ELECTROMAGNETISM

Biot – Savart's Law and Ampere's Circuital Law

2011

1. In the given circuit for ideal diode, the current through the battery is

   1) 0.5 A 2) 1.5 A 3) 1.0 A 4) 2A 5) 2.5 A

2. The statement "Polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it" is known as

   1) Faraday's law 2) Gauss's law 3) Coulomb's law 4) Lenz's law

2010

3. A wire carrying current I and other carrying 2i in the same direction produce a magnetic field B at the mid – point. What will be the field when 2i current is switched off?

   1) $B/2$ 2) 2B 3) B 4) 4B

4. The distance at which the magnetic field on axis as compared to the magnetic field at the centre of the coil carrying current I and radius R is $1/8$, would be

   1) R 2) $\sqrt{2}$R 3) 2R 4) $\sqrt{3}$R

5. The current in straight wire if the magnetic field $10^{-6} Wm^{-2}$ produced at 0.02m away from it is

   1) 0.1 A 2) 1 A 3) zero 4) 10 A

6. An electric current passes through a long straight copper wire. At a distance 5cm from the straight wire, the magnetic field is B. The magnetic field at 20cm from the straight wire would be

   1) $\frac{B}{6}$ 2) $\frac{B}{4}$ 3) $\frac{B}{3}$ 4) $\frac{B}{2}$

7. For the magnetic field to be maximum due to a small element of current carrying conductor at a point, the angle between the element and the line joining the element and the line joining the element to the given point must be

   1) $0°$ 2) $90°$ 3) $180°$ 4) $45°$

8. A solenoid of 1.5m length and 4.0cm diameter possesses $10\,\text{turns/cm}$. A current of 5A is flowing through it. The magnetic induction at axis inside the solenoid is

   1) $2\pi \times 10^{-3} T$ 2) $2\pi \times 10^{-5} T$ 3) $2\pi \times 10^{-3} G$ 4) $2\pi \times 10^{-5} G$

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9. A square conducting loops of side length L carries a current I. The magnetic field at the centre of the loop is

1) independent of L 2) proportional to L^2
3) inversely proportional to L 4) linearly proportional to L

10. A solenoid of length 50cm and a radius of cross – section 1cm has 1000 turns of wire wound over it. If the current carried is 5A, the magnetic field on its axis, near the centre of the solenoid is approximately (permeability of free space $\mu_o = 4\pi \times 10^{-7} T - mA^{-1}$)

1) $0.63\times10^{-2}T$ 2) $1.26\times10^{-2}T$ 3) $251\times10^{-2}T$ 4) 6.3 T

11. Mark the correct statement

1) For long parallel conductors carrying steady current, the Biot – Savart law and Lorentz force yield results in accordance with Newton's third law

2) For long parallel conductors carrying steady current, the Biot – Savart law and Lorentz force, Newton's third law does not hold good

3) For long parallel conductors carrying time varying currents, the Biot – Savart law and Lorentz force, Newton's third law holds good

4) Both (a) and (c) are correct

12. A helium nucleus makes full rotation in a circle of radius 0.8m in 2s. The value of magnetic field B at the centre of the circle, will be (μ_o = permeability constant)

1) $\frac{2\times10^{-19}}{\mu_o}$ 2) $2\times10^{-19}\mu_o$ 3) $10^{-19}\mu_o$ 4) $\frac{10^{-19}}{\mu_o}$

13. A winding wire which is used to frame a solenoid can bear a maximum 10A current. If length of solenoid is 80cm and its cross – sectional radius is 3cm then required length of winding wire is

(B = 0.2T)

1) 1.2×10^2 m 2) 4.8×10^2 m 3) 2.4×10^3 m 4) 6×10^3 m

2009

14. Assertion (A) : A proton and an alpha particle having the same kinetic energy are moving in circular paths in a uniform magnetic field. The radii of their circular paths will be equal

Reason (R) : Any two charged particles having equal kinetic energies and entering a region of uniform magnetic field B in a direction perpendicular to B, will describe circular trajectories of equal radii

1) Both A and R are correct. R is the correct explanation of A.
2) Both A and R are correct. R is not the correct explanation of A.
3) A is true, but R is false 4) Both A and R are false

15. An electric current passes through a long straight wire. At a distance 5cm from the wire, the magnetic field is B. The field at 20cm from the wire would be

1) 2B　　2) $B/4$　　3) $B/2$　　4) B

16. A wire is wound in the form of a solenoid of length *l* and distance d. When a strong current is passed through a solenoid, there is a tendency to

1) increase *l* but decrease d　　2) keep both *l* and d constant
3) decrease *l* but increase d　　4) increase both *l* and d

17. A closely wound flat circular coil of 25 turns wire diameter of 10cm which carries current of 4A, the density at the centre of a coil will be

1) $2.28\times10^{-6}T$　　2) $1.678\times10^{-6}T$　　3) $1.256\times10^{-3}T$　　4) $1.572\times10^{-5}T$

