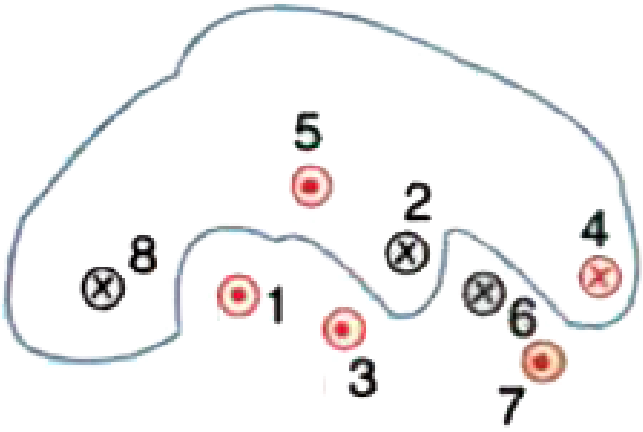
PHYSICS

BOOKS - AAKASH SERIES

ELECTROMAGNETICS

Example

1. Eight wires cut the page perpendicularly at the points shown. Each wire carries current i_0. Odd currents are out of the page and even currents into the page. Find the line intergal $\oint \vec{B} . \vec{dl}$ along the loop.



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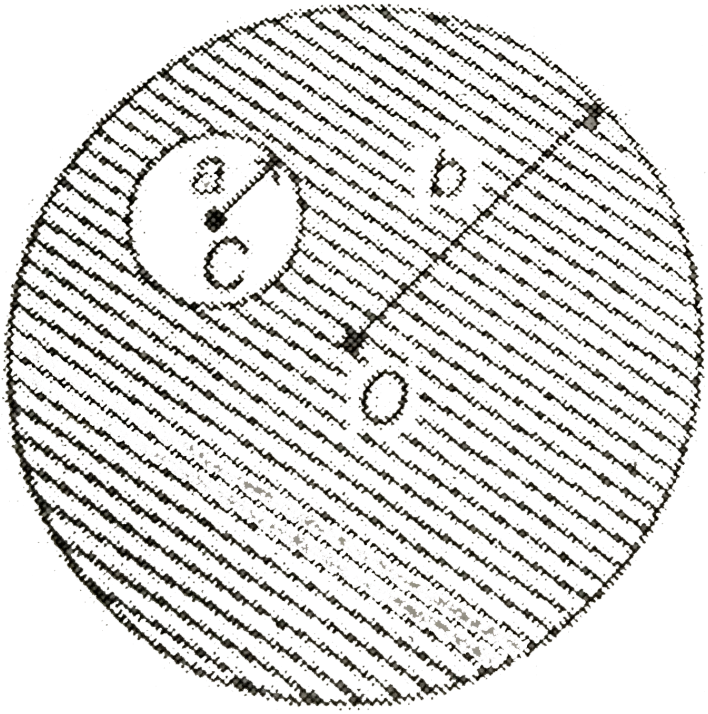
2. A long straight metal rod has a very long hole of radius 'a' drilled parallel to the rod axis as shown in the fiugre. If the rod carries a current I, find the value of magnetic induction on the axis of the hole, where OC=c



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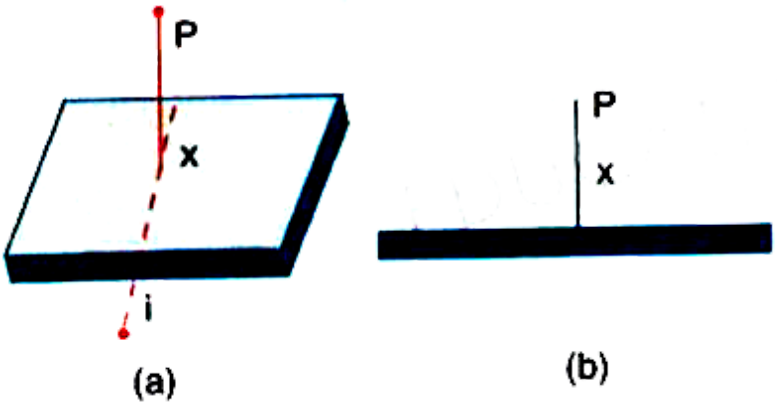
3. Figure shows a cross-section of a large metal sheet carrying an electric current along its axis. The current in a strip of width is k where k is a constant. Find the magnetic field at apoint P at a distance x From the metal sheet.



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4. A 2A current is flowing through a circular coil of radius 10 cm containing 100 turns. Find the magnetic flux density at the centre of the coil.

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5. Three rings, each having radius R, are placed mutually perpendicular to each other and each having its centre at the origin of co-ordinate system. If current I is flowing through each ring then the magnitude of the magnetic field at the common centre is:

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6. A current I flows around a closed path in the horizontal plane of the circle as shown in the figure. The path consists of eight arcs witli alternating radii r and 2r.

Each segment of arc subtends equal angle at the common centre P. Find

the magnetic field produced by current path at point P

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7. A thin insulated wire form a spiral of N=100 turns carrying a current of i=8mA . The inner and outer radii are equal to a=5cm and b=10cm. Find the magnetic field at the centre of the coil.

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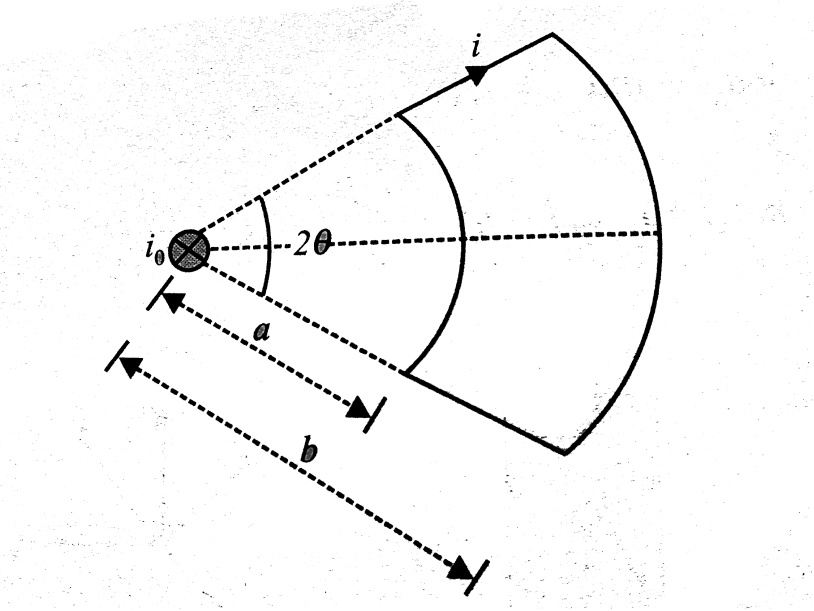
8. A loop, carring a current i, lying in the plane of the paper, is in the field of a long straight wire with current i_0 (inward) as shown in Fig. Find the torque acting on the loop.



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9. A rectangular polygon of n side is formed by bending a wire of total length $2\pi R$ which carries a current i. Find the magnetic field at the centre

of the polygon

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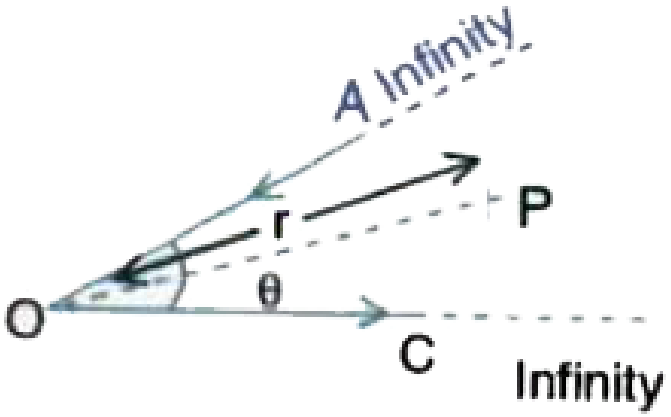
10. Two wires AO and OC carry equal currents i as shown in the figure where $\angle AOC = \theta$,Find the magnitude of the magnetic field at the point P on the bisector of anlge θ at a distance 'r' from O. Assume that the other ends of both wires extend to infinity



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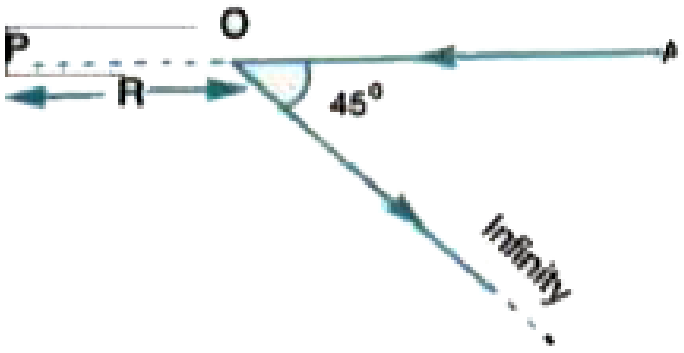
11. An infinitely long wire carrying a current i is bent at its mid point 0 to form an angle 45°. P is point a distance Rfrom the pointofbending. Find

the magnetic field at P.



