Applied Academy

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PHYSICS MAGNETISM

Class 12 - Physics

Section A

1. A galvanometer of resistance 20 Ω shows a deflection of 10 divisions when a current of 1 mA is passed through it. If a shunt of 4Ω is connected and there are 50 divisions on the scale, the range of the galvanometer is: **[1]**

   a) 40 mA
   b) 30 mA
   c) 25 mA
   d) 35 mA

2. Two parallel wires of length 9 m each are separated by a distance of 0.15 m. If they carry equal currents in the same direction and exert a total force of 30 $\times$ 10^{-7} N on each other, then the value of current must be: **[1]**

   a) 0.5 amp
   b) 1.5 amp
   c) 3.5 amp
   d) 2.5 amp

3. A charged particle is moving in a uniform magnetic field in a circular path with a radius R. When energy of the particle is doubled, then the new radius will be: **[1]**

   a) $R\sqrt{2}$
   b) $\frac{R}{\sqrt{2}}$
   c) $\frac{R}{2}$
   d) 2R

4. A metallic rod of mass per unit length 0.5 kg m^{-1} is lying horizontally on a smooth inclined plane which makes an angle of 30° with the horizontal. The rod is not allowed to slide down by flowing a current through it when a magnetic field of induction 0.25 T is acting on it in the vertical direction. The current flowing in the rod to keep it stationary is **[1]**

   a) 5.98 A
   b) 11.32 A
   c) 7.14 A
   d) 14.76 A

5. The magnetic field $d\vec{B}$ due to a small current element $d\vec{l}$ at a distance $\bar{r}$ and element carrying current I is: **[1]**

   a) $d\vec{B} = \frac{\mu_0}{4\pi} \times \frac{Id\vec{l} \times \vec{r}}{r^2}$
   b) $d\vec{B} = \frac{\mu_0}{4\pi} \times \frac{Id\vec{l} \times \vec{r}}{r^4}$
   c) $d\vec{B} = \frac{\mu_0}{4\pi} \times \frac{Id\vec{l} \times \vec{r}}{r}$
   d) $d\vec{B} = \frac{\mu_0}{4\pi} \times \frac{Id\vec{l} \times \vec{r}}{r^3}$

6. The ratio of the time period of alpha particle to that of a proton circulating with the same speed in the same uniform magnetic field is: **[1]**

   a) 1 : 2
   b) 1 : $\sqrt{2}$
   c) 2 : 1
   d) $\sqrt{2}$: 1

7. A voltmeter has a resistance of G ohm and a range of V volt. The value of resistance used in series to convert it into a voltmeter of range nV volt is **[1]**

   a) (n-1)G
   b) nG

c) $\frac{G}{n-1}$

d) $\frac{G}{n}$

8. A circular loop of area 0.01 m^2 carrying a current of 10 A, is held perpendicular to a magnetic field of intensity 0.1 T. The torque acting on the loop is **[1]**

a) 0.01 Nm

b) 0.8 Nm

c) zero

d) 0.001 Nm

9. A current loop in a magnetic field: **[1]**

a) can be in equilibrium in two orientations, both the equilibrium states are unstable

b) can be in equilibrium in two orientations, one stable while the other is unstable

c) experiences a torque whether the field is uniform or non-uniform in all orientations

d) can be in equilibrium in one orientation

10. A rectangular coil (dimension 5 cm $\times$ 2.5 cm) with 100 turns, carrying a current of 3A in the clockwise direction, is kept centred at the origin and in the X-Z plane. A magnetic field of 1 T is applied along X-axis. If the coil is tilted through 45^o about Z-axis, then the torque on the coil is **[1]**

a) 0.42 N-m

b) 0.27 N-m

c) 0.38 N-m

d) 0.55 N-m

11. A magnet is cut in three equal parts by cutting it perpendicular to its length. The time period of original magnet is T0 in a uniform magnetic field B. Then, the time period of each part in the same magnetic field is **[1]**

