.

(g) Induced current depends on the following-

(a) $i \propto \dfrac{d\phi}{dt}$

(b) $i \propto N$

(c) $i \propto \dfrac{1}{R}$

(h) If dq charge flows due to induction in time 'dt' then

$$i = \frac{dq}{dt} = \frac{1}{R}\frac{d\phi}{dt} \Rightarrow dq = \frac{d\phi}{R}$$

$$\Rightarrow \quad q = \frac{1}{R}\int \frac{d\phi}{dt} = \frac{(\phi_2 - \phi_1)}{R} \text{ (Imp)}$$

(i) This flow of charge is called induced charge.

(j) The charge induced does not depend on the time interval in which flux through the circuit changes. It simply depends on the net change in flux and resistance of the circuit.

Ex.3 A rectangular coil of size 10 cm × 20 cm has 60 turns. It is rotating in magnetic field 0.5 Wb/m^2 with a rate of 1800 revolutions per minutes. The maximum induced e.m.f. across the ends of the coil is-

(1) 111 V (2) 112 V (3) 113 V (4) 114 V

Sol. (4) Given, area = 10 × 20 cm^2 = 200 × 10^{-4} m^2

B = 0.5 T

N = 60

$\omega = 2\pi \times 1800/60$

$\because e = -\dfrac{d(N\phi)}{dt} = -N\dfrac{d}{dt}$ (BA cos ωt)

= NBAω sin ωt

$\therefore e_{max} = NAB\omega$

$= 60 \times 2 \times 10^{-2} \times 0.5 \times 2\pi \times 1800/60$

= 113 volt.

Ex.4 A closed coil of copper whose area is 1m x 1m is free to rotate about an axis. The coil is placed perpendicular to a magnetic field of 0.10 Wb/m^2. It is rotated through 180º in 0.01 second. The induced e.m.f. and induced current in the coil will respectively be-

(The resistance of the coil is 2.0 Ω)

(1) 20 V, 10A (2) 10 V, 20 A

(3) 10 V, 10 A (4) 20 V, 20 A

Sol. (1) The change is flux linked with the coil on rotating it through 180º is

= nAB – (–nAB) = 2nAB

$\therefore$ induced e.m.f. $= -\dfrac{d\phi}{dt}$

= 2nAB/dt (numerically) $= \dfrac{2 \times 1 \times 0.1}{0.01} = 20$ V

The coil is closed and has a resistance of 2.0 Ω. Therefore i = 20/2 = 10A.

Note : **When the coil is opened, the induced e.m.f. is still present in it but the induced current becomes zero.**

Ex.5 A coil having 100 turns and area of 0.001 m^2 is free to rotates about an axis. The coil is placed perpendicular to a magnetic field of 1 Wb/m^2. If the coil is rotates rapidly through an angle of 180º, the charge flown through coil will be-

(The resistance of the coil is 10Ω).

(1) 0.01 C (2) 0.02 C

(3) 0.03 C (4) 0.04 C

Sol. (2) The flux linked with the coil, when the plane of the coil is perpendicular to the magnetic field is.

$\phi = nAB\cos\theta = nAB$

The change in flux on rotating the coil by 180º is $d\phi = nAB - (-nAB) = 2nAB$

$\therefore$ induced charge $= \dfrac{d\phi}{R} = \dfrac{2nAB}{R}$

$\therefore$ induced charge $= \dfrac{2\times100\times0.001\times1}{10} = 0.02$ C

5. No E.M.I. Cases

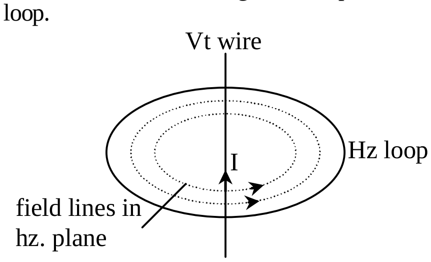
Condition of No EMI. if

$\phi = 0$ (No flux linkage through the coil) $\Rightarrow$ No EMI

ϕ = constant Flux linkage through the coil is constant $\Rightarrow$ No EMI

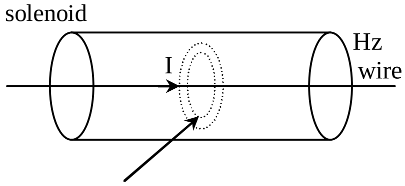
CASES

(i) If current I increases with respect to time, no emf induced in loop because no flux associated with it, as plane of circular field lines of straight wire is parallel to the plane of loop.



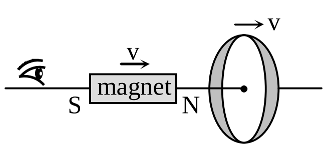
($\phi = 0$)

(ii) If current I increases with respect to time no emf induced in solenoid because no flux associated with solenoid



field lines in Vt plane ($\phi = 0$)

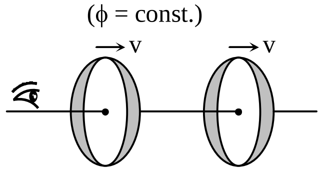
(iii) (a)



No relative motion

(ϕ = const.)

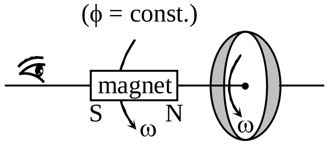
(b)



No relative motion

(ϕ = const.)

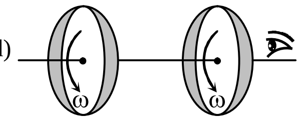
(c)



No relative motion

(ϕ = const.)

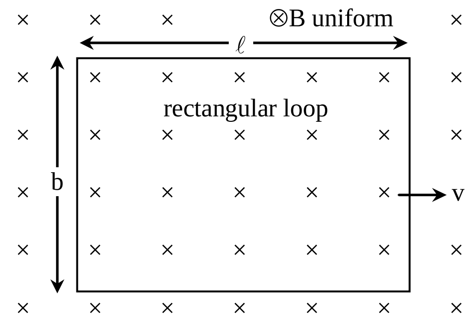
(d)



No relative motion

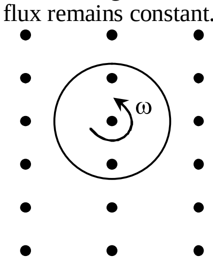
(ϕ = const.)

(iv) Any rectangular coil or loop translates within the uniform transverse magnetic field, no emf induced in it because its flux remains constant.



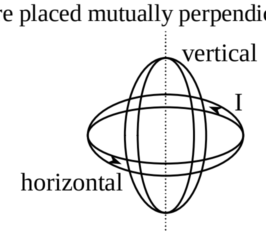
ϕ = constant

(v) Any coil or loop rotates about its geometrical axis in uniform transverse magnetic field, no emf induced in it because its flux remains constant.

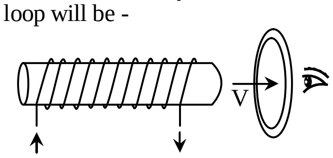


(ϕ = const.)

(vi) If current of one coil (or loop) either increase or decrease, no emf induced in another coil (or loop) because no flux associated for the coils (or loops) which are placed mutually perpendicular.



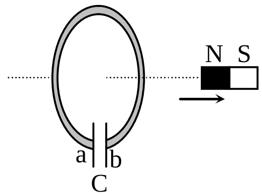
Ex.6 A current carrying solenoid is approaching a conducting loop as shown in the figure. The direction of induced current as observed by an observer on the other side of the loop will be -



(1) anticlockwise (2) clockwise
(3) east (4) west

Sol. The direction of current in the solenoid is clockwise. On displacing it towards the loop a current in the loop will be induced in clockwise direction so as to oppose its approach. Therefore the direction of induced current as observed by the observer will be anticlockwise. Hence the correct answer will be (1).

Ex.7 Consider the arrangement shown in figure in which the north pole of a magnet is moved away from a thick conducting loop containing capacitor. Then excess positive charge will arrive on -



(1) plate a
(2) plate b
(3) On both plates a and b
(4) On neither a nor b plates.

Sol. When north pole of the magnet is moved away, then south pole is induced on the face of the loop in front of the magnet i.e. as seen from the magnet side, a clockwise induced current flows in the loop. This makes free electrons to move in opposite direction, to plate a. Thus excess positive charge appear on plate b. The correct answer is (2).

Ex.8 The current changes in an inductance coil of 100 mH from 100 mA to zero in 2 millisecond. The e.m.f. induced in the coil will be :

(1) –5V (2) 5V (3) –50 V (4) 50 V

Sol.(2) $E = -L\frac{dI}{dt} = -100 \times 10^{-3}\frac{(0-100)\times 10^{-3}}{2\times 10^{-3}} = 5.0\text{ V}$

Ex.9 When a small piece of wire passes between the magnetic poles of a horse-shoe magnet in 0.1 sec, emf of 4×10^{-3} volt is induced in it. The magnetic flux between the poles is :

(1) 4×10^{-2} weber (2) 4×10^{-3} weber
(3) 4×10^{-4} weber (4) 4×10^{-6} weber

Sol.(3) $E = -\frac{d\phi}{dt}$ or $d\phi = -Edt = (0-\phi)$

or $\phi = 4 \times 10^{-3} \times 0.1 = 4 \times 10^{-4}$ Wb.

Ex.10 The normal magnetic flux passing through a coil changes with time according to following equation $\phi = 10t^2 + 5t + 1$.Where ϕ is in milliweber and t is in second. The value of induced e.m.f. produced in the coil at t = 5s will be –

(1) zero (2) 1V (3) 2V (4) 0.105 V

Sol.(4) $e = \frac{d\phi}{dt} = -\frac{d}{dt}[10t^2 + 5t + 1] \times 10^{-3}$

$= -[10 \times 10^{-3}(2t) + 5 \times 10^{-3}]$

at t = 5 second

$e = -[10 \times 10^{-2} + 5 \times 10^{-3}] \Rightarrow |e| = 0.105\text{V}$

6. Types of E.M.I.

For a loop flux, ($\phi = BA\cos\theta$) changes w.r.t. time in following three manner and according to it electro magnetic induction classify in three ways:

(A) If (A, θ) → const & $\frac{dB}{dt} \to \frac{d\phi}{dt} \Rightarrow$ **Static EMI**

(1) Self Induction (In this case EMI occurs for rest coil)
(2) Mutual Induction

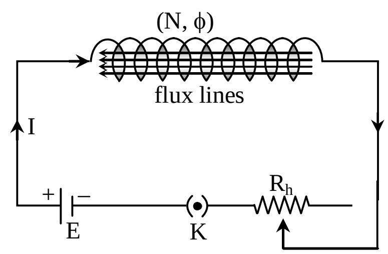
(B) If (B, θ) → const & $\frac{dA}{dt} \to \frac{d\phi}{dt} \Rightarrow$ **Dynamic EMI** (In this case EMI occurs for a moving straight wire)

(C) If (A, B) → const & $\frac{d\theta}{dt} \to \frac{d\phi}{dt} \Rightarrow$ **Periodic E.M.I** (In this case E.M.I. occurs for a rotating coil)

(A) Static E.M.I. $\Rightarrow \frac{dI}{dt} \to \frac{dB}{dt} \to \frac{d\phi}{dt} \Rightarrow$ **Static EMI**

(1). Self Induction : When current through the coil changes, with respect to time then magnetic flux linked with the coil also changes with respect to time. Dut to this an emf and a current induced in the coil. According to Lenz law induced current opposes the change in magnetic flux. This phenomenon is called self induction and a factor by virtue the coil shows opposition for change in magnetic flux called self inductance of coil. Considering this coil circuit in two cases:-

Case-I : Current through the coils constant:-



If I → B → ϕ → Const. ⇒ No EMI

total flux of coil (Nϕ) ∝ curent through the coil(I)

$N\phi \propto I \Rightarrow N\phi = LI$

$$\boxed{L = \frac{N\phi}{I} = \frac{NBA}{I} = \frac{\phi_{Total}}{I}}$$

Where L : self inductance of coil

S.I. unit of L → $1\frac{\text{weber}}{\text{A}} = 1$ henry $= 1\frac{\text{N}-\text{m}}{\text{A}^2} = 1\frac{\text{J}}{\text{A}^2}$

Dimension: $[M^1L^2T^{-2}A^{-2}]$

Sp. Note:- L is constant of coil it **does not depends on current** through the coil.

Case-II: Current through the coil changes w.r.t.:-

If $\frac{dI}{dt} \to \frac{dB}{dt} \to \frac{d\phi}{dt} \Rightarrow$ Static EMI

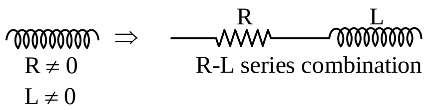
$N\phi = LI$

$-N\frac{d\phi}{dt} = -L\frac{dI}{dt}$, where $-N\frac{d\phi}{dt}$ called self induced emf of coil 'e_s' $\boxed{e_s = -L\frac{dI}{dt}}$

S.I. unit of L → $\frac{\text{V}-\text{sec}}{\text{A}}$

(i) Thin wire___________ R ≠ 0 & L = 0

⇒ Role of R → to opposes flow of current, now this wire moulded in form of coil.



Role of L → to opposes changes in current, if current becomes constant, then no role of 'L'

Note: Resistance is possible without inductance but inductance is not possible without resistance.

(ii) If w.r.t. $I\uparrow \Rightarrow \frac{dI}{dt}$ (+ve) ⇒ e_s(–ve) opposite emf

$$\Rightarrow \boxed{E_{net} = E - e_s}$$

(iii) If w.r.t. $I\downarrow \Rightarrow \frac{dI}{dt}$ (–ve) ⇒ e_s(+ve) same directed emf

$$\Rightarrow \boxed{E_{net} = E + e_s}$$

(iv) Current variation with key:-

(a) Just closing of key ⇒ $I\uparrow = dI$ (+ve) ⇒ e_s(–ve)

(b) Just opening of key (source emf E cut out) ⇒ $I\downarrow = dI$(–ve) ⇒ e_s(+ve)

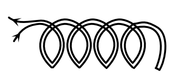
(c) At the time of sudden opening of key, due to high inductance of circuit a high momentarily emf induced and sparking occurs at key position. To avoid sparking a capacitor is connected parallel to the key.

(v) Self inductance always opposes the change of current in electric circuit so it is also called inertia of electric circuit.

(vi) Mechanics v/s Electricity:-

Mechanics	Electricity
Mass inertia (m)	Electric Inertia (L)
Velocity (v)	Current (I)
Momentum (mv)	Magnetic Flux (LI)
Kinetic energy ($\frac{1}{2}mv^2$)	Energy stored in Inductor ($\frac{1}{2}LI^2$)
Retarding force (–m dv/dt)	Self induced emf (–L dI/dt)

(vii) Resistance coil of resistance box, wound in two layer in opposite manner. The self inductance of coil becomes negligible



R ≠ 0

L 0 (Non inductive resistance)

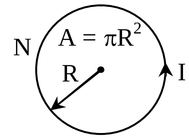
(viii) In checking balancing of wheat stone. Bridge, firstly we always pressed cell key and after wards galvanometer key, so that momentarily induced current due to self inductance of coil becomes almost zero or disappear.

Different Coefficient of Self inductance:-

(i) Plane circular coil-

$L_{coil} = \frac{NBA}{I}$ where $B = \frac{\mu_0 NI}{2R}$

$L_{coil} = \frac{N}{I}\left(\frac{\mu_0 NI}{2R}\right)\pi R^2$



$$\boxed{L_{coil} = \frac{\mu_0 N^2 \pi R}{2}}$$

→ $L_m \propto \mu_r$ (effect of medium)

→ $L \propto N^2$ (R → same)

→ $L \propto R$ (N → same)

(ii) Solenoid : $L_s = \frac{NBA}{I}$ where $B = \mu_0 \frac{N}{\ell} I$

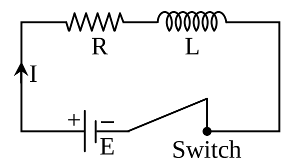
$L_s = \frac{N}{I}\left(\frac{\mu_0 NI}{\ell}\right)A$

$$\boxed{L_s = \frac{\mu_0 N^2 A}{\ell} = \mu_0 n^2 A\ell = \mu_0 n^2 V}$$

Where V: - Volume of solenoid = $A\ell$

and A:- Area of cross-section of frame of solenoid.

R-L d.c. Circuit:-



Case-I : Current Growth:-

(i) Emf equation:- $\boxed{E = IR + L\frac{dI}{dt}}$

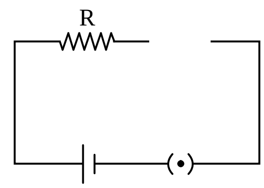
(ii) Current at any instant:- When key is closed the current in circuit increases exponentially with respect to time. The current in circuit at any instant 't' given by:-

$$\boxed{I = I_0(1 - e^{-t/\lambda})}$$

t = 0 (Just after the closing of key) ⇒ I = 0

$t \to \infty$ (Some time after closing of key) ⇒ $I \to I_0$

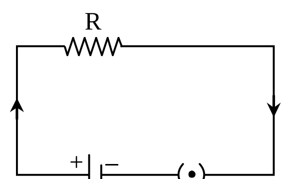
(iii) Just after the closing of the key inductance behaves like open circuit and current in circuit is zero.



(Open circuit, t = 0, I = 0)

(Inductor provide infinite resistance)

(iv) Some time after closing of the key inductance behaves like simple connecting wire (short circuit) and current in circuit is constant.



(short circuit $t \to \infty$, $I \to I_0$)

(Inductor provide zero resistance)

$\boxed{I_0 = \frac{E}{R}}$ (Final, steady, maximum or peak value of current)

Note : Peak value of current in circuit does not depends on self inductance of coil.

(v) Time constant of circuit (λ):- $\boxed{\lambda = \frac{L}{R}}_{sec.}$

It is a time in which current increases up to 63% or 0.63 times of peak current value.

(vi) Half life (T):- It is a time in which current increases upto 50% or 0.50 times of peak current value.

$$I = I_0 (1 - e^{-t/\lambda})$$

$t = T$, $I = I_0/2$ $\quad \frac{I_0}{2} = I_0(1 - e^{-T/\lambda})$

$\Rightarrow e^{-T/\lambda} = \frac{1}{2} \Rightarrow e^{T/\lambda} = 2$

$\frac{T}{\lambda} \log_e e = \log_e 2$

$$\boxed{\begin{array}{l} T = 0.693\lambda \\ T = 0.693\frac{L}{R} \end{array}}_{sec}$$

(vii) Rate of growth of current at any instant:-

$$\boxed{\left(\frac{dI}{dt}\right) = \frac{E}{L}(e^{-t/\lambda})}$$

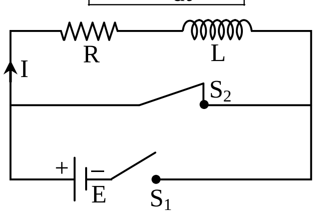
at $\quad t = 0 \Rightarrow \left(\frac{dI}{dt}\right)_{max} = \frac{E}{L}$

at $\quad t \to \infty \Rightarrow \left(\frac{dI}{dt}\right)_{min} \to 0$

Note: Maximum or initial value of rate of growth of current does not depends upon resistance of coil.

Case-II : Current Decay:-

(i) Emf equation:- $\boxed{IR + L\frac{dI}{dt} = 0}$



(ii) Current at any instant:- Once current acquires its final max steady value, if suddenly switch is put off then current start decreasing exponentially with respect to time. The current in circuit at any instant 't' is given by:-

$$\boxed{I = I_0(e^{-t/\lambda})}$$

(Just after opening of key) $t = 0 \Rightarrow I = I_0 = \frac{E}{R}$

(Some time after opening of key) $t \to \infty \Rightarrow I \to 0$

(iii) Time constant(λ):- It is a time in which current decreases up to 37% or 0.37 times of peak current value. $\boxed{\lambda = \frac{L}{R}}_{sec}$

(iv) Half life(T):- It is a time in which current decreases upto 50% or 0.50 times of peak current value.

$\boxed{T = (0.693)\lambda}_{sec}$

(v) Rate of decay of current at any instant:-

$$\boxed{\left(-\frac{dI}{dt}\right) = \left(\frac{E}{L}\right)e^{-t/\lambda}}$$

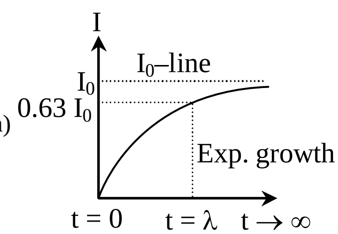
at $\quad t = 0 \quad \Rightarrow \quad \left(-\frac{dt}{dt}\right)_{max} = \frac{E}{L}$

at $\quad t \to \infty \quad \Rightarrow \quad \left(-\frac{dI}{dt}\right)_{min} \to 0$

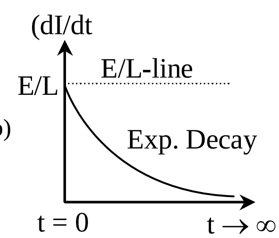
Special graph for R-L circuit:-

Current Growth:-

(a)

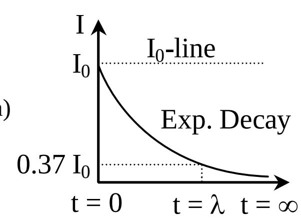


(b)

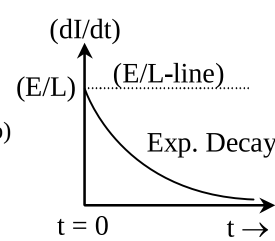


Current decay:-

(a)

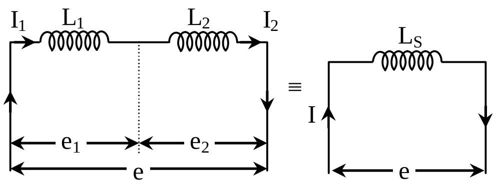


(b)



Combination of Inductances:-

(a) Series combination



Potential divides, $e = e_1 + e_2$

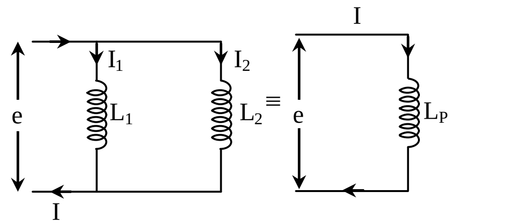
$$L_s \frac{dI}{dt} = L_1 \frac{dI_1}{dt} + L_2 \frac{dI_2}{dt} \quad (\text{as } e = -L \frac{dI}{dt})$$

Current remains same $I = I_1 = I_2$

$$\text{i.e. } \frac{dI}{dt} = \frac{dI_1}{dt} = \frac{dI_2}{dt}$$

$$\boxed{L_S = L_1 + L_2}$$

(b) Parallel combination:



Current divides, $I = I_1 + I_2$

$$\frac{dI}{dt} = \frac{dI_1}{dt} + \frac{dI_2}{dt}$$

$$\frac{e}{L_P} = \frac{e_1}{L_1} + \frac{e_2}{L_2}$$

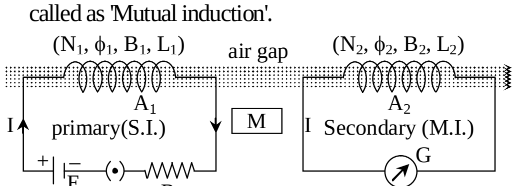
$$\left[\text{as } e = -L\frac{dI}{dt} \text{ i.e.} \frac{dI}{dt} = -\frac{e}{L}\right]$$

Potential remains same, $e = e_1 = e_2$

$$\frac{1}{L_P} = \frac{1}{L_1} + \frac{1}{L_2} \Rightarrow \boxed{L_P = \frac{L_1 L_2}{L_1 + L_2}}$$

(2). Mutual Induction:-(M.I.)

Whenever current passing through primary coil or circuit change with respect to time then magnetic flux in neighbouring secondary coil or circuit will also changes with respect to time. According to Lenz Law for opposition of flux change an emf and a current induced in the neighbouring coil or circuit. This phenomenon called as 'Mutual induction'.



Due to air gap always $\phi_2 < \phi_1$ and $\phi_2 = B_1 A_2$ $(\theta = 0)$

Case-I : When current through primary is constant:-

Total flux of secondary is directly proportional to current flow through the primary coil

$N_2 \phi_2 \propto I_1$

$N_2 \phi_2 = MI_1$

$$\boxed{M = \frac{N_2\phi_2}{I_1} = \frac{N_2 B_1 A_2}{I_1} = \frac{(\phi_T)_s}{I_p}},$$

Where M : mutual inductance of circuits.

(i) The units and dimension of M are same as 'L'.

(ii) The mutual inductance does not depends upon current through the primary and it is constant for both circuits.

Case-II: When current through primary chenges w.r.t.

If $\frac{dI_1}{dt} \to \frac{dB_1}{dt} \to \frac{d\phi_1}{dt} \to \frac{d\phi_2}{dt} \Rightarrow$ Static EMI

$$N_2\phi_2 = MI_1$$

$-N_2 \frac{d\phi_2}{dt} = -M\frac{dI_1}{dt}$, $\left(-N_2\frac{d\phi}{dt}\right)$ called total mutual induced emf of secondary coil e_m.

$$\boxed{e_m = -M\left(\frac{dI_1}{dt}\right)}$$

Secondary ← → Primary

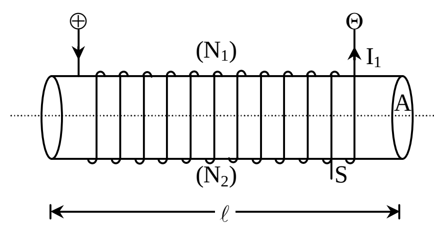
Different mutual inductances:-

(a) In terms of their number of turns

(b) In terms of their self inductances

(a) In terms of their number of turns (N_1, N_2):-

(1) Two co-axial solenoids :-

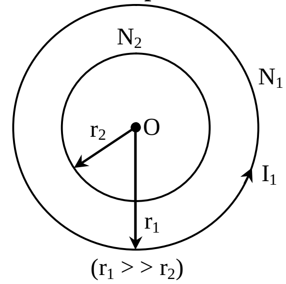


$$M_{S_1S_2} = \frac{N_2 B_1 A}{I_1}$$

$$= \frac{N_2}{I_1}\left(\frac{\mu_0 N_1 I_1}{\ell}\right) A, \text{ where } B_1 = \frac{\mu_0 N_1 I_1}{\ell}$$

$$\Rightarrow \boxed{M_{s_1s_2} = \left(\frac{\mu_0 N_1 N_2 A}{\ell}\right)}$$

(2) Two concentric and coplanar coils :-



$(r_1 >> r_2)$

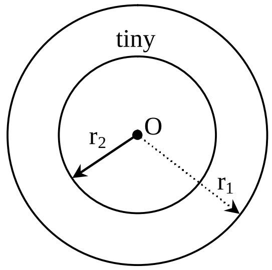
$$M_{c_1c_2} = \frac{N_2 B_1 A_2}{I_1}, \text{ where } B_1 = \frac{\mu_0 N_1 I_1}{2r_1} \;\&\; A_2 = \pi r_2^2$$

$$M_{c_1c_2} = \frac{N_2}{I_1}\left(\frac{\mu_0 N_1 I_1}{2r_1}\right)(\pi r_2^2)$$

$$\Rightarrow \boxed{M_{c_1c_2} = \frac{\mu_0 N_1 N_2 \pi r_2^2}{2r_1}}$$

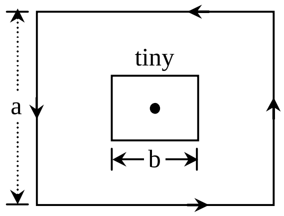
(i) Two concentric and coplanar loops:-

$\boxed{M \propto \frac{r_2^2}{r_1}}$ $(r_1 >> r_2)$

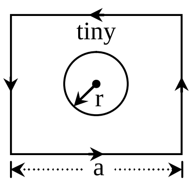


(ii) Two concentric and coplanar square loops:-

$\boxed{M \propto \frac{b^2}{a}}$



(iii) A square and a circular concentric and coplanar loop:-



$\boxed{M \propto \frac{r^2}{a}}$

(b) In terms of their self inductances (L_1,L_2) :-

For two magnetically coupled coils:-

$\boxed{M = K\sqrt{L_1L_2}}$, where 'K' is coupling factor between two coils and its range $0 \le K \le 1$

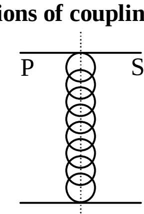
(i) For ideal coupling $K_{max} = 1 \Rightarrow$ $\boxed{M_{max} = \sqrt{L_1L_2}}$

(where M is geometrical mean of L_1 & L_2)

(ii) For real coupling $(0 < K < 1) \Rightarrow$ $\boxed{M = K\sqrt{L_1L_2}}$

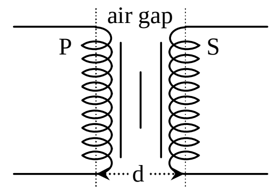
(iii) Value of coupling factor 'K' decides from fashion of coupling.