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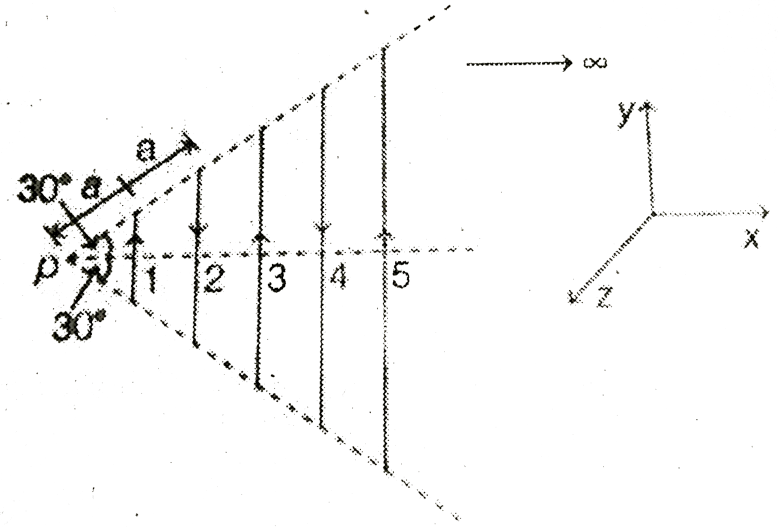
12. Infinte number of straight wires each carrying curret I are equally placed as show in the figure. Adjacent wire have currents in opposite direcation. Net magnetic field at point P is :



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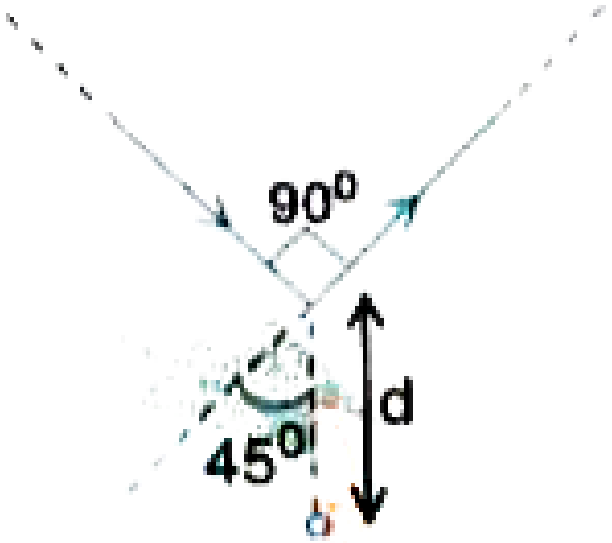
13. Find the magnetic field at P due to the arrangement shown



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14. Equal currents are flowing in three infinitely long wires along positive x, y and z -directions. The magnetic field at a point $(0, 0 - a)$ would be ($i =$ current in each wire)

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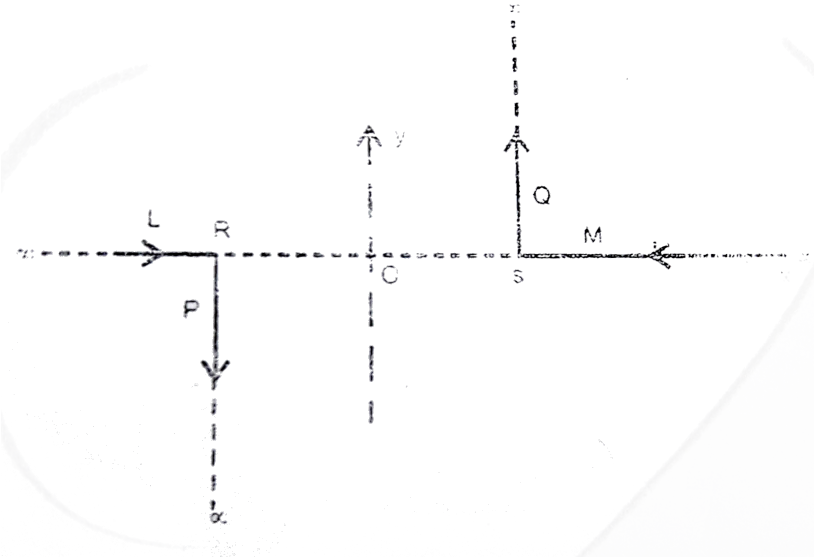
15. A pair of stationary and infinitely long bent wires is placed in the $X-Y$ plane as shown in figure.The wires carry currents of $10A$ each as shown.The segments L and M are along the x-axis.The segments P and Q are pallel to the Y-axis such that $OS = OR = 0.02m$.Find the magnitude and direction of the magnetic induction at the origin O.



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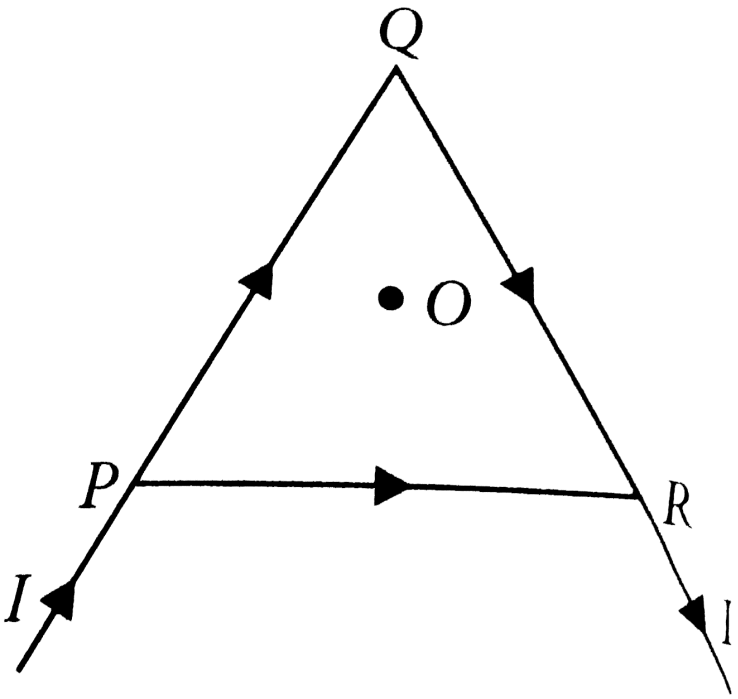
16. An equilateral triangle of side length l is formed from a piece of wire of uniform resistance. The current I is fed as shown in the figure. The magnitude of the magnetic field at its centre O is



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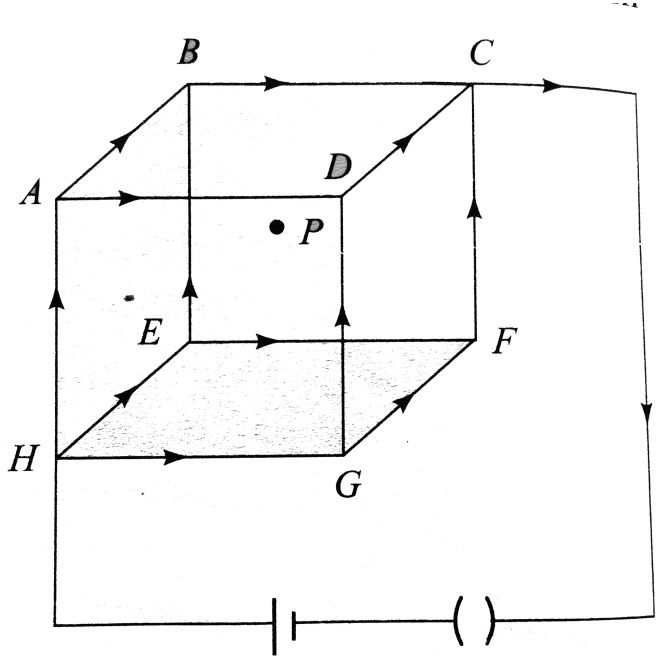
17. A steady current is set up in a cubic network composed of wires of equal resistance and length d as shown in Fig. What is the magnetic field

at centre P due to the cubic network?



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18. A current of I amperes is flowing through each of the bent wires as shown. Find the magnitude of magnetic field at O.

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19. Two parallel conductors A and B separated by 5 cm carry electric current of 6A and 2A in the same direction. Find the point between A and B where the field is zero.

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20. A magnetic field of $\left(4.0X10^{-3}\vec{k}\right)$ T exerts a force of $\left(4.0\vec{i}+3.0\vec{j}\right)X10^{-10}$ N on a particle having a charge of $1.0X10^{-9}$ C and going in the x-y plane. Find the velocity of the particle.

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21. A charged particle carrying charge $q=1\mu c$ moves in uniform magnetic with velocity $v_1=10^6 m/s$ at angle 45° with x-axis in the xy-plane and experiences a force $F_1=5\sqrt{2}N$ along the negative z-axis. When te same particle moves with velocity $v_2=10^6 m/s$ along the z-axis it experiences a force F_2 in y-direction. Find

a. the magnitude and direction of the magnetic field

b. the magnitude of the force F_2.

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22. A particle of mass m and charge q is projected into a region having a perpendicular magnetic, field B. Find the angle of deviation of the particle as it comes out of the magnetic field if the, width of the region is b, which is very slightly less than $\frac{mv}{2Bq}$

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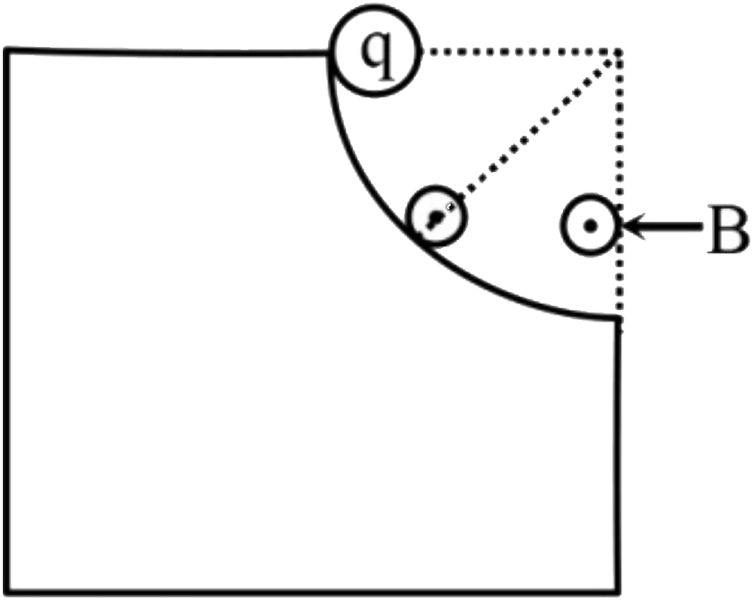
23. In the figure , a charged sphere of mass m and change q starts sliding from rest on a vertical fixed circular track of radius R from the position shown. There exists a uniform and constant horizontal magnetic field of