a) None of these

b) $\frac{T_o}{4}$

c) $\frac{T_o}{3}$

d) $\frac{T_o}{2}$

12. The magnetic moment of a revolving electron around the nucleus varies with principal quantum number n as **[1]**

a) $\mu \propto n$

b) $\mu \propto \frac{1}{n^2}$

c) $\mu \propto n^2$

d) $\mu \propto \frac{1}{n}$

13. A Rowland ring of mean radius 15 cm has 3500 turns of wire wound on a ferromagnetic core of relative permeability 800. What is the magnetic field B in the core for a magnetising current of 1.2A? **[1]**

a) 3.48 T

b) 5.48 T

c) 4.08 T

d) 4.48 T

14. The μ_0 is also known as : **[1]**

a) magnetic dipole

b) Absolute Permittivity

c) Magnetic dipole moment

d) Magnetic flux

15. Tesla is the unit of **[1]**

a) magnetic induction

b) electric field

c) electric flux

d) magnetic flux

16. **Assertion (A):** Voltmeter put across a part of the circuit, it read slightly more than the original voltage. **[1]**
Reason (R): Voltmeter is always connected in parallel in circuit across which voltage is to be measured.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false. d) A is false but R is true.

17. **Assertion (A):** To convert a galvanometer into an ammeter a small resistance is connected in parallel with it. **[1]**
Reason (R): The small resistance increases the combined resistance of the combination.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false but R is true.

18. **Assertion (A):** Free electrons always keep on moving in a conductor even then no magnetic force act on them in magnetic field unless a current is passed through it. **[1]**
Reason (R): The average velocity of free electron is zero.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false but R is true.

19. **Assertion (A):** The magnetic poles of earth do not coincide with the geographic poles. **[1]**
Reason (R): The discrepancy between the orientation of a compass and true north-south direction is known as magnetic declination.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false but R is true.

20. **Assertion (A):** The product of magnetic susceptibility and absolute temperature for a paramagnetic substance is a constant. **[1]**
Reason (R): The magnetic susceptibility of a paramagnetic material does not depend on temperature.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false but R is true.

21. Why should an ammeter have a high current carrying capacity? **[1]**

22. Two particles A and B of masses m and 2m have charges q and 2q respectively. They are moving with velocities v_1 and v_2 respectively in the same direction, enters the same magnetic field B acting normally to their direction of motion. If the two forces F_A and F_B acting on them are in the ratio of 1 : 2, find the ratio of their velocities. **[1]**

23. What is a magnetic dipole? Give an example. **[1]**

24. An electron is moving along +ve x-axis in the presence of uniform magnetic field along +ve y-axis. What is the direction of force acting on it? **[1]**

25. The force existing between two parallel current-carrying conductors is F. If the current in each conductor is doubled, what is the value of the force between them? **[1]**

26. An electron moving with a velocity of 10^7 m/s enters a uniform magnetic field of 1 T along a direction parallel to the field. What would be its trajectory? **[1]**

27. A charged particle moves in a uniform magnetic field at right angles to the direction of the field. Which of the following quantities will change: speed, velocity, momentum, kinetic energy, displacement? **[1]**

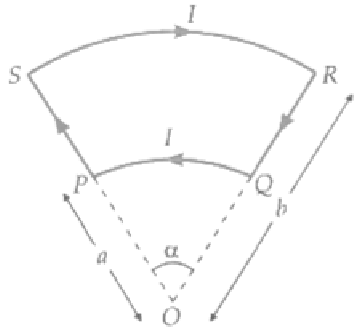
28. A galvanometer coil has a resistance of 15Ω and the metre shows full scale deflection for a current of 4 mA. How will you convert the metre into an ammeter of range 0 to 6 A? **[1]**

29. Why is the core of an electromagnet made of ferromagnetic materials? **[1]**

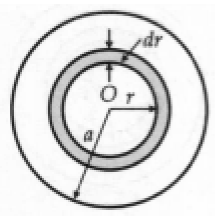
30. The magnetic field and angle of dip at a place on the earth are 0.3 G and 30^o, respectively. What will be the value of the vertical component of the earth's magnetic field at the place? **[1]**

