MOVING CHA & MAG

12th Standard CBSE

Date : 17-Nov-22

Physics

Reg.No. :

Exam Time : 02:00:00 Hrs

Total Marks : 100

105 x 5 = 525

1) An electron emitted by a heated cathode and accelerated through a potential difference of 2.0 kV, enters a region with uniform magnetic field of 0.15 T. Determine the trajectory of the electron if the field

(a) is transverse to its initial velocity,

(b) makes an angle of 30^o with the initial velocity.

2) A uniform magnetic field of 1.5 T exists in a cylindrical region of radius 10.0 cm, its direction is parallel to the axis along east to west. A wire carrying current of 7.0 A in the north to south direction passes through this region. What is the magnitude and direction of the force on the wire if,

(a) the wire intersects the axis,

(b) the wire is turned from N-S to northeast-southwest direction,

(c) the wire in the N-S direction is lowered from the axis by a distance of 6.0 cm?

3) In a chamber, a uniform magnetic field of 6.5 G (1 G = 10^{-4} T) is maintained. An electron is shot into the field with a speed of 4.8 x 10^6 m s^{-1} normal to the field. Explain why the path of the electron is a circle. Determine the radius of the circular orbit. (e = 1.6 x 10^{-19} C, m_e = 9.1 x 10^{-31} kg)

4) Assume the dipole model for earth's magnetic field B which by B_v = vertical component of magnetic field=$\frac{\mu_0}{4\pi}\frac{2M\cos\theta}{r^3}B_H =$ Horizontal component of magnetic field=$\frac{\mu_0}{4\pi}\frac{2M\sin\theta M}{r^3}, \theta = 90^\circ =$ lattitude as measured from magnetic equator.Find loci of points for which (i) $|B|$ is minimum:(ii) dip angle is zero.and (iii) dip angle is$\pm 45^\circ$.

5) Two concentric circular coils X and Y of radii 16 cm and 10 cm respectively lie in the same vertical plane containing the north-south direction. Coil X has 20 turns and carries a current of 16 A ; coil Y has 25 turns and carries a current of 18 A. The sense of the current in X is anticlockwise and in Y is clockwise, for an observer looking at the coil facing west. Give the magnitude and direction of the coils at their centre.

6) A toroid has a core(non-ferromagnetic) of inner radius 25 cm and outer radius 26 cm, around which 3500 turns of wire are wound. If the current in the wire is 11A, that is the magnetic field

(a) outside the toroid,

(b) Inside the core of the toroid,

(c) in the empty space surrounded by the toroid?

7) A magnetic field set up using Helmholts coils(described in Exercise) is uniform in a small region and has a magnitude of 0.75 T. In the same region, a uniform electrostatic field is maintained in a direction normal to the common axis of the coils. A narrow beam of(single-species) charged particles all accelerated through 15 kV enters this region in a direction perpendicular to both the axis of the coils and the electrostatic field. If the beam remains undeflected when the electrostatic field is $9.0 \times 10^{-5} Vm^{-1}$, make a simple guess as to what the beam contains. Why is the answer not unique?

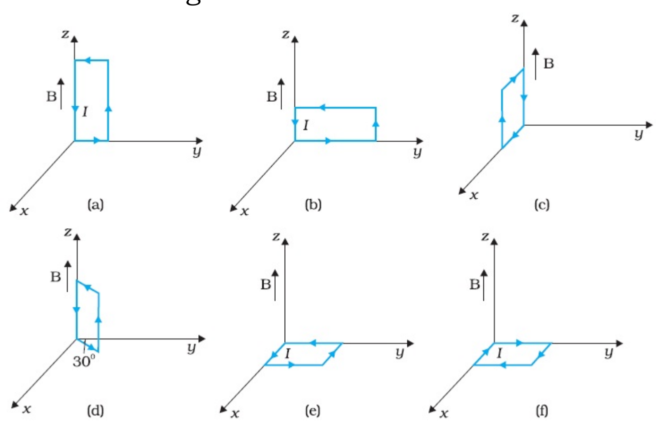
8) How are materials classified according to their behaviour in magnetic field?

9) Discuss relative strengths of electrical and magnetic forces.

10) Discuss the sensitivity of a moving coil galvanometer.

11) Find the expression for maximum energy of a charged particle accelerated by a cyclotron.

12) A uniform magnetic field of 3000 G is established along the positive Z direction. A rectangular loop sides 10 cm and 5 cm carries a current of 12 A. What is the torque on the loop in the different cases shown in Fig. What is the force on each case? Which case corresponds to stable equilibrium?



13) A current element 3 dl is at (0,0,0) along y-axis. if dl =1 cm, find the magnetic field at a distance 20 cm on the x-axis.

14) Same current I is flowing in three infintely long wires along x, y and z directions. What is the magnetic field at point (0, 0, -a) ?

15) A long straight wire carrying a current of 20 A is placed in an external uniform magnetic field of $3X10^{-4}$ T parallel to the current. Find the magnitude of the resultant field at a point 2.0 cm away from the wire.

16) An alpha particle is completing one circular round of radius 0.8 m in 2 seconds. Find the magnetic field at the centre of the circle. Electronic charge = 1.6×10^{-19} C.

17) The electron in a hydrogen atom circles around the proton with a speed of 2.18×10^{6} ms^{-1} in an orbit of radius 5.3×10^{-11} m. Calculate (a) the equivalent current (b) magnetic field produced at the

proton. Give charge on electron is 1.6 x 10^{-19} C and $\mu_o = 4\pi \times 10^{-7} TmA^{-1}$.

18) A circular loop of 2 turns carries a current of 5.0 A. If the magnetic field at the centre of loop is 0.40 mT, find the radius of the loop.

19) A circular coil of 120 turns has a radius of 18 cm and carries a current of 3. A. What is the magnitude of the magnetic field at a point on the axis of the coil at a distance from the centre equal to the radius of the circular coil?

20) A wire of radius 0.8 cm carries a current of 100 A which is uniformly distributed over its cross-section. Find the magnetic field (a) at 0.2 cm from the axis of the wire (b) at the surface of the wire and (c) at a point outside the wire 0.4 cm from the surface of the wire. Neglect the permeability of the material of wire.

21) A solenoid coil of 300 turns/m is carrying a current of 5 A. The length of the solenoid is 0.5 m and has a radius of 1 cm. Find the magnitude of the magnetic field well inside the solenoid.

22) A solenoid of length 50 cm, having 100 turns carries a current of 2.5 A. Find the magnetic field,
(a) in the interior of the solenoid,
(b) at one end of the solenoid.
Given $\mu_o = 4\pi \times 10^{-7} WbA^{-1}m^{-1}$.

23) A toroid has a core of inner radius 20 cm and outer radius 22 cm around which 4200 turns of a wire are wound. If the current in the wire is 10 A, what is the magnetic field (a) inside the core of toroid (b) outside the toroid (c) in the empty space surrounded by toroid ?

24) A coil wrapped around a toroid has inner radius of 15 cm and outer radius of 20 cm. If the toroid has 1000 turns of wire and carries a current of 12 A, find the maximum and minimum values of magnetic field within the toroid.

25) A proton enters a magnetic field of flux density 2.5 T with a speed of 1.5 x 10^7 ms^{-1} at an angle of 30^o with the field. Find the force on the proton.

26) An electron of energy 2000 eV describes a circular path in magnetic field of flux density 0.2 T. What is the radius of the path ? take e = 1.6 x 10^{-19} C, m = 9 x 10^{-31} kg.

27) A proton, a deutron and α - particle, whose kinetic energies are same, enter perpendicularly a uniform magnetic field. Compare the radii of their circular paths.

28) An electron beam passes through a magnetic field of 4 x 10^{-3} weber/m^2 and an electric field of 2 x 10^4 Vm^{-1}, both acting simultaneously. The path of electron remaining undeviated, calculate the speed of the electrons. If the electric field is removed, what will be the radius of the electron path ?

29) If the maximum value of accelerating potential provided by a radio frequency oscillator be 25 kV, find the number of revolutions made by a proton in a cyclotron to achieve one sixth of the speed of

light. Mass of proton = 1.67×10^{-27} kg.

30) A straight wire 50 cm long carries a current of 5 A. It is placed at right angle to a uniform magnetic field of 1 T. Find the mechanical force on the wire and the power required to move it at 10 ms^{-1} in a plane at right angles to the magnetic field.

31) A long straight conductor C carrying a current of 3 A is placed parallel to a short conductor D of length 5 cm, carrying a current 4 A. The two conductors are 10 cm apart. Find (i) the magnetic field due to C at D. (ii) The approximate force on D.

32) A horizontal wire 0.2 m long carries a current of 4 A. Find the magnitude and direction of the magnetic field, which can support the weight of the wire. Given the mass of the wire is 3×10^{-3} kg/m, g = 10 ms^{-2}

33) A straight horizontal conducting rod of length 0.60 m and mass 60 g is suspended by two vertical wires at its ends. A current of 5.0 A is set up in the rod through the wire.
(a) What magnetic field should be set up normal to the conductor in order that the tension in the wire is zero ?
(b) What will be total tension in the wires if the direction of current is reversed, keeping the magnetic field same as before (Ignore mass of the wire), g = 10 ms^{-2} .

34) Calculate the force per unit length on a long straight wire carrying current 4 A due to parallel wire carrying current 6 A current. Distance between the wires is 3 cm.

35) A wire AB is carrying a steady current of 12 A and is lying on the table. Another wire CD carrying current 5 A is held vertically above AB at a height of 1 mm.
Find the mass per unit length of the wire CD so that it remains suspended at the position when left free. Give the direction of the current flowing in CD with respect to that in AB.(g = 10 ms^{-2})

36) A rectangular coil of area 5.0×10^{-4} m^2 and 60 turns is pivoted about one of its vertical sides. The coil is in a radial horizontal field of 90 G (radial here means the field lines are in the plane of the coil for any rotation). What is the torsional constant of the hair springs connected to the coil, if a current of 2.0 mA produces an angular deflection of 18^o?

37) The current sensitivity of a moving coil galvanometer increases by 20% when its resistance is increased by a factor does the voltage sensitivity change ?

38) A current of 500 μA deflects the coil of a moving coil galvanometer through 60^o . What should be the current to cause the rotation through $\pi/5$ radian ? What is the sensitivity of galvanometer ?

39) When a galvanometer having 30 divisions scale and 100 Ω resistance is connected in series with the battery of e.m.f. 3 volt through a resistance of 200 Ω , it shows full scale deflection. Find the fogure of merit of the galvanometer in microampere.

40) A resistance of 1980 Ω is connected in series with a voltmeter, after which the scale division becomes 100 times larger. Find the resistance of voltmeter.

41) Two linear parallel conductors carrying currents in the same direction attract each other and two linear parallel conductors carrying in opposite directions repel each other. The force acting per unit length due to currents $I_1 and I_2$in two linear parallel conductors held distance r apart in vacuum in SI unit is $F = \frac{\mu_0}{2\pi}\frac{2I_1I_2}{r}$

Read the above passage and answer the following questions:

(i) What is the basic reason for the force between two linear parallel conductors currents?

(ii) Two straight wires A and B of lengths 2 cm and 20 cm, carrying currents 2.0 A and 5.0 A respectively in opposite directions are lying parallel to each other 4.0 cm apart. The wire A is held near the middle of wire B. What is the force on 20 cm long wire B?

(iii) What does this study imply in day to day life?

42) When a galvanometer of resistance G is shunted with a low resistance S, then the effective resistance $Re_{ff}$of galvanometer becomes

$Re_{ff} = \frac{GS}{G+S}$

If the current is passed through such a galvanometer, then the major amount of current flows through the shunt and the rest through the galvanometer, then the major amount of current flows through the shunt and the rest through galvanometer., the current divides itself in the inverse ratio of resistances.

Read the above passage and answer the following questions:

(i) Why is the resistance of shunted galvanometer lower than that of a shunt?

(ii) A galvanometer of resistance.30Ω What the fraction of the main current passes (i) through the galvanometer and (ii) through the galvanometer and (ii) through the shunt?

(iii) What are the basic values you learn from the above study?

43) Saniya and Priya are friends. Both of them know that a small compass needle point always along north-south direction. One day Saniya is plotting field due to a bar magnet in the laboratory. She discovers a point where compass needle does not point along N-S. Rather, it sets itself in any arbitrary direction. Saniya thinks first that compass needle has become faulty. Priya then explains to her the real situation.

Read the above passage and answer the following questions:

(i) How did Priya justify the situation?

(ii) If a bar magnet is placed along the N-S direction with its north pole pointing north, what is the position of neutral points?

(iii) If a bar magnet is placed along N-S direction with its north pole pointing South, What is the position of neutral points?

(iv) What values of life do you learn from this piece of knowledge?

44) Explain using a labelled diagram, the principle and working of a moving coil galvanometer. What is the function of

(i) uniform radial magnetic field

(ii) soft iron core?

Also, define the terms
(iii) current sensitivity and
(iv) voltage sensitivity of a galvanometer.
Why does increasing the current sensitivity not necessarily increase voltage sensitivity?

45) A proton is traveling with horizontal velocity. $u_x = 2.5 \times 10^8 cm/s$Calculate the transverse deflection in traveling horizontal distance, x = 5 cm in electric field of,$E_y = 400 V/cm$ mass of proton, $m = 1.6 \times 10^{-24} g$ charge oh proton, $m = 1.6 \times 10^{-19} c$

46) (i) Explain giving reasons, the basic difference in converting a galvanometer into
(a) a voltmeter and
(b) an ammeter
(ii) Two long straight parallel conductors carrying steady currents I_1 and I_2 are separated by a distance d. Explain briefly, with the help of a suitable diagram, how the magnetic field due to one conductor acts on the other. Hence, deduce the expression for the force acting between the two conductors. Mention the nature of this force.

47) Ms. Kanchan, a student of PG course in nanotechnology lab in IIT Kanpur on her first day in the lab met Mr. Cobra, the lab assistant. He advised her not to touch the wires, which were suspended from the roof at every part of the lab as they were from high voltage lines. He also told her not to bring any of the two wires closer to each other during any experimental applications. Read the above passage and answer the following questions:
(i) What values did Mr. Cobra exhibit? Give two reasons.
(ii) Why should not the the two high voltage wires be brought close to each other?

48) (i) Using Ampere's circuital law, derive the expression for the magnetic field in the vector from at a point on the axis of solenoid.
(ii) What does a toroid consist of? Find out the expression for the magnetic field inside a toroid for N turns of the coil having the average radius r and carrying a current I.Show that the magnetic field in the open space interior and exterior to the toroid is zero.

49) Alka and her sister were watching a movie in which the phenomena of Aurora Borealis was shown. Alka could not believe her eyes that, such a colourful display like the one during common wealth games could be created by the nature. She went to the library, but could not find the right book. So, she consulted her teacher who guided her. Hence, Alka understood that during a solar flare, a large number of electrons and protons are ejected from the sun. some of these get trapped in the earth's magnetic field and move in a helical path along the field lines. As the density of the field lines increases near the poles, these particles collide with atoms and molecules of the atmosphere emitting green and pink lights. Alka shared this knowledge with her class when they studied the chapter of moving charges in magnetic field.
Read the above passage and answer the following questions:
(i) What values did Alka have?
(ii) What is the radius of the path of an electron moving at a speed of $3 \times 10^7 m/s$ in a magnetic field of 6 gauss perpendicular to it?
What is its frequency? Calculate its energy in kilo electron volt.

50) In the birthday party of Kamal, his parents gave big slinkies to all his friends as a return gift. The very next day, during the physics class Mr. Mohan, the teacher explained them about the production of magnetic field using current carrying coil and also said that they can make permanent magnet, using such coils by passing high currents through them. That night Priyanshu, a friend of Kamal, asked his father about the coils, and their shape. His father asked him to bring the slinky, that his friend gave and explained the use of toroid and solenoid.

Read the above passage and answer the following questions:

(i) What value did Priyanshu's father have?

(ii) What is the difference between solenoid and toroid?

(iii) Give the value or magnitude of magnetic field in solenoid.

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51) Niyaz was using galvanometer in the practical class. Unfortunately, it fell from his hand and broke. He was upset, some of his friends advised him not to tell the teacher but Niyaz decided to tell his teacher. Teacher listened to him patiently and on knowing that the act was not intentional, but just an accident, did not scold him and used the opportunity to show the internal structure of galvanometer.

(i) What are the values displayed by Niyaz?

(ii) Give the principle of moving coil galvanometer.

(iii) How can you increase the sensitivity of a galvanometer?

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52) (i)Derive the expression for the torque on a rectangular current carrying loop suspended in a uniform magnetic field

(ii)A proton and a deuteron having equal momentum enter in a region of a uniform magnetic field at right angle to the direction of the field.Depict their trajectories in the field

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53) (i) Derive an expression for torque acting on a bar magnet held at an angle θ with the direction of magnetic field.

(ii) A bar magnet of magnetic moment 5A-m^2 has poles 0.20m apart. Calculate the pole strength.

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54) i)Discuss briefly electron theory of magnetism for diamagnetic and paramagnetic materials.

ii)Give two methods to destroy the magnetism of a magnet.

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55) Mandeep's mother had put lot of clothes for washing in the washing machine, but the machine did not start and an indicator was showing that the lid of the machine did not close.Mandeep seeing his mother disturbed thought that, he would close the lid by applying some force but would close the lid by applying some force but realised that the mechanism was different.It was a magnetic system.He went to the shop and got a small magnetic door closer and put it on the lid of the machine.The machine started working.His mother was happy that Mandeep helped her to save 500 rs also.

i)What were the values developed by Mandeep?

ii)What values did his mother impart to Mandeep?

iii)Every magnetic configuration has a North pole and a South pole, What about the field due to toroid?