induction B. The maximum force exerted by the track on the sphere is -



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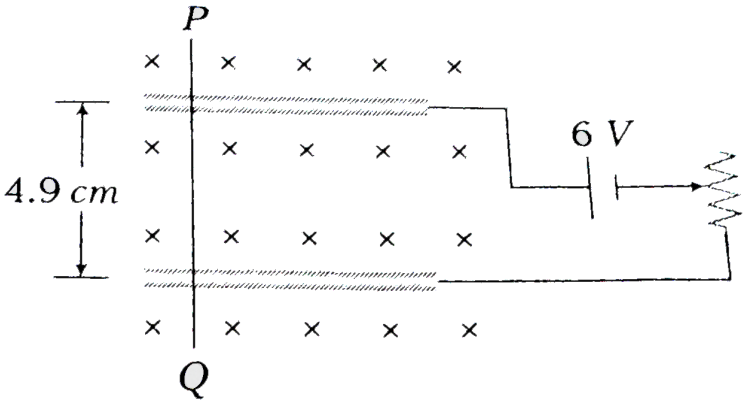
24. A wire PQ of mass 10g is at rest on two parallel metal rails.The separation betweem the rails is 4.9 cm.A magnetic field if 0.80 T is applied perpendicular to the plane of the rails, directed downwads. The resisitance of the circuit is slowly decreased. When the resistance to bleow 10 Ω the wire PQ begins to slide on the rails .Calculate the

coefficient of friction between the wire and the rails



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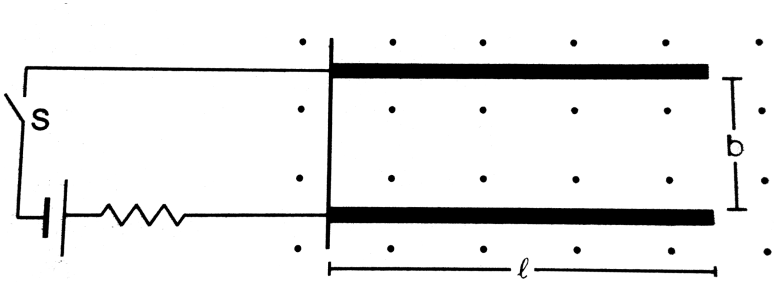
25. Two metal strips, each of length, each of length l, are clamped parallel to each other on a horizontal floor with a separation b between them. A wire of mass m line on them perpendicularly as shown in figure. A vertically upward magnetic field of strenght B exists in the space. The matal strips are smooth but the cofficient of freiction between the wire and the floor is μ. A current i is established when the switch S is closed at the instant $t = 0$. Discuss the motion of the wire after the switch is

closed. How far away from the strips will the wire reach?



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26. A Long straight conductor carrying a current of 2 A is in parallel to another conductor of length 5 cm. and carrying a current 3A. They are separated by a distance of 10 cm. Calculate (a) B due to first conductor at second conductor (b) the force on the short conductor.

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27. Two parallel horizontal conductors are suspended by two light vertical threads each 75 cm long. Each conductor has a mass of $40gm$, and when there is no current they are 0.5 cm apart. Equal current in the two wires

result in a separation of 1.5 cm. Find the values and directions of currents.

Take $g = 9.8ms^{-2}$.

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28. A square frame carrying a curren $I = 0.90A$ is located in the same plane as a long straight wire carrying a current $I_0 = 5.0A$.The frame side has a length $a = 8.0cm$.The axis of the frame passing through the midpoints of opposite sides is parallel to the wire and is separated from it by the distance which

$\eta = 1.5$ times greater than the side of the frame.

(a)Ampere force (magnetic force) acting on the frame is $\frac{9}{P}\mu N$,Then find value of P.

(b)The magnidute of mechanical work is $(144\ln P) \times 10^{-9}J$ to be performed in order to turn the frame slowly through 180° about its axis with the currents maintained constant.then find value of P

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29. Two parallel wires PQ, RS of resistance 10Ω and 20Ω are seperated by a distance of 10 cm and connected in parallel across a cell of emf200V and negligible intemal resistance. A wire AB of mass I g and length 1 cm is balanced exactly, between them. What must be the current in it.

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30. A conductor AB of length 10 cm at a distance of 10 cm from an infinitely long parallel conductor carrying a current 10A. What work must be done to move AB to a distance of 20cm if it carries 5A?

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31. Two conductors each of length 12 m lie parallel to each other in air. The centre to center distance between two conductors is 15×10^{-2} m and the current in each conductor is 300 amperes. Determine the force in newton tending to pull the conductors together.

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32. The area of the coil in a moving coil galvanometer is 16 cm^2 and has 20 turns. The magnetic induction is 0.2T and the couple per unit twist of the suspended wire is 10^{-6} Nm per degree. If the deflection is 45° calculate the current passing through it.

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33. A coil area 100 cm^2 having 500 tums carries a current of 1 mA . It is suspended in a uniform magnetic field of induction $10^{-3}Wb/m^2$. Its plane makes an angle of 60° with the lines of induction. Find the torque acting on the coil.

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34. A galvanometer of resistance 20Ω is shunted by a 2Ω resistor. What part of the main current flows through the galvanometer ?

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35. A galvanometer has resistance 500 ohm. It is shunted so that its sensitivity decreases by 100 times. Find the shunt resistance.

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36. The resistance of galvanometer is 999Ω. A shunt of 1Ω is connected to it. If the main current is $10^{-2}A$, what is the current flowing through the galvanometer.

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37. A galvanometer has a resistance of 98Ω. If 2% of the main current is to be passed through the meter what should be the value of the shunt?

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38. A maximum current of 0.5 mA can be passed through a galvanometer of resistance 20Ω. Calculate the resistance to be connected in series to convert it into a voltmeter of range $(0-5)V$.

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39. A galvanometer has a resistance of 100Ω. A current of $10^{-3}A$ pass through the galvanometer. How can it be converted into (a) ammeter of range 10 A and (b) voltmeter of range 10v.

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40. A galvanometer h aving 30 divisions has current sensitivity of $20\mu A$ /division. . It has a resistances of 25Ω

(i) How will you convert it into an ammeter measuring upto 1 ampere.

(ii) How will you convert this ammeter into a voltmeter upto 1 volt.

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Exercise Long Answer Questions

1. Explain Fleming's left hand rule? Deduce an expression for the force on a current carrying conductor in a magnetic field. Derive expression for the between two parallel conductors carrying current.

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2. Deduce an expression for torque acting on a bar magnet placed in uniform external magnetic field.

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3. What is the function of a galvanometer in a circuit?

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4. How is a galvanometer converted into an ammeter? Why parallel resistance is smallerthan galvanometer resistance? Explain.

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5. How is a galvanometer converted into a voltmeter? Why series resistance is greater than galvanometer resistance? Explain.

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Exercise Short Answer Questions

1. State Biot-Savart law.

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2. State and prove Ampere's law.

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3. Find intensity of magnetic induction of B due to a a long current carrying conductor.

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4. The magnetic field at the centre of the current carrying coil is

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5. Obtain an expression for the magnetic dipole,moment of current loop.

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6. Deduce the expression for the magnetic dipole moment of an electron orbiting around the central nucleus.

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Exercise Very Short Answer Questions

1. What is the importance of Oersted's experiment?

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2. An electric current flows in a wire from east to west- What will be the direction of the magnetic field due to this wire at a point north of the wire? South of the wire?

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3. What is the work done in taking a north pole of strength m around a long and straight conductor in a circular path at a perpendicular distance of r from the straight conductor?

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4. Does a current carrying circular coil produce uniform magnetic field ?

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5. Two parallel long wires separated by a distance 'd' carry equal current 'i' What is the magnetic induction at a point mid way between the wires if

(a) currents are in the same direction ?

(b) currents are in opposite direciton ?

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6. What is the force on a conductor of length l carrying current 'i' when it is situated in a magnetic field of induction B? When is it maximum?

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7. When a charged particle moves in a uniform magnetic field at right angles to the direction of the field, which of the following changes? Speed of the particle, Energy of the particle or Path of the particle.

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8. If an electron is not deflected in passing through a certain region of space can we be sure that there is no magnetic field in that region?

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9. What will be the path of a charged particle moving along the direction of a uniform magnetic field?

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10. An electron beam is moving horizontally towards east. If this beam passes through a uniform magnetic field directed upwards, then in which direction will the beam be deflected?

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11. What is the direction of the force acting on a charged particle q, moving with a velocity $\overrightarrow{v}$ a uniform magnetic field $\overrightarrow{B}$?

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12. Does the torque on a current loop in magnetic field change, when its shape is changed without changing its face area?

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13. A current carrying loop free to turn is placed in a uniform magnetic field. What will be its orientation relative to the rection of magnetic field in the equilibrium state?

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14. Is the resistance of an ammeter greater than or less than that of the galvanometer of which it is formed?

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15. Is the resistance of a voltmeter greater than or less that of the galvanometer of which it is formed?

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16. A moving coil galvanometer can measure a current of $10^{-6}A$. What is the resistance of the shunt to measure 1A?

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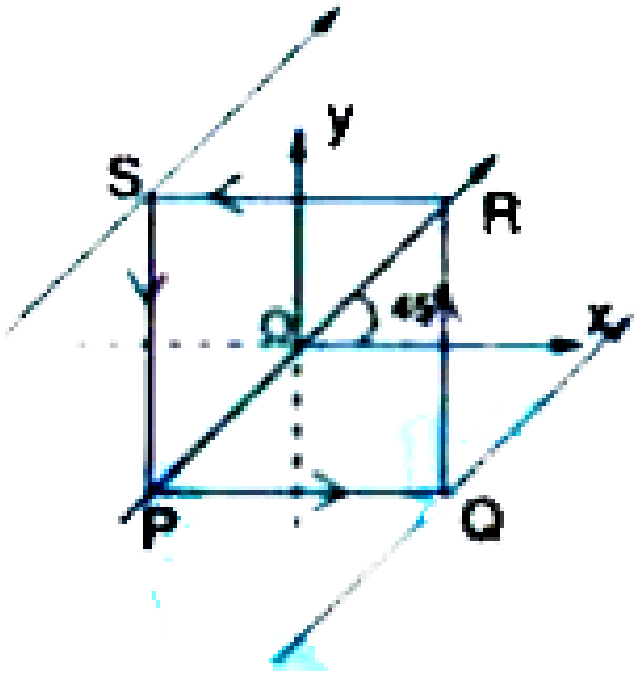
17. What is the smallest value of current that can be measured with a moving coil galvanometer, tangent galvanometer?



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18. How do you convert a moving coil galvanometer into an ammeter?

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19. The conversion of a moving coil galvanometer into a voltmeter is done by

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Problems Level I

1. If a long straight wire carries a current of 40 A, then the magnitude of the field B at a point 15 cm away from the wire is

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2. A wire carrying a current of 125 A is bent into the form of a circle of radius 5 cm. Calculate the flux density at the centre of the coil.

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3. A current of 4A is flowing through a circular coil of radius 20 cm containing 200 turns. Find the magnetic flux density at the centre of the coil.