Section B

31. Figure shows a current loop having two circular segments and joined by two radial lines. Find the magnetic field at the centre O. **[2]**



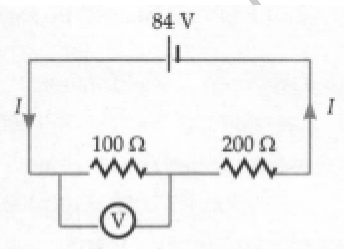
32. If the current density in a linear conductor of radius a varies with r according to the relation : $J = kr^1$, where k is a constant and r is the distance of a point from the axis of the conductor. Find the magnetic field at a point distance from the axis when (i) $r < a$. (ii) $r > a$ **[2]**



33. A rectangular coil having each turn of length 5 cm and breadth 2 cm is suspended freely in a radial magnetic field of induction 2.5×10^{-2} Wb m^{-2}, torsional constant of the suspension fibre is 1.5×10^{-8} Nm rad^{-1}. The coil deflects through an angle of 0.2 radian when a current of 2 μ A is passed through it. Find the number of turns of the coil. **[2]**

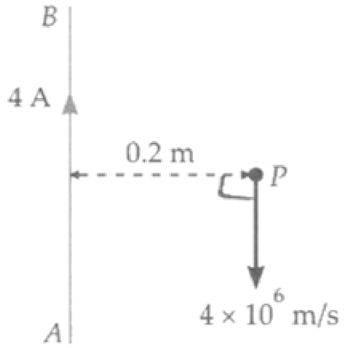
34. Voltmeter V of resistance 400 Ω is used to measure the potential difference across a 100 Ω resistor in the circuit shown in Fig. **[2]**

  i. What will be the reading on the voltmeter?
  ii. Calculate the potential difference across 100Ω resistor before the voltmeter is connected.



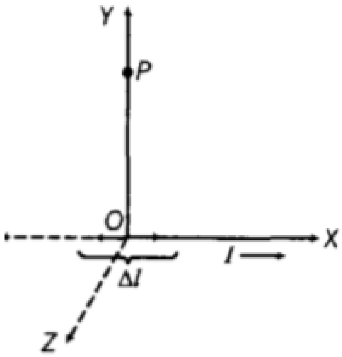
35. A long straight wire AB carries a current of 4 A. A proton P travels at 4×10^6 m/s, parallel to the wire, 0.2 m from it and in a direction opposite to the current as shown in given figure. Calculate the force which the **[2]**

magnetic field of current exerts on the proton. Also, specify the direction of the force.



36. A length of wire carries a steady current. It is bent first to form a circular plane coil of one turn. The same length is now bent more sharply to give a double loop of smaller radius. When the same current is passed, find the ratio of the magnetic field at the centre with its first value. **[2]**

37. An element M = $\triangle l = \triangle x\ \hat{i}$ is placed at the origin (as shown in figure) and carries a current I = 2 A. Find out the magnetic field at a point P on the Y-axis at a distance of 1.0 m due to the element $\Delta x = 1\ cm$. Also, give the direction of the field produced. **[2]**



38. Two parallel conducting wires carrying currents in the same direction attract each other. Why? **[2]**

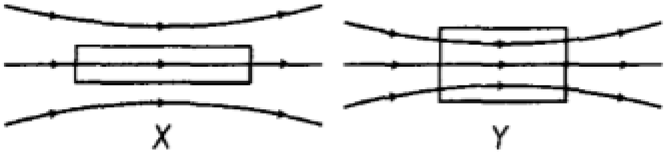
39. Two straight long conductors AOB and COD are perpendicular to each other and carry currents I_1 and I_2 respectively. Find the magnitude of the magnetic field at a point P at a distance a from the point O in a direction perpendicular to the plane ABCD. **[2]**

40. A rectangular loop of sides 25 cm and 10 cm carrying a current of 15 A is placed with its longer side parallel to a long straight conductor 2.0 cm apart carrying a current of 25A. What is the net force on the loop? **[2]**

41. A dip circle shows an apparent dip of 60° at a place where the true dip is 45°. If the dip circle is rotated through 90°, what apparent dip will it show? **[2]**