(iv) Different fashions of coupling:-

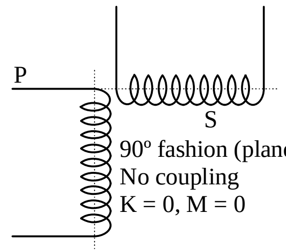


Ideal coupling (Coaxial fashion)

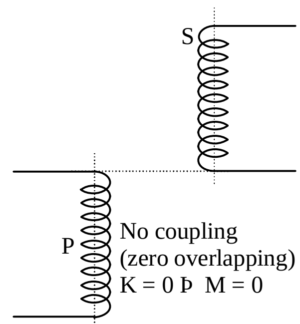
$K = 1 \Rightarrow M_{max} = \sqrt{L_1L_2}$



Normal coupling (0º fashion) (Planes are parallel)
$(0 < K < 1 \Rightarrow M = K\sqrt{L_1L_2}$, if $d\downarrow \Rightarrow K\uparrow \Rightarrow M\uparrow)$



90º fashion (planes are perp.)
No coupling
K = 0, M = 0



No coupling
(zero overlapping)
K = 0 Þ M = 0

(v) 'K' also defined as

$$K = \frac{\phi_s}{\phi_p} = \frac{\text{mag. flux linked with Secondary}}{\text{mag. flux linked with Primary}}$$

'M' depends on:-

$\Rightarrow$ Number of turns (N_1, N_2)

$\Rightarrow$ Self inductances (L_1, L_2)

$\Rightarrow$ Area of cross section

$\Rightarrow$ Magnetic permeability of medium (μ_r)

$\Rightarrow$ Distance between two coils (As $d\downarrow = M\uparrow$)

$\Rightarrow$ Orientation between two coils

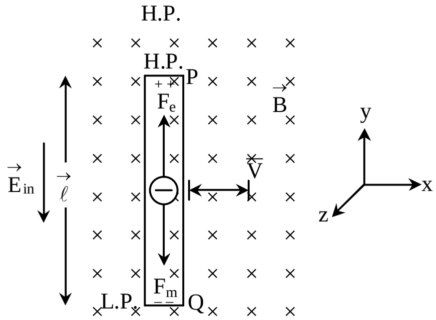
$\Rightarrow$ Coupling factor 'K' between two coils.

(B) Dynamic E.M.I $\left(\frac{dA}{dt} \rightarrow \frac{d\varphi}{dt} \rightarrow \text{Dynamic E.M.I.}\right)$ (only for conducting rod or wire)

7. Generation of EMF and Current in Various Objects

7.1 Induced Emf due to Uniform Motion of a Conducting Rod in a Uniform Magnetic Field :

If a conducting rod of length ℓ is in the plane of paper, magnetic field $\vec{B}$ is pointing into the plane of paper and velocity $\vec{v}$ of the rod is pointing towards + x-axis, then the force $\vec{F} = q(\vec{v} \times \vec{B})$ acts downwards $(-\hat{j})$ on the free electrons present in the conductor due to the magnetic field. As a result electrons are concentrated at the Q end of the conductor due to which Q end of the conductor becomes negatively charged and P end positively charged.



(i) Due to motion of free electrons a current is also induced in rod which flow from LP to HP end of the rod.

(ii) Phenomenon of dynamic EMI does not takes place for non conducting rod due to absence of free electrons.

(iii) Induced electric field inside the rod:-

$\vec{E}_{in} = -(\vec{v} \times \vec{B})$

$\boxed{\vec{E}_{in} = (\vec{B} \times \vec{v})}$

(iv) Dynamic emf or induced emf across the ends of the rod:-

$e_d = -\vec{\ell}\,(\vec{v} \times \vec{B})$

$\boxed{e_d = \vec{\ell}\,(\vec{B} \times \vec{v})}$

- $\vec{v} \times \vec{B}$ & $\vec{\ell}$ " $\vec{B}$ & $\vec{\ell} \not\parallel \vec{v}$ $\Rightarrow$ $\boxed{(e_d)_{max.} = Bv\ell}$ (max. flux cutting)
- $\vec{v} \parallel \vec{B}$ or $\vec{\ell} \parallel \vec{B}$ & $\vec{\ell} \parallel \vec{v}$ $\Rightarrow$ $\boxed{(e_d)_{min.} = 0}$ (No flux cutting)

(v) If all three vectors are perpendicular to each other then value of dynamic emf is maximum across the ends of the rod

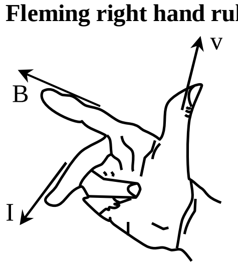
$\boxed{(e_d)_{max.} = Bv\ell}$

(vi) If any of the two vectors are parallel (or antiparallel) to each other then value of induced emf across the ends of the rod is zero

$\boxed{(e_d)_{min.} = 0}$

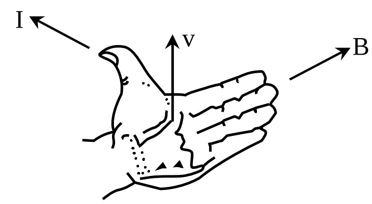
(vii) Do flux cutting $\Rightarrow$ Dynamic EMI
No flux cutting $\Rightarrow$ No Dynamic EMI

(viii) Direction of induced current or HP end of the rod find with the help of:-
(a) Flemming right hand rule.
(b) Left hand palm rule.
(a) **Fleming right hand rule:-**



Fore finger $\rightarrow$ In external field direction.
Thumb $\rightarrow$ In the direction of motion of conductor.
Middle finger $\rightarrow$ It indicates HP ends of conductor/direction of induced conductor

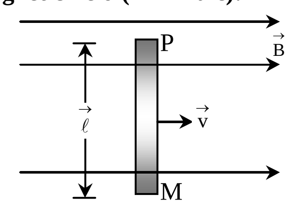
(b) **Left hand palm rule**



Fingers $\rightarrow$ In external field direction
Palm $\rightarrow$ In direction of motion of conductor.
Thumb $\rightarrow$ It indicates HP end of conductor/direction of induced current in conductor

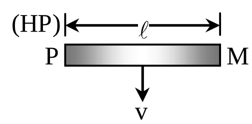
Type-I:- When straight conductor moves in external magnetic field (LHP rule):-

(i)



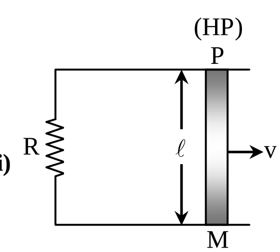
HP end = ?

(ii)



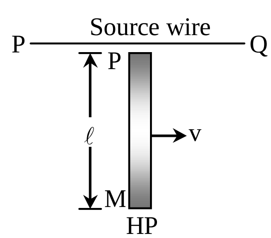
Direction of ext. B = ?

(iii)



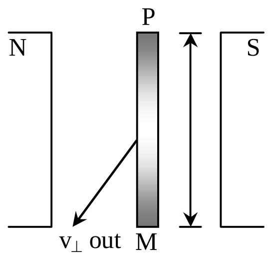
Direction ext. B = ?

(iv)



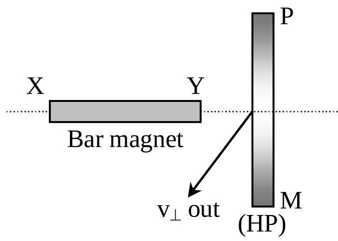
Direction of current in source wire PQ = ?

(v)



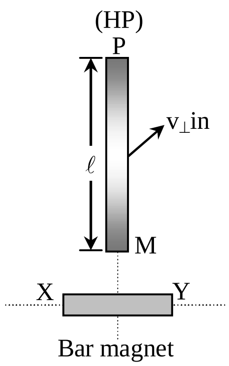
LP end = ?

(vi)



Poles of magnet = ?

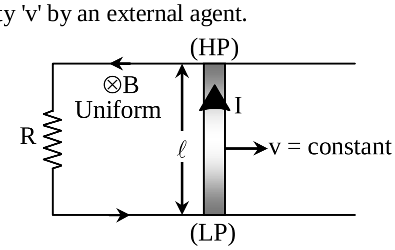
(vii)



Poles of magnet = ?

Type-II : (a) Motion of straight conductor in horizontal plane:-

For the given circuit, If metal rod moves with uniform velocity 'v' by an external agent.



(i) Induced emf in circuit $\boxed{e = Bv\ell}$

(ii) Current flows through circuit $\boxed{I = \frac{e}{R} = \frac{Bv\ell}{R}}$

(iii) Retarding opposing force exerted on metal rod by action of induced current

$\vec{F}_m = I(\vec{\ell} \times \vec{B})$

$F_m = BI\ell$, where θ = 90º

$$\boxed{F_m = \frac{B^2\ell^2 v}{R}}$$

(iv) External mechanical force required for uniform velocity of metal rod.

For constant velocity resultant force on metal rod must zero and for that $F_{ext} = F_m$

$$\boxed{F_{ext.} = F_m = \frac{B^2\ell^2 v}{R}}$$

$\Rightarrow$ If (B, ℓ, R) $\rightarrow$ const. $\Rightarrow$ $\boxed{F_{ext.} \propto v}$

(v) For uniform motion of metal rod, The rate of doing mechanical work by extenal agent or mechanical power delivered by external source given as:-

$$P_{ext.} = p_{ext} = \vec{F}_{ext}.\vec{v} = F_{ext} v$$

$$\boxed{p_{ext.} = p_m = \frac{B^2\ell^2 v^2}{R}}$$

$\Rightarrow$ If (B,ℓ,R) $\rightarrow$ const. $\Rightarrow$ $\boxed{p_{mech.} \propto v^2}$

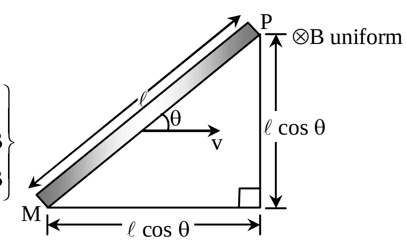
(vi) Rate of heat dissipation across resistance or thermal power developed across resistance is:-

$$P_{th} = I^2R = \frac{1}{R}\left(\frac{Bv\ell}{R}\right)^2$$

$$\boxed{p_{th} = \frac{B^2\ell^2 v^2}{R}}$$

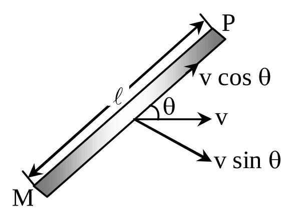
It is clear that $p_{th} = p_{mech}$ which is consistent with the principle of conservation of energy.

(b) $\left\{ \begin{array}{c} \vec{\ell}\,\theta\,\vec{v} \\ \vec{\ell} \perp \vec{B} \\ \vec{v} \perp \vec{B} \end{array} \right\}$



$\boxed{e_d = Bv(\ell \sin\theta)}$

(ℓ) — ℓ cos θ ∥ v, No flux cutting
— ℓ cos θ ⊥ v, No flux cutting

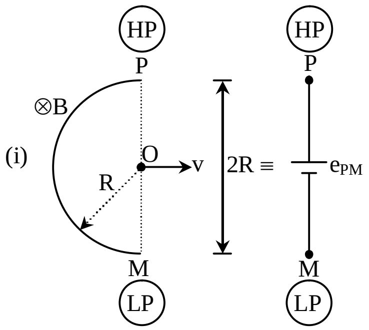


$\boxed{e_d = B(v\sin\theta)\ell}$

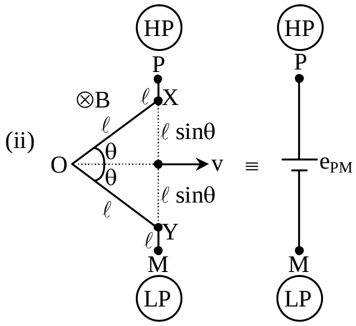
(v) — v cos θ ∥ ℓ, No flux cutting
— v cos θ ⊥ ℓ, No flux cutting

Type-III: When an arbitrary conductor moves in uniform magnetic field with constant velocity in such a way that it cuts the field lines then induced emf across its ends given by:-

$\boxed{e_d = Bv\ell_{i-f}}$, where ℓ_{i-f} displacement between free ends of the conductor.

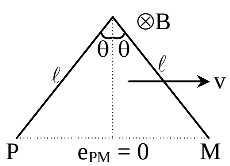


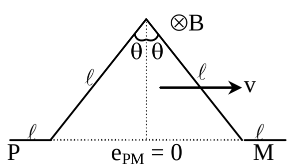
$e_{PM} = Bv(2R) = 2BvR$

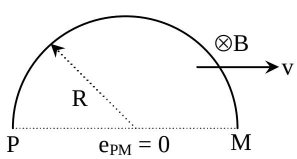


$e_{PM} = Bv(2\ell + 2\ell\sin\theta) = 2Bv\ell(1 + \sin\theta)$

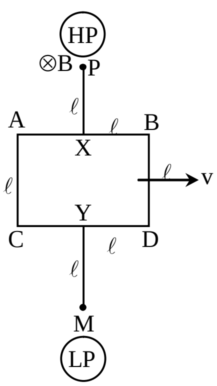
(iii)

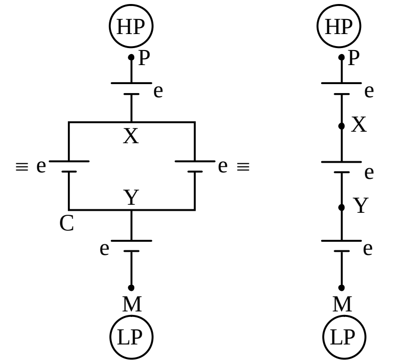






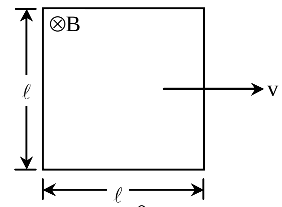
(iv)



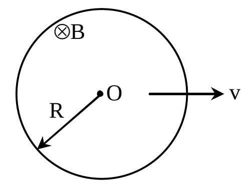


where $e = Bv\ell$ $\quad$ $e_{PM} = 3e = Bv\ell$

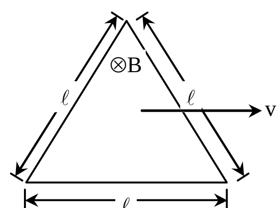
(v)



$e_{net} = 0$

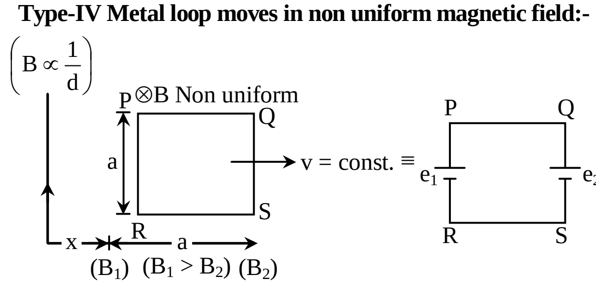


$e_{net} = 0$



$e_{net} = 0$

Type-IV Metal loop moves in non uniform magnetic field:-



Instantaneous induced emf in square metal loop is:-

$e_{net} = e_1 - e_2$

$= av(B_1 - B_2)$, where $B_1 = \frac{\mu_0 I}{2\pi x}$ & $B_2 = \frac{\mu_0 I}{2\pi(x+a)}$

using the values of B_1 and B_2

$$e_{net} = \frac{\mu_0 Iva}{2\pi}\left[\frac{1}{x} - \frac{1}{x+a}\right]$$

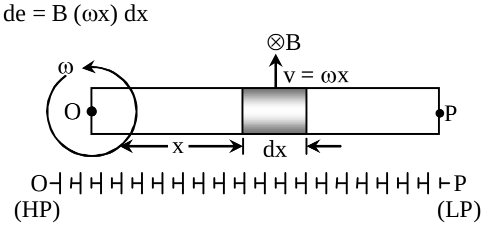
$$\boxed{e_{net} = \frac{\mu_0 Iva^2}{2\pi x(x+a)}}$$ (always non zero)

Type-V:- Rotational motion in uniform transverse magnetic field

(a) A metal rod of length ℓ rotates about an end with a uniform angular velocity ω. A uniform magnetic field B exist in the direction of axis of rotation. Find induced emf between the ends of the rod.

Sol. Considering an element dx of rod at a distance x from the axis of rotation. The linear speed of this element is ωx. The element moves in a direction perpendicular to its length as well as perpendicular to the magnetic field. The emf induced between the ends. of this element is

$$de = B(\omega x)\,dx$$



The emf of all such elements will add to give the net emf between the ends of the rod.

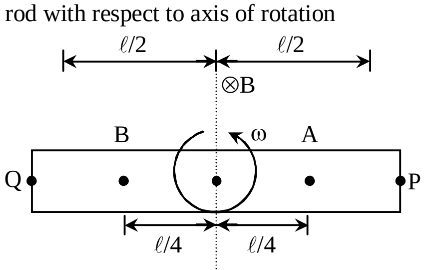
$$e = \int_O^P de = \int_0^\ell B\omega x\,dx = \frac{1}{2}B\omega\ell^2$$

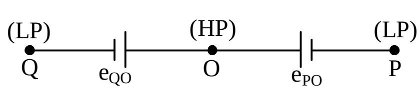
$$\boxed{e_{PO} = \frac{1}{2}B\omega\ell^2 \quad \omega = 2\pi f}$$

note:- Induced emf between any two points of linear rod is

$$\boxed{e_{xy} = \frac{1}{2}B\omega(x^2)_y^x}$$

(b) The metal rod rotates about its geometrical axis. Find induced emf between any pair of identical located points of rod with respect to axis of rotation



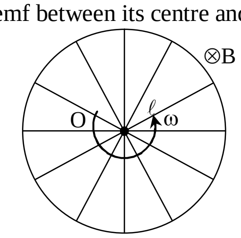


Sol. Parts PO & QO are represents identical cell

$e_{PO} = e_{QO} = \frac{1}{2}B\omega(\ell/2)^2 = \frac{1}{8}B\omega\ell^2$

hence $e_{PQ} = e_{P0} - e_{PQ} = 0$, similarly $e_{AB} = 0$

(c) A conducting cycle wheel with each spoke of length ℓ, is rotating about its geometrical axis with uniform angular velocity ω in uniform magnetic field as shown in figure. Find induced emf between its centre and rim.

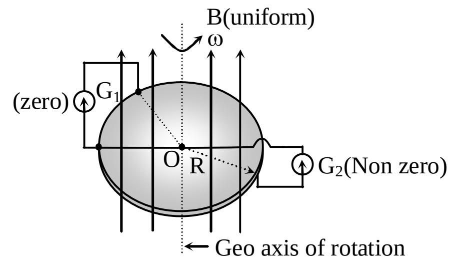


Sol. Due to flux cutting each metal spoke becomes identical cell of emf e (say), all such identical cells connected in parallel fashion e_{net} = e (emf of single cell)

$$\boxed{e_{net} = \frac{1}{2}B\omega\ell^2 \quad \omega = 2\pi f}$$

Note:- This emf does not depends on number of spokes ('N') in wheel.

(d) Faraday Copper disc generator (Based on Dy. EMI)



(Rotating metal disc in Transverse uniform magnetic field)

- During rotational motion of disc it cuts the magnetic flux.
- A metal disc can be assumed to made of uncountable radial conductors. When metal disc rotates in uniform transverse magnetic field these radial conductors cuts the magnetic flux and because of this flux cutting all becomes identical cells each of emf 'e'. where $e = \frac{1}{2}B\omega R^2$, and periphery of disc becomes equipotential.
- All identical cells connected in parallel fashion so net emf

  e_{net} = e(emf of single cell)

$$\boxed{e_{net} = \frac{1}{2}B\omega R^2 \quad \omega = 2\pi f}$$, where R is radius of disc.

Type-VI:- Moving conducting rod in earth's magnetic field:-

Case-I Placed Horizontally and moves in horizontal plane.

If its ends in → E–W $dir^n \Rightarrow B_v$ cuts; → N–S $dir^n \Rightarrow B_v$ cuts

Dynamic emf:- $\boxed{e_d = B_v v\ell}$

Case II Hold vertically and moves in horizontal plane:-

If it moves on → E–W line ⇒ B_H cuts} dynamic emf – $\boxed{e_d = B_H v\ell}$; → N–S line ⇒ No flux cutting = No. Dy. EMI

Case III Placed horizontally and allow to fall under gravity in vertical plane:-

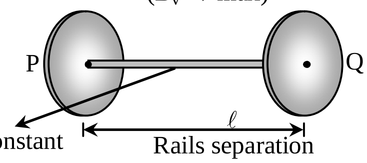
If its ends in → E–W $dir^n \Rightarrow B_H$ cuts; → N–S dir^n ⇒ No flux cutting ⇒ No Dy EMI

Applications:-

(i) Moving Train (Hz – Hz):- Induced emf across axle of moving train is:-

$e_{PQ} = B_v v \ell$ → *At equator ⇒ $e_{PQ} = 0$ ($B_v = 0$)

→ At poles ($B_v \to$ max) ⇒ e_{PQ} = max



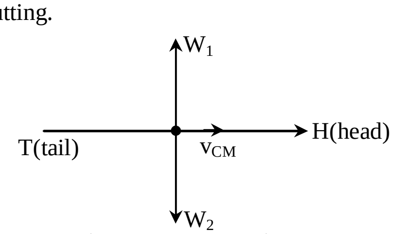
where $B_v = B\sin\theta$, θ angle of dip at that place

v → always in m/s

(ii) Moving Aeroplane:-

Motion of aeroplane can be deal as motion of two metal rods (H-T) and ($W_1 - W_2$) which are perpendicular to each other.

For (H-T) conductor $\vec{\ell} \parallel \vec{v}_{CM}$, so (H-T) conductor never do flux cutting hence no induced emf across (H-T) of aeroplane for its any sort of motion, only ($W_1 - W_2$) conductor can do flux cutting.



(W_1 & W_2 = wings)

(a) When aeroplane flying at a certain height i.e. parallel to earth surface (Hz – Hz):-

If wings ($W_1 - W_2$) in
→ E–W dir^n ⇒ B_v cuts
→ N–S dir^n ⇒ B_v cuts

Induced emf across wings of aeroplane given as (both cases):-

$e_{W_1W_2} = B_v \ell_{W_1W_2} v$, where $B_v = B\sin\theta$ [θ angle of dip.]

(b) When aeroplane dives vertically (Hz – Vt):-

If wings ($W_1 - W_2$) in
→ E–W dir^n ⇒ B_H cuts
→ *N–S dir^n ⇒ No flux cutting ⇒ No Dy. EMI

Induced emf across wings of aeroplane given as (only in one case)

$e_{W_1W_2} = B_H \ell_{W_1W_2} v$, where $B_H = B\cos\theta$ [θ angle of dip.]

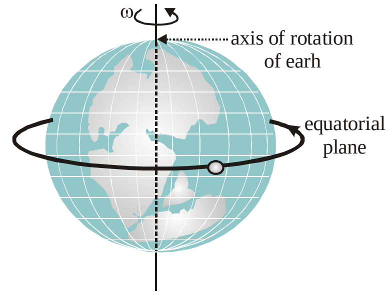
(iii) Human body (Vt – Hz):

A human body of height 'h' moves with constant velocity v then induced emf between his head and feet, if it moves along:-

→ E–W line ⇒ B_H cuts} dynamic emf ⇒ $e_d = B_H vh$

→ *N–S line ⇒ No flux cutting ⇒ No Dyn. EMI

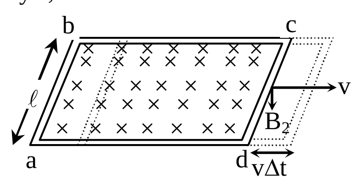
(iv) Motion of an Artificial satellite (Hz – Hz):-



If a geo-stationary satellite revolves around the earth in equatorial plane ⇒ No flux cutting ⇒ No Dy. EMI

7.2 Induced EMF, Current and Energy Conservation in a Rectangular Loop Moving in a Non-uniform Magnetic Field with a Constant Velocity :

(a) A rectangular coil abcd is placed in a non-uniform magnetic field perpendicular to it such that the magnetic field at the arm ab is B_1 and at arm cd is B_2($B_1 > B_2$). The lengths of the ab and cd arms are ℓ. If coil is moved normal to the magnetic field with a velocity v, then



(i) Net increase in flux crossing through the coil in time Δt

$\Delta\phi = (B_2 - B_1)\,\ell\, v\,\Delta t$

(ii) Emf induced in the coil

$E = (B_1 - B_2)\ell v$

(b) If the resistance of the coil is R, then the current induced in the coil

$$I = \frac{E}{R} = \frac{(B_1 - B_2)}{R}\ell v$$

(c) Resultant force acting on the coil

$F = I\,\ell\,(B_1 - B_2)$ (towards left)

(d) The work done against the resultant force

$$W = (B_1 - B_2)^2 \frac{\ell^2 v^2}{R} \Delta t \text{ joule}$$

Energy supplied in this work appears in the form of electrical energy in the circuit.