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56) Bala and rama (Class X students), were assigned a project based on magnetism.In their project work, they had calculated the value of the earth's magnetic field.When they submitted their project for verification.Mr.Santosh, their Physics techer, corrected the mistakes. He also suggested few books which could be useful for them.

i) What values did Mr.Santosh exhibit towards his students?Mention any two.

ii) Mention the three magnetic elements required to calculate the value of the earth's magnetic field.

iii) What is the strength of the earth's magnetic fields at the surface of the earth?

57) Mr. Sairam, the chief development officer in southern railway went on an official went on an official tour to attend a seminar on fast moving trains.He met his friend Ontosaki in Tokyo after he finished his seminar there.His friend explained to sairam , how Japanese people are concentrating on energy conservation and saving of fossil fuels using Maglev trains.

Mr. Sairam traveled from Tokyo to Osaka in Maglev train and found that noise is less, travelling is smooth and understood in what way we are lagging behind Japnese in mass transporting systems.This works on the principle of Meissner's effect.

i) What values did Mr.sairam found from Ontosaki?Mention any two.

ii)What are superconductors?

iii)What is Meissner,s effect?

58) A monoenergetic(18kev) electron beam initially in the horizontal direction is subjected to a horizontal magnetic field of 0.4 passes normal to the initial direction.Estimate the up or down deflection of the beam over a distance of 30 cm.

$(mc = 9.11 \times 10 - 19C)$.

59) Two concentric circular coils x and y of radii 16 cm and 10 cm respectively lie in the same vertical plane containing the North to South direction. Coil x has 20 turns and carries a current of 16 A, coil y has 25 turns and carries a current of 18 A. The sense of the current in x is anti-clockwise and clockwise in y, for an observer looking at the coils facing West. Find the magnitude and direcion of the net magnetic field due to the coils at their centre.

Here, we have to find the magnetic field due to two coils. So, first of all find the magnetic fields due to individual coil and find the net field using the law of vector addition, as magnetic field is a vector quantitiy.

60) State Biot-Savart law giving the mathematical expression for it. Use this law to derive the expression. Use this law to derive the expression for the magnetic field due to a circular coil carrying current at a point along its axis. How does a circular loop carrying current behave as a magnet?

61) Dimpi's class was shown a video on effects of magnetic field on a current carrying straight conductor. She noticed that the force on the straight current carrying conductor becomes zero when it is oriented parallel to the magnetic field and this force becomes maximum when it is perpendicular to the field. She shared this interesting information with her grandfather in the evening. The grandfather could immediately relate it to something similar in real life situations. He explained it to Dimpi that similar things happen in real life too. When we align and orient our thinking and actions in an adaptive and accommodating way our lives become more peaceful and

happy. However, when we adopt an unaccommodating and stubborn attitude, life becomes troubled and miserable. We should therefore always be careful in our response to different situations in life and avoid unnecessary conflicts.

Answer the following based on above information:

(a) Express the force acting on a straight current carrying conductor kept in a magnetic field in vector form. State the rule used to find the direction of this force.

(b) Which one value is displayed and conveyed by the grandfather as well as Dimpi?

(c) Mention one specific situation from your own life which reflects similar values shown by you towards your elders.

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62) Ms. Sumathy wife of Mr. Varadan complained about the non-availability of gas cylinders and explained to him to look out for alternate methods for cooking.

Mr. Varadan bought an induction stove to overcome the fuel problem. The next day Sumathy used her copper bottom cooker and kept it on the induction stove. But even after using it for half an hour she found that the cooker was not hot and food not cooked. As she was not aware of the method to use the induction stove, she asked her elder daughter Dhanya, studying first year engineering about it. She told her, that some vessels can not be used on this stove. She took the instruction manual and explained to her mother, that the stove works on magnetic material, will not respond to it.

(a) What value dis Mr.Varadan and Dhanya exhibit towards Ms. Sumathy?

(b) Give few examples of diamagnetic materials and explain how their susceptiblity varies with temperature?

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63) A magnetic dipole is placed in a uniform magnetic field with its axis tilted with respect to its position of stable equilibrium. Deduce an expression for the time period of (small amplitude) oscillation of this magnetic dipole about an axis, passing through its centre and perpendicular to its plane. If this bar magnet is replaced by a combination of two similar bar magnets, placed over each other, how will the time period vary?

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64) (a) Using Ampere's circutial law, obtain the expression for the magnetic field due to a long solenoid a point inside the solenoid on its axis.

(b) In what respect is a toroid different from a solenoid? Draw and compare the pattern of the magnetic field lines in the two cases.

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65) (a) Draw a labelled diagram of a moving coil galvanometer. Describe briefly its principle and working.

(b) Answer the following:

(i) Why is it necessary to introduce a cylindrical soft iron core inside the coil of a galvanometer?

(ii) Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity. Explain, giving reason.

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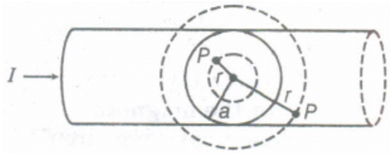
66) Figure shows a long straight wire of a circular cross-section of radius a carrying steady current I. The current I is uniformly distributed across this cross-section. Derive the expressions for the magnetic field in the region

(i) $r < a$ and

(ii) r > a.



67) (i) A small compass needle of magnetic moment M is free to turn about an axis perpendicular to the direction of uniform magnetic field B. The moment of inertia of the needle about the axis is I . The needle is slightly disturbed from its stable position and then released. Prove that it executes simple harmonic motion. Hence, deduce the expression for its time period.

(ii) A compass needle free to turn in a vertical plane orients itself with its axis vertical at a certain place on the earth. Find out the values of

(a) horizontal component of the earth's magnetic field and

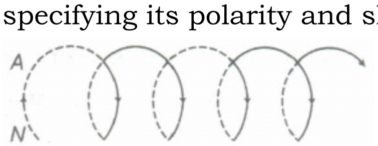
(b) angle of dip at the place

68) (i) Write using Biot - Savart law, the expression for the magnetic field B due to an element dl carrying current I at a distance r from it in a vector form. Hence, derive the expression for the magnetic field due to a current carrying loop of radius R at a point P and distance x from its centre along the axis of the loop.

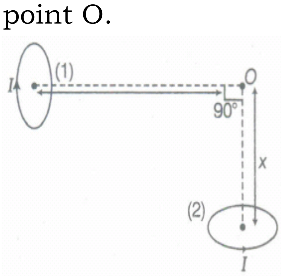
(ii) Explain how Biot-Savart law enables one to express the Ampere's circuital law in the integral form, viz. $\oint B.dl = \mu_0 I$ where, I is the total current passing through the surface.

69) (i) State Ampere's circuital law. Use this law to obtain the expression for the magnetic field inside an air cored toroid of average radius r, having n turns per unit length and carrying a steady current I.

(ii) An observer to the left of a solenoid of N turns each of cross-section areas A observes that a steady current I flows in the clockwise direction. Depict the magnetic field lines due to the solenoid specifying its polarity and show that it acts as a bar magnet of magnetic moment m = NIA.



70) Two very small identical circular loop (1) and (2) carrying equal current I are placed vertically (with respect to the plane of the paper) with their geometrical axes perpendicular to each other as shown in the figure. Find the magnitude and direction of the net magnetic field produced at the point O.



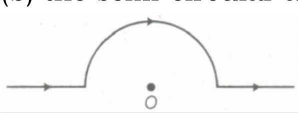
71) State Biot-Savart's law expressing it in the vector form. Use it to obtain the expression for the magnetic field at an axial point distance d from the centre of a circular coil of radius a carrying

current 1. Also, find the ratio of the magnitudes of the-magnetic field of this coil at the centre and at and axial point for which d = $a\sqrt{3}$.

72) (i) Using Ampere's circuital law, obtain the expression for the magnetic field due to a long solenoid at a point inside the solenoid on its axis.
(ii) In what respect, is a toroid different from a solenoid? Draw and compare the pattern of the magnetic field lines in the two cases.
(iii) How is the magnetic field inside a given solenoid made strong?

73) (i) State Ampere's circuital law.
(ii) Use it to derive an expression for magnetic field inside along the axis of an air cored solenoid.
(iii) Sketch the magnetic field lines for a finite solenoid. How are these field lines different from the electric field lines from an electric dipole?

74) (i) Using Biot-Savart's law, deduce an expression for the magnetic field on the axis of a circular current carrying loop.
(ii) Draw the magnetic field lines due to a current carrying loop.
(iii) A straight wire carrying a current of 12 A is bent into a semi-circular arc of radius 2.0 cm as shown in the figure. What is the magnetic field B at 0 due to
(a) straight segments,
(b) the semi-circular arc?



75) (i) State Ampere's circuital law. Show through an example, how this law enables an easy evaluation of this magnetic field when there is a symmetry in the system? .
(ii) What does a toroid consist of? Show that for an ideal toroid of closely wound turns, the magnetic field
(a) inside the toroid is constant.
(b) in the open space inside an exterior to the toroid is zero.

76) (i) Draw a schematic sketch of a cyclotron. Explain clearly the role of crossed electric and magnetic field in accelerating the charge. Hence, derive the expression for the kinetic energy acquired by the particles.

77) Write the expression for the force F, acting on a charged particle of charge q moving with a velocity v in the presence of both electric field E and magnetic field B. Obtain the condition under which the particle moves undeflected through the fields.

78) With the help of a labelled diagram, state the underlying principle of a cyclotron. Explain clearly how it works to accelerate the charged particles?Show that cyclotron frequency is independent of energy of the particle. Is there an upper limit on the energy acquired by the particle? Give reason.

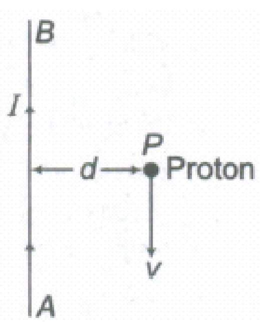
79) (i) Draw a schematic sketch of a cyclotron, explain its working principle and deduce the expression for the kinetic energy of the ions accelerated.
(ii) Two long and parallel straight wires car.rying currents of 2A and 5A in the opposite directions are separated by a distance of 1 cm. Find the nature and magnitude of the magnetic force between them.

80) Draw a schematic sketch of cyclotron. Explain briefly how it works and" how it is used to accelerate the charge particles?
(i) Show the time period of ions in a cyclotron is independent of both the speed and radius of circular path.
(ii) What is resonance condition? How is it used to accelerate the charged particles?

81) A rectangular loop of size l x b carrying a steady current I is placed in a uniform magnetic field B. Prove that the torque τ acting on the loop is given by $\tau = m \times B$, where, m is the magnetic moment of the loop.

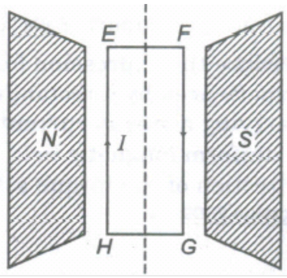
82) (i) Show that a planer loop carrying a current I, having N closely wound turns and area of cross-section A, possesses a magnetic moment m = NIA.
(ii) When this loop is placed in a magnetic field B, find out the expression for the torque acting on it.
(iii) A galvanometer coil of 50 n resistance shows full scale deflection for a current of 5 mA. How will you convert this galvanometer into a voltmeter of range 0 to 15V?

83) (i) Derive an expression for the force between two long parallel current carrying conductors.
(ii) Use this expression to define SI unit of current.
(iii) A long straight wire AB carries a current I. A proton P travels with a speed v,parallel to the wire at a distance d from it in a direction opposite to the current as shown in the figure. What is the force experienced by the proton and what is
its direction?



84) (i) Two straight long parallel conductors carry currents I_1 and I_2 in the same direction. Deduce the expression for the force per unit length between them. Depict the pattern of magnetic. field lines around them.
(ii) A rectangular current carrying loop EFGH is kept in a uniform magnetic field as shown in the figure.
(a) What is the direction of the magnetic moment of the current loop?

(b) What is the torque acting on the loop maximum and zero?



85) Kamal's uncle was advised by his doctor to undergo an MR1 scan test of his chestand gave him an estimate of the cost. Not knowing much about the significance of this test and finding it to be too expensive he first hesitated. When Kamal learnt about this, he decided to take help of his family, friends and neighbours and arranged for the cost. He convinced his uncle to undergo this test so as to enable the doctor to diagnose the disease, he got the test done and resulting information greatly helped the doctor to give him proper treatment.

(a) What according to you, are the values displayed by Kamal?

(b) Assuming that the MR1 scan test involved a magnetic field of O.l T, find the maximum and minimum values of the force that this field could exert on a proton moving with a speed of $10ms^{-1}$.State the condition under which the force can be minimum.

86) Mr. Sharma a 65 year old person often complained of neck pain. One day his grandson Mridul, suggested that magnetic therapy is very effective in reducing pain. He said that the permanent magnet! electromagnet, used in the device will help to produce joule's heating effects in the blood stream, which helps the blood flow better. He immediately contacted his friend in Chennai who was running a magnetic therapy clinic.

Read the above passage and answer the following questions.

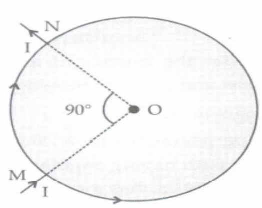
(i) What values did Mridul exhibit towards grandfather?

(ii) What is the S1 unit of magnetic field?

(iii) Give the magnitude of magnetic field in 4A current carrying circular coil or radius 2 cm.

87) (i). Use Biot-Savart law to derive the expression for the magnetic field due to a circular coil of radius R having N turns at a point on the axis at a distance 'x' from its center. Draw the magnetic field lines due to this coil.

(ii). A current T enters a uniform circular loop of radius 'R' at point M and flows out at N as shown in the figure. Obtain the net magnetic field at the center of the loop.



88) Ria recently read about earth's magnetic field and its causes. She became so much fascinated by the topic that she further studied it in detail. She collected information as follows :

The magnitude of the magnetic field at the Earth's surface ranges from 0.25 to 0.65 gauss.

The Earth's magnetic field varies with time.There are short-term and long-term variations.

One the scale of million years, the Earth's magnetic field reverses its direction, and much more.

She made a power point presentation on the same and shared all this information with her classmates.
(i) Suggest another activity related to the same topic, which will help a student to internalize the same values gained by Ria.
(ii) Draw a labeled diagram showing the three magnetic elements of earth.

89) Ms. Nita Chander consulted a specialist when she ca e to know that her son is not able to hear property. The specialist recommends the hearing aid for her son. He told that hearing aid has electromagnet which is fitted in the loudspeakers of the device.
(i) What two values does Ms. Nita exhibit towards her son and students? Mention any two.
(ii) What is an electromagnet? In what way its hysteresis curve is different from that used for permanent magnets?

90) Mr. Varadan purchased an induction stove when his wife Ms. Sumathy told him about the shortage of gas cylinders in the city. For preparing food, Ms. Sumathy kept copper bottom cooker on her induction stove. After half an hour, she finds that the cooker was not hot, so she happen to discuss with her elder daughter Dhanya who is studying first year engineering. As she has no idea about induction stove, so her daughter took the instruction manual and explained her that some vessels cannot be used on induction stove. Dhanya further told her mom that since induction stove works on magnetic induction and copper being a diamagnetic material, so it will not respond to it.
(i) What values did Mr. Varadan and Dhanya exhibit towards Ms. Sumathy?
(ii) Give few examples of diamagnetic materials and explain how their susceptibility varies with temperature.

91) While working on class X project based on magnetism, Bala and Rama in their project work calculate the value of earth's magnetic field and submitted it to their Physics teacher Mr. Santosh for verification. Their Physics teacher Mr. Santosh corrected their mistakes suggested certain reference books to read.
(i) What values did Mr. Santosh exhibit towards his students? Mention any two.
(ii) Mention the three magnetic elements required to calculate the value of the earth's magnetic field. and draw a neat diagram to explain them.

92) On an official tour in Tokyo, Mr. Sairam who was a chief development officer in Southern railway attended the seminar after taking a fast-moving train. After the seminar, he met his friend Ontosaki. In a discussion, his friend told to Sairam, how Japanese people are focusing on energy conservation and saving of fossil fuels with the use of Maglev trains. Totake idea about it, Sairam traveled from Tokyo to Osaka in Maglev train and observed that its sound is less as compared to Indian rails with smooth traveling. So all the way he was thinking that what could be our reasons that we are lagging behind Japanese in mass transporting systems. Onto saki told to Sairam that our trains work on the principle of Mesiner's effect.
(i) What values did Mr. Sairam found from Ontosaki? Mention any two.
(ii) What is Meissner effect? What is the value of X and μ_r for perfect diamagnetism?

93) (i) Show how Biot-Savart law can be alternatively expressed in the form of Ampere's circuital law. Use this law to obtain the expression for the magnetic field inside a solenoid of length 'l', cross-

sectional area 'A' having 'N' closely wound turns and carrying a steady current 'I'.
Draw the magnetic field lines of a finite solenoid carrying current I.
A straight horizontal conducting rod of length 0.45 m and mass 60 g is suspended by two vertical wires at its ends. A current of 5.0 A is set up in the rod through the wires.
Find the magnitude and direction of the magnetic field which should be set up in order that the tension in the wire is zero.

94) Draw the "Energy bands', diagrams for a(i) pure semiconductor, (ii) insulator. How does the energy band, for a pure semiconductor, get affected when this semiconductor is doped with (a) an acceptor impurity (b) donor impurity?
Hence discuss why the 'holes, and the 'electrons' respectively, become the 'majority charge carriers' in these two cases?
Write the two process involved in the formation of p-n junction.

95) A closely wound solenoid 80 cm long has 5 layers of windings of 400 turns each. The diameter of the solenoid is 1.8 cm. If the current carried is 8.0 A, estimate the magnitude of B inside the solenoid near its centre.