42. An iron rod of 0.2 cm^2 cross-sectional area is subjected to a magnetising field of 1200 Am^{-1}. The susceptibility of iron is 599. Find the permeability and the magnetic flux produced. **[2]**

43. When two materials are placed in an external magnetic field, the behaviour of magnetic field lines is as shown in the figure. Identify the magnetic nature of each of these two materials. **[2]**



Section C

44. In a chamber, a uniform magnetic field of 8.0 G (1 G = 10^{-4} T) is maintained. An electron with a speed of 4.0 × 10^6 ms^{-1} enters the chamber in a direction normal to the field. **[3]**

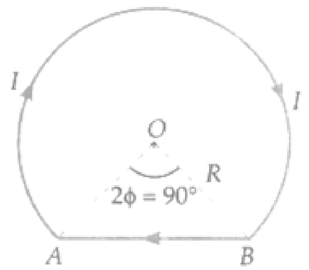
i. Describe the path of the electron.

ii. What is the frequency of revolution of the electron?
iii. What happens to the path of the electron if it progressively loses its energy due to collisions with the atoms or molecules of the environment?

45. An iron core is inserted into a solenoid 0.5 m long with 400 turns per unit length. The area of cross section of the solenoid is 0.01 m^2. **[3]**

a. Find the permeability of the core when a current of 5 A flows through the solenoid winding. Under these conditions, the magnetic flux through the cross section of the solenoid is $1.6 \times 10^{-3} Wb$.
b. Find the inductance of the solenoid under these conditions.

46. A current I = 5.0 A flows along a thin wire shaped as shown in the given figure. The radius of the curved part of the wire is equal to R = 120 mm, the angle 2ϕ = 90^o. Find the magnetic induction of the field at point O. **[3]**



47. 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 $\times$ 10^6 ms^{-1} normal to the field. Explain why the path of the electron is a circle. Determine the radius of the circular orbit. (e = 1.5 $\times$ 10^{-19} C, m_e = 9.1 $\times$ 10^{-31} kg) **[3]**

48. The scale of a galvanometer is divided into 150 equal divisions. The galvanometer has the current sensitivity of 10 divisions per mA and the voltage sensitivity of 2 divisions per mV. How the galvanometer can be designed to read (i) 6 A $division^{-1}$ and (ii) 1 V per $division^{-1}$? **[3]**

49. **[3]**
i. State the condition under which a charged particle moving with velocity v goes undeflected in a magnetic field B.
ii. An electron, after being accelerated through a potential difference of 10^4 V enters a uniform magnetic field of 0-04 T, perpendicular to its direction of motion. Calculate the radius of curvature of its trajectory.

50. A magnetic field of $\left(4.0 \times 10^{-3} \hat{k}\right) T$ exerts a force of $(4.0\hat{i} + 3.0\hat{j}) \times 10^{-10}$ N on a particle having a charge of 1.0×10^{-9}C and going in the X-Y plane. Find the velocity of the particle. **[3]**

51. A wire of radius 0.5 cm carries a current of 100 A which is uniformly distributed over its cross-section. Find the magnetic field: **[3]**
i. at 0.1 cm from the axis of the wire,
ii. at the surface of the wire and
iii. at a point outside the wire 0.2 cm from the surface of the wire.

52. 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. **[3]**

53. Define current sensitivity and voltage sensitivity of a galvanometer. Increasing the current sensitivity may not necessarily increase the voltage sensitivity of galvanometer. Justify. **[3]**

54. Define neutral point. Locate the positions of neutral points, when a small bar magnet is placed with its north pole **[3]**
i. towards the north of the earth and

ii. towards the south of the earth.

