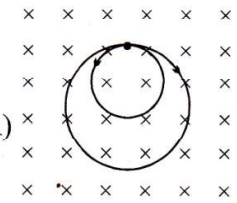
PHYSICS **Max Marks: 80**

SECTION – I
(SINGLE CORRECT CHOICE TYPE)

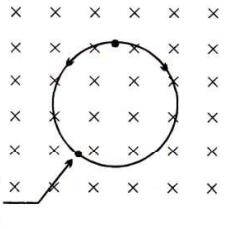
This section contains **7 multiple choice questions.** Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct

24. A neutral particle at rest in a magnetic field decays into two charged particles of different mass. The energy released goes into their kinetic energy. Then what can be the path of the two particles. Neglect any interaction between the two charges.

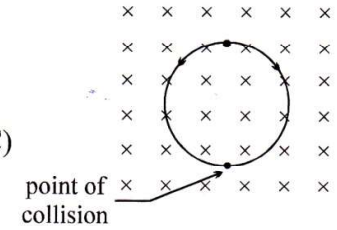
(A)



(B)



(C)



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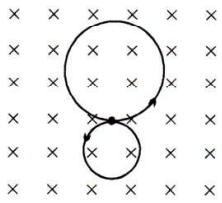
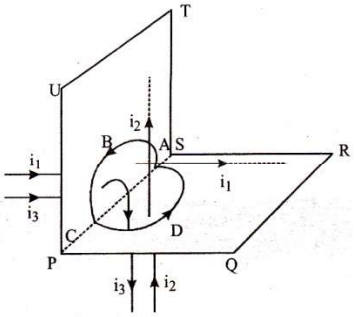
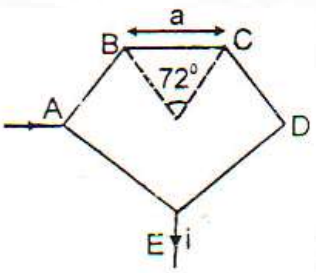


25. Figure shows an amperian path ABCDA. Part ABC is in vertical plane PSTU while part CDA is in horizontal plane PQRS. Direction of circulation along the path is shown by an arrow near point B and at D. $\oint \vec{B}.\vec{d\ell}$ for this path according to Ampere's law will be



A) $(i_1 - i_2 + i_3)\mu_0$ B) $(-i_1 + i_2)\mu_0$ C) $i_3\mu_0$ D) $(i_1 + i_2)\mu_0$

26. Magnetic field strength at the centre of regular pentagon made of a conducting wire of uniform cross section area as shown in figure is: (i amount of current enters at A and leaves at E)



A) $\frac{5\mu_0 i}{4\pi a}\left[2\sin\frac{72^0}{2}\right]$ B)0 C) $\frac{3\mu_0 i}{4\pi a}\left[2\sin\frac{72^0}{2}\right]$ D) $\frac{\mu_0 i}{4\pi a}\left[2\sin\frac{72^0}{2}\right]$

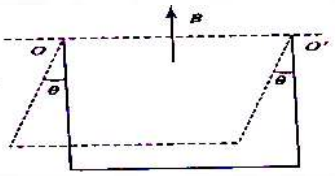
27. A very long straight conducting wire, lying along the z-axis, carries a current of 2A. The integral $\int \vec{B}.d\vec{l}$ is computed along the straight line PQ, where P has the coordinates (2cm,0,0) and Q has the coordinates (2cm, 2cm,0). The integral has the magnitude (in S.I units)

A) $\frac{\pi}{2}\times10^{-7}$ B) $8\pi\times10^{-7}$ C) $2\pi\times10^{-7}$ D) $\pi\times10^{-7}$

28. An α-particle is moving along a circle of radius R with a constant angular velocity ω. Point A lies in the same plane at a distance $2R$ from the centre. Point A records magnetic field produced by the α-particle. If the minimum time interval between two successive times at which A records zero magnetic field is 't', the angular speed ω, in terms of t, is