(e) Energy supplied due to flow of current I in time Δt

$H = I^2 R\,\Delta t$

or $H = (B_1 - B_2)^2 \dfrac{\ell^2 v^2}{R} \Delta t$ joule

or $H = W$

(f) In electromagnetic induction electrical energy is produced by the mechanical energy which is then transformed into heat energy by current flow. As these energies are equal in magnitude it is proved that energy is conserved, i.e., in electromagnetic induction law of conservation of energy is obeyed.

(g) **When magnetic field is uniform**

If a coil is moved in a uniform magnetic field with constant velocity, then the magnetic flux crossing this coil does not change with time. Hence emf induced in it is zero, i.e., in this case

$B_1 = B_2$

$\therefore \quad E = (B_1 - B_2)v\ell = 0$

(h) When magnetic field is uniform and in limited region : In this case as long as the moving coil remains completely in the magnetic field $\vec{B}$, induced emf remains zero. But as soon as one arm of the coil enters a region of zero magnetic field, that is, $B_2 = 0$, $B_1 = B$, induced emf becomes $E = (B_1 - B_2)v\ell = Bv\ell$

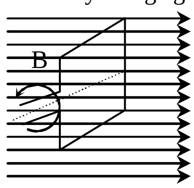
As soon as the coil is totally out of the magnetic field region, induced emf becomes zero again.

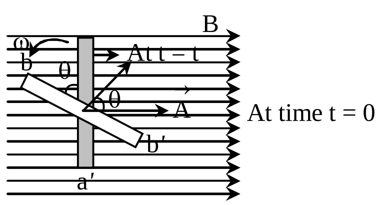
(i) If a rectangular loop is moved in a uniform magnetic field $\vec{B}$ with a velocity $\vec{v}$, then induced emf and current will not be produced because the magnetic flux linked with the coil does not change. But if loop is drawn out of the magnetic field, then emf and current will be induced in it.

(C) Periodic E.M.I. $\left(\frac{d\theta}{dt} \rightarrow \frac{d\varphi}{dt} \rightarrow \text{EMI}\right)$

Rotation of a Rectangular Coil in a Uniform Magnetic Field :

(a) In the figure a conducting rectangular coil of area A and turns N is shown. It is rotated in a uniform magnetic field B about a horizontal axis perpendicular to the field with an angular velocity ω. The magnetic flux linked with the coil is continuously changing due to rotation.





θ is the angle between the perpendicular to the plane of the coil and the direction of magnetic field.

(b) The magnetic flux passing through the rectangular coil depends upon the orientation of the plane of the coil about is axis.

(c) Magnetic flux passing through the coil

$\phi = \vec{B}.\vec{A} = BA\cos\theta = BA\cos\omega t$

If there are N turns in the coil, then the flux linked with the coil $\phi = BAN\cos\omega t$

(d) Since ϕ depends upon the time t, the rate of change of magnetic flux

$$\frac{d\phi}{dt} = -BAN\omega\sin\omega t$$

(e) According to Faraday's law, the emf induced in the coil

$E = -\frac{d\phi}{dt}$ or $E = BAN\omega\sin\omega t$

BANω is the maximum value of emf induced, Thus writing

$BAN\omega = E_0$

$\therefore \quad E = E_0 \sin\omega t$

This equation represents the instantaneous value of emf induced at time t.

(f) If the total resistance of circuit along with the coil is R, then the induced current due to alternating voltage

$I = \frac{E}{R} = \frac{E_0}{R}\sin\omega t$ or $I = I_0\sin\omega t$

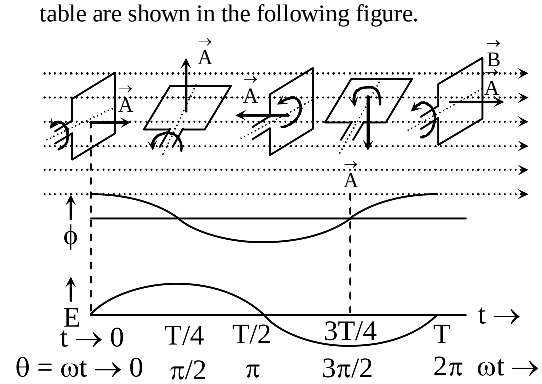
where $I_0 = \frac{E_0}{R}$

is the maximum value of current.

(g) The magnetic flux linked with coil and the emf induced at different positions of the coil in one rotational cycle are shown in the following table :

Time	Position of coil	Magnetic flux	Induced emf
$t = 0$	Plane of the coil normal to $\vec{B}$ ($\theta = 0$)	$\phi = NBA$ = maximum flux	0
$t = \frac{T}{4}$	Plane of the coil parallel to $\vec{B}$ ($\theta = 90°$)	$\phi = 0$	NBA ω = maximum
$t = \frac{T}{2}$	Plane of the coil normal to $\vec{B}$ again ($\theta = 180°$)	$\phi = -NBA$	0
$t = \frac{3T}{4}$	Plane of the coil parallel to $\vec{B}$ again ($\theta = 270°$)	$\phi = 0$	– NBAω
$t = T$	Plane of the coil normal to $\vec{B}$ ($\theta = 360°$)	$\phi = NBA$	0

(h) The variations of magnetic flux linked with the coil and induced e.m.f. at different times given in the above table are shown in the following figure.



(i) The phase difference between the instantaneous magnetic flux and induced emf is π/2.

(j) The ratio of E_{max} and ϕ_{max} is equal to the angular velocity of the coil. Thus

$$\frac{E_{max}}{\phi_{max}} = \frac{NBA\omega}{NBA} = \omega$$

(k) If $\theta = \frac{\pi}{4} = 45^\circ$, then

$$\phi = \frac{NBA}{\sqrt{2}} \text{ and } E = \frac{NBA\omega}{\sqrt{2}}$$

In this case the ratio of the induced emf and the magnetic flux is equal to the angular velocity of the coil. Thus

$$\frac{E}{\phi} = \frac{NBA\omega}{\sqrt{2}} / \frac{NBA}{\sqrt{2}} = \omega$$

(l) The direction of induced emf in the coil changes during one cycle so it is called alternating emf and current induced due to it is called alternating current. This is the principle of AC generator.

Ex.11 A bicycle wheel of radius 0.5 m has 32 spokes. It is rotating at the rate of 120 revolutions per minute, perpendicular to the horizontal component of earth's magnetic field $B_H = 4 \times 10^{-5}$ tesla. The emf induced between the rim and the centre of the wheel will be -

(1) 6.28×10^{-5} V (2) 4.8×10^{-5} V

(3) 6.0×10^{-5} V (4) 1.6×10^{-5} V

Sol. (1) For each spoke, the induced emf between the centre O and the rim will be the same

$$e = \frac{1}{2} B\omega L^2 = B\pi L^2 f \; (\because \; \omega = 2\pi f)$$

Further for all spokes, centre O will be positive while rim will be negative. Thus all emf's are inparallel giving total emf

$$e = B\pi L^2 f$$

independent of the number of the spokes.

Substituting the values

$e = 4 \times 10^{-5} \times 3.14 \times (.5)^2 \times 2 = 6.28 \times 10^{-5}$ volt

Note : **If a copper disc of radius R is rotating about its own axis, with angular frequency ω, in magnetic field B, which is perpendicular to the disc, then the induced emf between its centre and rim, will be**

$$\mathbf{E = \frac{1}{2} B\omega R^2 \text{ or } E = BAf = B\pi R^2 f}$$

($\because$ A = πR^2 = area of disc and f is frequency of rotation).

Ex.12 A Thick wire in the form of a semicircle of radius 'r' is rotated with a frequency '*f*' in a magnetic field. What will be the peak value of emf induced ?

(1) $B\pi r^2 f$ (2) $B\pi^2 r^2 f$

(3) $2Br^2 f$ (4) $2B\pi^2 r^2 f$

Sol. (2) $\phi = BA\cos\omega t = \frac{B\pi r^2}{2} \cos 2\pi f t$

$$e = -\frac{d\phi}{dt} = \frac{B\pi r^2}{2} . 2\pi f \sin 2\pi f t = B\pi^2 r^2 f \sin 2\pi f t$$

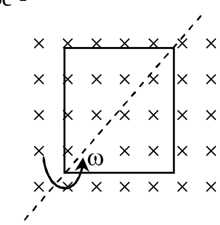
Peak value = $B^2 r^2 f$

Ex.13 A aeroplane having a distance of 50 metre between the edges of its wings is flying horizontally with a speed of 360 km/hour. If the vertical component of earth's magnetic field is 4×10^{-4} weber/m^2, then the induced emf between the edges of it wings will be –

(1) 2 mV (2) 2 V (3) 0.2 V (4) 20 V

Sol.(2) $E = B\ell v = 4 \times 10^{-4} \times 50 \times \frac{360 \times 1000}{60 \times 60} = 2$ V

Ex.14 A square loop of side a is rotating about its diagonal with angular velocity ω in a perpendicular magnetic field as shown in the figure. If the number of turns in it is 10 then the magnetic flux linked with the loop at any instant will be -



(1) $10Ba^2 \cos\omega t$ (2) 10Ba

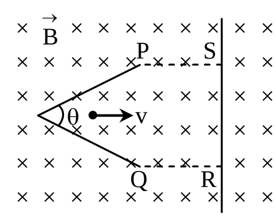
(3) $10Ba^2$ (4) $20Ba^2$

Sol.(1) The magnetic flux linked with the loop at any instant of time t is given by

$\phi = BAN\cos\omega t$ or $\phi = 10Ba^2\cos\omega t$

Here N = 10, A = a^2

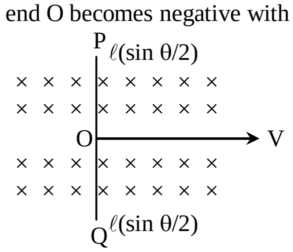
Ex.15 An angular conductor is moving with velocity v along its angular bisector in a perpendicular magnetic field (B) as shown in the figure. The induced potential difference between its free ends will be –



(1) $2Bv\ell \sin\frac{\theta}{2}$ (2) $2Bv\ell$

(3) $2Bv\ell\sin\theta$ (4) Zero

Sol.(1) A positive charge will be induced at the P of rod OP and the end O becomes negative with respect to P.



The e.m.f. induced at the P = $B\ell v \sin\frac{\theta}{2}$

Similarly e.m.f. induced at end Q = $B\ell v \sin\frac{\theta}{2}$

Potential difference between P and Q

$$= Bv\ell\sin\frac{\theta}{2} - \left(-B\ell v \sin\frac{\theta}{2}\right) = 2Bv\ell\sin\frac{\theta}{2}$$

Ex.16 The distance between the ends of wings of an aeroplane is 3m. This aeroplane is descending down with a speed of 300 Km/hour. If the horizontal component of earths magnetic field is 0.4 Gauss then the value of e.m.f. induced in the wings of the plane will be -

(1) 1 V (2) 2 V (3) 0.01 V (4) 0.1 V

Sol.(3) $e = Hv\ell = 0.4 \times 10^{-4} \times \frac{300 \times 10^3}{60 \times 60} \times 3 = 10^{-2}$ V

Hence the correct answer will be (3)

8. Transformer

(a) This is based on the principle of mutual induction.

(b) This can be used only for AC input and not for DC.

(c) These are used for converting large AC at low voltages in to small currents at high voltages, and vice-versa. Accordingly, these are of two types :

(i) Step-up $V_{Input} < V_{Output}$

(ii) Step-down $V_{Input} > V_{Output}$

(d) Energy is transferred without altering the frequency using transformers.

(e) A simple transformer consists of two coils :

(i) Primary coil : a.c. mains is connected this (input)

(ii) Secondary coil : output voltage is taken form this.

(f) These two coils are insulated from each other and wound on a common soft iron laminated core. This is to reduce the Eddy currents.

(g) Resistance between the coil is infinite.

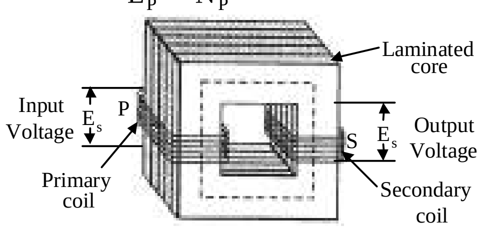
(h) Let N_P : Number of turns in primary coil.

N_S : Number of turns in secondary coil.

E_P : Input voltage

E_S : Output voltage.

Now, $\frac{E_S}{E_P} = \frac{N_S}{N_P}$



(i) For a step down transformer-

(i) $E_P > E_S$ (ii) $N_P > N_S$ (iii) $I_S > I_P$.

(j) For a step-up transformer-

(i) $E_S > E_P$ (ii)$N_S > N_P$ (iii) $I_P > I_S$.

(k) Comparison between ideal and real transformer :

	Ideal	**Real**
(i)	No power loss	Power loss due to eddy current etc.
(ii)	Input Power = Output power	Output power $= \frac{\eta}{100}$ Input power where η = efficiency
(iii)	$V_P I_P = V_S I_S$	$\frac{V_s}{V_p} = \frac{\eta}{100} \times \frac{I_P}{I_S}$
(iv)	$\frac{V_S}{V_P} = \frac{I_P}{I_S} = \frac{N_S}{N_P}$	$\eta = \frac{V_S I_S}{V_P I_P} \times 100$
(v)	$M = \sqrt{L_1 L_2}$	$M = K\sqrt{L_1 L_2}$

(l) Phase difference between input and output voltage is zero.

Note :

Transformer is not a generator of electricity.

8.1 <u>Energy Losses in a Transformer</u> :

(a) Coppoer losses : Due to resistance of coils.

(b) Eddy current losses : Eddy current are set up in the iron core of the transformer. To minimize these. The iron core is laminated by making it of a number of thin sheets of iron insulated from each other.

(c) **Flux losses :** The coupling of primary and secondary coils is never perfect. K should be high.

8.2 <u>Uses</u> :

(a) Power stations

(b) Radio, Television, Telegraph etc.

Example based on Transformer

Ex.17 The current in the primary coil of a transformer as shown in fig. will be -

(1) 0.01 A (2) 1.0 A (3) 0.1 A (4) 10^{-6} A

Sol. (1) $V_S = I_S Z_S \Rightarrow 22 = I_S \times 220 \therefore I_S = 0.1A$

$\frac{V_S}{V_P} = \frac{I_P}{I_S}$

$\frac{22}{220} = \frac{I_P}{o.1} \Rightarrow I_P = 0.01$ A.

Ex.18 A current of 5A is flowing at 220V in the primary coil of a transformer. If the voltage produced in the secondary coil is 2200V and 50% of power is lost, then the current in the secondary coil will be –

(1) 2.5A (2) 5A (3) 0.25A (4) 0.025A

Sol. (3) $V_p = 220V$, $I_p = 5S$, $V_s = 2200V$

$P_s = \frac{P_p}{2}$, $I_s = ?$

$\because V_s I_s = \frac{V_p I_p}{2}$

After putting the given value you will find

$I_s = 0.25$ S.

Ex.19 10 ampere alternating current flows through the primary coil of transformer at 230 volt. If a voltage of 23000 volt is produced in the secondary coil and half of the power is lost in it, then the current in the secondary coil will be –

(1) 0.05A (2) 0.5A (3) 0.1A (4) 1A

Sol.(1) $\frac{1}{2} E_p I_p = E_s I_s$, $\therefore I_s = \frac{E_p I_p}{2E_s}$

$= \frac{230 \times 10}{2 \times 23000} = \frac{1}{20}$

= 0.05A

9. Electric Motor

(a) It convert electric energy into mechanical energy.

(b) Working principle :

Electric energy → Current → Current

Carrying coil in a magnetic field → Torque on the coil → Rotation of coil.

(c) **This does not work on principle of electromagnetic induction (EMI)**

(d) The D.C. battery continues to flow a current through the armature coil and this emf also keep a control on back emf (due to EMI)

(e) Current is maximum when Motor is just started. Later on motor read justs its speed appropriate to any load.

Steady State :

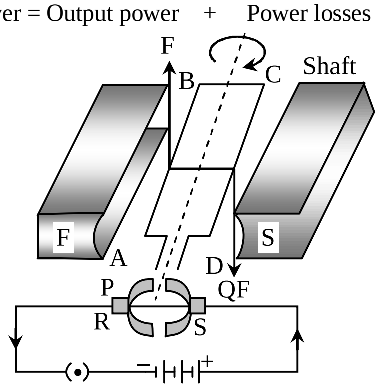
$E - e_b = I_a R_a$

$$\begin{cases} e_b = \text{back emf} \\ R_a = \text{armature resistance} \\ I_a = \text{current in the armature coil} \end{cases}$$

$E = e_b + I_a R_a \Rightarrow E I_a = e_b I_a + I_a^2 R_a$

electric power mechanical power Joul's heat

⇒ Input power = Output power + Power losses



(f) Back emf ∝ ω

ω = frequency of rotation.

(g) Efficiency of Motor

$$\eta = \frac{e_b}{E} \times 100$$

if $e_b = E$, $\eta = 100\%$

(h) Current in motor

$$I_a = \frac{E - e_b}{R_a}$$

(i) There is a possibility of damage to the insulation of windings due to a large current flow in the beginning (when back emf is zero). This is prevented by introducing a large variable resistance R called starter resistance or starter.

(j) **Losses :**

(i) Copper losses

(ii) Flux leakage

(iii) mechanical losses

(iv) Eddy currents.

10. Generator

(a) This converts mechanical energy into electrical energy.

(b) **This is based on principle of electromagnetic induction.**

(c) It consists of following parts :

(i) Armature

(ii) Field magnet

(iii) Convertor system :

(A) Brushes (A.C.)

(B) Commutator (D.C.)

(iv) Slip Rings.

(v) Load resistance.

(vi) Indicator

(vii) Driver

(d) Efficiency of generator :

$e_g = I_a (R_a + R_L)$

Where R_L = Load resistance

R_a = Armature resistance

I_a = Armature current

e_g = emf of generator

$e_g = V_L + I_a R_a$ output

$$\eta = \frac{V_L}{e_g} \times 100$$

(e) Maximum power transfer will take place when,

Load resistance = Armature resistances.

(f) **Losses :**

(i) Mechanical loss

(ii) Copper losses

(iii) Flux leakage

(iv) Eddy current losses.

POINTS TO REMEMBER

1. The unit of magnetic flux φ is weber. Since B = φ/A, so the unit of magnetic field is also expressed as 'weber/meter^2'. That is why the magnetic field induction B is also called the 'magnetic flux density'. As we have read, the unit of B is also newton /(ampere-meter).

2. C.G.S. unit of flux is Maxwell. 1 weber = 10^8 Maxwell.

3. 1 weber/m^2 = 1 Tesla.

4. If a plane is parallel to the magnetic field, then no flux-line will pass through it and the magnetic flux linked with that plane will be zero.

5. Magnetic flux can change in a number of ways, Some of them are-

(i) If a coil with plane area A be kept perpendicular to a magnetic field B, then the magnetic flux linked with the coil will be $\phi_1 = BA$.

(ii) If the coil is suddenly withdrawn from the magnetic field, then the magnetic flux linked with the coil will become $\phi_2 = 0$. Hence, the change in flux

$$\Delta\phi = \phi_2 - \phi_1 = 0 - BA = -BA$$

(iii) If the coil be rotated through 90º in the magnetic field, then also the magnetic flux linked with the coil will become zero and the change in flux will again be BA.

(iv) If the coil be rotated through 180º (half-turn), then the magnetic flux will become - BA and the change in flux will be $\Delta\phi = (-BA - BA) = -2BA$.

6. The use of the conducting copper ring for the coil in the dead-beat galvanometer closely follows the Lenz's law, as the induced current in the ring opposes the relative motion of the coil with respect to the magnetic field, and due to which the current is induced.

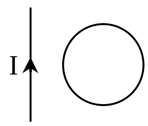
7. In a motor, (a) the current at start is $I = E/R$; (b) the current at full speed is, $I = (E - e)/R$; (c) the current at switch off is, $I = -e/R$, where e = back e.m.f., R = armature resistance, E = e.m.f. of battery.

EXERCISE # 1

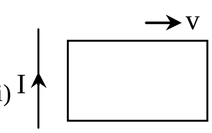
Type-I: Coils (or loop) are in plane of the paper:-

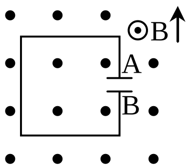
Find direction of induced current for the given cases:-

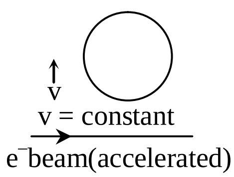
(Where w.r.t. = with respect to time, ob = observer = 👁)

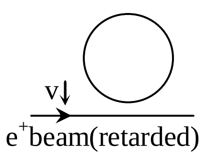
(i) 

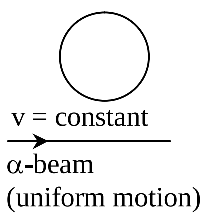
If I ↑ w.r.t.

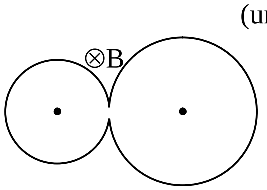
(ii) 

(iii) 

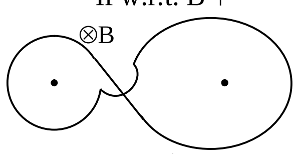
(iv) 

(v) 

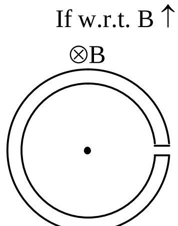
(vi) 

(vii) (a) 

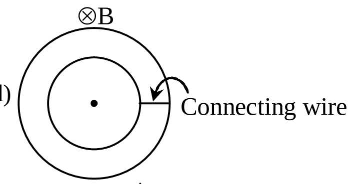
If w.r.t. B ↑

(b) 

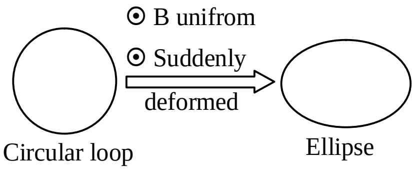
If w.r.t. B ↑

(c) 

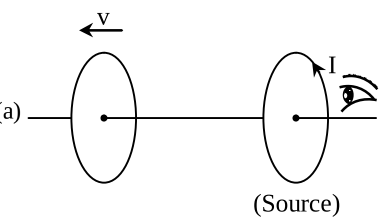
If w.r.t. B↑

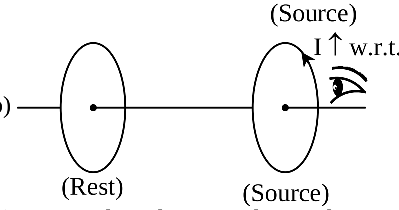
(d) 

If w.r.t. B↑

(viii) 

Type-II: Coils (or loop) are perpendicular to plane of the paper:- Find direction of induced current for the given cases:-

(i) (a) 

(b) 

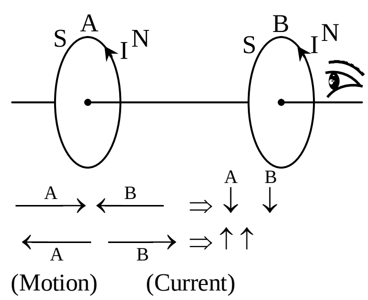
(ii) Two idential co-axial circular coils carries equal currents:-

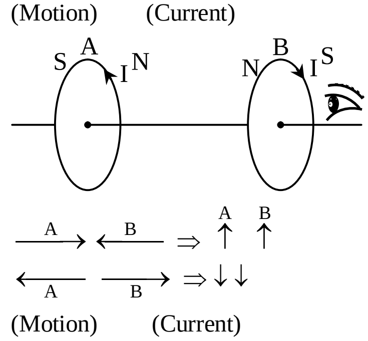
(a) In same direction (b) In opposite direction.

If both the coils moves towards each other and away from each other respectively then current in both coils:-

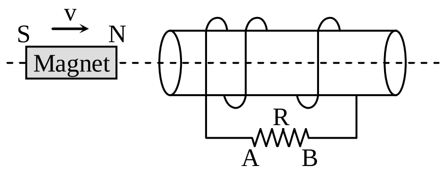
(1) Increases (2) Decreases

(3) Remains same (4) None

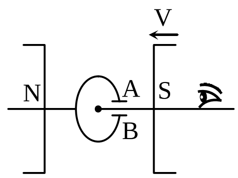




(iii) What is the direction of induced current in resistance 'R' ?

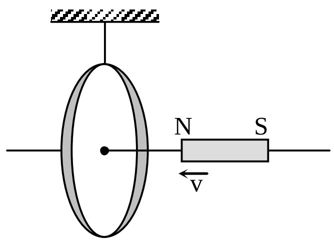


(iv) What is the nature of the charge on the plates of capacitor ?



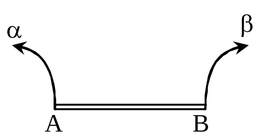
Type-III: Special Question:-

(i)

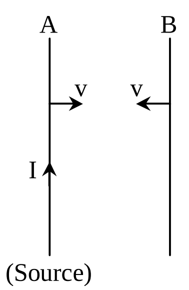


Due to motion of bar magnet freely suspended ring with attract or repel by the magnet. If ring is made up (a) Cu (b) Fe

(ii) For a radioactive wire, if α radiations emitted from the end A and β radiations emitted from the end B. What is direction of induced current in wire ?



(iii) Two parallel straight wires A and B moves towards each other. If current in A is I. What is the direction of current in wire B ?