96) Two moving coil meters, M_1 and M_2 have the following particulars:
$R_1 = 10\ \Omega$, $N_1 = 30$,
$A_1 = 3.6 \times 10^{-3}\ m^2$, $B_1 = 0.25$ T
$R_2 = 14\ \Omega$, $N_2 = 42$,
$A_2 = 1.8 \times 10^{-3}\ m^2$, $B_2 = 0.50$ T
(The spring constants are identical for the two meters). Determine the ratio of (a) current sensitivity and (b) voltage sensitivity of M_2 and M_1.

97) Obtain the frequency of revolution of the electron in its circular orbit. Does the answer depend on the speed of the electron? Explain.

98) For a circular coil of radius R and N turns carrying current I, the magnitude of the magnetic field at a point on its axis at a distance x from its centre is given by,

$$B = \frac{\mu_0 I R^2 N}{2\left(x^2+R^2\right)^{3/2}}$$

(a) Show that this reduces to the familiar result for field at the centre of the coil.
(b) Consider two parallel co-axial circular coils of equal radius R, and number of turns N, carrying equal currents in the same direction, and separated by a distance R. Show that the field on the axis around the mid-point between the coils is uniform over a distance that is small as compared to R, and is given by,

$B = 0.72\frac{\mu_0 NI}{R}$ approximately.

[Such an arrangement to produce a nearly uniform magnetic field over a small region is known as Helmholtz coils.]

99) A solenoid 60 cm long and of radius 4.0 cm has 3 layers of windings of 300 turns each. A 2.0 cm long wire of mass 2.5 g lies inside the solenoid (near its centre) normal to its axis; both the wire and

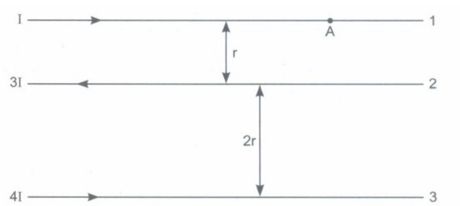
the axis of the solenoid are in the horizontal plane. The wire is connected through two leads parallel to the axis of the solenoid to an external battery which supplies a current of 6.0 A in the wire. What value of current (with appropriate sense of circulation) in the windings of the solenoid can support the weight of the wire? g = 9.8 m s^{-2}

100) An α-particle and a proton are released from the centre of the cyclotron and made to accelerate.
(a) Can both be accelerated at the same cyclotron frequency? Give reason to justify your answer.
(b) When they are accelerated in turn, which of the two will have higher velocity at the exit slit of the dees?

101) A beam of protons passes undeflected with a horizontal velocity v, through a region of electric and magnetic fields, mutually perpendicular to each other and normal to the direction of beam. If the magnitudes of electric and magnetic fields are 100 kV / m and 50 mT respectively, calculate the
(i) velocity of the beam and
(ii) force with which it strikes the target on a screen, if the proton beam current is equal to 0.80 mA.

102) Two concentric circular wire loops of radii 20 cm and 30 em are located in an XY -plane, each carries a clockwise current of 7 A.
(i) Find the magnitude of the net magnetic dipole moment of the system.
(ii) Repeat for reversed current in the inner loop.

103) The figure shows three infinitely long straight parallel current carrying conductors. Find the
(i) magnitude and direction of the net magnetic field at point A laying on conductor 1,
(ii) magnetic force on conductor 2.



104) (a) A long straight wire of a circular cross-section of radius a carries a steady current I. The current is uniformly distributed across the cross-section. Apply Ampere's circuital law to calculate the magnetic field at a point r in the region for (i) r < a and (ii) r > a. Plot a graph showing the nature of this variation.
(b) Calculate the ratio of magnetic field at a point a/2 above the surface of the wire to that at a point a/2 below its surface. What is the maximum value of the field of this wire?

105) Write any two important points of similarities and differences each between Coulomb's law for the electrostatic field and Biot-Savart's law for the magnetic field. Use Biot-Savart's law to find the expression for the magnetic field due to a circular loop of radius r carrying current I at its centre.

****

105 x 5 = 525

1)

Magnetic field strength, B = 0.15 T

Charge on the electron, e = 1.6 x 10^{-19} C

Mass of the electron, m = 9.1 x 10^{-31} kg

Potential difference, V = 2.0 kV = 2 x 10^{3} V

Thus, kinetic energy of the electron = eV

$$\Rightarrow eV = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2eV}{m}} \qquad ......(i)$$

Where,

v = velocity of the electron

(a) Magnetic force on the electron provides the required centripetal force of the electron. Hence, the electron traces a circular path of radius r.

Magnetic force on the electron is given by the relation,B ev

Centripetal force $= \frac{mv^2}{r}$

$$\therefore Bev = \frac{mv^2}{r}$$

$$r = \frac{mv}{Be} \qquad .....(ii)$$

From equations (1) and (2), we get

$$r = \frac{m}{Be}\left[\frac{2eV}{m}\right]^{\frac{1}{2}}$$

$$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \left(\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9.1 \times 10^{-31}}\right)^{\frac{1}{2}}$$

= 100.55 x 10^{-5}

= 1.01 x 10^{-3}

= 1 mm

Hence, the electron has a circular trajectory of radius 1.0 mm normal to the magnetic field.

(b) When the field makes an angle θ of 30° with initial velocity, the initial velocity will be,

$$v_1 = v\sin\theta$$

From equation (2), we can write the expression for new radius as:

$$r_1 = \frac{mv_1}{Be}$$

$$= \frac{mv\sin\theta}{Be}$$

$$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \left[\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9 \times 10^{-31}}\right]^{\frac{1}{2}} \times \sin 30^{\circ}$$

= 0.15 x 10^{-3} m

= 0.5 mm

Hence, the electron has a helical trajectory of radius 0.5 mm along the magnetic field direction.

2)

Magnetic field strength, B = 1.5 T

Radius of the cylindrical region, r = 10 cm = 0.1 m

Current in the wire passing through the cylindrical region, I = 7 A

(a) If the wire intersects the axis, then the length of the wire is the diameter of the cylindrical region.

Thus, l = 2r = 0.2 m

Angle between magnetic field and current, $\theta = 90°$

Magnetic force acting on the wire is given by the relation,

$F = BIl \sin\theta$

$= 1.5 \times 7 \times 0.2 \times \sin 90°$

= 2.1 N

Hence, a force of 2.1 N acts on the wire in a vertically downward direction.

(b) New length of the wire after turning it to the Northeast-Northwest direction can be given as:

$$l_1 = \frac{l}{\sin\theta}$$

Angle between magnetic field and current, $\theta = 45°$

Force on the wire,

$F = BIl1 \sin\theta$

= BIl

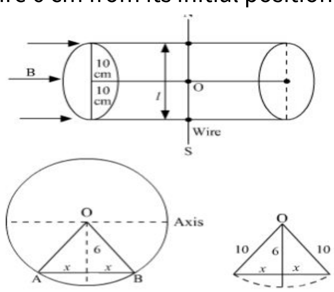
$= 1.5 \times 7 \times 0.2$

= 2.1 N

Hence, a force of 2.1 N acts vertically downward on the wire. This is independent of angleθbecause l sinθ is fixed.

(c) The wire is lowered from the axis by distance, d = 6.0 cm

Suppose wire is passing perpendicularly to the axis of cylindrical magnetic field then lowering 6 cm means displacing the wire 6 cm from its initial position towards to end of cross sectional area.



Thus the length of wire in magnetic field will be 16 cm as AB= L = 2x =16 cm

Now the force,

F = iLB sin90° as the wire will be perpendicular to the magnetic field.

$F = 7 \times 0.16 \times 1.5 = 1.68$ N

The direction will be given by right hand curl rule or screw rule i.e. vertically downwards.

3)

Magnetic field strength, B = 6.5 G = 6.5×10^{-4} T

Speed of the electron, v = 4.8×10^{6} m/s

Charge on the electron, e = 1.6×10^{-19} C

Mass of the electron, $m_e = 9.1 \times 10^{-31}$ kg

Angle between the shot electron and magnetic field, θ = 90°

Magnetic force exerted on the electron in the magnetic field is given as:

F = evB $\sin\theta$

This force provides centripetal force to the moving electron. Hence, the electron starts moving in a circular path of radius *r*.

Hence, centripetal force exerted on the electron,

$$F_c = \frac{mv^2}{r}$$

In equilibrium, the centripetal force exerted on the electron is equal to the magnetic force i.e.,

$F_C = F$

$$\frac{mv^2}{r} = evB\sin\theta$$

$$r = \frac{mv}{Be\sin\theta}$$

$$= \frac{9.1 \times 10^{-31} \times 4.8 \times 10^{6}}{6.5 \times 10^{-4} \times 1.6 \times 10^{-19} \times \sin 90^\circ}$$

= 4.2×10^{-2} m = 4.2 cm

Hence, the radius of the circular orbit of the electron is 4.2 cm.

4)

$$B_v = \frac{\mu_0}{4\pi}\frac{2M\cos\theta}{r^3}$$

$$B_H = \frac{\mu_0}{4\pi}\frac{M\sin\theta}{r^3}$$

$$B = \sqrt{B_v^2 + B_H^2} = \frac{\mu_0 M}{4\pi r^3}\left[4\cos^2\theta + \sin^2\theta\right]$$

$$B = \frac{\mu_0 M}{4\pi r^3}\left[3\cos^2\theta + 1\right]$$

Now B will be minimum if $\cos\theta = 0 \; or \; \theta = 90^\circ$

i.e. B will be minimum at magnetic equator.

(ii) Angle of dip is given by

$$\tan\delta = \frac{B_V}{B_H} = \frac{2\cos\theta}{\sin\theta} = 2\cot\theta$$

$$\delta = 0, \; if \cot\theta = 0 \; or \; \theta = \frac{\pi}{2}$$

i.e. angle of dip is zero at magnetic equator(iii) $\delta = 45^\circ, \cot\theta = \frac{1}{2} or \tan\theta = 2$

$\theta = \tan^{-1}2 \; is \; the \; locus.$

5) Radius of coil X, r_1 = 16 cm = 0.16 m

Radius of coil Y, r_2 = 10 cm = 0.1 m

Number of turns of on coil X, n_1 = 20

Number of turns of on coil Y, n_2 = 25

Current in coil X, I_1 = 16 A

Current in coil Y, I_2 = 18 A

Magnetic field due to coil X at their centre is given by the relation,

$$B_i = \frac{\mu_0 n_1 I_1}{2r_1}$$

Where,

μ_0 = Permeability of free space = $4\pi \times 10^{-7}$ TmA^{-1}

$$\therefore B_1 = \frac{4\pi \times 10^{-7} \times 20 \times 16}{2 \times 0.16}$$

= $4\pi \times 10^{-4}$ T (towards East)

Magnetic field due to coil Y at their centre is given by the relation,

$$B_2 = \frac{\mu_0 n_2 I_2}{2r_2}$$

$$= \frac{4\pi \times 10^{-7} \times 25 \times 18}{2 \times 0.10}$$

= $9\pi \times 10^{-4}$ T (towards west)

Hence, net magnetic field can be obtained as:

B = B_2 - B_1

= $9\pi \times 10^{-4} - 4\pi \times 10^{-4}$

= $5\pi \times 10^{-4}$ T

= 1.57×10^{-3} T (towards west)

6) Inner radius of the toroid, r_1 = 25 cm = 0.25 m

Outer radius of the toroid, r_2 = 26 cm = 0.26 m

Number of turns on the coil, N = 3500

Current in the coil, I = 11 A

(a) Magnetic field outside a toroid is zero. It is non-zero only inside the core of a toroid.

(b) Magnetic field inside the core of a toroid is given by the relation,

$$\mathrm{B} = \frac{\mu_0 \mathrm{NI}}{l}$$

Where,

μ_0 = Permeability of free space = $4\pi \times 10^{-7}$ T m A^{-1}

l = length of toroid

$$= 2\pi \left[\frac{r_1 + r_2}{2}\right]$$

= π (0.25 + 0.26)

= 0.51 π

$$\therefore B = \frac{4\pi \times 10^{-7} \times 3500 \times 11}{051\pi}$$

$\approx$ 3.0×10^{-2} T

(c) Magnetic field in the empty space surrounded by the toroid is zero.

7)

Magnetic field, B = 0.75 T

Accelerating voltage, V = 15 kV = 15 × 103 V

Electrostatic field, E = 9 × 105 V m - 1

Mass of the electron = m

Charge of the electron = e

Velocity of the electron = v

Kinetic energy of the electron = eV

$$\frac{1}{2}mv^2 = eV$$

$$\therefore \frac{e}{m} = \frac{v^2}{2V} \quad ....(1)$$

Since the particle remains undeflected by electric and magnetic fields, we can infer that the electric field is balancing the magnetic field.

∴ eV = evB

$$v = \frac{E}{B} \quad ....(2)$$

Putting equation (2) in equation (1), we get

$$\frac{e}{m} = \frac{1}{2}\frac{\left(\frac{E}{B}\right)^2}{V} = \frac{E^2}{2VB^2}$$

$$= \frac{\left(9.0\times10^5\right)^2}{2\times15000\times(0.75)^2} = 4.8\times10^7 \text{C/kg}$$

This value of specific charge e/m is equal to the value of deuteron or deuterium ions. This is not a unique answer. Other possible answers are He^{++}, Li^{++}, etc.

8)

On the basis of their in a magnetic field, the various materials can be classified in three classes.

(i)Diamagnetic.Those materials, which when placed in a magnetic field, are feebly magnetised in a direction opposite to the magnetising field are called diamagnetic substances.A few examples of diamagnetic materials are copper, zinc, bismuth, water, sodium chloride, helium, argon etc.

When a diamagnetic substance is suspended in a magnetic field, it arranges itself in the direction of the magnetic field.

(ii) Paramagnetic. Those materials, which when placed in a magnetic field, are feebly magnetised in the direction of magnetic field, are called paramagnetic substances.A few examples of paramagnetic substances are aluminium, sodium, antimony, platinum, copper chloride, liquid oxygen etc.

When a paramagnetic substance is suspended in a magnetic field it arranges itself to the direction of magnetic field.

(iii) Ferromagnetic. Those materials which when placed in a magnetic field are strongly magnetised in the direction of the magnetising field, are ferromagnetic substances.A few examples of ferromagnetic substances are iron, nickel, cobalt, alnico, mercury etc.

9)

Consider two charges q_1 and q_2 placed at a distance $|r_2|$ apart in air. The force between two charges

$$\left|\vec{F}_e\right| = \frac{q_1 q_2}{4\pi\varepsilon_0}\frac{1}{|r_{12}|^2}$$

Again consider two electrically neutral parallel current carrying elements of length dl_1 and dl_2 carrying currents I_1 and I_2 .

∴ Magnetic force between two current elements

$$\left|\vec{F}_m\right| = \frac{\mu_0}{4\pi}\frac{I_1 I_2}{|r_{12}|^2}dl_1 dl_2$$

$$I_1 dl_1 = \frac{q_1}{t} \times dl_1 = q_1 v_1$$

$$I_2 dl_2 = \frac{q_2}{t} dl_2 = q_2 v_2$$

$$\left|\vec{F}_m\right| = \frac{\mu_0}{4\pi}\frac{q_1 q_2}{|r_{12}|^2}v_1 v_2 \quad \ldots (2)$$

$$\frac{\left|\vec{F}_m\right|}{\left|\vec{F}_e\right|} = v_1 v_2 . \mu_0 \varepsilon_1 \ldots (3)$$

Since L.H.S. is a dimensionless quantity therefore, the quantity $\mu_0\varepsilon_1$ must have dimensions of $(velocity)^2$ as numerator has dimensions of $(velocity)^2$ as v_1 and v_2 are the drift velocities of electrons in current elements $\therefore v_1 v_2 = 10^{-5} \times 10^{-5} = 10^{-10} m^2 s^{-2}$

Where $\mu_0\varepsilon_1 = 1/c^2$, where c is velocity of light $\left(c^2 = 9 \times 10^{16} m^2 s^{-2}\right)$

From (3)

$$\therefore \frac{\left|\vec{F}_m\right|}{\left|\vec{F}_e\right|} < 1 \quad \left|\vec{F}_m\right| < \left|\vec{F}_e\right|$$

10)

A galvanometer is said to be sensitive, if it gives a large deflection, even when a small voltage is applied cross its coil.

Current sensitivity. It is defined as the deflection produced in the galvanometer on passing unit current through its coil. Therefore,

Current sensitivity $= \frac{\theta}{1} = \frac{nBA}{k}$

Voltage sensitivity. It is defined as the deflection produced in produced in the galvanometer when a unit voltage is applied across its coil. Therefore V, then Voltage sensitivity $= \frac{\theta}{V}$

If R is resistance of coil and I is current that passes through coil on applying voltage V, then $V = IR$

∴ Voltage sensitivity $= \frac{\theta}{IR} = \frac{nBA}{kR}$

Thus, a galvanometer will be highly sensitive, if (i) n is large ; (ii) B is large ; (iii) A is large ; (iv) R is small and (v) k is small. However, n and A cannot be increased beyond certain limit otherwise, the sixe of the galvanomert and the resistance of the instrument will become large. Therefore, B is made as large as possible. To increase B, very strong permanent magnet is used. The suspension wire is made of phosphor bronze, as for this material, k is very small. The value of k furthyr decreases, if the wire is hammered into flat strip. In very sensitive galvanometers, quartz k, is still smaller.

