PHYSICS

BOOKS - HC VERMA

MAGNETIC FIELD DUE TO CURRENT

Examples

1. A wire placed along north-south direction carries a current of 10 A from south to north. Find the magnetic field due to a 1 cm piece of wire at a point 200cm north-east from the piece.

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2. Figure shows two long, straight wires carrying electric currents in opposite directions. The separation between the wires is 5.0 cm. Find the magnetic field at a point P midway between the wires.

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3. Two long, staight wires, each carrying an electric current of 5.0 A, are kept parallel to each other at a separation of 2.5 cm. Find the magnitude of the magnetic force experienced by 10 cm of a wire.

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4. A circular coil of radius $1.5 cm$ carries a current of $1.5 A$. If the coil has 25 turns , find the magnetic field at the centre.

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5. A long solenoid is formed by winding 20 turns cm^{-1}. What current is necessary to produce a magnetic field of 20 mT inside the solenoid?

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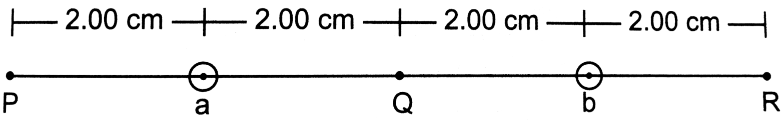
Worked Out Examples

1. Two long wires a and b, carrying equal currents of 10*0A, are placed parallel to each other with a separation of 4*00 cm between them as shown in figure. Find the magnetic field B at each of the points P,Q and R.



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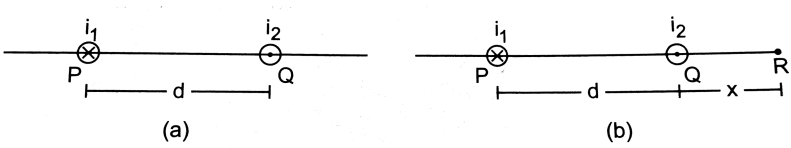
2. Two parallel wires P and Q placed at a separation

$d = 6cmcarrye \leq ctriccurrentsi_1 = 5A$ and $i_2 = 2A \in$

$oppositedirectionsasshown \in figure. F \in dthe$

$p\oint onthel \in ePQwherethere st\underline{\tan} tmag \neq ticfield$

is zero.



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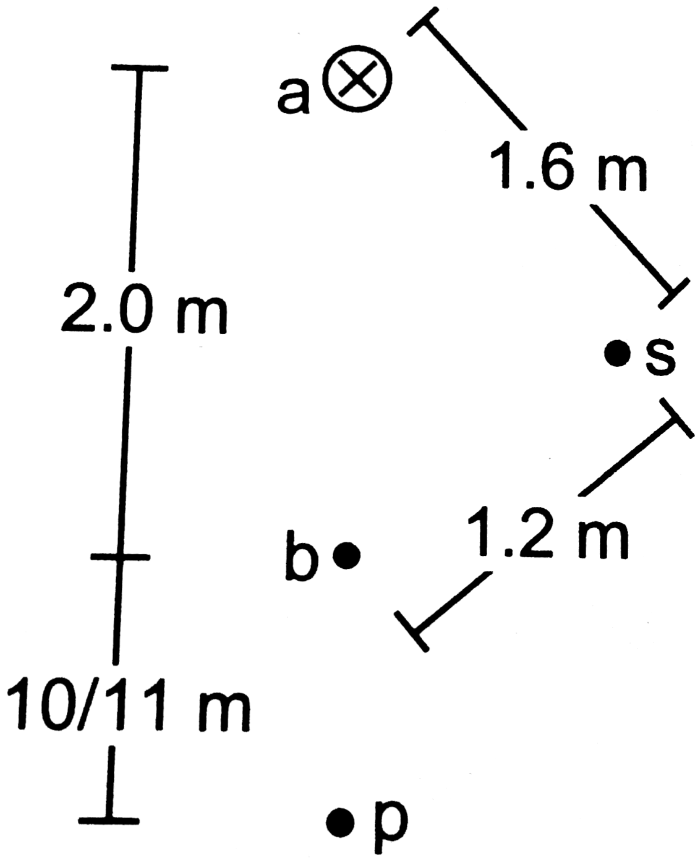
3. Two long, straight wires a and b are $2\cdot 0$ m apart, perpendicular to the plane of the paper as shown in figure . The wire a carries a current of $9\cdot 6A$ directed into the plane of the figure,The magnetic field at the point P at a distance of 10/11 m from the wire b is zero. Find (a) the magnitude and direction of the current in b, (b) the magnitude of the magnetic field B at the point s and (c) the force per unit length on the wire b`.



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4. A current of$2 \cdot 00A$ exists in a square loop of edge $10 \cdot 0cm$. Find the magnetic field B at the centre of the square loop.

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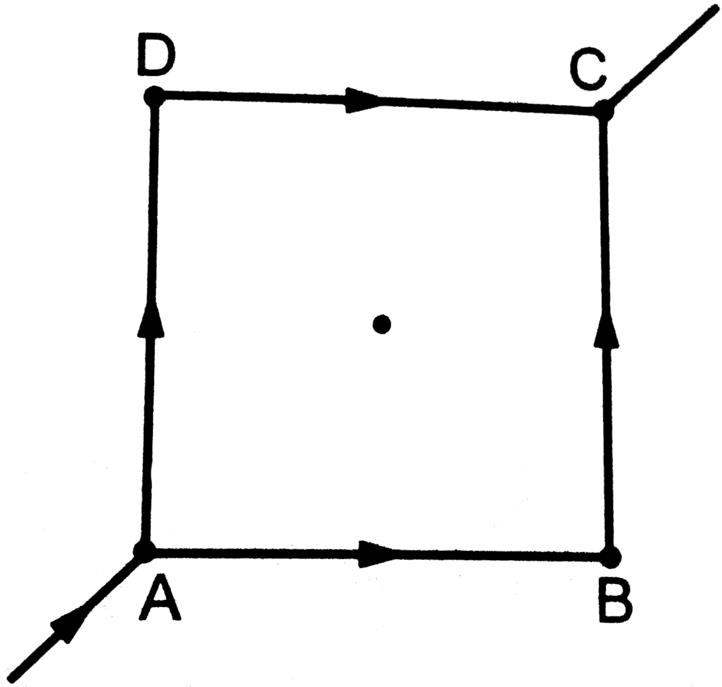
5. Figure shows a square loop made from a uniform wire. Find the magnetic field at the centre of the square if a battery is connected between the points A and C.