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4. A wire carrying a current of 12A is in the form of a circle. It is necessary to have a magnetic field of induction 10^{-6} T at the centre. What should be the radius?

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5. Two conductors each of length 18 m lie parallel to each other in air. The centre to centre distance between the two conductors is 30×10^{-2} m and the current in each conductor is 450 A. Determine the force in newton tending to pull the conductors together.

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6. A long straight conductor carrying a current of 4 A is in parallel to another conductor of length 5 cm and carrying a current 9 A. They are separated by a distance of 10 cm. Calculate (a) B due to first conductor at second conductor (b) The force on the short conductor.

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7. Two parallel conductors A and B separated by 15 cm carry electric current of 9 A and 4 A in the same direction. Find the point between A and B where the field is zero.

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8. The area of the coil in a moving coil galvanometer is $8cm^2$ and has 10 turns. The magnetic induction is 0.1 T and the couple per unit twist of the suspended fibre is 10^{-6} Nm per degree. If the deflection is 90^0, calculate the current passing through it

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9. A coil of area $150cm^2$ having 250 turns carriers a current of 2 mA. It is suspended in a uniform magnetic field of induction $9 \times 10^{-3}\mathrm{Wbm}^{-2}$. Its plane makes an angle of 60^0 with the line of induction. Find the torque acting on the coil.

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10. A galvanometer of resistance 30Ω is shunted by a 30Ω resistor. What part of the main current flows through the meter ?

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11. A maximum current of 1.5 mA can be passed through a galvanometer of resistance 30Ω. Calculate the resistance to be connected in series to convert it into a voltmeter of range 0-9V.

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12. A galvanometer has resistance 500 ohm. It is shunted so that its sensitivity decreases by 100 times. Find the shunt resistance.

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13. A galvanometer has a resistance of 100Ω. A current of 2×10^{-3} A can pass through the galvanometer. How can it be converted into (a) Ammeter of range 20 A and (b) voltmeter of range 20 V?

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14. The resistance of galvanometer is 999Ω. A shunt of 1Ω is connected to it. If the main current is $10^{-2}A$, what is the current flowing through the galvanometer.

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15. A galvanometer has a resistance of 96Ω. If 4% of the main current is to be passed through the meter, what should be the value of the shunt?

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16. A circular coil of wire of radius 'r' has 'n' turns and carries a current 'I'. The magnetic induction (B) at a point on the axis of the coil at a distance $\sqrt{3}r$ from its centre is

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17. Two wires A and B are of lengths 40 cm and 30 cm. A is bent into a circle of radius r and B into an arc of radius r. A current i_1 is passed through A and i_2 through B. To have the same magnetic induction at the centre, the ratio of $i_1 : i_2$ is

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18. A long horizontal rigidly supported wire carriers a current $i_a = 96A$. Directly above it and parallel to it at a distance, another wire of 0.144 N weight per metre carries a current $i_b = 24$ A, in a direction opposite to that of i_a If the upper wire is to float in air due to magnetic repulsion, what is its distance (in mm) from the lower wire ?

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19. A circular coil of radius 3cm has 50 turns. It is placed on the horizontal plane and a current of 3A flows through it in clockwise direction as seen from above. Calculate the magnetic field at a point on the axis of the coil,

at a distance of 4cm from its centre. Also indicate the direction of the magnetic field.

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20. A cable 5 m above the ground carries a current of 50 A from south to north. Find the direction and magnitude of the magnetic field on the ground directly below the cable.

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21. The electron in hydrogen atom moves with a speed of $2.2 \times 10^6 m/s$ in an orbit of radius $5.3 \times 10^{-11} cm$. Find the magnetic moment of the orbiting electron.

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22. A solenoid of infinite length consists of a single layer 1000 turns per unit length of a wire carrying a current of 2mA. Calculate the magnetic field on the axis at the middle of the solenoid.

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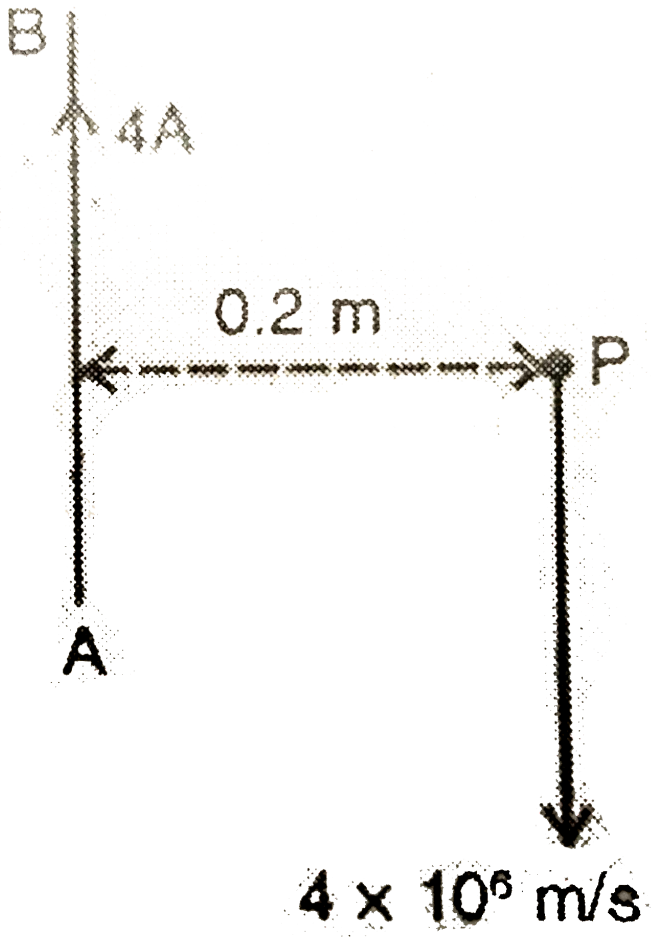
23. A long straight wire AB carries a current of 4 A. A proton P travels at $4 \times 10^6 ms^{-1}$ parallel to the wire 0.2 m from it and in a direction opposite to the current as shown in the figure. Calculate the force which the magnetic field due to the current carrying wire exerts on the proton.

Also specify its direction.



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24. A helium ion $(He)^{2+}$ travels at right angles to a magnetic field of intensity 1.2T with a velocity of $2 \times 10^7 cms^{-1}$. Find the magnitude of the

force acting on the ion.

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25. An electron experiences a force of 2.4×10^{-13} N when it enters a magnetic field with a velocity of $10^{6} ms^{-1}$ at an angle of 30°. What is the flux density ?

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26. 10 A and 2A currents are passed through two parallel wires A and B respectively in the opposite directions. If the wire A is infinitely long and the length of wire B is 4 m, which is 10cm away from the wire A, calculate the force on the wire 'B'

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27. Two infinitely long parallel wires 5 cm apart in air carry currents of 2A and 4A respectively. Find the magnitude of the force on each metre of wire if currents are (i) in the same direction. (ii) in opposite direction.

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28. A horizontal wire of length 0.2m long carries a current of 3A. Find the magnitude of the magnetic field, which can support the weight of the wire. Mass per unit length of wire is $2 \times 10^{-3} kgm^{-1}$

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29. A rectangular coil of sides 12cm and 8cm having 1000 turns and carrying current of 100mA is held in a uniform magnetic field of 0.1 Tesla. What is the maximum torque the coil can experience ?

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30. A coil of 20 turns of area $8 \times 10^{-2} cm^2$ with its plane parallel to the magnetic field of intensity 3000G and carrying a certain current experiences a torque 2.4×10^{-3} Nm .Calculate the value of current.

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31. The coil of a pivoted coil galvanometer has 25 turns and has area 10 cm 2. The coil is placed in a radial magnetic field of flux density 8×10^{-2} T. The torsional constant of the spring is 1.0×10^{-6} Nm per degree. Find the deflection of the coil for a current of 4m A.

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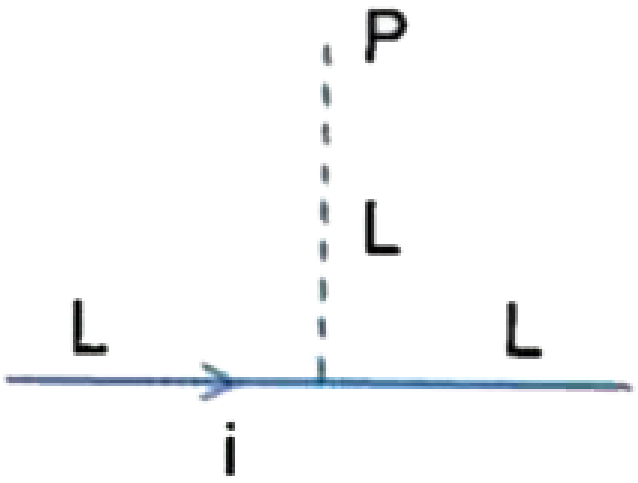
32. Figure shows a straight wire of length L carrying a current i. Find the magnitude of magnetic field produced by the current at point P.