11) Let $r_0 =$ Maximum radius of circular path followed by charged particle (Equal to the radius of the Dees)

$v_0 =$ Maximum velocity

Since the necessary centripetal force is provided by the Lorentz magnetic force, therefore,

$$\frac{mv_0{}^2}{r_0} = Bqv_0$$

$$v_0 = \frac{Bqr_0}{m}$$

$$\therefore\ K.E_{maxi} = \frac{1}{2} \times m \times \left(\frac{Bqr_0}{m}\right)^2$$

$$= \frac{b^2q^2r_0{}^2}{2m}$$

This is the required result.

12)

Magnetic field strength, B = 3000 G = 3000 x 10^{-4} T = 0.3 T

Length of the rectangular loop, l = 10 cm

Width of the rectangular loop, b = 5 cm

Area of the loop,

A = l x b = 10 x 5 = 50 cm^2 = 50 x 10^{-4} m^2

Current in the loop, I = 12 A

Now, taking the anti-clockwise direction of the current as positive and vise-versa:

(a) Torque, $\vec{\tau} = I\vec{A} \times \vec{B}$

From the given figure, it can be observed that A is normal to the y-z plane and B is directed along the z-axis.

$$\therefore \tau = 12 \times \left(50 \times 10^{-4}\right)\hat{i} \times 0.3\hat{k}$$

$$= -1.8 \times 10^{-2}\hat{j} \text{ N m}$$

The torque 1.8 x 10^{-2} is N m along the negative y-direction. The force on the loop is zero because the angle between A and B is zero.

b) This case is similar to case (a). Hence, the answer is the same as (a).

(c) Torque $\vec{\tau} = I\vec{A} \times \vec{B}$

From the given figure, it can be observed that A is normal to the x-z plane and B is directed along the z-axis.

$$\therefore \tau = 12 \times \left(50 \times 10^{-4}\right)\hat{j} \times 0.3\hat{k}$$

$$= -1.8 \times 10^{-2}\hat{i} \text{ N m}$$

The torque 1.8 x 10^{-2} is N m along the negative x direction and the force is zero.

(d) Magnitude of torque is given as:

|r| = IAB

= 12 x 50 x 10^{-4} x 0.3

= 1.8 x 10^{-2} N m

Torque is 1.8 x 10^{-2} N m at an angle of 240° with positive x direction. The force is zero.

(e) Torque $\vec{\tau} = I\vec{A} \times \vec{B}$

= (50 x 10-4 x 12) $\hat{k}$ x 0.3 $\hat{k}$

= 0

Hence, the torque is zero. The force is also zero.

(f) Torque $\vec{\tau} = I\vec{A} \times \vec{B}$

= (50 x 10-4 x 12) $\hat{k}$ x 0.3 $\hat{k}$

= 0

In case (e), the direction of $I\vec{A}$ and $\vec{B}$ is the same and the angle between them is zero. If displaced, they come back to an equilibrium. Hence, its equilibrium is stable.

Whereas, in case (f), the direction of $I\vec{A}$ and $\vec{B}$ is opposite. The angle between them is 180°. If disturbed, it does not come back to its original position. Hence, its equilibrium is unstable.

13) Here, dl= 1 cm = 10^{-2} m,

r= (20 cm) = (0.20 m) and $\vec{r} = 0.2\hat{i}$

$$\overrightarrow{Idl} = (3 \times 10^{-2})\hat{j}$$

$$\overrightarrow{dB} = \frac{\mu_o}{4\pi}\frac{\overrightarrow{Idl} \times \vec{r}}{r^3}$$

$$= \frac{10^{-7} \times \left(3 \times 10^{-2}\hat{j}\right) \times \left(0.20\hat{i}\right)}{(0.20)^3}$$

$$= 7.5 \times 10^{-8}\left(\hat{j} \times \hat{i}\right) = 7.5 \times 10^{-8}\left(-\hat{k}\right)$$

$$= -\left(7.5 \times 10^{-8}T\right)\hat{k}$$

Thus magnitude of magnetic field is 7.5X10^{-8} T and its direction is along negative Z-axis.

14)

The point (0, 0, -a) lies on z-axis. Therefore the magnetic field induction at the given point due to current along z-axis is zero.

The magnetic field induction due to current along x-axis at the given point is $\overrightarrow{B_x} = \frac{\mu_0}{4\pi}\frac{I}{a}\hat{j}$

The magnetic field induction due to current along y-axis at the given point is

$$\overrightarrow{B_y} = \frac{\mu_0}{4\pi}\frac{I}{a}(-\hat{i})$$

Total magnetic field induction,

$$\vec{B} = \overrightarrow{B_x} + \overrightarrow{B_y} = \frac{\mu_0}{4\pi}\frac{I}{a}(\hat{j} - \hat{i})$$

15)

Here, I = 20 A, $B_2 = 3 \times 10^{-4}$ T,

r = 2.0 x 10^{-2} m

Magnetic field due to a straight wire carrying current is

$$B_1 = \frac{\mu_o}{4\pi}\frac{2I}{r} = 10^{-7} \times \frac{2 \times 20}{2.0 \times 10^{-2}} = 2 \times 10^{-4} \quad T$$

This magnetic field will act perpendicular to magnetic field B_2(= 3 x 10^{-4}T). Therefore, the magnitude of the resultant magnetic field

$$B = \sqrt{B_1^2 + B_2^2} = \sqrt{\left(2 \times 10^{-4}\right)^2 + \left(3 \times 10^{-4}\right)^2}$$

= 3.6 x 10^{-4} T

16) Charge on alpha particle is +2 e. The revolving alpha particle is equivalent to current loop, having current

$$I = \frac{charge}{time} = \frac{2e}{t} = \frac{2 \times 1.6 \times 10^{-19}C}{2 \quad s}$$

= 1.6 x 10^{-19} A

Magnetic field at the centre of the circular loop is

$$B = \frac{\mu_o}{4\pi}\frac{2\pi I}{r} = \frac{\mu_o I}{2r}$$

$$= \frac{\left(4\pi \times 10^{-7}\right) \times \left(1.6 \times 10^{-19}\right)}{2 \times 0.8}$$

$$= 4 \times \frac{22}{7} \times \frac{10^{-7} \times 1.6 \times 10^{-19}}{2 \times 0.8}$$

= 12.57x s10^{-26} T

17) Here, $v=2.18 \times 10^6\ ms^{-1}$,

$r=5.3 \times 10^{-11}$ m, $e=1.6 \times 10^{-19}$ C.

(a) Time period of revolution of electron is given by,

$$T = \frac{2\pi r}{v} = \frac{2\pi \times 5.3 \times 10^{-11}}{2.18 \times 10^6} = 1.528 \times 10^{-16} s$$

Equivalent current, $I = \frac{charge}{time} = \frac{e}{T}$

$$= \frac{1.6 \times 10^{-19}}{1.528 \times 10^{-16}} = 1.05 \times 10^{-3} A$$

$$(b) B = \frac{\mu_o}{4\pi}\frac{2\pi I}{r} = \frac{10^{-7} \times 2\pi \times 1.05 \times 10^{-3}}{5.3 \times 10^{-11}}$$

=12.4 T

18) Here, n= 2, I= 5.0 A,

$B= 0.4 \times 10^{-3}$ T, r=?

Magnetic field at the centre of current loop is

$$B = \frac{\mu_o}{4\pi}\frac{2\pi nI}{r} \ or\ r = \frac{\mu_o}{4\pi}\frac{2\pi nI}{B}$$

$$\therefore\ r = 10^{-7} \times 2 \times \frac{22}{7} \times \frac{2 \times 5.0}{0.4 \times 10^{-3}}$$

$=157.1 \times 10^{-4}$m =1.57 cm

19) Here, n = 120, I = 3.0 A,

r = 18 cm = 0.18 m, x = a = 0.18 m

Case (i) Now, $B = \frac{\mu_o}{4\pi} \times \frac{2\pi nI}{r}$

$$= 10^{-7} \times 2 \times \frac{22}{7} \times \frac{120 \times 3}{0.18} = 1.26 \times 10^{-3} T$$

Case (ii) As, $B = \frac{\mu_o}{4\pi} \times \frac{2\pi nIa^2}{\left(a^2+x^2\right)^{3/2}}$

$$= 10^{-7} \times 2 \times \frac{22}{7} \times \frac{120 \times 3 \times (0.18)^2}{\left[(0.18)^2+(0.18)^2\right]^{3/2}}$$

$=4.4 \times 10^{-4}$ T

20) Here, R = 0.8 cm = 8 x 10^{-3} m ;

I = 100 A

$$(a)\ B_{inside} = \frac{\mu_o}{4\pi}\frac{2Ir}{R^2}$$

$$= 10^{-7} \times \frac{2 \times 100 \times \left(0.2 \times 10^{-2}\right)^2}{\left(8 \times 10^{-3}\right)^2}$$

= 6.25 x 10^{-4} T

$$(b)\ B_{surface} = \frac{\mu_o}{4\pi}\frac{2I}{R} = 10^{-7} \times \frac{2 \times 100}{8 \times 10^{-3}}$$

= 2.5 x 10^{-5} T

(c) When point is outside the wire,

r = 0.8 + 0.4 = 1.2 cm = 1.2 x 10^{-2} m.

$$B_{outside} = \frac{\mu_o}{4\pi}\frac{2I}{r} = 10^{-7} \times \frac{2 \times 100}{1.2 \times 10^{-2}}$$

= 1.67 x 10^{-5} T.

---

21) n = 300 turns/m ;

I = 5 A ; l = 0.5 m, r = 10^{-2} m.

$$B = \mu_o nI = \left(4\pi \times 10^{-7}\right) \times 300 \times 5$$

= 1.9 x 10^{-3} T.

---

22) Here, I = 2.5 A,

n = 100 / 0.50 = 200 m^{-1}

$$(a)\quad B = \mu_o nI = 4\pi \times 10^{-7} \times 200 \times 2.5$$

= 6.28 x 10^{-4} T

$$(b)\ B = \frac{\mu_o nI}{2} = \frac{4\pi \times 10^{-7} \times 200 \times 2.5}{2}$$

= 3.14 x 10^{-4} T

---

23)

Here, inner radius, r_1 = 20 cm.

Outer radius, r_2 = 22 cm ;

I = 10 A

Mean radius of toroid,

$$r = \frac{r_1 + r_2}{2}$$

$$= \frac{20+22}{2} = 21\ cm \ = 0.21\ m$$

Total length of toroid = circumference of toroid

$$= 2\pi r = 2\pi \times 0.21 \ = 0.42\pi m$$

Total number of turns, N = 4200

Number of turns per unit length will be,

$$n = \frac{4200}{0.42\pi} = \frac{10000}{\pi} m^{-1}$$

(a) Magnetic field induction inside the core of toroid, $B = \mu_o nI = 4\pi \times 10^{-7} \times \frac{10000}{\pi} \times 10 = 0.04\ T$

(b) Magnetic field induction outside the toroid is zero, since the field is only confined inside the core of the toroid on which winding has been made.

(c) Magnetic field induction in the empty space surrounded by toroid is also zero.

---

24) Here, r_1 = 15 cm = 0.15 m ;

r_2= 20 cm = 0.20 m ; N = 1000 ; I = 12 A

$$B_{max.} = \mu_o \frac{N}{2\pi r_1} I = \frac{\left(4\pi \times 10^{-7}\right) \times 1000 \times 12}{2\pi \times 0.15}$$

=1.6 x 10^{-2} T

$$B_{min.} = \mu_o \frac{N}{2\pi r_2} I = \frac{\left(4\pi \times 10^{-7}\right) \times 1000 \times 12}{2\pi \times 0.20}$$

= 1.2 x 10^{-2} T

---

25) Here, q = e = 1.6 x 10^{-19} C,

B = 2.5 T, v = 1.5 x 10^7 ms^{-1}, θ = 30°

F = qv B sin θ = (1.6 x 10^{-19}) x (1.5 x 10^7) x 25 x sin 30°

= 3 x 10^{-12} N.

---

26) Here, energy of electron,

E' = 2000 eV = 2000 x 1.6 x 10^{-19} J

= 3.2 x 10^{-16} J

B = 0.2 T ; r = ?

As, $E' = \frac{1}{2} mv^2 \quad \therefore \ v = \sqrt{\frac{2E'}{m}}$

Also, $Bev = \frac{mv^2}{r}$

or $r = \frac{mv}{Be} = \frac{m}{Be}\sqrt{\frac{2E'}{m}} = \frac{\sqrt{2E'm}}{Be}$

$$r = \frac{\sqrt{2 \times 3.2 \times 10^{-16} \times 9 \times 10^{-31}}}{0.2 \times 1.6 \times 10^{-19}}$$

= 7.5 x 10^{-4} m

27)

Here, mass of proton, m_p = m ; mass of deutron, m_d = 2 m and mass of α - particle m_α = 4 m ; charge on proton, q_p = e and charge on α - particle, q_α = 2 e.

K.E. of charged particle,

$$E = \frac{1}{2}mv^2 \quad or \quad v = \sqrt{2E/m}$$

Radius of the circular path of a charged particle in the magnetic field is given by

$$r = \frac{mv}{Bq} = \frac{m}{Bq}\sqrt{\frac{2E}{m}} = \frac{\sqrt{2mE}}{Bq}; so \quad r \propto \frac{\sqrt{m}}{q}$$

$$\therefore \ r_p : r_d : r_\alpha = \frac{\sqrt{m_p}}{q_p} : \frac{\sqrt{m_d}}{q_d} : \frac{\sqrt{m_\alpha}}{q_\alpha}$$

$$= \frac{\sqrt{m}}{e} : \frac{\sqrt{2m}}{e} : \frac{\sqrt{4m}}{2e} = 1 : \sqrt{2} : 1$$

28)

Here, B = 4 x 10^{-3} weber/m^2;

E = 2 x 10^4 V/m.

As the path of moving electron is undeviated, so force on moving electron due to electric field is equal and opposite to the force on moving electron due to magnetic field, i.e., eE = evB

$$or\ v = \frac{E}{B} = \frac{2 \times 10^4}{4 \times 10^{-3}} = 5 \times 10^6\ m/s$$

When electron moves perpendicular to magnetic field, the radius r of circular path traced by electron is

$$or\ r = \frac{mv}{eB} = \frac{\left(9.1 \times 10^{-31}\right) \times \left(5 \times 10^6\right)}{\left(1.6 \times 10^{-19}\right) \times 4 \times 10^{-3}}$$

$$= 7.11 \times 10^{-3}\ m = 7.11\ mm$$

29)

In a cyclotron, when a proton crosses a region of potential difference V, the energy gained is eV. In cyclotron, in one revolution, the proton crosses the gap twice. So the energy gained by proton in each revolution = 2 eV.

Let the proton make n revolutions before emerging from the dees. The gain in its kinetic energy is

$$E_k = \frac{1}{2}mv^2 = n \times 2eV\ or\ n = \frac{mv^2}{4eV} = \frac{m(c/6)^2}{4eV}$$

$$or\ n = \frac{mc^2}{4 \times 36 \times eV}$$

$$= \frac{1.67 \times 10^{-27} \times \left(3 \times 10^8\right)^2}{4 \times 36 \times \left(1.6 \times 10^{-19}\right) \times \left(25 \times 10^3\right)}$$

= 261 revolutions.

30)

Here, l = 50 cm = 0.50 m ; I = 5 A,

θ = 90°, B = 1 T, v = 10 ms^{-1}

F = BIl sinθ = 1 x 5 x 0.50 x sin 90° = 2.5 N

Power = Fv = 2.5 x 10 = 25 W

31) (i) Magnetic field due to C at D is

$$B = \frac{\mu_o}{4\pi}\frac{2I}{r} = 10^{-7} \times \frac{2 \times 3}{0.10} = 6 \times 10^{-6} T$$

(ii) Force on D, F = BI_1 lsinθ = (6 x 10^{-6}) x 4 x (5 x 10^{-2}) x sin90^o

= 1.2 x 10^{-6} N

32)

Here, mass of wire,

m = (3 x 10^{-3}) x 0.2 kg ; I = 4 A ; l = 0.2 m

In equilibrium position, force (F = IlB) on wire carrying current I due to magnetic field is equal to weight (mg) of wire, i.e.,

IlB = mg

$$or\ B = \frac{mg}{Il} = \frac{\left(3 \times 10^{-3}\right) \times 0.2 \times 10}{4 \times 0.2}$$

= 7.5 x 10^{-3} T

The weight of wire can be supported by force F if $\vec{F}$ is acting vertically upwards (i.e., opposite to the weight of will). It will be so if the direction of $\vec{B}$ is horizontal and perpendicular to wire carrying current.

33)

Here, l = 0.60 m;

m = 60 g = 60 x 10^{-3} kg ; I = 5.0 A

(a) Tension in the wire is zero if the force on the wire carrying current due to magnetic field is equal and opposite current due to magnetic field is equal and opposite to the weight of wire, i.e.,

BIl = mg

$$or\ B = \frac{mg}{Il} = \frac{\left(60 \times 10^{-3}\right) \times 10}{5.0 \times 0.60} = 0.20\ T$$

The force on the conductor due to magnetic field will be upwards if the direction of magnetic field is horizontal and normal to the conductor.

(b) When direction of current is reversed, BIl and mg will act vertically downwards, the effective tension in the wires,

T = BIl + mg

= 0.2 x 5.0 x 0.60 + (60 x 10^{-3}) x 10

= 1.2 N

34) Here, I_1 = 4 A, I_2 = 6 A,

r = 3 cm = 3 x 10^{-2} m

Force per unit length, $F = \frac{\mu_o}{4\pi} \times \frac{2I_1I_2}{r}$

$$= 10^{-7} \times \frac{2 \times 4 \times 6}{3 \times 10^{-2}} = 1.6 \times 10^{-4} Nm^{-1}$$

35)

Weight per unit length of upper wire = magnetic force per unit length

$$\frac{mg}{l} = \frac{\mu_o}{4\pi}\frac{2I_1I_2}{r}$$

Mass per unit length

$$= \frac{m}{l} = \frac{\mu_o}{4\pi}\frac{2I_1I_2}{rg} = \frac{10^{-7} \times 2 \times 12 \times 5}{\left(10^{-3}\right) \times 10}$$

= 1.2 x 10^{-3} kg m^{-1}

The direction of current in CD must be opposite to that of current in AB so that the force between the two wires is repulsive.