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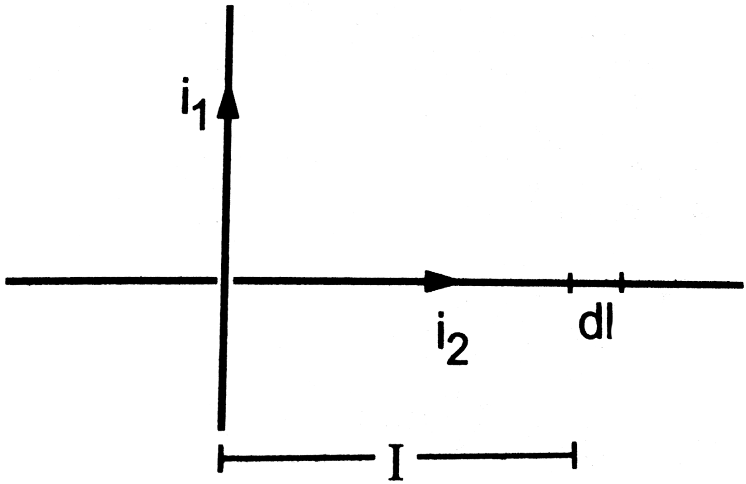
6. Two long wires, carrying currents i_1 and i_2, are placed perpendicular to each other in such a way that they just avoid a contact. Find the magnetic force on a small length dl of the second wire situated at a distance l from the first wire. (figure)



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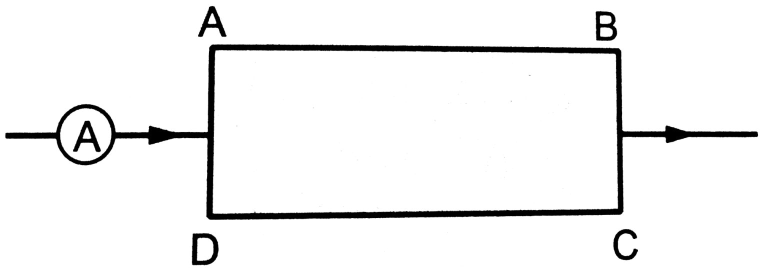
7. Figure shows a part of an electric circuit. ABCD is a rectangular loop made of uniform wire. The length AD= BC = 1 cm. The sides AB and DC are long as compared to the other two sides. Find the magnetic force per unit length acting on the wire DC due to the wire AB if the ammeter reads

10A.



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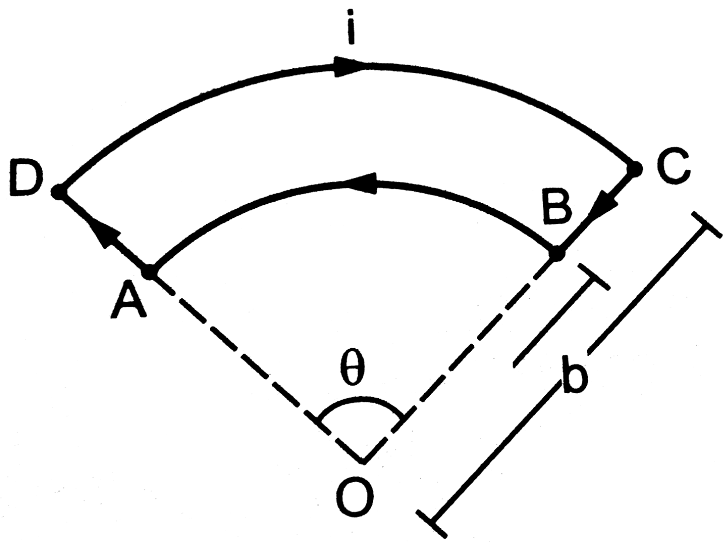
8. Figure shows a current loop having two circular arcs joined by two radial lines. Find the magnetic field B at the centre O.



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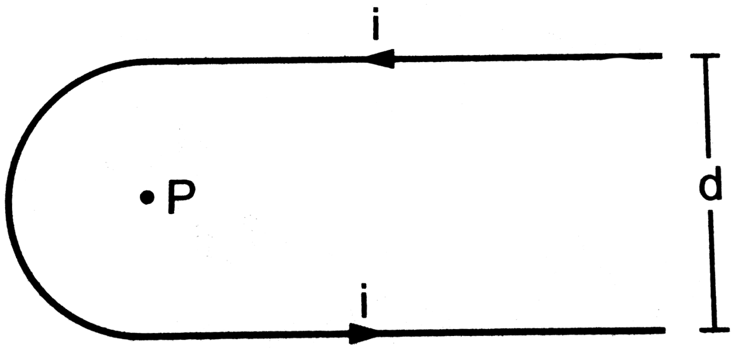
9. Find the magnetic field at the point P in figure. The curved portion is a semicircle and the straight wires are long.



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10. The magnetic field B due to a current- carrying circular loop of radius 12cm at its center is $0.50 \times (10^{-4})T$. Find the magnetic field due to this loop at a point on the axis at a distance of 5.0 cm from the centre.

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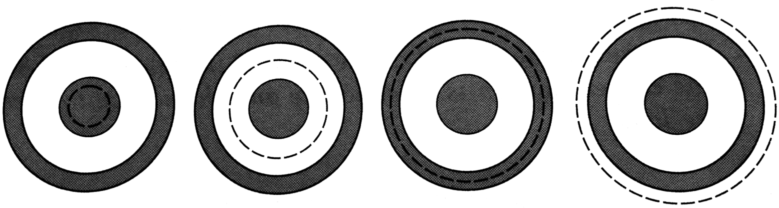
11. Consider a coaxial cable which consists of an inner wire of radius a surrounded by an outer shell of inner and outer radii b and c respectively. The inner wire carries an electric current `(i_0) and the outer shell carries an equal current in opposite direction. Find the magnetic field at a distance x from the axis where (a) xlta, (b) altxltb, (c) bltxltc and (d)xgtc. Assume that the current density is uniform in the inner wire and also uniform in the outer shell.



(b) (c) (d)

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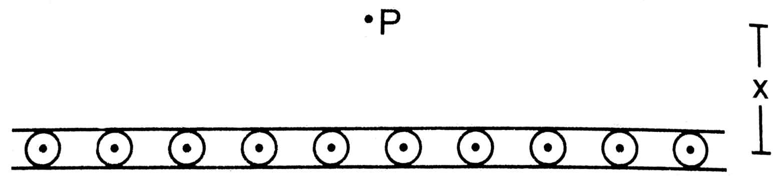
12. Figure shows a cross section of a large metal. Sheet carrying an electric current along its surface. The current in a strip of width dl is Kdl where K is a constant. Find the magnetic field at a point P at a distance x from the metal sheet.



