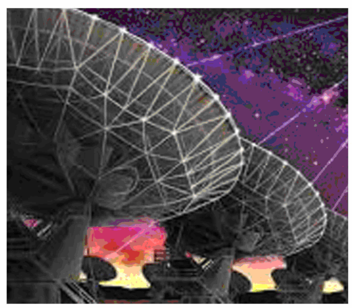
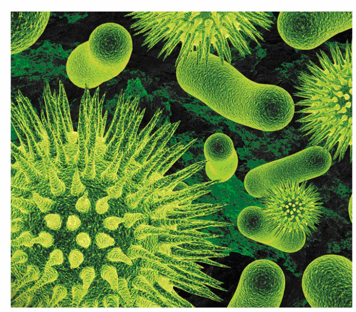
STUDY MATERIAL

NEET

XI & XII STD



PHYSICS



CP PUBLICATION

PHYSICS

Study Material for NEET preparation
Prepared by Career Point Kota Experts

CAREER POINT

CONTENTS OF THE PACKAGE AT A GLANCE

PHYSICS

Class 11

Mechanics (Part-I)
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Modern Physics
- Atomic Structure
- Matter Waves
- Photoelectric Effect
- X-Rays
- Nuclear Physics
- Semicounductor & Electronic Devices

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

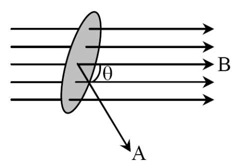
1. Magnetic Flux

(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** $= \dfrac{\textbf{newton}}{\textbf{amp.m}} \times \mathbf{m^2} = \dfrac{\textbf{newton .m}}{\textbf{amp}}$

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

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

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

(iii) weber = volt-sec

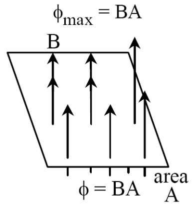
$= \dfrac{\textbf{volt}}{\textbf{amp / sec}}$ **× amp = henry-amp.**

(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.

$$\phi_{max} = BA$$



$\phi = BA$

(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 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

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

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

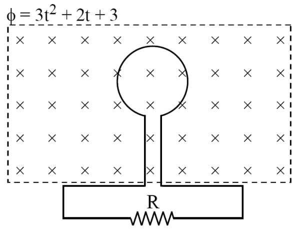
Sol.(1) $\phi = \vec{B}\,.\,\vec{A}$

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

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

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

(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 ϕ = BA

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

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

$= 7.065 \times 10^{-4} \times \dfrac{100}{60 \times 3} = 3.9 \times 10^{-4}$ 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 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

ϕ_1 = BA.

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

ϕ_2 = – BA.(– sign is put because now the flux lines enters the coils through the outer face)

$\therefore$ 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) $\pi/2$ (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

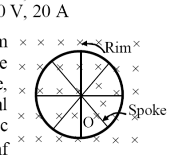
Q.5 In a step-down transformer the number of turns in-

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

Q.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

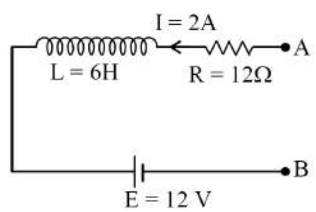
Exercise Level -3 : It contains previous years NEET exam quesiotns from 2005 to upto to present year.

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.59 A sheet is placed on a horizontal surface in front of a strong magnetic pole. A force is needed to:
A. hold the sheet there if it is magnetic.
B. hold the sheet there if it non–magnetic.
C. move the sheet away from the pole with uniform velocity if it is conducting.
D. move the sheet away from the pole with uniform velocity if it is both, non-conducting and non-polar.
Choose the correct statement(s) from the options given below: **[NEET-2024]**
(1) A, C and D only (2) C only
(3) B and D only (4) A and C only

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]**

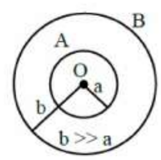
Q.45 A square loop of side 2.0 cm is placed inside a long solenoid that has 50 turns per centimetre and carries a sinusoidally varying current of amplitude 2.5 A and angular frequency 700 rad s^{-1}. The central axes of the loop and solenoid coincide. The amplitude of the emf induced in the loop is $x \times 10^{-4}$ 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]**

Q.49 A capacitor of capacitance 100 μF is charged to a potential of 12 V and connected to a 6.4 mH inductor to produce oscillations. The maximum current in the circuit would be: **[JEE Main 2024]**
(1) 2.0 A (2) 1.2 A
(3) 1.5 A (4) 3.2 A

Q.50 A square loop of side 10 cm and resistance 0.7 Ω is placed vertically in east-west plane. A uniform magnetic field of 0.20 T is set up across the plane in north east direction. The magnetic field is decreased to zero in 1 s at a steady rate. Then magnitude of induced emf is $\sqrt{x} \times 10^{-3}$ V. The value of x is ________. **[JEE Main 2024]**

Q.51 Two conducting circular loops A and B are placed in the same plane with their centres coinciding as shown in figure. The mutual inductance between them is : **[JEE Main 2024]**



(1) $\frac{\mu_0 \pi a^2}{2b}$ (2) $\frac{\mu_0}{2\pi} \cdot \frac{b^2}{a}$
(3) $\frac{\mu_0 \pi b^2}{2a}$ (4) $\frac{\mu_0}{2\pi} \cdot \frac{a^2}{b}$

Answer key

Above mentioned all exercises provided with 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		

Electromagnetic Induction

This chapter covers the following syllabus

1. Faraday's law of electromagnetic induction.
2. Lenz's law.
3. Induced emf.
4. Self and mutual inductance.

Revision Plan

Prepare Your Revision plan today!

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

Key Concept

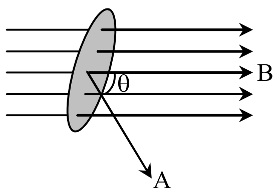
1. Magnetic Flux

(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** $= \dfrac{\textbf{newton}}{\textbf{amp.m}} \times \mathbf{m^2} = \dfrac{\textbf{newton .m}}{\textbf{amp}}$

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

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

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

(iii) weber = volt-sec

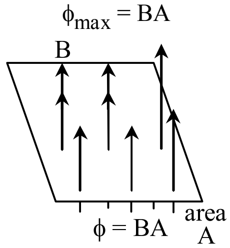
$= \dfrac{\textbf{volt}}{\textbf{amp / sec}} \times$ **amp = henry-amp.**

(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 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.

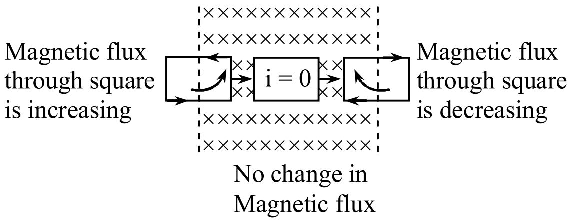
(c) From Lenz's law and Faraday's Law, induced emf is given by $e = -\dfrac{d\phi}{dt}$, Where minus sign is to show that emf opposes the change of flux linked with it.

(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)

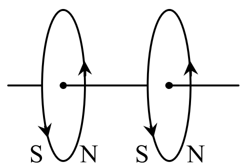


(ii) Case 1 : brought closer $\rightarrow \leftarrow$

$\Rightarrow$ 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 = $10 \times 20\ cm^2 = 200 \times 10^{-4}\ m^2$

$B = 0.5$ 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 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 $i = 20/2 = 10$A.

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 180° is $d\phi = nAB - (-nAB) = 2nAB$

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

$\therefore$ induced charge $= \dfrac{2 \times 100 \times 0.001 \times 1}{10} = 0.02$ C

5. No E.M.I. Cases

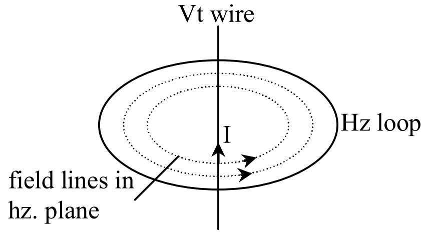
Condition of No EMI. if

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

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

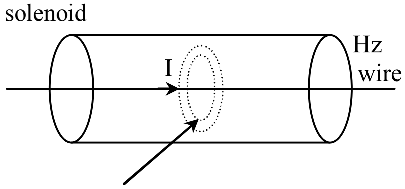
CASES

(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.



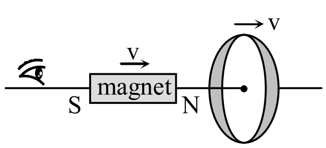
($\phi = 0$)

(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 ($\phi = 0$)

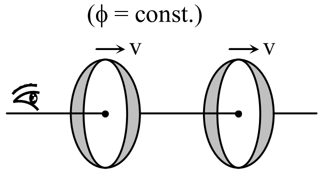
(iii) (a)



No relative motion

(ϕ = const.)

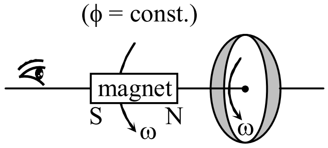
(b)



No relative motion

(ϕ = const.)

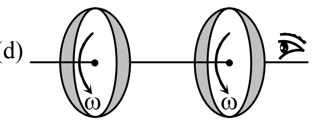
(c)



No relative motion

(ϕ = const.)

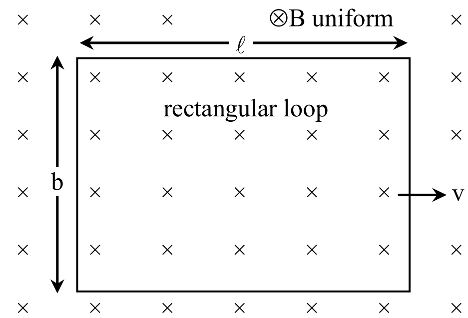
(d)



No relative motion

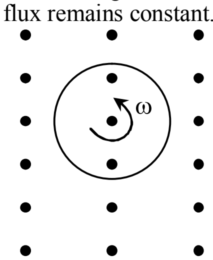
(ϕ = const.)

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



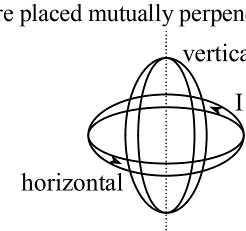
ϕ = constant

(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.

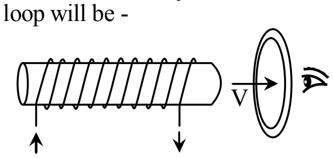


(ϕ = const.)

(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 -

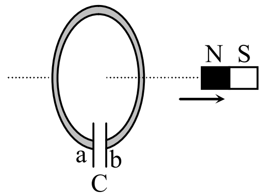


(1) anticlockwise (2) clockwise

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

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) $E = -\dfrac{d\phi}{dt}$ 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) $e = \dfrac{d\phi}{dt} = -\dfrac{d}{dt}[10t^2 + 5t + 1] \times 10^{-3}$

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

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, (ϕ = BA cosθ) changes w.r.t. time in following three manner and according to it electro magnetic induction classify in three ways:

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

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

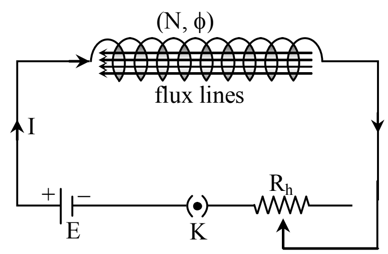
(B) If (B, θ) $\rightarrow$ const & $\dfrac{dA}{dt} \rightarrow \dfrac{d\phi}{dt} \Rightarrow$ **Dynamic EMI** (In this case EMI occurs for a moving straight wire)

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

(A) Static E.M.I. $\Rightarrow \dfrac{dI}{dt} \rightarrow \dfrac{dB}{dt} \rightarrow \dfrac{d\phi}{dt} \Rightarrow$ **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 $\rightarrow$ B $\rightarrow$ ϕ $\rightarrow$ Const. $\Rightarrow$ No EMI

total flux of coil (Nϕ) $\propto$ current 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 $\rightarrow 1\dfrac{\text{weber}}{A} = 1$ henry $= 1\dfrac{N-m}{A^2} = 1\dfrac{J}{A^2}$

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 $\dfrac{dI}{dt} \rightarrow \dfrac{dB}{dt} \rightarrow \dfrac{d\phi}{dt} \Rightarrow$ Static EMI

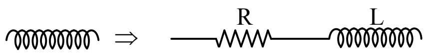
$N\phi = LI$

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

S.I. unit of L $\rightarrow \dfrac{V-\sec}{A}$

(i) Thin wire___________ R $\neq$ 0 & L = 0

$\Rightarrow$ Role of R $\rightarrow$ to opposes flow of current, now this wire moulded in form of coil.



$R \neq 0$ R-L series combination

$L \neq 0$

Role of L $\rightarrow$ 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) $\Rightarrow e_s$(–ve) opposite emf

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

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

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

(iv) Current variation with key:-

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

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

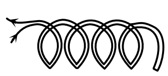
(c) At the time of sudden opening of key, due to high inductance of circuit a high momentarily emf induced and sparking occurs at key position. To avoid sparking a capacitor is connected parallel to the key.

(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 (½ mv^2)	Energy stored in Inductor (½ 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



$R \neq 0$

L 0 (Non inductive resistance)

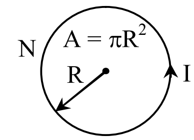
(viii) In checking balancing of wheat stone. Bridge, firstly we always pressed cell key and after wards galvanometer key, so that momentarily induced current due to self inductance of coil becomes almost zero or disappear.

Different Coefficient of Self inductance:-

(i) Plane circular coil-

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

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



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

- $L_m \propto \mu_r$ (effect of medium)
- $L \propto N^2$ (R $\rightarrow$ same)
- $L \propto R$ (N $\rightarrow$ same)

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

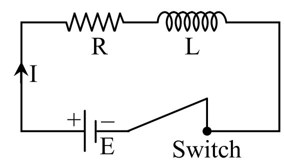
$L_s = \frac{N}{I}\left(\frac{\mu_0 NI}{\ell}\right)A$

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

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:- $\boxed{E = IR + L\frac{dI}{dt}}$

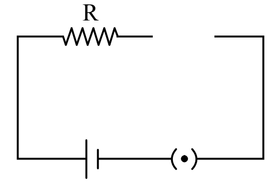
(ii) Current at any instant:- When key is closed the current in circuit increases exponentially with respect to time. The current in circuit at any instant 't' given by:-

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

t = 0 (Just after the closing of key) $\Rightarrow I = 0$

$t \rightarrow \infty$ (Some time after closing of key) $\Rightarrow I \rightarrow I_0$

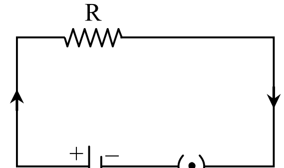
(iii) Just after the closing of the key inductance behaves like open circuit and current in circuit is zero.



(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 $t \rightarrow \infty$, $I \rightarrow I_0$)

(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:-

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

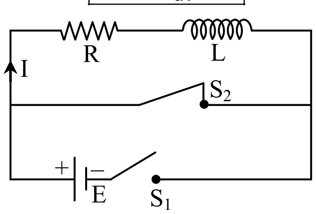
at $t = 0 \Rightarrow \left(\frac{dI}{dt}\right)_{max} = \frac{E}{L}$

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

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:-

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

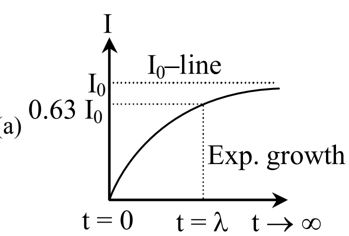
at $t = 0 \Rightarrow \left(-\frac{dt}{dt}\right)_{max} = \frac{E}{L}$

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

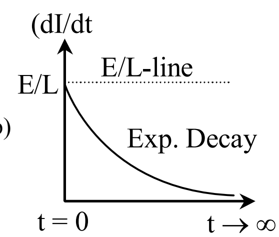
Special graph for R-L circuit:-

Current Growth : -

(a)

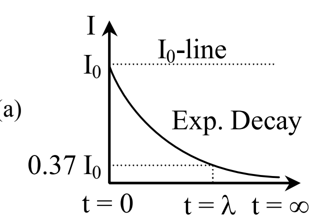


(b)

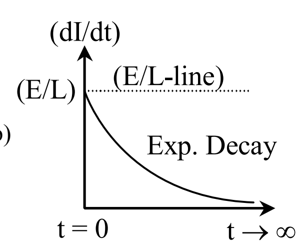


Current decay:-

(a)

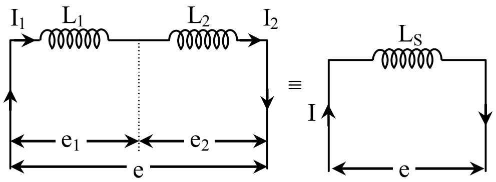


(b)



Combination of Inductances:-

(a) Series combination



Potential divides, $e = e_1 + e_2$

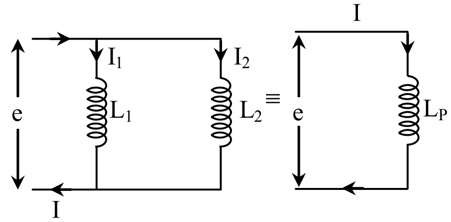
$$L_s\frac{dI}{dt} = L_1\frac{dI_1}{dt} + L_2\frac{dI_2}{dt} \quad (\text{as } e = -L\frac{dI}{dt})$$

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, $I = I_1 + I_2$

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

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

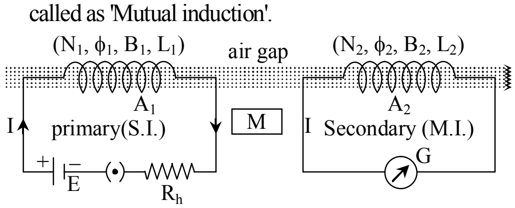
$$\left[\text{as } e = -L\frac{dI}{dt} \text{ i.e. } \frac{dI}{dt} = -\frac{e}{L}\right]$$

Potential remains same, $e = e_1 = e_2$

$$\frac{1}{L_P} = \frac{1}{L_1} + \frac{1}{L_2} \Rightarrow \boxed{L_P = \frac{L_1L_2}{L_1 + L_2}}$$

(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 $\phi_2 = B_1A_2$ $(\theta = 0)$

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

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

$N_2\,\phi_2 \propto I_1$

$N_2\,\phi_2 = MI_1$

$$\boxed{M = \frac{N_2\phi_2}{I_1} = \frac{N_2B_1A_2}{I_1} = \frac{(\phi_T)_s}{I_p}},$$

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 changes 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 ← e_m $\frac{dI_1}{dt}$ → Primary

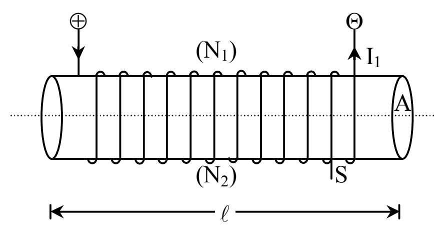
Different mutual inductances:-

(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 :-

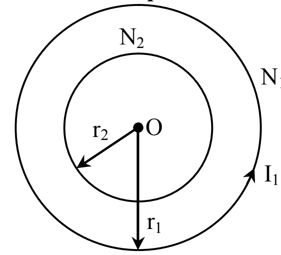


$$M_{S_1S_2} = \frac{N_2B_1A}{I_1}$$

$$= \frac{N_2}{I_1}\left(\frac{\mu_0N_1I_1}{\ell}\right)A, \text{ where } B_1 = \frac{\mu_0N_1I_1}{\ell}$$

$$\Rightarrow \boxed{M_{s_1s_2} = \left(\frac{\mu_0N_1N_2A}{\ell}\right)}$$

(2) Two concentric and coplanar coils :-



$(r_1 >> r_2)$

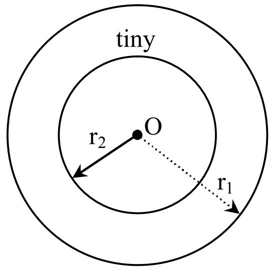
$$M_{c_1c_2} = \frac{N_2B_1A_2}{I_1}, \text{ where } B_1 = \frac{\mu_0N_1I_1}{2r_1} \;\&\; A_2 = \pi r_2^2$$

$$M_{c_1c_2} = \frac{N_2}{I_1}\left(\frac{\mu_0N_1I_1}{2r_1}\right)(\pi r_2^2)$$

$$\Rightarrow \boxed{M_{c_1c_2} = \frac{\mu_0N_1N_2\pi r_2^2}{2r_1}}$$

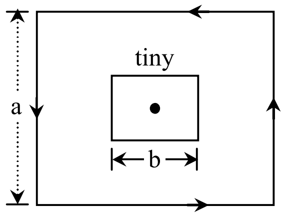
(i) Two concentric and coplanar loops:-

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

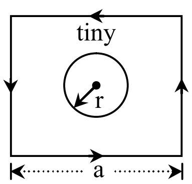


(ii) Two concentric and coplanar square loops:-

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



(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:-

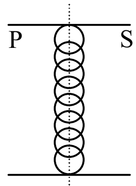
$\boxed{M = K\sqrt{L_1 L_2}}$, where 'K' is coupling factor between two coils and its range $0 \le K \le 1$

(i) For ideal coupling $K_{max} = 1 \Rightarrow \boxed{M_{max} = \sqrt{L_1 L_2}}$
(where M is geometrical mean of L_1 & L_2)

(ii) For real coupling $(0 < K < 1) \Rightarrow \boxed{M = K\sqrt{L_1 L_2}}$

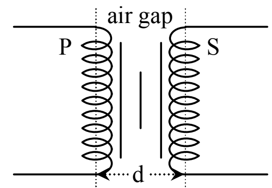
(iii) Value of coupling factor 'K' decides from fashion of coupling.

(iv) Different fashions of coupling:-

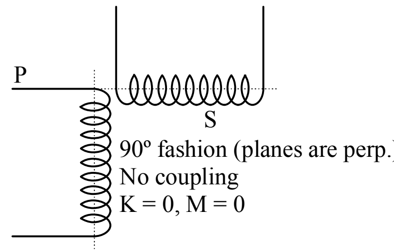


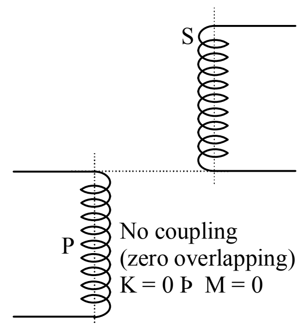
Ideal coupling (Coaxial fashion)

$K = 1 \Rightarrow M_{max} = \sqrt{L_1 L_2}$



Normal coupling (0º fashion) (Planes are parallel)
$(0 < K < 1 \Rightarrow M = K\sqrt{L_1 L_2}$, if $d\downarrow \Rightarrow K\uparrow \Rightarrow M\uparrow)$





(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

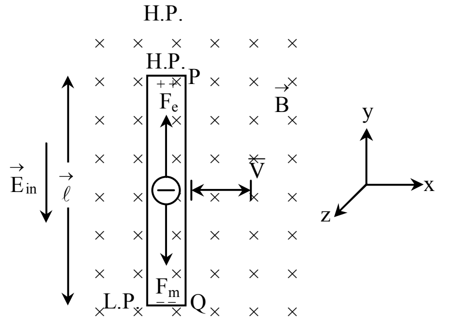
$\Rightarrow$ Coupling factor 'K' between two coils.

(B) Dynamic E.M.I $\left(\frac{dA}{dt} \to \frac{d\varphi}{dt} \to \text{Dynamic E.M.I.}\right)$ (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:-

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

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

→ $\vec{v}\times\vec{B}$ & $\vec{\ell}$ " $\vec{B}$ & $\vec{\ell}\ \forall\ \vec{v}$ ⇒ $\boxed{(e_d)_{max.} = Bv\ell}$ (max. flux cutting)

→ $\vec{v}\,||\,\vec{B}$ or $\vec{\ell}\,||\,\vec{B}$ & $\vec{\ell}\,||\,\vec{v}$ ⇒ $\boxed{(e_d)_{min.} = 0}$ (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

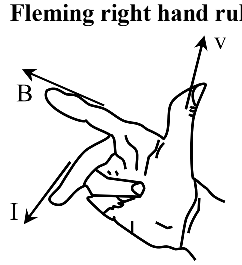
$\boxed{(e_d)_{min.} = 0}$

(vii) Do flux cutting ⇒ Dynamic EMI
No flux cutting ⇒ No Dynamic EMI

(viii) Direction of induced current or HP end of the rod find with the help of:-

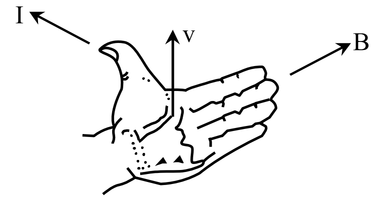
(a) Flemming right hand rule.
(b) Left hand palm rule.

(a) **Fleming right hand rule:-**



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

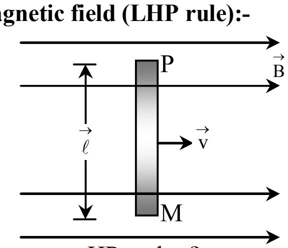
(b) **Left hand palm rule**



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

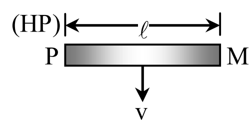
Type-I:- When straight conductor moves in external magnetic field (LHP rule):-

(i)



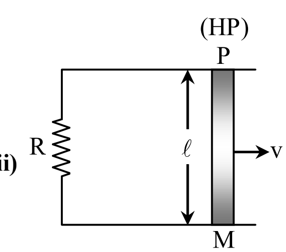
HP end = ?

(ii)



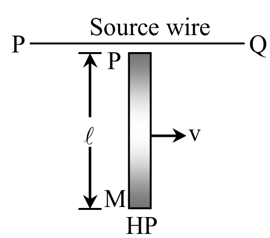
Direction of ext. B = ?

(iii)



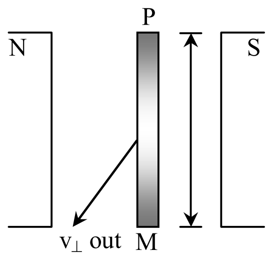
Direction ext. B = ?

(iv)



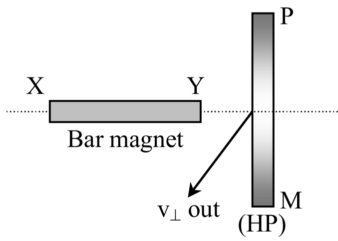
Direction of current in source wire PQ = ?

(v)



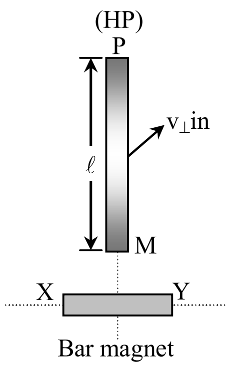
LP end = ?

(vi)



Poles of magnet = ?

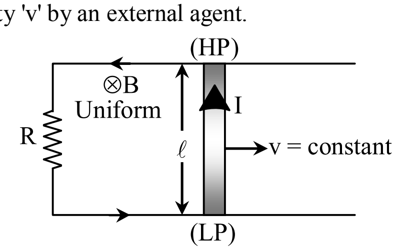
(vii)



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 $\theta = 90^\circ$

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

(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 $(B, \ell, R) \to$ const. $\Rightarrow$ $\boxed{F_{ext.} \propto v}$

(v) For uniform motion of metal rod, The rate of doing mechanical work by external 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 $(B,\ell,R) \to$ const. $\Rightarrow$ $\boxed{p_{mech.} \propto v^2}$

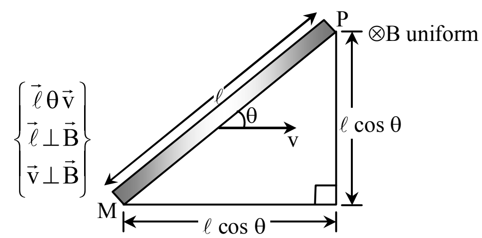
(vi) Rate of heat dissipation across resistance or thermal power developed across resistance is:-

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

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

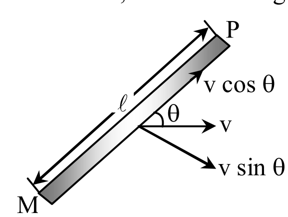
It is clear that $p_{th} = p_{mech}$ which is consistent with the principle of conservation of energy.

(b)



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

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



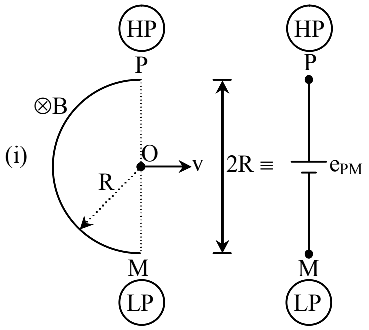
$\boxed{e_d = B(v\sin\theta)\ell}$

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:-

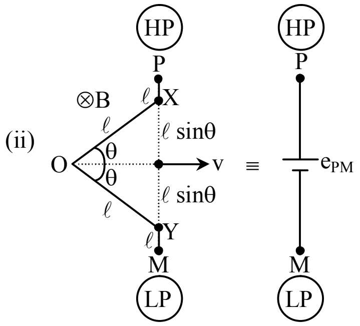
$\boxed{e_d = Bv\ell_{i-f}}$, where ℓ_{i-f} displacement between free ends of the conductor.

(i)



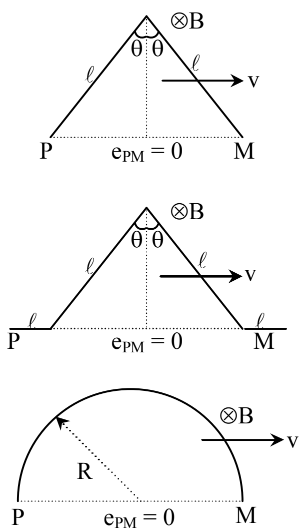
$e_{PM} = Bv(2R) = 2BvR$

(ii)

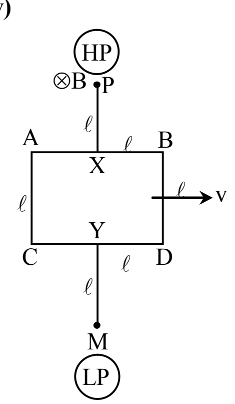


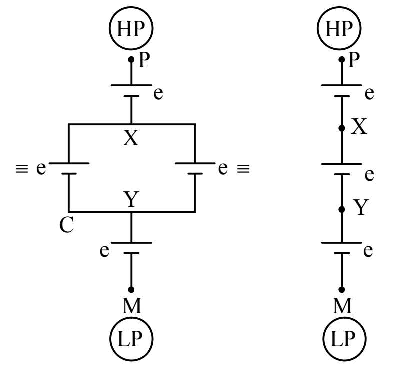
$e_{PM} = Bv(2\ell + 2\ell \sin\theta) = 2Bv\ell(1 + \sin\theta)$

(iii)



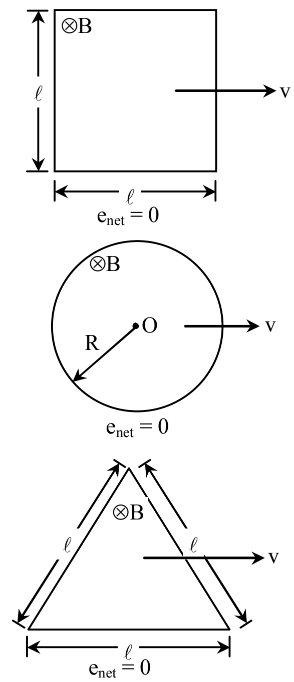
(iv)



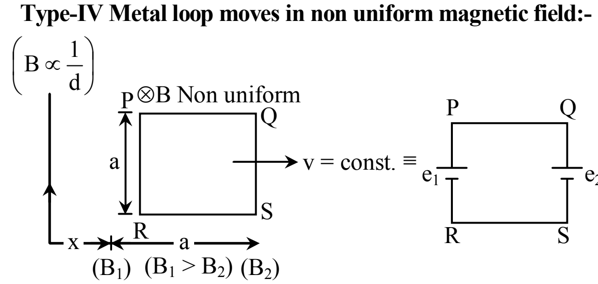


where $e = Bv\ell$ $\quad$ $e_{PM} = 3e = Bv\ell$

(v)



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

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

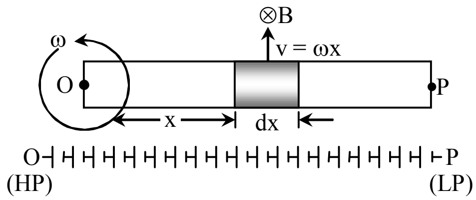
$$\boxed{e_{net} = \frac{\mu_0 Iva^2}{2\pi x(x+a)}}$$ (always non zero)

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.

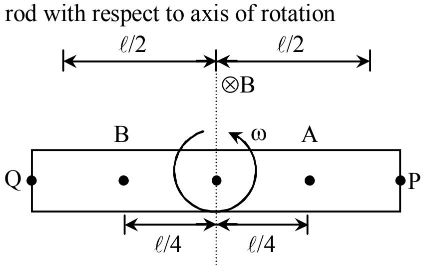
$$e = \int_O^P de = \int_0^{\ell} B\omega x\,dx = \frac{1}{2}B\omega\ell^2$$

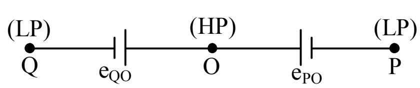
$$\boxed{\begin{array}{l} e_{PO} = \frac{1}{2}B\omega\ell^2 \\ \omega = 2\pi f \end{array}}$$

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



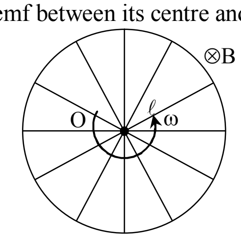


Sol. Parts PO & QO are represents identical cell

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

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.

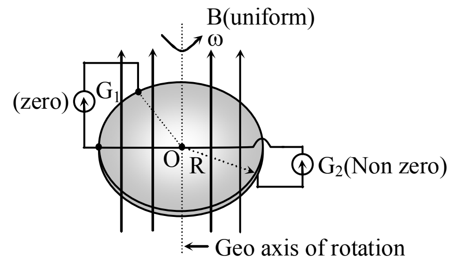


Sol. Due to flux cutting each metal spoke becomes identical cell of emf e (say), all such identical cells connected in parallel fashion e_{net} = e (emf of single cell)

$$\boxed{\begin{array}{l} e_{net} = \frac{1}{2}B\omega\ell^2 \\ \omega = 2\pi f \end{array}}$$

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)

  $\boxed{\begin{array}{l} e_{net} = \frac{1}{2}B\omega R^2 \\ \omega = 2\pi f \end{array}}$, 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 $\Rightarrow B_H$ cuts} dynamic emf – $\boxed{e_d = B_H v\ell}$
- → N–S line $\Rightarrow$ 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 $dir^n \Rightarrow$ No flux cutting $\Rightarrow$ No Dy EMI

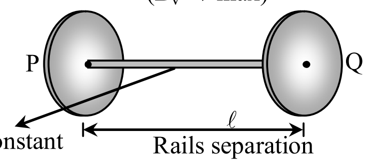
Applications:-

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

$\boxed{e_{PQ} = B_v v \ell}$

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

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



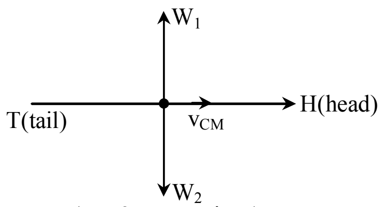
where $B_v = B\sin\theta$, θ angle of dip at that place

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):-

$\boxed{e_{W_1W_2} = B_v \ell_{W_1W_2} v}$, 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)

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

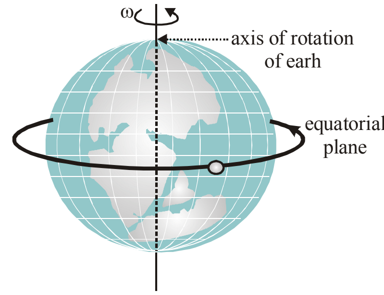
(iii) Human body (Vt – Hz):

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

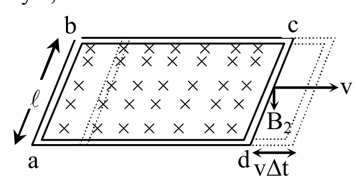
(iv) Motion of an Artificial satellite (Hz – Hz):-



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

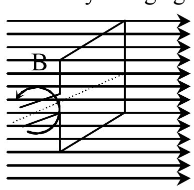
As soon as the coil is totally out of the magnetic field region, induced emf becomes zero again.

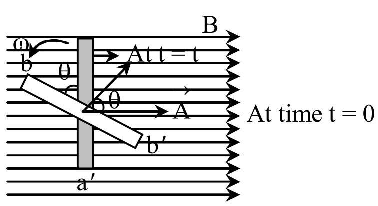
(i) If a rectangular loop is moved in a uniform magnetic field $\vec{B}$ with a velocity $\vec{v}$, then induced emf and current will not be produced because the magnetic flux linked with the coil does not change. But if loop is drawn out of the magnetic field, then emf and current will be induced in 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 $I = I_0\sin\omega t$

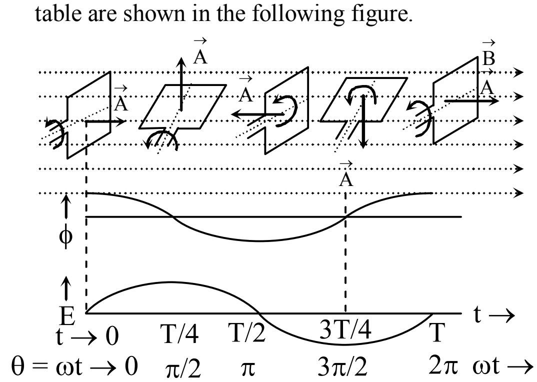
where $I_0 = \frac{E_0}{R}$

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

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

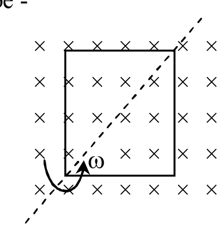
Peak value = $B^2 r^2 f$

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 -



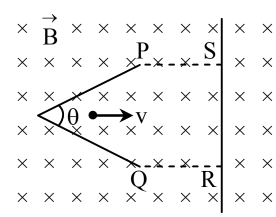
(1) $10Ba^2 \cos \omega t$ (2) 10Ba
(3) $10Ba^2$ (4) $20Ba^2$

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

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

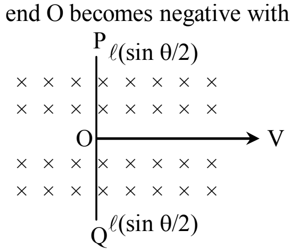
Here N = 10, A = a^2

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

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

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.

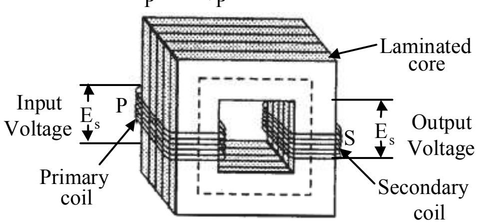
(h) Let N_P : Number of turns in primary coil.

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) $V_S = I_S Z_S \Rightarrow 22 = I_S \times 220 \therefore I_S = 0.1$A

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

$\frac{22}{220} = \frac{I_P}{o.1} \Rightarrow I_P = 0.01$ 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) $\frac{1}{2} E_p I_p = E_s I_s,\quad \therefore I_s = \frac{E_p I_p}{2E_s}$

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

$= 0.05$A

9. Electric Motor

(a) It convert electric energy into mechanical energy.

(b) Working principle :

Electric energy $\rightarrow$ Current $\rightarrow$ Current

Carrying coil in a magnetic field $\rightarrow$ Torque on the coil $\rightarrow$ 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 :

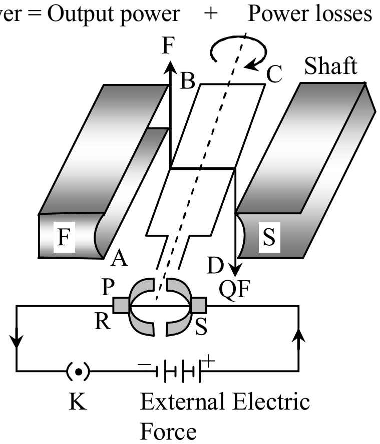
$E - e_b = I_a R_a$

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

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

electric power   mechanical power   Joul's heat

$\Rightarrow$ Input power = Output power + Power losses



(f) Back emf $\propto \omega$

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 $B = \phi/A$, 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 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.

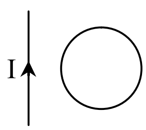
7. In a motor, (a) the current at start is $I = E/R$; (b) the current at full speed is, $I = (E - e)/R$; (c) the current at switch off is, $I = - e/R$, where e = back e.m.f., R = armature resistance, E = e.m.f. of battery.

EXERCISE # 1

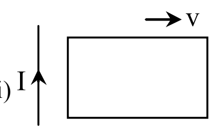
Type-I: Coils (or loop) are in plane of the paper:-

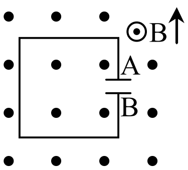
Find direction of induced current for the given cases:-

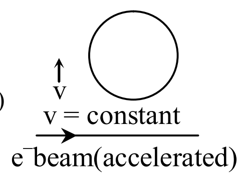
(Where w.r.t. = with respect to time, ob = observer =)

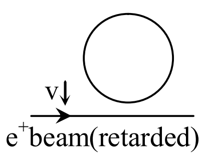
(i)


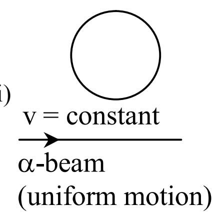
If I ↑ w.r.t.