EXCERCISE # 02

1. Flux linked through following coils changes with respect to time then for which coil an e.m.f. is not induced:-

(1) Copper coils (2) Wood coil
(3) Iron coil (4) None

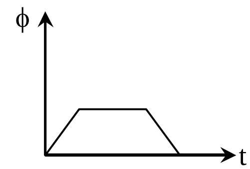
2. A coil and a magnet moves with their constant speeds 5m/s and 3m/s respectively, towards each other, then induced emf in coil is 16mV. If both are moves in same direction, then induced emf in coil :

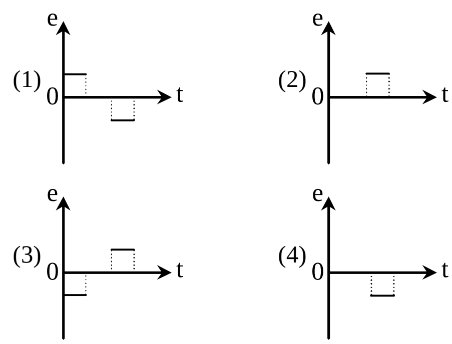
(1) 15 mV (2) 4 mV (3) 64 mV (4) Zero

3. Magnetic flux ϕ (in weber) linked with a closed circuit of resistance 10 ohm varies with time t(in seconds) as $\phi = 5t^2 - 4t + 1$. The induced emf in the circuit at t = 0.2 sec. is -

(1) 0.4 V (2) – 0.4 V (3) – 2.0 V (4) 2.0 V

4. Magnetic flux linked through the coil changes with respect to time according to following graph, then induced emf v/s time graph for coil is :





5. The radius of a circular coil having 50 turns is 2 cm. Its plane is normal to the magnetic field. The magnetic field changes from 2T to 4T in 3.14 sec. The induced emf in coil will be:-

(1) 0.4V (2) 0.04 V (3) 4 mV (4) 0.12 V

6. A conducting circular loop is placed in a uniform magnetic field 0.02T with its plane normal to the field. The radius of loop starts shrinking at a rate of 1.0 mm/sec. then induced emf in the loop at an instant when the radius is 2 cm:-

(1) 2.5 μV (2) 0.25 μV (3) 0.25 V (4) 2.5 mV

7. Magnetic field changes at the rate of 0.4 T/sec. in a square coil of side 4 cm. kept perpendicular to the field. If the resistance of the coil is $2 \times 10^{-3}\Omega$, then induced current in coil is-

(1) 0.16 A (2) 0.32A (3) 3.2 A (4) 1.6 A

8. A short bar magnet is allowed to fall along the axis of horizontal metallic ring. Starting from rest, the distance fallen by the magent in one second may be:-

(1) 4.0 m (2) 5.0 m (3) 6.0 m (4) 7.0 m

9. In a circuit a coil of resistance 2Ω, then magnetic flux changes from 2.0 Wb to 10.0 Wb in 0.2 sec. The charge flow in the coil during this time is:-

(1) 5.0 C (2) 4.0 C (3) 1.0 C (4) 0.8 C

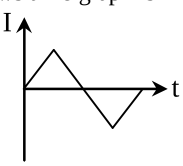
10. A coil of N turns having cross sectional area A, and resistance 'R' placed in transverse uniform magnetic field B. If it is rotates about its one of the diameter through an angle 'θ' in time interval 't'. Find following induced parameters in coil :
(a) E.M.F. (b) Current
(c) Charge

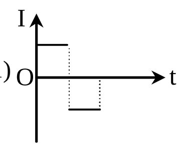
11. The value of self inductance of a coil is 5H. The value of current changes from 1A to 2A in 5 sec., then value of induced emf in it:-
(1) 10V (2) 0.1V (3) 1.0 V (4) 100 V

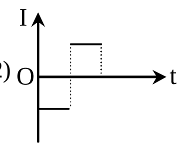
12. A coil of self inductance 2H carries a 2A current. If direction of current is reversed in 1 sec., then induced emf in it:-
(1) –8V (2) 8V (3) –4V (4) Zero

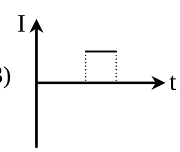
13. For a coil having L = 2mH, current flow through it is $I = t^2e^{-t}$ then the time at which emf becomes zero:-
(1) 2 sec. (2) 1 sec. (3) 4 sec. (4) 3 sec.

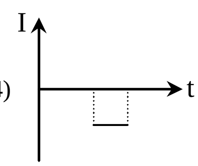
14. Current through the coil varies according to graph then induced emf v/s time graph is



(1) 

(2) 

(3) 

(4) 

15. Area of cross section of plane circular coil makes twice keeping it number of turns same, then percentage increases in its self inductance -
(1) 41.4% (2) 141.4% (3) 200% (4) 100%

16. A circular coil of self inductance 'L' is made by a constant length wire. If its number of turns makes double, then new self inductance is :
(1) L/4 (2) 4L (3) L/2 (4) 2L

17. The number of turns makes four times keeping the radius of plane circular coil same then its self inductance becomes:-
(1) 16 times (2) 4 times
(3) 1/4 times (4) Remains same

18. A solenoid have the self inductance 2H. If length of the solenoid is doubled having turn density and area constant then new self inductance is:-
(1) 4H (2) 1H (3) 8H (4) 0.5 H

19. A solenoid wound over a rectangular frame. If all the linear dimensions of the frame are increased by a factor 3 and the number of turns per unit length remains the same, the self inductance increased by a factor of:-
(1) 3 (2) 9 (3) 27 (4) 63

20. A coil of inductance 2H has a current of 5.8A. The flux in weber through the coil is:-
(1) 0.29 (2) 2.9 (3) 3.12 (4) 11.6

21. L, C and R respectively indicate inductance, capacitance and resistance. Select the combination, which does not have dimensions of frequency :
(1) 1/RC (2) R/L (3) $1/\sqrt{LC}$ (4) C/L

22. A coil of 10 H inductance and 5Ω resistance is connected to 5 volt battery in series. The current in ampere in circuit 2 seconds after switched is on:-
(1) e^{-1} (2) $(1 - e^{-1})$ (3) $(1 - e)$ (4) e

23. An L-R circuit consists of an inductance of 8mH and a resistance of 4Ω. The time constant of the circuit is:-
(1) 2ms (2) 12 ms (3) 32ms (4) 500 s

24. In an L-R circuit, time constant is that time in which current grows from zero to the value (Where I_0 is the steady state current):-
(1) $0.63\ I_0$ (2) $0.50\ I_0$ (3) $0.37I_0$ (4) I_0

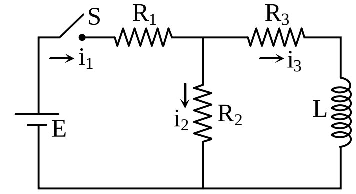
25. An inductor of 20 H and a resistance of 10Ω, are connected to a battery of 5 volt in series, then initial rate of change of current is:-
(1) 0.5 amp/s (2) 2.0 amp/s
(3) 2.5 amp/s (4) 0.25 amp/s

26. A coil of $L = 5 \times 10^{-3}$ H and R = 18 Ω is abruptly supplied a potential of 5 volts. What will be the rate of change of current in 0.001 second ? ($e^{-3.6} = 0.0273$)
(1) 27.3 amp/sec. (2) 27.8 amp/sec.
(3) 2.73 amp/sec. (4) 2.78 amp/sec.

27. A coil of inductance 8.4 mH and resistance 6Ω is connected to a 12V battery in series. The current in the coil is 1.0A at approximately the time:-
(1) 500s (2) 20s (3) 35ms (4) 1ms

28. The dimensions of combination $\frac{L}{CVR}$ are same as dimensions of:-
(1) Charge (2) Current
(3) $Charge^{-1}$ (4) $Current^{-1}$

29. In the circuit shown in adjoining fig. E = 10V, $R_1 = 1\Omega$, $R_2 = 2\Omega$, $R_3 = 3\Omega$ and L = 2H. Calculate the value of current i_1, i_2 and i_3 immediately after key S is closed:-



(1) 3.3 amp, 3.3 amp, 3.3 amp
(2) 3.3 amp, 3.3 amp, 0 amp
(3) 3.3 amp, 0 amp, 0 amp
(4) 3.3 amp, 3.3 amp, 1.1 amp

30. The mutual inductance between a primary and secondary circuits is 0.5H. The resistance of the primary and the secondary circuits are 20Ω and 5Ω respectively. To generate a current of 0.4A in the secondary current in the primary must be changed at the rate of:-

(1) 4.0 A/s (2) 16.0 A/s (3) 1.6 A/s (4) 8.0 A/s

31. Two coils A and B having turns 300 and 600 respectively are placed near each other, on passing a current of 3.0 ampere in A, the flux linked with A is 1.2×10^{-4} weber and with B it is 9.0×10^{-5} weber. The mutual inductance of the system is:-

(1) 2×10^{-5} H (2) 3×10^{-5} H

(3) 4×10^{-5}H (4) 6×10^{-5} H

32. If the current in a primary circuit is $I = I_0 \sin \omega t$ and the mutual inductance is M, then the value of induced voltage in secondary circuit will be:-

(1) $e = MI_0\, \omega \cos \omega t$ (2) $e = -MI_0\, \omega \cos \omega t$

(3) $e = [M\omega \cos \omega t]/I_0$ (4) $e = -(M\omega \cos \omega t)/I_0$

33. An a.c. of 50 Hz and 1A peak value flows in primary coil transformer whose mutual inductance is 1.5 H. Then peak value of induced emf in secondary is:-

(1) 150 V (2) 150 πV (3) 300 V (4) 200 V

34. The number of turn of primary and secondary coil of a transformer is 5 and 10 respectively and the mutual inductance is 25 H. If the number of turns of the primary and secondary is made 10 and 5, then the mutual inductance of the coils will be :

(1) 6.25 H (2) 12.5 H (3) 25 H (4) 50 H

35. The length of a solenoid is 0.3 m and the number of turns is 2000. The area of cross-section of the solenoid is $1.2 \times 10^{-3} m^2$. Another coil of 300 turns is wrapped over the solenoid. A current of 2A is passed through the solenoid and its direction is change in 0.25 sec. then the induced emf in coil:

(1) 4.8×10^{-2}V (2) 4.8×10^{-3} V

(3) 3.2×10^{-4}V (4) 3.2×10^{-2} V

36. Two conducting loops of radii R_1 and R_2 are concentric and are placed in the same plane. If $R_1 > R_2$, the mutual inductance M between them will be directly proportional to:-

(1) R_1/R_2 (2) R_2/R_1

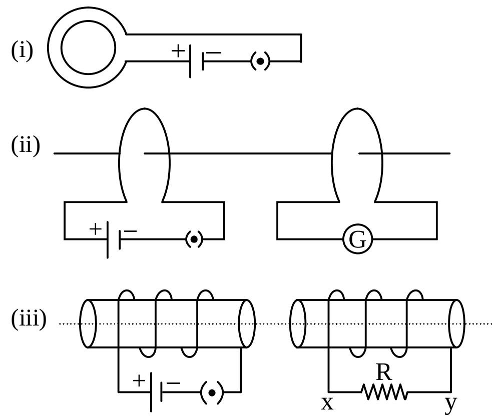
(3) R_1^2/R_2^2 (4) R_2^2/R_1

37. Find direction of instantaneous induced current in secondary circuit for the following changes in primary circuit:-

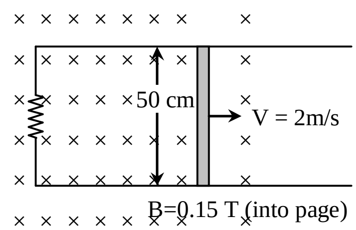
(a) Key is just closed

(b) Some time after the closing of key

(c) Key is just opened



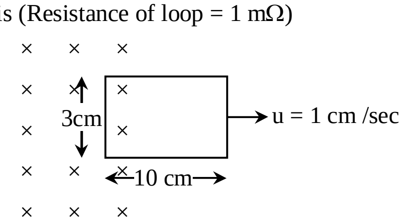
38. A metallic rod completes its circuit as shown in the figure. The circuit is normal to a magnetic field of B = 0.15 T. If the resistance of the circuit is 3Ω the force required to move the rod with a constant velocity of 2m/sec. is:



(1) 3.75×10^{-3} N (2) 3.75×10^{-2} N

(3) 3.75×10^{2} N (4) 3.75×10^{-4} N

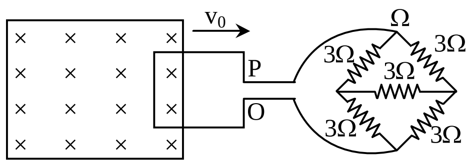
39. A rectangular loop sides 10 cm and 3cm moving out of a region of uniform magnetic field of 0.5T directed normal to the loop. If we want to move loop with a constant velocity 1cm/sec. then required mechanical force is (Resistance of loop = 1 mΩ)



(1) 2.25×10^{-3} N (2) 4.5×10^{-3} N

(3) 9×10^{-3} N (4) 1.25×10^{-3} N

40. A metallic square wire loop of side 10 cm and resistance 1Ω is moved with a constant velocity v_0 in a uniform magnetic field of induction B = 2T as shown in the figure. The magnetic field perpendicular to the plane of the loop. The loop is connected to a network of resistors each of value 3Ω . The resistance of the lead wires OS and PQ are negligible. What should be the speed of the loop so as to have a steady current of 1 mA in it ? Give the direction of current in the loop.



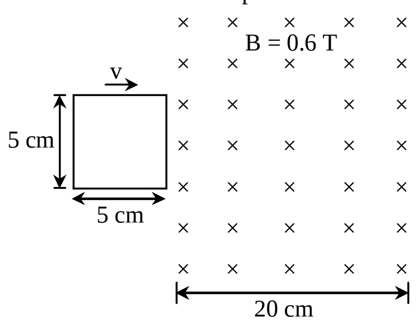
(1) 2×10^{-2} m/sec., anticlockwise direction

(2) 4×10^{-2} m/sec., anticlockwise direction

(3) 2×10^{-2} m/sec., clockwise direction

(4) 4×10^{-2} m/sec., clockwise direction

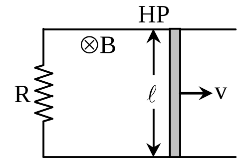
41. Figure shows a square loop of side 5 cm being moved towards right at a constant speed of 1 cm/sec. The front edge just enters the 20 cm wide magnetic field at t = 0. Find the induced emf in the loop at t = 2s and t = 10s.



(1) 3×10^{-2}, zero (2) 3×10^{-2}, 3×10^{-4}

(3) 3×10^{-4}, 3×10^{-4} (4) 3×10^{-4}, zero

42. A conducting rod moves towards right with constant velocity v in uniform transverse magnetic field. Graph between force applied by the external agent v/s velocity and power supplied by the external agent v/s velocity.



(1) St. line, parabola (2) Parabola, st. line

(3) St. line, St. line (4) Parabola, Parabola

ANSWER KEY

Ans. Q. No. 37

(i) (ii) (iii)

(a) ACW (a) ACW (a) x to y

(b) Zero (b) Zero (b) Zero

(c) CW (c) CW (c) y to x

Ques.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Ans.	4	2	4	3	2	1	2	1	2	3	2	1	2	1	4	1	1	3	4	4
Ques.	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**38**	**39**	**40**	**41**	**42**
Ans.	2	1	1	4	1	4	4	2	1	2	2	2	3	1	4	1	1	3	4	1

SOLVED EXAMPLES

Ex.1 A loop of wire is placed in a magnetic field $\vec{B} = 0.02\hat{i}$ tesla. Then the flux through the loop is its area vector is $\vec{A} = 30\hat{i} + 16\hat{j} + 23\hat{k}$ cm^2, is .

(1) 60μW (2) 32μ Wb
(3) 46μ Wb (4) 138μ Wb

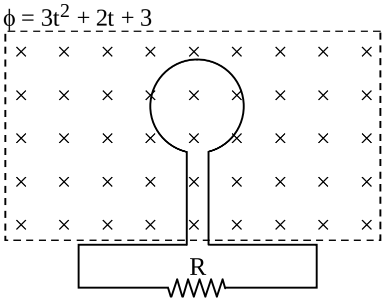
Sol.(1) $\phi = \vec{B} \cdot \vec{A}$

$= (0.02\hat{i}) \cdot (30\hat{i} + 16\hat{j} + 23\hat{k}) \times 10^{-4}$

$= 0.6 \times 10^{-4}$ Wb = 60μ Wb

Ex. 2 The magnetic flux passing perpendicular to the plane of the coil and directed into the paper is varying according to the relation.

$\phi = 3t^2 + 2t + 3$



Where ϕ is in milliwebers and t is in seconds. Then the magnitude of emf induced in the loop when t = 2 second is-

(1) 31 mV (2) 19 mV (3) 14 mV (4) 6 mV

Sol.(3) The induced emf

$E = -d\phi/dt = -\frac{d}{dt}(3t^2 + 2t + 3) \times 10^{-3}$

(because given flux is in mWb).

Thus $E = (-6t - 2) \times 10^{-3}$

at t = 2 sec,

$E = (-6 \times 2 - 2) \times 10^{-3} = -14$ mV.

Note : **The direction of the current flow in the resistance R would be anticlockwise. Think why ?**

Ex.3 5.5×10^{-4} magnetic flux lines are passing through a coil of resistance 10 ohm and number of turns 1000. If the number of flux lines reduces to 5×10^{-5} in 0.1 sec. The electromotive force and the current induced in the coil will be respectively-

(1) 5V, 0.5 A
(2) 5×10^{-4} V, 5×10^{-4} A
(3) 50 V, 5 A
(4) none of the above.

Sol.(1) Initial magnetic flux $\phi_1 = 5.5 \times 10^{-4}$ weber.

Final magnetic flux $\phi_2 = 5 \times 10^{-5}$ weber.

∴ change in flux

$\Delta\phi = \phi_2 - \phi_1 = (5 \times 10^{-5}) - (5.5 \times 10^{-4})$

$= -50 \times 10^{-5}$ weber.

Time interval for this change, $\Delta t = 0.1$ sec.

∴ induced emf in the coil

$$e = -N\frac{\Delta\Phi}{\Delta t} = -1000 \times \frac{(-50\times10^{-5})}{0.1} = 5 \text{ volt.}$$

Resistance of the coil, R = 10 ohm. Hence induced current in the coil is

$$i = \frac{e}{R} = \frac{5 \text{ volt}}{10 \text{ ohm}} = 0.5 \text{ ampere.}$$

Ex.4 A gramophone disc of brass of diameter 30 cm rotates horizontally at the rate of 100/3 revolutions per minute. If the vertical component of the earth's magnetic field be 0.01 weber / meter^2, then the emf induced between the centre and the rim of the disc will be-

(1) 7.065×10^{-4} V (2) 3.9×10^{-4} V
(3) 2.32×10^{-4} V (4) none of the above.

Sol. (2) Magnetic flux passing through the disc is $\phi = BA$

$= 0.01 \frac{\text{weber}}{\text{meter}^2} \times 3.14 \times (15 \times 10^{-2} \text{ meter})^2$

$= 7.065 \times 10^{-4}$ weber.

The line joining the centre and the circumference of the disc cuts 7.065×10^{-4} weber flux in one round. So, the rate of cutting flux (i.e. induced emf)

= flux x number of revolutions per second

$= 7.065 \times 10^{-4} \times \frac{100}{60\times3} = 3.9 \times 10^{-4}$ volt.

Ex.5 A closed coil consists of 500 turns on a rectangular frame of area 4.0 cm^2 and has a resistance of 50 ohm. The coil is kept with its plane perpendicular to a uniform magnetic field of 0.2 weber/meter^2. The amount of charge flowing through the coil if it is turned over (rotated through 180º) will be -

(1) 1.6×10^{-19} C (2) 1.6×10^{-9} C
(3) 1.6×10^{-3} C (4) 1.6×10^{-2} C

Sol. (3) The magnetic flux passing through each turn of a coil of area A, perpendicular to a magnetic field B is given by

$\phi_1 = BA.$

The magnetic flux through it on rotating it through 180º will be

$\phi_2 = -BA$.(– sign is put because now the flux lines enters the coils through the outer face)

∴ change in magnetic flux

$\Delta\phi = \phi_1 - \phi_2 = -BA - (BA) = -2BA.$

Suppose this change takes in time Δt. According to Faraday's law, the emf induced in the coil is given by

$$e = -N\frac{\Delta\Phi}{\Delta t} = \frac{2NBA}{\Delta t},$$

where N is number of turns in the coil. The current in the coil will be

$$i = \frac{e}{R} = \frac{1}{R}\frac{2NBA}{\Delta t}$$

where R is the resistance of the circuit. The current persists only during the change of flux i.e. for the time interval Δt second. So, the charge passed through the circuit is

$$q = i \times \Delta t = \frac{2NBA}{R}.$$

Here N = 500, B = 0.2 weber/meter^2,

A = 4.0 cm^2 = 4.0×10^{-4} meter^2 and R = 50 ohm.

$$\therefore q = \frac{2\times500\times0.2\times4.0\times10^{-4}}{50} = 1.6\times10^{-3} \text{ coulomb.}$$

Note : **Rotating the coil slow or fast has no effect on the charge flown through the coil. Charge flow depends upon the total change in magnetic flux, not on the rate of change of magnetic flux.**

Ex.6 A very small circular loop of area 5×10^{-4} m^2, resistance 2 ohm and negligible inductance is initially coplanar and concentric with a much larger fixed circular loop of radius 0.1 m. A constant current of 1 ampere is passed in a bigger loop and the smaller loop is rotated with angular velocity ω rad/sec about a diameter. Calculate (i) the flux linked with the smaller loop, (ii) induced emf, and ((iii) induced current in the smaller loop, as a function of time
($\mu_0 = 4\pi \times 10^{-7}$ V-s/A-m).

Sol. The magnetic field at the centre of the larger loop of radius a is

$$B = \frac{\mu_0 i}{2a} = \frac{(4\pi \times 10^{-7}) \times 1}{2 \times 0.1} = 2\pi \times 10^{-6} \text{ weber/m}^2.$$

This field is perpendicular to the plane of the loop. The instantaneous magnetic flux linked with the smaller loop (area A) placed at the centre of the larger loop is

$$\Phi = \vec{B}\,.\,\vec{A} = BA \cos \omega t$$
$$= (2\pi \times 10^{-6}) \times (5 \times 10^{-4}) \cos \omega t.$$
$$= \pi \times 10^{-9} \cos \omega t \text{ weber.}$$

(ii) Induced emf

$$e = -\frac{d\Phi}{dt} = BA\omega \sin \omega t = \pi \times 10^{-9}\, \omega \sin \omega t \text{ volt.}$$

(iii) Induced current

$$i = \frac{e}{R} = \frac{\pi}{2} \times 10^{-9}\, \omega \sin \omega t. \text{ ampere}$$

Ex.7 A copper disc of radius 0.1 m rotates about its centre with 10 revolutions per second in 'a uniform magnetic field of 0.1 tesla. The emf induced across the radius of the disc is-
(1) π/10 V (2) 2π/10 V (3) 10π mV (4) 20π mV

Sol. (3) The induced emf between centre and rim of the rotating disc is

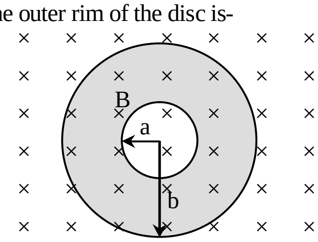
$$E = \frac{1}{2} B\omega R^2 = \frac{1}{2} \times 0.1 \times 2\pi \times 10 \times (0.1)^2 = 10\pi \times 10^{-3} \text{ volt,}$$

Ex.8 Two rail tracks, insulated from each other and the ground, are connected to millivoltmeter. What is the reading of the milli voltmeter when a train passes at a speed of 180 km/hr along the track, given that the horizontal component of earth's magnetic field is 0.2×10^{-4} Wb/m^2 and rails are separated by 1 meter.
(1) 1 mV (2) 10 mV (3) 100 mV (4) 1 V

Sol.(1) The induced emf

$$E = B\ell v = 0.2 \times 10^{-4} \times 1 \times 180 \times 1000/3600$$
$$= 0.2 \times 18/3600 = 1 \times 10^{-3}. \text{ V} = 1\text{mV}$$

Ex.9 The annular disc of copper, with inner radius a and outer radius b is rotating with a uniform angular speed ω, in a region where a uniform magnetic field B along the axis of rotation exists. Then, the emf induced between inner side and the outer rim of the disc is-



(1) Zero (2) $\frac{1}{2} B\omega a^2$

(3) $\frac{1}{2} B\omega b^2$ (4) $\frac{1}{2} B\omega (b^2 - a^2)$

Sol.(4) The induced emf is obtained by considering a strip on the disc fig. Then, the linear speed of a small element dr at a distance r from the centre is = ωr. The induced emf across the ends of the small element is-
de = B(dr)v = B ωr dr
Thus the induced emf across the inner and outer sides of the disc is

$$e = \int_a^b B\omega r\, dr = \frac{1}{2} B\omega (b^2 - a^2)$$

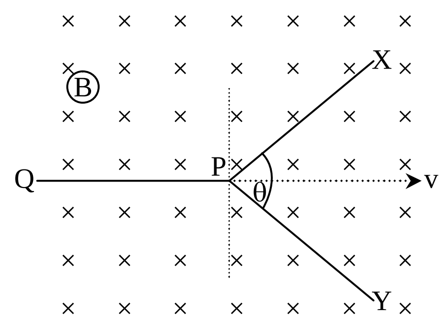
Ex.10 A coil with 200 turns and area of 70 cm^2 is placed in a uniform magnetic field of strength 0.3 tesla pointing normal to the plate of the coil. If the coil turns through 180º in 0.1 sec, then the value of induced emf is-
(1) 4.2 V (2) 8.4 V (3) 42 V (4) 84 V

Sol.(2) The change is flux = 2 BAN

Thus induced emf $e = \frac{2BAN}{0.1}$

$$= 2 \times 0.3 \times 200 \times 10^{-4} \times 70/0.1 = 8.4 \text{ V}$$

Ex.11 A conducting wire in the shape of Y; with each side of length ℓ is moving in a uniform magnetic field B, with a uniform speed v as shown in fig. The induced emf at the two ends X and Y of the wire will be-



(1) Zero (2) $2 B\ell v$
(3) $2 B\ell v \sin(\theta/2)$ (4) $2 B\ell v \cos(\theta/2)$

Sol.(3) the induced emf $e = -(\vec{v} \times \vec{B})\,.\,\vec{\ell}$

For the part PX,, $\vec{v} \perp \vec{B}$, and the angle between $(\vec{v} \times \vec{B})$ direction (the dotted line in figure and $\vec{\ell}$ is (90 – θ). Thus

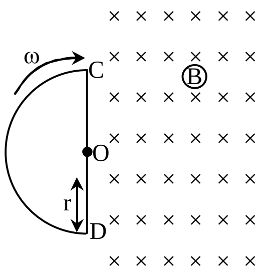
$e_P - e_x = vB\ell \cos(90 - \theta/2) = vB\ell \sin(\theta/2)$

Similarly $e_y - e_p = vB\ell \sin(\theta/2)$

Therefore induced emf
between X and Y is $e_{yx} = 2\, B\, v\ell \sin(\theta/2)$

Note : **The induced emf between points P and Q is zero because is parallel to . The induced emf between Q and X is $Bv\ell \sin(\theta/2)$. The end Y is positive while X is negative. If the movement of the wire segment was upwards or downwards in fig, than $e_{xy} = 0$.**

Ex.12 In fig, CODF is a semicircular loop of a conducting wire of resistance R and radius r. It is placed in a uniform magnetic field B, which is directed into the page (perpendicular to the plane of the loop). The loop is rotated with a constant angular speed ω about an axis passing through the centre O, and perpendicular to the page. Then the induced current in the wire loop is-



(1) Zero (2) $Br^2\ \omega/R$
(3) $Br^2\ \omega/2R$ (4) $B\pi r^2\ \omega/R$

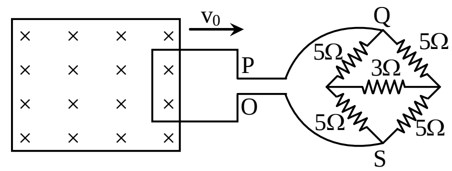
Sol.(3) The area swept by radius OC in one half circle is $\pi r^2/2$. The flux change in time T/2 is thus (πr^2 B/2). The induced emf is then $e = \pi r^2 B/T$
$= 2\pi r^2 B/Tx^2 = B\omega r^2/2$
The induced current is then
$I = e/R = B\omega r^2/2R$

Ex.13 A 10-meter wire is kept in east-west direction. It is falling down with a speed of 5.0 meter/second, perpendicular to the horizontal component of earth's magnetic field of 0.30×10^{-4} weber/meter^2. The momentary potential difference induced between the ends of the wire will be-
(1) 0.0015 V (2) 0.015 V
(3) 0.15 V (4) 1.5 V

Sol. (1) If a wire, ℓ meter in length, moves perpendicular to a magnetic field of B weber/meter^2 with a velocity of v meter/second, then the e.m.f. induced in the wire is given by
$V = Bv\ell$ volt.
Here, $B = 0.30 \times 10^{-4}$ weber/meter^2,
v = 5.0 meter/second and ℓ = 10 meter.
$\therefore$ $B = 0.30 \times 10^{-4} \times 5.0 \times 10 = 0.0015$ volt
= 1.5 millivolt.