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13. Consider the situation described in the previous example. A particle of mass m having a charge q is placed at a distance d from the metal sheet and is projected towards it. Find the maximum velocity of projection for which the particle does not hit the sheet.

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14. Three identical long solenoids P,Q and R are connected to each other as shown in figure . If the magnetic field at the centre of P is 2.0 T, what would be the field at the centre of Q? Assume that the field due to any solenoid is confined within the volume of that solenoid only.

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15. 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. Find the minimum separation between the wire and the particle.

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Short Answer

1. An electric current flows in a wire from north to south.

What will be the direction of the magnetic field due to this wire at a point.

A. east of the wire,

B. west of the wire,

C. vertically above the wire and

D. vertically below the wire?

Answer:

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2. The magnetic field due to a long straight wire has been derived in terms of μ_0,i and d. Express this in terms of ε_0, c, I, and d.

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3. You are facing a circular wire carrying an electric current. The current is clockwise as seen by you. Is the field at the centre coming towards you or going away from you?

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4. In Ampere's law $\left(\oint\left(\vec{B}\right).\left(\vec{d}\ l\right)\right) = (\mu_0)I$, the current outside the curve is not included on the right hand side. Does it mean that the magnetic field B calculated by using Ampere's law , gives the contribution of only the currents crossing the area bounded by the curve?

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5. The magnetic field inside a tightly wound, long solenoid is ` B= (mu_0)ni. It suggests that the field does not depend on the total length of the solenoid, and hence if we add more loops at the ends of a solenoid the field should not increase. Explain qualitatively why the extra added loops do not have a considerable effect on the field inside the solenoid.

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6. A long, straight wire carries a current. Is Ampere's law valid for a loop that does not enclose the wire, or that encloses the wire but is not circular?

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7. A straight wire carrying an electric current is placed along the axis of a uniformly charged ring. Will there be a magnetic force on the wire if the ring starts rotating about the wire? If yes, in which direction?

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8. Two wires carrying equal currents i each, are placed perpendicular to each other, just avoiding a contact. If one wire is held fixed and the other is free to move under magnetic forces, what kind of motion wil results?

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9. Two proton beams going in the same direction repel each other whereas two wires carrying currents in the same direction attract each other. Explain.

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10. In order to have a current in a long wire, it should be connected to a battery or some such device. Can we obtain the magnetic field due to a straight, long wire by using Ampere's law without mentioning this other part of the circuit?

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11. Quite often, connecting wires carrying currents in opposite directions are twisted together in using electrical appliances. Explain how it avoids unwanted magnetic fields.

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12. Two currents- carrying wires may attract each other. In absence of other forces, the wires will move towards each other increasing the kinetic energy . Does it contradict the fact that the magnetic force cannot do any work and hence cannot increase the kinetic energy?

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Objective 1

1. A vertical wire carries a current in upward direction. An electron beam sent horizontally towards the wire will be deflected

A. towards right

B. towards left

C. upwards

D. downwards

Answer: C

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2. A current- carrying straight wire is kept along the axis of a circular loop carrying a current. The straight wire

A. will exert an inward force on the circular loop

B. will exert an outward force on the circular loop

C. will not exert any force on the circular loop

D. will exert a force on the circular loop parallel to itself.

Answer: C

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3. A proton beam is going from north to south and an electron beam is going from south to north. Neglecting the earth's magnetic field, the electron beam will be deflected

A. towards the proton beam

B. away from the proton beam

C. upwards

D. downwards

Answer: A

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4. A circular loop is kept in that vertical plane which contains the north-south direction. It carries a current that is towards north at the topmost point. Let A be a point on the axis of the circle to the east of it and B a point on this axis to the west of it. The magnetic field due to the loop.

A. is towards east at A and towards west at B

B. is towards west at A and towards east at B

C. is towards east at both A and B

D. is towards west at both A and B.

Answer: D

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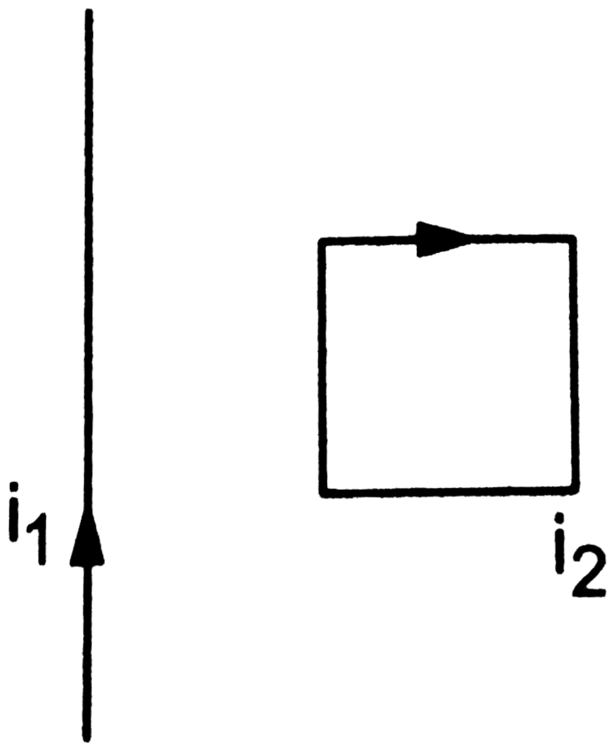
5. Consider the situation shown in figure. The straight wire is fixed but the loop can move under magnetic force. The loop will



A. remain stationary

B. move towards the wire

C. move away form the wire

D. rotate about the wire.

Answer: B

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6. A charged particle is moved along a magnetic field line. The magnetic force on the particle is

A. along its velocity

B. opposite to its velocity

C. perpendicular to its velocity

D. zero.

Answer: D

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7. A moving charge produces

A. electric field only

B. magnetic field only

C. both of them

D. none of them.

Answer: C

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8. A particle is projected in a plane perpendicular to a uniform magnetic field. The area bounded by the path described by the particle is proportional to

A. the velocity

B. the momentum

C. the kinetic energy

D. none of them.

Answer: C

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9. Two particle X and Y having equal charge, after being accelerated through the same potential difference enter a region of uniform magnetic field and describe circular paths of radii R_1 and R_2 respectively. The ratio of the mass of X to that of Y is