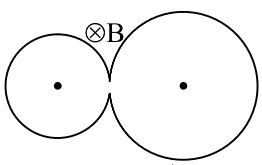
(ii)


(iii)


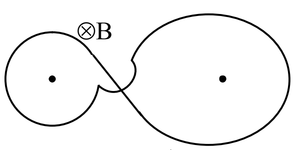
(iv)


(v)


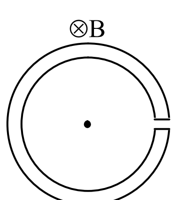
(vi)


(vii) (a)


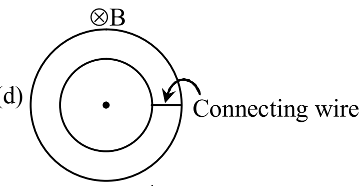
If w.r.t. B ↑

(b)


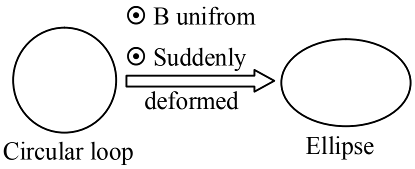
If w.r.t. B ↑

(c)


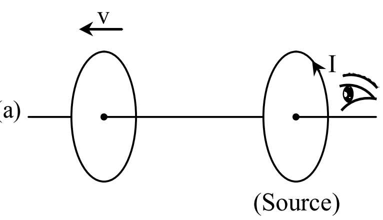
If w.r.t. B↑

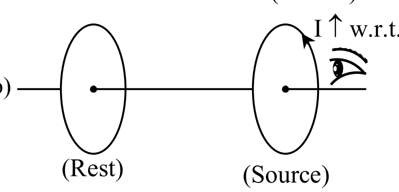
(d)


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)


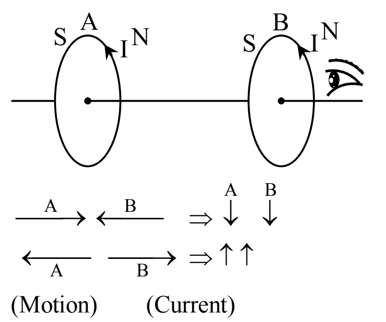
(ii) Two idential co-axial circular coils carries equal currents:-

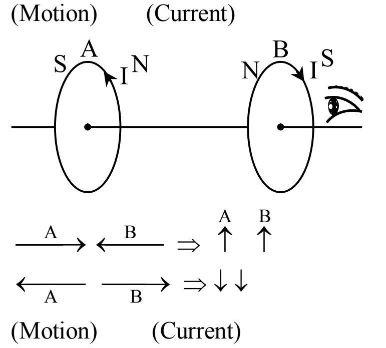
(a) In same direction (b) In opposite direction.

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

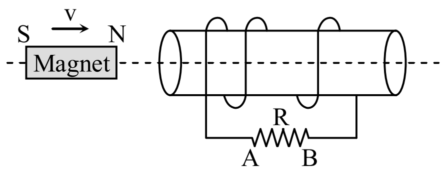
(1) Increases (2) Decreases

(3) Remains same (4) None

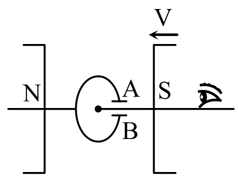




(iii) What is the direction of induced current in resistance 'R' ?

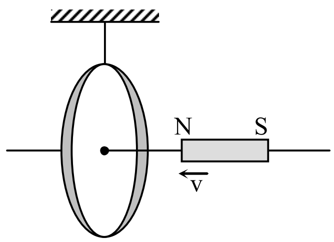


(iv) What is the nature of the charge on the plates of capacitor ?



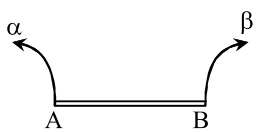
Type-III: Special Question:-

(i)

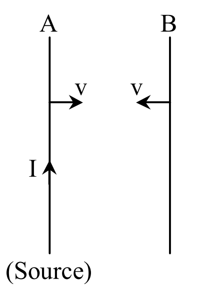


Due to motion of bar magnet freely suspended ring with attract or repel by the magnet. If ring is made up (a) Cu (b) Fe

(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 ?



(Source)

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

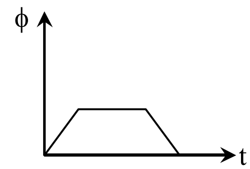
2. A coil and a magnet moves with their constant speeds 5 m/s and 3 m/s respectively, towards each other, then induced emf in coil is 16 mV. If both are moves in same direction, then induced emf in coil :

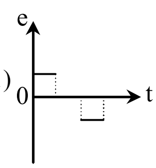
(1) 15 mV (2) 4 mV (3) 64 mV (4) Zero

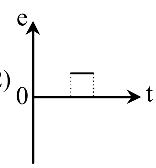
3. Magnetic flux ϕ (in weber) linked with a closed circuit of resistance 10 ohm varies with time t(in seconds) as $\phi = 5t^2 - 4t + 1$. The induced emf in the circuit at t = 0.2 sec. is -

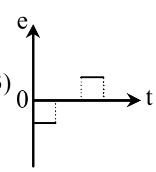
(1) 0.4 V (2) – 0.4 V (3) – 2.0 V (4) 2.0 V

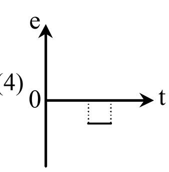
4. Magnetic flux linked through the coil changes with respect to time according to following graph, then induced emf v/s time graph for coil is :



(1)


(2)


(3)


(4)


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 magnet 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

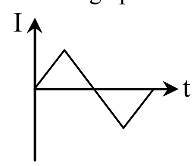
10. A coil of N turns having cross sectional area A, and resistance 'R' placed in transverse uniform magnetic field B. If it is rotates about its one of the diameter through an angle 'θ' in time interval 't'. Find following induced parameters in coil :
(a) E.M.F. (b) Current
(c) Charge

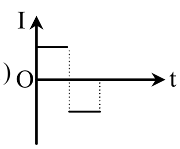
11. The value of self inductance of a coil is 5H. The value of current changes from 1A to 2A in 5 sec., then value of induced emf in it:-
(1) 10V (2) 0.1V (3) 1.0 V (4) 100 V

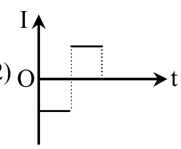
12. A coil of self inductance 2H carries a 2A current. If direction of current is reversed in 1 sec., then induced emf in it:-
(1) –8V (2) 8V (3) –4V (4) Zero

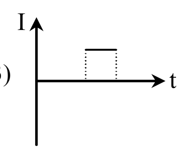
13. For a coil having L = 2mH, current flow through it is $I = t^2e^{-t}$ then the time at which emf becomes zero:-
(1) 2 sec. (2) 1 sec. (3) 4 sec. (4) 3 sec.

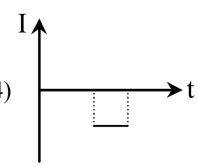
14. Current through the coil varies according to graph then induced emf v/s time graph is



(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

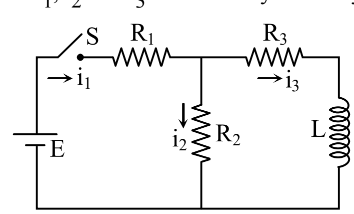
25. An inductor of 20 H and a resistance of 10Ω, are connected to a battery of 5 volt in series, then initial rate of change of current is:-
(1) 0.5 amp/s (2) 2.0 amp/s
(3) 2.5 amp/s (4) 0.25 amp/s

26. A coil of L = 5 × 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

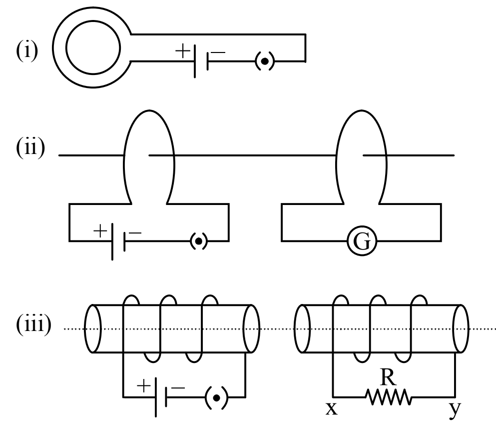
(3) R_1^2/R_2^2 (4) R_2^2/R_1

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

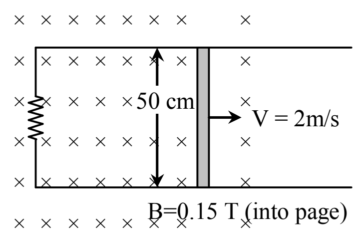
(a) Key is just closed

(b) Some time after the closing of key

(c) Key is just opened



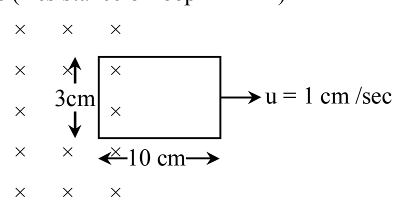
38. A metallic rod completes its circuit as shown in the figure. The circuit is normal to a magnetic field of B = 0.15 T. If the resistance of the circuit is 3Ω the force required to move the rod with a constant velocity of 2m/sec. is:



(1) 3.75×10^{-3} N (2) 3.75×10^{-2} N

(3) 3.75×10^{2} N (4) 3.75×10^{-4} N

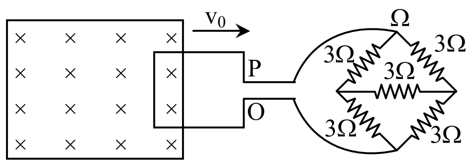
39. A rectangular loop sides 10 cm and 3 cm moving out of a region of uniform magnetic field of 0.5T directed normal to the loop. If we want to move loop with a constant velocity 1cm/sec. then required mechanical force is (Resistance of loop = 1 mΩ)



(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 1 Ω 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 3 Ω. 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.



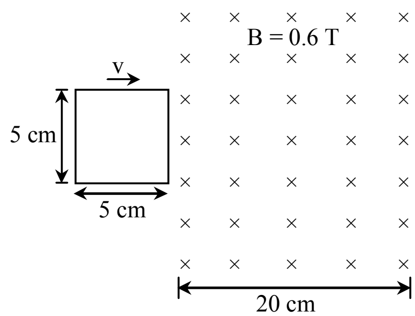
(1) 2×10^{-2} m/sec., anticlockwise direction

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

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

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

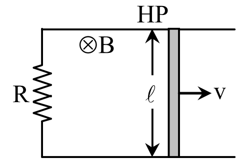
41. Figure shows a square loop of side 5 cm being moved towards right at a constant speed of 1 cm/sec. The front edge just enters the 20 cm wide magnetic field at t = 0. Find the induced emf in the loop at t = 2s and t = 10s.



(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 EXAMPLE

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

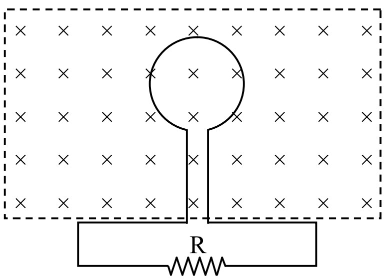
Sol.(1) $\phi = \vec{B} \cdot \vec{A}$

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

$= 0.6 \times 10^{-4}$ 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

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

(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.

$\therefore$ 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.

$\therefore$ 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 ϕ = BA

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

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

$= 7.065 \times 10^{-4} \times \dfrac{100}{60\times3} = 3.9 \times 10^{-4}$ 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

ϕ_1 = BA.

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

ϕ_2 = – BA.(– sign is put because now the flux lines enters the coils through the outer face)

$\therefore$ 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.

$$\therefore q = \frac{2\times500\times0.2\times4.0\times10^{-4}}{50} = 1.6 \times 10^{-3} \text{ coulomb.}$$

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

$$B = \frac{\mu_0 i}{2a} = \frac{(4\pi\times10^{-7})\times1}{2\times0.1} = 2\pi \times 10^{-6} \text{ weber/m}^2.$$

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) $\pi/10$ V (2) $2\pi/10$ V (3) 10π mV (4) 20π mV

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

$$E = \frac{1}{2}B\omega R^2 = \frac{1}{2}\times 0.1\times 2\pi\times 10\times(0.1)^2 = 10\pi\times10^{-3} \text{ volt,}$$

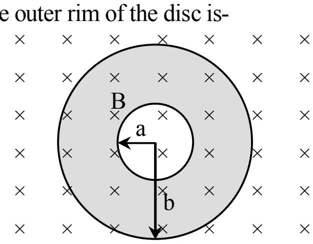
Ex.8 Two rail tracks, insulated from each other and the ground, are connected to millivoltmeter. What is the reading of the milli voltmeter when a train passes at a speed of 180 km/hr along the track, given that the horizontal component of earth's magnetic field is 0.2×10^{-4} Wb/m^2 and rails are separated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

(1) 1 mV (2) 10 mV (3) 100 mV (4) 1 V

Sol.(1) The induced emf

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

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-

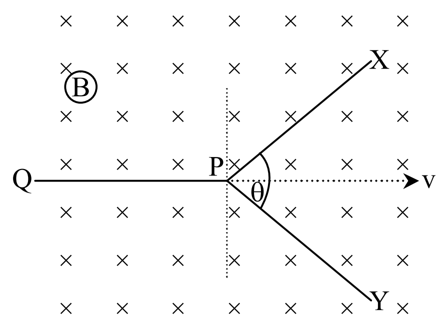
(1) 4.2 V (2) 8.4 V (3) 42 V (4) 84 V

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

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

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

(3) 2 Bℓv sin (θ/2) (4) 2 Bℓv cos (θ/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 $(90 - \theta)$. Thus

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

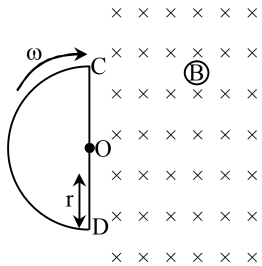
Similarly $e_y - e_p = vB\ell \sin(\theta/2)$

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 Bvℓ sin(θ/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 $e = \pi r^2 B/T$

$= 2\pi r^2 B/T\times 2 = B\omega r^2/2$

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

$V = B v\ell$ volt.

Here, $B = 0.30 \times 10^{-4}$ weber/meter^2,

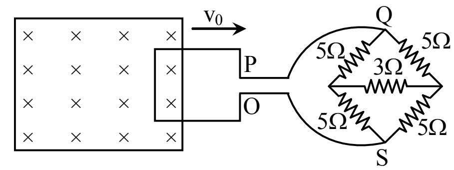
v = 5.0 meter/second and ℓ = 10 meter.

$\therefore B = 0.30 \times 10^{-4} \times 5.0 \times 10 = 0.0015$ 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

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

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 $= 0.4 \times 10^{-3}$ henry,

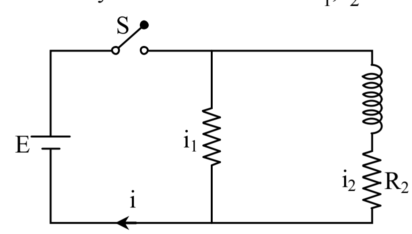
$\Delta i = 0.250$ ampere

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

$= 1 \times 10^{-3}$ 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 individually, 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.

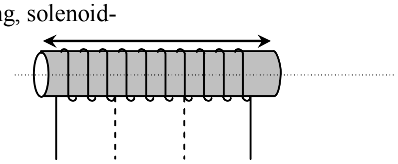
Hence $$e = -L_1\frac{di_1}{dt} = -L_2\frac{di_2}{dt}.$$

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)

$$= \left(\mu_0\frac{N_2}{\ell_2}I\right)(AN_1) = \frac{\mu_0N_1N_2AI}{\ell_2}$$

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

Questions based on Flux and Faraday's Law of EMI

Q.1 A flux of 1 m 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 0.628 m. A current of 10 A 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 ωt (2) 10^{-7} cos ωt
(3) 10^{-9} sin ωt (4) 10^{-9} cos ωt

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 10 Ω 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

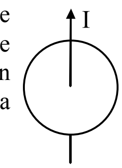
Q.6 A cylindrical bar magnetic is lying along the axis of a circular coil. If the magnet is rotated about the axis of the coil then-
(1) e.m.f. will be induced in the coil
(2) Only induced current will be generated in the coil
(3) No current will be induced in the coil
(4) Both e.m.f. and current will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

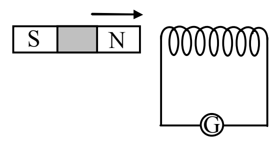
Questions based on Lenz Law

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 × 10^4/π 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 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

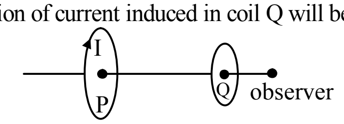
Q.15 A long solenoid contains 1000 turns/cm and an alternating current of peak value 1A is flowing in it. A search coil of area of cross-section 1 × 10^{-4} m^2 and having 50 turns is placed inside the solenoid with its plane perpendicular to the axis of the solenoid. A peak voltage of $2\pi^2 \times 10^{-2}$ 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.16 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.17 Lenz's law is consistent with law of conservation of -
(1) current (2) emf
(3) energy (4) all of the above

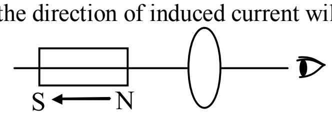
Q.18 The north pole of a magnet is brought near a coil. The induced current in the coil as seen by an observer on the side of magnet will be-
(1) in the clockwise direction
(2) in the anticlockwise direction
(3) initially in the clockwise and then anticlockwise direction
(4) initially in the anticlockwise and then clockwise direction.

Q.19 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-



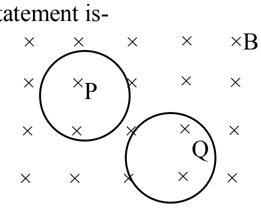
(1) clockwise (2) towards north
(3) towards south (4) anticlockwise

Q.20 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.

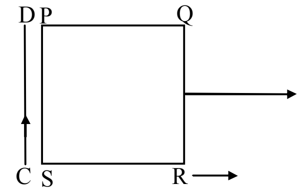
Q.21 P and Q are two circular thin coils of same radius and subjected to the same rate of change of flux. If coil P is made up of copper and Q is made up of iron, then the wrong statement is-



(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.

Questions based on Moving Conductor and Motional EMF

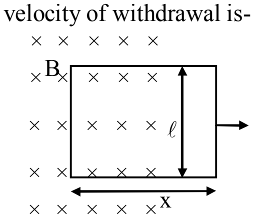
Q.22 A square loop PQRS is carried away from a current carrying long straight conducting wire CD. The direction of induced current in the loop will be-



(1) anticlockwise
(2) clockwise
(3) sometimes clockwise some times anticlockwise
(4) current will not be induced

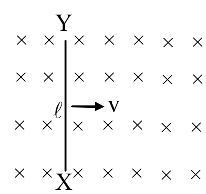
Q.23 A wire of length 4 m placed normal to the magnetic field of $(2\hat{i}+4\hat{j})$ Tesla is moving with a velocity $(4\hat{i}+6\hat{j}+8\hat{k})$ m/s. The emf induced across the ends of the wire will be-
(1) 4 V (2) 8 V (3) 16 V (4) 32 V

Q.24 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-



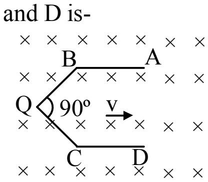
(1) $\frac{B\ell^2 v}{R}$ (2) $\frac{B^2\ell^2 v}{R}$
(3) $\frac{B^2\ell^2 v^2}{R}$ (4) 0

Q.25 A small conducting rod of length ℓ, moves with a uniform velocity v in a uniform magnetic field B as shown in fig-



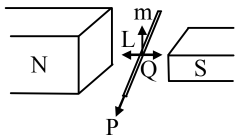
(1) Then the end X of the rod becomes positively charged
(2) the end Y of the rod becomes positively charged
(3) the entire rod is unevenly charged
(4) the rod becomes hot due to joule heating.

Q.26 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-



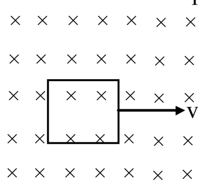
(1) 0 (2) 1.41 volt
(3) 0.71 volt (4) none of the above

Q.27 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.28 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 -



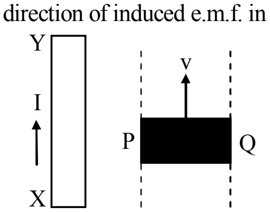
(1) Zero

(2) $\frac{BLv}{R}$ in anticlockwise direction

(3) $\frac{BLv}{R}$ in clockwise direction

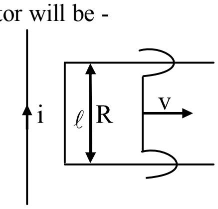
(4) $\frac{2BLv}{R}$ in clockwise direction

Q.29 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

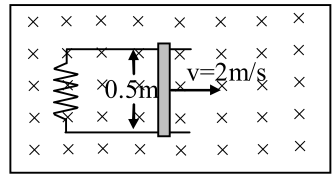
Q.30 A straight conductor carrying current i and a loop closed by a sliding connector of resistance R lie in the same plane. The connector slides towards right with a uniform velocity v. The induced current generated in the loop in terms of distance r of the connector form the straight conductor will be -



(1) $\frac{\mu_0 i\ell v}{2\pi r}$ (2) $\frac{\mu_0 i\ell}{2\pi r}$

(3) $\frac{\mu_0 i\ell v}{2\pi rR}$ (4) None of these

Q.31 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-

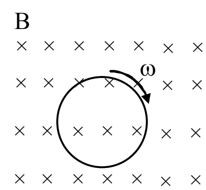


(1) 3.75×10^{-3} N (2) 3.75×10^{-2} N
(3) 3.75×10^{2} N (4) 3.75×10^{-4} N

Questions based on **Induced EMF due to Rotation of conductor**

Q.32 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.33 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-



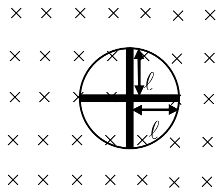
(1) $\frac{BA\omega}{2\pi}$ (2) B (2πr) ω

(3) 0 (4) None of the above

Q.34 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.35 A 1.2 m 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.36 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 –



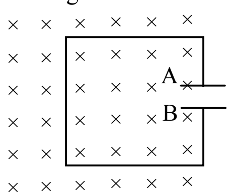
(1) 0 (2) $B\ell^2\omega$ (3) $B^2\ell\omega$ (4) $\dfrac{B\ell^2\omega}{2}$

Q.37 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

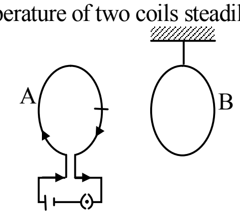
Questions based on Time varying magnetic field and induced electric field

Q.38 A magnetic field is directed normally downwards through a metallic frame as shown in the figure. On increasing the magnetic field-



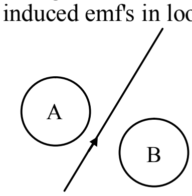
(1) plate B will be positively charged
(2) plate A will be positively charged
(3) none of the plates will be positively charged
(4) all of the above

Q.39 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-



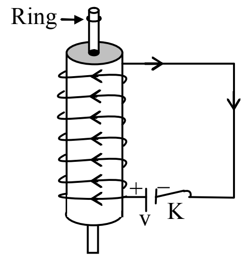
(1) the two coils show attraction
(2) the two coils show repulsion
(3) there is no change in the position of the two coils
(4) induced currents are not possible in coil B.

Q.40 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-



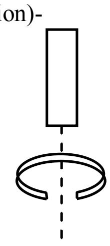
(1) clockwise in A, anticlockwise in B
(2) anticlockwise in A, clockwise in B
(3) clockwise in both A and B
(4) anticlockwise in both A and B

Q.41 A conducting ring is placed around the core of an electromagnet as shown in fig. When key K is pressed, the ring-



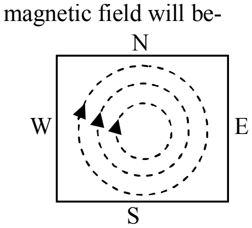
(1) remains stationary
(2) is attracted towards the electromagnet
(3) jumps out of the core
(4) none of the above

Q.42 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

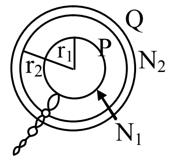
Q.43 A metal sheet is placed in a variable magnetic field which is increasing from zero to maximum. Induced current flows in the directions as shown in figure. The direction of magnetic field will be-



(1) normal to the paper, inwards
(2) normal to the paper, outwards.
(3) from east to west
(4) from north to south

Questions based on Self and Mutual Inductance

Q.44 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.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 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.53 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.54 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.55 The coefficient of mutual inductance of the two coils is 5 H. The current through the primary coil is reduced to zero value from 3 A 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.56 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.57 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.58 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.59 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.60 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.61 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.62 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.63 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

Questions based on L-R or L-C Circuit

Q.64 An inductance stores energy in-
(1) electric field (2) magnetic field
(3) resistance of coils (4) all of the above

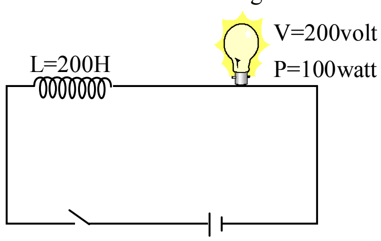
Q.65 The growth of current in an L - R circuit in time $t = L / R$ is equal to about-
(1) 37% of maximum (2) 63% of maximum
(3) 57% of maximum (4) 67% of maximum

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.

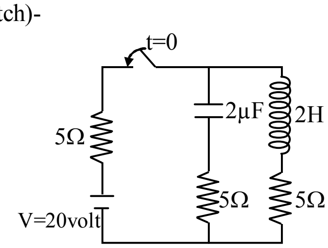
Q.68 A coil of resistance R and inductance L is connected to a battery of E volt e.m.f. This final current in the coil is-
(1) E/R (2) E/L
(3) $\sqrt{[E/(R^2+L^2)]}$ (4) $\sqrt{[EL/(R^2+L^2)]}$

Q.69 Calculate the ratio of power dissipated by the bulb at t = 1 sec and t = 2 sec after closing the switch-



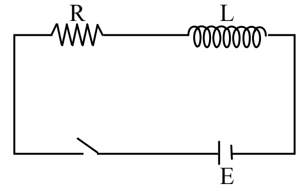
(1) $\dfrac{e^2}{e^4-1}$ (2) $\left(\dfrac{e^2}{(e^2+1)}\right)^2$
(3) $\dfrac{e^2-1}{e^4+1}$ (4) None of these

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-



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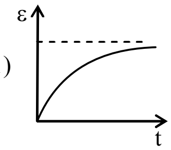

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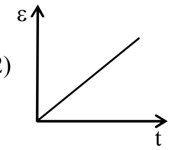

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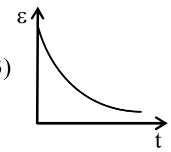

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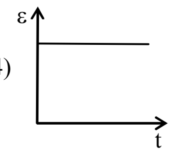


Q.72 To transmit electrical energy from a generator to distant consumers-
(1) high voltage and low current are transmitted
(2) high voltage and high current are transmitted
(3) low voltage and low current are transmitted
(4) low voltage and high current are transmitted

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

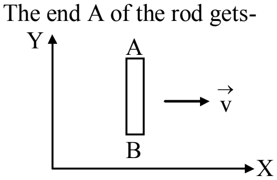
Q.6 An inductor coil stores 32 J of magnetic field energy and dissipates energy as heat at the rate of 320 W, when a current of 4 A is passed through it. The time constant of the circuit when this coil is joined across an ideal battery will be-
(1) 0.2 s (2) 0.3 s (3) 0.4 s (4) 0.5 s

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) $\frac{\mu_0 \pi R_2^2}{2R_1^2}$

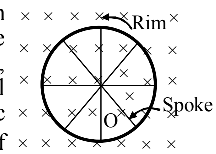
Q.10 A conductor rod AB moves parallel to X-axis in a uniform magnetic field, pointing in the positive Z-direction. The end A of the rod gets-



(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

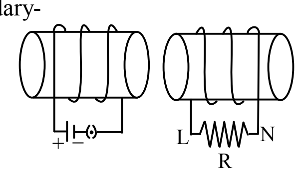
Q.18 When the current through a solenoid increases at a constant rate, the induced current-
(1) is a constant and is in the direction of the inducing current
(2) is a constant and is opposite to the direction of the inducing current
(3) increase with time and is in the direction of the inducing current
(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

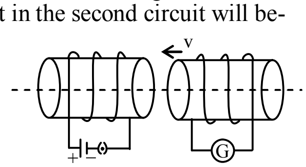
Q.22 Two co-axial solenoids shown in figure. If key of primary suddenly opened then direction of instantaneous induced current in resistance 'R' which connected in secondary-



(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

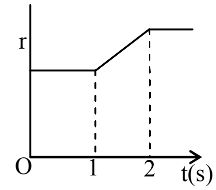
Q.25 Two identical circular coils A and B are placed parallel to each other with their centres on the same axis. The coil B carries a current I in the clock wise direction as seen from A. What would be the direction of the induced current in A seen from B when-
(a) The current in B is increased ?
(b) 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 10 Ω 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 160 Ω resistance. The coil has radius 6 mm 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-



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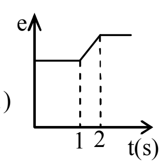

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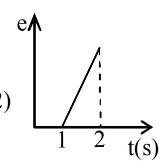

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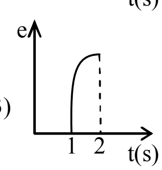

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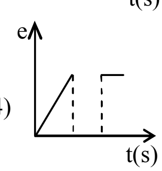
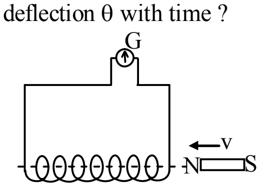


Q.30 A short bar magnet passes at a steady speed right through a long solenoid. A galvanometer is connected across the solenoid. Which graph best represents the variation of the galvanometer deflection θ with time ?



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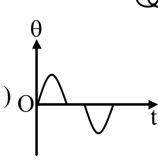

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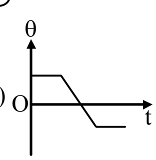

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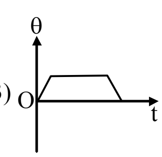

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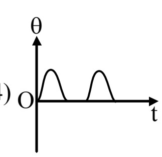


Q.31 A square loop of side 22 cm is changed to a circle in time 0.4 s. The magnetic field present is 0.2 T. The emf induced is-
(1) – 6.6 mV (2) – 13.2 mV
(3) + 6.6 mV (4) + 13.2 mV

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

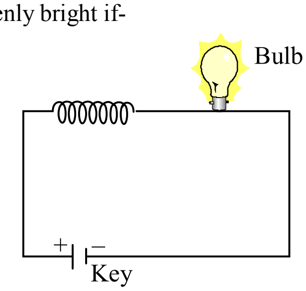
Q.36 Which statement is correct from following -
(a) inductor store energy in the form of magnetic field
(b) capacitor store energy in the form of electric field
(c) inductor store energy in the form of electric and magnetic field both
(d) capacitor store energy in the form of electric and magnetic field 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

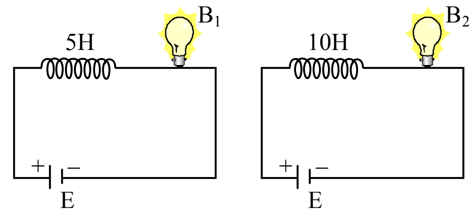
Q.39 For a solenoid keeping the turn density constant its length makes halved and its cross section radius is doubled then the inductance of the solenoid increased by -
(1) 200% (2) 100% (3) 800% (4) 700%

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-



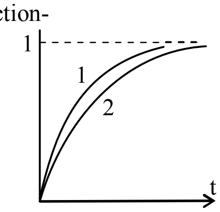
(1) B_1 (2) B_2
(3) Both take same time (4) None

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-



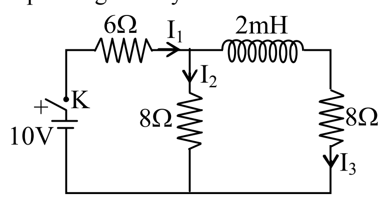
(1) L is increased (2) L is decreased
(3) R is increased (4) R is decreased

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

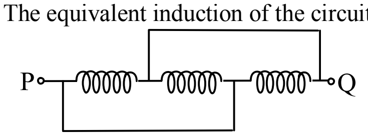
Q.48 A closely wound coil of 100 turns and area of cross section 1 cm^2 has a self inductance 1mH. The magnetic induction at the centre of the coil, when a current of 2A flows in it, will be-
(1) $0.2\ \frac{Wb}{m^2}$ (2) $0.4\ \frac{Wb}{m^2}$
(3) $0.8\ \frac{Wb}{m^2}$ (4) $1\ \frac{Wb}{m^2}$

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

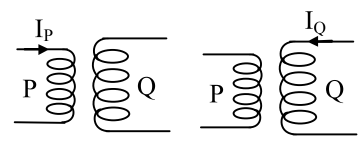
Q.51 The time constant of an inductance coil is 2.0×10^{-3} s. When a 90Ω resistance is joined in series, the time constant becomes 0.5×10^{-3} s. The inductance and resistance of the coil are-
(1) 30 mH ; 30 Ω (2) 30 mH ; 60 Ω
(3) 60 mH ; 30 Ω (4) 60 mH ; 60 Ω

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)

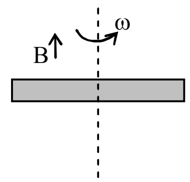
(1) 8×10^{-4} V (2) 2×10^{-8} V
(3) 5×10^{-3} V (4) 8×10^{-2} V

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

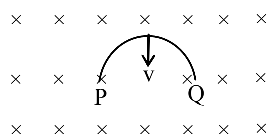
Q.59 A conducting rod of length 2ℓ is rotating with constant angular speed ω about its perpendicular bisector. A uniform magnetic field $\vec{B}$ exists parallel to the axis of rotation. The emf induced between two ends of the rod is-



(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

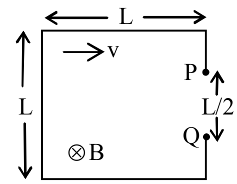
Q.62 A car moves up on a plane road. The induced emf in axle connecting the two wheels is maximum when it moves-
(1) At the poles
(2) At the equator
(3) Remain stationary
(4) At the equator and poles both

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

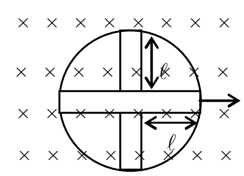
Q.65 A metal aeroplane having a distance of 50 meter between the tips of its wings is flying horizontally with a speed of 360 km/hour. At the place of flight, the earth's total magnetic field is 4.0×10^{-5} W/m^2 and the angle of dip is 30º. Find out the induced potential difference between the tips 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' -



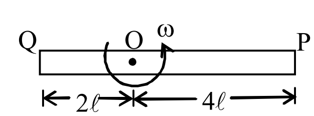
(1) $e = \frac{1}{2}BLv$, Q is positive with respect to P
(2) $e = \frac{BLv}{2}$, P is positive with respect to Q
(3) e = 0
(4) e = BLv, Q is positive with respect to P

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-



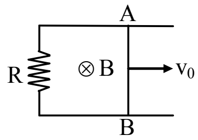
(1) $2B\omega\ell^2$ (2) $\sqrt{B\ell^2\omega}$
(3) $\frac{B\ell\omega}{2}$ (4) $\frac{B\ell^2\omega}{2}$

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-



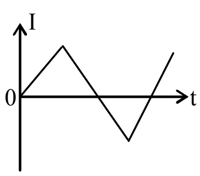
(1) $v > v_0$ (2) $v < v_0$
(3) $v = v_0$ (4) $v = -v_0$

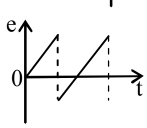
Q.70 If a bar magnet is dropped vertically into a long copper tube then its final acceleration will be-
(1) a = g (2) a > g (3) a < g (4) a = 0

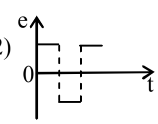
Q.71 A closed coil consists of 500 turns on a rectangular frame of area 4.0 cm^2 and has a resistance of 50 ohms. The coil is kept with its plane perpendicular to a uniform magnetic field of 0.2 wb/m^2, the amount of charge flowing through the coil if it is turned over (rotated through 180º) -
(1) 1.6×10^{-3} C (2) 16×10^{-3} C
(3) 0.16×10^{-3} C (4) 160×10^{-3} C

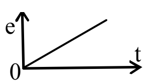
Q.72 A coil of mean area 500 cm^2 and having 1000 turns is held perpendicular to a uniform field of 0.4 gauss. The coil is turned through 180º in $\frac{1}{10}$ second. The average induced e.m.f. -
(1) 0.04 V (2) 0.4 V (3) 4 V (4) 0.004 V

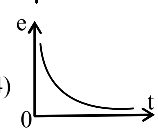
Q.73 A current time curve is shown in the following diagram. This type of current is passed in the primary coil of transformer. The nature of induced emf in the secondary coil will be-



(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 1 Ω 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 10 Ω 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

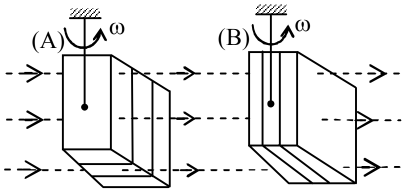
Q.84 Eddy current do not cause -
(1) Sparking (2) Loss of energy
(3) Damping (4) Heating

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

OLD EXAMINATION QUESTIONS [NEET]

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- **[AIIMS-1994]**
(1) increases
(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

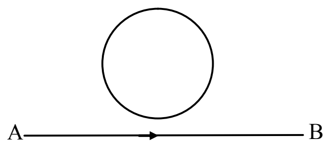
Q.20 A coil of copper having 1000 turns is placed in a magnetic field ($B = 4 \times 10^{-3}$ T) perpendicular to its plane. The cross sectional area of the coil is 0.05 m^2. If it turns through 180º in 0.01 sec, then the induced emf in the coil is- **[AIIMS-1997]**
(1) 0.4 V (2) 0.2 V (3) 40 V (4) 4 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]**

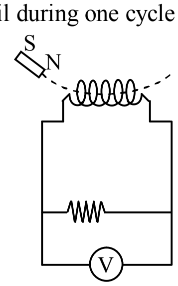


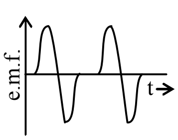
(1) clockwise (2) anticlockwise
(3) straight line (4) none of these

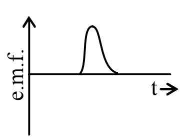
Q.25 The mutual inductance of two coils when magnetic flux changes by 2×10^{-2} Wb and current changes by 0.01 A is- **[AIIMS-2002]**
(1) 2 H (2) 3 H (3) 4 H (4) 8 H

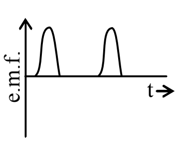
Q.26 A conducting ring of radius 1 meter is placed in an uniform magnetic field B of 0.01 T, oscillating with frequency 100 Hz with its plane at right angles to magnetic field. What will be the induced electric field- **[AIIMS-2005]**
(1) π volts/m (2) 2π volts/m
(3) 10 volts/m (4) 62 volts/m

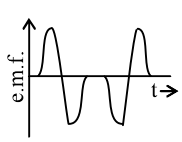
Q.27 A magnet is made to oscillate with a particular frequency, passing through a coil as shown in figure. The time variation of the magnitude of e.m.f. generated across the coil during one cycle is- **[AIIMS-2005]**



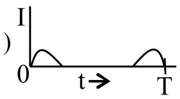
(1) 

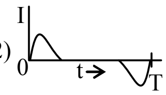
(2) 

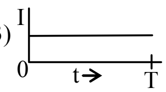
(3) 

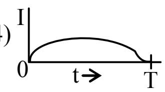
(4) 

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) $1.6\ \pi\mu V$

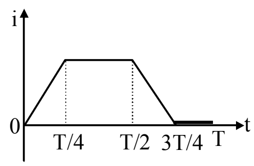
Q.33 A rectangular, a square, a circular and an elliptical loop, all in the (x – y) plane, are moving out of a uniform magnetic field with a constant velocity, $\vec{V} = v\hat{i}$. The magnetic field is directed along the negative z-axis direction. The induced emf, during the passage of these loops, 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

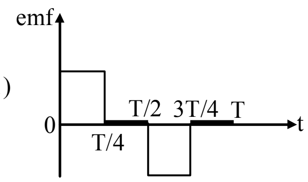
Q.34 A conducting circular loop is placed in a uniform field, B = 0.025 T with its plane perpendicular to the loop. The radius of the loop is made to shrink at a constant rate of 1 mm/s. The induced e.m.f. when the radius is 2cm, is- **[AIPMT Pre-2010]**
(1) $2\ \mu V$ (2) $2\pi\mu V$ (3) $\pi\mu V$ (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)


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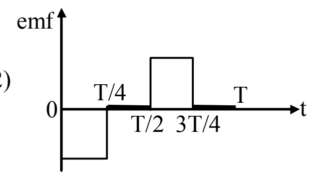

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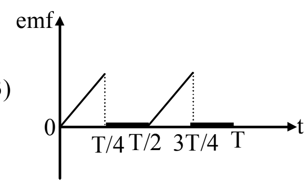
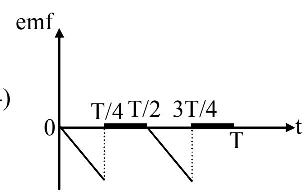
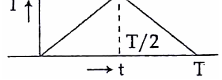


(4)


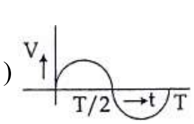
Q.37 A coil of resistance 400Ω is placed in a magnetic filed. If the magnetic flux ϕ (wb) linked with the coil varies with times t(sec) as $\phi = 50\,t^2 + 4$. The current is the coil at t = 2 sec is - : **[AIPMT (Pre)-2012]**

(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)


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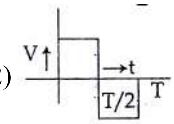

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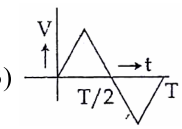
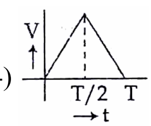
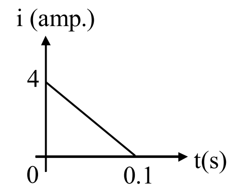


(4)


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]**

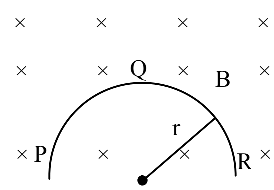


(1) 2 (2) 6 (3) 4 (4) 8

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]**

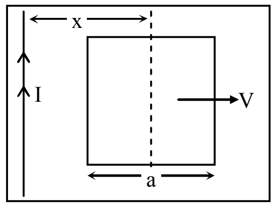


(1) Zero
(2) $Bv\pi r^2/2$ and P is at higher potential
(3) πrBv and R is at higher potential
(4) 2rBv and R is at higher potential

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

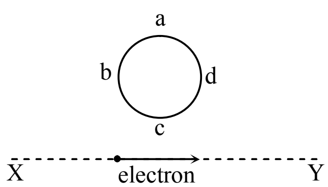
Q.43 A conducting square frame of side 'a' and a long straight wire carrying current I are located in the same plane as shown in the figure. The frame moves to the right with a constant velocity 'V'. The emf induced in the frame will be proportional to : **[AIPMT-2015]**



(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]**

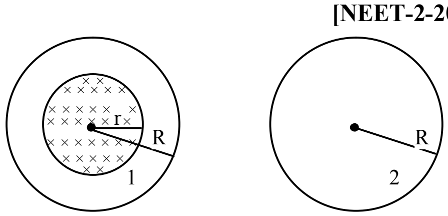


(1) No current induced
(2) abcd
(3) adcb
(4) The current will reverse its direction as the electron goes past the coil

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

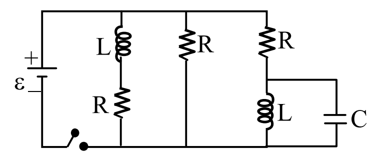
(3) $-\frac{d\vec{B}}{dt}\pi R^2$ in loop 1 and zero in loop 2

(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 π μC (2) 32 π μC
(3) 16 μ C (4) 32 μ 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

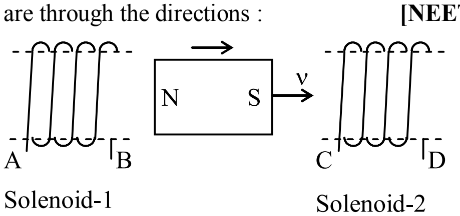
Q.56 The magnetic energy stored in an inductor of inductance 4 μH carrying a current of 2 A is : **[NEET-2023]**

(1) 8 μJ (2) 4 μJ (3) 4 mJ (4) 8 mJ

Q.57 In an ideal transformer, the turns ratio is $\frac{N_p}{N_s} = \frac{1}{2}$. The ratio $V_s : V_p$ is equal to (the symbols carry their usual meaning) - **[NEET-2024]**

(1) 1 : 1 (2) 1 : 4 (3) 1 : 2 (4) 2 : 1

Q.58 In the diagram, a strong bar magnet is moving towards solenoid-2 from solenoid-1. The direction of induced current in solenoid-1 and that in solenoid-2, respectively, are through the directions : **[NEET-2024]**



(1) AB and CD (2) BA and DC
(3) AB and DC (4) BA and CD

Q.59 A sheet is placed on a horizontal surface in front of a strong magnetic pole. A force is needed to:

A. hold the sheet there if it is magnetic.

B. hold the sheet there if it non–magnetic.

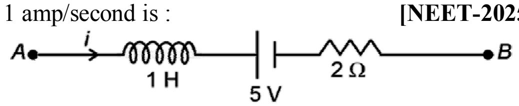
C. move the sheet away from the pole with uniform velocity if it is conducting.