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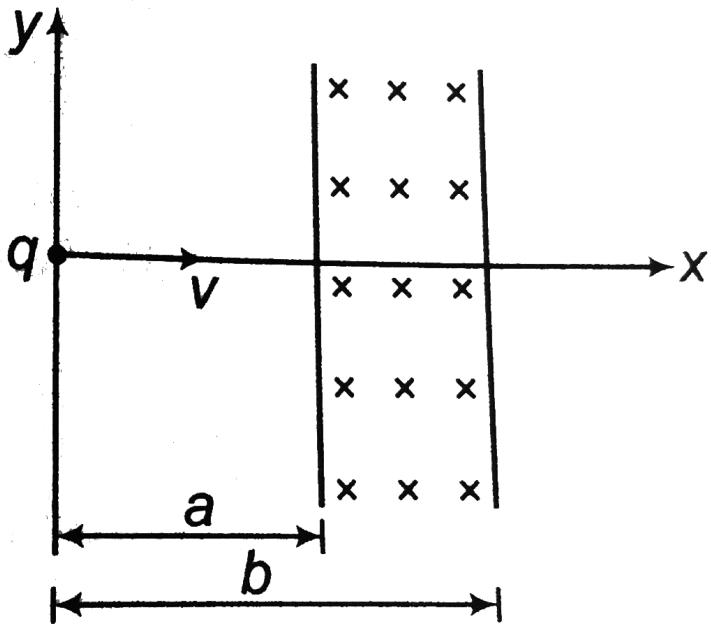
33. In the figure shown a charge q moving with a velocity v along the x-axis enter into a region of uniform magnetic field. The minimum value v

so that the charge q is able to enter the region $x > b$



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34. A charged particle of charge 4 mC enters a uniform magnetic field of induction $\vec{B} = 3\bar{i} + 6\bar{j} + 6\bar{k}$ tesla with a velocity $\bar{v} = 4\bar{i} - x\bar{j} + y\bar{k}$. If the particles continues to move undeviated, then the magnitude of velocity of the particle is

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35. A proton, a deuteron and an α particle having same momentum enter a uniform magnetic field at right angles to the field. Then the ratio of their angular momenta during their motion in the magnetic field is

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36. The shunt resistance is $(3/8)^{th}$ of that of the galvanometer, then fraction of the main current that passes through the galvanometer is

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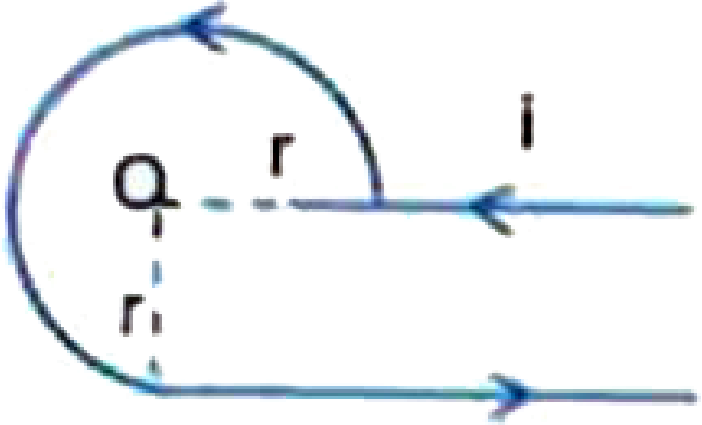
37. Find the magnetic induction at point O, if the current carrying wire is in the shape shown in the figure.



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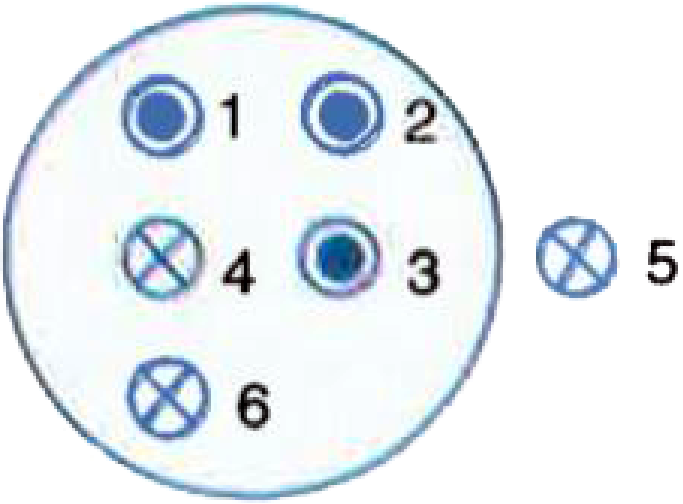
38. Six wires of current $I_1 = 1A, I_2 = 2A, I_3 = 3A, I_4 = 1A, I_5 = 5A$ and $I_6 = 4A$ cut the page perpendicularly at the points 1, 2,3,4,5 and 6. respectively as shown in the figure . Find the value of the integral

$\oint \vec{B} . d\vec{1}$ around the closed path.



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39. Electric charge q is distributed uniformly over a rod of length l. The rod is placed parallel to a long wire carrying a current i. The separation between the rod and the wire is a. The force needed to move the rod along its length with a uniform velocity v is

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40. A charged particle (charge q, mass m) has velocity v_0 at origin in +x direction. In space there is a uniform magnetic field B in -z direction. Find the y coordinate of particle when is crosses y axis.

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Problems Level Ii

1. Two long straight parallel wires A and B are placed 50 cm apart and carry currents 20 amp and 15 amp respectively. A point 'P' is 40 cm from wire A and 30cm from wire B. Find the magnitude of the resultant magnetic field at 'P'.

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2. Two striaght long conductors AOB and COD are pendicular to each other and carry currents i_1 and i_2 . The magnitude of the magnetic

induction at a point P at a distance a from the point O in a direction perpendicular to the plane ACBD is

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3. A $2\mu C$ charge moves in a circular orbit of radius 2cm around the nucleus at a frequency 10 rev/sec. Find the magnetic moment associated with the orbital motion of the particle.

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4. The magnetic induction at the centre of a current carrying circular coil of radius $10cm$ is $5\sqrt{5}$ times the magnetic induction at a point on its axis. The distance of the point from the centre of the soild in cm is

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5. A straight wire is first bent into a circle of radius 'r' and then into a square of side 'a' each of 1 turn. If the currents flowing through them are in the ratio 2:3, find the ratio between their effective magnetic moments?

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6. A galvanometer of resistance 40Ω can measure a current of 2mA for full scale deflection. It is converted into an ammeter having range 6 times the previous value by using proper shunt. Find the resistance of ammeter so formed ?

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7. A moving coil galvanometer has 150 equal divisions. Its current sensitivity is 10 divisions per milliampere and vlotage sensitivity is 2 divisions per millivolt. In order that each division reads 1 V the resistance in ohm needed to be connected in series with the coil will be

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8. What current would be maintained in a circular coil of wire of 1000 turns and 10 cm in radius in order to just cancel the earth's magnetic field at a place where the horizontal component of Earth's magnetic field is $2 \times 10^{-4} T$.

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9. A solenoid 1.5 metre and 4.0 cm in diameter possesses 10 turns/cm. A current of 5.0 A is flowing throught it. Calculate the magnetic induction (i) inside are (ii) At one end on the axis of solenoid respectively

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10. A horizontal wire carries 200A current below which another wire of linear density 20×10^{-3} Kg/m carrying a current is kept at 2cm distance. If the wire kept below hangs in air, then the current in the wire is

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11. Two long parallel wires are placed vertically, 10cm apart. One of them carries a current of 20A and other carries a current of 25A. Both the currents flow in the upward direction. A third wire carrying a current of 5A flowing downward is placed between the two parallel wires in such a way that its distance from the wire carrying current 20A is 6 cm. Calculate the force per unit length experienced by the third wire.

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12. A wire of length 5 cm is placed inside the solenoid near its centre such that it makes an angle of 30° with the axis of the solenoid The wire carries a current of 5A and the magnetic field due to solenoid is $2.5 \times 10^{-2} T$ Calculate the force on the wire.

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13. A rectangular coil of area $5.0 \times 10^{-4} m^2$ and 60 turns is pivoted about one of its vertical sides. The coil is in a radial horizontal magnetic field of $9 \times 10^{-3} T$. What is the torsional constant of the spring connected to the coil if a current of $0.20 mA$ produces an angular deflection of 18°?

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14. Two circular coils A and B of radius $\frac{5}{\sqrt{2}}$ cm and $5cm$ carry currents $5A$ and $5\sqrt{2}A,$ respectively. The plane of B is perpendilcular to plane of A and their centres coincide. Magnetic field at the centre is

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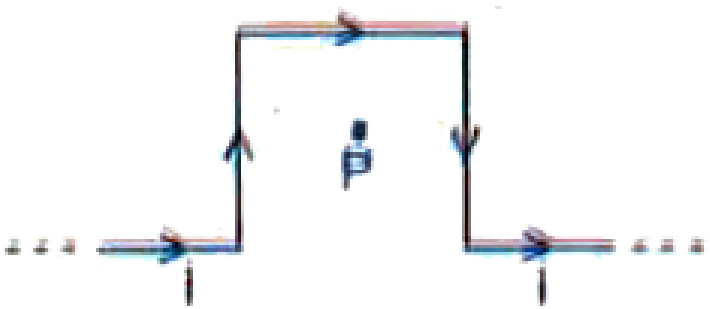
15. 

Find the magnetic field at the centre P of square of side shown in figure.

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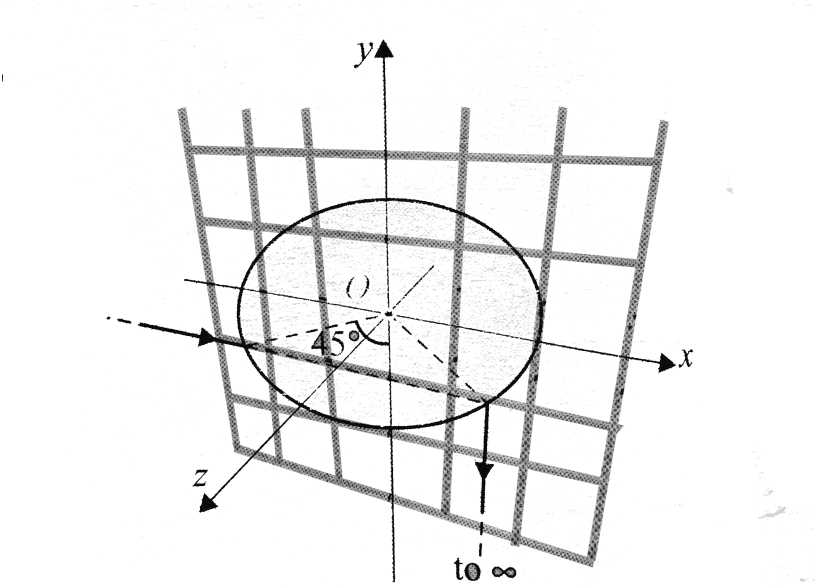
16. What is the magnitude of magnetic field at the centre O of loop of radius $\sqrt{2}m$ made of uniform wire when a current of 1amp entres in the

loop and taken out of it by two long wires as shown in the Fig.