A. $\left(\frac{\left(\frac{R_1}{R_2}\right)^1}{2}\right)$

B. $\frac{R_1}{R_2}$

C. $\left(\frac{R_1}{R_2}\right)^2$

D. $(R_1)(R_2)$

Answer: C

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10. Two parallel wires carry currents of 20A and 40A in opposite directions. Another wire carrying a current antiparallel to 20A is placed midway between the two wires. The magnetic force on it will be

A. towards 20 A

B. towards 40 A

C. zero

D. perpendicular to the plane of the currents .

Answer: B

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11. Two parallel, long wires carry currents i_1 and i_2 with $i_1 > i_2$. When the currents are in the same direction, the magnetic field at a point midway between the wires is 10mu T. If the direction of i_2 is reversed, the field becomes 30mu T . The ration $\frac{i_1}{i_2}$ is

A. 4

B. 3

C. 2

D. 1

Answer: C

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12. Consider a long, straight wire of cross-sectional area A carrying a current i. Let there be n free electrons per unit volume. An observed places himself on a trolley moving in the direction opposite to the current with a moving in the direction opposite to the current with a speed `(v= i/nAe) and separated from the wire by a distance r. The magnetic field seen by the observer is very nearly

A. $\frac{\mu_0 i}{2\pi r}$

B. zero

C. $\frac{\mu_0 i}{\pi r}$

D. $\frac{(2\mu_0) i}{\pi r}$

Answer: A

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Objective 2

1. The magnetic field at the origin due to a current element I $\left(\overrightarrow{d}\ l\right)$ placed at a positon $\left(\overrightarrow{r}\right)$ is

A. $\left(\left(\frac{\mu_0 i}{4\pi}\right)\frac{\overrightarrow{dl}\times\overrightarrow{r}}{r^3}\right)$

B. $\left(-\left((\mu_0)\frac{i}{4\pi}\left(\vec{r}\times\frac{\vec{dl}}{r^3}\right)\right)\right)$

C. $\left((\mu_0)\frac{i}{4\pi}\left(\vec{r}\times\frac{\vec{dl}}{r^3}\right)\right)$

D. $\left(-\left((\mu_0)\frac{i}{4\pi}\frac{\vec{dl}\times\vec{r}}{r^3}\right)\right)$

Answer: C::D

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2. Consider three quantities ($x=\frac{E}{B}, y=\left(\sqrt{\frac{1}{(\mu_0)(\varepsilon_0)}}\right)$ and $z=\left(\frac{1}{C}R\right)$. Here, l is the length of a wire, C is a capacitance and R is a resistance. All other symbols have standard meanings.

A. x,y have the same dimensions.

B. y,z have the same dimensions.

C. z,x have the same dimensions.

D. none of the three pairs have the same dimensions.

Answer: A::B::C

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3. A long, straight wire carries a current along the z-axis. One can find two points in the x-y plane such that

A. the magnetic fields are equal

B. the directions of the magnetic fields are the same

C. the magnitudes of the magnetic fields are equal

D. the field at one point is opposite to that at the other point.

Answer: B::C::D

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4. A long, straight wire of radius R carries a current distributed uniformly over its cross section. The magnitude of the magnetic field is

A. maximum at the axis of the wire

B. minimum at the axis of the wire

C. maximum at the surface of the wire

D. minimum at the surface of the wire.

Answer: B::C

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5. A hollow tube is carrying an electric current along its length distributed uniformly over its surface. The magnetic field

A. increase linearly from the axis to the surface.

B. is constant inside the tube

C. is zero at the axis

D. is zero just outside the tude.

Answer: B::C

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6. In a coaxial, straight cable, the central conductor and the outer conductor carry equal currents in opposite directions. The magnetic field is zero.

A. outside the cable

B. inside the inner conductor

C. inside the outer conductor

D. in between the two conductor

Answer: A

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7. A steady electric current is flowing through a cylindrical conductor. Then,

A. The electric field at the axis of the conductor is zero.

B. The magnetic field at the axis of the conductor is zero.

C. The electric field in the vicinity of the conductor is zero.

D. The magnetic field in the vicinity of the conductor is zero.

Answer: B::C

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Exercises

1. Using the formulae ($\left(\overrightarrow{F}\right)=\left(\overrightarrow{q}v\right)\times\left(\overrightarrow{B}\right)$ and $\left(B=(\mu_0)\frac{i}{2}\pi r\right)$, show that the SI units of the magnetic field B and the permeability constant (μ_0) may be written as $\left(NmA^{-1}\right)$ and $\left(NA^{-2}\right)$ respectively.

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2. A current of 10A is established in a long wire along the positive z-axis. Find the magnetic field $\left(\overrightarrow{B}\right)$ at the point (1m , 0 , 0).

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3. A copper wire of diameter 1.6 mm carries a current of 20A. Find the maximum magnitude of the magnetic field $\left(\overrightarrow{B}\right)$ due to this current.

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4. A transmission wire carries a current of 100A. What would be the magnetic field B at a point on the road if the wire is 8 m above the road?

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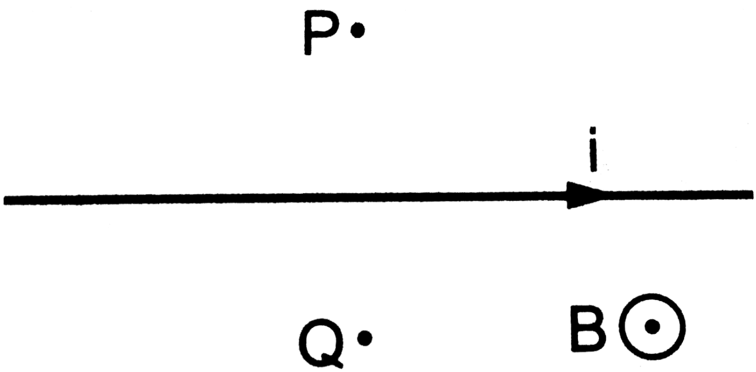
5. A long, straight wire carrying a current of 1.0 A is placed horizontally in a uniform magnetic field B= (1.0×10^{-5}) T pointing vertically upward.

Find the magnitude of the resultant magnetic field at the points P and Q, both situated at a distance of 2.0 cm from the wire in the same horizontal plane.



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6. A long, straight wire of radius r carries a current i and is placed horizontally in a uniform magnetic field B pointing vertically upward. The current is uniformly distributed over its cross section. (a) At what points will the resultantant magnetic field have maximum magnitude? What will be the maximum magnitude? (b) What will be the minimum magnitude of the resultant magnetic field?