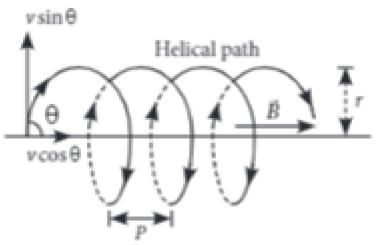
55. A small compass needle of magnetic moment M and moment of inertia I is free to oscillate in a magnetic field B. It is slightly disturbed from its equilibrium position and then released. Show that it executes simple harmonic motion. Write the expression for its time period. **[3]**

56. What are magnetic lines of force? Give their important properties. **[3]**

Section D

Question No. 57 to 61 are based on the given text. Read the text carefully and answer the questions: **[5]**

The path of a charged particle in magnetic field depends upon angle between velocity and magnetic field. If velocity $\vec{v}$ is at angle θ to $\vec{B}$, component of velocity parallel to magnetic field (v cos θ) remains constant and component of velocity perpendicular to magnetic field (v sin θ) is responsible for circular motion, thus the charge particle moves in a helical path.



The plane of the circle is perpendicular to the magnetic field and the axis of the helix is parallel to the magnetic field. The charged particle moves along helical path touching the line parallel to the magnetic field passing through the starting point after each rotation.

Radius of circular path is r = $\frac{mv\sin\theta}{qB}$

Hence the resultant path of the charged particle will be a helix, with its axis along the direction of $\vec{B}$ as shown in figure.

57. When a positively charged particle enters into a uniform magnetic field with uniform velocity, its trajectory can be

i. a straight line
ii. a circle
iii. a helix

a) (i) only
b) any one of (i), (ii) and (iii)
c) (i) or (ii)
d) (i) or (iii)

58. Two charged particles A and B having the same charge, mass and speed enter into a magnetic field in such a way that the initial path of A makes an angle of 30^o and that of B makes an angle of 90^o with the field. Then the trajectory of

a) will have smaller radius of curvature than that of A
b) A will have smaller radius of curvature than that of B
c) both will move along the direction of their original velocities
d) both will have the same curvature

59. An electron having momentum 2.4×10^{-23} kg m/s enters a region of uniform magnetic field of 0.15 T. The field vector makes an angle of 30^o with the initial velocity vector of the electron. The radius of the helical path of the electron in the field shall be

a) 0.5 mm
b) 2 mm
c) $\frac{\sqrt{3}}{2}$ mm
d) 1 mm

60. The magnetic field in a certain region of space is giver by B = 8.35 $\times$ 10^{-2} $\hat{i}$ T. A proton is shot into the field with velocity $\vec{v} = \left(2 \times 10^5 \hat{i} + 4 \times 10^5 \hat{j}\right)$ m/s. The proton follows a helical path in the field. The distance moved by proton in the x-direction during the period of one revolution in the yz-plane will be (Mass of proton = 1.67 $\times$ 10^{-27} kg)

a) 0.053 m
b) 0.157 m
c) 0.236 m
d) 0.136 m

61. The frequency of revolution of the particle is

a) $\frac{m}{qB}$
b) $\frac{2\pi R}{v\cos\theta}$
c) $\frac{2\pi R}{v\sin\theta}$
d) $\frac{qB}{2\pi m}$

Question No. 62 to 66 are based on the given text. Read the text carefully and answer the questions: **[5]**

A magnetic field can be produced by moving charges or electric currents. The basic equation governing the magnetic field due to a current distribution is the Biot-Savart law. Finding the magnetic field resulting from a current distribution involves the vector product, and is inherently a calculus problem when the distance from the current to the field point is continuously changing. According to this law, the magnetic field at a point due to a current element of length $d\vec{l}$ carrying current I, at a distance r from the element is dB = $\frac{\mu_0}{4\pi}\frac{I(d\vec{l}\times\vec{r})}{r^3}$.

Biot-Savart law has certain similarities as well as difference with Coloumb's law for electrostatic field e.g., there is an angle dependence in Biot-Savart law which is not present in electrostatic case.