D. move the sheet away from the pole with uniform velocity if it is both, non-conducting and non-polar.

Choose the correct statement(s) from the options given below: **[NEET-2024]**

(1) A, C and D only (2) C only
(3) B and D only (4) A and C only

Q.60 AB is a part of an electrical circuit (see figure). The potential difference "$V_A - V_B$", at the instant when current i = 2A and is increasing at a rate of 1 amp/second is : **[NEET-2025]**

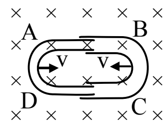


(1) 9 volt (2) 10 volt (3) 5 volt (4) 6 volt

Exercise 4

OLD EXAMINATION QUESTIONS [JEE MAIN]

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) $B\ell v$

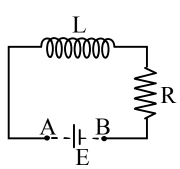
Q.2 A coil of inductance 300 mH and resistance 2Ω is connected to a source of voltage 2V. The current reaches half of its steady state value in- **[AIEEE-2005]**
(1) 0.3 s (2) 0.15 s (3) 0.1 s (4) 0.05 s

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) $NAB\omega$ (2) $NABR\omega$ (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]**



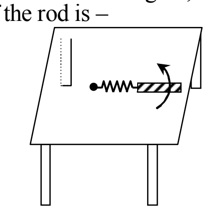
(1) 1A (2) 1/e A (3) e A (4) 0.1 A

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

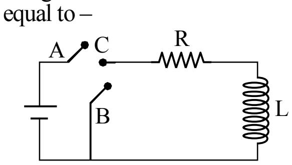
Q.10 A metallic rod of length 'ℓ ' is tied to a string of length 2ℓ and made to rotate with angular speed ω on a horizontal table with one end of the string fixed. If there is a vertical magnetic field 'B' in the region, the e.m.f. induced across the ends of the rod is – **[JEE-Main 2013]**



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

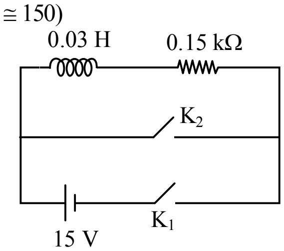
Q.11 A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flow through the smaller loop, then the flux linked with bigger loop is- **[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]**



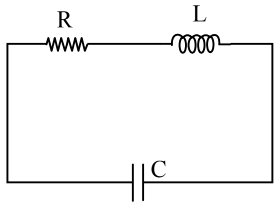
(1) 1 (2) –1 (3) $\frac{1-e}{e}$ (4) $\frac{e}{1-e}$

Q.13 An inductor (L = 0.03 H) and a resistor (R = 0.15 $k\Omega$) 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]**

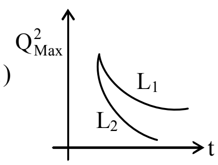


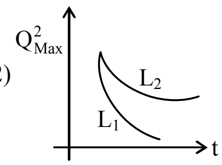
(1) 100 mA (2) 67 mA (3) 6.7 mA (4) 0.67 mA

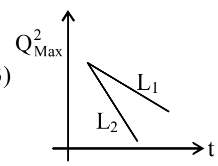
Q.14 A LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown below :

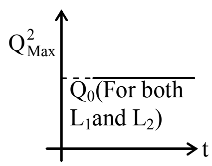


If a student plots graphs of the square of maximum charge (Q^2_{Max}) on the capacitor with time (t) for two different values L_1 and L_2($L_1 > L_2$) of L then which of the following represents this graph correctly ?
[JEE Main - 2015]

(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

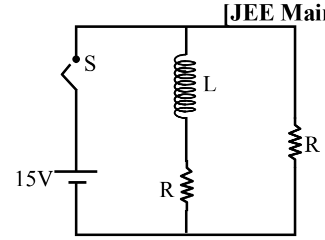
Q.17 There are two long co-axial solenoids of same length l. The inner and outer coils have radii r_1 and r_2 and number of turns per unit length n_1 and n_2, respectively. The ratio of mutual inductance to the self - inductance of the inner-coil is : **[JEE Main Online - 2019]**

(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

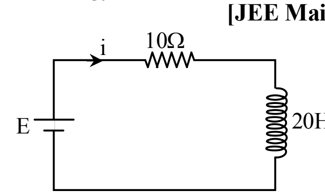
Q.19 In the figure shown, a circuit contains two identical resistors with resistance R = 5Ω and an inductance with L = 2mH. An ideal battery of 15 V is connected in the circuit. What will be the current through the battery long after the switch is closed?
[JEE Main Online - 2019]



(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

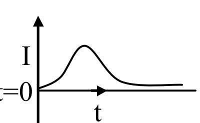
Q.21 A 20 Henry inductor and coil is connected to a 10 ohm resistance in series as shown in figure. The time at which rated of dissipation of energy (Joule's heat) across resistance is equal to the rate at which magnetic energy is stored in the inductor, is -
[JEE Main Online - 2019]

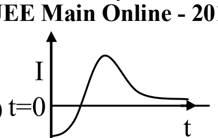


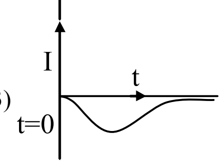
(1) $\frac{1}{2} \ell n 2$ (2) $\ell n 2$ (3) $2 \ell n 2$ (4) $\frac{2}{\ell n 2}$

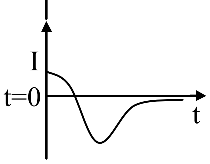
Q.22 The total number of turns and cross-section area in a solenoid is fixed. However, its length L is varied by adjusting the separation between windings. The inductance of solenoid will be proportional to :
[JEE Main Online - 2019]
(1) L (2) L^2 (3) $1/L^2$ (4) 1/L

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)


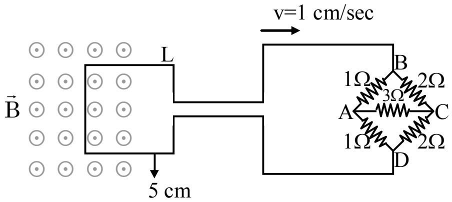
(3)


(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

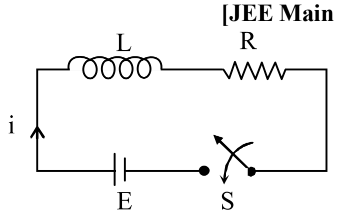
Q.25 A coil of self inductance 10 mH and resistance 0.1 Ω is connected through a switch to a battery of internal resistance 0.9 Ω. After the switch is closed, the time taken for the current to attain 80% of the saturation value is: [take $ln\,5 = 1.6$] **[JEE Main Online - 2019]**
(1) 0.324 s (2) 0.002 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

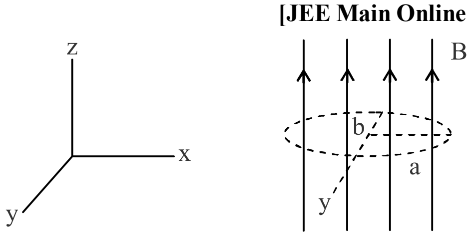
Q.27 Consider the LR circuit shown in the figure. If the switch S is closed at t = 0 then the amount of charge that passes through the battery between t = 0 and $t = \frac{L}{R}$ is :
[JEE Main Online - 2019]



(1) $\frac{7.3\,EL}{R^2}$ (2) $\frac{2.7\,EL}{R^2}$ (3) $\frac{EL}{7.3\,R^2}$ (4) $\frac{EL}{2.7R^2}$

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]

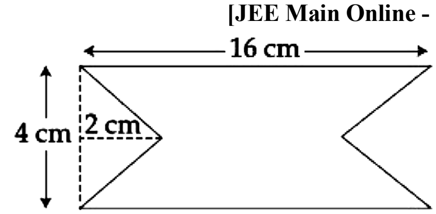


(1) zero (2) $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{R}$
(3) $\frac{\pi^2 a^2 b^2 B^2 \omega^2}{2R}$ (4) $\frac{\pi abB\omega}{R}$

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

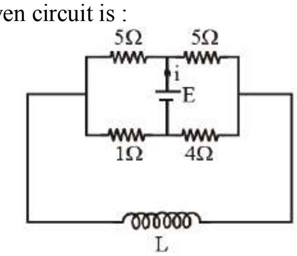
Q.31 A long solenoid of radius R carries a time (t) – dependent current $I(t) = I_0 t(1 - t)$. A ring of radius 2R is placed coaxially near its middle. During the time interval $0 \le t \le 1$, the induced current (I_R) and the induced EMF(V_R) in the ring change as -
[JEE Main Online - 2020]
(1) Direction 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]



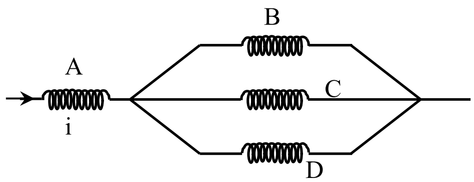
(1) 48 μV (2) 28 μV (3) 36 μV (4) 56 μV

Q.33 The current (i) at time t = 0 and t = ∞ respectively for the given circuit is : **[JEE Main 2021]**



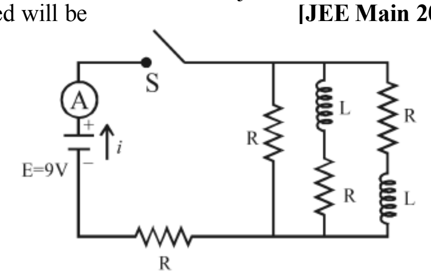
(1) $\frac{18E}{55}, \frac{5E}{18}$ (2) $\frac{10E}{33}, \frac{5E}{18}$
(3) $\frac{5E}{18}, \frac{18E}{55}$ (4) $\frac{5E}{18}, \frac{10E}{33}$

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]



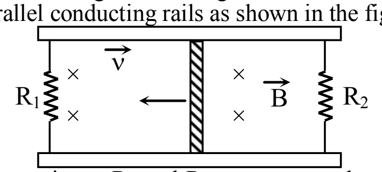
(1) 12T (2) 6T (3) 9T (4) 1T

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



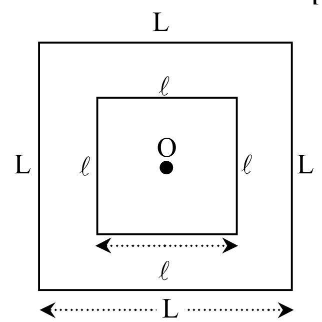
Two resistors R_1 and R_2 are connected across the ends of the rails. There is a uniform magnetic field $\vec{B}$ pointing into the page. An external agent pulls the bar to the left at a constant speed v.
The correct statement about the directions of induced currents I_1 and I_2 flowing through R_1 and 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]**

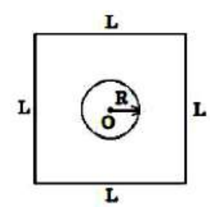
Q.40 A small square loop of wire of side ℓ is placed inside a large square loop of wire $L(L >> \ell)$. Both loops are coplanar and their centres coincide at point O as shown in figure. The mutual inductance of the system is : **[JEE Main 2022]**



(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]**

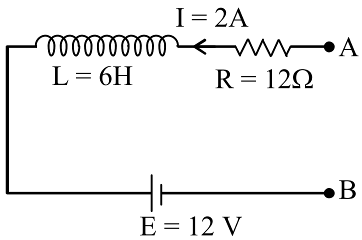
Q.42 Find the mutual inductance in the arrangement, when a small circular loop of wire of radius 'R' is placed inside a large square loop of wire of side L (L >> R). The loops are coplanar and their centres coincide: **[JEE Main 2023]**



(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

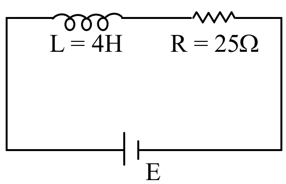


As per the given figure, if $\frac{dI}{dT} = -1$ A/s then the value of V_{AB} at this instant will be ______V.

[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 × 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]**



Q.47 A coil of 200 turns and area 0.20 m^2 is rotated at half a revolution per second and is placed in uniform magnetic field of 0.01 T perpendicular to axis of rotation of the coil. The maximum voltage generated in the coil is $\frac{2\pi}{\beta}$ volt. The value of β is _______.

[JEE Main 2024]

Q.48 A rectangular loop of sides 12 cm and 5 cm, with its sides parallel to the x-axis and y-axis respectively, moves with a velocity of 5 cm/s in the positive x-axis direction, in a space containing a variable magnetic field in the positive z direction. The field has a gradient of 10^{-3} T/cm along the negative x direction and it is decreasing with time at the rate of 10^{-3} T/s. If the resistance of the loop is 6 mΩ, the power dissipated by the loop as heat is _______ × 10^{-9} W. **[JEE Main 2024]**

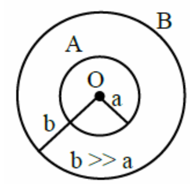
Q.49 A capacitor of capacitance 100 μF is charged to a potential of 12 V and connected to a 6.4 mH inductor to produce oscillations. The maximum current in the circuit would be: **[JEE Main 2024]**

(1) 2.0 A (2) 1.2 A
(3) 1.5 A (4) 3.2 A

Q.50 A square loop of side 10 cm and resistance 0.7 Ω is placed vertically in east-west plane. A uniform magnetic field of 0.20 T is set up across the plane in north east direction. The magnetic field is decreased to zero in 1 s at a steady rate. Then magnitude of induced emf is $\sqrt{x} \times 10^{-3}$ V. The value of x is _________ .

[JEE Main 2024]

Q.51 Two conducting circular loops A and B are placed in the same plane with their centres coinciding as shown in figure. The mutual inductance between them is : **[JEE Main 2024]**



(1) $\frac{\mu_0 \pi a^2}{2b}$ (2) $\frac{\mu_0}{2\pi} \cdot \frac{b^2}{a}$
(3) $\frac{\mu_0 \pi b^2}{2a}$ (4) $\frac{\mu_0}{2\pi} \cdot \frac{a^2}{b}$

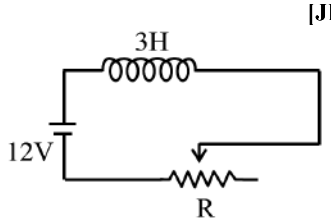
Q.52 Consider I_1 and I_2 are the currents flowing simultaneously in two nearby coils 1 & 2, respectively. If L_1 = self inductance of coil 1, M_{12} = mutual inductance of coil 1 with respect to coil 2, then the value of induced emf in coil 1 will be : **[JEE Main 2025]**

(1) $\varepsilon_1 = -L_1 \frac{dI_1}{dt} + M_{12} \frac{dI_2}{dt}$
(2) $\varepsilon_1 = -L_1 \frac{dI_1}{dt} - M_{12} \frac{dI_1}{dt}$
(3) $\varepsilon_1 = -L_1 \frac{dI_1}{dt} - M_{12} \frac{dI_2}{dt}$
(4) $\varepsilon_1 = -L_1 \frac{dI_2}{dt} - M_{12} \frac{dI_1}{dt}$

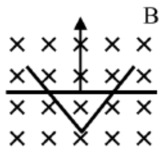
Q.53 A coil of area A and N turns is rotating with angular velocity ω in a uniform magnetic field $\vec{B}$ about an axis perpendicular to $\vec{B}$. Magnetic flux φ and induced emf ε across it, at an instant when B is parallel to the plane of coil, are : **[JEE Main 2025]**

(1) φ = AB, ε = 0 (2) φ = 0, ε = NABω
(3) φ = 0, ε = 0 (4) φ = AB, ε = NABω

Q.54 In the given circuit the sliding contact is pulled outwards such that electric current in the circuit changes at the rate of 8 A/s. At an instant when R is 12 Ω, the value of the current in the circuit will be ____A. **[JEE Main 2025]**

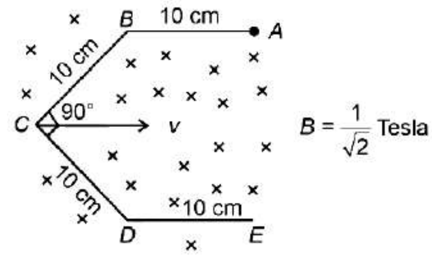


Q.55



A conducting bar moves on two conducting rails as shown in the figure. A constant magnetic field B exists into the page. The bar starts to move from the vertex at time t = 0 with a constant velocity. If the induced EMF is $E \propto t^n$, then value of n is ____ . **[JEE Main 2025]**

Q.56 Conductor wire ABCDE with each arm 10 cm in length is placed in magnetic field of $\frac{1}{\sqrt{2}}$ Tesla, perpendicular to its plane. When conductor is pulled towards right with constant velocity of 10 cm/s, induced emf between points A and E is ______ mV. **[JEE Main 2025]**



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

EXERCISE -4

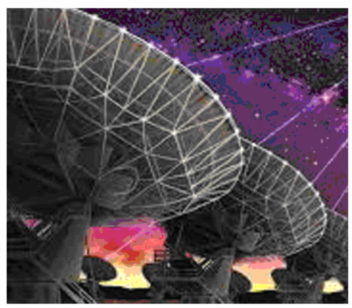
Q.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ans.	1	3	3	1	3	2	3	4	3	2	3	2	4	1	2	4	2	2	1	4
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	3	4	2	2	4	3	4	4	3	3	4	4	4	4	1	3	3	2	2.00	3
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56				
Ans.	10.00	3	10	30	44	25	5	216	3	2	1	3	2	3.00	1.00	10.00				

NOTES

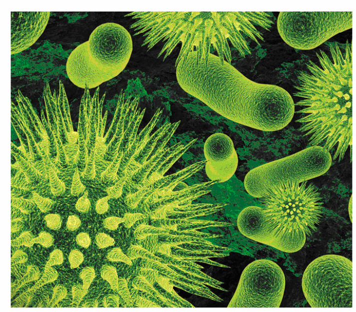
STUDY MATERIAL

NEET

XI & XII STD



CHEMISTRY



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- Chemical Equilibrium
- Acid Base & Ionic Equilibrium

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- Chemical Bonding

Organic Chemistry (I)

- Classifaction & Nomenclature
- Isomerism
- GOC
- Hydrocarbon
- Aromatic Hydrocarbons

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- Solution
- Chemical Kinetics

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- Alcohol, Phenol, Ether
- Carbonyl Compound
- Carboxylic acid & Its Derivatives
- Nitrogen Compounds
- Biomolecules
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- d & f Block
- Coordination compound
- Practical Chemistry

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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.

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SOLUTION

KEY CONCEPT

1. Solution

A solution is a homogeneous mixture of a solute, the substance that dissolves and a solvent, the substance in which the solute dissolves.

(a) The component of solution which is in lesser amount (Which is dissolved) is called **solute.**

(b) The component of solution in which solute is dissolved is called **solvent.**

Solution = Solute + Solvent

2. Concentration of Solution

It is calculated by following two methods

(a) Weight % : Weight of solute per 100 gram of solution.

(b) Volume % :

(i) Weight of solute per 100 ml of solution

(ii) Volume of solute per 100 ml of solution

(c) Concentration of a solution expressed in following terms.

2.1 MOLARITY (M)

It is the number of moles of solute in one litre of solution

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{\text{Volume of solution (litre)}}$$

(a) Molarity is expressed by putting a suffix 'M' after a number, say 'X'. It means if concentration of a solution is given to be XM, it means X moles of solute are there per litre of solution.

(b) Some times amount of solute is given in grams. So,

$$\text{Moles of solute} = \frac{\text{amount (gram)}}{\text{mol.wt.in (gram)}}$$

(c) We Should be careful about unit of volume taken. We have to use volume in litre in the formula for molarity. So, if volume is given in ml (mili litre) convert it into litre as-

volume in litre = volume in ml $\times 10^{-3}$

(d) Some times we get confused when volume is given in cm^3. A cm^3 is nothing but a milliliter. So, volume in litre = volume $(cm^3) \times 10^{-3}$

(e) Unit of molarity is mole L^{-1}.

(f) $\text{Millimoles} = M \times V(\text{ml}) = \frac{\text{wt.} \times 1000}{\text{mol. wt.}}$

(g) $\text{Strength of solution} = \frac{\text{wt. of solute} \times 1000}{\text{volume of solution(ml)}}$

(h) Molarity is a temperature dependent unit.

$$\text{Molarity} \propto \frac{1}{\text{temp.}}$$

2.2 MOLALITY (m)

It is the number of moles of solute per kilogram of solvent.

$$\text{Molality} = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$$

(a) Unit of molality is mole kg^{-1}

(b) Sometimes mass of solution is given instead of solvent, so subtract the mass of solute to get mass of solvent

(c) Represented by a suffix 'm' after a number x. xm means x moles of solute are there per kg of solvent.

(d) Molality does not change with increase of temperature.

(e) Relation between molarity and molality-

$$m = \frac{1000M}{1000d - MM_B}$$

Where,

m = Molality

M = Molarity

d = density of solution in gm/litre

M_B = Molecular wt. of solute

Derivation :–

$$\frac{M}{m} = \frac{\text{wt. of solvent}}{\text{volume of solution}}$$

$$\frac{M}{m} = \frac{W_A}{V(\text{litre})}$$

Since, wt. of solvent = wt. of solution – wt. of solute

$= V \times d - MM_B$

Therefore, $$\frac{M}{m} = \frac{Vd - MM_B}{V}$$

$$m = \frac{MV}{Vd - MM_B}$$

2.3 MOLE FRACTION (X)

(a) Mole fraction of a component in solution is equal to the ratio of number of moles of that component to the total number of moles of all the components in the solution. Mole fraction of component A is represented by x_A.

(b) Let, there be two components A (solvent) & B (solute)

$X_A = \frac{n_A}{n_A + n_B}$ and $X_B = \frac{n_B}{n_A + n_B}$ where,

X_A = Mole fraction of solvent and

X_B = Mole fraction of solute.

Here, $$n_A = \frac{w_A}{M_A}$$

(wt. of A in grams/mol.wt. of A, $x_A + x_B = 1$)

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.

Questions based on **Raoult's Law**

Ex.1 At 300 K, the vapour pressure of an ideal solution containing one mole of A and 3 moles of B is 550 mm of Hg. At the same temperature, if one mole of B is added to this solution, the vapour pressure of solution increases by 10mm of Hg. Calculate the vapour pressure of A and B in their pure state.

(1) 400 mm, 600 mm

(2) 600 mm, 400 mm

(3) 200 mm, 300 mm

(4) 300 mm, 200 mm **(Ans. 1)**

Sol. Initially,

$P_M = P^o_A \cdot X_A + P^o_B \cdot X_B$

$550 = P^o_A\left(\frac{1}{1+3}\right) + P^o_B\left(\frac{3}{1+3}\right)$

$P^o_A + 3P^o_B = 2200$

When 1 mole of B is further added to it

$P_M = P^o_A \cdot X_A + P^o_B \cdot X_B$

$560 = P^o_A\left(\frac{1}{1+4}\right) + P^o_B\left(\frac{4}{1+4}\right)$

or $P^o_A + 4P^o_B = 2800$

By (i) and (ii)

P^o_A **= 400 mm** ; P^o_B **= 600 mm**

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 6.90 M solution of KOH in water has 30% by weight of KOH. Calculate density of solution.

(A) 1.288 g mL^{-1} (B) 12.88 g mL^{-1}

(C) 24.88 g mL^{-1} (D) 2.488 g mL^{-1}

(Ans. A)

Sol. KOH solution is 30% by weight.

$\therefore$ wt. of KOH = 30 g

and Wt. of solution = 100 g

$\therefore$ Volume of solution $= \frac{100}{d}$

$\therefore$ Molarity $= 6.90 = \left(\dfrac{30}{56 \times \dfrac{100}{1000 \times d}}\right)$

= 1.288 g mL^{-1}

Ex.2 What is mole fraction in its one molal aqueous solution-

(A) 0.108 (B) 0.018

(C) 0.008 (D) None **(Ans. B)**

Sol. Mole fraction $= \frac{n_A}{n_A + n_B}$

$n_A = 1$ and $n_B = \frac{1000}{18} = 55.4$

$= \frac{1}{1+55.4} = \frac{1}{56.4}$ **= 0.018**

Ex.4 Calculate the molality and mole fraction of the solute in aqueous solution containing 3.0 gm of urea per 250 gm of water (Mol. wt. of urea = 60).

(A) 0.2 m, 0.00357 (B) 0.4 m, 0.00357

(C) 0.5 m, 0.00357 (D) 0.7m, 0.00357

(Ans. A)

Sol. Wt. of solute (urea) dissolved = 3.0 gm

Wt. of the solvent (water) = 250 gm

Mol. wt. of the solute = 60

3.0 gm of the solute $= \frac{3.0}{60}$ moles = 0.05 moles

Thus 250 gm of the solvent contain = 0.05 moles of solute

$\therefore$ 1000 gm of the solvent contain

$= \frac{0.05 \times 100}{250} = 0.2$ moles

Hence molality of the solution = 0.2 m

In short,

Molality = No. of moles of solute/1000 g of solvent

$\therefore$ Molality $= \frac{3/60}{250} \times 1000 =$ **0.2 m**

Calculation of mole fraction

3.0 gm of solute = 3/60 moles = 0.05 moles

250 gm of water $= \frac{250}{18}$ moles

= 13.94 moles

$\therefore$ Mole fraction of the solute

$= \frac{0.05}{0.05+13.94} = \frac{0.05}{13.99}$

= 0.00357

Ex.5 15 gram of methyl alcohol is dissolved in 35 gram of water. What is the mass percentage of methyl alcohol

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 Select correct statement -
(1) b.p. of 1 molal NaCl solution is twice that of 1 molal sucrose solution
(2) b.p. elevation of 1 molal glucose solution is half of the 1 molal KCl solution
(3) b.p. is a colligative property
(4) All of the above

Q.2 At a given temperature, total vapour pressure in Torr of a mixture of volatile components A and B is given by
$$P = 120 - 75\,X_B$$
hence, vapour pressure of pure A and B respectively (in Torr) are -
(1) 120, 75 (2) 120, 195
(3) 120, 45 (4) 75, 45

Q.3 Decimolar solution of potassium ferricyanide, $K_3[Fe(CN)_6]$ has osmotic pressure of 3.94 atm at 27ºC. Hence percent ionisation of the solute is -
(1) 10% (2) 20%
(3) 30% (4) 40%

Q.4 A complex containing K^+, Pt (IV) and Cl^- is 100% ionised giving i = 3. Thus, complex is -
(1) $K_2[PtCl_4]$ (2) $K_2[PtCl_6]$
(3) $K_3[PtCl_5]$ (4) $K[PtCl_3]$

Q.5 If $pK_a = -\log K_a = 4$, and $K_a = C\alpha^2$ then van't Hoff factor for weak monobasic acid when C = 0.01 M is -
(1) 0.01 (2) 1.02 (3) 1.10 (4) 1.20

Q.10 The value of K_b for water is 1.86, calculated from Glucose solution. The value of K_b for water calculated for NaCl solution will be -
(1) = 1.86 (2) < 1.86 (3) > 1.86 (4) Zero

Q.11 As a result of osmosis the volume of the concentrated solution -
(1) Gradually decreases (2) Gradually increases
(3) Suddenly increases (4) None

Q.12 If a thin slice of sugar beet is placed in concentrated solution of NaCl then -
(1) Sugar beet will lose water from its cells
(2) Sugar beet will absorb water from solution
(3) Sugar beet will neither absorb nor lose water
(4) Sugar beet will dissolve in solution

Q.13 If mole fraction of the solvent in solution decreases then -
(1) Vapour pressure of solution increases
(2) B. P. decreases
(3) Osmotic pressure increases
(4) All are correct

Q.14 A solution containing 4g of a non volatile organic solute per 100 ml was found to have an osmotic pressure equal to 500 cm of mercury at 27°C. The molecular weight of solute is -
(1) 14.97 (2) 149.7
(3) 1697 (4) 1.497

Q.15 If a 6.84% (wt./ vol.) solution of cane-sugar (mol. wt. 342) is isotonic with 1.52% (wt./vol.) solution of

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

(4) $\Delta G_{mix} = 0$

Q.53 If molality of the dilute solution is doubled, the value of molal depression constant (K_f) will be **[NEET -2017]**
(1) unchanged (2) doubled
(3) halved (4) tripled

Q.54 Which of the following is dependent on temperature ? **[NEET-2017]**
(1) Weight percentage (2) Molality
(3) Molarity (4) Mole fraction

Q.55 The mixture that forms maximum boiling azeotrope is : **[NEET -2019]**
(1) Acetone + Carbon disulphide
(2) Heptane + Octane
(3) Water + Nitric acid
(4) Ethanol + Water

Q.56 For an ideal solution, the correct option is - **[NEET-2019]**
(1) Δ_{mix} H = 0 at constant T and P
(2) Δ_{min} G = 0 at constant T and P
(3) Δ_{mix} S = 0 at constant T and P
(4) Δ_{mix} V ≠ 0 at constant T and P

Q.57 The mixture which shows positive devation form Raoult's law is : **[NEET 2020]**
(1) Benzene + Toluene

Q.62 K_H value for some gases at the same temperature 'T' are given :

Gas	K_H/k bar
Ar	40.3
CO_2	1.67
HCHO	1.83×10^{-5}
CH_4	0.413

where K_H is Henry's Law constant in water. The order of their solubility in water is : **[Re-NEET-2022]**
(1) HCHO < CH_4 < CO_2 < Ar
(2) Ar < CO_2 < CH_4 < HCHO
(3) Ar < CO_2 < CH_4 < HCHO
(4) HCHO < CO_2 < CH_4 < Ar

Q.63 The Henry's law constant (K_H) values of three gases (A, B, C) in water are 145, 2×10^{-5} and 35 kbar, respectively. The solubility of these gases in water follow the order : **[NEET-2024]**
(1) A > C > B (2) A > B > C
(3) B > A > C (4) B > C > A

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

Q.41 What weight of glucose must be dissolved in 100 g of water to lower the vapour pressure by 0.20 mm Hg? (Assume dilute solution is being formed)
Given : Vapour pressure of pure water is 54.2 mm Hg at room temperature. Molar mass of glucose is 180 g mol^{-1} **[Main - 2023]**

(1) 3.59 g (2) 3.69 g
(3) 4.69 g (4S) 2.59 g

Q.42 A solution containing 2 g of a non-volatile solute in 20 g of water boils at 373.52 K. The molecular mass of the solute is ________ g mol^{-1}. (Nearest integer)
Given, water boils at 373 K, K_b for water = 0.52 K kg mol^{-1}) **[Main - 2023]**

Q.43 The vapour pressure of 30% (w/v) aqueous solution of glucose is ________ mm Hg at 25°C.
[Given: The density of 30% (w/v), aqueous solution of glucose is 1.2 g cm^{-3} and vapour pressure of pure water is 24 mm Hg.] (Molar mass of glucose is 180 g mol^{-1}) **[Main - 2023]**

Q.44 A solution of two miscible liquids showing negative deviation from Raoult's law will have : **[Main - 2024]**

(1) increased vapour pressure, decreased boiling point
(2) increased vapour pressure, increased boiling point
(3) decreased vapour pressure, decreased boiling point
(4) decreased vapour pressure, increased boiling point

Q.45 The osmotic pressure of a dilute solution is 7×10^5 Pa at 273K. Osmotic pressure of the same solution at 283K is ______ $\times 10^4$ Nm^{-2}. **[Main - 2024]**

Q.46 What happens to freezing point of benzene when small quantity of naphthalene is added to benzene ? **[Main - 2024]**

(1) First decreases and then increases
(2) Increases
(3) Decreases
(4) Remains unchanged

Q.47 2.7 Kg of each of water and acetic acid are mixed, The freezing point of the solution will be –x °C. Consider the acetic acid does not dimerise in water, nor dissociates in water x = ______(nearest integer) **[Main - 2024]**
[Given : Molar mass of water = 18 g mol^{-1}, acetic acid = 60 g mol^{-1}]
$^{Kf}H_2O$: 1.86 K kg mol^{-1}
^{Kf}acetic acid : 3.90 K kg mol^{-1}
freezing point : H_2O = 273 K, acetic acid = 290 K]

Q.48 An artificial cell is made by encapsulating 0.2 M glucose solution within a semipermeable membrane. The osmotic pressure developed when the artificial cell is placed within a 0.05 M solution of NaCl at 300 K is _______ $\times 10^{-1}$ bar (Nearest Integer) **[Main - 2024]**
[Given : R = 0.083 L bar mol^{-1} K^{-1}]
Assume complete dissociation of NaCl

Answer key

Above mentioned all exercises provided with 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	1	1	3	1	2	3	1	4	3	4	2	3	3	4	1	2	1	3	1
Q.No.	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Ans.	2	1	4	2	1	4	4	2	1	2	1	4	2	3	3	1	3	2	3	3
Q.No.	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Ans.	4	2	4	1	1	4	2	2	2	3	2	2	2	3	2	3	3	2	1	2
Q.No.	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Ans.	2	4	3	1	3	4	3	3	4	3	4	3	1	2	4	3	4	1	3	1
Q.No.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Ans.	3	1	3	2	1	2	3	3	2	4	4	4	3	1	3	4	4	3	3	4
Q.No.	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115					
Ans.	3	1	3	2	2	4	3	4	1	1	2	4	2	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**

SOLUTION

EXERCISE-1

Answer Key & Solution

Question Number	Solution	Question Number	Solution	Question Number	Solution	Question Number	Solution
1	Click Here	30	Click Here	59	Click Here	88	Click Here
2	Click Here	31	Click Here	60	Click Here	89	Click Here
3	Click Here	32	Click Here	61	Click Here	90	Click Here
4	Click Here	33	Click Here	62	Click Here	91	Click Here
5	Click Here	34	Click Here	63	Click Here	92	Click Here
6	Click Here	35	Click Here	64	Click Here	93	Click Here
7	Click Here	36	Click Here	65	Click Here	94	Click Here
8	Click Here	37	Click Here	66	Click Here	95	Click Here
9	Click Here	38	Click Here	67	Click Here	96	Click Here
10	Click Here	39	Click Here	68	Click Here	97	Click Here
11	Click Here	40	Click Here	69	Click Here	98	Click Here
12	Click Here	41	Click Here	70	Click Here	99	Click Here
13	Click Here	42	Click Here	71	Click Here	100	Click Here
14	Click Here	43	Click Here	72	Click Here	101	Click Here
15	Click Here	44	Click Here	73	Click Here	102	Click Here
16	Click Here	45	Click Here	74	Click Here	103	Click Here
17	Click Here	46	Click Here	75	Click Here	104	Click Here
18	Click Here	47	Click Here	76	Click Here	105	Click Here
19	Click Here	48	Click Here	77	Click Here	106	Click Here
20	Click Here	49	Click Here	78	Click Here	107	Click Here
21	Click Here	50	Click Here	79	Click Here	108	Click Here
22	Click Here	51	Click Here	80	Click Here	109	Click Here
23	Click Here	52	Click Here	81	Click Here	110	Click Here
24	Click Here	53	Click Here	82	Click Here	111	Click Here
25	Click Here	54	Click Here	83	Click Here	112	Click Here
26	Click Here	55	Click Here	84	Click Here	113	Click Here
27	Click Here	56	Click Here	85	Click Here	114	Click Here
28	Click Here	57	Click Here	86	Click Here	115	Click Here
29	Click Here	58	Click Here	87	Click Here		

Solution

This chapter covers the following syllabus

1. Types of solution
2. Units of concentration
3. Mole fraction
4. Percentage [Volume & mass]
5. Vapour pressure, Roult's law.
6. Colligative properties [lowering of V.P., depression of F.P., elevation of B.P. & O.P.]
7. Determination of molecular masses, abnormal values of molecular masses.
8. Van't Hoff factor.

Revision Plan

Prepare Your Revision plan today!

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

- Write Question Number (QN) which you are unable to solve at your own in **column A**.
- 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.
- 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		
Exercise-5		

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.

Key Concept

1. Solution

A solution is a homogeneous mixture of a solute, the substance that dissolves and a solvent, the substance in which the solute dissolves.

(a) The component of solution which is in lesser amount (Which is dissolved) is called **solute.**

(b) The component of solution in which solute is dissolved is called **solvent.**

Solution = Solute + Solvent

2. Concentration of Solution

It is calculated by following two methods

(a) Weight % : Weight of solute per 100 gram of solution.

(b) Volume % :

(i) Weight of solute per 100 ml of solution

(ii) Volume of solute per 100 ml of solution

(c) Concentration of a solution expressed in following terms.

2.1 <u>MOLARITY</u> (M)

It is the number of moles of solute in one litre of solution

$$\text{Molarity} = \frac{\text{No. of moles of solute}}{\text{Volume of solution (litre)}}$$

(a) Molarity is expressed by putting a suffix 'M' after a number, say 'X'. It means if concentration of a solution is given to be XM, it means X moles of solute are there per litre of solution.

(b) Some times amount of solute is given in grams. So,

$$\text{Moles of solute} = \frac{\text{amount (gram)}}{\text{mol.wt.in (gram)}}$$

(c) We Should be careful about unit of volume taken. We have to use volume in litre in the formula for molarity. So, if volume is given in ml (mili litre) convert it into litre as-

volume in litre = volume in ml × 10^{-3}

(d) Some times we get confused when volume is given in cm^3. A cm^3 is nothing but a milliliter. So, volume in litre = volume (cm^3) × 10^{-3}

(e) Unit of molarity is mole L^{-1}.

(f) $\text{Millimoles} = M \times V(\text{ml}) = \dfrac{\text{wt.} \times 1000}{\text{mol. wt.}}$

(g) $\text{Strength of solution} = \dfrac{\text{wt. of solute} \times 1000}{\text{volume of solution (ml)}}$

(h) Molarity is a temperature dependent unit.

$$\text{Molarity} \propto \frac{1}{\text{temp.}}$$

2.2 <u>MOLALITY</u> (m)

It is the number of moles of solute per kilogram of solvent.

$$\text{Molality} = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$$

(a) Unit of molality is mole kg^{-1}

(b) Sometimes mass of solution is given instead of solvent, so subtract the mass of solute to get mass of solvent

(c) Represented by a suffix 'm' after a number x. xm means x moles of solute are there per kg of solvent.

(d) Molality does not change with increase of temperature.