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7. A long, straight wire carrying a current of 30 A is placed in an external, uniform magnetic field of $(4.0 \times (10^{-4})$ T exists from south to north.Find the magnitude of the resultant magnetic field at a point 2.0cm away from the wire.

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8. A long vertical wire carrying a current of 10A in the upward direction is placed in a region where a horizontal magnetic field of magnitude($2.0 \times 10^{-3})$ T exists from south to north. Find the point where the resultant magnetic field is zero.

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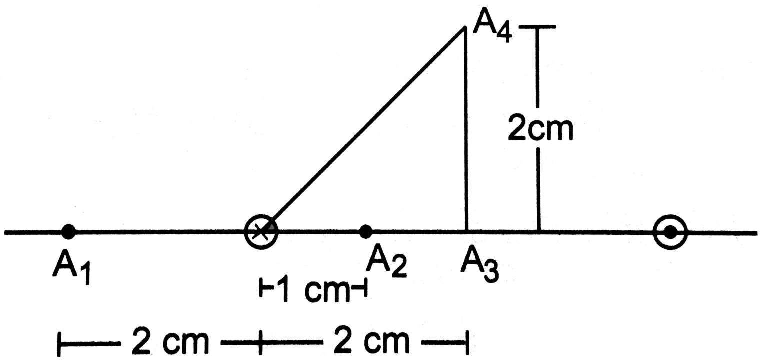
9. Figure shows two parallel wires separated by a distance of 4.0 cm and carrying equal currents of 10A along opposite directions. Find the magnitude of the magnetic field B at the points A_1, A_2, A_3 and A_4.



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10. Two parallel wires carry equal currents of 10A along the same direction and are separated by a distance of 2.0 cm. Find the magnetic field at a point which is 2.0 cm away from each of these wires.

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11. Two long, straight wires, each carrying a current of 5A, are placed along the x and y axes respectively. The currents point along the positive directions of the axes. Find the magnetic fields at the points (a) (1m, 1m), (b) (-1m, 1m), (c) (-1m, -1m) and (d) (1m, -1m).

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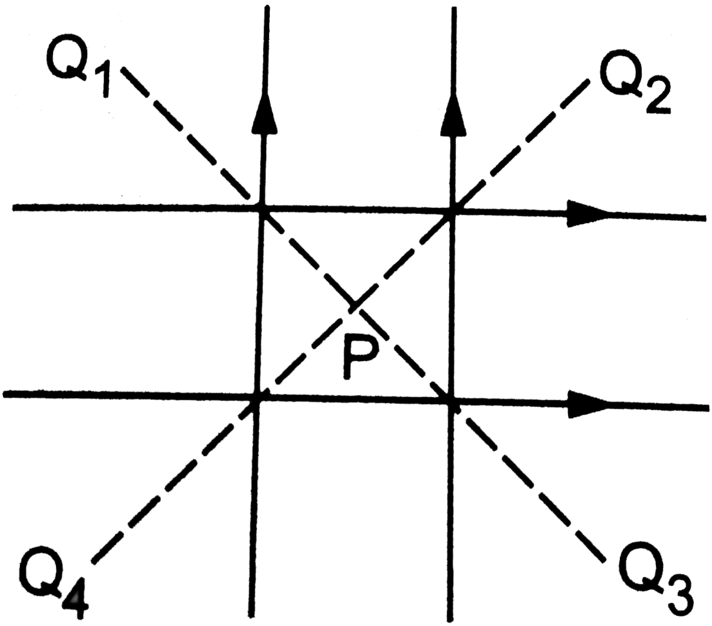
12. Four long, straight wires, each carrying a current of 5.0 A, are placed in a plane as shown in figure . The points of intersection form a square of side 5.0 cm. (a) Find the magnetic field at the centre P of the square. (b) Q_1, Q_2, Q_3 and Q_4 are points situated on the diagonals of the square and at a distance from P that is equal to the length of the diagonal of the square. Find the magnetic fields at these points. `



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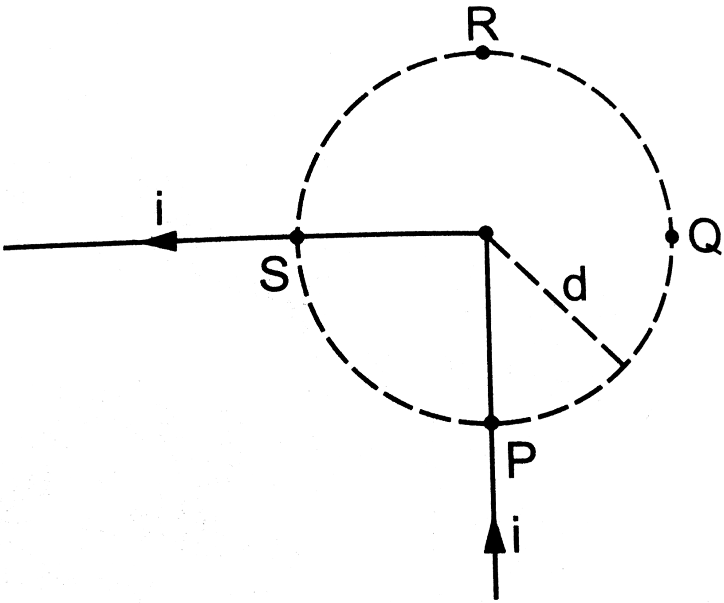
13. Figure shows a long wire bent at the middle to form a right angle. Show that the magnitudes of the magnetic fields at the points P,Q, R and

S are equal and find this magnitude.`



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14. Consider a straight piece of length x of a wire carrying a current i. Let P be a point on the perpendicular bisector of the piece, situated at a distance d from its middle point. Show that for dgtgtx, the magnetic field at P varies as $\left(\frac{1}{d^2}\right)$ whereas for dltltx, it varies as 1/d.

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15. Consider a 10-cm long piece of a wire which carries a current of 10A . Find the magnitude of the magnetic field due to the piece at a point which makes an equilateral triangle with the ends of the piece.

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16. A long, straight wire carries a current i. Let `B_1 be the magnetic field at a point P at a distance d from the wire. Consider a section of length l of this wire such that the point P lies on a perpendicular bisector of the section. Let B_2 be the magnetic field at this point due to this section only. Find the value of d/l so that B_2 differs from B_1 by 1 %.