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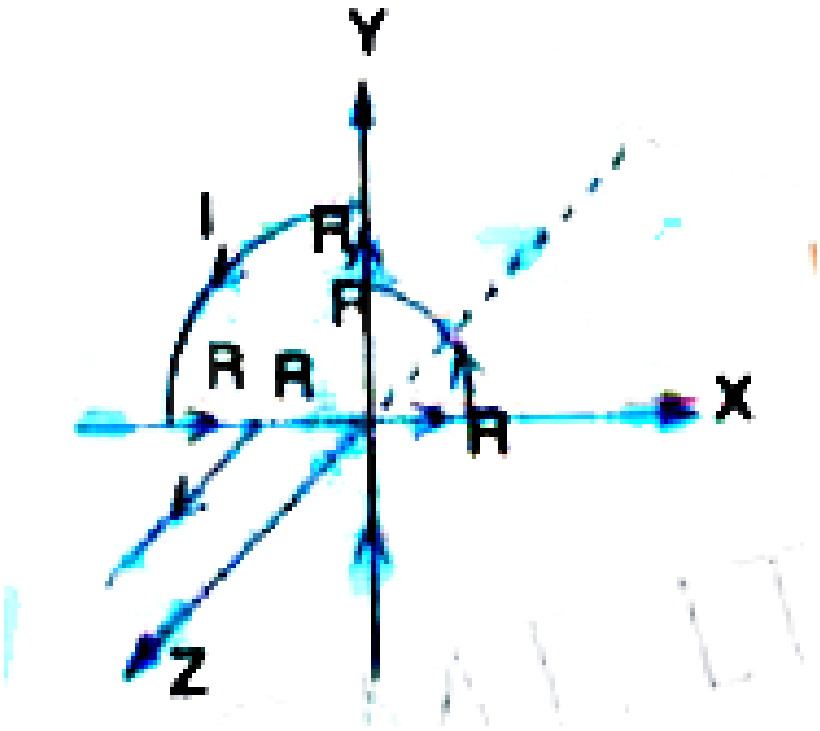
17. Find the magnetic induction at the origin in the figure shown.



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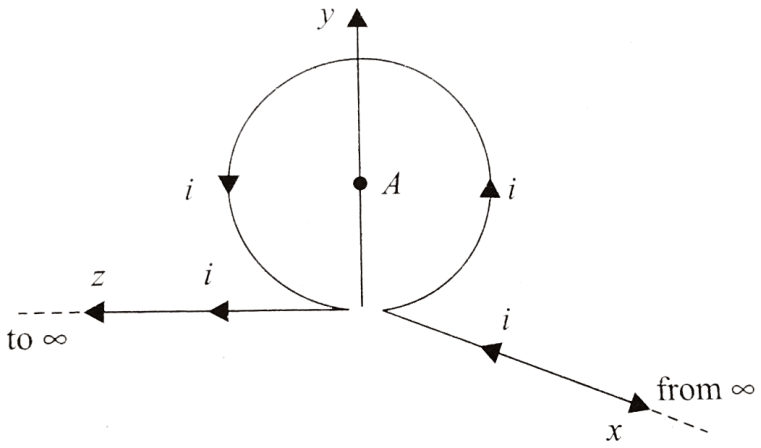
18. Find the magnitude of the magnetic induction B of a magnetic field generated by a system of thin conductors along which a current I is flowing at a point A (O, R, O), that is the centre of a circular conductor of

radius R. The ring is in yz plane.



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19. Two circular coils of wire each having a radius of $4cm$ and $10turns$ have a common axis and are $6cm$ apart.If a current of $1A$ passes through each coil in the opposite direction find the magnetic induction.

(a) At the centre of each coil:

(b) At a point on the axis, midway between them.

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20. An electron moting with a velocity of $5 \times 10^4 ms^{-1}$ enters into a uniform electric field and acquires a uniform accleleration of $10^4 ms^{-2}$ in the direction of its inintial motion.

(i) Colculate the time in which the electron would acquire a velocity double of its initial velocity

(ii) How much distance the electron would cover in this time ?

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21. A rectangular loop of wire is oriented with the left corner at the origin, one edge along X-axis and the other edge along Y-axis as shown in the figure. A magnetic field is directed into the page and has a magnitude that is given by B = α y where α is a constant. Find the total magnetic

force on the loop if it carries current i.

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22. Two coils each of 100 turns are held at right angles such that one lies in the vertical plane with their centres coinciding. The radius of the vertical coil is 20 cm and that of the horizontal coil is 30 cm. How would you neutralize the magnetic field of the earth at their common centre ? What is the current to be passed through each coil? Horizontal component of earth's magnetic induction $= 3.49 \times 10^{-5}$ T and angle of dip = 30°

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23. Magnetic field at a distance a from long current carrying wire is proportional to

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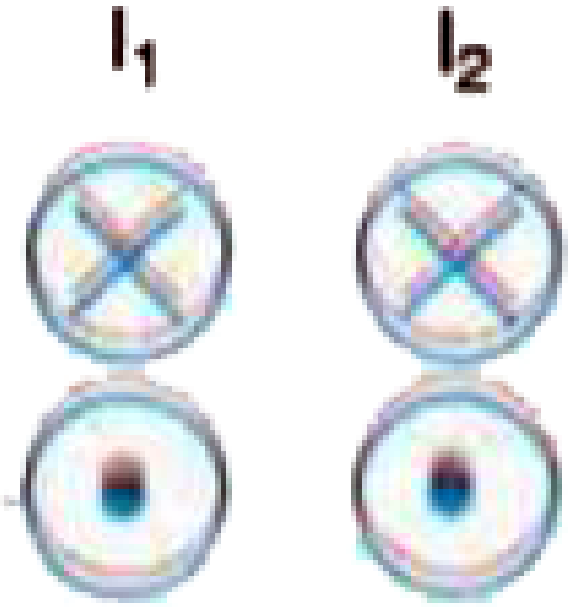
24. A system of long four parallel conductors whose sections with the plane of the drawing lie at the vertices of a square carry four equal currents. The directions of these currents are as follows: those marked $\otimes$ point away from the reader, while those marked with a dot point towards the reader. How is the vector of magnetic induction directed at

the centre of the square?



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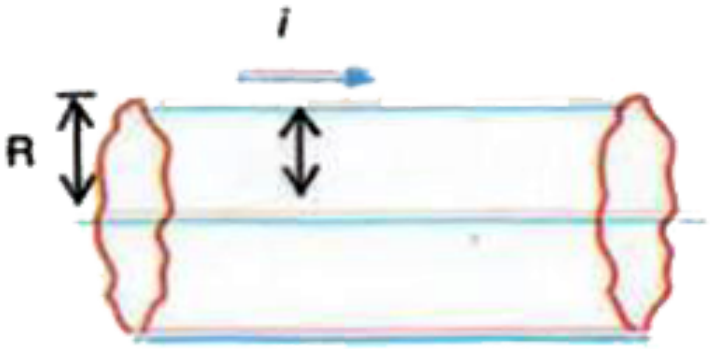
25. A cylindrical conductor of radius R carries a current along its length. The current density J, however, is not uniform over the cross section of the conductor but is a function of the radius according to J = br, where b is a constant. Find an expression for the magnetic field B.



(a) at $r_1 < R$

(b) at distance $r_2 > R$, measured from the axis.

Hint [use Ampere's Law]

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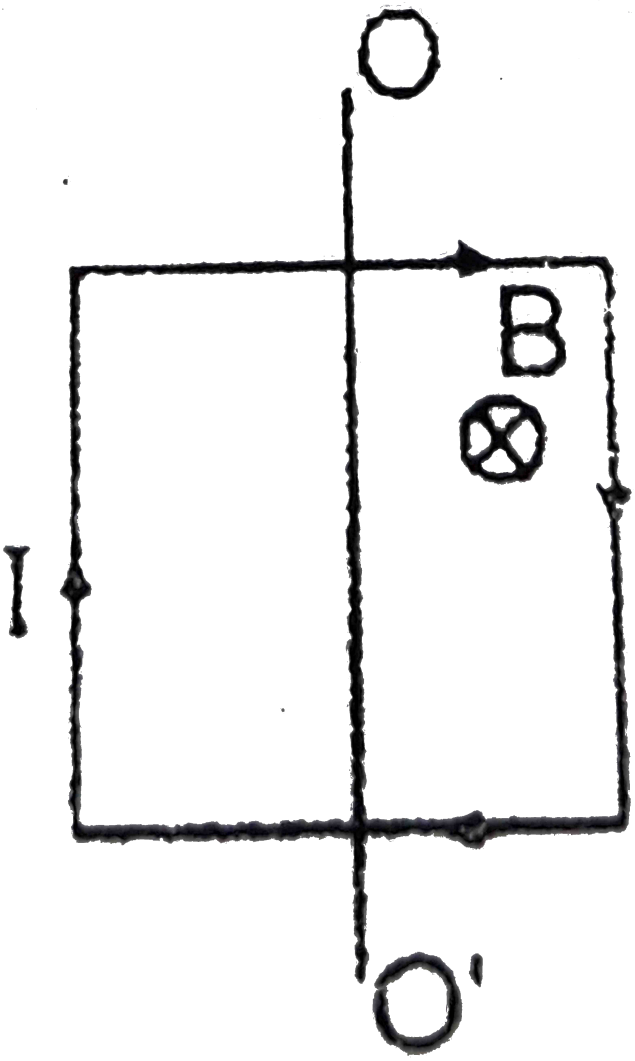
26. A square current carrying loop made of thin wire and having a mass $m = 10g$ can rotate without friction with respect to the vertical axis OO' passing through the centre of the loop at right angles to two opposite sides of the loop.The loop is placed in a homogeneous magnetic field with an induction $B = 10^{-1}T$ directed at right angles to the plane of the drawing.A current $I = 2A$ is flowing in the loop.Find the period of small oscillations that the loop perfoms about its position of stable

equilibrium.



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27. A current I flows through an infinitly long wire having infinite brands as shown. The radius of the first curved section is a and the radii of the successive curved portions each increases by a factor η. Find magnetic field at O.