(e) Relation between molarity and molality-

$$m = \frac{1000\,M}{1000d - MM_B}$$

Where,

m = Molality

M = Molarity

d = density of solution in gm/litre

M_B = Molecular wt. of solute

Derivation :–

$$\frac{M}{m} = \frac{\text{wt. of solvent}}{\text{volume of solution}}$$

$$\frac{M}{m} = \frac{W_A}{V(\text{litre})}$$

Since, wt. of solvent = wt. of solution – wt. of solute

$= V \times d - MM_B$

Therefore, $$\frac{M}{m} = \frac{Vd - MM_B}{V}$$

$$m = \frac{MV}{Vd - MM_B}$$

2.3 <u>MOLE FRACTION</u> (X)

(a) Mole fraction of a component in solution is equal to the ratio of number of moles of that component to the total number of moles of all the components in the solution. Mole fraction of component A is represented by x_A.

(b) Let, there be two components A (solvent) & B (solute)

$X_A = \dfrac{n_A}{n_A + n_B}$ and $X_B = \dfrac{n_B}{n_A + n_B}$ where,

X_A = Mole fraction of solvent and

X_B = Mole fraction of solute.

Here, $$n_A = \frac{w_A}{M_A}$$

(wt. of A in grams/mol.wt. of A, $x_A + x_B = 1$)

(c) It is temperature independent unit.

(d) Relation between mole fraction and molality -

Mole fraction of solvent

$$X_A = \frac{n_A}{n_A + n_B}$$

Mole fraction of solute

$$X_B = \frac{n_B}{n_A + n_B}$$

$$\frac{X_A}{X_B} = \frac{n_A}{n_B}$$

On multiplying 1000 in both side

$$\frac{X_A}{X_B} \times 1000 = 1000 \times \frac{n_A}{n_B}$$

$$\frac{X_A}{X_B} = \frac{m \times M_A}{1000}$$

2.4 <u>MASS FRACTION</u> :

Ratio of mass of component to the total mass of components

mass fraction of A = $\frac{w_A}{w_A + w_B}$

where, w_A = weight of A, and w_B = weight of B.

2.5 <u>MOLE PERCENT</u> :

number of moles of a component in 100 moles

Mole percent = mass fraction × 100

2.6 <u>PARTS PER MILLION</u> (PPM) :

(a) amount of component in mg in 1 kg of solution.

$$\text{ppm} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

$$\text{ppm} = \frac{\text{wt. of solute}}{\text{wt. of solute} + \text{wt. of solvent}} \times 10^6$$

(b) Generally, it is used for very-very little concentrations.

3. Colligative properties

Certain properties of dilute solutions containing nonvolatile solute do not depend upon the nature of the solute dissolved but depend only upon the concentration. i.e the number of the particles of the solute present in the solution. Such properties are called colligative properties. The four well known examples of the colligative properties are -

(a) Lowering of vapour pressure of the solvent

(b) Osmotic pressure of the solution

(c) Elevation in boiling point of the solvent

(d) Depression in freezing point of the solvent

4. Vapour Pressure of a Liquid

It is the pressure that its vapours exert when in equilibrium with the liquid at a given temperature. It depends upon the following factors :

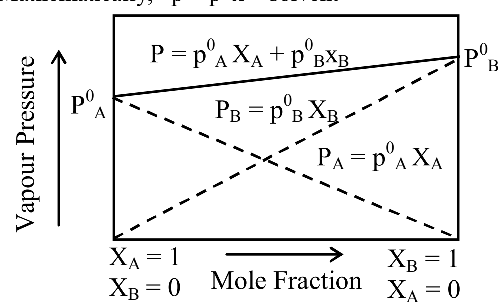
(a) Nature of solvent

(b) Temperature

5. Raoult's Law

(a) Raoult proposed a law which states that at a given temperature, the vapour pressure of a solvent in a solution containing non-volatile solute is directly proportional to its mole fraction.

Mathematically, $p = p^0 x \times$ solvent



(b) In the case of binary solutions of two volatile liquids, Raoult's law states that at a given temperature, the partial vapour pressure of any component of the solution is equal to the product of the vapour pressure of the pure component and its mole fraction in the solution i.e.

$$p_A = p^0_A X_A \text{ and } p_B = p^0_B X_B$$

(c) The total vapour pressure P of such a solution containing two components A and B is,

$$P = p_A + p_B = p^0_A X_A + p^0_B X_B$$

$$= (1 - X_B) p^0_A + p^0_B X_B$$

$$= (p^0_B - p^0_A) X_B + p^0_A$$

where, p_A and p_B are vapour pressures (of pure component) and X_A and X_B are mole fractions of components A and B respectively.

Plot of P should be a straight line which is true for ideal solution. Thus the addition of a solute may raise or lower the vapour pressure of solvent depending upon which one is more volatile.

(d) Raoult's Law mathematically expressed as

$$\frac{P_0 - P_S}{P_0} = \frac{n}{n + N} \quad \text{..... (i)}$$

where, P_0 = Vapour pressure of pure solvent

P_S = Vapour pressure of solution

n = moles of non-volatile solute

N = moles of solvent

If the solution is very dilute, then

$n << N$

So, $\dfrac{P_0 - P_S}{P_0} = \dfrac{n}{N}$ ….. (ii)

or $\dfrac{P_0 - P_S}{P_0} = \dfrac{w/m}{W/M}$

where, w = wt. of solute dissolved in grams

W = wt. of solvent in grams

m = molecular mass of solute

M = molecular weight of solvent

$$\frac{P_0 - P_S}{P_0} = \frac{w.M}{W.m} \quad ..... (iii)$$

This expression (iii) can be used for calculating the molecular weight of solutes.

5.1 Limitations of Raoult's law

(i) As described earlier, Raoult's law is applicable only to very dilute solutions.

(ii) Raoult's law is applicable to solutions containing non-volatile solute only.

(iii) Raoult's law is not applicable to solutes which dissociate or associate in the particular solution

Questions based on Raoult's Law

Ex.1 At 300 K, the vapour pressure of an ideal solution containing one mole of A and 3 moles of B is 550 mm of Hg. At the same temperature, if one mole of B is added to this solution, the vapour pressure of solution increases by 10mm of Hg. Calculate the vapour pressure of A and B in their pure state.

(1) 400 mm, 600 mm

(2) 600 mm, 400 mm

(3) 200 mm, 300 mm

(4) 300 mm, 200 mm **(Ans. 1)**

Sol. Initially,

$P_M = P^o_A \cdot X_A + P^o_B \cdot X_B$

$550 = P^o_A\left(\dfrac{1}{1+3}\right) + P^o_B\left(\dfrac{3}{1+3}\right)$

$P^o_A + 3P^o_B = 2200$

When 1 mole of B is further added to it

$P_M = P^o_A \cdot X_A + P^o_B \cdot X_B$

$560 = P^o_A\left(\dfrac{1}{1+4}\right) + P^o_B\left(\dfrac{4}{1+4}\right)$

or $P^o_A + 4P^o_B = 2800$

By (i) and (ii)

P^o_A = **400 mm** ; P^o_B = **600 mm**

6. Ideal Solution

These are the solutions in which solute-solute and solvent-solvent interactions are almost similar to solute-solvent interactions. Ideal solutions obey Raoult's law for all range of concentrations and temperature.

$\Delta H_{mix} = 0 \qquad \Delta V_{mix} = 0$

eg. Hexane + Heptane, ethyl chloride + ethyl bromide, chlorobenzene + Bromobenzene etc.

7. Non Ideal Solutions

(a) These are the solutions in which solute-solvent interactions are different than solute-solute and solvent-solvent interactions. The non-ideal solutions do not obey Raoult's law for all concentrations

$\Delta H_{mix} \neq 0 \qquad \Delta V_{mix} \neq 0$

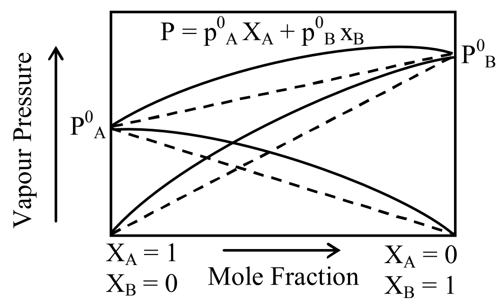
(b) These non-ideal solutions show two types of deviations from the ideal behaviour.

- If $\Delta V_{mix} > 0$ and $\Delta H_{mix} > 0$, then non-ideal solutions show positive deviations.
- If $\Delta V_{mix} < 0$ and $\Delta H_{mix} < 0$, then non-ideal solutions show negative deviations

7.1 Types of non-ideal solutions

7.1.1 Non-ideal solutions showing positive deviations : In such a case, the observed vapour pressure of each component and the total vapour pressure are greater than predicted by Raoult's law i.e.

$p_A > p^0_A X_A, \quad p_B > p^0_B x_B, \quad P > p_A + p_B$



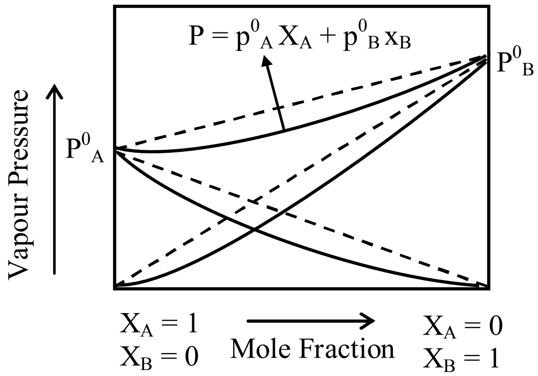
This is because the new interactions are weaker than those in the pure components.

eg. Acetone + Ethyl alcohol, Water + Ethyl alcohol, $CCl_4 + CHCl_3$

Ethanol + $CHCl_3$

Positive deviation (solid lines) from Raoult's law (dotted lines).

7.1.2 Non-ideal solutions showing negative deviations: In such a case the observed vapour pressure of each component and the total vapour pressure are less than predicted by Raoult's law i.e.



$p_A < p^0_A X_A$, $p_B < P^0_B X_B$, $P < p_A + p_B$

This is because the new interactions are stronger than those in the pure components.

eg. Acetone + Aniline, HCl + water,

HNO_3 + water,

water + H_2SO_4 etc

Negative deviations (solid lines) from Raoult's law (dotted lines)

8. Azeotropic Mixture

Azeotropic mixtures of two liquids which boil at a constant temperature and can be distilled unchanged in their composition. They are formed by non-ideal solutions.

8.1 TYPES OF AZEOTROPIC MIXTURES

8.1.1 "Minimum boiling azeotropes" are the mixture of two liquids, whose boiling points is less than either of the two pure components. They are formed by non-ideal solution showing positive deviation.

eg. ethanol (95.5%) + water (4.5%) mixture boiling at 351.15 K.

8.1.2 "Maximum boiling azeotropes" are the mixtures of two liquids, whose boiling points are more than either of the two components. They are formed by non-ideal solution showing negative deviation.

eg. HNO_3(68%) + water (32%) mixture boiling at 393.5 K

9. Colligative Properties of Dilute Solution

(a) A dilute solution is one in which the amount of the solute is very small in comparison to the amount of the solvent.

(b) Dilute solutions containing non-volatile solute exhibit some special properties which depend only upon the number of solute particles present in the solution irrespective of their nature. These properties are termed as colligative properties.

(c) The colligative properties are-
- Relative lowering of vapour pressure
- Elevation in boiling point
- Depression in freezing point
- Osmotic pressure

9.1 Expression for different colligative properties

(i) Osmotic pressure (π) = $\frac{n}{V}$ RT = CRT

when w gram of solute are dissolved in V litres of solutions and M is the molar mass of the solute, then

$$\pi = \frac{WRT}{MV} \left[\because n = \frac{W}{M}\right]$$

when height is involved π = hdg

(h = height, d = density, g = gravitational acceleration)

For isotonic or isosmotic solutions

$$\left[\frac{n_1}{V_1} = \frac{n_2}{V_2}\right] \quad [\because \pi_1 = \pi_2]$$

or $\frac{W_1}{M_1V_1} = \frac{W_2}{M_2V_2}$

(ii) Relative lowering in vapour pressure :

$$\frac{p^0_A - p_A}{p^0_A} = X_B = \frac{n}{n+N}$$

[n = moles of solute, N = moles of solvent]

(iii) Elevation in boiling point :

$$\Delta T_b = K_b \times m = \frac{K_b \times W_B \times 1000}{M_B \times W_A}$$

(iv) Depression in freezing point :

$$\Delta T_f = K_f \times m = \frac{K_f \times W_B \times 1000}{M_B \times W_A}$$

Here, A = refers to solvent, B = refers to solute

* Molal elevation constant (K_b)

$$K_b = \frac{RT_b^2}{1000\ell_v}$$

[ℓ_v = latent heat of vapourisation]

* Molal depression constant (K_f)

$$K_f = \frac{RT_f^2}{1000\ell_f}$$

[ℓ_f = latent heat of fusion]

Questions based on **Colligative properties of Dilute Solution**

Ex.2 What will be the temperature at which a solution containing 6 g of glucose per 1000 g water will boil, if molal elevation constant for water is 0.52 / 1000 g.

(1) 1000.173ºC (2) 100.0173ºC

(3) 100.173ºC (4) None **(Ans. 2)**

Sol. w = 6g, W = 1000 g,

Mol. wt. of glucose = 180

$$\Delta T_b = \frac{1000 \times k_b \times w}{m \times W}$$

$$= \frac{1000 \times 0.52 \times 6}{180 \times 1000}$$

$= 0.0173^\circ C$

Hence boiling point of solution

= b.p. of water + ΔT_b

= 100 + 0.0173 = **100.0173ºC**

10. Osmotic Pressure

(a) Osmotic pressure may be defined as the excess pressure which must be applied to a solution in order to prevent flow of solvent into the solution through the semipermeable membrane.

Osmotic pressure may also be defined in several other ways.

(b) Osmotic pressure is the excess pressure which must be applied to a given solution in order to increase its vapour pressure until it becomes equal to that of the solution

(c) Osmotic pressure is the negative pressure which must be applied to (i.e. the pressure which must be withdrawn from) the pure solvent in order to decrease its vapour pressure until it becomes equal to that of the solution

(d) Osmotic pressure is the hydrostatic pressure produced when a solution is separated from the solvent by a semipermeable membrane.

Measurements of Osmotic Pressure :

Following methods are used for the measurement of osmotic pressure

(a) Pfeffer's Method

(b) Morse and Frazer's method

(c) Bekeley and Hartley's method

(d) Townsend's negative pressure method

(e) De Vries plasmolytic method

11. Reverse Osmosis

If a pressure higher than osmotic pressure is applied on the solution , the solvent will flow from the solution into the pure solvent through the semipermeable membrane. Since here the flow of solvent is in the reverse direction to that observed in the usual osmosis, the process is called reverse osmosis.

12. Isotonic Solution

(a) A pair of solutions having the same osmotic pressure are known as isosmotic solutions. If two such solutions are separated by a semipermeable membrane there will be no transference of solvent from one solution to the other.

(b) Isotonic solutions have the same molar concentration. eg. 0.85% NaCl solutions is found to be isotonic with blood.

(c) A solution having lower or higher osmotic pressure than the other is said to be hypotonic or hypertonic respectively in respect to other solution.

(d) When cells are placed in hypotonic solutions, cells swell and burst (haemolysis)

(e) When placed in hypertonic solutions , cells contract in size (plasmolysis). When excess of fertilizers (like urea) are applied , plasmolysis takes place and plants dry up (wilt).

13. Colligative properties of Electrolytes

The colligative properties of solutions, viz, lowering of vapour pressure, osmotic pressure, elevation in b.p. and depression in freezing point, depend solely on the total number of solute particles present in solution. Since the electrolytes ionise and give more than one particle per formula unit in solution, the colligative effect of an electrolyte solution is always greater than that of a nonelectrolyte of the same molar concentration.

(a) Colligative properties $\propto$ Number of particles

$\propto$ Number of molecules (in case of nonelectrolytes)

$\propto$ Number of ions (In case of electrolytes)

$\propto$ Number of moles of solute

$\propto$ Mole fraction of solute

(b) For different solutes of same molar concentration, the magnitude of the colligative properties is more for that solution which gives more number of particles on ionisation.

(c) For different solutions of same molar concentration of different nonelectrolytes solutes, the magnitude of the colligative properties will be same for all.

(d) For different molar concentrations of the same solute, the magnitude of colligative properties is more for the more concentrated solution.

(e) For solutions of different solutes but of same percent strength, the magnitude of colligative property is more for the solute with least molecular weight.

(f) For solutions of different solutes of the same percent strength, the magnitude of colligative property is more for that solute which gives more number of particles which can be known by the knowledge of molecular weight and its ionisation behaviour.

eg. Among the 0.1M solutions of urea, NaCl, $BaCl_2$, Na_3PO_4 and $Al_2(SO_4)_3$ solutions

- Vapour pressure and freezing point will be lowest while b.p. will be highest for $Al_2(SO_4)_3$ solution
- The values of the four colligative properties will be highest for $Al_2(SO_4)_3$ solution

eg. Among 1% solution of urea, glucose and sucrose

- Vapour pressure and freezing point area lowest while boiling point is highest for urea solution
- The four colligative properties are highest for urea solution

eg. Among 0.1M glucose, 0.15M urea and 0.2M sucrose solutions

- Vapour pressure and freezing point is lowest, while boiling point is highest for sucrose solution
- The four colligative properties are highest for sucrose solution.

14. Van't Hoff Factor

Certain solutes which undergo dissociation or association in solutions are found to show abnormal molecular mass. Thus, in order to know about the extent of association or dissociation of solutes in solution Vant Hoff introduced a factor (i). It is defined as the ratio of the normal mass to the observed molecular mass of the solute i.e.

$$i = \frac{\text{Normal molar mass}}{\text{Observed molar mass}};$$

$$i = \frac{\text{Observed colligative property}}{\text{Normal colligative property}}$$

$$i = \frac{\text{Observed osmotic pressure}}{\text{Normal osmotic pressure}};$$

$$i = \frac{\text{Actual number of particles}}{\text{No. of particles for no ionisation}}$$

14.1 Van't Hoff factor and degree of association :

If a solute A forms associated molecules A_n and α is the degree of association then,

$$nA \rightleftharpoons A_n$$

Initial mole	1 mole	0
Associated change	$-\alpha$ mole	$+\alpha/n$ mole
Equilibrium mole	$(1-\alpha)$ mole	α/n mole

Total number of moles after association

1 mole of A = $[1 - \alpha + (\alpha/n)]$ mole

$$= [1 - \alpha (1 - \frac{1}{n})] \text{ mole}$$

Van't Hoff factor (i)

$$= \frac{\text{Number of moles after association}}{\text{Normal number of mole taken}}$$

$$= \frac{[1-\alpha(1-1/n)]}{1} = 1 - \alpha\left(1-\frac{1}{n}\right)$$

$$= 1 - \alpha + \frac{\alpha}{n}$$

$\therefore$ degree of association $\boxed{\alpha = (1-i)\frac{n}{n-1}}$

14.2 Van't Hoff factor and degree of dissociation:

If a molecule of solute on dissociation gives n ions and α is the degree of dissociation then,

$$(A)_n \rightleftharpoons nA$$

Initial mole	1 mole	0
dissociation change	$-\alpha$ mole	$+n\alpha$ mole
Equilibrium mole	$(1-\alpha)$ mole	$n\alpha$ mole

Total number of moles after dissociation of 1 mole of A

$= [(1 - \alpha) + n\alpha]$ mole

$= 1 + \alpha (n - 1)$ mole

$\therefore$ Van't Hoff factor (i)

$$= \frac{\text{Number of moles after dissociation}}{\text{Number of moles taken (normal)}}$$

$$= \frac{1+\alpha(n-1)}{1} = 1 + \alpha (n - 1)$$

$$= 1 + n\alpha - \alpha$$

$\therefore$ degree of dissociation $\boxed{(\alpha) = \frac{i-1}{n-1}}$

Questions based on Van't Hoff factor

Ex.3 The freezing point fo a solution containing 0.2g of acetic acid in 20.0 g benzene is lowered by 0.45ºC. Calculate the degree of association of acetic acid in benzene. Assume acetic acid dimerizes in benzene. K_f for benzene = 5.12 K mol^{-1} kg.

(1) 49.5 % (2) 94.5%

(3) 85.5% (4) 58.5% **(Ans. 2)**

Sol. Given, w = 0.2 g, W = 20 g, $\Delta T = 0.45$ºC

$$\Delta T = \frac{1000 \times K \times w}{m \times W}$$

or $$0.45 = \frac{1000 \times 5.12 \times 0.2}{20 \times m}$$

$\therefore$ m (observed) = 113.78

Now for $1\ CH_3COOH \rightleftharpoons (CHCOOH)_2$

Before association	1	0
After association	$1-\alpha$	$\alpha/2$

Where α is degree of association

$$\therefore \quad \frac{M_{normal}}{M_{observed}} = 1 - \alpha + \alpha/2$$

or $$\frac{60}{113.78} = 1 - \alpha + \alpha/2$$

or $\boldsymbol{\alpha = 0.945}$ or **94.5 %**

Table : 1 Example of ideal solution

Benzene + toluene, n-hexane + nheptane, $CCl_4 + SiCl_4$, $C_2H_5Br + C_2H_5I$ n-butyl chloride + n butyl bromide	Chlorobenzene + bromo – Benzene

Table : 2 Example of Non ideal solution -

Positive deviation from Raoult's law	Negative Deviation from Raoult's law
1. $(CH_3)_2CO + CS_2$	1. $(CH_3)_2CO + C_6H_5NH_2$
2. $(CH_3)_2CO + C_2H_5OH$	2. $(CH_3)_2\ CO + CHCl_3$
3. $CH_3CHO + CS_2$	3. $CHCl_3 + C_6H_6$
4. $C_6H_6 + (CH_3)_2CO$	4. $CHCl_3 + CH_3COOH$
5. $CCl_4 + C_6H_6$	5. $CH_3OH + CH_3COOH$
6. $CCl_4 + C_6H_5CH_3$	6. $CHCl_3 + (C_2H_5)_2O$
7. $CCl_4 + CHCl_3$	7. $CH_3COOH + C_5H_5N$
8. $CCl_4 + CH_3OH$	8. $H_2O + HCl$
9. $C_6H_6 + C_2H_5OH$	9. $H_2O + HNO_3$
10. $CH_3OH + H_2O$	
11. $C_2H_5OH + H_2O$	

Table : 3. (Molal elevation constants of some solvents)

Solvent	B.Pt. (°C)	Molal elevation constant (K_b) (K kg mol^{-1})
Water	100.0	0.52
Acetone	56.0	1.70
Chloroform	61.2	3.67
Carbon tetrachloride	76.8	5.02
Benzene	80.0	2.70
Ethyl alcohol	78.4	1.15

Table : 4. (Molal depression constant of some solvents)

Solvent	E.P.(°C)	Molal depression constant (K_f) (K kg mol^{-1})
Water	0.0	1.86
Ehtyl alcohol	– 114.6	1.99
Chloroform	– 63.5	4.70
Carbon tetrachloride	– 22.8	29.80
Benzene	5.5	5.12
Camphor	179.0	39.70

SOLVED EXAMPLE

Ex.1 A 6.90 M solution of KOH in water has 30% by weight of KOH. Calculate density of solution.

(A) 1.288 g mL^{-1} (B) 12.88 g mL^{-1}

(C) 24.88 g mL^{-1} (D) 2.488 g mL^{-1}

(Ans. A)

Sol. KOH solution is 30% by weight.

$\therefore$ wt. of KOH = 30 g

and Wt. of solution = 100 g

$\therefore$ Volume of solution = $\frac{100}{d}$

$$\therefore \quad \text{Molarity} = 6.90 = \left(\frac{30}{56 \times \frac{100}{1000 \times d}}\right)$$

$= \mathbf{1.288\ g\ mL^{-1}}$

Ex.2 What is mole fraction in its one molal aqueous solution-

(A) 0.108 (B) 0.018

(C) 0.008 (D) None **(Ans. B)**

Sol. Mole fraction = $\frac{n_A}{n_A + n_B}$

$n_A = 1$ and $n_B = \frac{1000}{18} = 55.4$

$= \frac{1}{1+55.4} = \frac{1}{56.4} = \mathbf{0.018}$

Ex.3 The density of a solution containing 13% by mass of sulphuric acid is 1.09 g/mL. Calculate the molarity and normality of the solution-

(A) 1.445 M (B) 14.45 M

(C) 144.5 M (D) 0.1445 M

(Ans. A)

Sol. Volume of 100 gram of the solution = $\frac{100}{d}$

$= \frac{100}{1.09}$ mL $= \frac{100}{1.09 \times 1000}$ litre

$= \frac{1}{1.09 \times 10}$ litre

Number of moles of H_2SO_4 in 100 gram of the solution = $\frac{13}{98}$

$$\text{Molarity} = \frac{\text{No. of moles of } H_2SO_4}{\text{Volume of solution in litre}}$$

$= \frac{13}{98} \times \frac{1.09 \times 10}{1} = \mathbf{1.445\ M}$

Ex.4 Calculate the molality and mole fraction of the solute in aqueous solution containing 3.0 gm of urea per 250 gm of water (Mol. wt. of urea = 60).

(A) 0.2 m, 0.00357 (B) 0.4 m, 0.00357

(C) 0.5 m, 0.00357 (D) 0.7m, 0.00357

(Ans. A)

Sol. Wt. of solute (urea) dissolved = 3.0 gm

Wt. of the solvent (water) = 250 gm

Mol. wt. of the solute = 60

3.0 gm of the solute = $\frac{3.0}{60}$ moles = 0.05 moles

Thus 250 gm of the solvent contain = 0.05 moles of solute

$\therefore$ 1000 gm of the solvent contain

$= \frac{0.05 \times 100}{250} = 0.2$ moles

Hence molality of the solution = 0.2 m

In short,

Molality = No. of moles of solute/1000 g of solvent

$\therefore$ Molality = $\frac{3/60}{250} \times 1000 = \mathbf{0.2\ m}$

Calculation of mole fraction

3.0 gm of solute = 3/60 moles = 0.05 moles

250 gm of water = $\frac{250}{18}$ moles

= 13.94 moles

$\therefore$ Mole fraction of the solute

$= \frac{0.05}{0.05 + 13.94} = \frac{0.05}{13.99}$

$= \mathbf{0.00357}$

Ex.5 15 gram of methyl alcohol is dissolved in 35 gram of water. What is the mass percentage of methyl alcohol in solution ?

(A) 30% (B) 50%

(C) 70% (D) 75% **(Ans. A)**

Sol. Total mass of solution = (15 + 35) gram = 50 gram

mass percentage of methyl alcohol

$$= \frac{\text{Mass of methyl alcohol}}{\text{Mass of solution}} \times 100$$

$= \frac{15}{50} \times 100 = \mathbf{30\%}$

Ex.6 214.2 g of sugar syrup contains 34.2 g of sugar. Calculate (i) molality of the solution and (ii) mole fraction of sugar in the syrup.

[IIT 1988]

Sol. (i) Mass of sugar = 34.2

moles of sugar = $\frac{34.2}{342} = 0.1$

Mass of water = (214.2 – 34.2) = 180 gm

No. of moles of water = $\frac{180}{18} = 10$

molality = $\frac{0.1}{180} \times 1000 = 0.555m$

(ii) Mole fraction of sugar = $\frac{0.1}{10+0.1} = 0.0099$

Ex.7 At 300 K, the vapour pressure of an ideal solution containing one mole of A and 3 moles of B is 550 mm of Hg. At the same temperature, if one mole of B is added to this solution, the vapour pressure of solution increases by 10mm of Hg. Calculate the vapour pressure of A and B in their pure state.

(A) 400 mm, 600 mm (B) 600 mm, 400 mm
(C) 200 mm, 300 mm (D) 300 mm, 200 mm

(Ans. A)

Sol. Initially, $P_M = P^o_A . X_A + P^o_B . X_B$

$$550 = P^o_A\left(\frac{1}{1+3}\right) + P^o_B\left(\frac{3}{1+3}\right)$$

or $P^o_A + 3P^o_B = 2200$

When 1 mole of B is further added to it

$$P_M = P^o_A . X_A + P^o_B . X_B$$

$$560 = P^o_A\left(\frac{1}{1+4}\right) + P^o_B\left(\frac{1}{1+4}\right)$$

or $P^o_A + 4P^o_B = 2800$

By (i) and (ii)

P^o_A = **400 mm**;

P^o_B = **600 mm**

Ex.8 The vapour pressure of pure liquid 'A' at 310ºC is 120 torr. The vapour pressure of this liquid in solution with liquid B is 72 torr. Calculate the mole fraction of 'A' in solution if the mixture obeys Raoult's law.

(A) 0.06 (B) 0.9
(C) 0.3 (D) 0.6 **(Ans. D)**

Sol. Given is vapour pressure of pure component 'A', P^o_A = 120 torr

Partial vapour pressure of 'A', P_A = 72 torr

Suppose, its mole fraction in solution is x_A, then according to Raoult's law

$$P_A = P^o_A . x_A$$

$$72 = 120 \times x_A$$

or $x_A = \frac{72}{120} = \mathbf{0.6}$

Ex.9 What will be the temperature at which a solution containing 6 g of glucose per 1000 g water will boil, if molal elevation constant for water is 0.52/1000 g.

(A) 1000.173ºC (B) 100.0173ºC
(C) 100.173ºC (D) None **(Ans. B)**

Sol. w = 6g, W = 1000g, Mol. wt. of glucose =180

$$\Delta T_b = \frac{1000 \times K_b \times w}{m \times W}$$

$$= \frac{1000 \times 0.52 \times 6}{180 \times 1000}$$

= 0.0173ºC

Hence boiling point of solution = b.p. of water + ΔT_b
= 100 + 0.0173 = **100.0173ºC**.

Ex.10 Calculate the molal elevation constant of water evaporates at 100ºC with the absorption of 536 calories per gm (R = 2 cals).

(A) 0.519ºC (B) 0.0519ºC
(C) 1.519ºC (D) 2.519ºC **(Ans. A)**

Sol. Molal elevation constant of the solvent.

$$K_b = \frac{RT^2_b}{\ell_v \times 1000} = \frac{2 \times 373 \times 373}{536 \times 1000} = \mathbf{0.519ºC}$$

Ex.11 The vapour pressure of CCl_4 (density = 1.58 g cm^{-3}) at 30ºC is 143 mm. A 0.5 g of a non-volatile solute of molecular weight 65 is dissolved in 100 ml of CCl_4. Calculate the vapour pressure of the solution-

(A) 141.93 mm (B) 14.193 mm
(C) 1.4193 mm (D) None **(Ans. A)**

Sol. Here w = 0.5 g, W = 100 × 1.58 = 158 g
(since d = W / V), m = 65,

M of CCl_4 = 154. $\frac{p^o - p}{p^o} = \frac{wM}{mW}$

or $\frac{143 - p}{143} = \frac{0.5 \times 154}{65 \times 158}$

or p = **141.93 mm**

Ex.12 The freezing point of a solution containing 0.2g of acetic acid in 20.0 g benzene is lowered by 0.45ºC. Calculate the degree of association of acetic acid in benzene. Assume acetic acid dimerizes in benzene. K_f for benzene = 5.12 K mol^{-1} kg.

(A) 49.5 % (B) 94.5%
(C) 85.5% (D) 58.5% **(Ans. B)**

Sol. Given, w = 0.2 g, W = 20 g,

$$\Delta T = 0.45ºC$$

$$\Delta T = \frac{1000 \times K \times w}{m \times W}$$

or $0.45 = \frac{1000 \times 5.12 \times 0.2}{20 \times m}$

∴ m(observed) = 113.78

Now for $2CH_3COOH \rightleftharpoons (CH_3COOH)_2$

Before association 1 0

After association $1 - \alpha$ $\alpha/2$

Where α is degree of association

∴ $\frac{m_{normal}}{m_{observed}} = 1 - \alpha + \alpha/2$

or $\frac{60}{113.78} = 1 - \alpha + \alpha / 2$

or **α = 0.945**

or **94.5 %**

Ex.13 An aqueous solution containing 28% by mass of a liquid A(mol. mass = 140) has a vapour pressure of 160 mm at 37^0C. Find the vapour pressure of the pure liquid A. (The vapour pressure of water at 37^0C is 150 mm).

(A) 360 mm (B) 150 mm
(C) 160 mm (D) None **(Ans. A)**

Sol. For two miscible liquids,

P_{total} = mol. fraction A x p^0_A mol. fraction B x p^0_B

No. of moles of A = $\frac{28}{140}$ = 0.2

Liquid B is water. Its mass is (100 - 28) = i.e. 72

No. of moles of B = $\frac{72}{18}$ = 4.0

Total number of moles = 0.2 + 4.0 = 4.2

Given P_{total} = 160 mm

p^0_B = 150 mm

So, $160 = \frac{0.2}{4.2} \times p^0_A + \frac{4.0}{4.2} \times 150$

$p^0_A = \frac{17.15 \times 4.2}{0.2}$

= 360.15 mm ≈ 360 mm

Ex.14 Twenty grams of a substance were dissolved in 500 ml. of water and the osmotic pressure of the solution was found to be 600 mm of mercury at 15^0C. Determine the molecular weight of the substance-

(A) 1120 (B) 1198

(C) 1200 (D) None of these

(Ans. B)

Sol. Here it is given that

w = 20 gm ; V = 500 ml .

$= \frac{500}{1000}$ = 0.5 litre

π = 600 mm = $\frac{600}{760}$ atm ;

T = 15 + 273 = 288^0A

m = ?

According to Van't Hoff equation ,

$\pi V = nST$

$\pi V = \frac{w}{m} ST$

$\therefore m = \frac{wST}{\pi V} = \frac{20 \times 0.0821 \times 288 \times 760}{600 \times 0.5}$

= 1198

Ex.15 Blood plasma has the following composition (milli-equivalents per litre). Calculate its osmotic pressure at 37^0C.

Na^+ = 138 , Ca^{2+} = 5.2, K^+ = 4.5,

Mg^{2+} = 2.0 , Cl^- = 105, HCO_3^- = 25,

PO_4^{3-} = 2.2 , SO_4^{2---} = 0.5,

Proteins = 16, Others = 1.0

(A) 7.47 atm (B) 7.30 atm

(C) 7.29 atm (D) 7.40 atm

(Ans. A)

Sol. Since for calculating osmotic pressure we require millimoles/litre therefore

Na^+ = 138 $Ca^{2+} = \frac{5.2}{2}$ = 2.6 , K^+ = 4.5, Mg^{2+}

$= \frac{2.0}{2}$ = 1.0 , Cl^- = 105 ,

HCO_3^- = 24, $PO_4^{3-} = \frac{22}{3}$ = 0.73,

$SO_4^{2-} = \frac{0.5}{2}$ = 0.25 , Proteins = 16 ,

others = 1.0

Total = 294.18 millimoles/litre = $\frac{294.18}{1000}$

= 0.294 moles/litre

Now since π = CST

= 0.294 x 0.0821 x .310 = 7.47 atm

Ex.16 0.15g of a substance dissolved in 15g of solvent boiled at a temperature higher by 0.216^0C than that of the pure solvent. Calculate the molecular weight of the substance. Molal elevation constant for the solvent is 2.16^0C.

(A) 216 (B) 100 (C) 178 (D) None of these

(Ans. B)

Sol. Here it is given that

w = 0.15 g,

ΔT_b = = 0.216^0C

W = 15g K_b = 2.16^0C

m = ?

Substituting values in the expression ,

$m = \frac{1000 \times K_b \times w}{\Delta T_b \times W}$

$m = \frac{1000 \times 2.16 \times 0.15}{0.216 \times 15}$ = 100

Ex.17 The freezing point of 0.2 molal K_2SO_4 is –1.1ºC. Calculate Van't Haff factor and percentage degree of dissociation of K_2SO_4. K_f for water is 1.86º

(A) 97.5 (B) 90.75

(C) 105.5 (D) 85.75 **(Ans. A)**

Sol. ΔT_f = freezing point of water – freezing point of solution = 0º C – (–1.1º C) = 1.1º

We know that,

$\Delta T_f = i \times K_f \times m$

$1.1 = i \times 1.86 \times 0.2$

$\therefore \quad i = \frac{1.1}{1.86 \times 0.2}$ = 2.95

But we know

$i = 1 + (n - 1)\alpha$

$2.95 = 1 + (3 - 1)\alpha = 1 + 2\alpha$

α = 0.975

Van't Haff factor (i) = 2.95

Degree of dissociation = 0.975

Percentage degree of dissociation = **97.5**

Ex.18 Pure benzene boiled at 80°C. The boiling point of a solution containing 1 g of substance dissolved in 83.4 g of benzene is 80.175°C. If latent heat of vaporization of benzene is 90 cal per g, calculate the molecular weight of solute .

Sol. Boiling point of $C_6H_6 = 80 + 273 = 353$ k

Latent heat $(1_v) = 90$ cal/g

$\Delta T = 80.175 - 80 = 0.175$, w = 1 g, W = 83.4 g

$\because \quad K_b = \dfrac{RT^2}{1000 1_v}$

or $k_b = \dfrac{2\times353\times353}{1000\times90} = 2.769 \text{ K mol}^{-1}\text{ kg}$

Now $\quad \Delta T = \dfrac{k_b\times1000\times w}{m\times W}$

$0.175 = \dfrac{2.769\times1000\times1}{m\times83.4}$

$\therefore \quad m = 189.79$

Ex.19 At 27°C, 36 g of glucose per litre has an O.P. of 4.92 atm. If the osmotic pressure of solution is 1.5 atm at the same temperature, what should be its concentration ?

Sol. Given that, $\pi_1 = 4.92$ atm, $\quad \pi_2 = 1.5$ atm

$C_1 = \dfrac{36}{180\times1} \quad \left(\because C = \dfrac{w}{m\times V}\right) \quad C_2 = ?$

$\pi_1V_1 = n_1S_1T_1 \quad$ and $\quad \pi_2V_2 = n_2ST_2$

At same temperature

$\dfrac{\pi_1}{\pi_2} = \dfrac{n_1}{n_2}\times\dfrac{V_2}{V_1} = \dfrac{C_1}{C_2}$ or $\dfrac{4.92}{1.5} = \dfrac{36}{180\times C_2}$

$C_2 = 0.061$ mol/litre

Ex.20 How many g of glucose must be present in 0.5 litre of a solution for its osmotic pressure to be same as that of solution of 9.2 g glucose per litre ?

Sol. For isotonic solutions, $C_1 = C_2$

or $\quad \dfrac{w_1}{m_1V_1} = \dfrac{w_2}{m_2V_2}$

or $\quad \dfrac{w_1}{180\times0.5} = \dfrac{9.2}{180\times1}$

$\therefore \quad w_1 = 4.60$ g

Ex.21 Two liquids A and B form an ideal solution at temperature T. When the total vapour pressure above the solution is 400 torr, the mol fraction of A in the vapour phase is 0.4 and in the liquid phase 0.75. What are the vapour pressure of pure A and pure B at temperature T ?

Sol. Mole fraction of A in vapour phase $Y_A = 0.4$ & in liquid phase $X_A = 0.75$

$P_{total} = 400$ torr

Let V.P. of pure A and B are P_A^0 & P_B^0.

$\because X_AP_A^0 = Y_A P_{total}$

$P_A^0 = \dfrac{Y_AP_{Total}}{x_A} = \dfrac{0.4\times400}{0.75} = \dfrac{160}{0.75}$

$P_A^0 = 213.33$ torr

$P_{total} = X_AP_A^0 + (1 - X_A)P_B^0$

$400 = 0.75\left(\dfrac{160}{0.75}\right) + (1 - 0.75)P_B^0$

$P_B^0 = 960$ torr

Ex.22 Vapour pressure of solution containing 6g of a non-volatile solute in 180 g water is 20.0 torr. If 1 mol water is further added vapour pressure increases by 0.02 torr. Calculate vapour pressure of water and molecular weight of non-volatile solute temperature remaining constant

Sol. Let moelcualr wt. of solute = m

and V.P. of water (solvent) = P^0

$P_{solution} = 20$ torr

moles of solute $n = \dfrac{6}{m}$

moles of solvent $N = \dfrac{180}{18} = 10$

$\because \quad P_S = \left(\dfrac{N}{n+N}\right)P^0$

$20 = \left(\dfrac{10}{\dfrac{6}{m}+10}\right)P^0$

$20 = \left(\dfrac{10m}{6+10m}\right)P^0$ ....(1)

If 1 mol water is further added moles of solvent

N = 10 + 1 = 11 mol

& V.P. of solution becomes

$P_S = 20 + 0.02 = 20.02$ torr

$P_S = \dfrac{N}{n+N}P^0$

$20.02 = \left(\dfrac{11}{\dfrac{6}{m}+11}\right)P^0$

$20.02 = \left(\dfrac{11m}{6+11m}\right)P^0$ ....(2)

divide eqn. (2) by (1)

$\dfrac{20.02}{20} = \dfrac{11(6+10m)}{10(6+11m)}$

m = 54 gm

Put this value of m in equation. (1) or (2)

$P^0 = 22.22$ torr

Ex.23 Phenol associates in benzene to a certain extent to form dimmer. A solution containing 20×10^{-3} kg of phenol in 1.0 kg of benzene has its freezing point decreased by 0.69 K. Calculate the fraction of the phenol that has dimerised. (K_f of benzene is 5.12ºKmol^{-1}).

[Roorkee 1998]

Sol. Given

$w = 20\times10^{-3}$ kg. = 20 gm

$W = 1$ kg $= 10^3$ gm

Observed

$\Delta T_f = i\left(\dfrac{w\times1000}{m\times W}\times K_f\right)$

$$0.69 = i\left(\frac{20\times1000\times5.12}{94\times10^3}\right)$$

$$i = 1-\alpha+\frac{\alpha}{n} \quad \text{or} \quad \alpha = \frac{(i-1)}{\left(\frac{1}{n}-1\right)}$$

$\alpha = 0.733$ or 73.3

Ex.24 Calculate the freezing point of an aqueous solution of a non-electrolyte having an osmotic pressure of 0.2 atmosphere at 300 K. **[Roorkee 1993]**

Sol. $\pi = CST$

$$C = \frac{\pi}{ST} = \frac{2}{0.0821\times300} \text{ mol lit}^{-1}$$

In dilute solution, the density fo water can be taken as 1.0 gm cm^{-3}.