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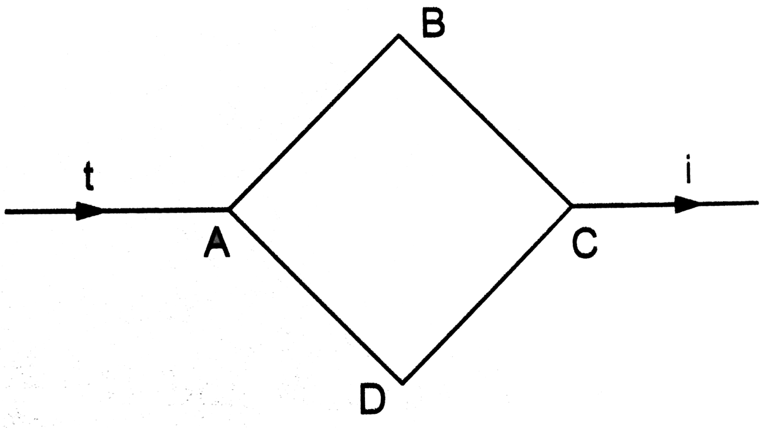
17. Figure shows a square loop ABCD with edge length a. The resistance of the wire ABC is r and that of ADC is 2r. Find the magnetic field B at the centre of the loop assuming uniform wires. `



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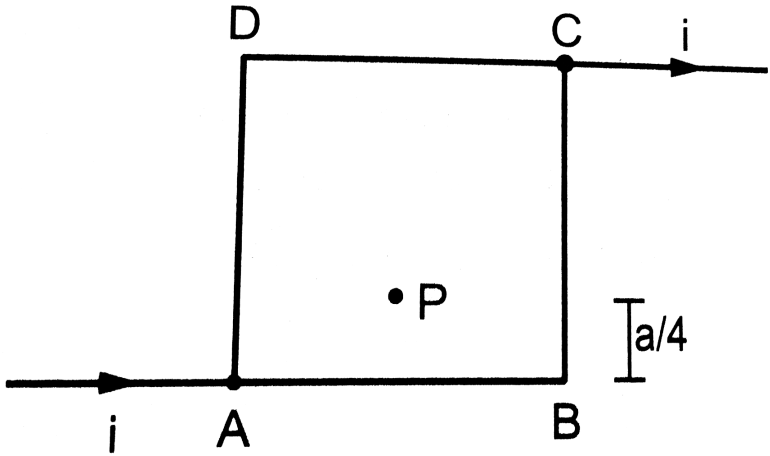
18. Figure shows a square loop of edge a made of a uniform wire. A current i enters the loop at the point A and leaves it at the point C. Find the magnetic field at the point P which is on the perpendicular bisector of

AB at a distance a/4 from it.`



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19. Consider the situation described in the previous problem. Suppose the current I enters the loop at the point A and leaves it at the point B. Find the magnetic field at the centre of the loop.

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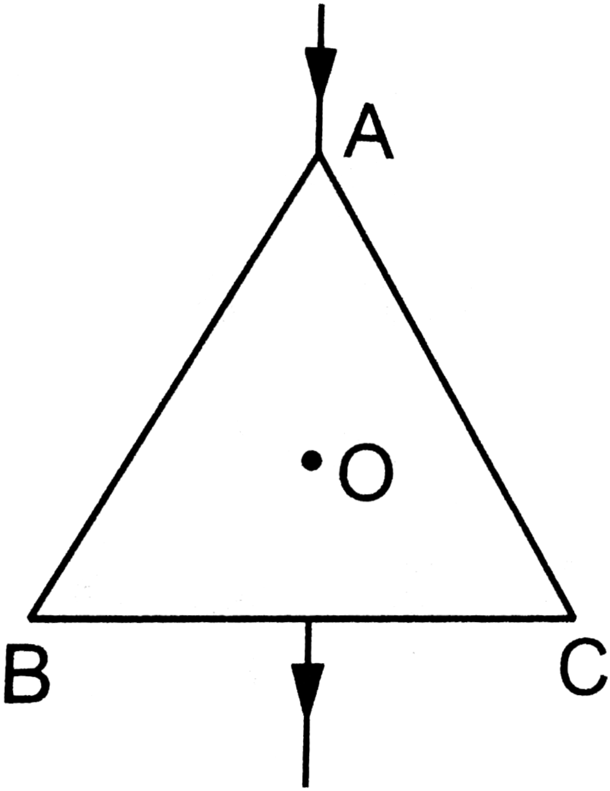
20. The wire ABC shown in figure forms an equilateral triangle. Find the magnetic field B at the centre O of the triangle assuming the wire to be uniform. `



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21. A wire of length l is bent in the form of an equilateral triangle and carries an electric current i. (a) Find the magnetic field B at the centre. (b) If the wire is bent in the form of a square, what would be the value of B at the centre?

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22. $Alongwirecarry \in gacurrentiisbent \rightarrow f$ or $mapla \neq \angle\alpha.$

$F \in dthemag \neq ticfieldBatap \oint onthebi \sec \rightarrow rofthis\angle situatedatadis$ ta

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23. Find the magnetic field B at the centre of a rectangular loop of length l and width b, carrying a current i.

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24. A regular polygon of n sides is formed by bending a wire of total length $2\pi r$ which carries a current i. (a) Find the magnetic field B at the centre of the polygon. (b) By letting $n \rightarrow \infty$, deduce the expression for the magnetic field at the centre of a circular current.

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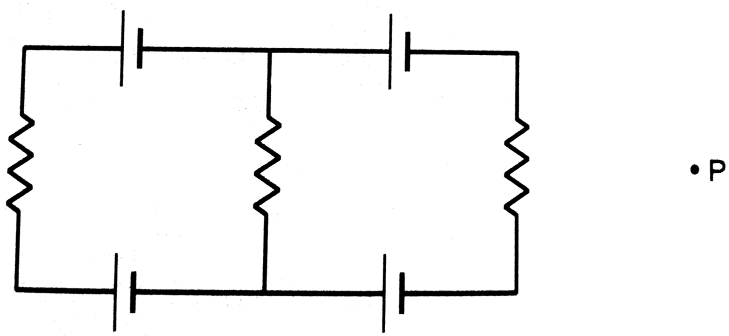
25. Each of the batteries shown in figure has an emf equal to 5 V. Show that the magnetic field B at the point P is zero for any set of values of the resistances .



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26. A straight , long wire carries a current a current of 20A. Another wire carrying equal current is placed parallel to it. If the force acting on a length of 10cm of the second wire is $(2.0 \times (10^{-5}))N$, what is the separation between them?