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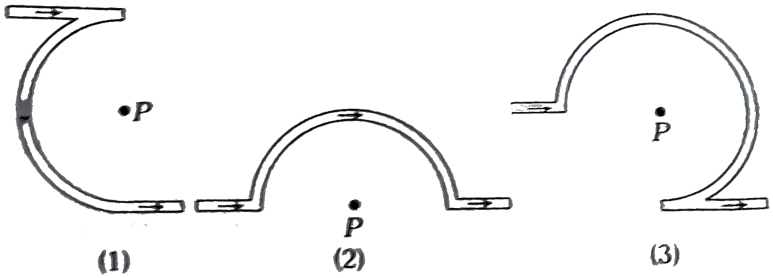
28. Figure here shows three cases, in all cases the circular path has radius r and straight ones are infinitely long. For same current, the magnetic field at the centre P in cases 1, 2 and 3 have the ratio



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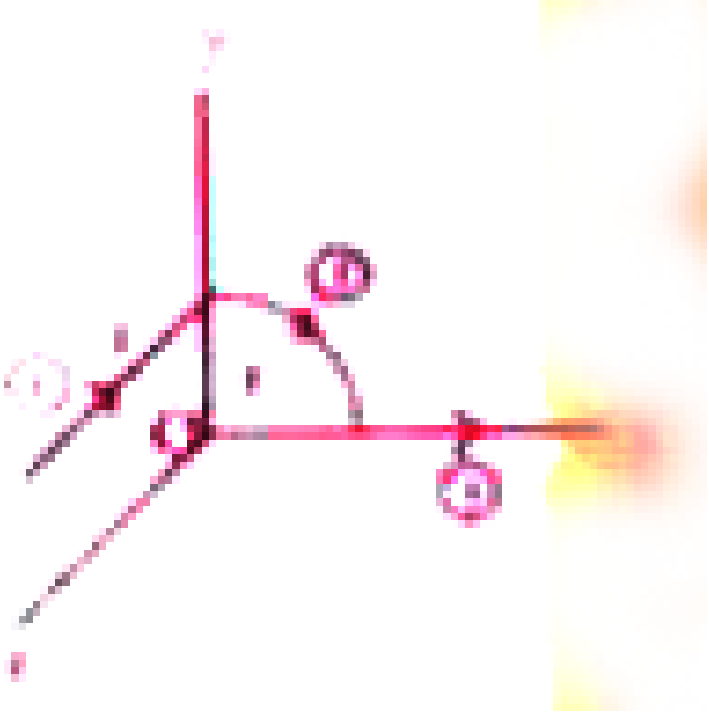
29. Find magnetic field at O due to the current carrying conductor as shown in the figure.



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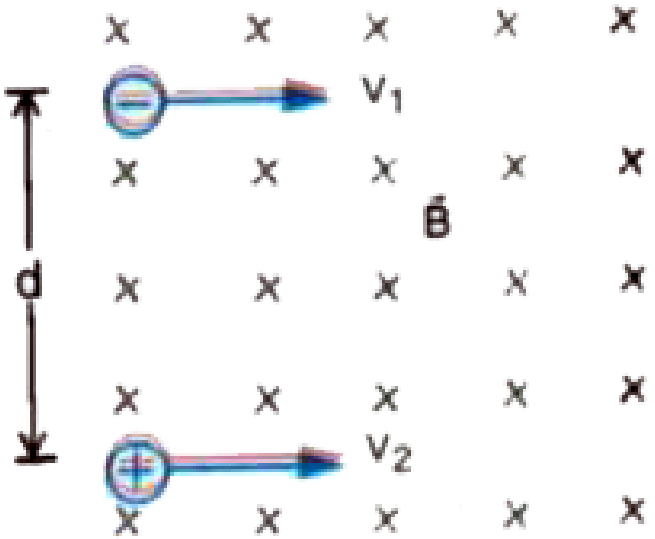
30. Two identical particles having the same mass m and charges +q and -q separated by a distance d enter a uniform magnetic field $\overline{B}$ as shown in

the figure. For what value of d the particles will not collide?



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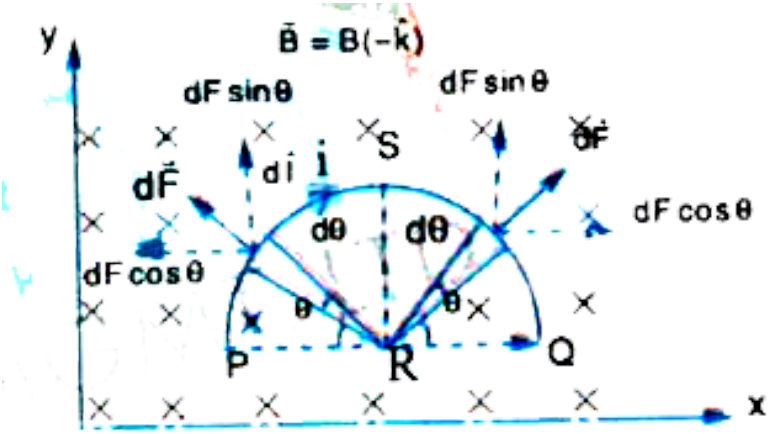
31. In the figure shown, a semi-circular wire loop of radius R is placed in a uniform magnetic field B. The plane of the loop is perpendicular to the

magnetic field. Find magnetic force on the loop.



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32. A flat dielectric disc of radius R carries an excess charge on its surface. The surface charge density σ. The disc rotastes about an axis perpendicular to its lane passing thrugh the centre with angulasr velocity ω. Find the toruque on the disc if it is placed in a uniform magnetic field B directed perpendicular to the rotation axis.

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33. Consider a solid sphere of radius r and mass m which has charge q distributed uniformly over its volume. The sphere is rotated abut a diameter with an angular speed ω. Show that the magnetic moment μ and the angular momentum l of the sphere are related as $\mu = \frac{q}{2m} l$.

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34. A thin uniform ring of radius R carrying charge q and mass m rotates about its axis with angular velocity ω. Find the ratio of its magnetic moment and angular momentum.

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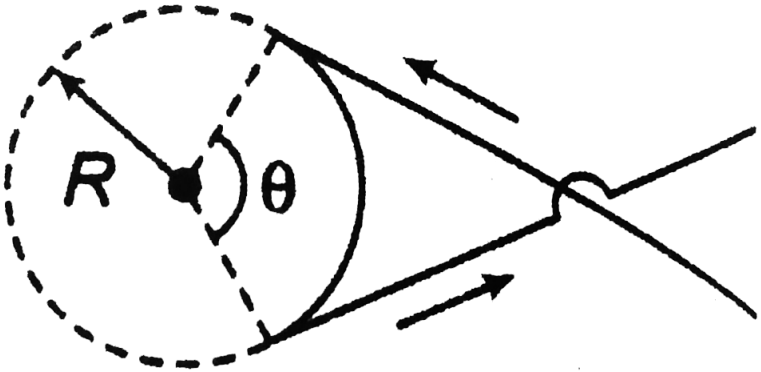
35. A wire carrying current i has the configuration as shown in figure. Two semi-infinite straight sections, both tangent to the same circle, are connected by a circular arc of central angle theta, along the circumference of the circle, with all sections lying in the same plane. What

must be for B to be zero at the centre of the circle?



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36. A uniform constant magnetic field B is directed at an angle of 45° to the $xa\xi s$ in the xy- plane . $PQRS$ is a rigid, square wire frame carrying a steady current I_0, with its centre at the origin O. At time $t = 0$, the frame is at rest in the position as shown in figure , with its sides parallel to the x and y axis. Each side of the frame is of mass M and length L.

(a) What is the torque τ about O acting on the frame due to the magnetic field?

(b) Find the angle by which the frame rotates under the action of this

torque in a short interval of time Δt, and the axis about this rotation occurs .

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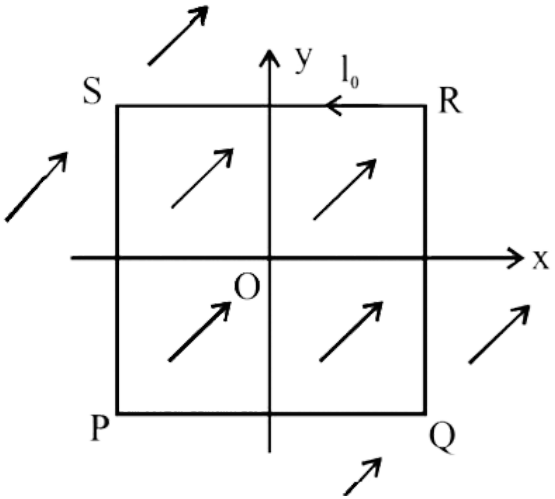
(4)/(3) ML^(2)`.



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37. A sphere of radius R, uniformly charged with the surface charge density σ rotates around the axis passing through its centre at an angular velocity. (a) Find the magnetic induction at the centre of the rotating sphere. (b) Also, find its magnetic moment.

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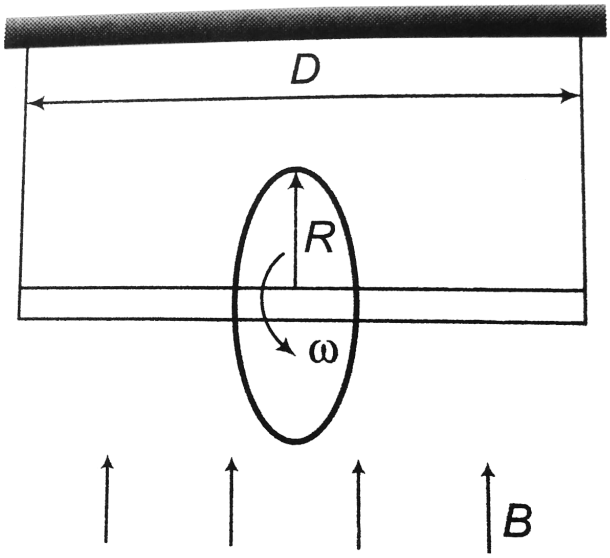
38. A ring of radius R having uniformly distributed charge Q. is mounted on a rod suspended by two identical strings. The tension in strings in equilibrium is T_0. Now, a vertical magnetic field is switched on and ring is rotated at constant angular velocity co. Find the maximum value of co h which the ring can be rotated if the strings can withstand a maximum tension of $\frac{3T_0}{2}$



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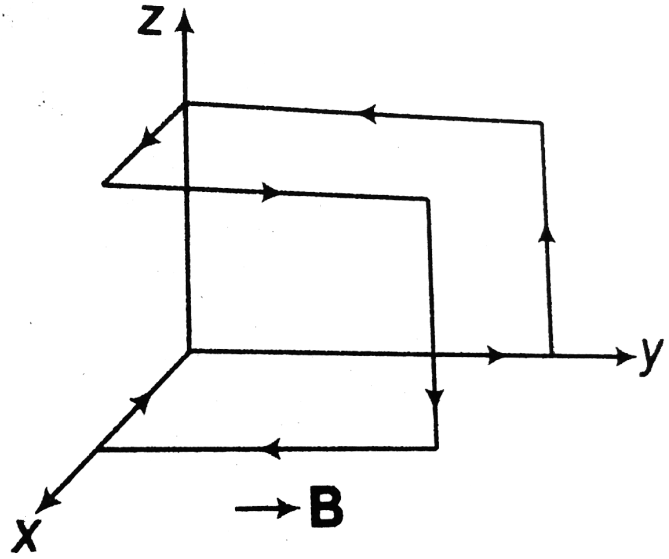
39. Given figure shows a coil bent with all edges of length $1m$ and carrying a current of $1A$. There exists in space a uniform magnetic field of $2T$ in positive y-direction. Find the torque on the loop.