Hence molality ≈ molarity

$$\Delta T_f = (\text{molality}\times K_f)$$

$$= \frac{2}{0.0821\times300}\times1.86$$

$$\Delta T_f = 0.151 \text{ K}$$

$\therefore$ $(T_f)_{solution} = (T_f)solvent - \Delta T_f$

$= (273 - 0.151)$

$(T_f)_{solution} = 272.749$ K or -0.151°C

Ex.25 x g of a non-electrolytic compound (molar mass = 200) is dissolved in 1.0 litre of 0.05 M NaCl solution. The osmotic pressure of this solution is found to be 4.92 atm at 27ºC. Calculate the value 'x'. Assume complete dissociation of NaCl and ideal behaviour of this solution. **[Roorkee 1998]**

Sol. (i) For NaCl : $\pi_1 = i\,(CST)$

$\pi_1 = 2\times0.05\times0.0821\times300$

$\pi_1 = 2.463$ atm

(ii) for unknown compound :

$\pi_2 = CST$

$$\pi_2 = \frac{x}{200\times1}\times0.0821\times300$$

$\pi_2 = 0.1231\,x$ atm

Total osmotic pressure $\pi = \pi_1 + \pi_2$

$4.92 = 2.463 + 0.1231x$

$x = 19.959$ gm

Ex.26 To 500 cm^3 of water, 3.0×10^{-3} kg of acetic acid is added. If 23% of acetic acid is dissociated, what will be the depression in freezing point ? K_f and density of water are 1.86 K kg^{-1} mol^{-1} and 0.997 g cm^{-3} respectively. **[IIT 2000]**

Sol. Mass of solute $= 3\times10^{-3}$ Kg = 3gm

Mass of solvent $= 500\times0.997 = 498.5$ gm

$\alpha = 23\% = 0.23$

$i = 1-\alpha+n\alpha$

$= 1 - 0.23 + 2\times0.23$

$i = 1.23$

$\Delta T_f = i\,(\text{molality}\times k_f)$

$$= 1.23\times\left(\frac{3\times1000}{60\times498.5}\right)\times1.86$$

$\Delta T_f = 0.229$

Ex. 27 0.1 formal solution of NaCl is found to be isotonic with 1.10% solution urea. Calculate the apparent degree of ionization of NaCl.

Sol. 0.1 formal = 0.1 M solu. of NaCl

1.1% solution of urea means ⟶

100 ml solu. contains 1.1 gm urea

$\pi_{NaCl} = \pi_{urea}$

$$i(0.4\times ST) = \frac{1.1\times1000}{60\times100}\times ST$$

$i = 1.83$

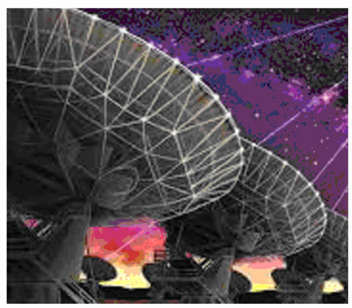
$$\alpha = \frac{(i-1)}{(n-1)}$$

$$\Rightarrow \frac{1.83-1}{2-1} = 0.83 \quad \alpha = 83\%$$

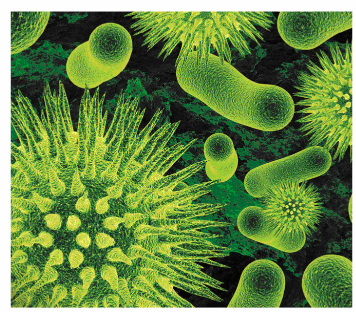
STUDY MATERIAL

NEET

XI & XII STD



BIOLOGY



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BIOLOGY

Study Material for NEET preparation

Prepared by Career Point Kota Experts

CAREER POINT

CONTENTS OF THE PACKAGE AT A GLANCE

BIOLOGY

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- Biological classification
- Plant Kingdom

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- Animal Kingdom (Chordata)

Structural Organisation in Plants & Animals
- Morphology of Flowering Plants
- Anatomy Of flowering plants
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Cell : Structure & Function
- Cell : the unit of life
- Cell Cycle and cell division
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Evolution & Biology in Human Welfare
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Ecology
- Organisms and Environment
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- Biodiversity and Conservation

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.

ANATOMY OF FLOWERING PLANTS

Chapter Contents

(I) <u>PRIMARY STRUCTURE OF PLANTS</u>

Plant anatomy

It is the branch of Botany which deals with study of internal structures and organization of plants by the section cutting is called **Plant anatomy.**

Anatomy is a Greek Word. Ana $\rightarrow$ asunder & temnein $\rightarrow$ to cut. Plant anatomy is also called as **Internal Morphology**.

N.Grew is known as father of plant anatomy. **K.A. Chaudhary** is known as father of Indian plant Anatomy.

Plant tissue

An organized group of cells which is having similar or dissimilar in shape, having a common origin and usually performing a common function is called **tissue.** The term tissue was coined by **Nehemiah Grew.**

- **Tissues**
  - Meristematic Tissues
  - Permanent Tissues
    - Simple Tissues
      - Parenchyma
        - Chlorenchyma
        - Aerenchyma
        - Prosenchyma
        - Stellate
        - Idioblast
        - Mucilagenous
      - Collenchyma
        - Lamellar
        - Tubular
        - Angular
      - Sclerenchyma
        - Fibres
        - Sclereids
    - Complex Tissue
      - Xylem
        - Tracheids
        - Vessels
        - Wood Parenchyma
        - Wood fibres
      - Phloem
        - Sieve tubes
        - Companion cell
        - Phloem parenchyma
        - Phloem fibres
    - Secretory Tissue
      - Glandur
        - External Glands
          - Glandular hairs
          - Nectaries
          - Digestive glands
          - Stinging hair
        - Internal Glands
          - Mucilage glands
          - Oil glands
          - Resin glands
          - Hydathodes
      - Laticiferous
        - Latex Cells
        - Latex Vessels

MERISTEMATIC TISSUE :

- Term given by Nageli.
- **Meristem :** Growth in plants is largely restricted to specialised regions of active cell division called meristerm. A meristem is a localized region in which actual cell division occurs.

Practice Exercises

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

EXERCISE # 1

Q.1 A tissue is a group of cells which are -
(1) Similar in origin, but dissimilar in form and function
(2) Dissimilar in origin, form and function
(3) Dissimilar in origin, but similar in form and function
(4) Similar in origin, form and function

Q.2 A meristem may be defined as the group of cells which
(1) Add to the bulk of the Plants
(2) Conserve food
(3) Divide continuously to give rise to new cells
(4) Elongate and add to the group of cells

Q.3 Embryo of a seed is made up of –
(1) Meristematic tissue (2) Parenchyma
(3) Collenchyma (4) Sclerenchyma

Q.4 Epidermal cells are -
(1) Guard cells (2) Root hairs
(3) Trichomes (4) All of the above

Q.5 Bamboo, grass and mint stem elongate by the activity of -
(1) Primary meristem (2) Secondary meristem
(3) Intercalary meristems (4) Apical meristems

Q.6 Maximum growth in root occurs –
(1) At its tip (2) Towards light
(3) Behind the apex (4) Towards apex

Q.7 A. Generally absent in primary phloem
B. Elongated unbranched pointed needle shaped cell
C. Devoid of protoplasm at maturity
D. Can be used commercially
Above mentioned statement can belongs to -
(1) Sclereids (2) Xylem sclerenchyma
(3) Phloem fiber (4) Xylem trachied

Q.8 Monocot leaves grow by -
(1) Apical meristem (2) Lateral meristem
(3) Intercalary meristem (4) Dermatogen

Q.9 Which of the following is a well differentiated plant tissue ?
(1) Apical meristem (2) Cambium
(3) Parenchyma (4) All of the above

Q.10 Which of the following is a primary meristem ?
(1) Intra fascicular cambium
(2) Cork cambium
(3) Vascular cambium in roots
(4) Inter fascicular cambium

Q.11 In plants, during embryonic condition –
(1) All cells of the embryo divide
(2) Meristematic activity is confined to single apical cell
(3) Meristematic activity is confined to a group of apical cells
(4) Apical & lateral cells only divide

Q.12 The secondary meristem originates from -
(1) Promeristem (2) Primary meristem
(3) Permanent tissue (4) Secretory tissue

Q.13 Which of the following is secondary meristem?
(1) Protoderm (2) Procambium
(3) Cork cambium (4) All of the above

Q.14 The function of root cap is -
(1) Protection of root tip and control of geotropic movement
(2) Storage of food products
(3) Absorption of nutrients
(4) None of the above

Q.15 In quiescent zone, DNA content is -
(1) High (2) Low
(3) Very high (4) Balanced

Q.16 The cells of a permanent tissue do not divide because these are -
(1) Dead (2) Enucleate
(3) Arrested at G-1 stage (4) Arrested at prophase

Q.17 Which of the following is present in monocot leaves
A. Bulliform cell B. Leaf base
C. Bundle sheath D. Resin gland
E. Water cavity
(1) A, B, C & E (2) A, B, D, E
(3) A, B, E (4) A, B, C

Q.18 A parenchyma cell which stores ergastic materials or waste substance is -
(1) Phragmoblast (2) Conidioblast
(3) Idioblast (4) Blastomere

Q.19 In plants, which of the following would most likely show totipotency -
(1) Xylem Vessels (2) Meristem
(3) Cork (4) Sieve tube

Q.20 The tissue not having specifically thickened walls are -
(1) Parenchyma (2) Collenchyma
(3) Fibres (4) Sclereids

Q.21 Which of the following tissues form the main bulk of storage organ -
(1) Parenchyma (2) Collenchyma
(3) Sclerenchyma (4) Aerenchyma

Q.22 Flesh of a fruit is mostly made up of -
(1) Parenchyma (2) Collenchyma
(3) Sclereids (4) Meristem

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 In plants maximum growth occurs during which season –
(1) Summer (2) Winter
(3) Autumn (4) Spring

Q.2 The tracheids differ from vessels in having –
(1) Thick wall
(2) Bordered pit
(3) Presence of pitted end wall
(4) Spiral thickening

Q.3 In Cucurbita stem vascular bundles are –
(1) Radial (2) Collateral
(3) Concentric (4) Bicollateral

Q.4 "Bast-fibers" obtained from which part of woody stem –
(1) Cork (2) Cortex
(3) Xylem (4) Phloem

Q.5 Thickness of stem increases due to activity of –
(1) Cambium (2) Xylem
(3) Phloem (4) Shoot apex

Q.6 Non-porous wood is found in which plants –
(1) Dicots (2) Monocots
(3) Gymnosperm (4) Cactus

Q.7 In dorsiventral leaf phloem is found in which side
(1) Adaxial
(2) Abaxial
(3) Lateral
(4) Adaxial and Abaxial both

Q.8 The leaves having stomata on both the surfaces are called as –
(1) Amphistomatic (2) Hypostomatic
(3) Epistomatic (4) Astomatic

Q.9 Most distinct annual rings are formed in which region -
(1) Tropical (2) Temperate
(3) Arctic (4) Equatorial

Q.10 Vessels and companion cells are characteristic feature of –
(1) Gymnosperm (2) Angiosperm
(3) Pteridophyta (4) Bryophyta

Q.11 Grafting is not possible in monocots because –
(1) Vascular bundles are scattered
(2) Vascular bundles are closed
(3) Hypodermis is sclerenchymatous
(4) Vascular bundles are open

Q.12 Companion cells are associated with –
(1) Tracheids of Angiosperms
(2) Vessels of Angiosperms
(3) Tracheids of Gymnosperms
(4) Sieve tubes of Angiosperms

Q.13 Lateral roots are arises from –
(1) Pericycle (2) Cortex
(3) Pith (4) Endodermis

Q.14 Bulliform cells are found in –
(1) Seeds of sunflower (2) Leaf of wheat
(3) Pod of pea (4) Tuber of potato

Q.15 In the T.S. of root –
(1) Protoxylem and metaxylem are not present on same radius
(2) Protoxylem is absent
(3) Protoxylem towards inside and metaxylem towards outside
(4) Metaxylem is towards inside and protoxylem towards outside

Q.16 The resin duct of Gymnosperm is an example of –
(1) Intracellular space
(2) Schizogenous cavity
(3) Lysigenous cavity
(4) Vacuole containing stored material

Q.17 Root cap is absent in –
(1) Mesophytes (2) Hydrophytes
(3) Epiphytes (4) Xerophytes

Q.18 Girth of dicot stem increases by the activity of –
(1) Apical meristem (2) Intercalary meristem
(3) Lateral meristem (4) Procambium meristem

Q.19 Which type of vascular bundles are found in monocot stem –
(1) Collateral, open, endarch
(2) Radial, open, diarch
(3) Radial, open, mesarch
(4) Collateral, closed, endarch

Q.20 The cells without nuclei are present in -
(1) Vascular cambium (2) Root hair
(3) Companion cell (4) Members of sieve tube

Q.21 The difference in phloem of Gymnosperms & Angiosperms is due to –
(1) Parenchyma (2) Sieve cell
(3) Companion cell (4) Fibres

Q.22 The position of protoxylem in leaf is –
(1) Adaxial
(2) Abaxial
(3) Surrounded by metaxylem
(4) Lateral

Q.23 Vascular cambium is more active towards -
(1) Outer side
(2) Inner side
(3) Sometime innerside, some time outside
(4) Equal on both side

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

EXERCISE # 3

Q.1 In monocots, root cap is formed by - **[AIIMS 2000]**
(1) Dermatogen (2) Calyptrogen
(3) Wound cambium (4) Vascular cambium

Q.2 The quiescent centre in the root meristem serves as a - **[AIIMS 2003]**
(1) Site for storage of food which is utilized during maturation
(2) Reservoir of growth hormones
(3) Reserve for replenishment of damaged cells of the meristem
(4) Region for absorption of water

Q.3 Which one of the following statements pertaining to plant structure is correct ? **[AIIMS 2005]**
(1) Cork lacks stomata, but lenticels carry out transpiration
(2) Passage cells help in transfer of food from cortex to phloem
(3) Sieve tube elements posses cytoplasm but no nuclei
(4) The shoot apical meristem has a quiescent centre

Q.4 Grafting is successful in dicots but not in monocots because the dicots have - **[AIIMS 2006]**
(1) Vascular bundles arranged in a ring
(2) Cambium for secondary growth
(3) Vessels with elements arranged end to end
(4) Cork cambium

Q.5 In the sieve elements, which one of the following is the most likely function of P-proteins – **[AIIMS 2006]**
(1) Deposition of callose on sieve plates
(2) providing energy for active translocation
(3) Autolytic enzymes
(4) Sealing mechanism on wounding

Q.6 Extrastelar secondary growth takes place by – **[AIPMT 1998]**
(1) Vascular cambium (2) Phellogen
(3) Phellem (4) Phelloderm

Q.7 Growth of leaf primordia is – **[AIPMT 1998]**
(1) First apical then marginal
(2) Only apical
(3) Only marginal
(4) Lateral

Q.8 A plant stem is showing 40 spring ring and 40 autumn ring. What will be the age of plant – **[AIPMT 1999]**
(1) 80 years (2) 40 years
(3) 20 years (4) Can not determined

Q.9 What happens in plants during vascularisation **[AIPMT 2000]**
(1) Differentiation of procambium, formation of primary phloem followed by formation of primary xylem
(2) Differentiation of procambium followed by the formation of primary phloem and xylem simultaneously
(3) Formation of procambium, primary phloem and xylem simultaneously
(4) Differentiation of procambium followed by the formation of secondary xylem

Q.10 Main function of lenticel is – **[AIPMT 2002]**
(1) Transpiration (2) Guttation
(3) Gaseous exchange (4) Bleeding

Q.11 Vessels are found in – **[AIPMT 2002]**
(1) All angiosperms and some gymnosperm
(2) Most of the angiosperms and few gymnosperms
(3) All angiosperms, all gymnosperms and some pteridophyta
(4) All pteridophyta

Q.12 Four radial vascular bundles are found in – **[AIPMT 2002]**
(1) Dicot root
(2) Monocot root
(3) Dicot stem
(4) Monocot stem

Q.13 Which of the following statement is true – **[AIPMT 2002]**
(1) Vessels are multicellular and with wide lumen.
(2) Tracheids are multicellular and with narrow lumen.
(3) Vessels are unicellular and with narrow lumen.
(4) Tracheids are unicellular and with wide lumen.

Q.14 The cells of the quiescent centre are characterised by - **[AIPMT 2003]**
(1) Having dense cytoplasm and prominent nuclei
(2) Having light cytoplasm and small nuclei
(3) Dividing regularly to add to the corpus
(4) Dividing regularly to add to tunica

Q.15 The apical meristem of the root is present – **[AIPMT 2003]**
(1) Only in radicals
(2) Only in tap roots
(3) Only in adventitious roots
(4) In all the roots

Q.16 In a longitudinal section of a root, starting from the tip upward, the four zones occur in the following order - **[AIPMT 2004]**
(1) Root cap, cell division, cell maturation , cell enlargement
(2) Cell division, cell enlargement, cell maturation, root cap
(3) Cell division, cell maturation cell enlargement, root cap
(4) Root cap, cell division, cell enlargement, cell maturation

Q.17 A common structural feature of vessel elements and sieve tube elements is - **[AIPMT 2006]**
(1) presence of p-protein
(2) enucleate condition
(3) thick secondary walls
(4) pores on lateral walls

Q.18 For a critical study of secondary growth in plants, which one of the following pairs is suitable ? **[AIPMT 2007]**
(1) Wheat and maiden hair fern
(2) Sugarcane and sunflower
(3) Teak and pine
(4) Deodar and fern

Answer key

Above mentioned all exercises provided with answer key

EXERCISE # 1

Ques.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	4	3	1	4	3	3	3	3	3	1	1	3	3	1	2	3	4	3	2	1
Ques.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	1	1	1	2	1	1	4	2	3	3	1	3	2	3	2	3	3	2	3	3
Ques.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	3	2	3	1	2	1	1	4	1	4	2	1	2	2	2	2	1	3	3	1
Ques.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Ans.	1	1	1	3	1	1	3	3	2	3	1	2	3	3	3	4	1	1	3	1
Ques.	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
Ans.	3	3	4	2	2	2	3	1	3	2	4	1	3	1	1	4	3	1	4	1
Ques.	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**
Ans.	4	3	4	1	4	4	4	3	2	2	1	4	1	1	2	1	1	1	2	1
Ques.	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**	
Ans.	2	2	2	1	4	4	3	2	3	1	3	2	2	4	2	4	1	2	2	

ANATOMY OF FLOWERING PLANTS

Chapter Contents

(I) <u>PRIMARY STRUCTURE OF PLANTS</u>

Plant anatomy

It is the branch of Botany which deals with study of internal structures and organization of plants by the section cutting is called **Plant anatomy.**

Anatomy is a Greek Word. Ana $\rightarrow$ asunder & temnein $\rightarrow$ to cut. Plant anatomy is also called as **Internal Morphology**.

N.Grew is known as father of plant anatomy. **K.A. Chaudhary** is known as father of Indian plant Anatomy.

Plant tissue

An organized group of cells which is having similar or dissimilar in shape, having a common origin and usually performing a common function is called **tissue.** The term tissue was coined by **Nehemiah Grew.**

Tissues
- Meristematic Tissues
- Permanent Tissues
  - Simple Tissues
    - Parenchyma
      - Chlorenchyma
      - Aerenchyma
      - Prosenchyma
      - Stellate
      - Idioblast
      - Mucilagenous
    - Collenchyma
      - Lamellar
      - Tubular
      - Angular
    - Sclerenchyma
      - Fibres
      - Sclereids
  - Complex Tissue
    - Xylem
      - Tracheids
      - Vessels
      - Wood Parenchyma
      - Wood fibres
    - Phloem
      - Sieve tubes
      - Companion cell
      - Phloem parenchyma
      - Phloem fibres
  - Secretory Tissue
    - Glandur
      - External Glands
        - Glandular hairs
        - Nectaries
        - Digestive glands
        - Stinging hair
      - Internal Glands
        - Mucilage glands
        - Oil glands
        - Resin glands
        - Hydathodes
    - Laticiferous
      - Latex Cells
      - Latex Vessels

MERISTEMATIC TISSUE :

- Term given by Nageli.
- **Meristem :** Growth in plants is largely restricted to specialised regions of active cell division called meristerm. A meristem is a localized region in which actual cell division occurs.

Characteristics of meristematic tissues

- It is an **undifferentiated tissue.**
- Cell cycle of meristem is in **continuous** state of division. It means they have the capacity to divide. So meristematic tissue is composed of **immature cells.**
- Meristematic cells have only primary cell wall which is thin and flexible (elastic) and made up of cellulose. Secondary cell wall is absent.
- Cells of meristem are small and isodiametric.
- They have **dense cytoplasm.**
- **Normally vacuoles are absent in meristematic cells but if present then small.**
- They have **prominent** and large nucleus.
- Meristematic cells are **metabolically** highly active so lack of reserve food occur in these cells.
- **Plastids** are **absent** in meristems. If they are present, then only in the **proplastid stage** ER is poorly developed.
- They do not have **intercellular** spaces. Cells are closely fitted (Packed) together. So it is a **compact tissue.**

Classification of meristematic tissue

Meristematic tissue based on origin and development

On the basis of origin and development meristems can be divided into following three types :

(i) Promeristem/embryonic meristem/primordial meristem :

- This meristem develops in begining during embryonic stage.
- They divide and give rise to primary meristem.

(ii) Primary meristem :

- Meristematic cell developed from promeristem are known as **primary meristem.**
- These cells are always in division phase and form primary permanent tissue.
- They are present below the promeristem at shoot and root apices, at the apex of leaves and in intercalary parts.

(iii) Secondary meristem :

- These are the meristems developed from primary permanent tissues. They are not present in the embryonic stage of the plant. These are present in mature region of root and stem of many plants particularly those that produce woody axis.
- Some of the cells of primary permanent tissues become meristematic and constitute secondary meristem.
- By the activity of secondary meristems, **secondary growth** takes place.
- Cork cambium, Interfascicular cambium & root cambium are excellent examples of secondary meristems.

  Note : Formation of meristem from any permanent tissue is called **dedifferentiation.**

  or

  Formation of undifferentiated tissue from differentiated tissues is called **dedifferentiation.**
- Promeristem $\longrightarrow$ Primary meristem $\longrightarrow$ Permanent tissue

  $\downarrow$

  Secondary meristem

Meristematic tissues based on location (position) in plant body

On the basis of position, meristematic tissues are divided into three types :

(i) Apical meristem :

- The meristems which occur at the tips of roots and shoots and produce primary tissues are called apical meristems. They are responsible for increase in the length of plant organs. Example : **Root apex, Shoot apex.** They are responsible for primary growth.
- During formation of leaves and elongation of stem, some cells left behind, they form auxillary bud and from new branches or a flowers.
- Apical meristem in shoot and root is terminal and subterminal respectively.

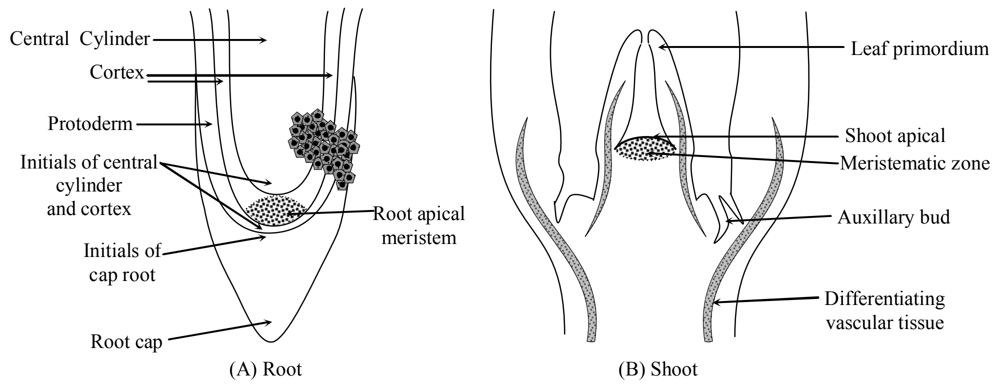


Fig.: Apical Meristem

(ii) Intercalary meristem :

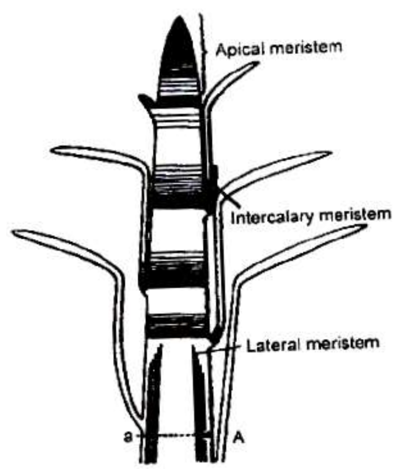
- The meristem which occurs between mature tissues.
- This is the separated region of apical meristem.
- By the activity of this meristem length of the plant organs increases.
- They are present in some plants stem.
- They are responsible for regeneration of parts removed by grazing herbivores in grasses.
- They may be present either at the base of internode e.g., **grasses, bamboo** and **Equisetum** etc. or at the base of node e.g., **Mint.** They are also present at the base of leaves e.g., **Pinus.** By the activity of this meristem, **length** of leaves increases.

  Note : They are short lived and convert into permanent tissue.

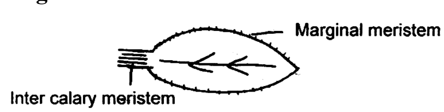
  Both apical meristem & intercalary meristems are primary meristem because they appear early in the life of a plant and contribute to the formation of primary plant body.

(iii) Lateral meristem :

- Lateral meristem occurs in **lateral side** of plant organs or parallel to the **longitudinal axis** (Tangential plane) of plant organs. They are cyllindrical meristem.
- Activity of lateral meristem increases the **girth of plant** organ, so it is **responsible** for **secondary growth** and **produce secondary tissue.**
- Lateral meristems are both primary and secondary in origin **(mostly secondary in origin).** There are two examples of **primary lateral meristem.**



1. **Marginal meristem :-** It occurs at the margin of leaf. Its activity increases the **width** of leaf so total growth of leaf is called **intercalary marginal growth.**



2. **Intra fascicular cambium or fascicular cambium :-** This cambium occurs inside the vascular bundle of the stem. Except intra fascicular cambium all cambia are secondary in origin.

Classification based on plane of division

(i) Rib-meristem/File meristem :

- Meristem in which anticlinal division occurs in **one plane**. For example, **tunica** is a type of rib-meristem. Formation of some cells of **cortex** and **pith** takes place by this meristem.

(ii) Plate-meristem :

- Meristem which divides anticlinally into **two plane** at right angle to each other. By this division a plate like structure is formed. Formation of leaf blade takes place by the activity of this meristem.

(ii) Mass-meristem :

- Meristem which divides in **all possible planes** resulting in the increase in the volume of plant body (organ). **Example :** The formation of embryo and endosperm takes place by this kind of meristem.

On the basis of function

- On the basis of function, **Haberlandt** divided meristem into three group.
  (i) **Protoderm :-** It is the outer most layer of eumeristem. By the activity of protoderm **epidermal tissue system** is formed. It includes Epidermis, Root hair, Stem hair etc.
  (ii) **Procambium :** These cells are long and it gives rise to the **vascular tissue system.** It includes Xylem and phloem.
  (iii) **Ground meristem :** The cells of this region are large, thin walled and **isodiametric. Ground tissue system** is formed by the activity of these cells. It includes hypodermis, cortex, endodermis, pericycle, pith-rays and pith.

COMPOSITION OF APICAL MERISTEM IN DIFFERENT PLANTS

- **Apical meristem** is **absent** in lower **Algae** and **Fungi.** All the cells of these plants are divisible, So they do not show apical growth. Thus such type of growth in these plants is called diffused growth.
- Apical meristem in higher algae (eg., *Fucus, Dictyota & Sargassum*), Bryophytes and Some Pteridophytes (eg., *Selaginella*) is consist of **single cell.** This cell is known as **apical cell.**
- Apical meristem in **Ferns, Gymnosperms** and **Angiosperms** consist of **many cells.**

Apical cell theory

- This theory proposed by **Karl Nageli** and **Hofmeister** and supported by **Wolff.**
- According to Nageli and Hofmeister, the apical meristem is composed of single apical cell. This view is only applicable on Bryophytes and some Pteridophytes and some higher algae (*Fucus, Dictyota* & *Sargassum*).

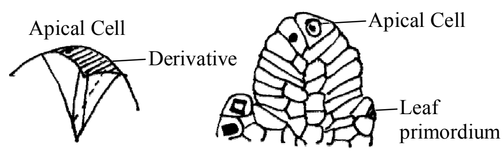
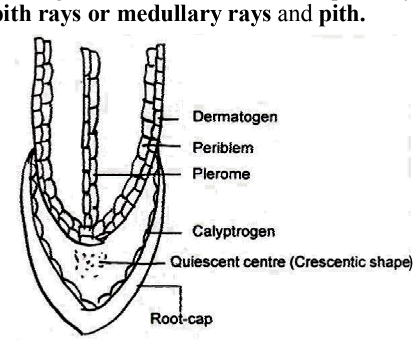


Fig.: Apical Cell

Histogen theory

- It was proposed by **Hanstein (1870).** According to him, the root and shoot apices are distinguished into three meristematic regions or three layers of histogen cells. These are as follows -
  (a) Dermatogen : This is the outermost single layer of cells. These cells form **single layered epidermis** by anticlinal division.
  (b) Periblem : This region is situated just below the dermatogen. It forms cortex **(Hypodermis, General cortex** and **endodermis).**
  (c) Plerome : This is the innermost region. Stele formation takes place by division of these cells. It means formation of **pericycle, vascular bundles, pith rays or medullary rays** and **pith.**



Histogen theory - Organization of root apex

- This theory is only true for root apex. It is not applicable for shoot apex of higher plants because in most of the gymnosperms and angiosperms, shoot apex does not have distinct differentiation of three layers.
- Except above described three histogens, a fourth type of histogen is also present in **monocotyledon root apex.** This is known as **Calyptrogen.** Root cap is produced by Calyptrogen in monocots. Root cap is produced by dermatogen in dicotyledons.
- **Exception :** There is only **one histogen** present in **Ranunculus. Two** histogens occurs in **Casuarina.**
- Due to presence of root cap position of **root apex is sub terminal.** So maximum growth in root takes place **behind the apex.**

Note :

1. In hydrophytes root cap is absent.
2. Generally root cap is single layered but in ***Pandanus*** (Screw pine) root cap is multilayered.
3. Root cap contains large number of Golgibody which secrete mucilage which make the root slimy.

QUIESCENT CENTRE

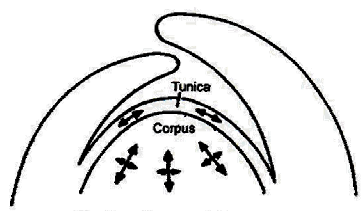
- A group of inactive or less active cells present **between the dermatogen** and **calyptrogen** is called **quiescent centre.**
- These cells contain **less amount of DNA, light cytoplasm, small nuclei** and **synthesis of protein is also less.** Quiescent centre name coined by **"Clowes ".**
- Quiescent centre was discovered in **Maize root** with the help of **autoradiography.**
- If calyptrogen get damaged, this zone becomes active to form new cells of calyptrogen.

Tunica corpus theory

- This theory was proposed by **Schmidt (1924).** This theory is **applicable on shoot apex.** According to this theory **two** types of layers are found in the shoot apex.

(a) Tunica :

- This is peripheral layer, **epidermis** is formed by this layer. In tunica cells, **anticlinal division** takes place only in one plane.
- Anticlinal division occurs at right angle to longitudinal axis (tangential plane) of cell.
- When division occurs in single anticlinal plane they do not increase the number of layers.
- Generally, tunica is **single** layered, but some times it is multilayered, then the outer most layer forms the epidermis and remaining layers form rest types of the tissue system with the association of corpus.



Tunica Corpus Theory
Organisation of shoot apex

(b) Corpus : The mass of cells present below the tunica is called **Corpus.** The cells of this zone divide in all direction (many planes) due to which, **volume** increases. It forms rest of the tissue system.

Permanent tissues

- Following division of cells in meristem the newly formed cells become structurally and functionally specialized and lose the division ability and they form permanent tissue. They are formed by division and differentiation of meristematic tissues.
- They are present either in permanent G_0 stage or in arrested G_1 stage. Their cells may be **living** or **dead.**

(A) SIMPLE TISSUES

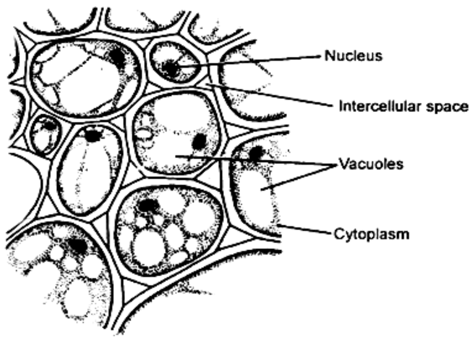
- These tissues are **made up of similar type of cells** that perform a common function and have common origin. Simple tissues are of three types :-
  (I) Parenchyma
  (II) Collenchyma
  (III) Sclerenchyma

(I) PARENCHYMA : It is very **primitive** type of tissue. It is first evolved tissue. Remaining all different type of tissues are derived from this tissue. So it is also called as **fundamental tissue**.

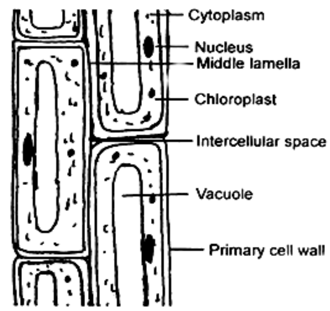
- It is a **universal tissue** and a major component of internal plant organs.
- Parenchyma name coined by **Grew.**

Characteristic features :

1. It is a living tissue.
2. Tissue first to be differentiated from meristem is parenchyma.
3. All the cells of parenchyma are thin walled. Cell wall is made up of pectocellulose. **(Mainly cellulose).** So parenchyma is a soft tissue.
4. Each cell containing large central vacuole.
5. Inter cellular spaces are present between cells of this tissue, it is a loose tissue. Intercellular spaces are **schizogenous** in origin.
6. Body of Bryophyte is mainly composed of parenchyma.
7. Flesh of a fruit is mainly composed of parenchyma.
8. The cells are **isodiametric.** The cells of parenchyma are spherical, oval or polygonal in shape. Each parenchymatous cell contains 14 planes of lateral line, which are maximum possible plane in a cell. These are known as **tetrakaidecahedron.**



T.S. of Parenchyma



L.S. of Parenchyma

Modification of parenchyma :

(a) Prosenchyma : The cells of this parenchyma are long with pointed ends. This parenchyma forms the **Pericycle of roots.**

(b) Aerenchyma : This parenchyma is made up of **rounded** cells. These cells surround the large **air chambers.** Air chambers are **lysigenous** in origin. It is found in cortex region. It provides **buoyancy** to **hydrophyte** plants.

(c) Stellate parenchyma : The cells of this tissue are stellate and branched. Air spaces are also present but they are less developed. Main function of this parenchyma is to provide **mechanical support.**

- It is found in the leaf bases of **banana** and **canna.** It provides strength to leaf bases.

(d) Chlorenchyma : Such type of parenchyma in which abundant quantity of chloroplasts are found. Two types of chlorenchyma are present in dorsiventral leaves :-

(i) Palisade tissues :- Inter cellular spaces are absent. Their cells are tightly fitted together. They are present towards adaxial/ventral/upper side of leaf. Numbers of chloroplasts are more in palisade tissue as compare to spongy tissue. So upper surface of a leaf appears more green as compared to lower surface.

(ii) Spongy tissues :- Large intercellular spaces are present. So they facilitate transpiration and gaseous exchange. They are present towards abaxial/dorsal/lower side of leaf.

(e) Mucilage parenchyma : In the mucilage parenchyma **large vacuoles** and Mucilage will be found. eg., Succulent xerophytic plants. e.g., ***Aloe.*** Function –storage of water.

(f) Idioblast : In this type of parenchyma non-living ergastic substances like tannins, oils, crystals etc. are present.

Functions of parenchyma :

The main function of this tissue is **storage of food, photosynthesis and secretion.**

(II) COLLENCHYMA : Term coined by **Schleiden.**

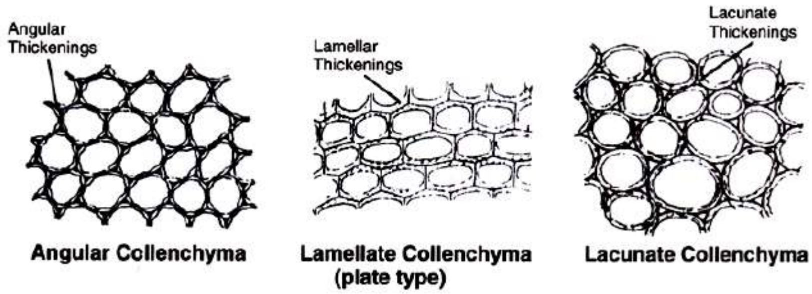
Main characteristics :

- Collenchyma is a **living mechanical tissue.**
- It is made up of **elongated (oval, spherical or polygonal** shape in section) cells.
- **Localized** deposition of pectocellulose (mainly **pectin**) & hemi cellulose is the characteristics feature of collenchyma.
- Vacuolated cytoplasm is found in the cells of collenchyma. Intercellular spaces are not present. These cell assimilate food when they contain chloroplast.
- **Origin of collenchyma :-** Collenchyma originates from **ground meristem.**

Occurance :

- It is found in the stems of **herbaceous dicotyledons.**
- Collenchyma is absent in woody plant parts, root and monocotyledons.
- Collenchyma forms the **hypodermis** of **dicotyledon** stems. It is found either as a homogenous layer or in patches.
- Collenchyma is absent in plants after the secondary growth because plant becomes woody.
- **Lamina margins** of leaves also bear collenchyma. This protects the cracking of lamina margin due to the action of wind.
- They are present in leaf petiole.

Type of Collenchyma :



Functions :

- **Mechanical** as well as **Physiological.**
- They provide mechanical support to growing parts of plant such as young stem and petiole of leaf.
- Due to the presence of chloroplast, it is also participates in the process of **photosynthesis.**

(III) SCLERENCHYMA : Name coined by **Mattenius.**

Main features :

- Sclerenchyma is the **main mechanical tissue.**
- These cells are long, narrow, thick walled and dead.
- Cell wall is **thick** and **lignified and have different types of pit.**

Function : It provide mechanical support/mechanical strength to plants.

Type of sclerenchyma :

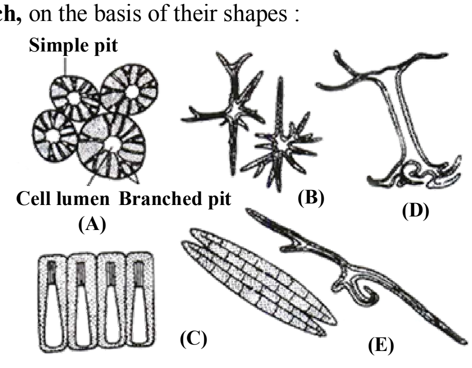
- On the basis of variation in form, structure, origin and development, sclerenchyma cells are of **two types.**

  (1) Sclereids

  (2) Sclerenchymatous fibres

(1) Sclereids : These cells are small, extremely thick walled and their ends are not pointed. Sclereids are isodiametric or **irregular** in shape. Sclereids cells have **more pits** and **lumen** is almost **very narrow.** There pit cavity is **branched.**

Sclereids are classify by **Tschierch,** on the basis of their shapes :



(A) Brachysclereid, (B) Astrosclereid, (C) Macrosclereid, (D) Osteosclereid, (E) Trichosclereid,

(a) Stone cells or Brachysclereids or Grit cells : These cells are spherical or oval in shape. They are found in endocarp of drupe fruits, so endocarp becomes hard.

- They are present in endocarp of **Coconut, Mango, Almond, and Walnut** etc.
- Brachysclereids are also present in **fleshy (edible) part of pear (*Pyrus*), Guava and Sapota.**

(b) Trichosclereids : These are also known as **internal hairs.** They are spines like, bifurcated cells. These are found in **floating leaves.**

- Also present in aerial roots of monstera.

(c) Astrosclereids or **Stellate sclerenchyma :** These cells are stellate (star) shaped. They are found in floating leaves.

Astrosclereids are also found in **tea leaves**.

Example : Both Astro and Tricho sclereids are present in floating leaves.

Victoria, Nelumbo (Lotus) and *Nymphaea* petiole.

(d) Macro-sclereids or Rod cells or Malpighi cells :

- They are small and rod like cells. They are present in **seed coats.**

Example :

- They form part of **seed coat in legume plants**. Due to their presence seed coat becomes hard and dormancy is present in legume seeds.
- In **leguminous plants** hardest seed coat is found in **French bean.**
- In plant kingdom, hardest **Seed coat** is found in lotus.

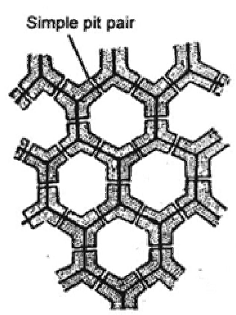
(e) Osteo-Sclereids or Bone cell :

- These are known as prop-cells. These are pillar like cells. Both end of pillar like cells spreads to form bone like structure.

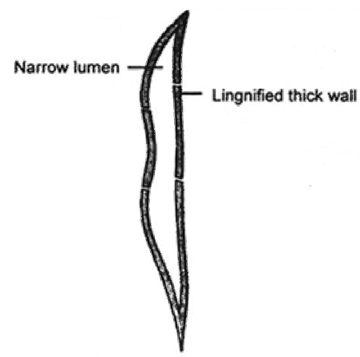
Example : These cells are found in leaves of *Hakea* and *Osmanthus***.**

(2) Sclerenchymatous fibres :

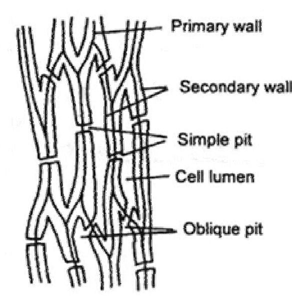
- These cells are fibrous. They are longest cells in plant body. Their both ends are pointed (tapering). Due to thick wall, lumen is reduced. Fibers are generally occurring in groups.
- Their cell wall contains simple and bordered pits.