A) $\frac{2\pi}{t}$ B) $\frac{2\pi}{3t}$ C) $\frac{\pi}{3t}$ D) $\frac{\pi}{t}$

29. A wire of cross-sectional area A forms three sides of a square and is free to rotate about horizontal axis OO`. The structure is deflected by an angle θ from the vertical, and comes to equilibrium when current i is passed through it. A magnetic field B acting vertically upward and density of the wire is ρ, then the value of θ is given by



A) $\frac{2A\rho g}{iB}=\cot\theta$ B) $\frac{2A\rho g}{iB}=\tan\theta$ C) $\frac{A\rho g}{iB}=\sin\theta$ D) $\frac{A\rho g}{2iB}=\cos\theta$

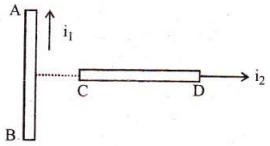
30. Two identical wires A and B have the same length l and carry the same current I. Wire A is bent into a circle and wire B is bent to form a square (both have same number of loops). If B_1 and B_2 are the values of magnetic induction at the centre of the circle and the centre of the square, respectively, then the ratio B_1/B_2 is

A) $(\pi^2/8)$ B) $(\pi^2/8\sqrt{2})$ C) $(\pi^2/16)$ D) $(\pi^2/16\sqrt{2})$

SECTION – II
(MULTIPLE CORRECT CHOICE TYPE)

This section contains **4 multiple choice questions.** Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONE OR MORE** is/ are correct

31. An infinitely long, straight conductor AB is fixed and a current is passed through it. Another movable straight wire CD of finite length and carrying current is held perpendicular to it and released. Neglect weight of the wire. Then



A) The rod CD will move parallel to current in AB

B) The rod CD will move anti-parallel to current in AB

C) The rod CD will turn clockwise as seen by the reader

D) The rod AB will turn anticlockwise as seen by the reader

32. Suppose that the current density in a wire of radius a varies with r according to Kr^2 where K is a constant and r is the distance from the axis of the wire.

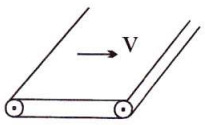
A) The magnetic field at a point at a distance r from the axis is $\frac{\mu_0 Kr^3}{4}$ $when\ r < a$

B) The magnetic field at a point at a distance r from the axis is $\frac{\mu_0 Ka^4}{4r}$ $when\ r > a$

C) The magnetic field at a point at a distance r from the axis is $\frac{\mu_0 Ka^3}{4r}$ $when\ r < a$

D) The magnetic field at a point at a distance r from the axis is $\frac{\mu_0 Kr^3}{4a}$ $when\ r > a$

33. Positive charge is sprayed onto a large non-conducting belt above the left hand roller. The belt carries charge with a uniform surface charge density σ, as it moves with a speed v between the rollers as shown. The charge is removed by a wiper at right hand roller. Correct option regarding the fields near the belt on the either side.



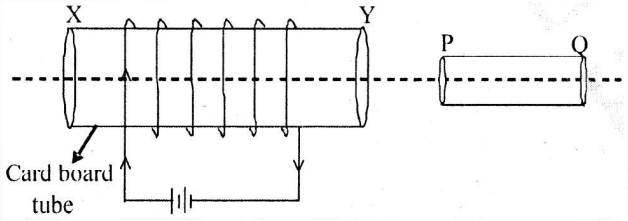
A) Magnetic field is $\frac{\mu_0 \sigma v}{2}$, parallel to axis of roller

B) Magnetic field is $\mu_0 \sigma$, perpendicular to axis

C) Eclectic field is $\frac{\sigma}{2\varepsilon_0}$ perpendicular to the plane of sheet

D) If an electron moves parallel to V just above the sheet it will experience an upward magnetic force.