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40. A long, straight wire carries a current i. A particle having a positive charge q and mass m kept at a distance x_0 from the wire is projected towards it with a speed v as shown in figure.Find the minimum separation between the wire and the particle.

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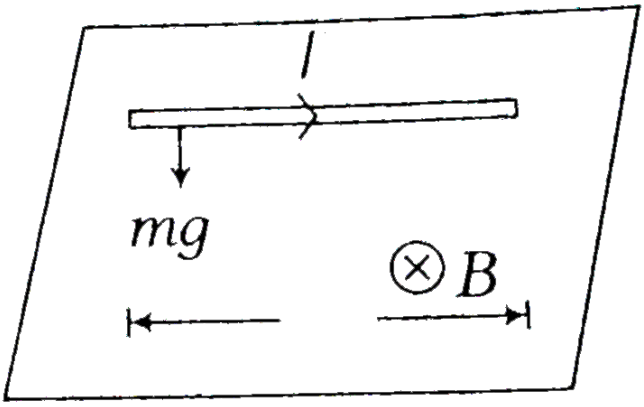
Additional Exercise

1. A straight wire of mass 200 g and length 1.5 m carries a current of 2 A .It is suspended in mid air by a unifrom horizontal magnetic field B , What is the magnitude of the magnetic field ?



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2. What is the radius of the path of an electron (mass 9×10^{-31} kg and charge $1.6 \times 10^{-19} C$) moving at a speed of $3 \times 10^{7} m/s$ in a magnetic

field of $6 \times 10^{-4} T$ perpendicular to it? What is its frequency? Calculate its energy in keV. $\left(1eV = 1.6 \times 10^{-19} J\right)$.

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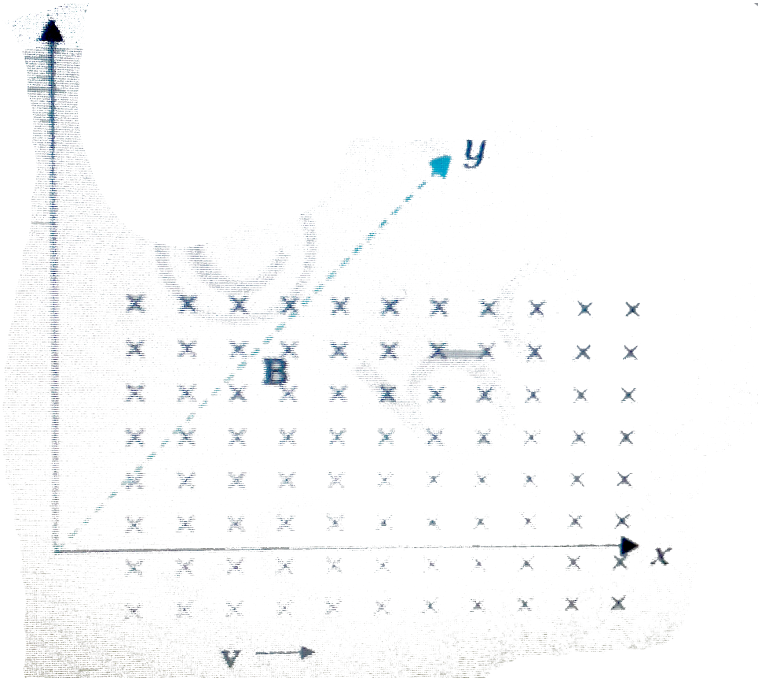
3. If the magnetic field is parallel to the positive y-axis and the charged particle is moving along the positive x-axis (Fig.), which way would the Lorentz force be for (a) an electron (negative charge), (b) a proton (positive charge).



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4. A cyclotron's oscillator frequency is $10MHz$. What should be the operating magnetic field fro accelerating protons? If the radius of its dees is $60cm$, what is the kinetic energy (in MeV) of the proton beam produced by the acceleration?

$\left(e - 1.60 \times 10^{-19}C, m_p = 1.67 \times 10^{-27}kg, 1MeV = 1.6 \times 10^{-13}J\right)$

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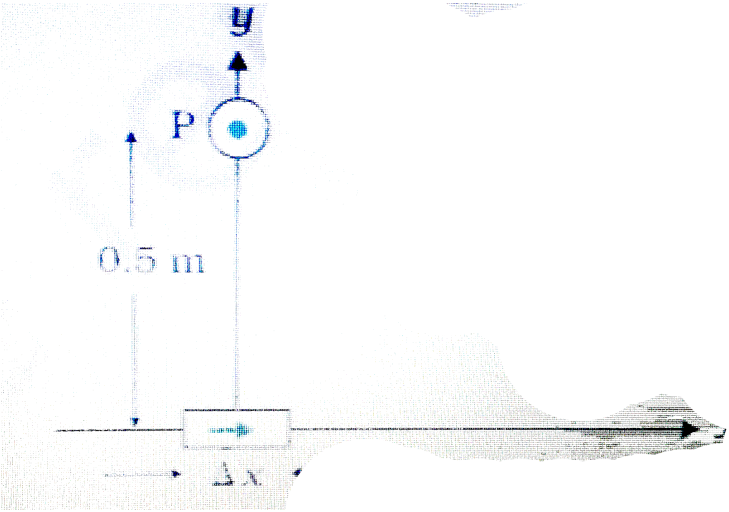
5. An element $\Delta l = \Delta x\hat{i}$ is placed at the origin and carries a large current $I = 10A$ (Fig.) . What is the magnetic field on the y-axis at a

distance of $0.5m$. $\Delta x = 1cm$.



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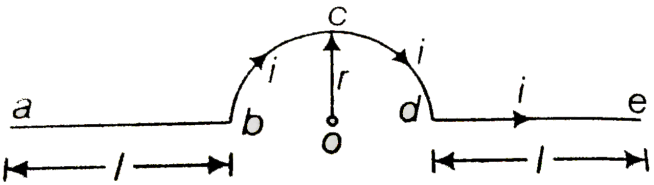
6. A long wire having a semicircular loop of radius r carries a current I as shown in figure.The magnetic induction at the centre O due to entire wire is



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7. Consider a tightly wound 100 turn coil of radius 10 cm, carrying a current of 1 A. What is the magnitude of the magnetic field at the centre of the coil?

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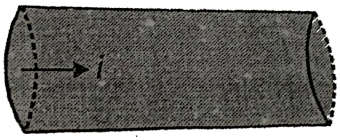
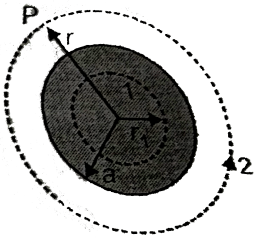
8. Figure shows a long straight wire of a circular cross-section (radius a) carrying steady current I. The current I is uniformly distributed across this cross-section. Calculate the magnetic field in the region $r < a$ and $r > a$





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9. A solenoid of length 0.5 m has a radius of 1 cm and is made up of 500 turns. It carries a current of 5 A. What is the magnitude of the magnetic field inside the solenoid?

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10. The horizontal component of the earth's magnetic field at a certain place is $3.0x \times 10^{-5}T$ and the direction of the field is from the geographic south to the geographic north. A very long straight conductor is carrying a steady current of 1A. What is the force per unit length on it when it is placed on a horizontal table and the direction of the current is (a) east to west, (b) south to north?

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11. A 100 turn closely wound circular coil of radius $10cm$ carries a current of $3 \cdot 2A$. (i) What is the field at the centre of the coil? (ii) What is the magnetic moment of this arrangement?

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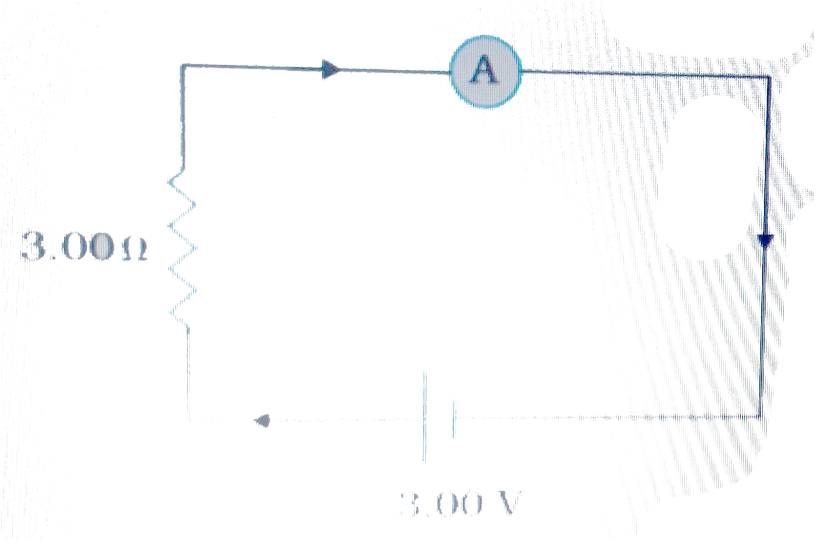
12. In the circuit (Fig.) the current is to be measured. What is the value of the current if the ammeter shown (a) is a galvanometer with a resistance $R_G = 60.00\Omega$, (b) is a galvanometer described in (a) but converted to an ammeter by a shunt resistance $r_s = 0.02\Omega$, (c) is an ideal ammeter with zero resistance



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13. (a) A current-carrying circular loop lies on a smooth horizontal plane. Can a uniform magnetic field be set up in such a manner that the loop turns around itself (i.e., turns about the vertical axis).

(b) A current-carrying circular loop is located in a uniform external magnetic field. If the loop is free to turn, what is its orientation of stable equilibrium? Show that in this orientation, the flux of the total field (external field + field produced by the loop) is maximum

(c) A loop of irregular shape carrying current is located in an external magnetic field. If the wire is flexible, why does it change to a circular shape?

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