Note: **According to the Fleming's left-hand rule, the magnetic force on the positive charge in the wire placed in the magnetic field will act towards east. Hence the magnetic force on the free electrons will act towards west and so they will move to the western end of the wire. Hence the eastern end of the wire be at higher (positive) potential.**

Ex.14 A metallic square wire-loop of side 10 cm and resistance 1 ohm is moved with a constant velocity v_d in a uniform magnetic field of induction B = 2 weber/meter^2 as shown in the fig. The magnetic field lines are perpendicular to the plane of the loop (directed into the paper). The loop is connected to a network of resistors each of value 5 ohm. The resistance of the lead wires OS and PQ are negligible. What should be the speed of the loop so as to have a steady current of 1 milliampere in it ? Give the direction of current in the loop.



Sol. The mesh of the resistances OCSA is a 'balanced' Wheatstone's bridge so that the resistance CA is ineffective. Let the equivalent resistance of the bridge be R'. Then

$$\frac{1}{R'} = \frac{1}{10} + \frac{1}{10} = \frac{1}{5} \quad \text{or} \quad R' = 5 \text{ ohm}$$

Total resistance of the circuit, R = 5 + 1 = 6 ohm.
The e.m.f. induced in the loop $e = Bv\ell$.

therefore current in the loop, $i = \frac{e}{R} = \frac{Bv\ell}{R}$.

So speed of loop, $v = \frac{iR}{B\ell}$.

If current i = 1 milliampere
$= 1 \times 10^{-3}$ ampere, then

$$v = \frac{(1\times10^{-3})\times 6}{2\times 0.1} = 3 \times 10^{-2} \text{ meter/second.}$$

According to the Fleming's right-hand the current in the loop will be clockwise.

Ex.15 The current flowing in a coil whose coefficient of self-induction is 0.4 mH changes by 250 mA in 0.1 sec. The electromotive force (e.m.f.) induced in the coil will be-
(1) 100 mV (2) 30 mV (3) .01 mV (4) 1mV

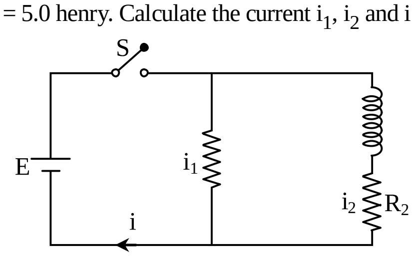
Sol. (4) Induced e.m.f $e = -L\ \frac{\Delta i}{\Delta t}$

Here L = 0.4 mH = 0.4×10^{-3} henry,
Δi = 0.250 ampere

$$\therefore\ e = -(0.4 \times 10^{-3})\ \frac{0.250}{0.1}$$

$= 1 \times 10^{-3}$ volt = 1 millivolt.
The minus sign indicates that the direction of the induced e.m.f. is such as to oppose the change in current.

Ex.16 In the circuit, E = 10 volt, R_1 = 5.0 ohm, R_2 = 10 ohm and L = 5.0 henry. Calculate the current i_1, i_2 and i



(i) just when the switch S is pressed,
(ii) after sufficient time the switch S is pressed.

Sol. (i) 'Immediately' after pressing the switch S, the current in the coil L, due to its self-induction will be zero, that is $i_2 = 0$.
The current will only be found in the resistance R_1 and this will be the total current in the circuit.

$$\therefore\ i = i_1 = \frac{E}{R_2} = \frac{10 \text{ volt}}{5.0 \text{ volt}} = 2.0 \text{ ampere.}$$

(ii) After some time the switch S is pressed, the current will be established in L and in R_2 also. Because R_1 and R_2 are in parallel, the equivalent resistance in the circuit is

$$R = \frac{R_1R_2}{R_1+R_2} = \frac{5.0\times10}{5.0\times10} = \frac{10}{3}\text{ ohm.}$$

$\therefore$ total current in the circuit is

$$i = \frac{E}{R} = \frac{10\text{ volt}}{(10/3)\text{ohm}} = 3.0\text{ ampere.}$$

Since the internal resistance of the cell is negligible, the potential difference across R_1 is V = 10 volt. Hence the current in R_1 is

$$i_1 = \frac{V}{R_1} = \frac{10\text{ volt}}{5.0\text{ ohm}} = 2.0\text{ ampere.}$$

The current in R_2 is

$$i_2 = i - i_1 = 3.0 - 2.0 = 1.0\text{ ampere.}$$

Ex.17 Two inductors L_1 and L_2 are at a sufficient distance apart. Find out equivalent inductance when they are connected (i) in series (ii) in parallel.

Sol. (i) In series the same current i will be induced in both the inductors and the total magnetic-flux linked with them will be equal to the sum of the fluxes linked with them individualy, that is,

$$\Phi = L_1i + L_2i.$$

If the equivalent inductance be L, then $\Phi = Li$.

$\therefore Li = L_1i + L_2i$ or $L = L_1 + L_2$.

(ii) In parallel, let the induced currents in the two coils be i_1 and i_2. Then the total induced current is

$$i = i_1 + i_2 \qquad \therefore \frac{di}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt}$$

In parallel, the induced e.m.f. across each coil will be the same.

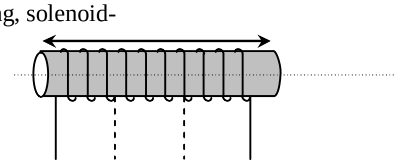
Hence $$e = -L_1\frac{di_1}{dt} = -L_2\frac{di_2}{dt}.$$

If the equivalent inductance be L, then $e = -L\frac{di}{dt}$.

$$\therefore \frac{e}{L} = \frac{di}{dt} - = -\left(\frac{di_1}{dt}+\frac{di_2}{dt}\right) = \frac{e}{L_1} + \frac{e}{L_2}$$

or $$\frac{1}{L} = \frac{1}{L_1}+\frac{1}{L_2} \text{ or } L = \frac{L_1L_2}{L_1+L_2}.$$

Ex.18 A small coil of N_1 turns, ℓ_1 length, is tightly wound over the centre of a long solenoid of length ℓ_2, area of cross-section A and number of turns N_2. If a current I flows in the small coil, Then what is the flux through the long, solenoid-



(1) Zero (2) $\frac{\mu_0N_1^2AI}{\ell_1}$

(3) infinite (4) $\frac{\mu_0N_1N_2AI}{\ell_2}$

Sol.(4) If we try to find field of the small coil and then calculate flux through long solenoid, the problem becomes very difficult. So we use the following fact about mutual inductance.

$$M_{21} = M_{12}, \frac{\phi_2}{I_1} = \frac{\phi_1}{I_2}$$

Thus if I current flows in long solenoid, then flux ϕ through small coil is the same as the flux ϕ_2 that is obtained when I current flows through the small coil. Therefore,

$\phi_2 = \phi_1$ = (Field at small coil) × (area) × (turns)

$$= \left(\mu_0\frac{N_2}{\ell_2}I\right)(AN_1) = \frac{\mu_0N_1N_2Al}{\ell_2}$$

Ex.19 If the current in the primary coil is reduced from 3.0 ampere to zero in 0.001 second, the induced e.m.f in the secondary coil is 1500 volt. The mutual inductance of the two coils will be-

(1) 0.5 H (2) 0.05 H
(3) 0.005 H (4) 0.0005 H

Sol.(1) the induced e.m.f. is

$$e = -M\frac{\Delta i}{\Delta t} \text{ or } M = -\frac{e}{\Delta i/\Delta t}$$

Here e = 1500 volt.

$$\therefore M = -\frac{1500}{(0-3.0)/0.001} = \frac{1500\times0.001}{3.0} = 0.5\text{ henry.}$$

Ex.20 A 50 Hz a.c. current of crest value 1A flows through the primary of a transformer. If the mutual inductance between the primary and secondary be 1.5 H, the crest voltage induced in secondary is-

(1) 75 V (2) 150 V (3) 225 V (4) 300 V

Sol.(4) The crest value is attained in T/4 time where T is the time period of A.C.

Thus dI = 1A in dt = T/4 sec

$$T = \frac{1}{50} \text{ or } dt = \frac{1}{200}$$

The induced emf is

$$|E_2| = M\frac{dI_1}{dt} = 1.5\times\frac{1}{(1/200)}$$
$$= 1.5 \times 200 = 300\text{ V}$$

EXERCISE # 1

Q.1 A flux of 1m Wb passes through a strip having an area A = 0.02 m^2. The plane of the strip is at an angle of 60º to the direction of a uniform field B. The value of B is-
(1) 0.1 T (2) 0.058 T
(3) 4.0 mT (4) none of the above.

Q.2 A small loop of area of cross section 10^{-4} m^2 is lying concentrically and coplanar inside a bigger loop of radius 0.628m. A current of 10A is passed in the bigger loop. The smaller loop is rotated about is diameter with an angular velocity ω. The magnetic flux linked with the smaller loop will be-
(1) $10^{-7} \sin \omega t$ (2) $10^{-7} \cos \omega t$
(3) $10^{-9} \sin \omega t$ (4) $10^{-9} \cos \omega t$

Q.3 A coil of N turns and area A is rotated at the rate of n rotations per second in a magnetic field of intensity B, the magnitude of the maximum magnetic flux will be-
(1) NAB (2) nAB (3) NnAB (4) 2πnNAB

Q.4 The number of turns in a long solenoid is 500. The area of cross-section of solenoid is 2×10^{-3} m^2. If the value of magnetic induction, on passing a current of 2 amp, through it is 5×10^{-3} Tesla, the magnitude of magnetic flux connected with it in Weber will be-
(1) 5×10^{-3} (2) 10^{-2} (3) 10^{-5} (4) 2.5

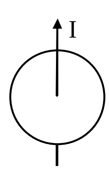
Q.5 The instantaneous flux associated with a closed circuit of 10Ω resistance is indicated by the following reaction $\phi = 6t^2 - 5t + 1$, then the value in amperes of the induced current at t = 0.25 sec will be-
(1) 1.2 (2) 0.8 (3) 6 (4) 0.2

Q.6 A cylindrical bar magnetic is lying along the axis of a circular coil. If the magnet is rotated about the axis of the coil then-
(1) e.m.f. will be induced in the coil
(2) Only induced current will be generated in the coil
(3) No current will be induced in the coil
(4) Both e.m.f. and current will be induced in the coil

Q.7 When a coil of area 2 cm^2 and having 30 turns, whose plane is normal to the magnetic field, is drawn out of the magnetic field, a charge of 1.5×10^{-4} coulomb flows in the circuit. If its resistance is 40 ohm, then the magnetic flux density in Tesla will be-
(1) 10 (2) 0.1 (3) 1 (4) 0.01

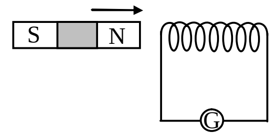
Q.8 When a magnet is being moved towards a coil, the induced emf does not depend upon-
(1) the number of turns of the coil
(2) the motion of the magnet
(3) the magnetic moment of the magnet
(4) the resistance of the coil

Q.9 A wire carrying current I, lie on the axis of a conducting ring. The direction of the induced current in the ring, when I is decreasing at a steady rate is-



(1) clockwise
(2) anticlockwise
(3) alternatively clock and anticlockwise
(4) no induced current flow in the ring

Q.10 A magnet is brought towards a fixed coil rapidly. Due to this induced emf, current and charge are E, I and Q respectively. If the speed of the magnet is doubled, then wrong statement is-



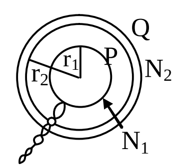
(1) E increases (2) I increases
(3) Q remains unchanged (4) Q increases

Q.11 A field of $5 \times 10^4/\pi$ ampere-turns/metre acts at right angles to a coil of 50 turns of area 10^{-2} m^2. The coil is removed from the field in 0.1 second. Then the induced emf in the coil is-
(1) 0.1 V (2) 80 KV
(3) 7.96 V (4) none of the above

Q.12 A coil having n turns and area A is initially placed with its plane normal to the magnetic field B. It is then rotated through 180º in 0.2 sec. The emf induced at the ends of the coils is-
(1) 0.1 nAB (2) nAB (3) 5 nAB (4) 10 nAB

Q.13 A conducting circular loop is placed in a uniform magnetic field B = 40 mT with its plane perpendicular to the field. If the radius of the loop starts shrinking at a constant rate of 2mm/s, then the induced emf in the loop at an instant when its radius is 1.0 cm is-
(1) 0.1 π μ V (2) 0.2 π μ V
(3) 1.0 π μ V (4) 1.6 π μ V

Q.14 Two plane circular coils P and Q have radii r_1 and r_2, respectively, ($r_1 << r_2$) and are coaxial as shown in fig. The number of turns in P and Q are respectively N_1 and N_2. If current in coil Q is varied steadily at a rate x ampere/sec then the induced emf in the coil P will be approximately-



(1) $\mu_0 N_1 N_2 \pi r_1^2$ (2) $\mu_0 N_1 N_2 \pi r_1^2 x$
(3) $\mu_0 N_1 N_2 \pi r_1^2 x / 2r_2$ (4) 0

Q.15 The rate of change of magnetic flux density through a circular coil of area 10^{-2} m and number of turns 100 is 10^3 Wb/m^2/s. The value of induced e.m.f. will be -
(1) 10^{-2}V (2) 10^{-3}V (3) 10V (4) 10^3V

Q.16 A long solenoid contains 1000 turns/cm and an alternating current of peak value 1A is flowing in it. A search coil of area of cross-section 1×10^{-4} m^2 and having 50 turns is placed inside the solenoid with its plane perpendicular to the axis of the solenoid. A peak voltage of $2\pi^2 \times 10^{-2}$V is produced in the search coil. The frequency of current in the solenoid will be -
(1) 50 Hz (2) 100 Hz (3) 500 Hz (4) 1000 Hz

Q.17 A coil of cross-sectional area 5×10^{-4} m^2 and having number of turns 1000 is placed perpendicular to a magnetic field of 10^{-2} T. The coil is connected to a galvanometer of resistance 500Ω. The induced charge generated in the coil on rotating it through an angle of π radian will be -

(1) 10 μC (2) 20 μC (3) 50 μC (4) 100 μC

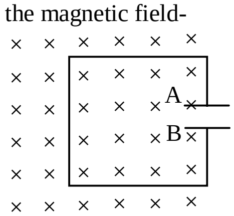
Q.18 Lenz's law is consistent with law of conservation of -

(1) current (2) emf
(3) energy (4) all of the above

Q.19 The north pole of a magnet is brought near a coil. The induced current in the coil as seen by an observer on the side of magnet will be-

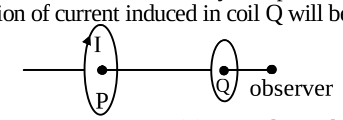
(1) in the clockwise direction
(2) in the anticlockwise direction
(3) initially in the clockwise and then anticlockwise direction
(4) initially in the anticlockwise and then clockwise direction.

Q.20 A magnetic field is directed normally downwards through a metallic frame as shown in the figure. On increasing the magnetic field-



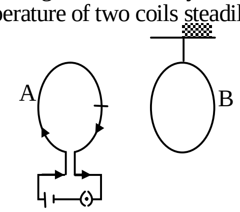
(1) plate B will be positively charged
(2) plate A will be positively charged
(3) none of the plates will be positively charged
(4) all of the above

Q.21 Two coils P and Q are lying a little distance apart coaxially. If a current I is suddenly set up in the coil P then the direction of current induced in coil Q will be-



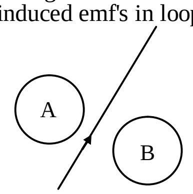
(1) clockwise (2) towards north
(3) towards south (4) anticlockwise

Q.22 A system S consists of two coils A and B. The coil A carries a steady current I while the coil B is suspended near by as shown in fig. Now if the system is heated so as to raise the temperature of two coils steadily then-



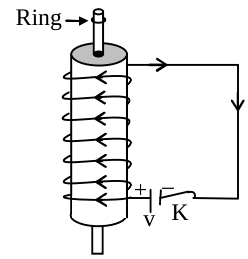
(1) the two coils show attraction
(2) the two coils show repulsion
(3) there is no change in the position of the two coils
(4) induced currents are not possible in coil B.

Q.23 Consider the situation shown in fig. If the current I in the long straight wire XY is increased at a steady rate then the induced emf's in loops A and B will be-



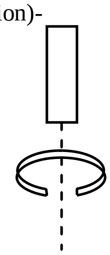
(1) clockwise in A, anticlockwise in B
(2) anticlockwise in A, clockwise in B
(3) clockwise in both A and B
(4) anticlockwise in both A and B

Q.24 A conducting ring is placed around the core of an electromagnet as shown in fig. When key K is pressed, the ring-



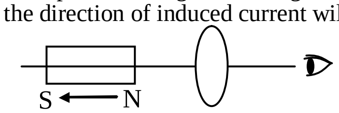
(1) remains stationary
(2) is attracted towards the electromagnet
(3) jumps out of the core
(4) none of the above

Q.25 A copper ring having a cut such as not to form a complete loop is held horizontally and a bar magnet is dropped through the ring with its length along the axis of the ring. Then acceleration of the falling magnet is- (neglect air friction)-



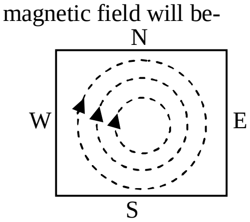
(1) g (2) less than g
(3) more than g (4) 0

Q.26 The north pole of a magnet is brought away from a coil, then the direction of induced current will be-



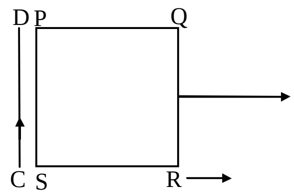
(1) in the clockwise direction
(2) in the anticlockwise direction
(3) initially in the clockwise and then anticlockwise direction
(4) initially in the anticlockwise and then clockwise direction.

Q.27 A metal sheet is placed in a variable magnetic field which is increasing from zero to maximum. Induced current flows in the directions as shown in figure. The direction of magnetic field will be-



(1) normal to the paper, inwards
(2) normal to the paper, outwards.
(3) from east to west
(4) from north to south

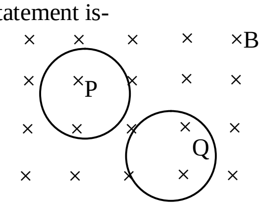
Q.28 A square loop PQRS is carried away from a current carrying long straight conducting wire CD. The direction of induced current in the loop will be-



(1) anticlockwise
(2) clockwise
(3) sometimes clockwise some times anticlockwise
(4) current will not be induced

Q.29 A thin sheet of conductor, when allowed to oscillate in a magnetic field normal to the sheet, then the motion is-
(1) damped due to air friction
(2) damped due to eddy currents
(3) accelerated due to eddy currents
(4) not effected by induced currents

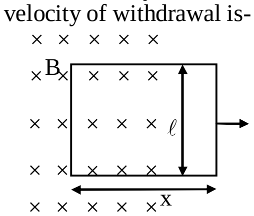
Q.30 P and Q are two circular thin coils of same radius and subjected to the same rate of change of flux. If coil P is made up of copper and Q is made up of iron, then the wrong statement is-



(1) emf induced in the two coils is the same
(2) the induced current in P is more than that in Q
(3) the induced current in P and Q are in the same direction
(4) the induced currents are the same in both the coils.

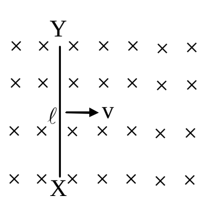
Q.31 A wire of length 4 m placed normal to the magnetic field of $(2\hat{i}+4\hat{j})$ Tesla is moving with a velocity $(4\hat{i}+6\hat{j}+8\hat{k})$ m/s. The emf induced across the ends of the wire will be-
(1) 4 V (2) 8 V (3) 16 V (4) 32 V

Q.32 A rectangular loop of resistance R, and sides I and x, is pulled out of a uniform magnetic field B with a steady velocity v. The necessary force F required for maintaining uniform velocity of withdrawal is-



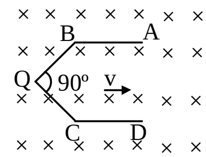
(1) $\frac{B\ell^2 v}{R}$ (2) $\frac{B^2\ell^2 v}{R}$ (3) $\frac{B^2\ell^2 v^2}{R}$ (4) 0

Q.33 A small conducting rod of length ℓ, moves with a uniform velocity v in a uniform magnetic field B as shown in fig-



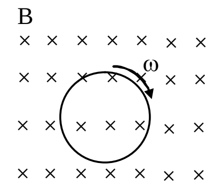
(1) Then the end X of the rod becomes positively charged
(2) the end Y of the rod becomes positively charged
(3) the entire rod is unevenly charged
(4) the rod becomes hot due to joule heating.

Q.34 A conductor ABOCD moves along its bisector with a velocity of 1 m/s through a perpendicular magnetic field of 1 Wb/m^2, as shown in fig. If all the four sides are of 1m length each, then the induced emf between points A and D is-



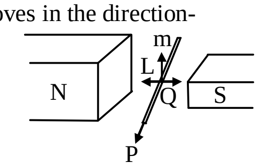
(1) 0 (2) 1.41 volt
(3) 0.71 volt (4) none of the above

Q.35 A circular coil of radius r is placed in a uniform magnetic field B. The magnetic field is normal to the plane of the coil, as shown in fig. Now if the coil is rotated at an angular speed of ω, about its own axis, then the induced emf in the coil is-



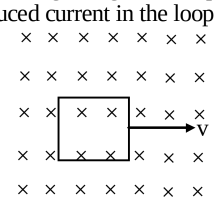
(1) $\frac{BA\omega}{2\pi}$ (2) B (2πr) ω
(3) 0 (4) None of the above

Q.36 An electric potential difference will be induced between the ends of the conductor shows in fig, when conductor moves in the direction-



(1) P (2) Q (3) L (4) M

Q.37 A square conducting loop of side L and resistance R is moving with a uniform velocity at right angles to one of the sides in its own plane. On applying a uniform magnetic field at right angles to its plane as shown in the figure the induced current in the loop will be -



(1) Zero
(2) $\frac{BLv}{R}$ in anticlockwise direction
(3) $\frac{BLv}{R}$ in clockwise direction
(4) $\frac{2BLv}{R}$ in clockwise direction

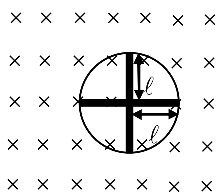
Q.38 A circular copper disc of radius 25 cm is rotating about its own axis with a constant angular velocity of 130 rad/s. If a magnetic field of 5×10^{-3} Tesla is applied at right angles to the disc, then the induced potential difference between the centre and the rim of the disc will approximately be -

(1) 20×10^{-3} V (2) 20×10^{-6} V
(3) 20×10^{-9} (4) Zero

Q.39 A 1.2m wide railway track is parallel to magnetic meridian. The vertical component of earth's magnetic field is 0.5 Gauss. When a train runs on the rails at a speed of 60Km/hr, then the induced potential difference between the ends of its axle will be-

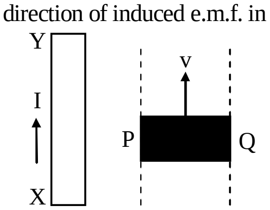
(1) 10^{-4} V (2) 2×10^{-4} V
(3) 10^{-3} V (4) Zero

Q.40 A conducting wheel in which there are four rods of length ℓ is rotating with angular velocity ω in a uniform magnetic field B. The induced potential difference between its centre and rim will be –



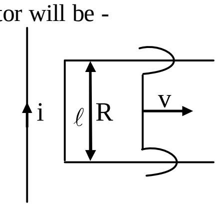
(1) 0 (2) $B\ell^2\omega$ (3) $B^2\ell\omega$ (4) $\frac{B\ell^2\omega}{2}$

Q.41 A small straight conductor PQ is lying at right angles to an infinite current carrying conductor XY. If the conductor PQ is displaced on metallic rails parallel to the conductor XY then the direction of induced e.m.f. in the PQ will be-



(1) From Q to P (2) From P to Q
(3) Vertically downwards (4) Vertically upwards

Q.42 A straight conductor carrying current i and a loop closed by a sliding connector of resistance R lie in the same plane. The connector slides towards right with a uniform velocity v. The induced current generated in the loop in terms of distance r of the connector form the straight conductor will be -



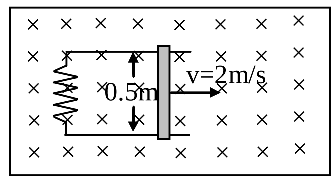
(1) $\frac{\mu_0 i\ell v}{2\pi r}$ (2) $\frac{\mu_0 i\ell}{2\pi r}$

(3) $\frac{\mu_0 i\ell v}{2\pi r R}$ (4) None of these

Q.43 The spokes of a wheel are made of metal and their lengths are of one metre. On rotating the wheel about its own axis in a uniform magnetic field of 5×10^{-5} Tesla normal to the plane of wheel, a potential difference of 3.14 mV is generated between the rim and the axis. The rotational velocity of the wheel is-

(1) 63 rev./s (2) 50 rev./s
(3) 31.4 rev./s (4) 20 rev./s

Q.44 A metal rod completes a circuit as shown in the figure. The circuit is normal to a magnetic field B = 0.15 T. If the resistance of the circuit is 3 ohm then the force required to move the rod with a constant velocity of 2 m/s will be-



(1) 3.75×10^{-3} N (2) 3.75×10^{-2} N
(3) 3.75×10^{2} N (4) 3.75×10^{-4} N

Q.45 The significance of self inductance L is the same as of that of .... in the linear motion-

(1) mass (2) velocity
(3) acceleration (4) displacement

Q.46 On making a coil of copper wire of length ℓ and coil radius r, the value of self inductance is obtained as L. If the coil of same wire, but of coil radius r/2, is made, the value of self inductance will be-

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

Q.47 Out of the two coils placed near each other, when a current of 2 amp is passed in one, a flux of 6×10^{-5} Weber passes through the other. If the number of turns in the secondary coils is 20, the value of coefficient of mutual induction in the coils will be-

(1) 6H (2) 6 mH (3) 0.6H (4) 0.6 mH

Q.48 The coefficient of mutual induction between two coils is 4H. If the current in the primary reduces from 5A to zero in 10^{-3} second then the induced e.m.f. in the secondary coil will be-

(1) 10^4 V (2) 25×10^3 V
(3) 2×10^4 V (4) 15×10^3 V

Q.49 The coefficient of mutual induction between two closely lying coils does not depend upon-

(1) their mutual orientation
(2) the permeability of their core material
(3) their structure
(4) the current flowing in them

Q.50 The number of turns in a coil of wire of fixed radius is 600 and its self inductance is 108 mH. The self inductance of a coil of 500 turns will be-

(1) 74 mH (2) 75 mH (3) 76 mH (4) 77 mH

Q.51 The value of the self inductance of a coil is 5 H. If the current in the coil changes steadily from 1A to 2A in 0.5 seconds, then the magnitude of induced emf is-

(1) 1V (2) 10 V
(3) 100 V (4) 0.1 V

Q.52 An inductance stores energy in-
(1) electric field (2) magnetic field
(3) resistance of coils (4) all of the above

Q.53 A thin copper wire of length 100 metres is wound as a solenoid of length ℓ and radius r. Its self inductance is found to be L. Now if the same length of wire is wound as a solenoid of length ℓ but of radius r/2, then its self inductance will be-
(1) 4L (2) 2L (3) L (4) L/2

Q.54 The coefficient of coupling between two coil is maximum when the two coils are-
(1) placed at right angles
(2) placed parallel at close distance
(3) wound around a common ferromagnetic core and insulated from it
(4) placed at an angle of 45º with each other

Q.55 Two coils of self inductances L_1 and L_2 are tightly wrapped one over the other. The maximum mutual inductance of the combination will be -
(1) $L_1 + L_2$ (2) $L_1 L_2$
(3) $\sqrt{L_1L_2}$ (4) $\frac{L_1L_2}{L_1+L_2}$

Q.56 The coefficient of mutual inductance of the two coils is 5 H. The current through the primary coil is reduced to zero value from 3A in 1 milli second. The induced emf in the secondary coils is-
(1) 0 (2) 1.67 KV
(3) 15 KV (4) 600 V

Q.57 The value of coefficient of mutual induction in two coils can be increased by-
(1) placing the coils mutually perpendicular.
(2) keeping the coils near to each other.
(3) keeping the coils considerably apart.
(4) winding the core on the common iron magnetic material and insulating them.