34. In the diagram XY is a long solenoid of insulated wire wound on a hallow cardboard tube. PQ is a soft iron cylinder. The current is flowing in the wounded wire in the direction shown in figure. For this arrangement mark the correct statement.



A) X represents North pole; Y represents South pole and P represents North pole

B) If the rod PQ is free to move along its axis then rod comes to rest in the middle of XY.

C) The initial force of attraction between rod and solenoid will increase considerably if cardboard tube is replaced by one made from some magnetic material

D) Inside the rod PQ, the magnetic field lines are directed from Q to P

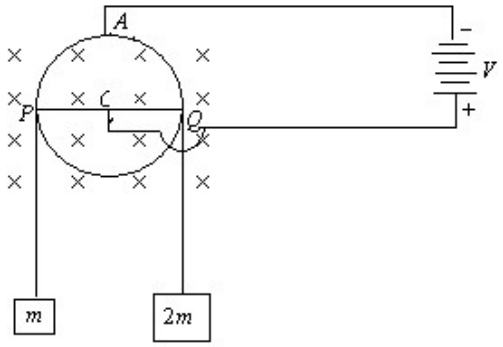
SECTION – III

(COMPREHENSION TYPE)

This section contains 2 groups of questions. Each group has 2&3 multiple choice questions based on a paragraph. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which **ONLY ONE** is correct.

Paragraph for Questions Nos. 35 to 37

A conducting ring of mass m and radius r has a weightless conducting rod PQ of length $2r$ and resistance $2R$ welded to it along its diameter. It is pivoted at its center C with its plane vertical, and two blocks of mass m and $2m$ are suspended by means of a light inextensible and non-conducting string passing over it as shown in figure. The ring is free to rotate about C and the system is placed in a magnetic field B (into the plane of the ring). A circuit is now completed by connecting the ring at A and C to a battery e.m.f. V. It is found that for certain value of V, the system remains in static equilibrium. [Neglect resistance of the ring]



35. Find the current through rod *CP*.

A) V/R B) $V/2R$ C) $4V/R$ D) $2V/R$

36. Net torque on ring about C only due to tension in the strings is:

A) $\frac{3BVr^2}{R}$ B) $\frac{BVr^2}{R}$ C) $\frac{BVr^2}{3R}$ D) $\frac{BVr^2}{2R}$

37. Mass of the right block 2m, is:

A) $\frac{BVr}{Rg}$ B) $\frac{2BVr}{Rg}$ C) $\frac{BVr}{2Rg}$ D) $\frac{2BVr}{3Rg}$

Paragraph for Questions Nos. 38 to 39

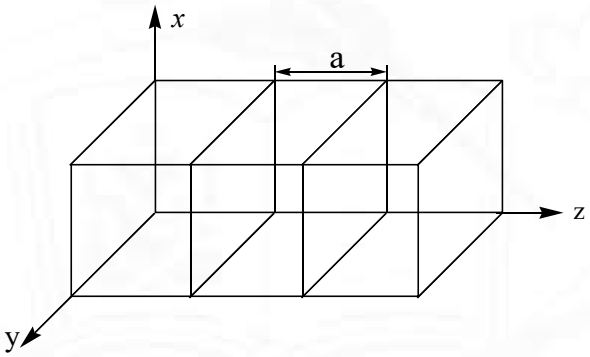
Consider a horizontal insulated tube of rectangular cross-section with liquid sodium filled in it, placed along z-axis. If a current of density $\vec{J}$ is maintained through the metal and a uniform magnetic field $\vec{B}$ is applied in the region (such

that $\vec{J}$ *and* $\vec{B}$ are parallel to xy-plane and $\vec{J} \perp \vec{B}$), liquid starts flowing through the tube.