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27. Three coplanar parallel wires, each carrying a current of 10 A along the same direction, are placed with a separation 5.0 cm between the consecutive ones. Find the magnitude of the magnetic force per unit length acting on the wires.

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28. Two parallel wires separated by a distance of 10cm carry currents of 10 A and 40 A along the same direction, Where should a third current be placed so that it experience no magnetic force?

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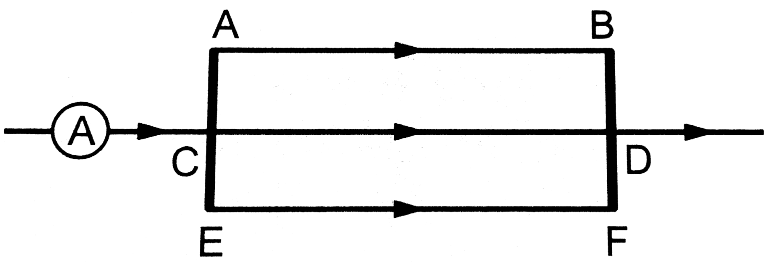
29. Figure shows a part of an electric circuit. The wires AB, CD, and EF are long and have identical resistances. The separation between the neighbouring wires is 1.0 cm. The wires AE and BF have negligible resistances and the ammeter reads 30 A . Calculate the magnetic force per unit length of AB and CD.`



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30. A long, straight wire is fixed horizontally and carries a current of 50.0 A. A second wire having linear mass density 1 x 10^(-4) is placed directly above this wire at a separation of 5.0 mm. What current should this second wire carry such that the magnetic repulsion can balance its weight?

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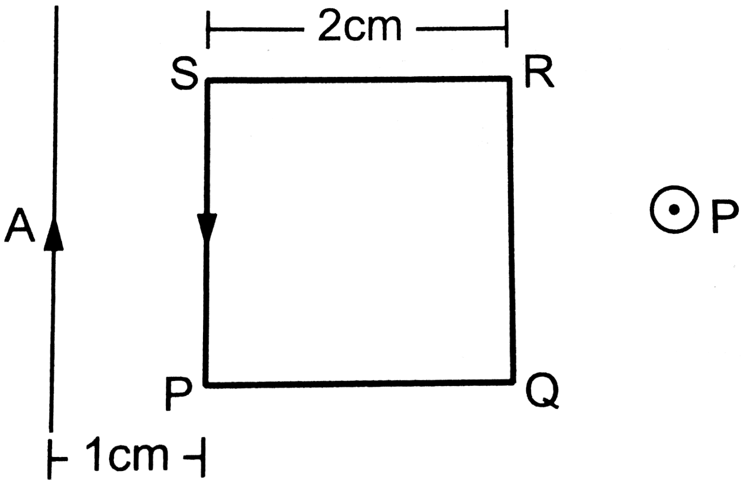
31. A square loop PQRS carrying a current of 6.0 A is placed near a long wire carrying 10 A as shown in figure . (a) Show that the magnetic force acting on the part PQ is equal and opposite to that on the part RS. (b) Find the magnetic force on the square loop. `



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32. A circular loop of one turn carries a current of 5.00 A. If the magnetic field B at the centre is 0.200 mT, find the radius of the loop.

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33. A current - carrying circular coil of 100 turns and radius 5.0 cm produces a magnetic field of (6.0×10^{-5}) T at its centre. Find the value of the current.

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34. An electron makes (3×10^{5}) revolutions per second in a circle of radius 0.5 angstrom. Find the magnetic field B at the centre of the circle.

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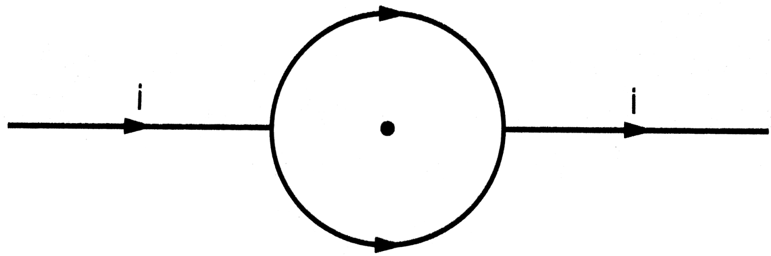
35. A conducting circular loop of radius a is connected to two long, straight wires . The straight wires carry a current I as shown in figure .

Find the magnetic field B at the centre of the loop.



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36. Two circular coils of radii 5.0 cm and 10 cm carry equal currents of 2.0 A. The coils have 50 and 100 turns respectively and are placed in such a way that their planes as well as the centres coincide. Find the magnitude of the magnetic field B at the common centre of the coils if the currents in the coils are (a) in the same sense (b) in the opposite sense.

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37. If the outer coil of the precious problem is rotated through 90^@ about a diameter, what would be the magnitude of the magnetic field B at the centre ?

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38. A circular loop of radius 20 cm carries a current of 10 A. An electron crosses the plane of the loop with a speed of (` 2.0 xx (10^6) m s^-1). The direction of motion makes an angle of 30^@ with the axis of the circle and passes through its centre. Find the magnitude of the magnetic force on the electron at the instant it crosses the plane.

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39. A circular loop of radius R carries a current I. Another circular loop of radius r(ltltR) carries a current I. The plane of the smaller loop makes an angle of 30^@ with that of the larger loop. The planes of the two circles are at right angle to each other. Find the torque acting on the smaller loop.

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40. A circular loop of radius r carrying a current i is held at the centre of another circular loop of radius R(>> r) carrying a current I. The plane of the smaller loop makes an angle of 30° with that of the larger loop. It the smaller loop is held fixed in this position by applying a single force at a point on its periphery, what would be the minimum magnitude of this force?

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41. Find the magnetic field B due to a semicircular wire of radius 10.0 cm carrying a current of 5.0A at its centre of curvature .

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42. A piece of wire carrying a current of 6.00 A is bent in the form of a circular arc of radius 10.0 cm, and it subtends an angle of 120° at the centre. Find the magnetic field B due to this piece of wire at the centre.

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43. A circular loop of radius r carries a current i. How should a long , straight wire carrying a current 4i be placed in the plane of the circle so that the magnetic field at the centre becomes zero?

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44. A circular coil of 200 turns has a radius of 10 cm and carries a current of 2.0 A. (a) Find the magnitude of the magnetic field $\left(\overrightarrow{B}\right)$ at the centre of the coil. (b) At what distance from the centre along the axis of the coil will the field B drop to half its value at the centre?