T.S. of Sclerenchyma fibre



L.S. of Single Sc. fibre



L.S. of Sclerenchyma fibre

☛ On the basis of structure fibres are classified into two groups :

(a) Libriform fibres : They are thickened long fibres. They posses **simple pits** and narrow lumen. Libriform fibres are found in phloem, xylem, pericycle and hypodermis **(Maximum in phloem).**

(b) Fibre tracheids : They are also highly thickened. **Bordered pits** are present in these fibres and lumen is broad. They are only found in **xylem.**

TYPES OF PLANT FIBERS :

☛ On the basis of position, fibres are divided into three types :

A. Surface fibres : They are present on the surface of plant. These fibres are also called as filling fibres.

(i) Seed surface fibres –

Example 1 : Cotton fibres : Cotton fibres are formed by the **out growth of seed coat.** They are not any type of tissue or cell.

Cotton fibres are composed of **cellulose** these fibres are **non-lignified.** So cotton fibres are **not true fibres.** Two types of fibres are found in cotton. Long fibres are called **'lint'** and small fibres are known as **'fuzz'.** Lint fibres are used in cloth industry. Fuzz are filling fibre. Cotton fibres are most pure form of cellulose in nature.

Cotton fibres are not an example of any type of cell because these fibres are formed by out growth of testa.

(ii) Coir of coconut is also a type of surface fibre. They are derived from the **mesocarp.** These are **true fibres.**

B. Xylary or wood fibres : These are hard fibres. These fibres are not flexible. They can not be knitted (weaved) easily so they are not useful. These are found in xylem. Ex. Munj fibre (*Saccharum munja*)

C. **Bast fibres / Extra xylary fibres / Phloem fibre :** These are known as **commercial fibres.** These fibres are flexible and can be **knitted (weaved)** easily. They have great economic value.

- These fibres are obtained from the phloem and pericycle of plants.
- The bast fibres of *Corchorus capsularis* (Jute), *Crotalaria juncea* (Sunn hemp) and *Hibiscus sabdariffa* (patua) are obtained from the secondary phloem of stem.
- The bast fibres of hemp (*Cannabis sativa*) and *Linum usitatissimum* (flax) are obtained from the pericycle. Fibres which are obtained from pericycle are called perivascular fibres.

  Leaf fibres ⇒ Manila hemp (*Musa textilis*) and agave hemp (*Agave sislana*) : These are obtained from sclerenchymatous bundle sheath.

Special points

- Fibres are longest plant cell. Longest fibres occur in *Boehmeria nivea* (Ramie fibre) length – 55 cm.
- In plant kingdom hardest seed coat is found in *Nelumbo* (Lotus).
- In plant kingdom largest leaves are found in *Victoria regia.*
- Longest leaves are found in *Raphia vinifera*. Length 10-15 m.
- Longest commercial fibres – Jute fibres.
- Living sclerenchymatous fibres are present in *Tamarix***.**

(B) COMPLEX PERMANENT TISSUES

- The complex tissues are made up of more than one type of cells and these work as a unit. Complex tissue are heterogenous. Complex tissues are of two types : (a) Xylem (b) Phloem.
- During vascularisation in plants differentiation of procambium followed by the formation of primary phloem and primary xylem simultaneously. Complex tissues are absent in gametophytes.

(a) Xylem :

- The term 'Xylem' is coined by **Nageli.** (Greek xyles – wood.)
- The function of xylem is to conduct water and mineral salts upwards form the root to stem and leaves and to give mechanical strength to the plant body.
- For conduction of water, death of protoplasm is must. Dead tissues are more develop in water scares condition.
- On the basis of **origin,** xylem is divided into primary xylem and secondary xylem.

1. Primary xylem originates form **procambium.**

On the basis of development primary xylem divided into two parts.

(1) Protoxylem **(2) Metaxylem**

- Cells of protoxylem are small as compare to metaxylem. Metaxylem is more mature than protoxylem.

DEVELOPMENT OF WATER CONDUCTING ELEMENTS OF XYLEM :

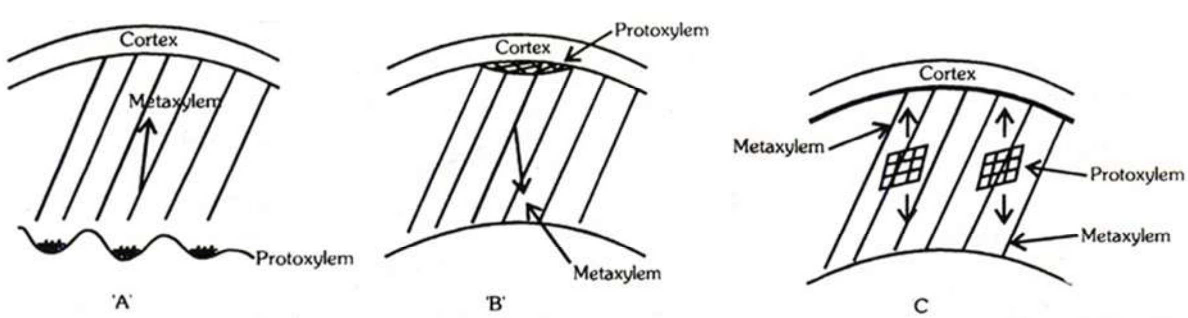
It is of three types:-

(i) Centrifugal : In this type of development, the protoxylem formed near the central axis and metaxylem is formed away from the centre it means towards the periphery.

- This condition is known as **endarch. Ex.-** stem of Angiosperm and Gymnosperm.

(ii) Centripetal : In which protoxylem is formed away from the centre it means near the pericycle and metaxylem is formed toward the centre. This condition is called **exarch.** Ex. Roots.

(iii) Centrifugal and Centripetal : In which elements of metaxylem is formed from both side of the elements of protoxylem. In this type of development protoxylem is surrounded by metaxylem. This condition is known as **Mesarch.** Ex.-Fern rhizome.



2. Secondary xylem originates from vascular cambium.

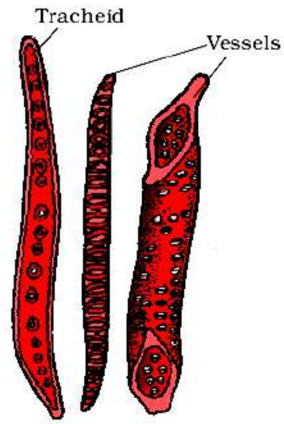
- The elements of xylem are :

(1) Tracheids, (2) Vessels or tracheae, (3) Xylem fibres & (4) Xylem parenchyma

$\underbrace{\text{(1) Tracheids, (2) Vessels or tracheae, (3) Xylem fibres}}_{\text{Dead elements}}$ & $\underbrace{\text{(4) Xylem parenchyma}}_{\text{Living elements}}$

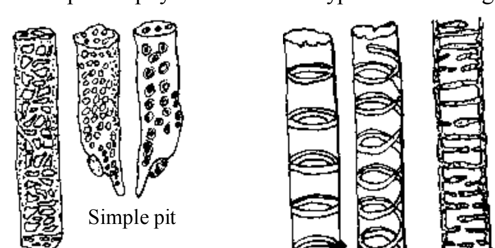
(1) Tracheids : Term was coined by **Sanio**.

- **Tracheids** are primitive **conducting elements** of xylem. They are present in all tracheophytes. They are elongated or tube like cell with thick and lignified wall and tapering end.
- **Tracheids** having a **narrow lumen**.
- Tracheids join together from **their ends** to form a **long row.** These rows extending form the root to leaves via stem.
- A **transverse septum** lies between each two tracheids. It bears **pits.** Water moves from one tracheid to another Tracheids through pits.
- Due to presence of transeverse septum lumen is discontinuous in tracheids.
- Tracheids are **dead** and **lignified** cells. The deposition of lignin on cell wall is responsible to form different type of thickenings. (Pits are nonlignified areas on lignified wall)



Note :

1. Usually broadered pits are present at end wall of tracheids.
2. The maximum bordered pits are found in the tracheids of Gymnosperm plants.
3. Maximum deposition of lignin is found in pitted type of thickening.
4. Annular and Spiral type of thickening of lignin is found in protoxylem.
5. Reticulate and Pitted (mainly) type of thickening of lignin is found in metaxylem.
6. In metaxylem tracheids of pteridophytes scalariform type of thickening is found.



Different lignified thickening in xylem (tracheids and vessels)

(2) Vessels :

- It is advance water conducting element of xylem. It is a long cylindrical tube like structure made up of many cell called vessel members each with lignified walls and large central cavity.
- The **lumen of vessels** is **wider** than tracheids and end wall is perforated **(Transverse septum** is absent between two vessel elements. If present then **porous.)** Thus vessles are more capable for conduction of water than tracheids. Due to presence of perforated end, vessels work as a pipe line during conduction of water.

- Vessels contain usually simple pits at their lateral wall. Thickening type of wall is the same as tracheids.

  Note :

  1. Vessels are only found in xylem of angiosperm but exceptionally it is also present in some Gymnosperms like *Ephedra, Gnetum* and *Welwitschia.*
  2. Vessels are absent in some Angiospermic plants such as *Dracaena, Yucca, Dazinaria, Drimys.* There are some angiosperms families in which vesselless angiosperms are include. eg., Winteraceae, Tetracentronaceae and Trochodendronaceae.
  3. Vessels are example of dead syncyte.

     ⇒ **Syncyte :** Cell which is formed by fusion of cells, called as syncyte.

(3) Xylem fibres :

- Xylem fibres **provides strength** to the tracheids and vessels. Mainly these fibres provide strength to the vessels. They have highly thickened walls and obliterated central lumen.
- They are present **more abundantly** in **secondary xylem.**

(4) Xylem parenchyma :

- It's cell wall is made up of cellulose. It store starch, fats and tannin etc.
- The **radial conduction of water** is the function of xylem parenchyma. (It conducts water to peripheral part of plant organs).
- They store food material in the form of starch, fat and other substance.
- Their wall possesses pits.

Hadrom :

Tracheids and **Vessels** are **collectively** known as **water conducting elements** or **"Hadrom".** Hadrom term was proposed by **Haberlandt.**

(b) Phloem :

- The term **'Phloem'** is coined by **Nageli.**
- The main function of the phloem is to conduct food materials, usually from the leaf to other plant parts (eg., storage organ and growing regions.)
- On the basis of origin, phloem is classified into two categories primary and secondary phloem.
- Primary phloem originates from procambium and secondary phloem originates from vascular cambium.
- On the basis of development primary phloem categorised into protophloem and metaphloem.
- The protophloem has narrow sieve tubes whereas metaphloem has bigger sieve tubes.
- Phloem remains active for less duration as compared to xylem.
- Phloem consist of **4 types** of cells.

1. Sieve cell / Sieve tube

Sieve cell	**Sieve tube**
↓	↓
In Gymnosperms and pteridophytes	In Angiosperms

- Sieve elements was discovered by **Hartig.**
- Sieve cell/sieve tube element are living and thin **walled.**
- Mature sieve tube elements are **enucleated** living cells.
- **Central vacuole** is present in each sieve cells/sieve tube element.
- **In Angiosperm plants** sieve tube elements are arranged with their ends and form **sieve tube.**
- Sieve plate (oblique transverse perforated septa) is present between the two sieve tube elements. Materials are transported through these pores.
- **Callose** deposited on the radius of pores during **dropping season** (autumn) of leaves, to form a thick layer. This is called **Callus pad.**
- Sieve plate is protected by callus pad. It is also prevented from **bacterial infection** and drought.
- Callose dissolves during spring season by callase enzyme. Callose is a β-1-3 glucan.
- In Gymnosperms and pteridophytes sieve cells are arranged irregularly. Sieve cell have sieve plates on their lateral walls. Thus conduction of food takes place in zig-zag manner.

- In Angiosperms food conduction is erect and efficient.
- Sieve elements contain special type of protein **P-protein** (p-phloem)

Note :

1. Food conduction is **bidirectional** in sieve tube.
2. Sieve tube is an example of living enucleated syncyte.
3. Most likely function of p-protein is sealing mechanism on wounding.

2. Companion cell :

- The companion cells are specialized parenchymatous cell which are closely associated with sieve tube element. The sieve tube element and companion cells are connected by pits field present between their common longitudinal walls.
- Sieve tube element and companion cell originates together. Both of them originates from **a single mother cell**. So called as **sister cells.**
- Companion cell maintain pressure gradient in sieve tube. Functions of sieve tube are regulated by companion cell.
- Companion cells are only found in Angiosperms. (Exception – *Austrobaileya* is angiosperm plant but companion cells are absent).
- Special type of cells attached with the sieve cells in gymnosperm and pteridophytes in place of companion cells. These cells are called as albuminous cells/strassburger cell. It is analogous to companion cell.

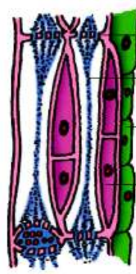


Fig. L.S. of Phloem Tissue

3. Phloem fibres :

- Fibres which are present in **phloem** are called bast fibres. These fibres are generally not found in primary phloem.
- These fibres provide mechanical support to the **conducting elements** (sieve cells and sieve tube.)

4. Phloem parenchyma :

- It is also known as bast parenchyma. It is made up of elongated tapering cylindrical cells which have dense cytoplasm and nucleus and connected through Plasmodesmata.
- It's cells are living and thin walled. It store various **material. eg.,** Resin, Latex, Mucilage etc.
- The main function of phloem parenchyma is **conduction of food in radial direction** and **storage of food.** The food conducting element of phloem is called **Leptom. Leptom** includes $\left\langle \begin{array}{l}\text{Sieve cell}\\ \text{Sieve tubes}\end{array}\right.$
- **Leptom** term was proposed by **Haberlandt.**

Note :

1. Phloem parenchyma is absent in the stems of monocotyledon plants and in primary phloem of dicot plant.
2. Phloem parenchyma is absent in the stems of Ranunculaceae plants. (dicot family).
   e.g., *Thalictrum*.

Tissue system

- In higher plants several tissues work together in form of a unit to perform a particular function. These tissues have the same origin. Such tissues form a system which is called **tissue system.** On the basis of **their structure and location** tissue categorized by **Sachs** into three different system.

1. **Epidermal tissue system :** The epidermal tissue system forms the outermost covering of the plant body. It is made up of elongated compactly arranged cells which form a continuous layer. Epidermal cells are Parenchymatous cells. This system includes epidermis and its related structures. eg., Root hairs, trichomes, stomata and bulliform cells etc. It is developed from **protoderm.**

- The epidermis (Greek, Epi = upon ; Derma = skin) of most of plant organs is uniseriate, i.e. composed of single layer of epidermal cells but in some cases it may be multilayered e.g., *Ficus , Nerium, Peperomia.*
- Each cell has a large central vacuole & peripheral thin cytoplasm. They may contain anthocyanin pigments, tannins, oils and crystals etc.
- The outside of the epidermis is often covered with waxy thick layer cuticle. Cuticle is absent in roots.

Stomata : Stomata are minute apertures in the epidermis. Each aperture is bounded by two kidney/ bean shaped cells, called as guard cells. Dumbell shaped guard cell are present in grasses.

- Guard cell contains chloroplasts. Inner wall of guard cell is thickened and outer wall are thin. There are different numbers of cells of variable size in the epidermis around the guard cells. These are called as subsidiary cells.

Stomatal appertus = Guard cell + Stomatal pore + Subsidiary cell.

- Stomata are absent in roots, underground parts and submerged hydrophytes. Stomata regulate the process of transpiration and gaseous exchange.

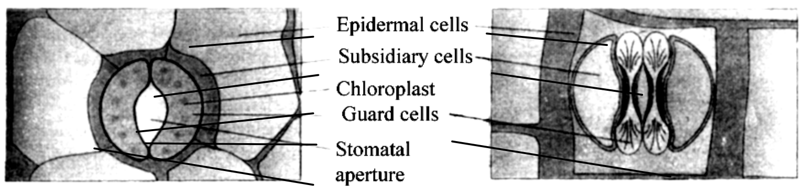


Fig.: Diagrammatic representation : (a) Stomata with bean-shaped guard cells.
(b) Stomata with dumb-bell shaped guard cell.

Trichomes : On the stem the epidermal hairs are called Trichome. These Trichome are usually multicellular. They may be branched or unbranched and soft and stiff.

Function : The trichomes help in protection, dispersal of seeds and fruits and preventing water loss due to transpiration.

Root hair : The root hairs are unicellular elongation of the epidermal cells. The thin wall is made up of cellulose and pectic materials. Root hairs are **endogenous** in origin.

Function : Root hairs play an important role in anchoring the plant body in the soil besides absorbing water and mineral solution from it.

Ground tissue culture

It is the largest tissue system. All the tissues except epidermis and vascular bundle form the ground tissue system. It includes hypodermis, general cortex, endodermis, pericycle pith and medullary rays (pith rays). It is also called as **fundamental tissue system.** In leaves ground tissue consist of chloroplast containing mesophyll.

Vascular bundles / Vascular tissue system

This tissue system originates from **pro-cambium.**

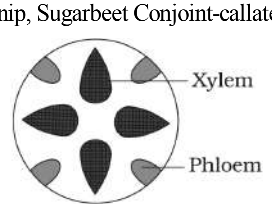
☛ Xylem and phloem are collectively termed as **Vascular bundles** or **Vascular tissues system**.

Type of vascular bundles :

☛ On the basis of arrangement of different parts, vascular bundles are divided into three categories.

I. **Radial vascular bundles :**

- When the xylem and phloem are present separately on different radii in alternate manner. Such vascular bundles are called **radial vascular bundle.**
- The order of development of xylem in these vascular bundles is **centripetal.** Thus, these vascular bundles are called exarch. Example : Most of the roots.
- **Exception :-** In Radish, Carrot, Turnip, Sugarbeet Conjoint-callateral, Vascular bundle are present.

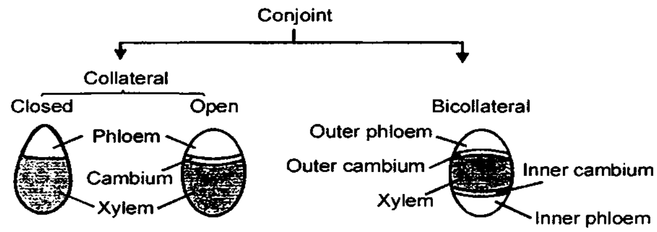


Radial vascular bundle

II. Conjoint vascular bundles :

- In this type of vascular bundle xylem and phloem are present on the same radius. These are of two types -

(1) Conjoint collateral : In this type of vascular bundle xylem and phloem are present on the same radius and phloem present towards the periphery. These are two types :



(i) Open – If the cambium is present between the xylem and phloem. It is known as **open** vascular bundle. Ex. Open vascular bundle is found in stem of **dicotyledons** and **gymnosperm.**

(ii) Close – When cambium is absent between the xylem and phloem, in conjoint vascular bundle, it is called as **closed vascular bundle.** Ex.- Closed vascular bundles are found in **monocotyledons stem.**

- In this type of vascular bundle, order of development of xylem is **centrifugal.** So **endarch** condition is found in xylem.

(2) Conjoint bicollateral and open vascular bundle – There are two patches of phloem, one on each side of xylem, are found. There are two strips of cambium (outer and inner), one on each side of xylem, are found. Such types of vascular bundles are known as conjoint, bicollateral and open vascular bundle.

- Order of development of xylem is centrifugal so endarch condition is found.

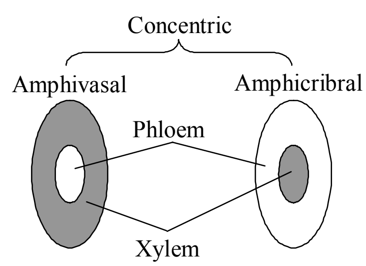
Ex.- Stem of family Cucurbitaceae, Apocynaceae and Solanaceae.

III. Concentric vascular bundles :

- In this type of vascular bundle either xylem surrounds the phloem or phloem surrounds the xylem. Concentric vascular bundles are always closed. They are of two types -

(a) Amphicribral or hadrocentric :

- In this type of vascular bundle xylem is completely surrounded by phloem. It means xylem is present in the centre of vascular bundle. Such type of vascular bundle is termed as **amphicribral.**
- The order of development of xylem in these vascular bundles both centripetal and centrifugal manner. In this type of vascular bundle protoxylem surrounded by metaxylem. These are known as mesarch vascular bundle. Such types of vascular bundles are found **ferns rhizomes**.



(a) Amphivasal or leptocentric :

- In this type of vascular bundle phloem is completely surrounded by xylem. It means phloem is present in the centre of the vascular bundle. In this type of vascular bundle, xylem is endarch. Eg., Stem of ***Dracaena, Yucca*** etc.

Internal structure of stems, roots & leaves

Internal structure of typical dicotyledon - root

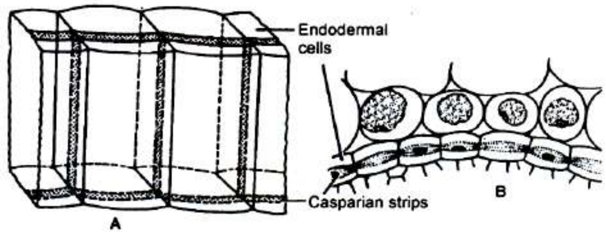
Internal structure of a typical dicotyledon root shows following features : -

1. **Epidermis : -** It is **uniseriate** outermost layer. It comprising tubular living components. Cuticle and stomata are absent. Unicellular root hairs are formed due to elongation of some cells of epidermis.
2. **Cortex : -** It is made up of parenchymatous cells with intercellular space.

Note : The cells of outer part of cortex are suberized in old root. It is called **exodermis.**

Exodermis found in some dicotyledon roots and most of the monocotyledon roots.

3. **Endodermis :** Inner most layer of cortex is known as endodermis. **Casparain strips** are present on radial and tangential wall of endodermis. These strips are made up of **suberin**. Casparian strips are discovered by **Caspari**.



Endodermal cells : Casparian strips in tangential and radial walls

- The cells of endodermis which are situated in front of protoxylem cells lack of casparain strips. These are called **passage cells.** The number of **passage cells** is equivalent to the **protoxylem cells** and number of rows of root hair equivalent to protoylem cells.
- Passage cells provide path to absorbed water from cortex to pericycle.

Note :

(1) Root hairs are linearly arranged on root apex.

(2) Casparian bands and passage cells are well developed in monocot root.

(3) Endodermis acts as a **water tight jacket** and prevents radial conduction of water

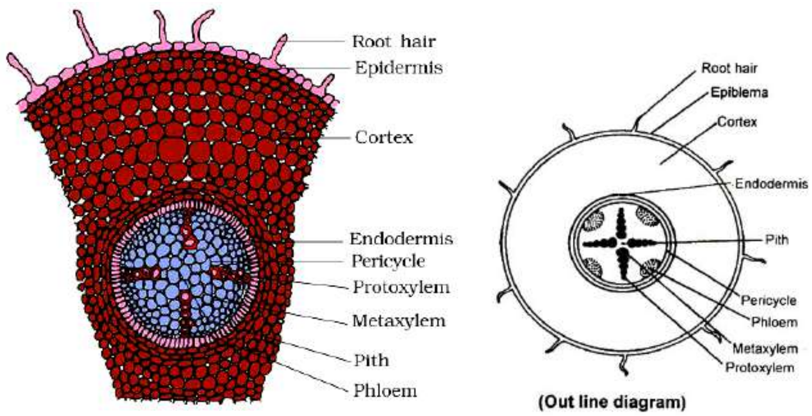


FIG.: T.S. OF TYPICAL DICOTYLEDON ROOT

4. **Pericycle :** It is few thick layered. It is composed of **prosenchyma**.

- **Lateral** roots are originated from the part of **pericycle** which is lying opposite to protoxylem. Thus lateral root are **endogenous** in origin.
- A few mature cells of pericycle usually opposite to protoxylem, become meristematic. these cells divide by periclinal divisions and form some layers of cells. these divisions are followed by anticlinal divisions forming a primordium which grows to form a lateral root.

  Note : Adventitious root are also **endogenous.** Because these are originated from stellar region.
- Some part of vascular cambium in root is originated from pericycle.

5. **Vascular bundles : -** Vascular bundles are **radial** and **exarch**. Xylem and phloems are separate and equal in number. The numbers of xylem bundles are usually two to four (**diarch** to **tetrarch upto hexarch**).

- But exceptionally, **Ficus** (Banyan tree) root is **polyarch.**
- Parenchyma which is found between xylem and phloem, called **Conjunctive tissue.**
- Vascular cambium is developed from it.

6. **Pith : -** In dicot root pith is **small or inconspicous.**

Internal structure of monocotyledonous – root

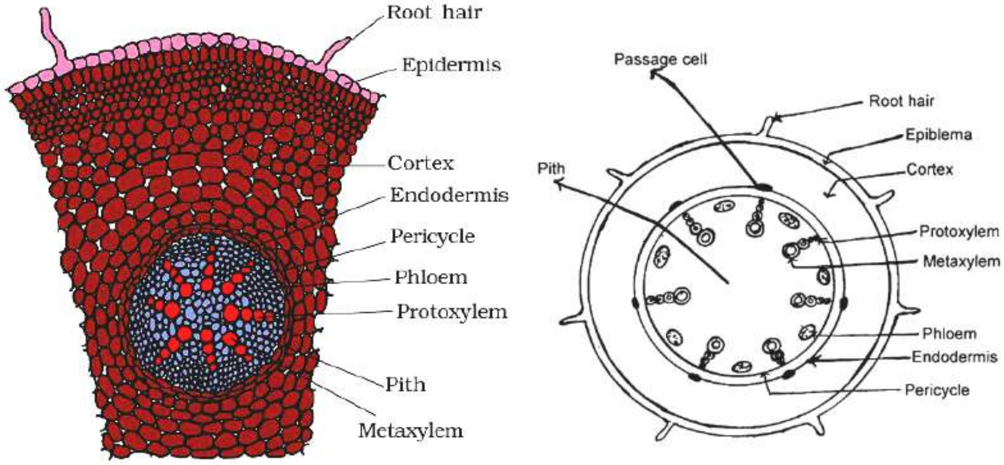
- The internal structure of a typical monocotyledon root is similar to dicotyledon root.

  But

  (1) Number of xylem bundles are **more than six** (Polyarch) in monocotyledon root (**exceptionally** the number of xylem bundles are two to **six** in **onion**).

  (2) Pith is **well developed** in monocotyledon root

  (3) Only lateral roots are originated from pericycle.



(Out line diagram)

Fig.: T.S. of Monocotyledon Root

- **Difference between dicot root and monocot root**

S.No.	Character	Dicot root	Monocot root
1	Pericycle	Gives rise to secondary roots and lateral meristem	Gives rise to lateral roots only.
2	Vascular bundles	Diarch to hexarch	Polyarch
3	Cambium	Develops at the time of secondary growth	Absent
4	Pith	Absent or poorly developed	Fully developed

INTERNAL STRUCTURE OF DICOTYLEDONOUS STEM :

Internal structure of a typical dicot stem show following features :

1. **Epidermis :** Epidermis is the outermost layer of the stem. It is single layered. Multicellular hair (trichomes) and stomata are found on epidermis. Outer side of epidermis, a layer is present which is made up of cutin is called cuticle.
   - Epidermis plays a significant role in protection.
2. **Cortex :** In dicotyledon stem cortex divided into three parts :

   (a) Hypodermis (b) General cortex (c) Endodermis

   (a) Hypodermis : It is present just below the epidermis. It provides mechanical support to young stem. This layer is composed of **collenchyma** and their cells contain **chloroplast.** So hypodermis is **green** and **photosynthetic.**

   (b) General cortex : This part is composed of **parenchyma.** Storage of food is the main function of the cortex. Resin canal/mucilage canal are present in it. These are **schizogenous** in origin.

   (c) Endodermis : It is single celled thick layer. The cells of **endodermis are barrel shaped.** These cells accumulate **starch** in stem of dicot. Thus, it is known as **"starch sheath".**
3. **Pericycle :** Pericycle is present on the inner side of the endodermis and above the phloem in the form of semi lunar patches of sclerenchyma.

   Note : In **sunflower** stem, pericycle is made of alternate bands of **parenchymatous** and **sclerenchymatous** cells. In which pericycle which is present in front of the vascular bundle is made up of sclerenchyma and remaining is composed of **parenchyma.** Part of pericycle which is situated in front of vascular bundle is known as **Bundle cap.** Pericycle is **heterogenous** in sunflower stem.
4. **Vascular bundle :** Large number of vascular bundles **(wedge shaped)** are arranged in a ring. Each vascular bundle is **conjoint, collateral** and **open.** Each vascular bundle is made of phloem, cambium and xylem. **Eustele** is present in dicotyledon stems.
5. **Pith :** This is well developed region, spreading from ring of vascular bundle to the centre. The cells of this region mainly made up of **parenchyma.**

   Function of pith – Storage of water and food.

   Note : The part of pith which is radially arranged between the vascular bundles, called **pith rays or medullary rays.** The main function of pith rays is radial conduction of food and water.

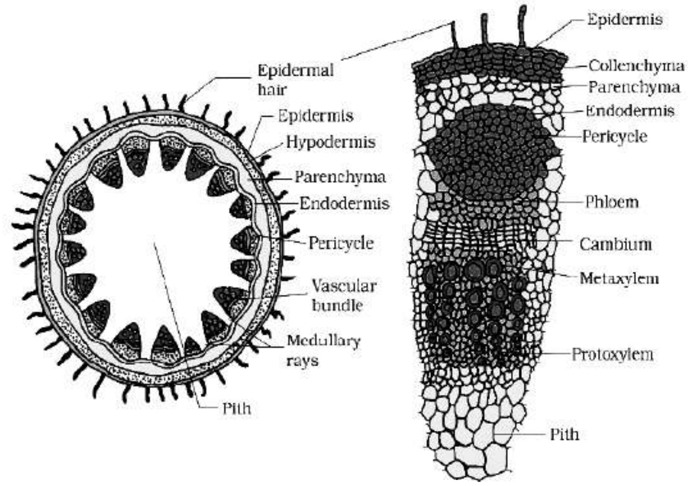


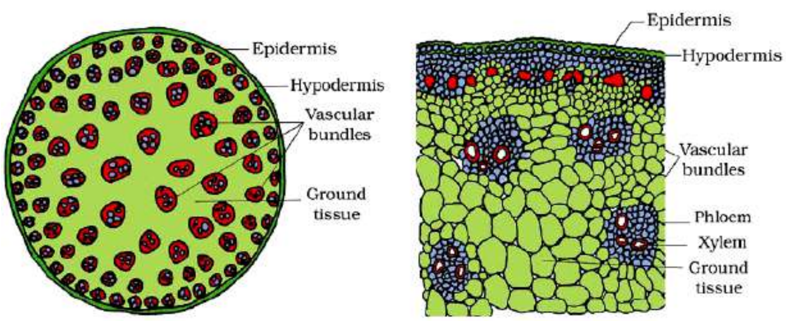
Fig.: T.S. of Stem

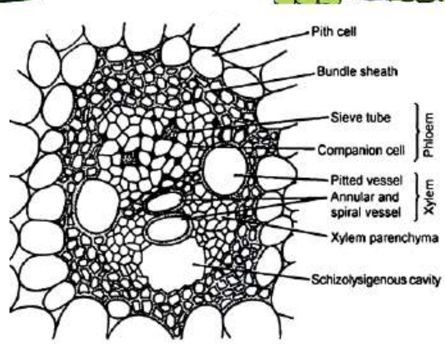
Internal structure of monocotyledonous stem

1. **Epidermis :** Epidermis is the outer most single celled thick layer. It is covered with thick cuticle. Multicellular hair are absent and stomata are also less.
2. **Hypodermis :** Hypodermis of monocotyledon is made up of **sclerenchyma.** It is 2-3 layered. It provides **mechanical** support to plant.
3. **Ground tissue :** The entire mass of parenchyma cells next to hypodermis and extending to the centre is called ground tissue. There is **no differentiation** of ground tissue in monocotyledon stem.
4. **Vascular bundle :** Many vascular bundle each surrounded by sclerenchymatous bundle sheath are scattered in the ground tissue and V.B. are generally oval shape. Each vascular bundle is conjoint collateral and closed. Peripheral vascular bundle are generally smaller than centrally located ones.
   - **(a) Xylem :** In xylem number of **vessels** is less. In metaxylem there are **two** large vessels while in protoxylem there are **one** or **two** small vessels. Vessels are arranged in **V** or **Y** shape. Just beneath protoxylem vessels, there are a **water cavity** which is schizolysigenous in origin but major part of water cavity is **lysigenous.** This cavity is formed by disintegration of the element present below the protoxylem and neighbouring parenchyma.

     Exception : In *Asparagus* water cavity and bundle sheath are absent.
   - **(b) Phloem :** It consist of sieve tube elements and companion cells. **Phloem parenchyma** is absent.

     Stele : Atactostele is found in monocotyledon. This is the most **developed stele.**





A Vascular Bundle

S.No.	Monocot stem	Dicot stem
1.	Epidermis with generally comparatively **smaller** cells.	Epidermis is made of comparatively **larger** cells.
2	Hairs are generally **absent**.	Multicellular hairs are **present**.
3.	Hypodermis is **sclerenchymatous**.	Hypodermis is **collenchymatous**.
4.	Cortex is generally absent, but from hypodermis to centre of stem there is **ground tissue** present.	Cortex is made of many layered parenchymatous cells.
5.	Endodermis is absent.	Endodermis is **present** but usually poorly developed.
6.	Pericycle is **absent**.	Pericycle is made of one or many layers of cells.
7.	Medullary rays are **absent**.	Medullary rays are **present** between vascular bundles.
8.	Pith is **absent**.	Pith is **present**.
9.	Vascular bundles :	
	(a) Scattered V.B.	(a) V.B. are arranged in a ring.
	(b) V.B. are conjoint, collateral and **closed**.	(b) V.B. are conjoint, collateral and **open**
	(c) There is differences in the size of V.B. in the centre and at periphery, i.e., V.B. in centre are larger in size and towards periphery are smaller.	(c) V.B. are of same size.
	(d) Bundle sheath is **present** around vascular bundle in monocot stem	(d) Bundle sheath is **absent**.
	(e) **Oval** vascular bundles.	(e) **Wedge shaped** vascular bundles.
	(f) Phloem parenchyma is **absent**.	(f) Phloem parenchyma is **present**.
	(g) Xylem vessels are 'Y' or 'V' shaped.	(g) Xylem vessels are radial.

Internal structure of leaf

Generally leaves divided into two categories – Dorsiventral leaves and isobilateral leaves. The differences in between them as follows :

Dorsiventral or Bi-facial	Iso-bilateral or Equifacial
1. Present at right angle to stem	**1.** Arranged parallel to stem.
2. Upper surface of leaf receive more sun light as compared to lower surface, so there are difference between internal structure of upper and lower surface of leaf. Examples : Dicots Exception – *Eucalyptus*, *Nerium*.	**2.** Both surface of leaf receive equal amount of sun light so there are no difference between internal structure of upper & lower surfaces. Example : Monocots Exception – *Lilium longiflorum*

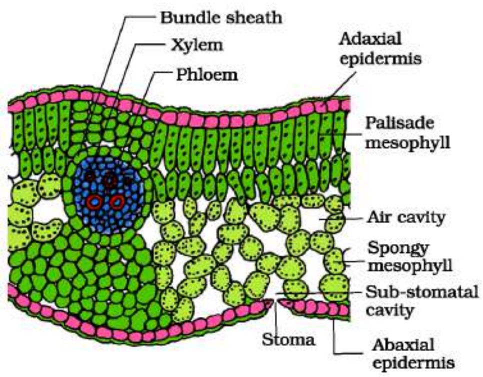
Difference between dicot leaf (dorsiventral) & monocot (isobilateral)

	Character	Dicot leaf	Monocot leaf
(i)	Leaf	Dorsiventral	Isobilateral
(ii)	Stomata	Usually more on lower epidermis (Hypostomatic)	Equal on lower and upper epidermis (Amphistomatic)
(iii)	Mesophyll	Made up of two types of tissues (A) Palisade parenchyma (B) Spongy Parenchyma with large intercellular spaces	Only spongy parenchyma is present which has very small spaces.
(iv)	Bundle sheath	Made up of parenchyma just above and below vascular bundle. Some parenchyma cells or collenchymatous cells are present upto epidermis	Just above and below the vascular bundles sclerenchymatous cells (up to epidermis) are found.
(v)	Bulliform Cells	Absent	Present

Internal structure of dorsiventral leaves

- Cuticle is present on both surfaces but cuticle of upper surface is thicker.
- Dorsiventral leaves are mostly **hypostomatic** i.e. stomata present on lower surface.

  Note : In amphistomatic dorsiventral leaves stomata are more on lower surface.
- Mesophyll of these leaves is divided into two regions – Palisade tissue and spongy tissue.
- Palisade tissue is found towards upper surface. These cells have more chloroplasts. Spongy tissues is found towards lower surface and have large intercellular space.

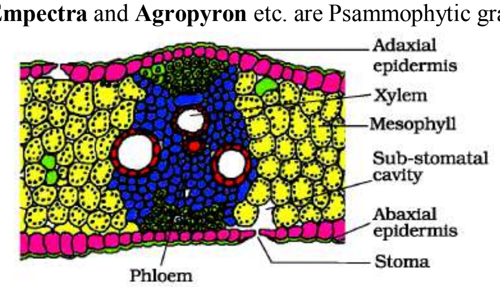


Internal structure of isobilateral leaves

- The thickness of cuticle on the both surface is equal.
- Distribution of stomata on both surface's are **equal**.

  Note : Isobilateral leaves are **Amphistomatic** i.e. stomata present on both sides.
- Mesophyll of isobilateral leaves is not differentiated into palisade and spongy tissues. It is completely made up of spongy tissues. **Palisade tissues are absent.**
- **Bulliform cells : -** Large cells are found in the epidermis of psammophytic (desert) grasses which are filled by liquid or empty (mostly) and colourless are called bulliform cells or motor cells. When the bulliform cells in the leaves have absorb water and become turgid the leaf surface is exposed. When they are flaccid due to water stress they make the leaf curl and minimize water loss.

  Example : - Ammophila, Poa, Empectra and **Agropyron** etc. are Psammophytic grasses



Vascular bundles of leaves

- Similar types of vascular bundles are found in both dorsiventral and isobilateral leaves. Vascular bundles of leaves are **conjoint, collateral** and **closed.** Protoxylem is situated towards the adaxial surface and protophloem towards the abaxial surface in the vascular bundle.
- The sizes of the vascular bundle are dependant on the size of vein. The veins vary in thickness in the reticulate venation. Thus different size vascular bundles are present in dicot while in parallel venation similar size vascular bundle are present.

  Vascular bundles are surrounded by a **bundle sheath**. Bundle sheath is **chlorenchymatous** in C-4 plants. Epidermis of **Nerium** (both upper & lower) and **Ficus** (only upper epidermis) becomes **multilayered**. This is an adaptation to reduce transpiration.

Anatomy – secondary growth

Secondary growth :

- By the activity of lateral meristems, increase in the **circumference/girth** of the plant organs due to the formation of secondary tissues in stelar & extra stelar regions called secondary growth.
- Normally secondary growth takes place in roots and stem of **dicotyledons & Gymnosperms**.
- Due to lack of cambium in monocotyledons, secondary growth is absent. But exceptionally secondary growth takes place in some monocotyledons. Such as- ***Palm, Yucca, Dracaena, Smilax, Agave, Coconut*** etc.
- Pteridophytes and monocots have only primary structure but gymnosperm and dicots soon start undergoing secondary growth.

Secondary growth in dicot stem

[A] Secondary growth in stelar region or secondary growth in vascular region

Secondary growth in stelar region begins earlier than the extra stelar region.

I. Formation of ring of vascular cambium : - A cambium which is present inside the vascular bundle is called **intrafascicular – cambium**. This is a type of primary meristem.

- First of all, cells of medullary rays become meristematic to form interfascicular cambium which is secondary lateral meristem.
- Intrafascicular and interfascicular cambium are collectively known as **vascular cambium**. Vascular cambium is formed in the form of a complete ring which is made up of single layer of cells.
- In dicot stem some part of vascular cambium is primary and some part is secondary.
- Two types of cells are found in the ring of this vascular cambium.

  (i) Fusiform initials

  (ii) Ray initials.
- Fusiform initials are long with **pointed ends**, while ray initials are **spherical** (oval).
- **Amount of fusiform initials** is more in **vascular cambium**.

II. Activity of vascular fusiform initials :

(a) Activity of fusiform initials :

- Continuous **periclinal** divisions or **tangential** division takes place in fusiform initials .
- This type of activity few cells are formed towards the periphery and these cells differentiate into secondary phloem or bast and some of the cells are formed towards the central axis and these cells are differentiated into secondary xylem or wood.
- Normally more secondary xylem is formed as compared to secondary phloem due to unequal distribution of hormones.

  (Secondary xylem is formed 8-10 times more as compared to sec. phloem).
- By the pressure of newly formed secondary phloem, primary phloem and initially formed secondary phloem is pushed towards the outside and get crushed.
- The primary xylem however remain less or more intact in or around centre.
- By the pressure of secondary xylem, all the primary tissues-such as primary xylem, pith etc and old secondary xylem degenerates in the centre of the stem. Due to this, central part of the stem becomes woody. These activities are going on continuously in plants throughout the life.