---

36) Here, A = 5.0 x $10^{-4} m^2$, n = 60 ;

B = 90 G = 90 x 10^{-4} T, K = ?

I = 2.0 mA = 2.0 x 10^{-3} A, $\theta = 18^o$,

As, $I = \frac{k}{nBA}\theta$

$$\therefore k = \frac{nBAI}{\theta}$$

$$= \frac{60 \times 90 \times 10^{-4} \times 5.0 \times 10^{-4} \times 2.0 \times 10^{-3}}{18}$$

= 3.0 x 10^{-9} Nm per degree

---

37) Given, $I'_s = I_s + \frac{20}{100}I_s = \frac{120}{100}I_s$

$R' = 2R$

Then, initial voltage sensitivity, $V_s = \frac{I_s}{R}$

New voltage sensitivity,

$$V'_s = \frac{I'_s}{R'} = \left(\frac{120}{100}I_s\right) \times \frac{1}{2R} = \frac{3}{5}V_s$$

% decrease in voltage sensitivity

$$= \frac{V_s - V'_s}{V_s} \times 100 = \frac{V_s - \frac{3}{5}V_s}{V_s} \times 100$$

= 40%

---

38) Here, I_1 = 500μA = 500 x 10^{-6} A,

$$\theta_1 = 60^o, I_2 = ?, \theta_2 = \frac{\pi}{5}rad. = \frac{180^o}{5} = 36^o$$

$I_1 = \frac{k}{nBA}\theta_1$ and $I_2 = \frac{k}{nBA}\theta_2$

$$\therefore \frac{I_2}{I_1} = \frac{\theta_2}{\theta_1} or$$

$$I_2 = \frac{\theta_2}{\theta_1}I_1 = \frac{36}{60} \times 500 \times 10^{-6} = 300 \times 10^{-6} \quad A$$

Current sensitivity $= \frac{\theta_2}{I_2} = \frac{36^o}{300 \times 10^{-6}}$

= 0.12 x 10^{-6} degree/A = 0.12 degree/μA

---

39) Here, n= 30, G = 100 Ω , ε = 3 V,

R= 200 Ω , K = ?

Total resistance of the circuit

= G + R = 100 + 200 = 300 Ω

Current in the circuit which produces full scale deflection in the galvanometer,

$$I_g = \frac{\varepsilon}{G+R} = \frac{3}{300} = \frac{1}{100}A$$

$$K = \frac{I_g}{n} = \frac{1/100}{30} = \frac{1}{3} \times 10^{-3} A/division$$

$$= \frac{1}{3} \times 10^{-3} \times 10^{6}\mu \quad A/division$$

$$= 333.3\mu\ A/division$$

40)

Let R be the resistance of voltmeter. Let n be the number of divisions in the voltmeter. The voltage (V) recorded by each division of voltmeter when current i_g flows through it is

i_g R/n = V ....(i)

When resistance is connected in series with voltmeter, then

i_g(R + 1980)/n = 100 V ...(ii)

Dividing (ii) by (i), we get

R + 1980 = 100 R or R = 1980/99 = 20 Ω

41)

(i) The force is due to the interaction between magnetic fields due to currents in two linear parallel conductors.

(ii) Here, $l_1 = 2cm = 2 \times 10^{-2}m; l_2 = 20 \times 10^{-2}m; I_1 = 2.0A; I_2 = 5.0A; r = 4 \times 10^{-2}m$

Since action and reaction are equal and opposite so the magnitude of repulsive force on 20 cm long wire = the magnitude of repulsive force on 2 cm long wire

$$= \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r}l_1 = 10^{-7} \times \frac{2 \times 2 \times 5 \times (2 \times 10^{-2})}{4 \times 10^{-2}}$$

$$= 10^{-6}$$

This study shows that when the current through two parallel conductors flow in the same direction, they attract each other and vice versa. It implies that when the thoughts and actions of two business partners are aligned in the same direction, their behavior is cohesive and they succeed. If there thoughts and actions are opposing, the partnership is likely to collapse. The same thing is true for husband and wife. For a successful family life, the coherence of thoughts and action is a must.

42)

(i) The shunt is a low resistance connected in parallel with the galvanometer. Therefore, the combined resistance is less than that of the shunt.

(ii) Let I be the total current passing through the shunt galvanometer. Let I_g,I_s be the currents through galvanometer of resistances G and shunt of resistance S respectively. As current divides itself in the inverse ratio of the resistances, therefore, fraction of current passing through galvanometer

$$= \frac{I_g}{I} = \frac{S}{G+S} = \frac{3}{30+3} = \frac{1}{11}$$

$$Fraction\ of\ current\ passing\ through\ shunt = \frac{I_s}{I} = \frac{G}{G+S} = \frac{30}{30+3} = \frac{10}{11}$$

(iii) From the above study, we find that the current always divides itself in the inverse ratio of resistances. The major part of current flows through the shunt, which is the path of low resistance. Similarly in life, if different paths are available to reach a destination, then one selects a path of least resistance to reach there. This would save both, time and energy.

43)

(i) Priya tells Saniya that while plotting field due to a bar magnet, we obtain the resultant of the magnetic field of magnet and that of earth. At certain points, field due to the magnet becomes equal and opposite to the horizontal component of earth's field. Therefore, net magnetic field due to magnet and due to earth becomes zero at these points.
(ii) When noth pole of bar magnet is pointing north, two neutral pointa are along E-W line passing through centre of magnet.
(iii) When north pole of magnet is pointing south, two neutral points are obtained along the axis of the magnet on opposite sides from the center of the magnet.
(iv) From this piece of knowledge, we learn that staying neutral in a situation is the best. If you are aligned to one group or person, you are forced to go by the dictates of that group, right or wrong. You are not independent. If you are non aligned, you can choose your own course of action without killing your conscience.

44)

Current sensitivity, $I_s = \frac{NAB}{k}$ and
Voltage sensitivity, $V_s = \frac{NAB}{kR}$
Since, the resistance of the coil may vary, it implies an increase in current sensitivity may not necessarily increase voltage sensitivity.
Thus, the trajectory of both the particles will be same.

45)

Here, the mass of the proton
$m = 1.6 \times 10^{-24} g$
$= 1.6 \times 10^{-27} kg$
Charge on proton
$e = 1.6 \times 10^{-19} C$
$E_y = 400 V/cm = 4 \times 10^4 V/m, x = 5cm = 0.05m$
$v_x = 2.5 \times 10^8 cm/s = 2.5 \times 10^6 m/s.$
$t = \frac{x}{v_x} = \frac{0.05}{2.5 \times 10^6} = 2 \times 10^{-8} s$
$F_y = eE_y$
$F_y = (1.6 \times 10^{-19}) \times (4 \times 10^4) N$
$a_y = \frac{F_y}{m} = \frac{1.6 \times 10^{-19} \times 4 \times 10^4}{1.6 \times 10^{-27}}$
$a_y = 4 \times 10^{12} m/s^2$
$u_y = 0, a_y = 4 \times 10^{12} m/m^2, t = 2 \times 10^{-8} s, y = \ ?$

46)

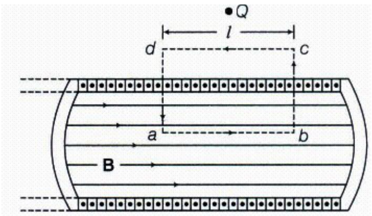
(i) A galvanometer of range I_g and resistance G_1 can be converted into
(a) a voltmeter of range V, by connecting a high resistance R in series with galvanometer whose value is given by
$R = \frac{V}{I_g} - G$
(b) an ammeter of range I, by connecting a very low resistance (shunt) in parallel with galvanometer whose value is given by
$S = \frac{I_g G}{I - I_g} - G$
Thus, the nature of force is attractive.
When direction of flow of current is in opposite direction, the nature of force becomes repulsive.

47) (i) He exhibits responsible behaviour, sensitivity and concern for others.

(ii) Because the two wires have high magnetic field around them.

48)

(i) Figure shows, the longitudinal sectional View of long current carrying solenoid.



The current comes out of the plant of paper at point marked.B is the magnetic field at any point inside the solenoid. Considering the rectangular closed path abcd.

applying Ampere's circuital law over loop abcd.

$\oint B.\, dI = \mu_0 \times (total\ current\ passes\ through\ loop\ abcd)$

$\int_a^b B.\, D1 + \int_b^c B.\, d1 + \int_c^d B.\, d1 + \int_d^a B.\, d1 = \mu_0[(\frac{N}{L})li]$

$where,\ \frac{N}{L} = number\ of\ turns\ per\ unit\ length,$

$ab = cd = l = length\ of\ rectangle$

$\int_a^b Bdl\cos 0^0 + \int_b^c BdlCos 90^0 + 0 + \int_b^a Bdl cos 90^0 = \mu_0(\frac{N}{L})li$

$[\because cos 0^0 = 1 \quad and \quad cos 90^0 = 0]$

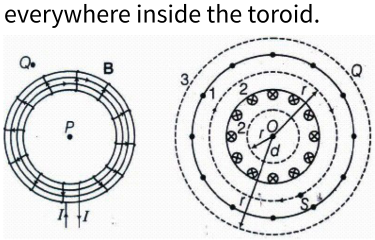
$B\int_a^b dl = \mu_0(\frac{N}{l})li$

$\Rightarrow B = \mu_0(\frac{N}{l})i \quad or \quad B = \mu_0 ni$

Where, a n = number of turns per unit length.

This is a required expression for magnetic field inside the long current carrying solenoid.

(ii)A solenoid bent into the form of closed loop is called toroid. The magnetic field B has a constant magnitude everywhere inside the toroid.



(a) Let magnetic field inside the toroid be B along the consider loop 1 as shown in the figure.

Applying ampere's circuital law,

$\oint B.\, dI = \mu_0(NI)$

since, toroid of N turns, therads the loop 1, N times, each carrying current / inside the loop. Therefore, total current threading the loop.Therefore, total current threading the loop 1 is Ni

$\Rightarrow \oint loop1 B.\, d1 = \mu_0 \quad NI \Rightarrow B\oint loop1 d1 = \mu_0 \quad NI$

$B \times 2\pi r = \mu_0\ NI\ or\ B = \frac{\mu_0 NI}{2\pi r}$

(b)The magnetic field inside the open space interior of the toroid Let the loop 2 be which in the open space inside the toroid.

$\therefore$ By Ampere's circuital law,

$\oint loop2 B.\, dl = \mu_0(\theta) = 0$

$\Rightarrow dB = 0$

the magnetic field in the open space exterior of the toroid Let us consider a coplanar loop 3 in the open space of exterior of the toroid Here, each turn of toroid threads the loop two times in opposite direction of the toroid.Here, each turn of toroid threads the loop two times in opposite direction

therefore, net current threading the loop

$= NI - NI = 0$

$\oint loop3B.\,dl = \mu_0(NI - NI) = 0$

$\Rightarrow B = 0$hus, there is no magnetic field in the open space interior and exterior of the toroid.

49) (i) She has nature of appreciations, diligence, curiosity, research mind.

(ii) Using equation,

$qvB = \frac{mv^2}{r}$

$\Rightarrow r = \frac{mv}{qB} = \frac{9 \times 10^{-31} \times 3 \times 10^7}{1.6 \times 10^{-19} \times 6 \times 10^{-4}}$

$= 2.8125 \times 10^{-1} = 28.125cm$

Frequency, $v = \frac{v}{2\pi r} = 2 \times 10^6 s^{-1}$

$= 2 \times 10^6 Hz = 2Mhz$

Energy

$E = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 9 \times 10^{-31} \times 9 \times 10^{14}$

$= 40.5 \times 10^{-17} J = 4 \times 10^{-16} J$

$= 2.5keV$

50) (i) Priyanshu's father is responsible, makes his child understood the concepts of solenoid and toroid.

(ii) A solenoid has magnetic field straight within the turns and in toroid, it is in form of concentric circles.

(iii) The magnitude of magnetic field in solenoid is given by $B = \mu_\circ nI$

(where, n=number of turns/length, I=current in coil)

51) (i) Niyaz shows the values of courage to tell truth and determination.

(ii). It is based on the principle when a current carrying coil placed in external magnetic field, it develops torque.

(iii) Sensitivity of galvanometer can be increased by

(a) increasing number of turns in the coil and

(b) by increasing current in the coil.

52) (ii) We know, Lorentz force, F=Bqv sinθ

Where θ=angle between velocity of particle and magnetic field=90^0

So,Lorentz force,F=Bqv [sin 90^0=1]

When a charged particle enters in a magnetic field in a direction normal to the field, then in this condition,

Lorentz force =Centripetal force

$Bqv = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{Bq}$

53) (ii) Here,M = 5Am^2

2l = 0.20m and m = ?

As, M = m x 2l

$\Rightarrow$ m = M | 2l = $\frac{5}{0.2}$ = 25A-m

54) ii)We can destroy the magnetism of a magnet

a)by heating it

b)by applying magnetic field across it in reverse direction.

55)

i)The values developed by Mndeep were sympathy, responsibility, helping nature and self-reliance.

ii)The vlue imparted by mother are appreciation and thankfulness.

iii)It is not necessary that every magnetic configuration has a North pole and a South pole.It is true only if the source of the field has a net non-zero magnetic moment.This is not possible for a toroid or even for a straight infinite conductor.

56) i) Mr.Santosh is helping in nature, honest and has concern for the students to create interest in the subject.

ii) Magnetic declination, magnetic inclination and horizontal component of the earth's magnetic field.

iii) It is of the order of 10^{-5} T.

57)

i) Awareness about new techonology, concern for energy conservation,decrease of noise pollution and air pollution, i.e. concern for environment.

ii) Superconductors are the most exotic diamagnetic materials.These are metals cooled to very low temperature which exhibits both perfect conductivity and perfect diamagnetism.

iii) A superconductor repels a magnet and in turn, is repelled by the magnet.This phenomenon of perfect diamagnetism in superconductors is called Meissner's effect.

58)

$E = 18keV = 18 \times 10^3 \times 1.6 \times 10^{-19}J$

[eV = 1.6 x10^{-19}J]

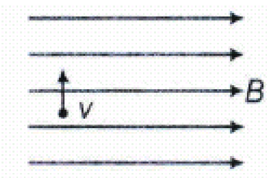
$= 8 \times 1.6 \times 10^{-16}$

Let velocity of an electron be v.

Magnetic field, B = 0.4 gauss =$0.4 \times 10^{-4}\ T$

Distance = 30 cm =0.3

Mass of electron, $m_e = 9.1 \times 10^{-31}kg$



Energy of electron, $E = \frac{1}{2}mv^2$

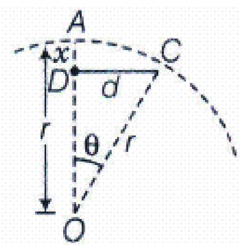
$18 \times 1.6 \times 10^{-16} = \frac{1}{2} \times 9.1 \times 10^{-31}v^2$

$v = 0.795 \times 10^8 \quad m/s$

Let the electron beam defects along a circular path of radius r.The magnetic force applied on the electron provides the centripetal force.

$evB = \frac{mv^2}{r}\left[B_yF = q(v \times B)\right]$; between $(v \times B)$ 90_0

OA = r = OC;DC = d = 30cm



$r = \frac{mv}{Be} = \frac{9.1 \times 10^{-31} \times 0.795 \times 10^8}{0.4 \times 10^{-4} \times 1.6 \times 10^{-19}} = 11.3m$

Let the deflection be AD = x.

From$\Delta DCO,\ sin\theta = \frac{DC}{OC} = \frac{d}{r} = \frac{0.3}{11.3} \Rightarrow \ \theta = 1.521^0$

and $cos\theta = \frac{OD}{OC} = \frac{OD}{r} \quad or \quad OD = rcos\theta$

Deflection at the end of the path,

$AD = x = AO - OD = r - rcos\theta = r(1 - cos\theta)$

or x = 11.3(1-cos1.521^0) = 0.0039m = 3.9mm

x = 4 mm

Thus, the up or down deflection of the beam is approximately 4 mm.

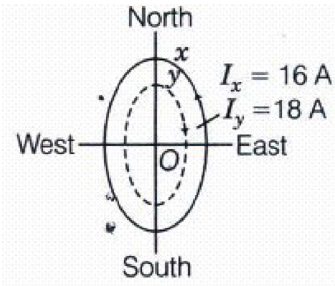
59)

For coil x

Radius of coil, r_x = 16 cm = 0.16 m

Number of turns, n_x = 20

Current in the coil, I_x = 16 A (anti=clockwise)



For coil y

Radius of coil, r_y =10 cm = 0.1 m

Number of turns, n_y = 25

Current in the coil, I_y = 18 A (clockwise)

The magnitude of the magnetic field at the centre of coil x,

$B_x = \frac{\mu_0}{4\pi} \cdot \frac{2I_x \pi n_x}{r_x} = \frac{10^{-7} \times 2 \times 16 \times \pi \times 20}{0.16}$

$= 4\pi \times 10^{-4} T$

The direction of magnetic field due to the coil x at centre O is towards right, i.e. East, according to right hand thumb rule.

The magnitude of the magnetic field at the centre of coil y,

$B_y = \frac{\mu_0}{4\pi} \cdot \frac{2\pi I_y n_y}{r_y} = \frac{10^{-7} \times 2 \times \pi \times 18 \times 25}{0.1}$

$= 9\pi \times 10^{-4} T$

The direction of magnetic field due to coil y at centre O is towards left, i.e. West, according to right hand thumb rule.