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45. A circular loop of radius 4.0 cm is placed in a horizontal plane and carries an electric current of 5.0 A in the clockwise direction as seen from above. Find the magnetic field (a) at a point 3.0 cm above the centre of the loop (b) at a point 3.0 cm below the centre of the loop.

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46. A charge of (3.14×10^{-6}) C is distributed uniformly over a circular ring of radius 20.0 cm. The ring rotates about its axis with an angular velocity of 60.0 rad ` s^-1 . Find the ratio of the electric field to the magnetic field at a point on the axis at a distance of 5.00 cm from the centre.

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47. A thin but long, hollow, cylindrical tube of radius r carries a current i along its length. Find the magnitude of the magnetic field at a distance r/2 from the surface (a) inside the tube (b) outside the tube.

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48. A long, cylindrical tube of inner and outer radii a and b carries a current i distributed uniformly over its cross section. Find the magnitude of the magnetic field at a point (a) just inside the tube (b) just outside the tube.

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49. A long, cylindrical wire of radius b carries a current i distributed uniformly over its cross section. Find the magnitude of the magnetic field at a point inside the wire at a distance a from the axis.

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50. A solid wire of radius 10 cm carries a current of 5.0 A distributed uniformly over its cross section. Find the magnetic field B at a point at a distance (a) 2 cm (b) 10 cm and (c) 20 cm away from the axis. Sketch a graph of B versus x for 0ltxlt20 cm .

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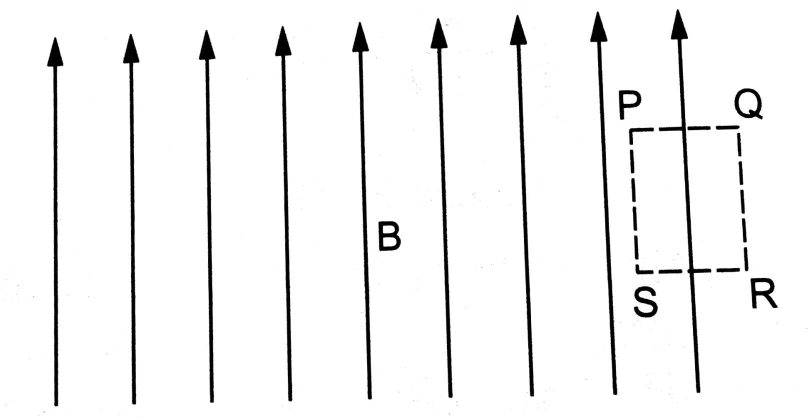
51. Sometimes we show an idealised magnetic field which is uniform in a given region and falls to zero abruptly. One such field is represented in figure . Using Ampere's law over the path PQRS, show that such a field is not possible.



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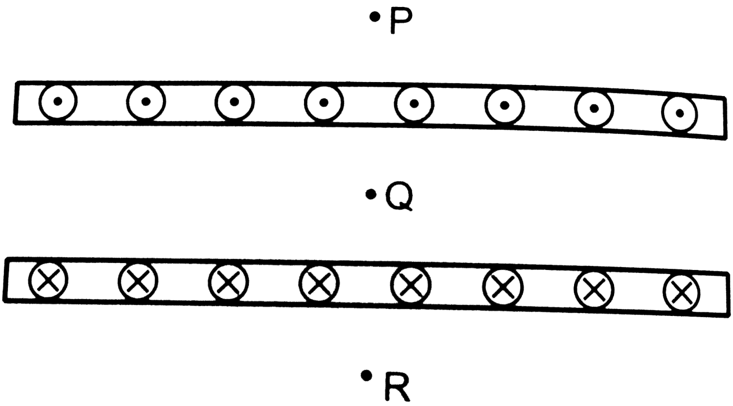
52. Two large metal sheets carry surface currents as shown in figure . The current through a strip of width dl is Kdl where K is a constant . Find the magnetic field at the points P,Q and R. `



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53. Consider the situation of the previous problem. A particle having charge q and mass m is projected from the point Q in a direction going into the plane of the diagram. It is found to describe a circle of radius r between the two plates. Find the speed of the charged particle.

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54. The magnetic field B inside a long solenoid, carrying a current of 5.00 A, is $\left(3.14 \times 10^{-2}\right)$ T. Find the number of turns per unit length of the solenoid.

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55. A long solenoid is fabricated by closely winding a wire of radius 0.5 mm over a cylindrical nonmagnetic frame so that the successive turns nearly touch each other. What would be the magnetic field B at the centre of the solenoid if it carries a current of 5 A?

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56. A copper wire having resistance 0.01 ohm in each metre is used to wind a 400 turn solenoid of radius 1.0 cm and length 20 cm. Find the emf of a battery which when connected across the solenoid will cause a magnetic field of (1.0×10^{-2}) T near the centre of the solenoid.

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57. A tightly- wound solenoid of radius a and length l has n turns per unit length. It carries an electric current i. Consider a length dx of the solenoid at a distance x from one end. This contains n dx turns and may be approximated as a circular current I n dx. (a) Write the magnetic field at the centre of the solenoid due to this circular current. Integrate this expression under proper limits to find the magnetic field at the centre of the solenoid. (b) Verify that if $l > > a$, the field tends to $(B = (\mu_0)ni)$ and if $a > > 1$, the field tends to $B = \left((\mu_0)ni\frac{l}{2}a\right)$. Interpret these results.

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58. A tightly- wound , long solenoid carries a current of 2.00 A. An electron is found to execute a uniform circular motion inside the solenoid with a frequency of $(1.00 \times 10^8 revs^{-1})$. Find the number of turns per metre in the solenoid.

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59. A tightly-wound, long solenoid has n turns per unit length, a radius r and carries a current i. A particle having charge q and mass m is projected from a point on the axis in a direction perpendicular to the axis. What can be the maximum speed for which the particle does not strike the solenoid?

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60. A tightly- wound, long solenoid is kept with its axis parallel to a large metal sheet carrying a surface current. The surgace current through a width dl of the sheet is Kdl and the number of turns per unit length of the solenoid is n. The magnetic field near the centre of the solenoid is found to be zero. (a) find the current in the solenoid. (b) If the solenoid is rotated to make its axis perpendicular to the metal sheet, what would be the magnitude of the magnetic field near its centre?

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61. A capacitor of capacitance $100 \mu F$ is connected to a battery of 20 volts for a long time and then disconnected from it. It is now connected across a long solenoid having 4000 turns per meter. It is found that the potential difference across the capacitor drops to 90° of its maximum value in 2.0 seconds. Estimate the average magnetic field produced at the centre of the solenoid during this period.

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