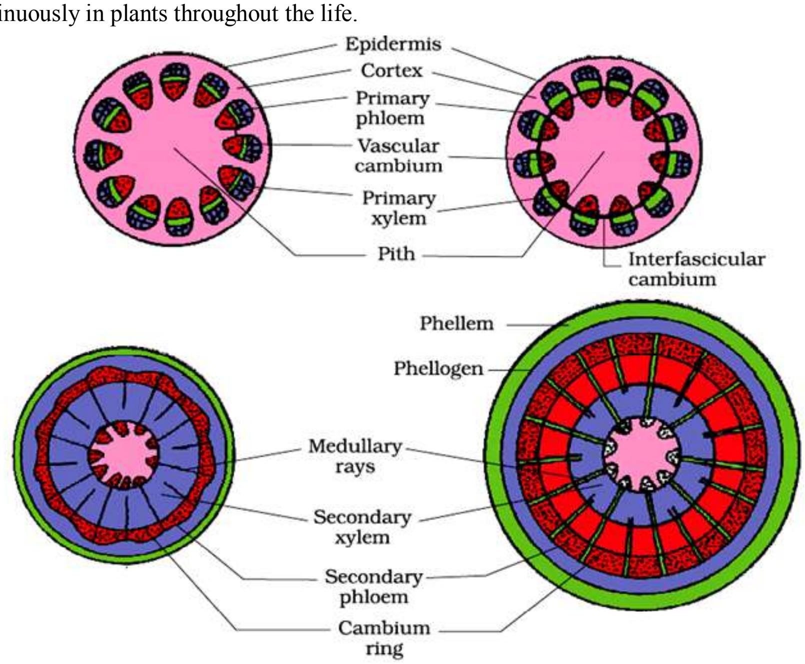


Fig.: Secondary growth in a dicot stem (diagrammatic) – stages in transverse views

- Secondary xylem forms in plant regularly and primary tissues degenerate continuously. This new secondary xylem also degenerate the old secondary xylem. Waste materials are formed in the stem such as **lignin, suberin, tannin, resin, gums** etc. due to degeneration of the cells. All these waste materials are filled in the **lumen** (cavity) of **tracheids** and **vessels of secondary xylem**.

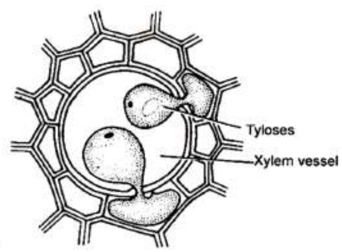
  Because of this, wood in the central region of the stem becomes dark coloured (Black brown). It is called **Heart wood or Duramen**. The peripheral or outer wood which looks light in colour is known as **Sap wood or Alburnum**. As a result of growth of secondary xylem, the **diameter** of **heart wood increases**.

  Physiologically active wood is sapwood. The main function of sap wood is water conduction. Heart wood provides maximum mechanical strength to stem.

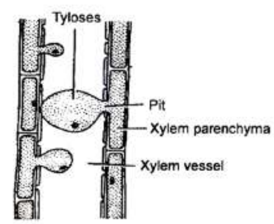
  Note : Conduction of water is not carried out by heart wood because : -

1. Cavities of tracheids and vessels are progressively filled by waste materials.
2. The bladder like ingrowth of parenchyma cells, which enter the lumen of vessels (mainly) & tracheids through the pits in their wall. Such bladders like ingrowth are called as **tyloses**. Tyloses blocks the **conduction** of water.

   Note: In gymnosperms **tylosoids** are formed in place of tyloses.



T.S. of Sec. xylem vessels showing tyloses



L.S. of Sec. xylem vessels showing tyloses

Special points

1. If the heart wood is destroyed in any stem, then there will be no effect on plants (any vital function is not effected), but if the sap wood is destroyed, then the plant will die because conduction of water will be blocked.
2. Study of wood is known as **Xylotomy**.
3. If a wood is exposed freely in air then **decomposition** of **sap wood** takes place **rapidly**.
4. Position of youngest layer of secondary phloem is just outside the vascular cambium.
5. Position of oldest layer of secondary phloem is just inside the primary phloem.
6. Position of youngest layer of secondary xylem is just inside the vascular cambium.
7. Position of oldest layer of secondary xylem is just outside the primary xylem.
8. If xylem is blocked then shoot will die first.

   Activity of ray initial : - Periclinal divisions are also going on continuously in ray intials of vascular cambium. Some of the cells are formed towards inside and some of the cells are formed towards outside through these divisions and these cells are made up of parenchyma. Radial lines of cells of parenchyma are formed in the stem. These are called **Vascular rays or Sec. medullary rays.** They conduct **water** and **food** in **radial direction**. Order of development of vascular rays is both centripetal and centrifugal manner. They pass through secondary xylem to secondary phloem in radial manner.

III. Formation of annual rings (spring wood and autumn wood)

Annual rings are formed due to unequal activity of vascular cambium.

- The activity of cambium does not remain same, it is **changeable** through out whole year. Activity of vascular cambium is affected by physiological and environmental factors.
- In **winter** or **autumn** season the activity of the cambium is less and forms fewer xylary elements. Cells formed during this period, are small, thick walled darker with higher density and have narrow lumens. This is called **autumn wood** or **late wood**.
- The vascular cambium is highly active in **spring** or **summer** season and produce a large number of xylary element and cells of secondary xylem are larger, thin walled lighter in colour with a lower density and have wider lumen. This wood is known as **spring wood** or **early wood**.
  (1) The **autumn** and spring wood are formed in the form of rings. The ring of any type of wood is called **growth ring**. Thus **two growth** rings are formed in one year and they collectively constitute annual ring.
  (2) The numbers of annual rings, formed in a tree give the idea of the age of the tree. The study of determination of age of the plant by this technique is called **Dendrochronology**.
  (3) The annual rings are counted from the base of the stem because basal part has maximum annual rings and upper part has less. Therefore counting from the basal region can give the correct idea.

- The width of annual ring is less in unfavorable conditions and more in favorable conditions. Thus the annual rings are also indicative of environment period, the tree has encountered perviously.

(4) A piece is taken from the stem from the base of stem with the help of **increment borer** instrument. The annual rings are counted from that piece and again inserted (fitted) into the same stem at the same place.

(5) More **distinct** annual rings are formed in that region where climatic variations are sharp.

(6) More distinct annual rings are formed in **temperate** plants.

(7) Distinct annual rings are not formed in tropical plants.

(8) Distinct annual rings are not formed in India except **Himalayan** regions.

(9) Least distinct annual rings are formed in **seashore** regions because the climate remains same through out the year.

(10) More clear annual rings are formed in **deciduous** plants as compared to **evergreen** plants. (In temperate region)

(11) In deserts annual rings are less distinct.

[B] Secondary growth in extra stelar region (cork cambium) :

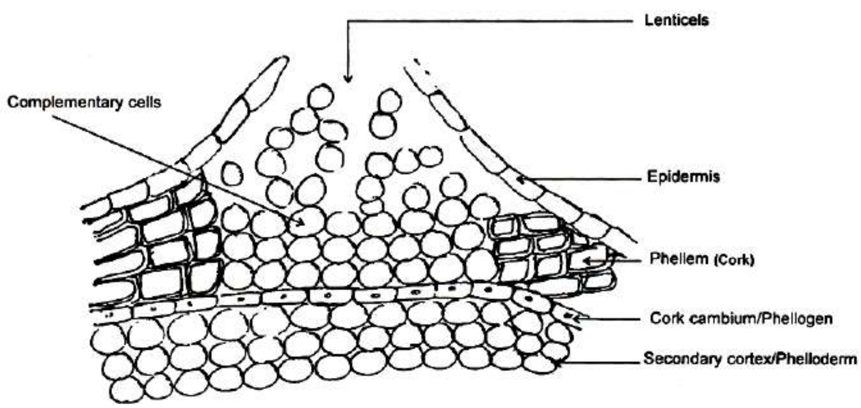
- Secondary growth takes place in extra stelar region due to the activity of cork cambium. Cork cambium is also known as Phellogen or Extrastelar cambium.
- Cork cambium arises from the hypodermis or from the outer layer of cortex because they become meristematic.
- Cork cambium forms some cells towards the outside (epidermis) and some cells towards the inside (cortex). Those cells formed towards outside, their middle lamella is suberized. Due to this, these cells become dead. These cells are known as Cork or Phellem. Those cells formed towards the inside, are differentiated into parenchyma and may contain chloroplasts. These are called secondary cortex or Phelloderm.

  Phellem (cork) + Phellogen (cork cambium) + Phelloderm (secondary cortex) = Periderm
- Cork is formed in more quantity and secondary cortex is in less quantity because activity of Cork cambium is more towards outside. The maximum activity of cork cambium is in **winter** (Autumn) season.

Bark :

- All the tissues situated out side the vascular cambium is called **Bark**. According to modern view bark includes both living and dead tissues. **Bark** has two parts. Outer layer of bark is called **Rhytidome** and inner layer of bark is **secondary** phloem.
- Bark that is formed early in the season is called early or soft Bark. Towards the end of season late or hard bark is formed.

Lenticels :



At certain region the phellogen cuts off closely arranged parenchymatous cell on the outer side of the cork cell instead of cork cell (complementary cell). These cell rupture and form lens shaped opening which is known as Lenticels.

Function :

1. The main function of lenticels is exchange of gases between plant and atmosphere.
2. Transpiration also takes place through the lenticles, is known as **Lenticular transpiration**.
3. Adventitious roots on cutting originate from the living cells of lenticels in vegetative reproduction.

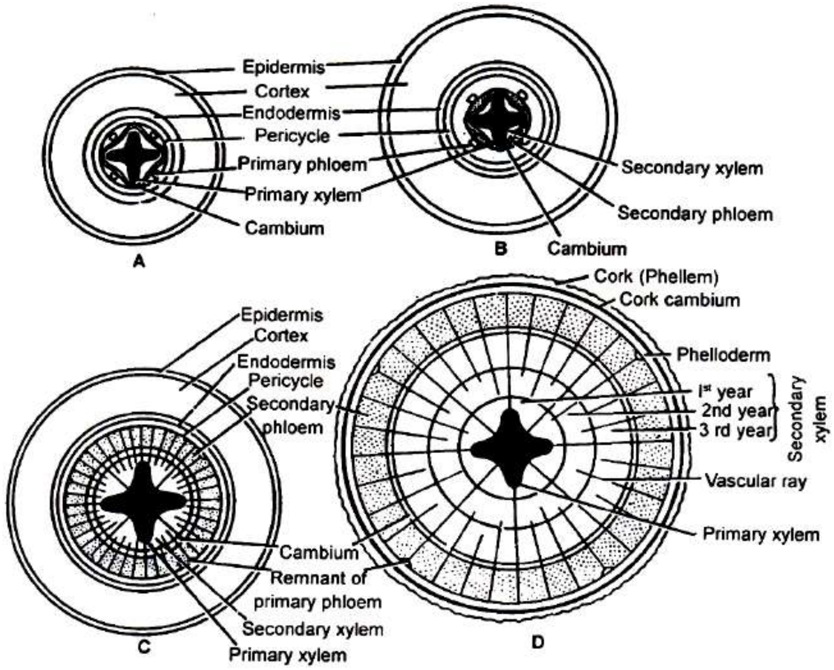
Note :

- Lenticels are found in most of the **woody trees** but absent in woody climbers.
- Lenticles are present all over the plant body. They are also present on **fruits**. They are never found on leaves.

SECONDARY GROWTH IN DICOT ROOT

- First of all, conjunctive tissue becomes meristematic during the secondary growth in a dicotyledon root and form separate **curved strips** of vasular cambium below phloem bundles. Then after, the cells of pericycle lying opposite to protoxylem also become meristematic to form additional strips of cambium. In this way a complete ring of vascular cambium is formed.

  The portion of vascular cambium formed by pericycle is less. The main portion of vascular cambium is formed by conjunctive tissue. Vascular cambiums in roots are secondary in origin.



Different Stages in Secondary Growth of Dicot Root

- The activity of vascular cambium of root is the same as the activity of vascular cambium of stem. Secondary xylem is formed towards the inner side and secondary phloem is formed towards the outer side by vascular cambium.
- The portion of vascular cambium which is formed by pericycle is responsible for the formation of **pith rays.** These are made up of parenchyma. These pith rays are known as **primary medullary rays** (Multiseriate).
- A few medullary or pith rays are also formed from remaining vascular cambium. These are called **secondary medullary rays** (uniseriate). Thus two types of medullary rays are found in the secondary structure of roots.

  Note : The presence of two types of medullary rays is basic characteristic feature of roots. Only secondary medullary rays are found in stem after the secondary growth. Both of them conduct **water** and **food in radial direction.**
- Cork cambium is developed from the **pericycle** in roots. Cork is formed towards the outside and secondary cortex is formed towards the inner side by the cork cambium. Lenticles are also found in roots but less in number as compared to stem. Cortex completely degenerate in roots after the secondary growth of one or two years. This falls down due to the pressure of cork, whereas in stem, it degenerates after the long duration.

  (i) Secondary growth is essential in roots to provide strength to the growing aerial parts of the plants and fulfill the requirement of water and minerals.

  (ii) Annual rings are not formed in roots because these are not effected by the changes of environment.

  (iii) Secondary growth is not found in monocot roots. Secondary growth present in *Yucca* and *Dracnea*.

  (iv) In roots, all cambia are secondary in origin.

Important Comparison Tables

Porous wood (Hard wood)	Non porous wood (Soft wood)
(i) This wood is found in angiosperms	It is found in Gymnosperms.
(ii) Vessels are present.	Vessels do not present.
(iii) This wood is hard.	It is soft.
(iv) Xylem fibres are present.	Xylem fibres are rarely present.
(v) Vessels are more in porous wood.	Xylem tracheids are dense.
(vi) It is also called heteroxylous wood	It is called homoxylous wood.

Duramen (Heart wood)	Alburnum (Sap wood)
(i) Duramen wood dark in colour.	Alburnum wood light in colour.
(ii) This wood does not conduct water.	Alburnum wood conduct the entire water.
(iii) In this wood, Tyloses are present.	In this wood tyloses are not present.
(iv) It gives the mechanical support to the plant.	It does not gives mechanical support.
(v) It is present in the central part of the tree stem.	It is found in outer part of stem.

Spring wood	Autumn wood
(i) Spring wood are generally light brown in colour.	Autumn wood are dark brown in colour.
(ii) In plant, its quantity is more.	In plant, its quantity is less.
(iii) Its vessel are broad and with large cavity.	Its vessels are small and with narrow cavity.
(iv) It is made up in favourable conditions.	It is made up in unfavourable conditions.
(v) It is produce from more activity of cambium.	It is produce from less activity of cambium.
(vi) In wood, the fibre are less present.	In wood, the fibre are more present.

Exercise 1

Question based on Introduction

Q.1 A tissue is a group of cells which are -
(1) Similar in origin, but dissimilar in form and function
(2) Dissimilar in origin, form and function
(3) Dissimilar in origin, but similar in form and function
(4) Similar in origin, form and function

Q.2 A meristem may be defined as the group of cells which
(1) Add to the bulk of the Plants
(2) Conserve food
(3) Divide continuously to give rise to new cells
(4) Elongate and add to the group of cells

Q.3 Embryo of a seed is made up of –
(1) Meristematic tissue (2) Parenchyma
(3) Collenchyma (4) Sclerenchyma

Q.4 Maximum growth in root occurs –
(1) At its tip (2) Towards light
(3) Behind the apex (4) Towards apex

Q.5 In plants, during embryonic condition –
(1) All cells of the embryo divide
(2) Meristematic activity is confined to single apical cell
(3) Meristematic activity is confined to a group of apical cells
(4) Apical & lateral cells only divide

Q.6 The function of root cap is -
(1) Protection of root tip and control of geotropic movement
(2) Storage of food products
(3) Absorption of nutrients
(4) None of the above

Q.7 In quiescent zone, DNA content is -
(1) High (2) Low
(3) Very high (4) Balanced

Question based on Plant Tissue

Q.8 Bamboo, grass and mint stem elongate by the activity of -
(1) Primary meristem (2) Secondary meristem
(3) Intercalary meristems (4) Apical meristems

Q.9 A. Generally absent in primary phloem
B. Elongated unbranched pointed needle shaped cell
C. Devoid of protoplasm at maturity
D. Can be used commercially
Above mentioned statement can belongs to -
(1) Sclereids (2) Xylem sclerenchyma
(3) Phloem fiber (4) Xylem trachied

Q.10 Which of the following is a well differentiated plant tissue ?
(1) Apical meristem (2) Cambium
(3) Parenchyma (4) All of the above

Q.11 Which of the following is a primary meristem ?
(1) Intra fascicular cambium
(2) Cork cambium
(3) Vascular cambium in roots
(4) Inter fascicular cambium

Q.12 The secondary meristem originates from -
(1) Promeristem (2) Primary meristem
(3) Permanent tissue (4) Secretory tissue

Q.13 Which of the following is secondary meristem?
(1) Protoderm (2) Procambium
(3) Cork cambium (4) All of the above

Q.14 The cells of a permanent tissue do not divide because these are -
(1) Dead (2) Enucleate
(3) Arrested at G-1 stage (4) Arrested at prophase

Q.15 A parenchyma cell which stores ergastic materials or waste substance is -
(1) Phragmoblast (2) Conidioblast
(3) Idioblast (4) Blastomere

Q.16 In plants, which of the following would most likely show totipotency -
(1) Xylem Vessels (2) Meristem
(3) Cork (4) Sieve tube

Q.17 The tissue not having specifically thickened walls are -
(1) Parenchyma (2) Collenchyma
(3) Fibres (4) Sclereids

Q.18 Which of the following tissues form the main bulk of storage organ -
(1) Parenchyma (2) Collenchyma
(3) Sclerenchyma (4) Aerenchyma

Q.19 Flesh of a fruit is mostly made up of -
(1) Parenchyma (2) Collenchyma
(3) Sclereids (4) Meristem

Q.20 Collenchyma is found in -
(1) Herbaceous climbers (2) Hydrophytes
(3) Woody climbers (4) Xerophytes

Q.21 A simple mechanical tissue devoid of lignin is -
(1) Parenchyma (2) Collenchyma
(3) Sclerenchyma (4) Chlorenchyma

Q.22 Collenchyma differs from sclerenchyma in -
(1) Retaining protoplasm at maturity
(2) Having thick walls
(3) Having a wide lumen
(4) Being meristematic

Q.23 Prosenchyma forms -
(1) Root-pericycle (2) Stem-pericycle
(3) Root-endodermis (4) Stem-hypodermis

Q.24 Which of the following tissue provide tensile strength against bending & swaying –
(1) Parenchyma (2) Collenchyma
(2) Sclerenchyma (4) Sclereids

Q.25 Sclerenchymatous cells in their cell walls have large percentage of -
(1) Cellulose (2) Pectin
(3) Lignin (4) Silica

Q.26 Fibre (longest plant cell), belongs to which tissue
(1) Parenchyma (2) Collenchyma
(3) Sclerenchyma (4) Aerenchyma

Q.27 Tissue which develops more due to scarcity of water –
(1) Sclerenchyma (2) Collenchyma
(3) Parenchyma (4) Meristem

Q.28 All the xylem elements, when mature are dead except -
(1) Tracheids (2) Vessels
(3) Xylem Parenchyma (4) Xylem Fibre

Q.29 Which of the following plant cells are without vacuoles and without nuclei -
(1) Cambium cells (2) Xylem vessels
(3) Root hairs (4) Companion cells

Q.30 Vessels differ from tracheids –
(1) In being living
(2) In being derived from a single cell
(3) In having vertical row of cells with cross walls dissolved
(4) Because they conduct water

Q.31 The tissue responsible for translocation of food material is –
(1) Parenchyma (2) Sieve tubes
(3) Vessels (4) Fibers

Q.32 Phloem of angiosperm is different from that of pteridophytes and gymnosperm in –
(1) The absence of enzymes
(2) Presence of endocytosis
(3) Presence of companion cells
(4) Presence of sieve tubes

Q.33 Cell which is functionally related to sieve tube
(1) Phloem fiber (2) Phloem parenchyma
(3) Companion cell (4) Collenchyma

Q.34 Mature sieve tube differs from vessels -
(1) Absence of functional nuclei
(2) Absence of lignified wall
(3) Almost Dead
(4) Absence in cytoplasm

Q.35 Vessels in xylem and companion cell in phloem is characteristic feature of -
(1) Gymnosperm (2) Pteridophyta
(3) Angiosperm (4) Bryophyta

Q.36 Sieve plate in angiosperm are present in
(1) Oblique and lateral wall
(2) Straight and end wall
(3) Oblique and end wall
(4) Straight and lateral wall

Q.37 Thickening in collenchyma occurs the due to deposition of
(1) Cellulose (2) Pectin
(3) Lignin (4) Suberin

Q.38 Complex tissue are not present in
(1) Some Bryophyta (2) Pteridophyta
(3) All gametophyte (4) All spermatophyta

Q.39 Main function of tracheids in plants are
(1) Sap conduction
(2) Only mineral transportation
(3) Loss of excess water in night
(4) Translocation of organic solute

Q.40 Presence of vessels in plant is
(1) A primitive character
(2) A progressive character
(3) A vestigial character
(4) None of the above

Q.41 End wall of tracheids and vessels are
(1) Pitted and porous
(2) Porous and pitted
(3) Both porous
(4) Both pitted

Q.42 Xylem fibers provide strength to
(1) Vessels
(2) Tracheids
(3) Parenchyma
(4) Storage tissue

Q.43 Sieve tube elements are ideal component for nutrients translocation because -
(1) End wall is not present
(2) Bordered pits are present
(3) Narrow lumen rich in cytoplasm
(4) Broad lumen with small quantity of peripheral cytoplasm

Q.44 Long pointed sclerenchyma cells are –
(1) Fibres (2) Tracheae
(3) Wood parenchyma (4) Sclereids

Q.45 Sieve tubes are characterised by –
(1) Absence of septa
(2) Simple oblique septa
(3) Perforated longitudinal walls
(4) Perforated oblique septa

Q.46 Sugar transport elements of gymnosperms & pteridophytes are –
(1) Sieve cells (2) Sieve elements
(3) Sieve tubes (4) Sieve tube elements

Q.47 Abscission layer is made up of –
(1) Cork cells (2) Sclerenchymatous cells
(3) Collenchymatous cells (4) Parenchymatous cells

Q.48 Gymnosperm wood is non porous because it –
(1) Lacks vessels
(2) Contains tracheae
(3) Has abundant fibres
(4) Contains no fibres

Q.49 Meristematic activity is at its maximum in the
(1) Shoot apex (2) Bud
(3) Leaf (4) Root hair

Q.50 Which of the following cell is not totipotent
(1) Pollen grain
(2) Sieve tube
(3) Pith cell
(4) Parenchyma

Question based on
The Tissue System

Q.51 Epidermal cells are -
(1) Guard cells (2) Root hairs
(3) Trichomes (4) All of the above

Q.52 When xylem and phloem are on same radius, the vascular bundles are said to be –
(1) Radial (2) Conjoint
(3) Concentric (4) Exarch

Q.53 When a meristematic tissue "Cambium" is present inside a vascular bundle, the bundle is said to be –
(1) Conjoint (2) Open
(3) Closed (4) Collateral

Q.54 A vascular Bundle in which phloem is on both the sides of the xylem and separated from it by strips of cambium is said to be –
(1) Collateral open (2) Bicollateral open
(3) Concentric (4) Bicollateral closed

Q.55 A concentric Amphivasal vascular bundle is that in which -
(1) centrally located xylem is surrounded by phloem
(2) centrally located phloem is surrounded by xylem
(3) Phloem is flanked by xylem on interior sides only
(4) xylem is flanked by phloem on exterior sides only

Q.56 The basic difference between stem and root is that stem is –
(1) Endarch (2) Exarch
(3) Mesarch (4) Polyarch

Q.57 At certain region the phellogen cut off closely arranged parenchymatous cell on the outer side instead of cork cell, these cell rupture the epidermis and form
(1) Stomata (2) Hydathodes
(3) Lenticels (4) (2) & (3) both

Q.58 Bulliform cells are –
(1) Water filled and highly vacuolated epidermal cell
(2) Prokaryotic cell
(3) Eukaryotic cell
(4) Ball like parenchymatous cells

Q.59 In general, the cells of cortex lack –
(1) Chlorophyll (2) Nucleus
(3) Reserve food (4) Nucleous

Q.60 Which of the statement is correct
(1) Organic food movement up by phloem
(2) Organic food movement up and down by phloem
(3) Organic food movement up and down by xylem
(4) All of these

Q.61 In roots, the pericycle give rise to –
(1) Lateral roots and Cork cambium
(2) Cortex and Pith
(3) Xylem and Phloem
(4) Epidermis and Vascular bundles

Q.62 T.S. of a Material exhibits conjoint collateral endarch and closed bundles scattered in a ground tissue what should be the material –
(1) Monocot root (2) Dicot root
(3) Monocot stem (4) Dicot stem

Q.63 In which of the following order, an exarch xylem develops –
(1) Centripetal
(2) Centrifugal
(3) Both centripetal & centrifugal
(4) Irregular

Q.64 The function of hypodermis is –
(1) Protection (2) Hardness
(3) Support (4) Storage

Q.65 The hypodermis present in maize stem is –
(1) Parenchymatous (2) Collenchymatous
(3) Sclerenchymatous (4) Meristematic

Q.66 Pith is produced by –
(1) Ground meristem (2) Procambium
(3) Periblem (4) Dermatogen

Q.67 When protoxylem faces pericycle, it is called –
(1) Endarch (2) Mesarch
(3) Exarch (4) Polyarch

Q.68 Fatty substance found in epidermal cell walls is-
(1) Cutin (2) Suberin
(3) Wax (4) Both (2) & (3)

Q.69 Stomata in true hydrophyte are present on
(1) upper epidermis (2) lower epidermis
(3) not on any surface (4) Both surface

Q.70 Layer of cell which is present in between endodermis and vascular tissue -
(1) Cortex (2) Pith
(3) Pericycle (4) Exodermis

Q.71 Leaves of some grasses shows rolling and unrolling. It occurs due to -
(1) Parellel venation (2) Isobilateral nature
(3) Thin wall (4) Bulliform cell

Q.72 In older, woody tissue, the gaseous exchange takes place through –
(1) Lenticel (2) Hydathode
(3) Stomata (4) Aerenchyma

Q.73 Stomata are absent in the epidermis of
(1) Leaf (2) Stem
(3) Branch (4) Root

Q.74 Amount of secondary xylem as compared to secondary phloem formed every year is –
(1) Equal (2) 8-10 times
(3) Half (4) 4-5 times

Q.75 Lenticels and its complementary cells are developed through the activity of –
(1) Phellogen (2) Stelar cambium
(3) Dermatogen (4) Intercalary meristem

Q.76 External Protective tissues are –
(1) Cortex and epidermis (2) Cork and pericycle
(3) Cortex and pericycle (4) Cork and epidermis

Q.77 Which of the tissue is present in periderm ?
(1) Xylem (2) Bast
(3) Phellem (4) Duramen

Q.78 If a stem is girdled –
(1) Root dies first (2) Shoot dies first
(3) Both die together (4) None of the above die

Q.79 Vascular cambium cuts cells more actively -
(1) Towards centre (2) Towards periphery
(3) In winter (4) In roots

Q.80 Formation of vascular rays occurs in which order-
(1) Centripetal (2) Centrifugal
(3) Acropetal order (4) (1) & (2) both

Q.81 Youngest layer of secondary xylem is located –
(1) In centre of stem
(2) Just outside pith
(3) Just outside vascular cambium
(4) Just inside vascular cambium

Q.82 Formation of secondary xylem and phloem respectively –
(1) Centrifugal and centripetal
(2) Centripetal and centrifugal
(3) Both the centripetal
(4) Both the centrifugal

Q.83 Formation of which tissue is example of dedifferentiation -
(1) Inter fascicular cambium
(2) Apical meristem
(3) Intra fascicular cambium
(4) Inter calary meristem

Q.84 Cork cambium is –
(1) Always primary meristem
(2) Always secondary meristem
(3) May be secondary or primary meristem
(4) Partly primary & partly secondary meristem

Q.85 Lenticels are –
(1) Scars on old stem
(2) Special stomata
(3) Aerating pores in bark
(4) Special stomata on hydrophytic plants

Q.86 Intrafascicular cambium is situated –
(1) In between the vascular bundles
(2) Inside the vascular bundles
(3) Outside the vascular bundles
(4) In pith

Question based on Anatomy of Dicotyledonous and Monocotyledonous Plant

Q.87 Phloem parenchyma is absent in -
(1) Dicot stem (2) Dicot leaf
(3) Monocot stem (4) Dicot root

Q.88 Casparian strip are characteristic feature of ....A........ endodermis and it is made up of ....B....... . What is A and B respectively -
(1) Shoot, Suberin (2) Root, Lignin
(3) Root, Suberin (4) Root & shoot, Suberin

Q.89 Collenchymatous hypodermis is characteristic feature in –
(1) Dicot stem
(2) Monocot stem
(3) Monocot as well as dicot stem
(4) Hydrophytes

Q.90 Resin ducts are found in –
(1) Pine (2) Bamboos
(3) Teak (4) Sal

Q.91 Cortex and pith are not distinguished in –
(1) Monocot stem (2) Monocot root
(3) Dicot stem (4) Dicot root

Q.92 What is the characteristics of a vascular bundle of monocot stem ?
(1) Open and surrounded by a sclerenchymatous bundle sheath
(2) Closed and not surrounded by bundle sheath
(3) Closed and surrounded by bundle sheath
(4) Open and not surrounded by a bundle sheath

Q.93 In dicot Root –
(1) Vascular bundles are scattered with cambium
(2) Vascular bundles are open and arranged in a ring
(3) Xylem and pholem are radial
(4) Xylem is always endarch

Q.94 The dicot root is identify by the presence of –
(1) Exarch xylem
(2) 2-6 radial vascular bundles
(3) > 6 radial vascular bundles
(4) Absence of pith and endodermis

Q.95 Sclerenchymatous bundle sheath is present in –
(1) Grass (2) Sunflower
(3) Banyan (4) Grain

Q.96 Lysigenous cavity & Y-shaped xylem occurs in–
(1) Dicot stem
(2) Monocot root
(3) Monocot stem
(4) Dicot root

Q.97 Which would do maximum harm to a tree ?
(1) Loss of half of its leaves
(2) Loss of half of its branches
(3) Loss of all of its leaves
(4) Loss of all its bark

Q.98 Normal secondary growth takes place in –
(1) Dicots & Monocots
(2) Gymnosperms & Monocots
(3) Dicots & Gymnosperms
(4) Only in dicots

Q.99 Normally in dicot stems, phellogen develops from-
(1) Hypodermis
(2) Phellem
(3) Endodermal cells
(4) Epidermal & pericycle cells

Q.100 In monocot stems, secondary growth cannot occur because vascular bundles are –
(1) Scattered (2) open
(3) Closed (4) Radial

Q.101 The process by which the plant becomes woody is called -
(1) Calcification (2) Lignification
(3) Impregnation (4) Fossilization

Q.102 Passage cells are more distinct in endodermis of-
(1) Dicot stem (2) Monocot stem
(3) Dicot root (4) Monocot roots

Question based on Internal Structure of Leaf

Q.103 Monocot leaves grow by -
(1) Apical meristem (2) Lateral meristem
(3) Intercalary meristem (4) Dermatogen

Q.104 Which of the following is present in monocot leaves
A. Bulliform cell
B. Leaf base
C. Bundle sheath
D. Resin gland
E. Water cavity
(1) A, B, C & E (2) A, B, D, E
(3) A, B, E (4) A, B, C

Q.105 Position of protoxylem & protophloem in leaf respectively –
(1) Abaxial & Adaxial (2) Adaxial & Abaxial
(3) Both Adaxial (4) Both abaxial

Q.106 In leaves, the vascular bundles are –
(1) Bicollateral & open (2) Collateral & open
(3) Collateral & closed (4) Radial & exarch

Exercise 2

Q.1 In plants maximum growth occurs during which season –
(1) Summer (2) Winter
(3) Autumn (4) Spring

Q.2 The tracheids differ from vessels in having –
(1) Thick wall
(2) Bordered pit
(3) Presence of pitted end wall
(4) Spiral thickening

Q.3 In Cucurbita stem vascular bundles are –
(1) Radial (2) Collateral
(3) Concentric (4) Bicollateral

Q.4 "Bast-fibers" obtained from which part of woody stem –
(1) Cork (2) Cortex
(3) Xylem (4) Phloem

Q.5 Thickness of stem increases due to activity of –
(1) Cambium (2) Xylem
(3) Phloem (4) Shoot apex

Q.6 Non-porous wood is found in which plants –
(1) Dicots (2) Monocots
(3) Gymnosperm (4) Cactus

Q.7 In dorsiventral leaf phloem is found in which side
(1) Adaxial
(2) Abaxial
(3) Lateral
(4) Adaxial and Abaxial both

Q.8 The leaves having stomata on both the surfaces are called as –
(1) Amphistomatic (2) Hypostomatic
(3) Epistomatic (4) Astomatic

Q.9 Most distinct annual rings are formed in which region -
(1) Tropical (2) Temperate
(3) Arctic (4) Equatorial

Q.10 Vessels and companion cells are characteristic feature of –
(1) Gymnosperm (2) Angiosperm
(3) Pteridophyta (4) Bryophyta

Q.11 Grafting is not possible in monocots because –
(1) Vascular bundles are scattered
(2) Vascular bundles are closed
(3) Hypodermis is sclerenchymatous
(4) Vascular bundles are open

Q.12 Companion cells are associated with –
(1) Tracheids of Angiosperms
(2) Vessels of Angiosperms
(3) Tracheids of Gymnosperms
(4) Sieve tubes of Angiosperms

Q.13 Lateral roots are arises from –
(1) Pericycle (2) Cortex
(3) Pith (4) Endodermis

Q.14 Bulliform cells are found in –
(1) Seeds of sunflower (2) Leaf of wheat
(3) Pod of pea (4) Tuber of potato

Q.15 In the T.S. of root –
(1) Protoxylem and metaxylem are not present on same radius
(2) Protoxylem is absent
(3) Protoxylem towards inside and metaxylem towards outside
(4) Metaxylem is towards inside and protoxylem towards outside

Q.16 The resin duct of Gymnosperm is an example of –
(1) Intracellular space
(2) Schizogenous cavity
(3) Lysigenous cavity
(4) Vacuole containing stored material

Q.17 Root cap is absent in –
(1) Mesophytes (2) Hydrophytes
(3) Epiphytes (4) Xerophytes

Q.18 Girth of dicot stem increases by the activity of –
(1) Apical meristem (2) Intercalary meristem
(3) Lateral meristem (4) Procambium meristem

Q.19 Which type of vascular bundles are found in monocot stem –
(1) Collateral, open, endarch
(2) Radial, open, diarch
(3) Radial, open, mesarch
(4) Collateral, closed, endarch

Q.20 The cells without nuclei are present in -
(1) Vascular cambium (2) Root hair
(3) Companion cell (4) Members of sieve tube

Q.21 The difference in phloem of Gymnosperms & Angiosperms is due to –
(1) Parenchyma (2) Sieve cell
(3) Companion cell (4) Fibres

Q.22 The position of protoxylem in leaf is –
(1) Adaxial
(2) Abaxial
(3) Surrounded by metaxylem
(4) Lateral

Q.23 Vascular cambium is more active towards -
(1) Outer side
(2) Inner side
(3) Sometime innerside, some time outside
(4) Equal on both side

Q.24 A student prepared two slide of leaves, but forget to label these slide. A slide show variable size vascular bundle and differentiated leaf mesophyll while B slide show almost similar size vascular bundle and undifferentiated mesophyll.
What type of leaves are A & B
(1) A = Isobilateral, B = Dorsiventral
(2) A = Dorsiventral, B = Isobilateral
(3) Can not be determined
(4) A = Dorsiventral, B = Dorsiventral

Q.25 Function of cork cambium is to produce –
(1) Secondary xylem & secondary phloem
(2) Cork & secondary cortex
(3) Secondary phloem & secondary cortex
(4) Cork

Q.26 Mesophyll is differentiated in spongy and palisade tissue in -
(1) Isobilateral leaf (2) Dorsiventral leaf
(3) Both (1) and (2) (4) None of these

Q.27 Which of the following is not a character of dicot root -
(1) Radial vascular bundle
(2) Secondary growth
(3) Pith less developed or absent
(4) Vascular bundles 15-20

Q.28 The continuity of protoplasm from cell to cell is maintained through -
(1) Stomata (2) Tracheids
(3) Vessels (4) Plasmodesmata

Q.29 Which of the following is not adaptation of Xerophytes ?
(1) Spongy tissue
(2) Well developed mechanical tissue
(3) Well developed vascular tissue
(4) Thick cuticle

Q.30 Sieve tube differs from vessels in –
(1) Absence of nucleus
(2) Less deposition of lignin
(3) Being dead
(4) Lack of cytoplasm

Q.31 Periderm includes -
(1) Phellem
(2) Phelloderm
(3) Phellogen
(4) Phellem, phelloderm, phellogen

Q.32 Lignin is a major component of cell wall of -
(1) Xylem (2) Phloem
(3) Parenchyma (4) Cambium

Q.33 In a woody dicotyledonous tree, which of the following parts will mainly consist of primary tissues ?
(1) Stem and root
(2) All parts
(3) Shoot tips and root tips
(4) Flowers, fruits and leaves

Q.34 Which xylem element is living -
(1) Vessels (2) Tracheids
(3) Fibre (4) Parenchyma

Q.35 Monocot root is differ from dicot root in having-
(1) Open vascular bundle
(2) Scattered vascular bundle
(3) Large pith
(4) Radial vascular bundle

Q.36 Autumn wood can be differentiated from spring wood by -
(1) Broad vessels and tracheids
(2) Narrow vessels and tracheids
(3) Red colour of xylem
(4) Cambium

Q.37 Vascular cambium forms -
(1) Secondary xylem and Secondary phloem
(2) Primary xylem and Primary Phloem
(3) Only Secondary phloem
(4) Only Primary xylem

Q.38 There is no result of 'Girdling Experiment' in monocot plants, due to -
(1) Presence of wax layer on the surface of its stem
(2) Stem is comparatively thin
(3) Phloem is inside xylem
(4) Vascular bundles are not in specific position

Q.39 Radial vascular bundles are found in -
(1) Only dicot root
(2) Only monocot root
(3) Only Pteridophyta
(4) Root of all vascular plants

Q.40 Cork cambium represents -
(1) Secondary meristem (2) Primary meristem
(3) Intercalary meristem (4) Apical meristem

Q.41 Cambium is a lateral meristem, as it -
(1) Increases girth (2) Forms lateral branches
(3) Lies on nodes (4) Increases length

Q.42 Root apex has a zone of slow dividing cells in the middle of rapidly dividing cells, it is -
(1) Quiescent centre (2) Sluggish centre
(3) Dormant centre (4) Non meristematic zone

Q.43 Root apex is subterminal because it is -
(1) Covered by root hairs (2) Covered by root cap
(3) Covered by epidermis (4) Under the soil

Q.44 Apical, intercalary and lateral meristems are differentiated on the basis of -
(1) Development (2) Origin
(3) Function (4) Position

Q.45 Active divisions occur in the cells of -
(1) Xylem (2) Phloem
(3) Cambium (4) Collenchyma

Q.46 Plant grow in length is due to activity of -
(1) Apical meristem (2) Dermatogen
(3) Periblem (4) Lateral meristem

Q.47 Leaf primordium grows into adult lamina by means of -
(1) Marginal meristem
(2) Lateral meristem
(3) First apical and then marginal meristem
(4) Apical meristem

Q.48 Periblem form -
(1) Endodermis (2) Cortex
(3) Both (1) and (2) (4) Epidermis

Q.49 A living mechanical tissue having pecto cellulosic wall thickening is –
(1) Sclerenchyma (2) Collenchyma
(3) Parenchyma (4) Aerenchyma

Q.50 Laticiferous vessels are found in -
(1) Xylem tissue (2) Phloem tissue
(3) Cortex (4) None of the above

Q.51 Secondary growth occurs in -
(1) Formation and division of meristematic cells
(2) Vascular region
(3) Cortical region
(4) Both (2) and (3) regions

Q.52 A narrow thin-walled cell with large nucleus and lying on the side of sieve tube is absent in -
(1) Angiosperms (2) Pteridophytes
(3) Gymnosperms (4) Both (2) and (3)

Q.53 A bundle having phloem on either side of xylem is -
(1) Bicollateral (2) Collateral
(3) Radial (4) Concentric

Q.54 Longest fibres are found in -
(1) Jute (2) Cotton
(3) Sunn Hemp (4) Coir

Q.55 Chief function of phloem is conduction of -
(1) Food (2) Minerals
(3) Water (4) Air

Q.56 Transport of water and dissolved minerals occurs through -
(1) Phloem (2) Xylem
(3) Sieve tubes (4) Sclerenchyma

Q.57 Plants yields latex is -
(1) *Ficus* (2) *Sonchus/Euphorbia*
(3) *Calotropis* (4) All of the above

Q.58 Which one of the following comprises only simple tissues -
(1) Parenchyma, Collenchyma and Sclerenchyma
(2) Parenchyma, Xylem and Collenchyma
(3) Parenchyma, Xylem and Sclerenchyma
(4) Parenchyma, Xylem and Phloem

Q.59 Mesarch xylem occurs in -
(1) Monocots (2) Dicots
(3) Ferns (4) Bryophytes

Q.60 Vessel elements differ from other elements of xylem in having -
(1) Simple and bordered pits on end walls
(2) Simple perforation on their end walls
(3) Simple pits on their radial walls
(4) Bordered pits on their lateral walls

Q.61 Match items of column-I and column-II

Column-I	**Column-II**
(a) Collateral and open	(p) Cucurbita stem
(b) Radial	(q) Fern rhizome
(c) Bicollateral	(r) Maize root
(d) Concentric	(s) sunflower stem
	(t) Maize stem

(1) a-t, b-s, c-r, d-p (2) a-s, b-r, c-p, d-q
(3) a-s, b-p, c-r, d-q (4) a-s, b-r, c-q, d-p

Q.62 Function of vessels is -
(1) Conduction of water and minerals
(2) Conduction of food
(3) Mechanical strength
(4) All of the above

Q.63 Stele consists of -
(1) Phloem (2) Xylem
(3) Pericycle (4) All of the above

Q.64 Parenchyma with larger air spaces is -
(1) Stellate parenchyma (2) Aerenchyma
(3) Angular parenchyma (4) Prosenchyma

Q.65 Jute of commerce is got from –
(1) Primary phloem (2) Secondary phloem
(3) Secondary xylem (4) Primary xylem

Q.66 Sap-wood is -
(1) Outer functional part of secondary xylem
(2) Inner non functional part of secondary xylem
(3) Outer as well as inner part of secondary xylem
(4) None of the above

Q.67 Vascular bundles in dicot stem are -
(1) Open, collateral, endarch
(2) Closed, collateral, endarch
(3) Open, collateral, exarch
(4) Closed, collateral, exarch

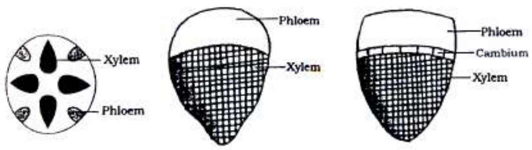
Q.68 The waxy substance associated with the walls of cork or the wall of cork cells are mostly impregenated with -
(1) Cutin (2) Suberin
(3) Lignin (4) Hemicellulose

Q.69 Function of cork cambium is to produce -
(1) Secondary xylem and secondary phloem
(2) Cork and secondary cortex
(3) Secondary cortex and phloem
(4) Cork

Q.70 Tyloses occur in -
(1) Secondary xylem (2) Secondary phloem
(3) Callus tissue (4) Cork cells

Q.71 Tyloses are -
(1) Tracheal plugs which plugs the lumen of the vessels and tracheids
(2) Compound sieve plates
(3) Specialized secretory cells
(4) Laticiferous channels

Q.72 What type of vascular bundles are A, B and C?