Q.58 The current is reduced from 3 amp to zero in 0.001 sec. in the primary coil. It induces an emf of 15000 volts in the secondary. The value of coefficient of mutual inductance in Henry will be-
(1) 5 (2) 0.5 (3) 4.5 (4) 50

Q.59 A solenoid having a core of cross-section 4 cm^2, half air and half iron (relative permeability = 500), is 22 cm long. If the number of turns on it is 10^3 its self inductance is-
(1) 570 H (2) 57 H (3) 5.7 H (4) 0.57 H

Q.60 The coefficients of self induction of two inductance coils are 0.01H and 0.03H respectively. When they are connected in series so as to support each other, then the resultant self inductance becomes 0.06 Henry. The value of coefficient of mutual induction will be-
(1) 0.02 H (2) 0.05 H (3) 0.01 H (4) zero

Q.61 Two identical solenoid coils, each of self inductance L are connected in series. Their turns are in the same sense, and the distance between them is such that the coefficient of coupling is half. Then the equivalent inductance of the combination is-
(1) L (2) 2L (3) 3L (4) L/2

Q.62 If two coils of negligible mutual induction and having coefficient of inductances L_1 and L_2 ($L_1 > L_2$) are arranged in parallel, the value of the equivalent self-induction will be-
(1) $L_1 L_2 / (L_1 - L_2)$ (2) $L_1 L_2 / (L_1 + L_2)$
(3) $(L_1 + L_2) / L_1 L_2$ (4) $(L_1 - L_2) / L_1 L_2$

Q.63 The self inductance and resistance of a coil are 5H and 20 Ω respectively. On applying an e.m.f. of 100 V on it, the magnetic potential energy stored in the coil will be-
(1) 62.5 Joule (2) 62.5 erg
(3) 62.5×10^{-3} Joule (4) zero

Q.64 The energy stored in an inductance is 1 joule when a current of 0.1 A is established in it. The self-inductance of the coil is-
(1) 25 H (2) 50 H (3) 200 H (4) 2.6 H

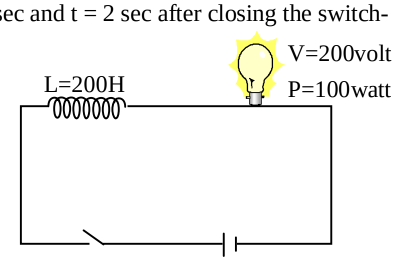
Q.65 The growth of current in an L - R circuit in time t = L / R is equal to about-
(1) 37% of maximum (2) 63% of maximum
(3) 57% of maximum (4) 67% of maximum

Q.66 The current in an L-R circuit in a time t = 2L / R reduces to-
(1) 36.5% of maximum (2) 13.5% of maximum
(3) 0.50% of maximum (4) 63.2% of maximum

Q.67 A coil of 10 H inductance has a 5 Ω resistance and is connected to a 5 volt battery in series. The current in ampere in the circuit 2 seconds after the circuit is switched on is-
(1) 1 amp (2) (1 – 1/e) amp
(3) (1 – e) amp (4) 1/e amp.

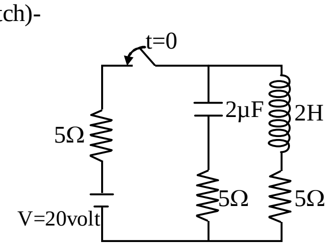
Q.68 A coil of resistance R and inductance L is connected to a battery of E volt e.m.f. This final current in the coil is-
(1) E/R (2) E/L
(3) $\sqrt{[E/(R^2+L^2)]}$ (4) $\sqrt{[EL/(R^2+L^2)]}$

Q.69 Calculate the ratio of power dissipated by the bulb at t = 1 sec and t = 2 sec after closing the switch-



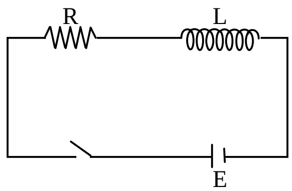
(1) $\frac{e^2}{e^4-1}$ (2) $\left(\frac{e^2}{(e^2+1)}\right)^2$
(3) $\frac{e^2-1}{e^4+1}$ (4) None of these

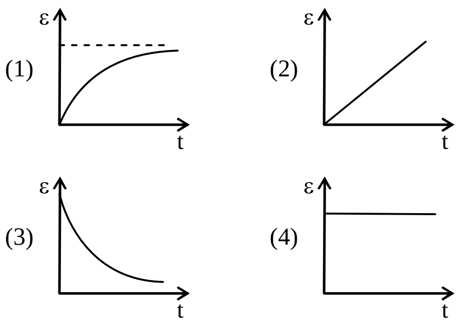
Q.70 Calculate the ratio of current flowing through the battery at t = 0 and t = ∞. (t = 0 is the time of closing of switch)-



(1) 1 (2) 2 (3) $\frac{1}{2}$ (4) 0

Q.71 Plot the variation of emf across the inductor with respect time-





Q.72 To transmit electrical energy from a generator to distant consumers-
(1) high voltage and low current are transmitted
(2) high voltage and high current are transmitted
(3) low voltage and low current are transmitted
(4) low voltage and high current are transmitted

Q.73 A transformer transforms 220 volts to 11 volts. If the current strength in the primary coil is 5 amp. and that in the secondary, 90 amp, what is the efficiency of the transformer-
(1) 90 % (2) 100 % (3) 211 % (4) 150 %

Q.74 A step up transformer operates on a 230 volt line and supplies a load of 2 amp. The ratio of primary and secondary windings is 1 : 25. Determine the primary current-
(1) 12.5 amp (2) 50 amp (3) 8.8 amp (4) 25 amp

Q.75 A transformer is used to light 140 watt 24 volt lamp from 240 volt AC mains, the current in the main cable is 0.7 amp. The efficiency of the transformer is-
(1) 63.8% (2) 84% (3) 83.3% (4) 48%

Q.76 In a step-up transformer, in comparison with the secondary the primary coil has-
(1) less voltage and high current
(2) high voltage and less current
(3) less voltage and less current
(4) high voltage and high current

Q.77 In the secondary coil of step-up transformer, the number of turns are-
(1) more and the copper wire is thicker
(2) more and the copper wire is thinner
(3) less and the copper wire is thicker
(4) less and the copper wire is thinner

Q.78 A dynamo-
(1) creates electrical energy
(2) converts mechanical energy into electrical energy
(3) converts electrical energy into mechanical energy
(4) creates mechanical energy

EXERCISE # 2

Q.1 The coefficient of mutual inductance of two circuits A and B is 3 mH and their respective resistances are 10 ohm and 4 ohm. How much current should change in 0.02 second in the circuit A. So that the induced current in B should be 0.006 ampere-
(1) 0.24 amp (2) 1.6 amp
(3) 0.18 amp (4) 0.16 amp

Q.2 The coefficient of self inductance is 5 mH. If the emf of the cell in the circuit is 1.1 volt and at any instant the rate of increase of current is 6 ampere/second, then at that instant, the resultant e.m.f. in the circuit will be-
(1) 1.13 V (2) 0.13 V (3) 1.07 V (4) 1.4 V

Q.3 The phase difference between the flux linkage and the induced e.m.f. in a rotating coil in a uniform magnetic field is-
(1) π (2) $\pi/2$ (3) $\pi/4$ (4) $\pi/6$

Q.4 A dynamo is sometimes said to generate electricity. It actually acts as a source of-
(1) charge (2) magnetism
(3) e.m.f. (4) energy

Q.5 In a step-down transformer the number of turns in-
(1) primary are less
(2) primary are more
(3) primary and secondary are equal
(4) primary are infinite

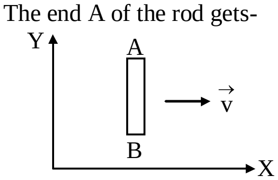
Q.6 An inductor coil stores 32 J of magnetic field energy and dissipates energy as heat at the rate of 320 W, when a current of 4 A is passed through it. The time constant of the circuit when this coil is joined across an ideal battery will be-
(1) 0.2 s (2) 0.3 s (3) 0.4 s (4) 0.5 s

Q.7 A solenoid of inductance 50 mH and resistance 10 Ω is connected to a battery of 6 V. The time elapsed before the current acquires half of its steady-state value will be-
(1) 3.01 s (2) 3.02 s (3) 3.03 s (4) 3.5 ms

Q.8 An inductor - resistance battery circuit is switched on at t = 0. If the emf of the battery is E. The charge which passes through the battery in one time constant τ will be-
(1) $i_0\ \tau/e$ (2) $i_0\ e/\tau$ (3) $\tau\ e/i_0$ (4) $i_0\ e\ \tau$

Q.9 Two conducting circular loops of radii R_1 and R_2 are placed in the same plane with their centres coinciding. The mutual inductance between them assuming $R_2 << R_1$, will be-
(1) $\frac{\mu_0 \pi R_2^2}{2R_1}$ (2) $\frac{\mu_0 R_2^2}{2R_1}$ (3) $\frac{\mu_0 R_2}{2R_1}$ (4) $\frac{\mu_0 \pi R_2^2}{2R_1^2}$

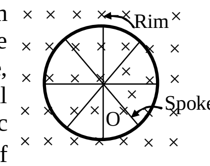
Q.10 A conductor rod AB moves parallel to X-axis in a uniform magnetic field, pointing in the positive Z-direction. The end A of the rod gets-



(1) positively charged
(2) negatively charged
(3) neutral
(4) first positively charged and then negatively charged

Q.11 A closed coil of copper whose area is 1m × 1m is free to rotate about an axis. The coil is placed perpendicular to a magnetic field of 0.10 Wb/m^2. It is rotated through 180º in 0.01 second. The induced e.m.f. and induced current in the coil will respectively be-
(The resistance of the coil is 2.0 Ω)
(1) 20 V, 10A (2) 10 V, 20 A
(3) 10 V, 10 A (4) 20 V, 20 A

Q.12 A bicycle wheel of radius 0.5 m has 32 spokes. It is rotating at the rate of 120 revolutions per minute, perpendicular to the horizontal component of earth's magnetic field $B_H = 4 \times 10^{-5}$ Tesla. The emf induced between the rim and the centre of the wheel will be-



(1) 6.28×10^{-5} V (2) 4.8×10^{-5} V
(3) 6.0×10^{-5} V (4) 1.6×10^{-5} V

Q.13 The current in a coil varies with respect to time t as $I = 3t^2 + 2t$. If the inductance of coil be 10 mH, the value of induced e.m.f. at t = 2s will be-
(1) 0.14 V (2) 0.12 V (3) 0.11 V (4) 0.13 V

Q.14 If circular coil with N_1 turns is changed in to a coil of N_2 turns. What will be the ratio of self inductances in both cases-
(1) $\frac{N_1}{N_2}$ (2) $\frac{N_2}{N_1}$ (3) $\frac{N_1^2}{N_2^2}$ (4) $\sqrt{\frac{N_1}{N_2}}$

Q.15 A solenoid has an inductance of 50 mH and a resistance of 0.025 Ω. If it is connected to a battery, how long will it take for the current to reach one half of its final equilibrium value ?
(1) 1.34 s (2) 1.2 s (3) 6.32 s (4) 0.23 s

Q.16 5.5×10^{-4} magnetic flux lines are passing through a coil of resistance 10 ohm and number of turns 1000. If the number of flux lines reduces to 5×10^{-5} in 0.1 sec. The electromotive force and the current induced in the coil will be respectively-
(1) 5V, 0.5 A (2) 5×10^{-4} V, 5×10^{-4} A
(3) 50 V, 5 A (4) none of the above

Q.17 A closed coil consists of 500 turns on a rectangular frame of area 4.0 cm^2 and has a resistance of 50 ohm. The coil is kept with its plane perpendicular to a uniform magnetic field of 0.2 Weber/meter^2. The amount of charge flowing through the coil if it is turned over (rotated through 180º) will be -
(1) 1.6×10^{-19} C (2) 1.6×10^{-9} C
(3) 1.6×10^{-3} C (4) 1.6×10^{-2} C

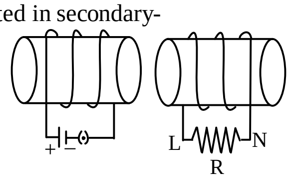
Q.18 When the current through a solenoid increases at a constant rate, the induced current-
(1) is a constant and is in the direction of the inducing current
(2) is a constant and is opposite to the direction of the inducing current
(3) increase with time and is in the direction of the inducing current
(4) increase with time and opposite to the direction of the inducing current

Q.19 According to Faraday's Laws of electro magnetic induction-
(1) The direction of the induced current is such that it opposes itself
(2) The induced emf in the coil is proportional to the rate of change of magnetic flux associated with it
(3) The direction of induced emf is such that it opposes it self
(4) None of the above

Q.20 A coil having an area of $2m^2$ is placed in a magnetic field which changes from 1 Weber/m^2 to 4 Weber/m^2 in 2 seconds. The e.m.f. induced in the coil will be-
(1) 4 volt (2) 3 volt (3) 2 volt (4) 1 volt

Q.21 A conducting loop is placed in an uniform magnetic field with its plane perpendicular to the field. An emf is induced in the loop if-
(a) It is translated within magnetic field
(b) It is rotated about its axis
(c) It is rotated about a diameter
(d) It is deformed
(1) b,c (2) b,d (3) c, d (4) a,c,d

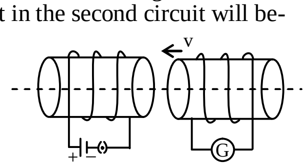
Q.22 Two co-axial solenoids shown in figure. If key of primary suddenly opened then direction of instantaneous induced current in resistance 'R' which connected in secondary-



(1) L to N (2) N to L
(3) Alternating (4) Zero

Q.23 Magnetic flux through a coil is changes with respect to time then emf induced in it which incorrect regarding induced emf in coil-
(1) Coil may be made up with wood
(2) Coil may be connected with an open circuit
(3) Coil must be of conducting nature
(4) Induced emf does not depends upon resistance of the coil

Q.24 The current flows in a circuit as shown below. If a second circuit is brought near the first circuit then the current in the second circuit will be-



(1) Clock wise
(2) Anti clock wise
(3) Depending on the value of R_G
(4) None of the above

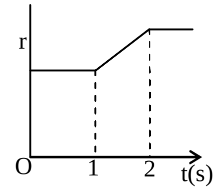
Q.25 Two identical circular coils A and B are placed parallel to each other with their centres on the same axis. The coil B carries a current I in the clock wise direction as seen from A. What would be the direction of the induced current in A seen from B when-
(a) The current in B is increased ?
(b) The coil B is moved towards A keeping the current in B constant ?
(1) clockwise, clockwise
(2) clockwise, anticlockwise
(3) anti clockwise, clockwise
(4) anticlockwise, anticlockwise

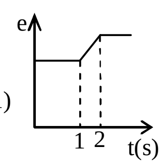
Q.26 An emf induced in a coil, the linking magnetic flux-
(1) Must decrease
(2) Must increase
(3) Must remain constant
(4) Can either increase of decrease

Q.27 A coil of resistance 10Ω and 1000 turns have the magnetic flux line of 5.5×10^{-4} Wb. If the magnetic flux changed 5×10^{-4} Wb in 0.1 sec, then the induced charge in coil is-
(1) 50 μC (2) 5 μC (3) 2 μC (4) 20 μC

Q.28 One coil of resistance 40Ω is connected to a galvanometer of 160Ω resistance. The coil has radius 6mm and turns 100. This coil is placed between the poles of a magnet such that magnetic field is perpendicular to coil. If coil is dragged out then the charge through the galvanometer is 32 μC. The magnetic field is-
(1) 6.55 T (2) 5.66 T (3) 0.655 T (4) 0.566 T

Q.29 A flexible wire bent in the form of a circle is placed in a uniform magnetic field perpendicular to the plane of the coil. The radius of the coil changes as shown in figure. The induced emf in the coil is-



(1)


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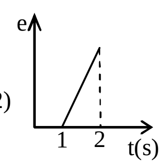

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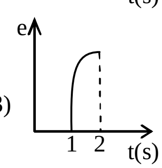

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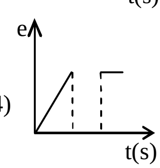
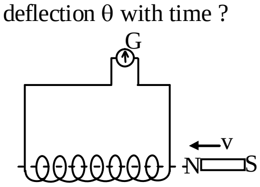
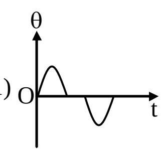


Q.30 A short bar magnet passes at a steady speed right through a long solenoid. A galvanometer is connected across the solenoid. Which graph best represents the variation of the galvanometer deflection θ with time ?



(1)


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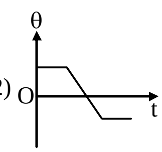

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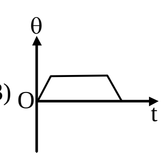
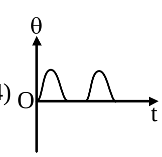


(4)


Q.31 A square loop of side 22 cm is changed to a circle in time 0.4 s. The magnetic field present is 0.2 T. The emf induced is-

(1) – 6.6 mV (2) – 13.2 mV
(3) + 6.6 mV (4) + 13.2 mV

Q.32 The magnetic flux in a coil of 100 turns increases by 12×10^3 Maxwell in 0.2 s due to the motion of a magnet. The emf induced in the coil will be-

(1) 0.6 mV (2) 0.6 V
(3) 6 V (4) 60 V

Q.33 Which one of the following can produce maximum induced emf-

(1) 50 ampere dc (2) 50 ampere 50 Hz ac
(3) 50 ampere 500 Hz ac (4) 100 ampere dc

Q.34 A solenoid of 10 henry inductance and 2 ohm resistance is connected to a 10 volt battery. In how much time the magnetic energy will be increases to $1/4^{th}$ of the maximum value ?

(1) 3.5 sec (2) 2.5 sec (3) 5.5 sec (4) 7.5 sec

Q.35 An inductance coil have the time constant 4 sec, if it is cut into two equal parts and connected parallel then new time constant of the circuit-

(1) 4 sec (2) 2 sec (3) 1 sec (4) 0.5 sec

Q.36 Which statement is correct from following-

(a) inductor store energy in the form of magnetic field
(b) capacitor store energy in the form of electric field
(c) inductor store energy in the form of electric and magnetic field both
(d) capacitor store energy in the form of electric and magnetic field both

(1) a, b (2) a, c (3) b, d (4) b, c

Q.37 Two coils are made of copper wires of same length. In the first coil the number of turns is 3n and radius is r. In the second coil number of turns is n and radius is 3r the ratio of self inductances of the coils will be-

(1) 9 : 1 (2) 3 : 1 (3) 1 : 3 (4) 1 : 9

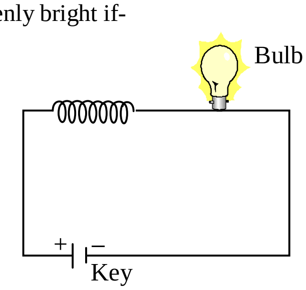
Q.38 If a current of 2A give rise in a magnetic flux of 5×10^{-5} weber/turn through a coil having 100 turns, then the magnetic energy stored in the medium surrounding by the coil is-

(1) 5 joule (2) 5×10^{-7} joule
(3) 5×10^{-3} joule (4) 0.5 joule

Q.39 For a solenoid keeping the turn density constant its length makes halved and its cross section radius is doubled then the inductance of the solenoid increased by-

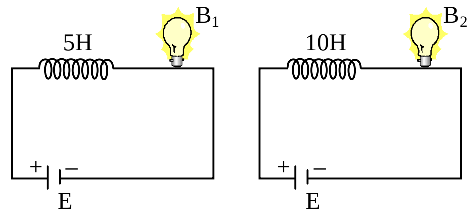
(1) 200% (2) 100% (3) 800% (4) 700%

Q.40 In the circuit shown in figure bulb will become suddenly bright if-



(1) key is closed
(2) key is opened
(3) key is opened or closed
(4) would not become bright

Q.41 Two bulb of same rating B_1 and B_2 are connected in series with the inductors as shown in figure which bulb take more time to light at maximum brightness-



(1) B_1 (2) B_2
(3) Both take same time (4) None

Q.42 A constant current i maintained in a solenoid. Which of the following quantities will increase if an iron rod is inserted in the solenoid along it axis-

(a) magnetic field at the centre
(b) magnetic flux linked with the solenoid
(c) self inductance of the solenoid
(d) rate of joule heating

(1) a, b, c (2) c, d (3) a, b (4) only b

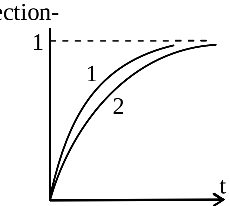
Q.43 A coil of copper wire is connected in series with a bulb, a battery and a switch. When the circuit is completed the bulb lights up immediately. The circuit is switched off and a rod of soft iron is placed inside the coil. On completing the circuit again. It is observed that-

(1) Bulb is not so bright
(2) There is a slight delay before bulb lights to its normal brightness
(3) The bulb is initially bright but gradually becomes dim
(4) The bulb is brighter than before

Q.44 The inductance of a solenoid is 5 henry and its resistance is 5Ω. If it is connected to a 10 volt battery then time taken by the current to reach $9/10^{th}$ of its maximum will be-

(1) 4.0 s (2) 2.3 s
(3) 1.4 s (4) 1.2 s

Q.45 When a certain circuit consisting of a constant emf E, an inductance L and a resistance R is closed, the current in it increases with time according to curve 1. After one parameter (E, L or R) is changed, the increase in current follows curve 2, when the circuit is closed second time. Which parameter was changed and in what direction-



(1) L is increased (2) L is decreased
(3) R is increased (4) R is decreased

Q.46 An LR circuit with a battery is connected at t = 0. Which of the following quantities is not zero just after the connection ?

(a) current in circuit
(b) magnetic potential energy in the inductor
(c power delivered by the battery
(d) emf induced in the inductor

(1) a, b (2) a, c
(3) c, d (4) only d

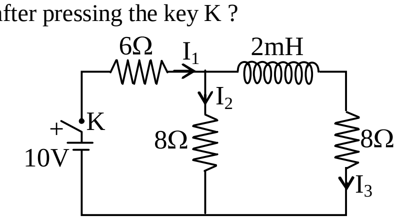
Q.47 During 0.1 sec current in a coil increases from 1A to 1.5A. If inductance of this coil is 60μH, induced current in external resistance of 600μΩ is-

(1) 1 A (2) 4/3 A
(3) 2/3 A (4) 1/2 A

Q.48 A closely wound coil of 100 turns and area of cross section 1 cm^2 has a self inductance 1mH. The magnetic induction at the centre of the coil, when a current of 2A flows in it, will be-

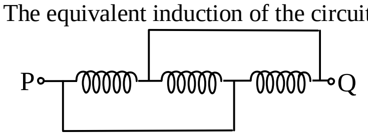
(1) $0.2\ \frac{Wb}{m^2}$ (2) $0.4\ \frac{Wb}{m^2}$
(3) $0.8\ \frac{Wb}{m^2}$ (4) $1\ \frac{Wb}{m^2}$

Q.49 In the circuit shown in figure what is the value of I_1 just after pressing the key K ?