Here, the magnitude of B_y is greater than B_x, so the resultant magnetic field will be in the direction of B_y , i.e. left (West).

Net magnetic field at the centre,

$B = B_y - B_x = (9\pi - 4\pi)\ 10^{-4}$ T = $5\pi \times 10^{-4}$ T

($\because$ B_y and B_x are opposite to each other)

= 1.6×10^{-3} T (towards West)

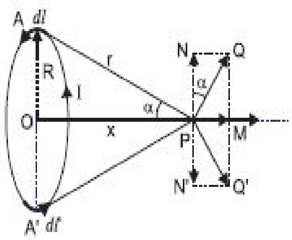
---

60)

Statement for Biot-Savart Law: The magnitude of magnetic field $\vec{dB}$ due to current element is directly proportional to the current I, the elements length $|dl|$ and inversely proportional to the square of the distance r of the field point. Its direction is perpendicular to the plane containing $\vec{dl}$ and $\vec{r}$.

$$\vec{dB} \alpha \frac{I\vec{dl} \times \vec{r}}{r^3}$$

Or $\vec{dB} = \frac{\mu_0}{4\pi} \frac{I\vec{dl} \times \vec{r}}{r^3}$



The magnetic field due to $\vec{dl}$ is given by Biot Savart law as

$$dB = \frac{\mu_0}{4\pi} \cdot \frac{I\left|\vec{dl} \times \vec{r}\right|}{r^3}$$

Now dB_x = Db Cos $\theta = \frac{\mu_0}{4\pi} \cdot \frac{Idl}{\left(x^2+R^2\right)} \cos\theta$

$$= \frac{\mu_0}{4\pi} \cdot \frac{Idl}{\left(x^2+R^2\right)} \frac{R}{\left(x^2+R^2\right)^{1/2}}$$

So, $B_x = \int dB_s = \frac{\mu_0}{4\pi} \frac{IR}{\left(x^2+R^2\right)^{3/2}} \int dl$

$$= \frac{\mu_0 IR^2}{2\left(x^2+R^2\right)^{3/2}}$$

(The y-components, of the field, add up to zero,due to symmetry)

∴ Magnetic field at P due to a circular loop

$$= B = B_x \vec{i} = \frac{\mu_0 IR^2}{2\left(x^2+R^2\right)^{3/2}} \vec{i}$$

Explanation: A circular current loop produces magnetic field and its magnetic moment is the product of current and its area $\vec{M} = L\vec{A}$

61)

(a) $\vec{F} = I(\vec{l} \times \vec{B})$, where $\vec{l}$ is a vector of magnitude l, the length of the rod, and with a direction identical to the current I. Note that the current I is not a vector. According to Fleming's left hand rule, $\vec{B}$ must act horizontally in a direction perpendicular to the wire carrying current.

(b) Adaptation to different situations and flexible and adjustable attitude.

(c) Avoiding unnecessary arguments in conflicting situations in everyday life.

62)

63) Honesty, helpfulness, responsible behaviour towards students, concern for the students to create interest in the subject.

64) Magnetic declination, magnetic inclination and horizontal component of earth's magnetic field.

65)
$sin\theta = \theta$

$\tau = mB \quad sin\theta = mB\theta$

This torque is in the nature of a restoring torque.

Hence equation of motion, for the oscillatory motion, of the magnet is

$I\frac{d^2\theta}{dt^2} = -mB\theta$

This is the equation of a S.H.M.

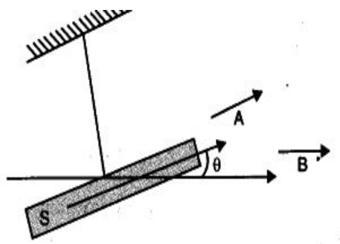
$\frac{d^2\theta}{dt^2} + \omega^2\theta = 0$

where $\omega^2 = \frac{mB}{I}$

Hence the time period of oscillation of the magnet is given by

$T = \frac{2\pi}{\omega}$

$= 2\pi\sqrt{\frac{I}{mB}}$



$m_{net} = 2m$

$I_{net} = 2I$

$\Rightarrow$ T will remain same.

66)
$\oint\vec{B}.\vec{dl} = \mu_0\Sigma i$

$\int_a^b\vec{B}.\vec{dl} + \int_b^c\vec{B}.\vec{dl} + \int_c^d\vec{B}.\vec{dl} + \int_d^a\vec{B}.\vec{dl} = \mu_0 I(nh)$

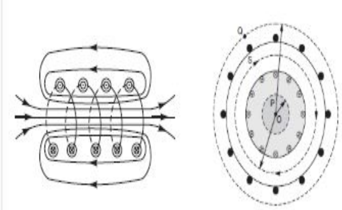
$Bh + 0 + 0 + 0 = \mu_0 I(nh)$

$B = \mu_0 nI$

(b) (Anyon difference ~ In a toroid, magnetic lines do not exist outside this body.

→Toroid is close whereas the solenoid is open on both sides

→ Magnetic field is uniform inside a toroid whereas for solenoid, it is different at the two ends and the centre.



Strengthing of magnetic field: (Anyone) 1

(i) By inserting a ferromagnetic substance inside the solenoid

(ii) By increasing the amount of current through the solenoid

67) **Principle and** working: A current carrying coil, placed in a uniform magnetic field, (can) experience a torque.

Consider a rectangular coil for which no. of turns = N

rea of cross-section = 1 x b = A,

Intensity of the uniform magnetic field = B,

Current through the coil = I

∴ Deflecting torque = $BIl \times b = BIA$

For N turns τ = NBIA

Restoring torque in the spring = kθ

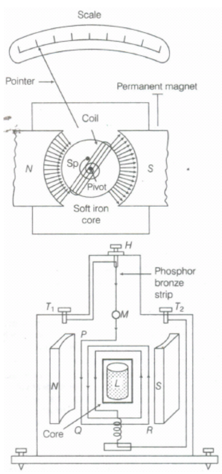
(k = restoring torque per unit twist)

$\therefore NBIA = k\theta$

$\therefore I = (\frac{k}{NBA})\theta$

$\therefore I\alpha\theta$

The deflection of the coil, is therefore, proportional to the current flowing through it.



(b) the soft iron core not only makes the field radial but also increase the strength of the magnetic field

(ii) We have

$Currentsensitivity = \frac{\theta}{I} = NBA/k$

Voltage sensitivity =$\frac{\theta}{V} = \frac{\theta}{IR} = (\frac{NBA}{K}). \frac{1}{R}1/2$

It follows that an increase in current sensitivity may not necessarily increase the voltage sensitivity.

68)

(a) Consider the case r > a. The Amperian loop, labelled 2, is a circle concentric with the cross-section. For this loop,

$L = 2\pi r$

I_e = Current enclosed by the loop = I

The result is the familiar expression for a long straight wire

$B(2\pi r) = \mu_0 I$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B \propto \frac{1}{r} \quad (r > a)$$

b) Consider the case r < a. The Amperian loop is a circle labelled 1. For this loop, taking the radius of the circle to be r,

$L = 2\pi r$

Now the current enclosed Ie is not I, but is less than this value. Since the current distribution is uniform, the current enclosed is

$$I_e = I\left(\frac{\pi r^2}{\pi a^2}\right) = \frac{I r^2}{a^2}$$

Using Ampere's law, $B(2\pi r) = \mu_0 \frac{I r^2}{a^2}$

$$B = \left(\frac{\mu_0 I}{2\pi a^2}\right) r$$

$B \propto r \ (r < a)$

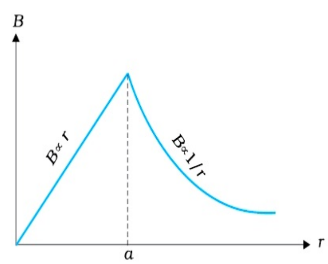


Figure shows a plot of the magnitude of B with distance r from the centre of the wire. The direction of the field is tangential to the respective circular loop (1 or 2) and given by the right-hand rule described earlier in this section. This example possesses the required symmetry so that Ampere's law can be applied readily.

69)

The torque always tries to bring back the needle in equilibrium position i.e. parallel to the existing field

(i) The torque on the needle is $\tau = M \times B$

Here τ is restoring torque and e is the angle

between M and B.

Therefore, in equilibrium,

Restoring force =Deflecting torque

$$I\frac{d^2\theta}{dt^2} = -MBsin\theta$$

Negative sign with MB sin θ implies that restoring torque is in opposition to deflecting torque.

For small values of θ in radians, we approximate sin $\theta = \theta$ we get

$$I\frac{d^2\theta}{dt^2} = -MB\theta$$

$$\Rightarrow \frac{d^2\theta}{dt^2} = -\frac{MB}{1}\theta$$

$$\Rightarrow \frac{d^2\theta}{dt^2} = -\omega^2\theta$$

This equation represents a simple harmonic motion. The square of the angular frequency is

$$\omega^2 = \frac{MB}{I} \quad \omega^2 = \frac{MB}{1}$$

Where $\omega = \sqrt{\frac{MB}{1}}$

Time period, T= $\frac{2\pi}{\omega} = 2\pi\sqrt{\frac{I}{MB}}$

(ii) (a) As, horizontal component of earth's magnetic field,$B_H = Bcos\delta$

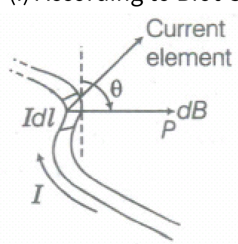
Putting $\delta = 90^0$ (as compass needle orients itself vertically)

$\therefore B_H = 0$

(b) For a compass needle oriented itself with its axis vertical at a certain place, angle of dip $\delta = 90^0$

70)

(i) According to Biot-Savart's law, Conductor is placed in air or vacuum,



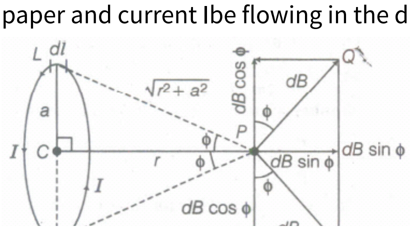
then dB = $\frac{\mu_0}{4\pi}\frac{idlsin\theta}{r^2}$

In vector form, Biot-Savart's law can be written as,

$$dB \propto \frac{Idl \times r}{r^3}$$

$$= \frac{\mu_0}{4\pi}\frac{Idl \times r}{r^3}$$

Let us consider a circular loop of radius a with centre C. Let, the plane of the coil be perpendicular to the plane of the paper and current Ibe flowing in the direction shown in the figure.



Suppose P is any point on the axis at a direction r from the centre.

Now, consider a current element Idlon top L, where current comes out of paper normally whereas at bottom (M) enters into the plane paper normally.

$\therefore LP \perp dl$

Also, $MP \perp dl$

$\therefore MP = LP = \sqrt{r^2 + a^2}$

The magnetic field at P due to current element Idl,

According to Biot-Savart's law,

$dB = \frac{\mu_0}{4\pi} . \frac{Idl sin 90^o}{(r^2+a^2)}$

Where, a = radius of circular loop

r = distance of point P from centre along the axis.The direction of dB is perpendicular to LP and along PQ, where PQ ⊥ LP.

Similarly, the same magnitude of magnetic field is obtained due to current element ldl at bottom and direction is along PQ', where $PQ \perp MP$.

Now, resolving dB due to current element at Land MdBcosϕ components balance each other and net magnetic field is given by

$B = \oint dB sin\phi = \oint \frac{\mu_0}{4\pi} (\frac{IdL}{r^2+a^2}). \frac{a}{\sqrt{r^2+a^2}}$

[$\therefore \Delta PCL, sin\phi = \frac{a}{\sqrt{r^2+a^2}}$]

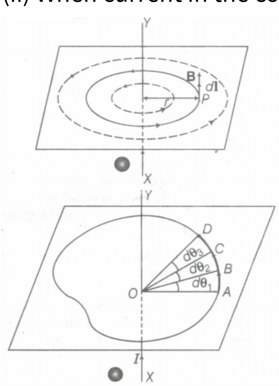
B = $\frac{\mu_0}{4\pi r} . \frac{Ia}{(r^2+a^2)^{3/2}} \oint dl$

$B = \frac{\mu_0}{4\pi} . \frac{Ia}{(r^2+a^2)^{3/2}} (2\pi a) = \frac{\mu_0 I a^2}{2(r^2+a^2)^{3/2}}$

For N turns, B = $\frac{\mu_0 N I a^2}{2(r^2+a^2)^{3/2}}$

The direction is along the axis and away from the loop.

(ii) When current in the coil is in anti-clockwise direction.



Consider any arbitrary closed path perpendicular to the plane of paper around a long straight conductor XY carrying current from X to Y, lying in the plane of paper.

Let, the closed path be made of large number of small elements, where

AB = dl_1,BC = dl_2,CD = dl_3

Let dθ_1, dθ_2, dθ_3, be the angles subtended by the various elements at point 0 through which conductor is passing. Then

$d\theta_1 + d\theta_2 + d\theta_3 + \ldots = 2\pi$

Suppose these small elements AB, BC, CD,... are small circular arcs of radii r_1,r_2,r_3 respectively.

Then, $d\theta_1 = \frac{dl_1}{r_1}, d\theta_2 = \frac{dl_2}{r_2}, d\theta_3 = \frac{dl_3}{r_3}$

If B_1,B_2,B_3 are the magnetic field induction at a point along the small elements dl_1,dl_2,dl_3 ... then from Biot-Savart's law we know that for the conductor of infinite length, magnetic field is given by

$B_1 = \frac{\mu_0}{4\pi}. \frac{2I}{r_1}; B_2 = \frac{\mu_0}{4\pi}. \frac{2I}{r_2}; B_3 = \frac{\mu_0}{4\pi}. \frac{2I}{r_3}$

In case of each elements, the magnetic field induction B and current element vector dl are in the same direction. Line integral of B around closed path is

$\oint B. dl = B_1. dI_1 + B_2. dl_2 + B_3. dl_3 + \ldots$

$= B_1(dl_1) + B_2(dl_2) + B_3(dl_3) + ..$

$= \frac{\mu_0}{4\pi}. \frac{2I}{r_1} dl_1 + \frac{\mu_0}{4\pi}. \frac{2I}{r_2} dl_2 + \frac{\mu_0}{4\pi}. \frac{2I}{r_3} dl_3 + \ldots$

$= \frac{\mu_0 2I}{4\pi} [\frac{dl_1}{r_1} + \frac{dl_2}{r_2} + \frac{dl_3}{r_3} + \ldots]$

$= \frac{\mu_0 2I}{4\pi} [d\theta_1 + d\theta_2 + d\theta_3 + \ldots] = \frac{\mu_0}{4\pi} 2I \times 2\pi = \mu_0 I$

$\Rightarrow \oint B. dl = \mu_0 I$, which is an expression of Ampere's circuital law.

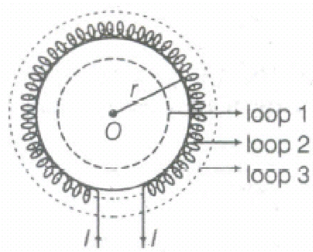
71)

(i) Ampere's circuital law states that the line integral of magnetic induction B around a closed path in vacuum is equal to μ_o times the total current 1 passing through the surface, i.e.$\oint B.\, dl = \mu_o I.$

A toroid is a hollow circular ring on which a large number of turns of a wire are closely wound.

Now, consider an air-cored toroid with centre O and in order to determine the magnetic field inside the toroid, we consider three amperian loops

(loop 1, loop 2 and loop 3).



For loop 1,

According to Ampere's circuital law, we have,

$\oint B.\, dI = \mu_0$(total current)

Total current for loop 1 is zero because no current is passing through this loop.

So, for loop 1,$\oint B.\, dl = 0$

For loop 3,

According to Ampere's circuital law, we have,

$\oint B.\, dI = \mu_o$ (total current)

Total current for loop 3 is zero because net current coming out of this loop is equal to the net current going inside the loop.

For loop 2,

The total current flowing through the toroid is NI. Where, N is the total number of turns.

$\oint B.\, dI = \mu_o(NI)$ -- (i)

Now, B and dlare in the same direction.

$\oint B.\, dI = B\oint dl \Rightarrow \oint B.\, dI = B(2\pi r)$ --- (ii)

On comparing Eqs. (i) and (ii), we get

$\Rightarrow B = \frac{\mu_0 NI}{2\pi r}$

Number of turns per unit length is given by

$n = \frac{N}{2\pi r}$

$\therefore B = \mu_0 NI$

This is the expression for magnetic field inside air-cored toroid.

(ii) Since, it is given that the current flows in the clockwise direction for an observer on the left side of the solenoid. It means that the left face of the solenoid acts as South pole and right face acts as North pole. Inside a bar, the magnetic field lines are directed from South to North.

Therefore, the magnetic field lines are directed from left to right in the solenoid.

Magnetic moment of a single current carrying loop is given by, m' = IA.

So, magnetic moment of the whole solenoid is given by m= Nm'=N(IA).

72)

The magnetic field at a point due to a circular loop is given by

$B = \frac{\mu_0}{4\pi}.\frac{2\pi Ia^2}{(a^2+r^2)^{3/2}}$

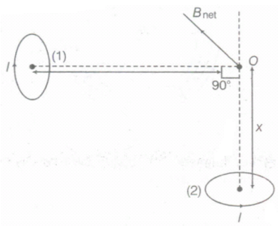
where, I = current through the loop

a = radius of the loop and r = distance of 0 from the centre of the loop.