(1) Radial; close collateral cojoint; open collateral conjoint
(2) Close collateral conjoint; Close collateral conjoint; Radial
(3) Open collateral conjoint; Close collateral conjoint; Radial
(4) Bicollateral; Concentric; Radial

Q.73 Mesophyll is differentiated into palisade and spongy tissues in -
(1) Extremely xerophytic leaves
(2) Hydrophytic leaves
(3) Monocot leaves
(4) Dicot leaves

Q.74 Bulliform or motor cells occur in -
(1) Upper epidermis of dicot leaves
(2) Upper epidermis of monocot leaves
(3) Lower epidermis of monocot leaves
(4) Lower epidermis of dicot leaves

Q.75 Xylem is exarch in -
(1) Leaf (2) Petiole
(3) Stem (4) Root

Q.76 Sea shore trees do not show distinct annual rings because -
(1) There is little climatic variations
(2) They belong to monocots
(3) There is enough moisture
(4) Soil is sandy

Q.77 A narrow layer of thin walled cells found between phloem and wood of a dicot stem is -
(1) Cork cambium (2) Vascular cambium
(3) Endodermis (4) Pericycle

Q.78 If all the lenticels of stem are blocked, the first to die will be -
(1) Leaves
(2) Shoot tips
(3) Roots
(4) None of the above

Q.79 In a dicotyledonous stem, the sequence of tissues from the outside to the inside is -
(1) Phellem-pericycle-Endodermis-Phloem
(2) Phellem-Phloem-Endodermis-Pericycle
(3) Phellem-endodermis-Pericycle-Phloem
(4) Pericycle-Phellem-Endodermis-Phloem

Q.80 Vascular cambium forms xylem on inner side and phloem on outer side due to -
(1) Effect of gravity
(2) Shearing force of wind
(3) Intrafascicular nature
(4) Differential action of hormones

Q.81 Hard woods have -
(1) More of parenchyma (2) Vessels in abundance
(3) Tracheids mainly (4) Non-Porous nature

Q.82 Which one of the following the most durable wood -
(1) *Shorea robusta* (2) *Cedrus deodara*
(3) *Dalbergia sisso* (4) *Tectona grandis (Teak)*

Q.83 Which one is responsible for radial conduction of water and food in woody stems -
(1) Vessels (2) Vascular rays
(3) Endodermis (4) Xylem fibres

Q.84 Functional xylem of dicot tree is -
(1) Sap wood (2) Autumn wood
(3) Heart wood (4) Hard wood

Q.85 Vascular bundle with protoxylem towards the periphery is
(1) Radial (2) Endarch
(3) Exarch (4) Closed

Q.86 Secondary growth is absent in -
(1) Hydrophytes (2) Mesophytes
(3) Halophytes (4) Xerophytes

Q.87 Cell wall is impermeable to water and deposition of suberin occurs in -
(1) Bark (2) Cork
(3) Bast (4) Xylem

Q.88 In dicot root showing secondary growth, cork is found -
(1) External to primary cortex
(2) Inner to epidermis and outer to pericycle
(3) Outer to endodermis and inner to primary cortex
(4) Inner to endodermis and external to primary phloem

Q.89 In floating leaves plants stomata occur on -
(1) Lower surface (2) Upper surface
(3) Both surfaces (4) Absent

Q.90 Casparian strips occur in -
(1) Longitudinal and radial walls of epidermal cells
(2) Longitudinal walls of xylem
(3) All walls of endodermis
(4) Radial and tangential walls of endodermis

Q.91 Passage cells occur in –
(1) Epidermis (2) Cortex
(3) Endodermis (4) Pericycle

Q.92 Vascular bundles occur in a ring in -
(1) Monocot stem (2) Leaf
(3) Root (4) Dicot stem

Q.93 Predominant material present in cork cell walls is
(1) Lignin (2) Chitin
(3) Suberin (4) Pectin

Q.94 Vascular bundles of a root are -
(1) Radial (2) Concentric
(3) Collateral (4) Bicollateral

Q.95 Determination of age of a tree by counting annual rings is -
(1) Dendrochronology (2) Dendrology
(3) Countrochronology (4) Chronology

Q.96 Waxy coating on epidermis of young stem is -
(1) Suberin (2) Periderm
(3) Phellem (4) Cuticle

Q.97 Monocot root has -
(1) Conjoint, collateral, open, polyarch vascular bundles
(2) Suberized exodermis, casparian strip, passage cells, cambium
(3) Suberized exodermis, polyarch xylem, exarch xylem and pith
(4) Exodermis, endarch, tetrarch vascular bundles

Q.98 Passage cells are found in -
(1) Monocot root (2) Monocot stem
(3) Aerial root (4) Dicot stem

Q.99 Grass stem elongates after initial growth due to-
(1) Apical meristem (2) Secondary meristem
(3) Intercalary meristem (4) Lateral meristem

Q.100 A simple tissue with mechanical and physiological functions in a young dicotyledonous plant is -
(1) Sclerenchyma (2) Collenchyma
(3) Parenchyma (4) Meristematic tissue

Q.101 The cells are chlorophyllous, fewer in number, unique in shape and inner walls thick. The description fits into
(1) Guard cells (2) subsidiary cells
(3) Passage cells (4) Bulliform cells

Q.102 Dorsiventral leaf is identified by the presence of -
(1) Stomata on both the epidermis
(2) Stomata mainly present on the lower epidermis
(3) No stomata on the epidermis
(4) Sunken stomata on the upper epidermis

Q.103 Sclereids and stone cells are modified -
(1) Collenchyma (2) Sclerenchyma
(3) Fibres (4) Xylem vessels

Q.104 In the leaf, vascular bundles are found in -
(1) Veins (2) Palisade tissue
(3) Upper epidermis (4) Lower epidermis

Q.105 During the formation of leaf and stem elongation, some cell left behind from shoot apical meristem, They constitute -
(1) Node (2) Intercalary meristem
(3) Auxillary bud (4) Internode

Q.106 Aerenchyma provides -
(1) Flexiblity to plants
(2) Mechanical strength to plants
(3) Buoyancy to hydrophytic plants
(4) Promoting nature of photosynthesis

Q.107 Two cross-sections of stem and root appear similar, when viewed by naked eye, but under microscope, they can be differentiated by -
(1) exarch condition of root and stem
(2) endarch condition of stem and root
(3) endarch condition of root and exarch condition of stem
(4) endarch condition of stem and exarch condition of root

Q.108 The function of vessel is -
(1) Conduction of food
(2) Conduction of water and minerals
(3) To help in transpiration
(4) To help in respiration

Q.109 Which of the following is related to increase in girth of plant -
(1) Shoot apex
(2) Root apex
(3) Lateral meristem
(4) Intercalary meristem of stem

Q.110 Which of the following is enucleate at maturity-
(1) Cortical cell (2) Cambial cell
(3) Meristematic cell (4) Sieve tube cell

Q.111 the cambium which produces cork is called as -
(1) Phelloderm (2) Phellogen
(3) Periblem (4) Plerome

Q.112 Casparian strips are characteristic feature of endodermis, made up of -
(1) cutin (2) pectin
(3) suberin (4) cellulose

Q.113 Procambium produces -
(1) Epidermis
(2) Pith
(3) Vascular bundle
(4) Vascular bundle and pith

Q.114 Aerenchyma is a modification of -
(1) Sclerenchyma (2) Parenchyma
(3) Phloem (4) None of these

Q.115 Whose living cells provide tensile and mechanical strength -
(1) Collenchyma (2) Sclerenchyma
(3) Phloem (4) Sclereids

Q.116 Which of the following is a surface fibre ?
(1) Flax (2) Cotton
(3) Sunn hemp (4) Manila hemp

Q.117 Which of the following is not a plant fibre ?
(1) Cotton (2) Coir
(3) Sunn hemp (4) Silk

Q.118 From which plant part, cotton fibers are obtained
(1) Root hairs (2) Stem hairs
(3) Leaf (4) Seed coat

Q.119 A component of xylem is -
(1) Sieve tube (2) Medullary rays
(3) Sclereid (4) Tracheid

Q.120 A group of cells similar in forms, function and origin is called –
(1) Organ (2) Organelle
(3) Tissue (4) None of these

Q.121 Hard, lignified, thick walled, long and pointed cells in plants are –
(1) Parenchyma (2) Sclerenchymatous fibre
(3) Collenchyma (4) Sclereids

Q.122 Pith and cortex belongs to -
(1) Epidermis (2) Ground tissue
(3) Vascular tissue (4) Bundle sheath

Q.123 Specialized parenchymatous cells which are closely associated with sieve tube element is -
(1) Campanion cell (2) Albuminous cell
(3) (1) & (2) both (4) Phloem parenchyma

Q.124 Which of the following have sunken stomata -
(1) *Nerium* (2) *Mangifera*
(3) *Hydrilla* (4) *Zea mays*

Q.125 Which of the following is true regarding epidermal tissue system -
(1) It is usually multicellular
(2) It is parenchymatous cell with intercellular space
(3) It is meant for protection
(4) All of the above

Q.126 In a dicot stem, secondary growth occurs due to the activity of -
(1) Apical meristem (2) Lateral meristem
(3) Cork (4) Bark

Q.127 Exarch and polyarch condition found in -
(1) Monocot stem (2) Dicot stem
(3) Monocot root (4) Dicot root

Q.128 Leaves of grasses roll and unroll due to -
(1) Hormonal change
(2) Change in temperature
(3) Change in turgor pressure
(4) Presence of bulliform apparatus

Q.129 How many of the following are true regarding monocot root –
A. Pith is large and well developed
B. Conjunctive tissue is present between pericycle and phloem
C. Pericycle is made up of thick walled sclerenchyma
D. Hypodermis is made up of collenchyma
(1) Three (2) Four
(3) One (4) Two

Q.130 Primary growth is caused by -
(1) Apical meristem (2) Lateral meristem
(3) Dermatogen (4) Plerome

Q.131 The veins vary in thickness in …..A….. venation and it is present in …..B….. leaves. What are A & B.
(1) A = Parallel, B = Dorsiventral
(2) A = Reticulate, B = Isobilateral
(3) A = Reticulate, B = Dorsiventral
(4) 2 & 3 both

Q.132 In which plant part laticiferous gland are found -
(1) Cortex (2) Epidermis
(3) Endodermis (4) Vascular bundle

Q.133 Conjoint, collateral and closed vascular bundles are found in -
(1) Monocot stem (2) Monocot root
(3) Dicot stem (4) Dicot root

Q.134 Vascular bundles, in which phloem is found on both sides of xylem are called -
(1) Collateral (2) Bicollateral
(3) Radial (4) Amphicribral

Q.135 Complex tissue includes -
(1) Collenchyma (2) Apical meristems
(3) Conducting tissue (4) Idioblast

Q.136 Tyloses thickenings are seen in -
(1) Phloem cells
(2) Ray parenchyma only
(3) Collenchyma
(4) xylem tracheids and vessels

Q.137 In the given flow chart different layer of monocot root is shown. What is A & B –

Epidermis → $\boxed{A}$ → Endodermis
↓
Pith ← $\boxed{B}$ ← Pericycle

(1) A=Hypodermis, B=Vascular bundle
(2) A=Cortex, B=Vascular bundle
(3) A=Cortex, B=Xylem
(4) A=Hypodermis, B=Xylem

Q.138 Lenticels and hydathodes are small pores with which of the following common attributes -
(1) They allow exchange of gases
(2) Their opening and closing is not regulated
(3) They always remain closed
(4) They are found on the same organ

Q.139 Which of the following is true regarding periderm -
(1) It is made up due to interstelar secondary growth
(2) It is protective covering of plant after secondary growth
(3) It consist of cork, cork cambium and primary cortex
(4) All of the above

Q.140 An example of monocot fibre yielding plant is -
(1) *Cocos* (2) *Corchorus*
(3) *Clematis* (4) *Crotalaria*

Q.141 Phloem conducts food by -
(1) Perforated sieve plates
(2) Bast fibres
(3) Xylem parenchyma
(4) Xylem fibres

Q.142 Quiescent centre is found in -
(1) Shoot tip (2) Root tip
(3) Both (1) & (2) (4) Meristematic

Q.143 Which of the following is correct sequence of layers in typical monocot root (from outer surface to inside)
(1) Pericycle, cortex, endodermis, epiblema
(2) Epiblema, endodermis, cortex, pericycle
(3) Epiblema, cortex, endodermis, pericycle
(4) Epiblema, pericycle, cortex, endodermis

Q.144 In old tree the greater part of secondary xylem is dark brown due to deposition of -
A. Tannin B. Cellulose
C. Lignin D. Essantial oil
(1) A, B, C & D (2) A, C & D
(3) A & D (4) A & C

Q.145 Endodermis mainly -
(1) Acts as water tight jacket
(2) Provides protection
(3) Maintains rigidity
(4) Help in transpiration

Q.146 Polyarch condition is found in -
(1) Monocot root (2) Dicot root
(3) Monocot stem (4) Dicot stem

Q.147 Most water absorption in plants takes place through -
(1) Root cap (2) Root apex
(3) Maturation zone (4) Meristematic zone

Q.148 Vascular bundles in Pinus stem are -
(1) Radial (2) Collateral and closed
(3) Collateral and open (4) Bicollateral

Q.149 Jute is obtained from -
(1) Primary phloem (2) Secondary phloem
(3) Primary xylem (4) Secondary xylem

Q.150 Parenchyma is commonly present in -
(1) Phelloderm (2) Pericycle of root
(3) Hypodermis (4) (1) & (2) both

Q.151 Lignin is the important component of the cell wall of -
(1) Phloem (2) Xylem
(3) Cambium (4) Parenchyma

Q.152 From which part of *Cocos nucifera*, coir is obtained -
(1) Endocarp (2) Mesocarp
(3) Epicarp (4) Any part of fruit

Q.153 Branch of Botany which deals with the internal organisation of plant is known as –
(1) Physiology (2) Ecology
(3) Cytology (4) Anatomy

Q.154 Cells of parenchymatous tissues are characterized by -
(1) Presence of uniform thickening
(2) Presence of thickening at the corner
(3) Presence of lignified walls
(4) Presence of intercellular spaces

Q.155 Wood is the common name of -
(1) Phloem (2) Vascular bundles
(3) Cambium (4) Secondary xylem

Q.156 From where the commercial jute fibers are obtained -
(1) Interxylary fibers (2) xylem fibers
(3) Phloem fibers (4) None of the above

Q.157 In a dicot root, the arrangement of xylem and phloem is-
(1) Collateral (2) Circular
(3) Radial (4) None of the above

Q.158 Fibres would have -
(1) Thick walled
(2) Thin walled
(3) Thickening of wall at corners
(4) Dense cytoplasm

Q.159 Annual growth rings are formed due to activity of
(1) Extra stelar cambium (2) Intra stelar cambium
(3) Inter stelar cambium (4) All of these

Q.160 The fibers associated with phloem are known as
(1) Wood fibres (2) Surfaces fibres
(3) Bast fibres (4) Hard fibres

Q.161 Meristematic tissue in vascular bundle is -
(1) Phellem
(2) Procambium
(3) Interfascicular cambium
(4) Intrafascicular cambium

Q.162 Age of plant can not be determined by counting annual ring in plant, which grow in-
(1) Temperate environment
(2) Tropical environment
(3) (1) & (2) both
(4) none of the above

Q.163 An old trunk of shisham (Dalbergia sissoo) tree would possess maximum amount of
(1) Primary xylem (2) Secondary xylem
(3) Primary phloem (4) Secondary cortex

Q.164 Vascular bundles are arranged in a ring in stem of
(1) Wheat (2) Rice
(3) Gram (4) Maize

Q.165 In higher plants transport of food material occurs through
(1) Companion cells
(2) Sieve elements
(3) Tracheids
(4) Transfusion tissue

Q.166 The term "Bark" refers to
(1) Phellem, Phelloderm and vascular cambium
(2) Periderm and Secondary xylem
(3) Cork cambium and Cork
(4) Phellogen, Phellem, Phelloderm and Secondary phloem

Q.167 A scientist who wish to study viral effect on plants should exclude -
(1) Cortex
(2) Pith
(3) Shoot apex
(4) Phloem

Q.168 Monocot root can be distinguished from dicot root by the
(1) Presence of cambium
(2) Number of vascular bundles 2 to 6
(3) Presence of pericycle
(4) Larger pith

Exercise 3

OLD EXAMINATION QUESTIONS [NEET]

Q.1 In monocots, root cap is formed by - **[AIIMS 2000]**
(1) Dermatogen (2) Calyptrogen
(3) Wound cambium (4) Vascular cambium

Q.2 The quiescent centre in the root meristem serves as a - **[AIIMS 2003]**
(1) Site for storage of food which is utilized during maturation
(2) Reservoir of growth hormones
(3) Reserve for replenishment of damaged cells of the meristem
(4) Region for absorption of water

Q.3 Which one of the following statements pertaining to plant structure is correct ? **[AIIMS 2005]**
(1) Cork lacks stomata, but lenticels carry out transpiration
(2) Passage cells help in transfer of food from cortex to phloem
(3) Sieve tube elements posses cytoplasm but no nuclei
(4) The shoot apical meristem has a quiescent centre

Q.4 Grafting is successful in dicots but not in monocots because the dicots have - **[AIIMS 2006]**
(1) Vascular bundles arranged in a ring
(2) Cambium for secondary growth
(3) Vessels with elements arranged end to end
(4) Cork cambium

Q.5 In the sieve elements, which one of the following is the most likely function of P-proteins – **[AIIMS 2006]**
(1) Deposition of callose on sieve plates
(2) providing energy for active translocation
(3) Autolytic enzymes
(4) Sealing mechanism on wounding

Q.6 Extrastelar secondary growth takes place by – **[AIPMT 1998]**
(1) Vascular cambium (2) Phellogen
(3) Phellem (4) Phelloderm

Q.7 Growth of leaf primordia is – **[AIPMT 1998]**
(1) First apical then marginal
(2) Only apical
(3) Only marginal
(4) Lateral

Q.8 A plant stem is showing 40 spring ring and 40 autumn ring. What will be the age of plant – **[AIPMT 1999]**
(1) 80 years (2) 40 years
(3) 20 years (4) Can not determined

Q.9 What happens in plants during vascularisation **[AIPMT 2000]**
(1) Differentiation of procambium, formation of primary phloem followed by formation of primary xylem
(2) Differentiation of procambium followed by the formation of primary phloem and xylem simultaneously
(3) Formation of procambium, primary phloem and xylem simultaneously
(4) Differentiation of procambium followed by the formation of secondary xylem

Q.10 Main function of lenticel is – **[AIPMT 2002]**
(1) Transpiration (2) Guttation
(3) Gaseous exchange (4) Bleeding

Q.11 Vessels are found in – **[AIPMT 2002]**
(1) All angiosperms and some gymnosperm
(2) Most of the angiosperms and few gymnosperms
(3) All angiosperms, all gymnosperms and some pteridophyta
(4) All pteridophyta

Q.12 Four radial vascular bundles are found in – **[AIPMT 2002]**
(1) Dicot root
(2) Monocot root
(3) Dicot stem
(4) Monocot stem

Q.13 Which of the following statement is true – **[AIPMT 2002]**
(1) Vessels are multicellular and with wide lumen.
(2) Tracheids are multicellular and with narrow lumen.
(3) Vessels are unicellular and with narrow lumen.
(4) Tracheids are unicellular and with wide lumen.

Q.14 The cells of the quiescent centre are characterised by - **[AIPMT 2003]**
(1) Having dense cytoplasm and prominent nuclei
(2) Having light cytoplasm and small nuclei
(3) Dividing regularly to add to the corpus
(4) Dividing regularly to add to tunica

Q.15 The apical meristem of the root is present – **[AIPMT 2003]**
(1) Only in radicals
(2) Only in tap roots
(3) Only in adventitious roots
(4) In all the roots

Q.16 In a longitudinal section of a root, starting from the tip upward, the four zones occur in the following order - **[AIPMT 2004]**
(1) Root cap, cell division, cell maturation , cell enlargement
(2) Cell division, cell enlargement, cell maturation, root cap
(3) Cell division, cell maturation cell enlargement, root cap
(4) Root cap, cell division, cell enlargement, cell maturation

Q.17 A common structural feature of vessel elements and sieve tube elements is - **[AIPMT 2006]**
(1) presence of p-protein
(2) enucleate condition
(3) thick secondary walls
(4) pores on lateral walls

Q.18 For a critical study of secondary growth in plants, which one of the following pairs is suitable ? **[AIPMT 2007]**
(1) Wheat and maiden hair fern
(2) Sugarcane and sunflower
(3) Teak and pine
(4) Deodar and fern

Q.19 Passage cells are thin-walled cells found in - **[AIPMT 2007]**
(1) Central region of style through which the pollen tube grows towards the ovary
(2) Endodermis of roots facilitating rapid transport of water from cortex to pericycle
(3) Phloem elements that serve as entry points for substance for transport to other plant parts
(4) Testa of seeds to enable emergence of growing embryonic axis during seed germination

Q.20 Vascular tissues in flowering plants develop from **[AIPMT 2008]**
(1) Pleurome (2) Periblem
(3) Dermatogen (4) Phellogen

Q.21 The length of different internodes in a culm of sugarcane is variable because of – **[AIPMT 2008]**
(1) Position of axillary buds
(2) Size of leaf lamina at the node below each internode
(3) Intercalary meristem
(4) Shoot apical meristem

Q.22 Angiospermic xylem consists of –
(1) Vessels + Tracheids only
(2) Tracheids + Fibres only
(3) Vessel, tracheids, fibres and xylem parenchyma
(4) Parenchyma and fibres only

Q.23 In barley stem vascular bundles are - **[AIPMT 2009]**
(1) Closed and Radial (2) Open and scattered
(3) Closed and scattered (4) Open and in a ring

Q.24 Palisade parenchyma is absent in leaves of - **[AIPMT 2009]**
(1) Gram (2) Sorghum
(3) Mustard (4) Soyabean

Q.25 Reduction in vascular tissue, mechanical tissue and cuticle is characteristic of - **[AIPMT 2009]**
(1) Hydrophytes (2) Xerophytes
(3) Mesophytes (4) Epiphytes

Q.26 Anatomically fairly old dicotyledonous root is distinguished from the dicotyledonous stem by **[AIPMT 2009]**
(1) Position of protoxylem
(2) Absence of secondary xylem
(3) Absence of secondary phloem
(4) Presence of cortex

Q.27 The annular and spirally thickened conducting elements generally develop in the protoxylem when the root or stem is - **[AIPMT-2009]**
(1) elongating (2) widening
(3) differentiating (4) maturing

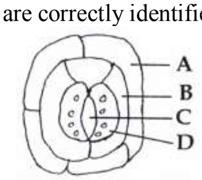
Q.28 The chief water conducting element of xylem in gymnosperms are : **[AIPMT 2010]**
(1) Vessels (2) Fibers
(3) Transfusion tissue (4) Tracheids

Q.29 Which of the following is not a lateral meristerm? **[AIPMT 2010]**
(1) Intrafasicular cambium
(2) Interfasicular cambium
(3) Phellogen
(4) Intercalary meristem

Q.30 Heartwood differs from sapwood in- **[AIPMT 2010]**
(1) Presence of rays and fibres
(2) Absence of vessels and parenchyma
(3) Having dead and non-conducting elements
(4) Being susceptible to pest and pathogens

Q.31 Transport of food material in higher plants takes place through- **[AIPMT 2010]**
(1) Companion cells (2) Transfusion tissue
(3) Tracheids (4) Sieve elements

Q.32 Given below is the diagram of a stomatal apparatus. In which of the following all the four parts labelled as A, B, C and D are correctly identified? **[AIPMT 2010]**



	A	B	C	D
(1)	Subsidiary cell	Epidermal cell	Guard cell	Stomatal aperture
(2)	Guard cell	Stomatal aperture	Subsidiary cell	Epidermal cell
(3)	Epidermal cell	Guard cell	Stomatal aperture	Subsidiary cell
(4)	Epidermal cell	Subsidiary cell	Stomatal aperture	Guard cell

Q.33 Ground tissue includes : **[AIPMT 2011]**
(1) All tissues internal to endodermis
(2) All tissues external to endodermis
(3) All tissues except epidermis and vascular bundles
(4) Epidermis and cortex

Q.34 In land plants, the guard cells differ from other epidermal cells in having : **[AIPMT 2011]**
(1) Chloroplasts (2) Cytoskeleton
(3) Mitochondria (4) Endoplasmic reticulum

Q.35 The cork cambium, cork and secondary cortex are collectively called : **[AIPMT 2011]**
(1) Phellem (2) Phelloderm
(3) Phellogen (4) Periderm

Q.36 Function of companion cells is : **[AIPMT 2011]**
(1) Loading of sucrose into sieve elements
(2) Providing energy to sieve elements for active transport
(3) Providing water to phloem
(4) Loading of sucrose into sieve elements by passive transport

Q.37 Some vascular bundles are described as open because these : **[AIPMT 2011]**
(1) are not surrounded by pericycle
(2) are surrounded by pericycle but no endodermis
(3) are capable of producing secondary xylem and phloem
(4) possess conjunctive tissue between xylem and phloem

Q.38 Water containing cavities in vascular bundles are found in - **[AIPMT 2012]**
(1) *Cycas* (2) *Pinus*
(3) Sunflower (4) Maize

Q.39 Closed vascular bundles lack **[AIPMT 2012]**
(1) Cambium (2) Pith
(3) Ground tissue (4) Conjunctive tissue

Q.40 Companion cells are closely associated with **[AIPMT 2012]**
(1) Trichomes (2) Guard cells
(3) Sieve elements (4) Vessel elements

Q.41 The common bottle cork is a product of **[AIPMT 2012]**
(1) Xylem (2) Vascular Cambium
(3) Dermatogen (4) Phellogen

Q.42 As compared to a dicot root, a monocot root has: **[AIPMT 2012]**
(1) Many xylem bundles
(2) Inconspicuous annual rings
(3) Relatively thicker periderm
(4) More abundant secondary xylem

Q.43 Gymnosperms are also called soft wood spermatophytes because they lack – **[AIPMT-2012]**
(1) cambium (2) phloem fibres
(3) thick-walled tracheids (4) xylem fibres

Q.44 Interfascicular cambium develops from the cells of : **[NEET - 2013]**
(1) Medullary rays (2) Xylem parenchyma
(3) Endodermis (4) Pericycle

Q.45 Lenticels are involved in - **[NEET-2013]**
(1) food transport (2) photosynthesis
(3) transpiration (4) gaseous exchange

Q.46 Meristematic tissue responsible for increase in girth of tree trunk is - **[NEET-2013]**
(1) intercalary meristem (2) lateral meristem
(3) phellogen (4) apical meristem

Q.47 Which of the following statements is not true for stomatal apparatus ? **[NEET-2013]**
(1) Guard cells invariably possess chloroplasts and mitochondria
(2) Guard cells are always surrounded by subsidiary cells
(3) Stomata are involved in gaseous exchange
(4) Inner wall of guard cells are thick

Q.48 Tracheids differ from other tracheary elements in- **[NEET-2014]**
(1) having casparian strips (2) being imperforate
(3) lacking nucleus (4) being lignified

Q.49 Select WRONG statement from the following **[RPMT 2014]**
(1) Bulliform cells are present in the leaves of monocots
(2) Intrafascicular cambium is present in monocots
(3) Phellem, phellogen and phelloderm constitute the periderm
(4) Spring wood and autumn wood constitute and annual ring

Q.50 A major characteristic of the monocot root is the presence of : **[NEET-2015]**
(1) Open vascular bundles
(2) Scattered vascular bundles
(3) Vasculature without cambium
(4) Cambium sandwiched between phloem and xylem along the radius

Q.51 In a ring girdled plant : **[NEET-2015]**
(1) The shoot dies first
(2) The root dies first
(3) The shoot and root die together
(4) Neither root nor shoot will die

Q.52 Read the different components from (a) to (d) in the list given below and tell the correct order of the components with reference to their arrangement from outer side to inner side in a woody dicot stem : **[NEET-2015]**
(a) Secondary cortex (b) Wood
(c) Secondary phoem (d) Phellem
The correct order is :
(1) (d), (c), (a), (b) (2) (c), (d), (b), (a)
(3) (a), (b), (d), (c) (4) (d), (a), (c), (b)

Q.53 Specialised epidermal cells surrounding the guard cells are called - **[NEET-I 2016]**
(1) bulliform cells (2) lenticels
(3) complementary cells (4) subsidiary cells

Q.54 Cortex is the region found between - **[NEET-II 2016]**
(1) epidermis and stele
(2) pericycle and endodermis
(3) endodermis and pith
(4) endodermis and vascular bundle

Q.55 The balloon-shaped structures called tyloses - **[NEET-II 2016]**
(1) originate in the lumen of vessels
(2) characterize the sapwood
(3) are extensions of xylem parenchyma cells into vessels
(4) are linked to the ascent of sap through xylem vessels

Q.56 The vascular cambium normally gives rise to - **[NEET-2017]**
(1) primary phloem (2) secondary xylem
(3) periderm (4) phelloderm

Q.57 Which of the following is made up of dead cells ? **[NEET-2017]**
(1) Collenchyma (2) Phellem
(3) Phloem (4) Xylem parenchyma

Q.58 Identify the wrong statement in context of heartwood - **[NEET-2017]**
(1) It is highly durable
(2) It conducts water and minerals efficiently
(3) It comprises dead elements with highly lignified walls
(4) Organic compounds are deposited in it

Q.59 Stomata in grass leaf are - **[NEET-2018]**
(1) dumb-bell shaped (2) kidney-shaped
(3) rectangular (4) barrel-shaped

Q.60 Secondary xylem and phloem in dicot stem are produced by - **[NEET-2018]**
(1) apical meristems (2) vascular cambium
(3) phellogen (4) axillary meristems

Q.61 Casparian strips occur in - **[NEET-2018]**
(1) epidermis (2) pericycle
(3) cortex (4) endodermis

Q.62 Plants having little or no secondary growth are- **[NEET-2018]**
(1) grasses (2) deciduous angiosperms
(3) conifers (4) cycads

Q.63 Grass leaves curl inwards during very dry weather. Select the most appropriate reason from the following - **[NEET-2019]**
(1) Tyloses in vessels
(2) Closure of stomata
(3) Flaccidity of bulliform cells
(4) Shrinkage of air spaces in spongy mesophyll

Q.64 Phloem in gymnosperms lacks - **[NEET-2019]**
(1) both sieve tubes and companion cells
(2) albuminous cells and sieve cells
(3) sieve tubes only
(4) companion cells only

Q.65 Which of the statements given below is not true about formation of annual rings in trees ? **[NEET-2019]**
(1) Annual rings are not prominent in trees of temperate region.
(2) Animal ring is a combination of spring wood and autumn wood produced in a year.
(3) Differential activity of cambium causes light and drak bands of tissue-early and late wood respectively.
(4) Activity of cambium depends upon variation in climate.

Q.66 In the dicot root the vascular cambium orginate from - **[NEET-2019]**
(1) Tissue located below the phloem bundles and a portion of pericycle tissue above protosylem.
(2) Cortical region.
(3) Parenchyma between endodermis and pericycle.
(4) Intrfascicular and interfascicular tissue in a ring.

Q.67 Regeneration of damaged growing grass following grazing is largely due to – **[NEET-2019]**
(1) Lateral meristem
(2) Apical meristem
(3) Intercalary metrsitem
(4) Secondary meristem

Q.68 Identify the incorrect statement. **[NEET-2020]**
(1) Sapwood is involved in conduction of water and minerals from root to leaf.
(2) Sapwood is the innermost secondary xylem and is lighter in colour.
(3) Due to deposition of tannins, resins, oils etc. heart wood is dark in colour.
(4) Heart wood does not conduct water but gives mechanical support.

Q.69 The transverse section of a plant shows following anatomical features: **[NEET-2020]**
(a) Large number of scattered vascular bundles surrounded by bundle sheath.
(b) Large conspicuous parenchymatous ground tissue.
(c) Vascular bundles conjoint and closed.
(d) Phloem parenchyma absent.
Identify the category of plant and its part:
(1) Monocotyledonous root
(2) Dicotyledonous stem
(3) Dicotyledonous root
(4) Monocotyledonous stem

Q.70 Match List-I with List-II **[NEET-2021]**

List-I		List-II	
(a)	Lenticels	(i)	Phellogen
(b)	Cork cambium	(ii)	Suberin deposition
(c)	Secondary cortex	(iii)	Exchange of gases
(d)	Cork	(iv)	Phelloderm

Choose the correct answer from the options given below.

	(a)	(b)	(c)	(d)
(1)	(iv)	(ii)	(i)	(iii)
(2)	(iv)	(i)	(iii)	(ii)
(3)	(iii)	(i)	(iv)	(ii)
(4)	(ii)	(iii)	(iv)	(i)

Q.71 Match List-I with List-II **[NEET-2021]**

	List-I		List-II
(a)	Cells with active cell division capacity	(i)	Vascular tissues
(b)	Tissue having all cells similar in structure and function	(ii)	Meristematic tissue
(c)	Tissue having different types of cells	(iii)	Sclereids
(d)	Dead cells with highly thickened walls and narrow lumen	(iv)	Simple tissue

Select the correct answer from the options given below.

	(a)	(b)	(c)	(d)
(1)	(iii)	(ii)	(iv)	(i)
(2)	(ii)	(iv)	(i)	(iii)
(3)	(iv)	(iii)	(ii)	(i)
(4)	(i)	(ii)	(iii)	(iv)

Q.72 Select the correct pair. **[NEET-2021]**

(1)	Loose parenchyma cells rupturing the epidermis and forming a lens shaped opening in bark	Spongy parenchyma
(2)	Large colorless empty cells in the epidermis of grass leaves	Subsidiary cells
(3)	In dicot leaves, vascular bundles are surrounded by large thick-walled cells	Conjunctive tissue
(4)	Cells of medullary rays that form part of cambial ring	Interfascicular cambium

Q.73 Hydrocolloid carrageen is obtained from: **[NEET-2022]**

(1) Phaeophyceae and Rhodophyceae
(2) Rhodophyceae only
(3) Phaeophyceae only
(4) Chlorophyceae and Phaeophyceae

Q.74 Interfascicular cambium is present between **[ReNEET-2022]**

(1) Secondary xylem and secondary phloem
(2) Primary xylem and primary phloem
(3) Pericycle and endodermis Two vascular bundles
(4) Two vascular bundles

Q.75 The type of tissue commonly found in the fruit wall of nuts is **[ReNEET-2022]**

(1) Sclereid (2) Parenchyma
(3) Collenchyma (4) Sclerenchyma

Q.76 Initiation of lateral roots and vascular cambium during secondary growth takes place in cells of **[ReNEET-2022]**

(1) Pericycle
(2) Epiblema
(3) Cortex
(4) Endodermis

Q.77 Given below are two statements : One is labelled as **Assertion A** and the other is labelled as **Reason R** :
Assertion A : Late wood has fewer xylary elements with narrow vessels.
Reason R : Cambium is less active in winters
In the light of the above statements, choose the correct answer from the options given below : **[NEET-2023]**

(1) A is false but R is true
(2) Both A and R are true and R is the correct explanation of A
(3) Both A and R are true but R is NOT the correct explanation of A
(4) A is true but R is false

Q.78 Given below are two statements : **[NEET-2023]**
Statement I : Endarch and exarch are the terms often used for describing the position of secondary xylem in the plant body.
Statement II : Exarch condition is the most common feature of the root system.
In the light of the above statements, choose the **correct** answer from the options given below:

(1) **Statement I** is incorrect but **Statement II** is true
(2) Both **Statement I** and **Statement II** are true
(3) Both **Statement I** and **Statement II** are false
(4) **Statement I** is correct but **Statement II** is false

Q.79 Identify the **correct** statements: **[NEET-2023]**

A. Lenticels are the lens-shaped openings permitting the exchange of gases.
B. Bark formed early in the season is called hard bark.
C. Bark is a technical term that refers to all tissues exterior to vascular cambium.
D. Bark refers to periderm and secondary phloem.
E. Phellogen is single-layered in thickness.

Choose the correct answer from the options given below:

(1) B and C only (2) B, C and E only
(3) A and D only (4) A, B and D only

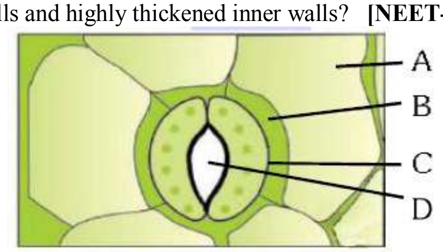
Q.80 Builiform cells are responsible for : **[NEET-2024]**

(1) Increased photosynthesis in monocots
(2) Providing large spaces for storage of sugar
(3) Inward curling of leaves in monocots
(4) Protecting the plant from salt stress

Q.81 Formation of interfascicular cambium from fully developed parenchyma cells is an example for : **[NEET-2024]**

(1) Dedifferentiation (2) Maturation
(3) Differentiation (4) Redifferentiation

Q.82 In the given figure, which component has thin outer walls and highly thickened inner walls? **[NEET-2024]**



(1) A (2) B (3) C (4) D

Q.83 Given below are two statements : **[NEET-2024]**
Statement I : Parenchyma is living but collenchyma is dead tissue
Statement II : Gymnosperms lack xylem vessels but presence of xylem vessels is the characteristic of angiosperms.
In the light of the above statements, choose the correct answer from the options given below:
(1) Statement I is true but Statement II is false.
(2) Statement I is false but Statement II is true.
(3) Both Statement I and Statement II are true.
(4) Both Statement I and Statement II are false

Q.84 Find the statement that is NOT correct with regard to the structure of monocot stem. **[NEET-2025]**
(1) Vascular bundles are conjoint and closed.
(2) Phloem parenchyma is absent.
(3) Hypodermis is parenchymatous.
(4) Vascular bundles are scattered.

Answer Key

EXERCISE -1

Ques.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	4	3	1	3	1	1	2	3	3	3	1	3	3	3	3	2	1	1	1	1
Ques.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	2	1	1	2	3	3	1	3	2	3	2	3	3	2	3	3	2	3	1	2
Ques.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	1	1	4	1	4	1	4	1	1	2	4	2	2	2	2	1	3	1	1	2
Ques.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Ans.	1	3	1	3	3	1	3	1	3	3	4	1	4	2	1	4	3	1	1	4
Ques.	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
Ans.	4	2	1	2	3	2	3	3	1	1	1	3	3	2	1	3	4	3	1	3
Ques.	**101**	**102**	**103**	**104**	**105**	**106**														
Ans.	2	4	3	4	2	3														

EXERCISE -2

Ques.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	4	3	4	4	1	3	2	1	2	2	2	4	1	2	4	2	2	3	4	4
Ques.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	3	1	2	2	2	2	4	4	1	2	4	1	4	4	3	2	1	4	4	1
Ques.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	1	1	2	4	3	1	3	3	2	3	4	4	1	1	1	2	4	1	3	2
Ques.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Ans.	2	1	4	2	2	1	1	2	2	1	1	1	4	2	4	1	2	3	3	4
Ques.	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
Ans.	2	4	2	1	3	1	2	2	2	4	3	4	3	1	1	4	3	1	3	2
Ques.	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**	**111**	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**
Ans.	1	2	2	1	3	3	4	2	3	4	2	3	3	2	1	2	4	4	4	3
Ques.	**121**	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**	**131**	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**	**140**
Ans.	2	2	1	1	3	2	3	4	3	1	3	1	1	2	3	4	2	2	2	1
Ques.	**141**	**142**	**143**	**144**	**145**	**146**	**147**	**148**	**149**	**150**	**151**	**152**	**153**	**154**	**155**	**156**	**157**	**158**	**159**	**160**
Ans.	1	2	3	2	1	1	3	3	2	4	2	2	4	4	1	3	3	1	2	3
Ques.	**161**	**162**	**163**	**164**	**165**	**166**	**167**	**168**												
Ans.	4	2	2	3	2	4	3	4												

EXERCISE -3

Ques.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.	2	3	3	2	4	2	1	2	2	2	2	1	1	2	4	4	2	3	2	1
Ques.	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Ans.	3	3	3	2	1	1	3	4	4	3	4	4	3	1	4	2	3	4	1	3
Ques.	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
Ans.	4	1	4	1	4	2	2	2	2	3	2	4	4	1	3	2	2	2	1	2
Ques.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Ans.	4	1	3	1	1	1	3	2	4	3	2	4	2	4	1	1	2	1	3	3
Ques.	**81**	**82**	**83**	**84**																
Ans.	1	3	2	3																

NOTES