(1) $\frac{5}{7}$A (2) $\frac{5}{11}$A
(3) 1A (4) None of the above

Q.50 Pure inductors each of inductance 3 H are connected as shown. The equivalent induction of the circuit is-



(1) 1H (2) 2H (3) 3H (4) 9H

Q.51 The time constant of an inductance coil is 2.0×10^{-3} s. When a 90Ω resistance is joined in series, the time constant becomes 0.5×10^{-3} s. The inductance and resistance of the coil are-

(1) 30 mH ; 30 Ω (2) 30 mH ; 60 Ω
(3) 60 mH ; 30 Ω (4) 60 mH ; 60 Ω

Q.52 A toroidal solenoid with an air core has an average radius of 15 cm, area of cross-section 12 cm^2 and 1200 turns. Ignoring the field variation across the cross-section of the toroid, the self-inductance of the toroid is-

(1) 4.6 mH (2) 6.9 mH (3) 2.3 mH (4) 9.2 mH

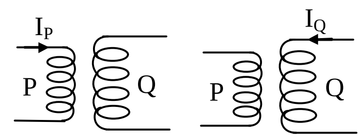
Q.53 A circular iron, core supports N turns. If a current I produces a magnetic flux ϕ across the core's cross section, then the magnetic energy is-

(1) $I\phi$ (2) $\frac{1}{2} I\phi$
(3) $\frac{1}{3} I\phi$ (4) $I^2\phi$

Q.54 The self inductance of a toroid is-

(1) $\frac{\mu_0 N^2 r^2}{2R_m}$ (2) $\frac{\mu_0 N^2 \pi r}{2R_m}$
(3) $\frac{\mu_0 N^2 r}{2R_m}$ (4) $\frac{\mu_0 N^2 r\pi}{2R_m}$

Q.55 In fig.(a) and fig.(b) two air-cored solenoids P and Q have been shown. They are placed near each other. In fig.(a), when I_p, the current in P, changes at the rate of 5 A/s, an emf of 2mV is induced in Q. The current in P is then switched off, and a current changing at 2 A/s is fed through Q as shown in diagram. What emf will be induced in P-



(a) (b)

(1) 8×10^{-4} V (2) 2×10^{-8} V
(3) 5×10^{-3} V (4) 8×10^{-2} V

Q.56 A small square loop of wire of side ℓ is placed inside a large square loop of wire of side L(L>> ℓ). The loops are coplanar and their centres coincide. The mutual inductance of the system is proportional to-

(1) $\frac{\ell}{L}$ (2) $\frac{\ell^2}{L}$
(3) $\frac{L}{\ell}$ (4) $\frac{L^2}{\ell}$

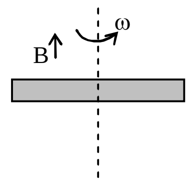
Q.57 An athlete runs at a velocity of 30 km/hr towards east with a 3 meter rod. The horizontal component of the earth is 4×10^5 weber/m^2. If he runs, keeping the rod (i) horizontal and (ii) vertical, the potential difference between the ends of the rod in both the cases, will be-

(1) Zero in vertical case and 1×10^{-3} V in the horizontal case
(2) 1×10^{-3} V in vertical case and zero in the horizontal case
(3) Zero in both the cases
(4) 1×10^{-3} V in both cases

Q.58 A 10 m long copper wire while remaining in the east-west horizontal direction is falling down with a constant speed of 5.0 m/s. If the horizontal component of the earth's magnetic field 0.3×10^{-4} Weber/m^2, the e.m.f. developed between the ends of the wire is-

(1) 0.15 volt (2) 1.5 volt
(3) 0.15 milli volt (4) 1.5 milli volt

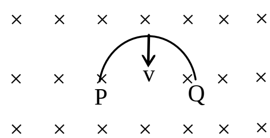
Q.59 A conducting rod of length 2ℓ is rotating with constant angular speed ω about its perpendicular bisector. A uniform magnetic field $\vec{B}$ exists parallel to the axis of rotation. The emf induced between two ends of the rod is-



(1) $B\omega\ell^2$ (2) $\frac{1}{2}B\omega\ell^2$ (3) $\frac{1}{8}B\omega\ell^2$ (4) Zero

Q.60 A conducting rod of 1m length rotating with a frequency of 50 rev/sec about its one of end inside the uniform magnetic field of 6.28 mT. The value of induced emf between end of rod is-
(1) 1 V (2) 2 V (3) 0.5 V (4) 0.25 V

Q.61 A semicircle loop PQ of radius 'R' is moved with velocity 'v' in transverse magnetic field as shown in figure. The value of induced emf between the ends of loop is-



(1) $Bv(\pi r)$, end 'P' at high potential
(2) 2BRv, end 'P' at high potential
(3) 2BRv, end 'Q' at high potential
(4) $B\frac{\pi R^2}{2}v$, end 'P' at high potential

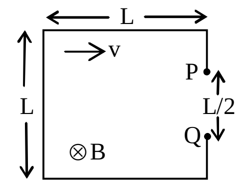
Q.62 A car moves up on a plane road. The induced emf in axle connecting the two wheels is maximum when it moves-
(1) At the poles
(2) At the equator
(3) Remain stationary
(4) At the equator and poles both

Q.63 If an artificial satellite with metal surface is moving in the equatorial plane of earth, then the e.m.f. induced in it due to earth's magnetism will be -
(1) Negative and the base towards earth
(2) Positive and the base towards earth
(3) No emf induced
(4) None of the above

Q.64 Which statement is not correct -
(1) Inductance is not possible without resistance
(2) Resistance is possible without inductance
(3) Sparking is occur due to high inductance
(4) An aeroplane is flying at equator there is induction of emf across the wings

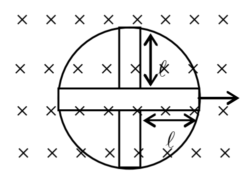
Q.65 A metal aeroplane having a distance of 50 meter between the tips of its wings is flying horizontally with a speed of 360 km/hour. At the place of flight, the earth's total magnetic field is 4.0×10^{-5} W/m^2 and the angle of dip is 30º. Find out the induced potential difference between the tips of its wings. If a bulb is connected across the edges of the wings, will it light up ?
(1) 0.1 volt, bulb will be light up
(2) 0.2 volt, bulb will be light up
(3) 0.1 volt, bulb will not light up
(4) 0.2 volt, bulb will not light up

Q.66 The loop shown moves with a constant velocity 'v' in a uniform magnetic field of magnitude 'B' directed into the paper. The potential difference between P and Q is 'e' -



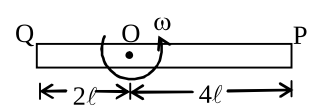
(1) $e = \frac{1}{2}BLv$, Q is positive with respect to P
(2) $e = \frac{BLv}{2}$, P is positive with respect to Q
(3) e = 0
(4) e = BLv, Q is positive with respect to P

Q.67 A conducting wheel in which there are four rods of length ℓ as shown in figure is rotating with angular velocity ω in a uniform magnetic field B. The induced potential difference between its centre and rim will be-



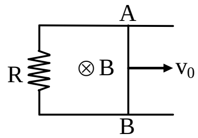
(1) $2B\omega\ell^2$ (2) $\sqrt{B\ell^2\omega}$
(3) $\frac{B\ell\omega}{2}$ (4) $\frac{B\ell^2\omega}{2}$

Q.68 A conducting rod rotates with a constant angular velocity 'ω' about the axis which passes through point 'O' and perpendicular to its length. A uniform magnetic field 'B' exists parallel to the axis of the rotation. Then potential difference between the two ends of the rods is-



(1) $6B\omega\ell^2$ (2) $B\omega\ell^2$ (3) $10B\omega\ell^2$ (4) zero

Q.69 Two long parallel metallic wires with a resistance 'R' form a horizontal plane. A conducting rod AB is on the wires shown in figure. The space has magnetic field pointing vertically downwards. The rod is given an initial velocity 'v_0'. There is no friction in the wires and the rod. After a time 't' the velocity v of the rod will be such that-



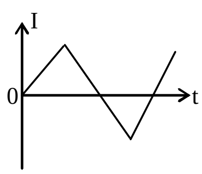
(1) $v > v_0$ (2) $v < v_0$
(3) $v = v_0$ (4) $v = -v_0$

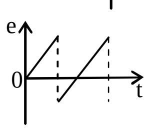
Q.70 If a bar magnet is dropped vertically into a long copper tube then its final acceleration will be-
(1) a = g (2) a > g (3) a < g (4) a = 0

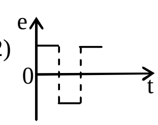
Q.71 A closed coil consists of 500 turns on a rectangular frame of area 4.0 cm^2 and has a resistance of 50 ohms. The coil is kept with its plane perpendicular to a uniform magnetic field of 0.2 wb/m^2, the amount of charge flowing through the coil if it is turned over (rotated through 180º) -
(1) 1.6×10^{-3} C (2) 16×10^{-3} C
(3) 0.16×10^{-3} C (4) 160×10^{-3} C

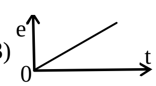
Q.72 A coil of mean area 500 cm^2 and having 1000 turns is held perpendicular to a uniform field of 0.4 gauss. The coil is turned through 180º in $\frac{1}{10}$ second. The average induced e.m.f. -
(1) 0.04 V (2) 0.4 V (3) 4 V (4) 0.004 V

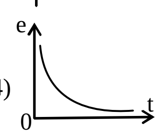
Q.73 A current time curve is shown in the following diagram. This type of current is passed in the primary coil of transformer. The nature of induced emf in the secondary coil will be-



(1) 

(2) 

(3) 

(4) 

Q.74 The armature coil of dynamo is in motion. The generated induced emf varies and the number of magnetic lines of force also varies. Which of the following condition is correct-
(1) lines of flux will be minimum, but induced emf will be zero
(2) lines of flux will be maximum, but the induced emf will be zero
(3) lines of flux will be maximum, but induced emf will not be zero
(4) the lines of flux will be maximum, and the induced emf will be also maximum

Q.75 A simple electric motor has an armature resistance of 1Ω and runs from a dc source of 12 volt. When running unloaded it draws a current of 2amp when a certain load is connected, its speed becomes one-half of its unloaded value. The new value of current drawn-
(1) 7 A (2) 2 A (3) 5 A (4) 3 A

Q.76 A d.c. motor has internal resistance 4 ohms. It is operated at 220 volts and draws 5 ampere current. The useful mechanical power developed is-
(1) 550 W (2) 100 W
(3) 1100 W (4) 1000 W

Q.77 An electric motor runs on a D.C., sources of emf. E and internal resistance 'r'. Then the power out put of source is maximum when the armature current (Suppose resistance of armature is zero) -
(1) $\frac{E}{r}$ (2) $\frac{E}{2r}$
(3) ∞ (4) 0

Q.78 A transformer is used to-
(1) change the alternating potential
(2) change the alternating current
(3) to prevent the power loss
(4) to increase the power of current source

Q.79 Large transformer, when used for some time becomes hot and are cooled by circulating oil. the heating of transformer is due to-
(1) heating effect of current alone
(2) hysteresis loss alone
(3) eddy currents losses alone
(4) all of above

Q.80 For same rating which have the maximum efficiency from following-
(1) Motor (2) Transformer
(3) D.C. generator (4) A.C. generator

Q.81 If 2.2 kW power transmits 22000 volts in a line of 10Ω resistance, the value of power loss will be-
(1) 0.1 watt (2) 14 watts
(3) 100 watts (4) 1000 watts

Q.82 If a transformer have turn ratio 5, frequency 50 Hz root mean square value of potential difference on primary 100 volts and the resistance of the secondary winding is 500 Ω then the peak value of voltage in secondary winding will be (the efficiency of the transformer is hundred percent) -
(1) $500\sqrt{2}$ (2) $10\sqrt{2}$
(3) $50\sqrt{2}$ (4) $20\sqrt{2}$

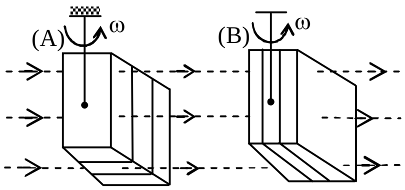
Q.83 Plane of eddy circulations makes an angle with the external time varying magnetic field is-
(1) 0º (2) 45º (3) 180º (4) 90º

Q.84 Eddy current do not cause -
(1) Sparking (2) Loss of energy
(3) Damping (4) Heating

Q.85 When a metallic sphere is moved in a magnetic field, it gets heated due to-

(1) Direct current (2) Eddy currents
(3) Alternating current (4) Additional current

Q.86 Two copper cubes A and B composed of identical insulated plates are suspended from strings in between the pole pieces of an electromagnet. Both cubes are rotating at the same angular velocity. The electromagnet is energies when we switched on the electro magnet, the cube that will come to rest letter is-



(1) A (2) B
(3) Both A and B (4) None of these

Q.87 A bar magnet is dropped into a vertical copper tube, considering the air resistance as negligible, the magnet acquired a constant speed. If the tube is heated the terminal velocity will be-

(1) Decrease
(2) Increase
(3) Remain unchanged
(4) Data's are incomplete

EXERCISE # 3

Q.1 A magnet is allowed to fall through a metal ring. During fall its acceleration will be- **[AIPMT-1996]**
(1) equal to g
(2) greater than g
(3) less than g
(4) less than or greater than g depending on which pole is pointing downwards

Q.2 An ideal transformer is used on 220 V line to deliver 2A at 110 V. The current through the primary is- **[AIPMT-1996]**
(1) 10A (2) 5A (3) 1A (4) 0.1A

Q.3 Which of the following combination has the dimension of time- **[AIPMT-1996]**
(1) R/L (2) LC (3) 1/LC (4) L/R

Q.4 The primary winding of a transformer has 500 turns whereas its secondary has 5000 turns. The primary is connected to a supply of 20V, 50 Hz. The secondary will have an output of- **[AIPMT-1997,AIIMS-1999]**
(1) 200 V, 50 Hz (2) 2 V, 50 Hz
(3) 200 V, 500 Hz (4) 2 V, 5 Hz

Q.5 Two coil have a mutual inductance 0.005 H. The current changes in first coil according to equation $I = I_0 \sin \omega t$, where $I_0 = 2A$ and $\omega = 100\pi$ rad/sec. The maximum value of induced emf in second coil is- **[AIPMT-1998]**
(1) $4\pi V$ (2) $3\pi V$ (3) $2\pi V$ (4) πV

Q.6 Turn ratio of a step-up transformer is 1 : 25. If current in load coil is 2A, then the current in primary coil will be- **[AIPMT-1998]**
(1) 25A (2) 50A (3) 0.25A (4) 0.5A

Q.7 Initially plane of coil is parallel to the uniform magnetic field B. In time Δt it makes to perpendicular to the magnetic field, then charge flows through the coil depends on this time as- **[AIPMT-1999]**
(1) $\propto \Delta t$ (2) $\propto \frac{1}{\Delta t}$
(3) $\propto (\Delta t)^0$ (4) $\propto (\Delta t)^2$

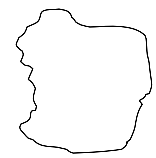
Q.8 For an inductor coil L = 0.04 H, then work done by source to establish a current of 5A in it is- **[AIPMT-1999]**
(1) 0.5 J (2) 1.00 J (3) 100 J (4) 20 J

Q.9 For a coil having L = 2 mH, current flow through it is $I = t^2e^{-t}$ then the time at which induced emf become zero- **[AIPMT-2001]**
(1) 2 sec (2) 1 sec (3) 4 sec (4) 3 sec

Q.10 The magnetic flux through a circuit of resistance R changes by an amount $\Delta\phi$ in a time Δt. The total quantity of electric charge Q that passes any point in the circuit during the time Δt is represented by- **[AIPMT-2004]**
(1) $Q = \frac{\Delta\phi}{R}$ (2) $Q = \frac{\Delta\phi}{\Delta t}$
(3) $Q = R \cdot \frac{\Delta\phi}{\Delta t}$ (4) $Q = \frac{1}{R} \cdot \frac{\Delta\phi}{\Delta t}$

Q.11 A coil of 40 henry inductance is connected in series with a resistance of 8 ohm and the combination is joined to the terminals of a 2 volt battery. The time constant of the circuit is- **[AIPMT-2004]**
(1) $\frac{1}{5}$ sec (2) 40 sec (3) 20 sec (4) 5 sec

Q.12 As a result of change in the magnetic flux linked to the closed loop shown in the figure, an e.m.f. V volt is induced in the loop. The work done (joules) in taking a charge Q coulomb once along the loop is- **[AIPMT-2005]**



(1) QV (2) QV/2 (3) 2QV (4) Zero

Q.13 Two coils of self inductances 2mH and 8 mH are placed so close together that the effective flux in one coil is completely linked with the other. The mutual inductance between these coils is- **[AIPMT-2006]**
(1) 10 mH (2) 6 mH (3) 4 mH (4) 16 mH

Q.14 The primary and secondary coils of a transformer have 50 and 1500 turns respectively. If the magnetic flux ϕ linked with the primary coil is given by $\phi = \phi_0 + 4t$, where ϕ is in webers, t is time in seconds and ϕ_0 is a constant, the output voltage across the secondary coil is- **[AIPMT-2007]**
(1) 30 volts (2) 90 volts
(3) 120 volts (4) 220 volts

Q.15 A transformer is used to light a 100 W and 110 V lamp from a 220 V mains. If the main current is 0.5 amp, the efficiency of the transformer is approximately- **[AIPMT-2007]**
(1) 10% (2) 30% (3) 50% (4) 90%

Q.16 An electric bulb in series with a large inductor when connected across a DC source take a little time before reaching a stable glow. If an iron core is inserted to the inductor, the delay will-
(1) increases **[AIIMS-1994]**
(2) decreases
(3) remain the same
(4) may change in either direction depending upon the values of inductance and resistance

Q.17 The device that does not work on the principle of mutual induction is- **[AIIMS-1996]**
(1) motor (2) tesla coil
(3) transformer (4) induction coil

Q.18 To induce an emf in a coil, the magnetic flux linking- **[AIIMS-1996]**
(1) can either increase or decrease
(2) must remain constant
(3) must increase
(4) must decrease

Q.19 The bob of a simple pendulum is replaced by a magnet. The oscillation are set along the length of the magnet. A copper coil is added so that one pole of the magnet passes in and out of the coil. The coil is shortcircuited. Then which of the following happens ? **[AIIMS-1996]**
(1) period does not change
(2) oscillations are damped
(3) amplitude increases
(4) period decreases

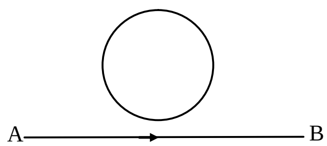
Q.20 A coil of copper having 1000 turns is placed in a magnetic field ($B = 4 \times 10^{-3}$ T) perpendicular to its plane. The cross sectional area of the coil is 0.05 m^2. If it turns through 180º in 0.01 sec, then the induced emf in the coil is- **[AIIMS-1997]**
(1) 0.4 V (2) 0.2 V (3) 40 V (4) 4 V

Q.21 In Lenz's law, there is conservation of- **[AIIMS-1997]**
(1) charge (2) momentum
(3) energy (4) current

Q.22 If the rotational velocity of a dynamo armature is doubled, then induced e.m.f. will become- **[AIIMS-1999,2000]**
(1) half (2) two times
(3) four times (4) unchanged

Q.23 The north pole of a magnet is brought near a metallic ring. The direction of the induced current in the ring will be- **[AIIMS-1999]**
(1) clockwise (2) anticlockwise
(3) towards north (4) towards south

Q.24 The current flows from A to B as shown in the figure. The direction of the induced current in the loop is- **[AIIMS-2001]**

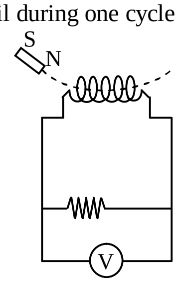


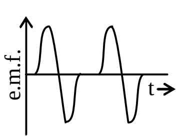
(1) clockwise (2) anticlockwise
(3) straight line (4) none of these

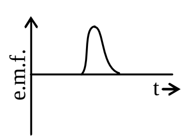
Q.25 The mutual inductance of two coils when magnetic flux changes by 2×10^{-2} Wb and current changes by 0.01 A is- **[AIIMS-2002]**
(1) 2 H (2) 3 H (3) 4 H (4) 8 H

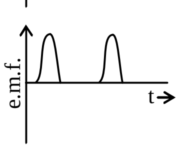
Q.26 A conducting ring of radius 1 meter is placed in an uniform magnetic field B of 0.01 T, oscillating with frequency 100 Hz with its plane at right angles to magnetic field. What will be the induced electric field- **[AIIMS-2005]**
(1) π volts/m (2) 2π volts/m
(3) 10 volts/m (4) 62 volts/m

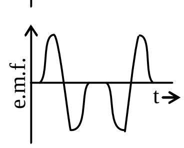
Q.27 A magnet is made to oscillate with a particular frequency, passing through a coil as shown in figure. The time variation of the magnitude of e.m.f. generated across the coil during one cycle is- **[AIIMS-2005]**



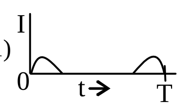
(1) 

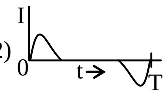
(2) 

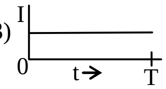
(3) 

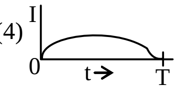
(4) 

Q.28 A metallic ring is dropped down, keeping its plane perpendicular to a constant and horizontal magnetic field. The ring enters the region of magnetic field at t = 0 and completely emerges out at t = T sec. The current in the ring varies as- **[AIIMS-2006]**

(1) 

(2) 

(3) 

(4) 

Q.29 The current passing through a choke coil of 5H is decreasing at the rate of 2 amp./sec. The e.m.f. developing across the coil is- **[CPMT-82,MPPMT-90,AIIMS-97]**
(1) 10 V (2) –10 V (3) 2.5 V (4) – 2.5 V

Q.30 Transformer works on the basis of the following phenomenon- **[AIIMS-98, RPMT-89]**
(1) Self-induction
(2) Mutual induction
(3) Electrical discharge
(4) Generation of electro-magnetic waves

Q.31 A long solenoid has 500 turns. When a current of 2 ampere is passed through it, the resulting magnetic flux linked with each turn of the solenoid is 4×10^{-3} wb. The self-inductance of the solenoid is- **[AIPMT-2008]**
(1) 1.0 henry (2) 4.0 henry
(3) 2.5 henry (4) 2.0 henry

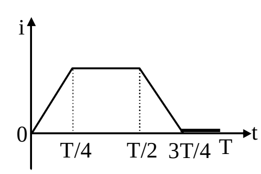
Q.32 A conducting circular loop is placed in a uniform magnetic field 0.04 T with its plane perpendicular to the magnetic field. The radius of the loop starts shrinking at 2 mm/s. The induced emf in the loop when the radius is 2 cm is- **[AIPMT-2009]**
(1) 3.2 $\pi\mu$V (2) 4.8 $\pi\mu$V (3) 0.8 $\pi\mu$V (4) 1.6 $\pi\mu$V

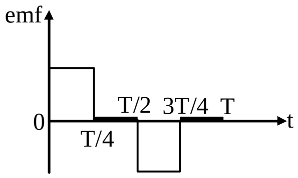
Q.33 A rectangular, a square, a circular and an elliptical loop, all in the (x – y) plane, are moving out of a uniform magnetic field with a constant velocity, $\vec{V} = v\hat{i}$. The magnetic field is directed along the negative z-axis direction. The induced emf, during the passage of these loops, come out of the field region, will not remain constant for- **[AIPMT-2009]**
(1) the rectangular, circular and elliptical loops
(2) the circular and the elliptical loops
(3) only the elliptical loop
(4) any of the four loops

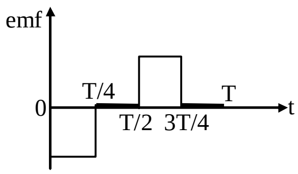
Q.34 A conducting circular loop is placed in a uniform field, B = 0.025 T with its plane perpendicular to the loop. The radius of the loop is made to shrink at a constant rate of 1 mm/s. The induced e.m.f. when the radius is 2cm, is- **[AIPMT Pre-2010]**
(1) 2 μV (2) $2\pi\mu$V (3) $\pi\mu$V (4) $\frac{\pi}{2}\mu$V

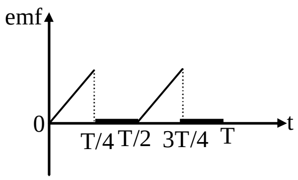
Q.35 A 220-volt input is supplied to a transformer. The output circuit draws a current of 2.0 ampere at 440 volts. If the efficiency of the transformer is 80%, the current drawn by the primary windings of the transformer is- **[AIPMT Pre-2010]**
(1) 5.0 ampere (2) 3.6 ampere
(3) 2.8 ampere (4) 2.5 ampere

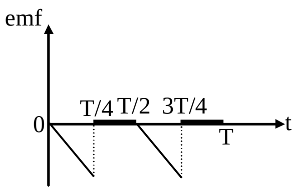
Q.36 The current i in a coil varies with time as shown in the figure. The variation of induced emf with time would be : **[AIPMT Pre-2011]**



(1) 

(2) 

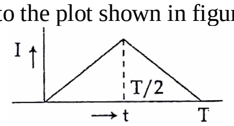
(3) 

(4) 

Q.37 A coil of resistance 400Ω is placed in a magnetic filed. If the magnetic flux ϕ (wb) linked with the coil varies with times t(sec) as $\phi = 50\,t^2 + 4$. The current is the coil at t = 2 sec is - : **[AIPMT (Pre)-2012]**

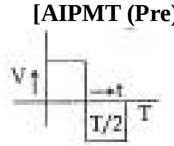
(1) 2A (2) 1A (3) 0.5A (4) 0.1 A

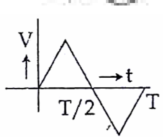
Q.38 The current (I) in the inductance is varying with time according to the plot shown in figure.