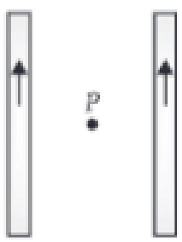
62. The direction of magnetic field $d\vec{B}$ due to a current element Idl current I passes through a long conductor is in the direction

a) of current element $\overrightarrow{dl}$
b) perpendicular to both $d\vec{l}$ and $\vec{r}$
c) of position vector $\vec{r}$ of the point
d) perpendicular to $d\vec{l}$ only

63. The magnetic field due to a current in a straight wire segment of length L at a point on its perpendicular bisector at a distance r(r >> L)

a) decreases as $\frac{1}{r^2}$
b) approaches a finite limit as $r \to \infty$
c) decreases as $\frac{1}{r}$
d) decreases as $\frac{1}{r^3}$

64. Two long straight wires are set parallel to each other. Each carries a current i in the same direction and the separation between them is 2r. The intensity of the magnetic field midway between them is



a) $\frac{\mu_0 i}{4r}$
b) $\frac{4\mu_0 i}{r}$
c) $\frac{\mu_0 i}{r}$
d) zero

65. A long straight wire carries a current along the z-axis for any two points in the x-y plane. Which of the following is always false?

a) The directions of the magnetic fields are the same
b) The field at one point is opposite to that at the other point

c) The magnitudes of the magnetic fields are equal

d) The magnetic fields are equal

66. Biot-Savart law can be expressed alternatively as

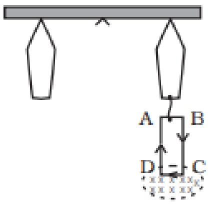
a) Ohm's Law

b) Ampere's circuital law

c) Gauss's Law

d) Coulomb's Law

67. A 100 turn rectangular coil ABCD (in XY plane) is hung from one arm of a balance (Fig.). A mass 500g is added to the other arm to balance the weight of the coil. A current 4.9 A passes through the coil and a constant magnetic field of 0.2 T acting inward (in xz plane) is switched on such that only arm CD of length 1 cm lies in the field. How much additional mass ‘m’ must be added to regain the balance? **[5]**



68. **[5]**

i. Show how Biot-Savart's 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.

ii. 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.

69. 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 **[5]**

a. is transverse to its initial velocity,

b. makes an angle of 30° with the initial velocity.

70. Derive an expression for the maximum force experienced by a straight conductor of length l, carrying current I and kept in a uniform magnetic field B. **[5]**

71. A 100 turn closely wound circular coil of radius 10 cm carries a current of 3.2 A. **[5]**

a. What is the field at the centre of the coil?

b. What is the magnetic moment of this coil? The coil is placed in a vertical plane and is free to rotate about a horizontal axis which coincides with its diameter. A uniform magnetic field of 2T in the horizontal direction exists such that initially the axis of the coil is in the direction of the field. The coil rotates through an angle of 90° under the influence of the magnetic field.

c. What are the magnitudes of the torques on the coil in the initial and final position?

d. What is the angular speed acquired by the coil when it has rotated by 90°? The moment of inertia of the coil is 0.1 kg m^2.

72. **[5]**

a. Two circular coils X and Y having radius R and $\frac{R}{2}$ respectively are placed in a horizontal plane with their centres coinciding with each other. Coil X has a current I flowing through it in the clockwise sense. What must be the current in coil Y to make the total magnetic field at the common centre of the two coils, zero?

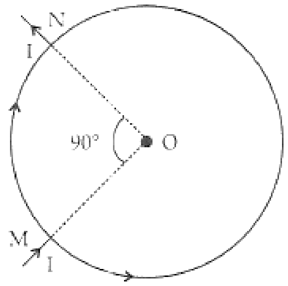
b. With the same currents flowing in the two coils, if the coil Y is now lifted vertically upwards through a distance R, what would be the net magnetic field at the centre of coil Y?

73. 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 an appropriate sense of circulation) in the windings of the solenoid can support the weight of the wire? g = 9.8 ms^{-2}. **[5]**

74. i. a. Use Biot-Savart's 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 V from its centre. **[5]**

b. Draw the magnetic field lines due to this coil,

ii. A current I 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 centre of the loop.



75. i. Express Biot-Savart law in the vector form. **[5]**

ii. Use it to obtain the expression for the magnetic field at an axial point, distanced from the centre of a circular coil of radius R carrying current I.

iii. Also, find the ratio of the magnitudes of the magnetic field of this coil at the centre and at an axial point for which x = $R\sqrt{3}$.