Since I, a and r = x are the same for both the loops, the magnitude of B will be the same and is given by

$B_1 = B_2 = \frac{\mu_0}{4\pi}.\frac{2\pi Ia^2}{(a^2+x^2)^3/2}$

The direction of magnetic field due to loop (1) will be away from 0 and that of the magnetic field due to loop (2) will be towards 0 as shown. The direction of the net magnetic field will be as shown below:



The magnitude of the net magnetic field is given by

$B_net = \sqrt{B_1^2 + B_2^2} \Rightarrow B_net = \frac{\mu_0}{4\pi}\frac{2\sqrt{2}\pi Ia^2}{4\pi(a^2+x^2)^{3/2}}$

73) In this answer, put r = d.

Magnetic field induction at the centre of the circular coil carrying current is

$B_2 = \frac{\mu_0}{4\pi}.\frac{2\pi I}{a}$

$B_1 = \frac{\mu_0}{4\pi}.\frac{2\pi a^2 I}{(a^2+d^2)^{3/2}}$

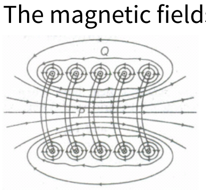
$\frac{B_1}{B_2} = \frac{a^2\times a}{(a^2+d^2)^{3/2}} = \frac{a^3}{(a^2+d^2)^{3/2}} \quad [\therefore d = a\sqrt{3}]$

$\frac{B_1}{B_2} = \frac{a^3}{(a^2+3a^2)^{3/2}} = \frac{a^3}{(4a^2)^{3/2}} = \frac{a^3}{8a^3} \Rightarrow \frac{B_1}{B_2} = \frac{1}{8}$

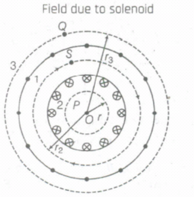
74)

(ii) Solenoid is a hollow circular ring having large number of turns of insulated copper wire on it. Therefore, we can assume that toroid is a bent solenoid to close on itself.

The magnetic fields due to solenoid and toroid is given in figures below:



Field due to solenoid



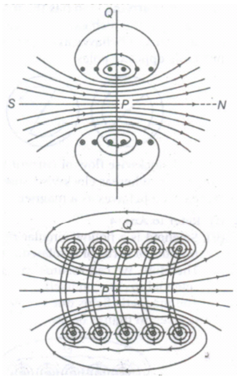
Field due to toroid

Magnetic field inside the solenoid is a uniform, strong and along its axis also field lines are all most parallel while inside the toroid field line makes closed path.

(ill) The magnetic field in the solenoid can be increased by inserting a soft iron core inside it.

75)

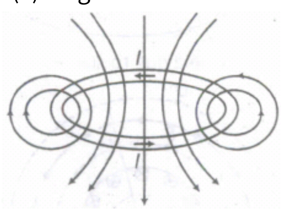
(iii) Magnetic field lines due to a finite solenoid has been shown as below:



All the magnetic field lines are necessarily dosed loops, whereas electric lines of force are not.

76)

(ii) Magnetic field lines due to a current carrying loop is given as below:



(iii) Magnetic field due to straight part

$B = \int \frac{\mu_0}{4\pi} \frac{Idl \times r}{r^3}$

For point 0, dl and r for each element of the straight segments AB and DE are parallel. Therefore, dI x r =0.Hence, magnetic field due to straight segments is-zero.

Magnetic field at the centre due to circular point

$= \frac{\text{Magnetic field at the centre of circular coil}}{2}$ [∵ Here, coil is stay]

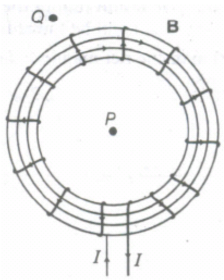
$= \frac{1}{2}(\frac{\mu_0 I}{2r}) = \frac{\mu_0 I}{4r}$

$\Rightarrow B = \frac{\mu_0 I}{4r} = \frac{(4\pi \times 10^{-7} \times 12}{4 \times 2 \times 10^{-2}} = 6\pi \times 10^{-5} T$

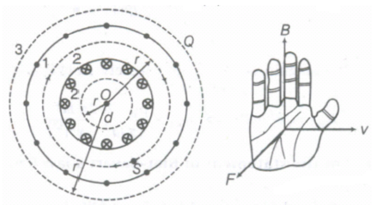
77)

(i) For the evaluation of magnetic field for a symmetrical system, we can consider the example of a current carrying solenoid.

(ii) A solenoid bent into the form of dosed loop is called toroid. The magnetic field B has a constant magnitude everywhere inside the toroid.



(a) Let magnetic field inside the toroid is B along the considered loop (1) as shown in figure.



Applying Ampere's circuital law,

$\oint_{loop_1} B.\,dI = \mu_0(NI)$

Since, toroid of N turns, threads the loop 1, N times, each carrying current I inside the loop. Therefore, total current threading the loop 1 is NI.

$\Rightarrow \oint_{loop1} B.\,dI = \mu_0 NI \Rightarrow B\oint_{loop} dI = \mu_0 NI$

$B \times 2\pi r = \mu_0 NI$

or B= $= \frac{\mu_0 NI}{2\pi r}$

(b) Magnetic field inside the open space interior the toroid. Let the loop (2) is shown in figure experience magnetic field B.

No current threads the loop 2 which lie in the open space inside the toroid.

:. Ampere's circuital law

$\oint_{loop2} B.\,dI = \mu_0(0) = 0 \Rightarrow B = 0$

Magnetic field in the open space exterior of toroid Let us consider a coplanar loop (3) in the open space of exterior of toroid.

Here, each turn of toroid threads the loop two times in opposite directions.

Therefore, net current threading the loop

=NI - NI = 0

∴ By Ampere's circuital law,

$\oint_{loop3} B.\,dI = \mu_0(NI - NI) = 0$

$\Rightarrow B = 0$

Thus, there is no magnetic field in the open space interior and exterior of toroid.

78)

(ii) (a) Let the mass of proton = m; charge of proton = q, mass of a-particle = 4m

Charge of α-particle = 2q

Cyclotron frequency,

$\nu = \frac{Bq}{2\pi m} \Rightarrow \nu \propto \frac{q}{m}$

For proton frequency, $v_p \propto \frac{q}{m}$

For α-particle,

Frequency, $v_a \propto \frac{2q}{4m}$

or $v_a \propto \frac{q}{2m}$

Thus, particles will not accelerate with same cyclotron frequency. The frequency of proton is twice than the frequency of α-particle.

(b) Velocity, $v = \frac{Bqr}{m} \Rightarrow v \propto \frac{q}{m}$

For proton velocity, $v_p \propto \frac{q}{m}$

For α-particle,

Velocity, $v_a \propto \frac{2q}{4m}$ or $v_a \propto \frac{q}{2m}$

Thus, particles will not exit the dees with same velocity. The velocity of proton is twice than the velocity of α-particles.

79) Force on the charged particle due to electric and magnetic fields, F=qE+q(v x B)

For undeflected motion,

F= 0

qE+q(vxB)=O

= > E + (v x B) = 0

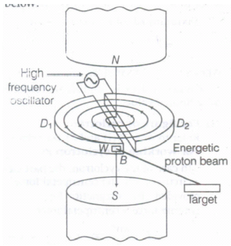
E= - (v x B) = > I E I = I - v x B I

E= vBsin θ

where, $\theta=90^0$

v = E/B

80)



Working Let initially positively charged is accelerated towards D_2 and enter into it.

Now, the charged particle experiences magnetic Lorentz force due to a strong normal magnetic field. It performs circular motion. The time taken by the charge particle to complete half revolution is equal to half of time period of AC oscillator between two dees.

The charge d particle again accelerated towards D_1 as D_2 acquires positive and d negative polarity. Thus, the charge particle is brought again and again in the small region of oscillating electrical field by strong normal magnetic field.

The charged particle repeatedly passes through oscillating electrical field. It traversed on spiral path and finally having radius of its circular path becomes equal to the radius of dees and finally comes out through window W and strikes to the target.

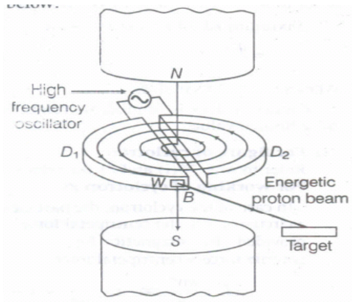
∵ Maximum KE of charged particle

$$= \frac{q^2B^2r_0^2}{2m}$$

where, r_0=radius of dees

∴ Radius of dees is limited, therefore, KE_{max} also have limited value.

81)



Working Let initially positively charged is accelerated towards D_2 and enter into it.

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The charge d particle again accelerated towards D_1 as D_2 acquires positive and d negative polarity. Thus, the charge particle is brought again and again in the small region of oscillating electrical field by strong normal magnetic field.

In case of the cyclotron, the particle moves on a circular path, the centripetal force required is provided by magnetic force, so magnetic

Lorentz force = centripetal force

qvB=$\frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB} \Rightarrow v = \frac{qBr}{m}$

$\therefore KE = \frac{1}{2}mv^2 = \frac{1}{2}m(\frac{qBr}{m})^2 = \frac{q^2B^2r^2}{2m}$

For maximum KE, $r = r_o$ (radius of dees).

(ii) Given, $I_1 = 2A$, $I_2 = 5A$, $r = 1$ cm $= 1 \times 10^{-2}$m

Force per unit length between two wires.

$\frac{F}{L} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r} = \frac{10^{-7}\times2\times2\times5}{1\times10^2} = 20 \times 10^{-5}$

$\frac{F}{L} = 2 \times 10^4 Nm^{-1}$

Currents flowing in wires are in opposite directions, so the force will be of repulsive nature.

82)

(ii) The frequencies of charge particle must be equal to the frequency of AC oscillator. This is known as resonance condition.

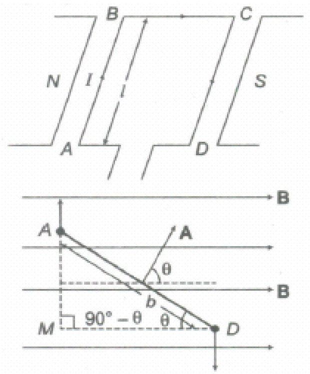
This makes time period of charged particle and oscillator equal. Therefore, the time taken by charge particle to complete half revolution is equal to the time of change the polarity of dees. This facilitate the acceleration of charge particle.

If two frequencies do not match, then instead of acceleration, charged particle may accelerate.

83)

Magnetic force on AB and CD parts of wire

$F_1 = F_2 = IBlas\theta = 90^o$



The magnetic force on BC and DA part of wire are equal in magnitude, opposite in direction along the same line.

Therefore, they balance each other.

Let at any instant area vector of coil made an angle θ with the direction of magnetic field.

∴ F_1 and F_2 form couple which try to rotate the. coil.

From figure,

∴ Torque, τ = force x arm of the couple

=(IBl) x MD

=IBl x bsinθ=IB (Ib) sinθ

τ =IB A sinθ

where, A = Ib = area of coil

∴ τ =LAB sinθ

But, m=IA

∴ τ =mB sinθ

In vector form,τ=m x B

84) (i) Torque on rectangular loop,

$\tau = NIABsin\theta$ --- (i)

where, symbols are as usual.

Also, torque experienced by magnetic dipole of moment m are placed in a uniform magnetic field.

$\tau = mBsin\theta$ --- (ii)

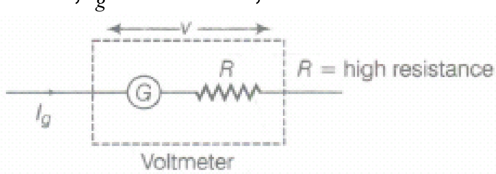
Comparing Eqs. (i) and (ii), we get

The magnetic dipole moment,

m= NlA

Also, m is along A. ⇒ m = NIA

(iii) G = 50 Ω, $I_g = 5 \times 10^{-3}$ A, V = 15 V



$\because \quad V = I_g (G + R)$

$\Rightarrow \quad \boxed{R = \frac{V}{I_g} - G}$

$\Rightarrow \frac{15}{5 \times 10^{-3}} - 50 \Rightarrow R = 2950\Omega$

A resistance R = 2950Ω is to be connected in series with galvanometer to convert it into a desired voltmeter.

85) (ii) As, $\frac{F}{L} = \frac{\mu_0}{4\pi}.\frac{2I_1I_2}{r}$

$I_1 = I_2 = IA, r = 1m$

$\frac{F}{L} = 2 \times 10^{-7} Nm^{-1}$

(iii) Here, magnetic field due to the current carrying conductor at a distance d from it is given by

$B = \frac{\mu_0}{4\pi}\frac{2I}{d}$

∴ Force on proton,

F = (e) (v) B sin 90°

⇒ F = evB

$F = ev(\frac{\mu_0}{4\pi}\frac{2I}{d})$

$F = \frac{\mu_0}{4\pi}.\frac{2Iev}{d}$

The proton is directed perpendicular to straight conductor and away from it.

86)

(ii) (a) Perpendicular to the plane of the paper and directed inward.

(b) When angle between area vector of coil and magnetic field is 90°, then maximum torque experienced by the coil. When θ = 0° or 180°, then torque will be minimum, i.e. zero.

87) (a) Values displayed by Kamal:

(i) Being educated, he knows about MRI

(magnetic resonance imaging).

(ii) Took prompt decisions to take the help of his family, friends and neighbours to arranged the cost of MRI.

(iii) He showed his empathy, helping attitude and caring nature for his uncle.

(b) Magnetic force on moving charge particle in uniform magnetic field B can be given as

F=q(v x B) or |F|=qvb sinθ

(i) Maximum force ate = 90°

F = qvB =$1.6 \times 10^{-19} \times 10^4 \times 0.1$

=$1.6 \times 10^{-16} N$

(ii) Minimum force at e = 0° and 180°

F=0

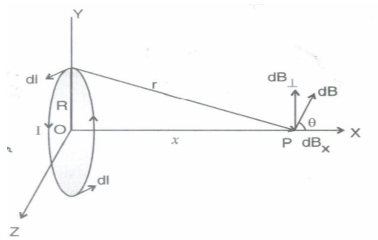
i.e. force is minimum when the charge particle either move parallel or anti-parallel to the magnetic field lines.

88) (i) He is of responsible behaviour, concern and awareness.

(ii) The SI unit of magnetic field is Tesla.

(iii) $B = \frac{\mu_0 I}{2r} = \frac{4\pi \times 10^{-7} \times 4}{2 \times 2 \times 10^{-2}} = \frac{50.24}{4} \times 10^{-5}$

89)



According to Biot- Savart law,

$$\vec{dB} = \frac{\mu_0}{4\pi}\frac{I(\vec{dl}\times\vec{r})}{r^3}$$

$$\vec{dB} = \frac{\mu_0}{(x^2+R^2)}\left[\because |\vec{d}\times\vec{r}| \qquad r=(x^2+R^2)^{1/2}\right]$$

From figure, $cos\ \theta = \frac{R}{(x^2+R^2)^{1/2}}$

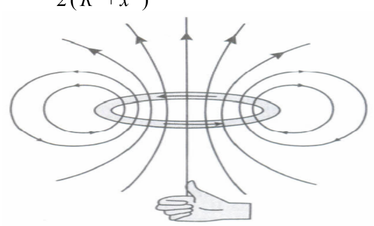
∴ Net contribution along x-direction

B = $\sum dB\ cos\ \theta$

= $\int dB\ cos\ \theta$

= $\int_0^{2\pi R}\frac{\mu_0 Idl}{4\pi}\frac{R}{(x^2+R^2)^{3/2}}$

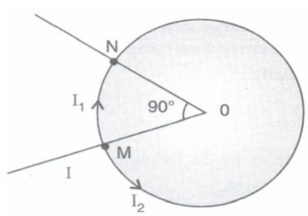
$$\vec{B} = \frac{\mu_0 IR^2}{2(R^2+x^2)^{3/2}}$$



Let current I be divided at point M into two parts I_1 and I_2 ; in bigger and smaller parts of the loop respectively.

Magnetic field of current I_1 at point O

$$\vec{B}_1 = \frac{\mu_0 I_1}{2R.}\times\frac{1}{4}$$



Magnetic field of current I_2 at point O

$$\vec{B}_2 = \frac{\mu_0 I_2}{2R}\times\frac{3}{4}.$$

Net magnetic field $\vec{B} = \vec{B}_1 + \vec{B}_2$

$$|\vec{B}| = \frac{\infty_0 I_1}{8R} = \frac{3\infty_0 I_2}{8R} \qquad ...(i)$$

But $I_1 = 3I_2$ (As resistance of bigger part is three times that of the smaller part of the loop.)

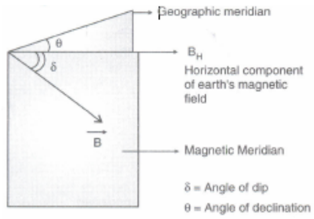
Substituting $I_1=3I_2$ in equation (i)

$\Rightarrow\ |\vec{B}| = 0$

90)

(i) A student can measure the angle of dip using dip circle at various lattitudes and map the earth's magnetic field lines.

(ii)



91) (i) Caring attitude, sensitive towards society, and concern for others.

(ii) It is a temporary magnet made by magnetising a soft iron core by passing electric current.

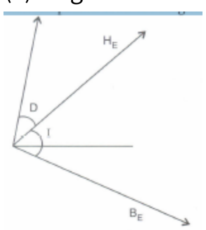
92) (i) Awareness, concern for conservation of energy and fossil fuels and sharing the knowledge.

(ii) Copper, silver, gold and bismuth susceptibility is independent of temperature as they have no permanent dipoles.

93)

(i) Honesty, helpfulness, responsible behaviour towards students and concern for the students to create interest in the subject.

(ii) Magnetic declination, magnetic inclination and horizontal component of earth's magnetic field.