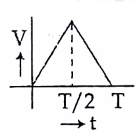


Which one of the following is the correct variation of voltage with time in the coil ? **[AIPMT (Pre)-2012]**

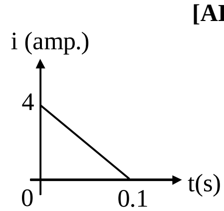
(1) 

(2) 

(3) 

(4) 

Q.39 In a coil of resistance 10 Ω, the induced current developed by changing magnetic flux through it, is shown in figure as a function of time. The magnitude of change in flux through the coil in Weber is - **[AIPMT Mains–2012]**

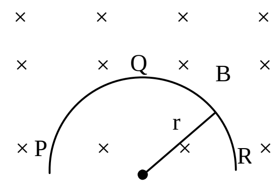


(1) 2 (2) 6 (3) 4 (4) 8

Q.40 Two cities are 150 km apart. Electric power is sent from one city to another city through copper wires. The fall of potential per km is 8 volt and the average resistance per km is 0.5Ω. The power loss in the wire is : **[AIPMT-2014]**

(1) 19.2 W (2) 19.2 kW (3) 19.2 J (4) 12.2 kW

Q.41 A thin semicircular conducting ring (PQR) of radius 'r' is falling with its plane vertical in a horizontal magnetic field B, as shown in figure. The potential difference developed across the ring when its speed is v, is : **[AIPMT-2014]**

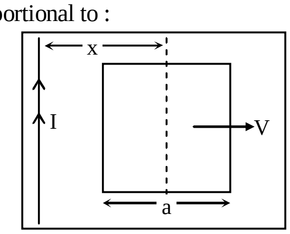


(1) Zero
(2) $Bv\pi r^2/2$ and P is at higher potential
(3) πrBv and R is at higher potential
(4) 2rBv and R is at higher potential

Q.42 A transformer having efficiency of 90% is working on 200 V and 3 kW power supply. If the current in the secondary coil is 6A, the voltage across the secondary coil and the current in the primary coil respectively are : **[AIPMT-2014]**

(1) 300 V, 15 A (2) 450 V, 15 A
(3) 450 V, 13.5 A (4) 600 V, 15 A

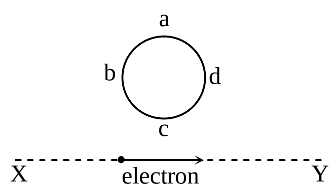
Q.43 A conducting square frame of side 'a' and a long straight wire carrying current I are located in the same plane as shown in the figure. The frame moves to the right with a constant velocity 'V'. The emf induced in the frame will be proportional to : **[AIPMT-2015]**



(1) $\frac{1}{x^2}$ (2) $\frac{1}{(2x-a)^2}$

(3) $\frac{1}{(2x+a)^2}$ (4) $\frac{1}{(2x-a)(2x+a)}$

Q.44 An electron moves on a straight line path XY as shown. The abcd is a coil adjacent to the path of electron. What will be the direction of current, if any, induced in the coil ? **[Re-AIPMT-2015]**

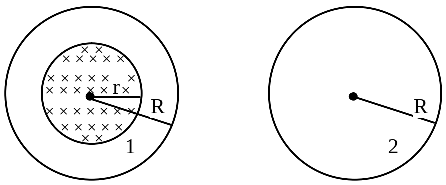


(1) No current induced
(2) abcd
(3) adcb
(4) The current will reverse its direction as the electron goes past the coil

Q.45 A long solenoid has 1000 turns. When a current of 4A flows through it, the magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self-inductance of the solenoid is : **[NEET-1-2016]**

(1) 3 H (2) 2 H (3) 1 H (4) 4 H

Q.46 A uniform magnetic field is restricted within a region of radius r. The magnetic field changes with time at a rate $\frac{d\vec{B}}{dt}$. Loop 1 of radius R > r enclosed the region r and loop 2 of radius R is outside the region of magnetic field as shown in the figure below. Then the e.m.f. generated is **[NEET-2-2016]**



(1) Zero in loop 1 and zero in loop 2

(2) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 2

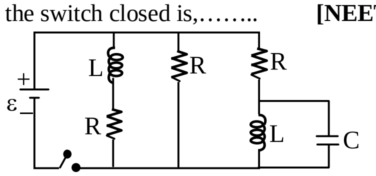
(3) $-\frac{d\vec{B}}{dt}\pi R^2$ in loop 1 and zero in loop 2

(4) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and zero in loop 2

Q.47 A long solenoid of diameter 0.1 m has 2×10^4 turns per meter. At the centre of the solenoid, a coil of 100 turns and radius 0.01 m is placed with its axis coinciding with the solenoid axis. The current in the solenoid reduces at a constant rate to 0A from 4 A in 0.05 s. If the resistance of the coil is $10\pi^2\,\Omega$, the total charge flowing through the coil during this time is : **[NEET-2017]**

(1) $16\pi\,\mu C$ (2) $32\pi\,\mu C$
(3) $16\,\mu C$ (4) $32\,\mu C$

Q.48 Figure shows a circuit that contains three identical resistors with resistance R = 9.0 Ω each, two identical inductors with inductance L = 2.0 mH each, and an ideal battery with emf ε = 18 V. The current 'I' through the battery just after the switch closed is,…….. **[NEET-2017]**



(1) 0 ampere (2) 2 mA
(3) 0.2 A (4) 4 A

Q.49 The magnetic potential energy stored in a certain inductor is 25 mJ, when the current in the inductor is 60 mA. This inductor is of inductance **[NEET-2018]**

(1) 0.138 H (2) 138.88 H
(3) 1.389 H (4) 13.89 H

Q.50 A 800 turn coil of effective area 0.05 m^2 is kept perpendicular to a magnetic field 5×10^{-5} T. When the plane of the coil is rotated by 90º around any of its coplanar axis in 0.1 s, the emf induced in the coil will be : **[NEET-2019]**

(1) 2×10^{-3} V (2) 0.02 V
(3) 2 V (4) 0.2 V

Q.51 In which of the following devices, the eddy current effect is **not** used ? **[NEET-2019]**

(1) electromagnet (2) electric heater
(3) induction furnace (4) magnetic braking in train

Q.52 Two conducting circular loops of radii R_1 and R_2 are placed in the same plane with their centres coinciding. If $R_1 >> R_2$, the mutual inductance M between them will be directly proportional to **[NEET-2021]**

(1) $\frac{R_2^2}{R_1}$ (2) $\frac{R_1}{R_2}$ (3) $\frac{R_2}{R_1}$ (4) $\frac{R_1^2}{R_2}$

Q.53 A square loop of side 1 m and resistance 1 Ω is placed in a magnetic field of 0.5 T. If the plane of loop is perpendicular to the direction of magnetic field, the magnetic flux through the loop is **[NEET-2022]**

(1) 0.5 weber (2) 1 weber
(3) Zero weber (4) 2 weber

Q.54 A big circular coil of 1000 turns and average radius 10 m is rotating about its horizontal diameter at 2 rad s^{-1}. If the vertical component of earth's magnetic field at that place is 2×10^{-5} T and electrical resistance of the coil is 12.56 Ω, then the maximum induced current in the coil will be **[NEET-2022]**

(1) 1.5 A (2) 1 A (3) 2 A (4) 0.25 A

Q.55 The magnetic flux linked to a circular coil of radius R is:

$\phi = 2t^3 + 4t^2 + 2t + 5$ Wb

The magnitude of induced emf in the coil at t = 5 s is:

[Re-NEET-2022]

(1) 192 V (2) 108 V (3) 197 V (4) 150 V

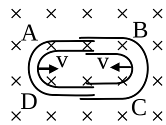
Q.56 The magnetic energy stored in an inductor of inductance 4 μH carrying a current of 2 A is :

[NEET-2023]

(1) 8 μJ (2) 4 μJ (3) 4 mJ (4) 8 mJ

EXERCISE # 4

Q.1 One conducting U tube can slide inside another as shown in figure, maintaining electrical contacts between the tubes. The magnetic field B is perpendicular to the plane of the figure. If each tube moves towards the other at a constant speed v, then the induced emf in the circuit, where ℓ is the width of each tube- **[AIEEE-2005]**



(1) $2B\ell v$ (2) Zero (3) $-B\ell v$ (4) $B\ell v$

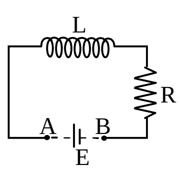
Q.2 A coil of inductance 300 mH and resistance 2Ω is connected to a source of voltage 2V. The current reaches half of its steady state value in- **[AIEEE-2005]**
(1) 0.3 s (2) 0.15 s (3) 0.1 s (4) 0.05 s

Q.3 Which of the following units denotes the dimensions ML^2/Q^2, where Q denotes the electric charge- **[AIEEE-2006]**
(1) Weber (2) Wb/m^2 (3) Henry (4) H/m^2

Q.4 In an AC generator, a coil with N turns, all of the same area A and total resistance R, rotates with frequency ω in a magnetic field B. The maximum value of emf generated in the coil is- **[AIEEE-2006]**
(1) NABω (2) NABRω (3) NAB (4) NABR

Q.5 The flux linked with a coil at any instant 't' is given by $\phi = 10t^2 - 50t + 250$. The induced emf at t = 3 s is- **[AIEEE-2006]**
(1) 190 V (2) –190 V (3) –10 V (4) 10 V

Q.6 An inductor (L = 100 mH), a resistor (R = 100Ω) and a battery (E = 100V) are initially connected in series as shown in the figure. After a long time the battery is disconnected after short circuiting the points A and B. The current in the circuit 1 ms after the short circuit is- **[AIEEE-2006]**



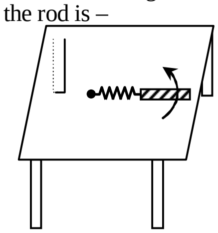
(1) 1A (2) 1/e A (3) e A (4) 0.1 A

Q.7 An ideal coil of 10H is connected in series with a resistance of 5Ω and a battery of 5V. 2 seconds after the connection is made, the current flowing in amperes in the circuit is- **[AIEEE-2007]**
(1) e (2) e – 1 (3) $(1 - e^{-1})$ (4) (1 – e)

Q.8 Two coaxial solenoids are made by winding thin Cu wire over a pipe of cross-sectional area A = 10 cm^2 and length = 20 cm. If one of the solenoids has 300 turns and the other 400 turns, their mutual inductance is- **[AIEEE-2008]**
(1) $2.4 \pi \times 10^{-5}$ H (2) $4.8 \pi \times 10^{-4}$ H
(3) $4.8 \pi \times 10^{-5}$ H (4) $2.4 \pi \times 10^{-4}$ H

Q.9 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

Q.10 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]**

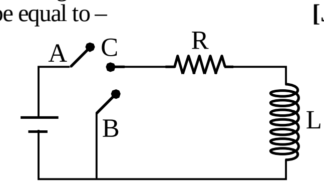


(1) $\frac{4B\omega\ell^2}{2}$ (2) $\frac{5B\omega\ell^2}{2}$

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

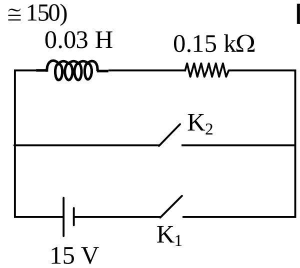
Q.11 A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flow through the smaller loop, then the flux linked with bigger loop is- **[JEE-Main 2013]**
(1) 3.3×10^{-11} weber (2) 6.6×10^{-9} weber
(3) 9.1×10^{-11} weber (4) 6×10^{-11} weber

Q.12 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]**



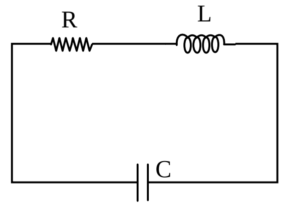
(1) 1 (2) –1 (3) $\frac{1-e}{e}$ (4) $\frac{e}{1-e}$

Q.13 An inductor (L = 0.03 H) and a resistor (R = 0.15 kΩ) are connected in series to a battery of 15V 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]**

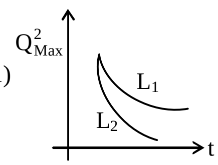


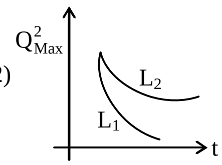
(1) 100 mA (2) 67 mA (3) 6.7 mA (4) 0.67 mA

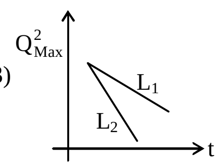
Q.14 A LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown below :

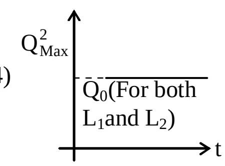


If a student plots graphs of the square of maximum charge (Q^2_{Max}) on the capacitor with time (t) for two different values L_1 and $L_2(L_1 > L_2)$ of L then which of the following represents this graph correctly ?
[JEE Main - 2015]

(1) 

(2) 

(3) 

(4) 

Q.15 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 Online - 2019]
(1) 2 mV (2) 12 mV (3) 6 mV (4) 1 mV

Q.16 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 1s, the change in the energy of the inductance is **[JEE Main Online - 2019]**
(1) 740 J (2) 637.5 J (3) 540 J (4) 437.5 J

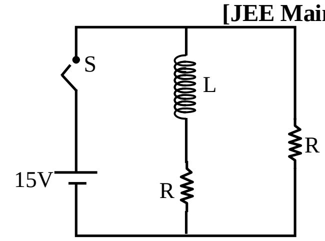
Q.17 There are two long co-axial solenoids of same length *l*. The inner and outer coils have radii r_1 and r_2 and number of turns per unit length n_1 and n_2, respectively. The ratio of mutual inductance to the self - inductance of the inner-coil is : **[JEE Main Online - 2019]**

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

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

Q.18 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 Online - 2019]**
(1) decreases by a factor of $9\sqrt{3}$
(2) increases by a factor of 27
(3) decreases by a factor of 9
(4) increases by a factor of 3

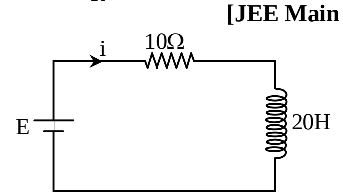
Q.19 In the figure shown, a circuit contains two identical resistors with resistance R = 5Ω and an inductance with L = 2mH. An ideal battery of 15 V is connected in the circuit. What will be the current through the battery long after the switch is closed?
[JEE Main Online - 2019]



(1) 6 A (2) 7.5 A (3) 3 A (4) 5.5 A

Q.20 A 10 m long horizontal wire extends from North East to South West. It is falling with a speed of 5.0 ms^{-1}, at right angles to the horizontal component of the earth's magnetic field of 0.3×10^{-4} Wb/m^2. The value of the induced emf in wire is : **[JEE Main Online - 2019]**
(1) 0.3×10^{-3} V (2) 2.5×10^{-3} V
(3) 1.5×10^{-3} V (4) 1.1×10^{-3} V

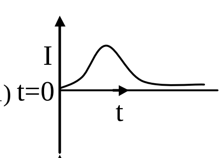
Q.21 A 20 Henry inductor and coil is connected to a 10 ohm resistance in series as shown in figure. The time at which rated of dissipation of energy (Joule's heat) across resistance is equal to the rate at which magnetic energy is stored in the inductor, is -
[JEE Main Online - 2019]

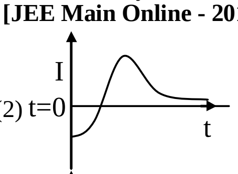


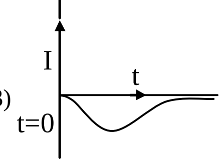
(1) $\frac{1}{2}\ell n\,2$ (2) $\ell n\,2$ (3) $2\,\ell n\,2$ (4) $\frac{2}{\ell n\,2}$

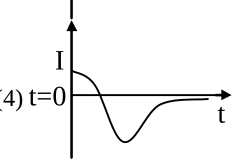
Q.22 The total number of turns and cross-section area in a solenoid is fixed. However, its length L is varied by adjusting the separation between windings. The inductance of solenoid will be proportional to :
[JEE Main Online - 2019]
(1) L (2) L^2 (3) $1/L^2$ (4) 1/L

Q.23 A very long solenoid of radius R is carrying current $I(t) = kte^{-\alpha t}$ (k > 0), as a function of time (t ≥ 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 Online - 2019]

(1) 

(2) 

(3) 

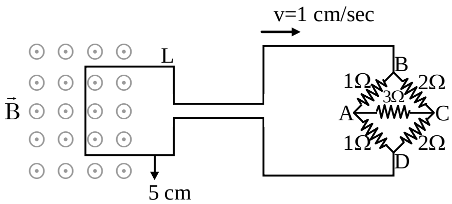
(4) 

Q.24 A transformer consisting of 300 turns in the primary and 150 turns in the secondary gives output power of 2.2 kW. If the current in the secondary coil is 10 A, then the input voltage and current in the primary coil are ; **[JEE Main Online - 2019]**
(1) 440 V and 20 A (2) 440 V and 5 A
(3) 220 V and 20 A (4) 220 V and 10 A

Q.25 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: [take $ln\ 5 = 1.6$] **[JEE Main Online - 2019]**

(1) 0.324 s (2) 0.002 s (3) 0.103 s (4) 0.016 s

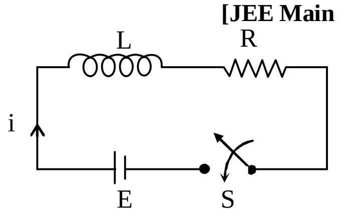
Q.26 The figure shows a square loop L of side 5 cm which is connected to a network of resistances. The whole setup is moving towards right with a constant speed of 1 cm s^{-1}. At some instant, a part of L is in a uniform magnetic field of 1 T, perpendicular to the plane of the loop. If the resistance of L is 1.7 Ω, the current in the loop at that instant will be close to : **[JEE Main Online - 2019]**



(1) 115 μA (2) 150 μA
(3) 170 μA (4) 60 μA

Q.27 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 Online - 2019]



(1) $\frac{7.3\ EL}{R^2}$ (2) $\frac{2.7\ EL}{R^2}$ (3) $\frac{EL}{7.3\ R^2}$ (4) $\frac{EL}{2.7 R^2}$

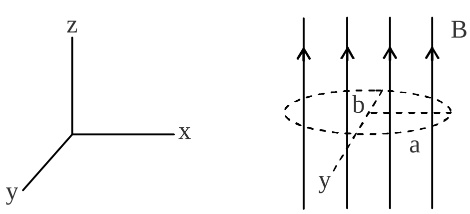
Q.28 A circuit connected to an ac source of emf $e = e_0 \sin(100t)$ with t in seconds, gives a phase difference of $\frac{\pi}{4}$ between the emf e and current i. Which of the following circuits will exhibit this ?

[JEE Main Online - 2019]

(1) RL circuit with R = 1 kΩ and L = 10 mH
(2) RL circuit with R = 1 kΩ and L = 1 mH
(3) RC circuit with R = 1 kΩ and C = 1μF
(4) RC circuit with R = 1 kΩ and C = 10μF

Q.29 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 Online - 2020]



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

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

Q.30 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 Online - 2020]**

(1) 0.34 A (2) 0.53 A (3) 0.61 A (4) 0.43 A

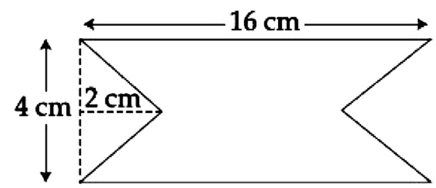
Q.31 A long solenoid of radius R carries a time (t) – dependent current $I(t) = I_0 t(1 - t)$. A ring of radius 2R is placed coaxially near its middle. During the time interval $0 \le t \le 1$, the induced current (I_R) and the induced EMF(V_R) in the ring change as -

[JEE Main Online - 2020]

(1) Direction of I_R remains unchanged and V_R is maximum at t = 0.5
(2) At t = 0.25 direction of I_R reverses and V_R is maximum
(3) Direction of I_R remains unchanged and V_R i zero at t = 0.25
(4) At t = 0.5 direction of I_R reverses and V_R is zero

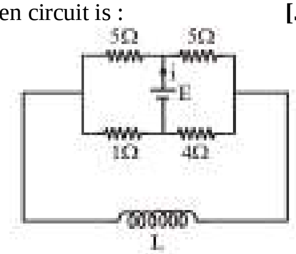
Q.32 At time t = 0 magnetic field of 1000 Gauss is passing perpendicularly through the area defined by the closed loop shown in the figure. If the magnetic field reduces linearly to 500 Gauss, in the next 5s, then induced EMF in the loop is :

[JEE Main Online - 2020]



(1) 48 μV (2) 28 μV (3) 36 μV (4) 56 μV

Q.33 The current (i) at time t = 0 and t = ∞ respectively for the given circuit is : **[JEE MAIN 2021]**

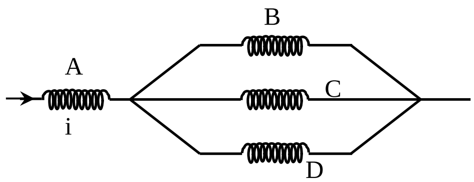


(1) $\frac{18E}{55}, \frac{5E}{18}$ (2) $\frac{10E}{33}, \frac{5E}{18}$

(3) $\frac{5E}{18}, \frac{18E}{55}$ (4) $\frac{5E}{18}, \frac{10E}{33}$

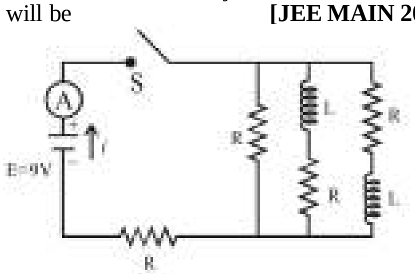
Q.34 Four identical long solenoids A, B, C and D are connected to each other as shown in the figure. If the magnetic field at the center of A is 3T. The field at the center of C would be : (Assume that the magnetic field is confined with in the volume of respective solenoid).

[JEE MAIN 2021]



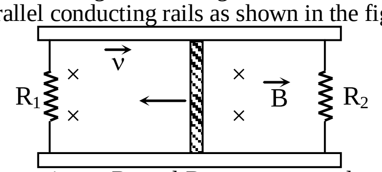
(1) 12T (2) 6T (3) 9T (4) 1T

Q.35 Figure shows a circuit that contains four identical resistors with resistance $R = 2.0\ \Omega$, two identical inductors with inductance $L = 2.0$ mH and an ideal battery with *emf* $E = 9$ V. The current 'i' just after the switch 'S' is closed will be **[JEE MAIN 2021]**



(1) 2.25 A (2) 3.0 A (3) 3.37 A (4) 9 A

Q.36 A conducting bar of length L is free to slide on two parallel conducting rails as shown in the figure



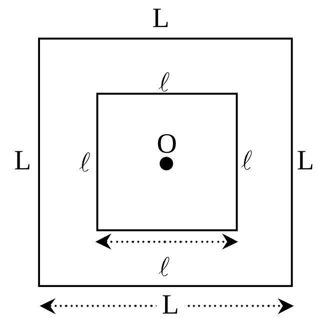
Two resistors R_1 and R_2 are connected across the ends of the rails. There is a uniform magnetic field $\vec{B}$ pointing into the page. An external agent pulls the bar to the left at a constant speed *v*.
The correct statement about the directions of induced currents I_1 and I_2 flowing through R_1 and R_2 respectively is : **[JEE MAIN 2021]**
(1) Both I_1 and I_2 are in anticlockwise direction
(2) Both I_1 and I_2 are in clockwise direction
(3) I_1 is in clockwise direction and I_2 is in anticlockwise direction
(4) I_1 is in anticlockwise direction and I_2 is in clockwise direction

Q.37 A coil of inductance 1 H and resistance $100\ \Omega$ is connected to a battery of 6 V. Determine approximately: **[JEE Main 2022]**
(a) The time elapsed before the current acquires half of its steady – state value
(b) The energy stored in the magnetic field associated with the coil at an instant 15 ms after the circuit is switched on.
(Given $\ln 2 = 0.693$, $e^{-3/2} = 0.25$)
(1) t = 10 ms ; U = 2 mJ (2) t = 10 ms ; U = 1 mJ
(3) t = 7 ms ; U = 1 mJ (4) t = 7 ms ; U = 2 mJ

Q.38 A metallic conductor of length 1 m rotates in a vertical plane parallel to east-west direction about one of its end with angular velocity 5 rad s^{-1}. If the horizontal component of earth's magnetic field is 0.2×10^{-4} T, then emf induced between the two ends of the conductor is: **[JEE Main 2022]**
(1) 5 μV (2) 50 μV
(3) 5 mV (4) 50 m

Q.39 In a coil of resistance $8\ \Omega$, the magnetic flux due to an external magnetic field varies with time as $\phi = \frac{2}{3}(9 - t^2)$. The value of total heat produced in the coil, till the flux becomes zero, will be ______ J. **[JEE Main 2022]**

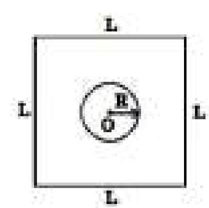
Q.40 A small square loop of wire of side ℓ is placed inside a large square loop of wire $L(L >> \ell)$. Both loops are coplanar and their centres coincide at point O as shown in figure. The mutual inductance of the system is : **[JEE Main 2022]**



(1) $\frac{2\sqrt{2}\mu_0 L^2}{\pi\ell}$ (2) $\frac{\mu_0 \ell^2}{2\sqrt{2}\pi L}$
(3) $\frac{2\sqrt{2}\mu_0 \ell^2}{\pi L}$ (4) $\frac{\mu_0 L^2}{2\sqrt{2}\pi\ell}$

Q.41 A capacitor of capacitance 500 μF is charged completely using a dc supply of 100 V. It is now connected to an inductor of inductance 50 mH to form an LC circuit. The maximum current in LC circuit will be ______A. **[JEE Main 2022]**

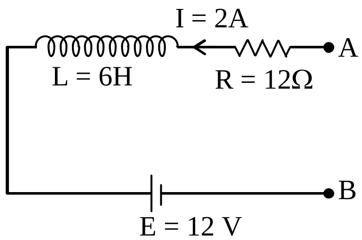
Q.42 Find the mutual inductance in the arrangement, when a small circular loop of wire of radius 'R' is placed inside a large square loop of wire of side L (L >> R). The loops are coplanar and their centres coincide: **[JEE Main 2023]**



(1) $M = \frac{2\sqrt{2}\mu_0 R}{L^2}$ (2) $M = \frac{\sqrt{2}\mu_0 R}{L^2}$
(3) $M = \frac{2\sqrt{2}\mu_0 R^2}{L}$ (4) $M = \frac{\sqrt{2}\mu_0 R^2}{L}$

Q.43 A certain elastic conducting material is stretched into a circular loop. It is placed with its plane perpendicular to a uniform magnetic field B = 0.8 T. When released the radius of the loop starts shrinking at a constant rate of 2 cms^{-1}. The induced emf in the loop at an instant when the radius of the loop is 10 cm will be _____ mV. **[JEE Main 2023]**

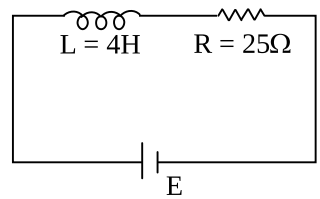
Q.44



As per the given figure, if $\frac{dI}{dT} = -1$ A/s then the value of V_{AB} at this instant will be ______V. **[JEE Main 2023]**

Q.45 A square loop of side 2.0 cm is placed inside a long solenoid that has 50 turns per centimetre and carries a sinusoidally varying current of amplitude 2.5 A and angular frequency 700 rad s^{-1}. The central axes of the loop and solenoid coincide. The amplitude of the emf induced in the loop is $x \times 10^{-4}$ V. The value of x is ________. (Take, $\pi = \frac{22}{7}$) **[JEE Main 2023]**

Q.46 In the given figure, an inductor and resistor are connected in series with a battery of emf E volt. $\frac{E^a}{2b}$ J/s represents the maximum rate at which the energy is stored in the magnetic field (inductor). The numerical value of $\frac{b}{a}$ will be ______. **[JEE Main 2023]**



ANSWER KEY

EXERCISE-1

Q.No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	2	4	1	1	4	3	3	4	4	4	1	4	4	3	4	1	2	3	2	1
Q.No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	4	1	1	3	1	2	2	2	2	4	3	2	2	2	3	4	1	1	3	4
Q.No.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	1	3	4	1	1	1	4	3	4	2	2	2	3	3	3	3	4	1	4	3
Q.No.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**		
Ans.	3	2	1	3	2	2	2	1	2	1	3	1	1	2	3	1	2	2		

EXERCISE-2

Q.No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	4	3	2	3	2	1	4	1	1	2	1	1	1	1	1	1	3	2	2	2
Q.No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	3	1	3	1	1	4	2	4	2	1	1	1	3	1	1	1	2	3	2	2
Q.No.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	2	1	2	2	1	4	4	1	1	1	3	3	2	1	1	2	2	4	4	1
Q.No.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Ans.	3	1	3	4	3	2	4	1	2	4	1	1	2	2	1	4	2	1	4	2
Q.No.	**81**	**82**	**83**	**84**	**85**	**86**	**87**													
Ans.	1	1	4	1	2	1	2													

EXERCISE-3

Q.No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	3	3	4	1	4	2	3	2	1	1	4	1	3	3	4	1	1	1	2	3
Q.No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	3	2	2	4	1	1	1	2	1	2	1	1	2	3	1	2	3	2	1	2
Q.No.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**				
Ans.	4	2	4	4	3	4	4	4	4	2	2	1	1	2	1	1				

EXERCISE-4

Q.No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	1	3	3	1	3	2	3	4	3	2	3	2	4	1	2	4	2	2	1	4
Q.No.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	3	4	2	2	4	3	4	4	3	3	4	4	4	4	1	3	3	2	2.00	3
Q.No.	**41**	**42**	**43**	**44**	**45**	**46**														
Ans.	10.00	3	10	30	44	25														

NOTES