38. For which of the following values of $\vec{J}$ & $\vec{B}$, liquid flows along +ve z-axis? $(J_0 B_0, B_1 \& B_2 > 0)$

A) $\vec{J} = J_0\hat{i}, \vec{B} = B_0\hat{i}$ B) $\vec{J} = J_0\hat{i}, \vec{B} = B_0\hat{k}$ C) $\vec{J} = J_0\hat{i}, \vec{B} = B_1\hat{i} + B_2\hat{j}$ D) $\vec{J} = J_0\hat{i}, \vec{B} = B_1\hat{i} - B_2\hat{j}$

39. Shown in the figure are two sections of the tube, separated by a distance 'a', current density corresponding to the current flowing through the tube is $\vec{J} = J\hat{i}$ and $\vec{B} = B\hat{j}$. If the liquid is prevented from flowing, pressure difference between the two sections is:



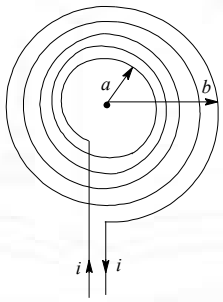
A) $\frac{JB}{a}$ B) JBa C) $\frac{Ba}{J}$ D) $\frac{a}{BJ}$

SECTION –IV
(INTEGER ANSWER TYPE)

This section contains 7 questions . The answer to each of the questions is a single digit integer, ranging from 0 to 9. The appropriate bubbles below the respective question numbers in the ORS have to be darkened.

40. A current I flows along the length of a thin walled, long metallic hollow cylinder of radius R, distributed uniformly on its surface. If the pressure on the wall is $P=\left(\frac{\mu_0 I^2}{\pi^2 R^2}\right)\times\left(\frac{1}{x}\right)$. Find the value of x.

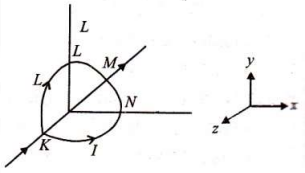
41. A thin insulated wire forms a plane spiral of 'N' tight turns carrying a current I. The radii of inside and outside turns are equal to $'a'$ and $'b'$ respectively. The magnetic induction at the centre of the spiral is $\mu_0\frac{1}{x}\left[\frac{IN\ln\left(\frac{b}{a}\right)}{b-a}\right]$. Find the value of $'x'$.



(Assume no contribution from the straight parts)

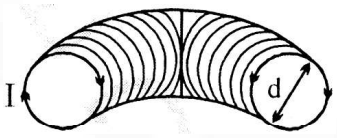
42. The radii of two concentric and coaxial coils having same number of turns are 10cm and 20 cm respectively. Equal currents are passed through them first in same direction and then in opposite direction. In these two conditions. Find the ratio of resultant magnetic fields at the centre?

43. A circular loop of radius R is bent about a diameter and given a shape as shown in the figure. One of the semicircles (KNM) lies in the x-z plane and the other one (KLM) in the y-z plane with their centres at the origin. Current I is flowing through each of the semi circles as shown in figure. A particle of charge q is projected form the origin with a velocity $\vec{v} = -v_0\hat{i}$. Find the magnitude of instantaneous force $\vec{F}$ on the particle if $\mu_0 q v_0 I = 8R$. Assume that space is gravity free.



44. A long straight wire lies on y-axis and carries a current of 7A in –ve Y direction. In addition to the magnetic field produced by the wire, a uniform magnetic field of $0.7\times10^{-6}T\hat{i}$ is also present. What is the magnitude of net magnetic field at $(1,1,1)$. Express your answer in $a\times10^{-7}T$ and fill a in OMR sheet.

45. Calculate the magnetic moment of a thin wire with a current $I = 0.8A$, wound tightly on half a toroid. The diameter of the cross-section of the toroid is equal to $d = 5.0\,cm$, the number of turns is $N = 500$. If the magnetic moment is $x \times 10^{-1}$, find $x+1$ and filling OMR



46. Figure shows a square loop 10cm on each side in the x-y plane with its centre at the origin. An infinite wire is at z = 12cm above y-axis.

Torque on loop due to magnetic force is $x \times 10^{-6}$ N-m. Find the sum of all the digits in *x*.