94)

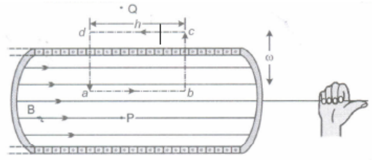
(i) Awareness about new technology, concern for energy conservation, decrease of noise pollution and air polslution, i.e. concern for environment.

(ii) When a superconductor is cooled in a magnetic field below its critical temperature, the magnetic field lines are expelled showing diamagnetic property. This is called Meissner effect.

95)

A current carrying surface with small line elements of length dl where tangential components of magnetic field and sum of elements B.dl in an integral form be expressed as:

$\oint \vec{B}.\vec{dl} = \mu_0 i,$ This form is known as Ampers's circuital law.



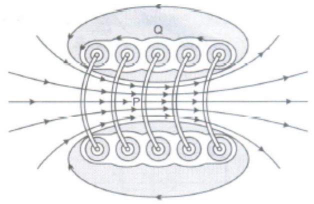
Let' n' be the number of turns per unit length. Then total number of turns in the length 'h' is nh. Hence, total enclosed current = nhI

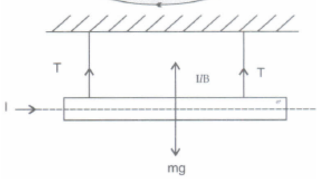
Using Ampere's circuital law

$\oint \vec{B}.\vec{dl} = \mu_0 nhI$

Bh = $\mu_0 nhI$

B = $\mu_0 nI$





As per the given figure, magnetic field must be vertically inwards, to make tension zero, (If a student shows current in opposite direction the magnetic field should be set up vertically upwards.

I/B=mg

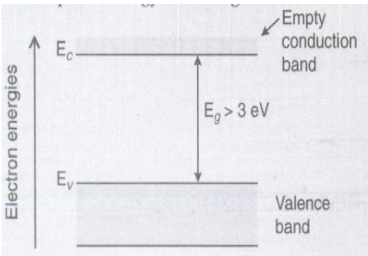
For tension to be zero

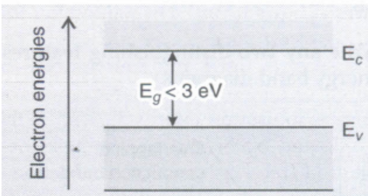
$B = \frac{mg}{Il} = \frac{60 \times 10^{-3} \times 9.8}{5.0 \times 0.45} T$

= 0.26 T

96)

The required energy band diagram are as shown:





(a) When the semiconductor is doped with an acceptor impurity there is an additional energy level a little above the top of the valence band.

(b) The donor impurity results in an additional energy level a little below the bottom of the conduction band.

(Also accept diagrammatic representations) In the first case, electrons, from the valence band, easily jump over to the acceptor level, leaving 'holes' behind. Hence, 'holes' become the majority charge carriers.

In the second case, electrons from the donor level, easily 'jump over' to the conduction band. Hence, electrons become the majority charge carriers.

The two processes, involved in the formation of the p-n junction are.

(i) Diffusion

(ii) Drift

97) Length of the solenoid, l = 80 cm = 0.8 m

There are five layers of windings of 400 turns each on the solenoid.

∴ Total number of turns on the solenoid, N = 5 x 400 = 2000

Diameter of the solenoid, D = 1.8 cm = 0.018 m

Current carried by the solenoid, I = 8.0 A

Magnitude of the magnetic field inside the solenoid near its centre is given by the relation,

$$B = \frac{\mu_0 NI}{l}$$

Where,

μ_0 = Permeability of free space = $4\pi \times 10^{-7}$ T m A^{-1}

$$B = \frac{4\pi \times 10^{-7} \times 2000 \times 8}{0.8}$$

$$= 8\pi \times 10^{-3} = 2.512 \times 10^{-2} T$$

Hence, the magnitude of the magnetic field inside the solenoid near its centre is 2.512×10^{-2} T.

98) For moving coil meter M_1:

Resistance, $R_1 = 10\ \Omega$

Number of turns, $N_1 = 30$

Area of cross-section, $A_1 = 3.6 \times 10^{-3}\ m^2$

Magnetic field strength, $B_1 = 0.25$ T

Spring constant $K_1 = K$

For moving coil meter M_2:

Resistance, $R_2 = 14\ \Omega$

Number of turns, $N_2 = 42$

Area of cross-section, $A_2 = 1.8 \times 10^{-3}\ m^2$

Magnetic field strength, $B_2 = 0.50$ T

Spring constant, $K_2 = K$

(a) Current sensitivity of M_1 is given as:

$$I_{s1} = \frac{N_1 B_1 A_1}{K_1}$$

∴ Ratio $\frac{I_{s2}}{I_{s1}} = \frac{N_2 B_2 A_2}{N_1 B_1 A_1} \frac{K_1}{K_2}$

$$= \frac{42 \times 0.5 \times 1.8 \times 10^{-3} \times K}{K \times 30 \times 0.25 \times 3.6 \times 10^{-3}} = 1.4$$

Hence, the ratio of current sensitivity of M_2 to M_1 is 1.4.

(b) Voltage sensitivity for M_2 is given as:

$$V_{s2} = \frac{N_2 B_2 A_2}{K_2 R_2}$$

∴ Ratio $\frac{v_{s2}}{v_{s1}} = \frac{N_2 B_2 A_2}{N_1 B_1 A_1} \frac{K_1 R_1}{K_2 R_2}$

$$= \frac{42 \times 0.5 \times 1.8 \times 10^{-3} \times 10 \times k}{K \times 14 \times 30 \times 0.25 \times 3.6 \times 10^{-3}} = 1$$

Hence, the ratio of voltage sensitivity of M_2 to M_1 is 1.

99) Magnetic field strength, B = 6.5 x 10^{-4} T

Charge of the electron, e = 1.6 x 10^{-19} C

Mass of the electron, m_e = 9.1 x 10^{-31} kg

Velocity of the electron, v = 4.8 x 10^6 m/s

Radius of the orbit, r = 4.2 cm = 0.042 m

Frequency of revolution of the electron = ν

Angular frequency of the electron = ω = 2πν

Velocity of the electron is related to the angular frequency as:

v = rω

In the circular orbit, the magnetic force on the electron is balanced by the centripetal force. Hence, we can write:

$$evB = \frac{mv^2}{r}$$

$$eB = \frac{m}{r}(r\omega) = \frac{m}{r}(2\pi r\nu)$$

$$\nu = \frac{Be}{2\pi m}$$

This expression for frequency is independent of the speed of the electron.

On substituting the known values in this expression, we get the frequency as:

$$V = \frac{6.5\times10^{-4}\times1.6\times10^{-19}}{2\times3.14\times9.1\times10^{-31}}$$

= 18.2 x 10^6 Hz

≈ 18 MHz

Hence, the frequency of the electron is around 18 MHz and is independent of the speed of the electron.

100) Radius of circular coil = R

Number of turns on the coil = N

Current in the coil = I

Magnetic field at a point on its axis at distance x is given by the relation,

$$B = \frac{\mu_0 I R^2 N}{2\left(x^2+R^2\right)^{\frac{3}{2}}}$$

Where,

μ_0 = Permeability of free space

(a) If the magnetic field at the centre of the coil is considered, then x = 0.

$$\therefore B = \frac{\mu_0 I R^2 N}{2R^3} = \frac{\mu_0 I N}{2R}$$

This is the familiar result for magnetic field at the centre of the coil.

(b) Radii of two parallel co-axial circular coils = R

Number of turns on each coil = N

Current in both coils = I

Distance between both the coils = R

Let us consider point Q at distance d from the centre.

Then, one coil is at a distance of $\frac{R}{2} + d$ from point Q.

Magnetic field due to this coil is given as:

$$B_2 = \frac{\mu_0 N I R^2}{2\left[\left(\frac{R}{2}-d\right)^2+R^2\right]^{\frac{3}{2}}}$$

Total magnetic field,

$B = B_1 + B_2$

$$= \frac{\mu_0 I R^2}{2}\left[\left\{\left(\frac{R}{2}-d\right)^2+R^2\right\}^{-\frac{3}{2}} + \left\{\left(\frac{R}{2}+d\right)^2+R^2\right\}^{-\frac{3}{2}}\right]$$

$$= \frac{\mu_0 I R^2}{2}\left[\left(\frac{5R^2}{4}+d^2-Rd\right)^{-\frac{3}{2}} + \left(\frac{5R^2}{4}+d^2+Rd\right)^{-\frac{3}{2}}\right]$$

$$= \frac{\mu_0 I R^2}{2} \times \left(\frac{5R^2}{4}\right)^{-\frac{3}{2}}\left[\left(1+\frac{4}{5}\frac{d^2}{R^2}-\frac{4}{5}\frac{d}{R}\right)^{-\frac{3}{2}} + \left(1+\frac{4}{5}\frac{d^2}{R^2}+\frac{4}{5}\frac{d}{R}\right)^{-\frac{3}{2}}\right]$$

For d < < R , neglecting the factor $\frac{d^2}{R^2}$, we get :

$$\approx \frac{\mu_0 I R^2}{2} \times \left(\frac{5R^2}{4}\right)^{-\frac{3}{2}} \times \left[\left(1-\frac{4d}{5R}\right)^{-\frac{3}{2}} + \left(1+\frac{4d}{5R}\right)^{-\frac{3}{2}}\right]$$

Hence, it is proved that the field on the axis around the mid-point between the coils is uniform.

101) Length of the solenoid, L = 60 cm = 0.6 m

Radius of the solenoid,r = 4.0 cm = 0.04 m

It is given that there are 3 layers of windings of 300 turns each.

Total number of turns, n = 3 x 300 = 900

Length of the wire, l = 2 cm = 0.02 m

Mass of the wire, m = 2.5 g = 2.5 x 10^{-3} kg

Current flowing through the wire, i = 6 A

Acceleration due to gravity, g = 9.8 m/s^2

Magnetic field produced inside the solenoid $B = \frac{\mu_0 nI}{L}$

Where,

μ_0 = Permeability of free space = 4π x 10^{-7}TmA^{-1}

I = Current flowing through the windings of the solenoid

Magnetic force is given by the relation,

F = Bil

$= \frac{\mu_0 nI}{L} il$

Also, the force on the wire is equal to the weight of the wire.

$\therefore m\text{ g} = \frac{\mu_0 nIil}{L}$

$I = \frac{mgL}{\mu_0 \text{ nil}}$

$= \frac{2.5 \times 10^{-3} \times 9.8 \times 0.6}{4\pi \times 10^{-7} \times 900 \times 0.02 \times 6} = 108 \text{ A}$

Hence, the current flowing through the solenoid is 108 A.

102)

(a) Let the mass of proton = m

Charge of proton = q

Mass of α-particle = 4m

Charge of α-particle = 2q

Cyclotron frequency, $v = \frac{Bq}{2\pi m} \Rightarrow v \propto \frac{q}{m}$

For proton frequency, $v_p \propto \frac{q}{m}$

For α-particle frequency , $v_\alpha \propto \frac{2q}{4m}$ or $v_\alpha \propto \frac{q}{2m}$

Thus, particles will not accelerate with same cyclotron frequency. The frequency of proton is twice than the frequency of α-particle.

(b) Velocity, $v = \frac{Bqr}{m} \Rightarrow v \propto \frac{q}{m}$

For proton velocity, $v_p \propto \frac{q}{m}$

For α-particle velocity ,$v_\alpha \propto \frac{2q}{4m}$

$\Rightarrow v_\alpha \propto \frac{q}{2m}$

Thus, particles will not exit the dees with same velocity. The velocity of proton is twice than the velocity of α-particle.

103) For undeflected beam, $v = \frac{E}{B}$

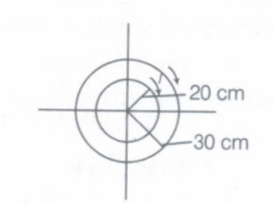
i) 2 x 10^6 m/s

(ii) F = q(E + v x B) = 1.675 x10^{-5} N

104) $M_1 = N_1 I_1 A_1 \otimes$

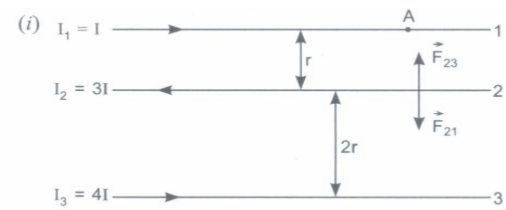
$M_2 = N_2 I_2 A_2 \otimes$

M = $M_1 + M_2$ = 2.86 A - m^2



M = | M1 -M2 | = 1.10 A-m^2

105)



At A

Magnetic field due to conductor perpendlcularly inwards $2 = B_1 = \frac{\mu_0(3I)}{2\pi r}$

Magnetic field due to conductor 3 perpendicular outwards $3 = B_2 = \frac{\mu_0(4I)}{2\pi(3r)}$

Net magnetic field at A

$$B = B_1 - B_2 = \frac{\mu_0 I}{2\pi r}\left[3 - \frac{4}{3}\right]$$

$B = \frac{5\mu_0 I}{6\pi r},$ perpendicularly inwards

(ii) Magnetic force per unit length on conductor 2 due to conductor $1 = F_{21} = \frac{\mu_0}{4\pi} \cdot \frac{2I_1I_2}{r}$

Magnetic force per unit length on conductor 2 and due to current flowing in conductor 3

$$F_{23} = \frac{\mu_0}{4\pi} \cdot \frac{2I_2I_3}{2r}$$

Since forces F_{23} and F_{21} are in opposite directions (as shown)

∴ Net force experienced by conductor 2

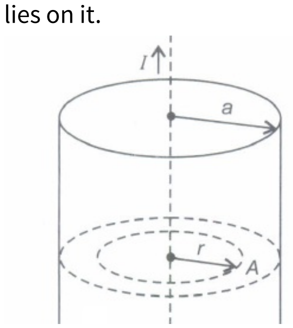
$$F_2 = F_{23} - F_{21} = \frac{\mu_0}{2\pi r}\left[3I^2 - \frac{12I^2}{2}\right]$$

$F_2 = \frac{3\mu_0 I^2}{2\pi r}$,towards conductor 1.

106)

(a) (i) Magnetic field at a point inside the current carrying wire, i.e. r < a

To calculate magnetic field at a point A inside the wire, we consider a circular loop of radius r in such a way that point A lies on it.



Current enclosed by this loop is

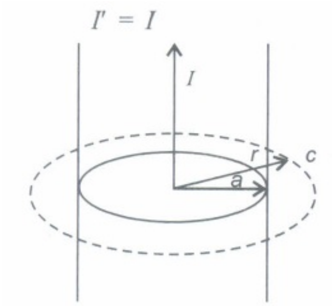
$$I' = I\left(\frac{\pi r^2}{\pi a^2}\right) = I\frac{r^2}{a^2}$$

Using Ampere's circuital law,

$$B(2\pi r) = \mu_0\left(\frac{Ir^2}{a^2}\right) \Rightarrow B = \frac{\mu_0 Ir}{2\pi a^2}$$

(ii) Magnetic field at a point outside the wire, i.e. r > a

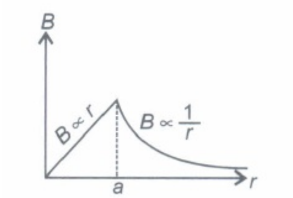
Current enclosed by the loop of radius r is



Using Ampere's circuital law,

$$B(2\pi r) = \mu_0 I$$

$$\Rightarrow B = \frac{\mu_0 I}{2\pi r}$$



(b) Magnetic field at point a/2 above the surface,

$$B_1 = \frac{\mu_0 I}{2\pi r}$$

$$B_1 = \frac{\mu_0 I}{2\pi\left(a+\frac{a}{2}\right)} = \frac{\mu_0 I}{3\pi a}$$

Magnetic field at point a/2 below the surface is calculated as

$$B_2 = \frac{\mu_0 Ir}{2\pi a^2} = \frac{\mu_0 I}{2\pi a^2}\left(\frac{a}{2}\right) = \frac{\mu_0 I}{4\pi a}$$

$$\therefore \frac{B_1}{B_2} = \frac{4}{3}$$

Magnetic field is maximum on the surface of wire,

$$B_{\max} = \frac{\mu_0 I}{2\pi a}$$

107) Similarities:

(i) Both are long range forces and obey inverse square law.

(ii) Both obey the principle of superposition.

Differences:

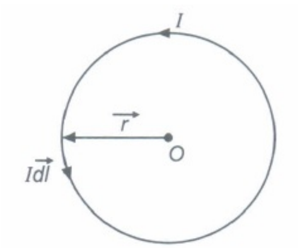
(i) The source of the magnetic field is a vector, i.e. I $\overrightarrow{dl}$

The source of the electric field is scalar, i.e. electric charge.

(ii) The electric field is along the displacement vector joining the source and field point.

The magnetic field is perpendicular to the plane containing the current element $\overrightarrow{(Idl)}$

We consider a circular loop of radius r carrying current 1.



According to the Biot-Savart's law,

$\overrightarrow{dB} = \frac{\mu_0}{4\pi}\frac{\overrightarrow{Idl} \times \vec{r}}{r^3}$

$\therefore dB = \frac{\mu_0}{4\pi}\frac{Idl}{r^2}\sin\theta$

In this case $dB = \frac{\mu_0 Idl}{4\pi r^2}\left(\because \theta = 90^\circ\right)$

Magnetic field due to the whole loop,

$B = \frac{\mu_0 I}{4\pi r^2}\int_{l=0}^{l=2\pi r} dl$

$B = \frac{\mu_0 I}{4\pi r^2} \times 2\pi r = \frac{\mu_0 I}{2r}$

According to the right-hand thumb rule, the direction of magnetic field is outwards.