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

1) $\frac{\mu_o i}{r}$　　2) $\frac{4\mu_o i}{r}$　　3) zero　　4) $\frac{\mu_o i}{4r}$

19. Two concentric circular loops of radii R and 2R carry currents of 2i and I respectively in opposite sense (i.e, clockwise in one coil and counter – clockwise in the other coil). The resultant magnetic field at their common centre is

1) $\mu_o \frac{i}{4R}$　　2) $\mu_o \frac{5i}{4R}$　　3) $\mu_o \frac{3i}{4R}$　　4) $\mu_o \frac{i}{2R}$

20. A charge q coulomb makes n revolutions in one second in a circular orbit of radius r. The magnetic field at the centre of the orbit in $NA^{-1}m^{-1}$ is

1) $\frac{2\pi rn}{q}\times10^{-7}$　　2) $\left(\frac{2\pi q}{r}\right)\times10^{-7}$
3) $\left(\frac{2\pi q}{nr}\right)\times10^{-7}$　　4) $\left(\frac{2\pi nq}{r}\right)\times10^{-7}$

21. Magnetic field at the centre of a coil in the form of a square of side 2m carrying a current of 4.414A is

1) $8\times10^{-5}T$　　2) $5\times10^{-5}T$　　3) $1.5\times10^{-5}T$　　4) $6\times10^{-5}T$

22. Which of the following relation represents Biot – Savart's law ?

1) $dB=\frac{\mu_o}{4\pi}\frac{dl\times r}{r}$　　2) $dB=\frac{\mu_o}{4\pi}\frac{dl\times r}{r^2}$
3) $dB=\frac{\mu_o}{4\pi}\frac{dl\times r}{r^3}$　　4) $dB=\frac{\mu_o}{4\pi}\frac{dl\times r}{r^4}$

23. A long wire carries a steady current. It is bent into a circle of one turn and the magnetic field at the centre of the coil is B. It is then bent into a circular loop of n turns. The magnetic field at the centre of the coil for same current will be

1) nB　　2) n^2B　　3) 2nB　　4) $2n^2B$

24. The phenomena in which proton flips is

1) nuclear magnetic resonance 2) lasers
3) radioactivity 4) nuclear fusion

25. A solenoid 1.5m long and 0.l4cm in diameter possesses 10 turns per cm length. A current of 5A falls through it. The magnetic field at the axis inside the solenoid is

1) $2\pi \times 10^{-3} T$ 2) $2\pi \times 10^{-5} T$ 3) $4\pi \times 10^{-2} T$ 4) $4\pi \times 10^{-3} T$

26. A long straight wire of radius a carries a steady current I. The current is uniformly distributed across its cross – section. The ratio of the magnetic field at $\frac{a}{2}$ and 2a is

1) $\frac{1}{4}$ 2) 4 3) 1 4) $\frac{1}{2}$

27. Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. 3A and 4A are the currents flowing in each coil respectively. The magnetic induction in $Wb\, m^{-2}$ at the centre of the coils will be $\left(\mu_o = 4\pi \times 10^{-7} Wb\, A^{-1} m^{-1}\right)$

1) 12×10^{-5} 2) 10^{-5} 3) 5×10^{-5} 4) 7×10^{-5}

28. Assertion (A): The magnetic field produced by a current carrying solenoid is independent of its length and cross – sectional area

Reason (R) : The magnetic field inside the solenoid is uniform

1) Both A and R are correct. R is the correct explanation of A.
2) Both A and R are correct. R is not the correct explanation of A.
3) A is true, but R is false
4) Both A and R are false

29. Two identical wires A and B have the same length L and carry the same current I. Wire A is bent into a circle of radius R and wire B is bent to form a square of side a. If B_1 and B_2 are the values of magnetic induction at the centre of the circle and the centre of the square respectively, then the ratio B_1/B_2 is

1) $\frac{\pi^2}{8}$ 2) $\frac{\pi^2}{8\sqrt{2}}$ 3) $\frac{\pi^2}{16}$ 4) $\frac{\pi^2}{16\sqrt{2}}$

30. The magnetic filed at the centre of a circular current carrying conductor of radius r is B_c. The magnetic field on its axis at a distance r from the centre is B_a. The value of $B_c : B_a$ will be

1) $1 : \sqrt{2}$ 2) $1 : 2\sqrt{2}$ 3) $2\sqrt{2} : 1$ 4) $\sqrt{2} : 1$

31. A vertical straight conductor carries a current upward. A point P lies to the east of it a small distance and another point Q lies to the west at the same distance. The magnetic field at P is

1) greater than at Q 2) same as at Q 3) less than at Q
4) greater or less than at Q depending upon the strength of current

32. Two concentric circular coils of ten turns each are situated in the same plane. Their radii are 20cm and 40cm and they carry respectively 0.2A and 0.3A currents in opposite direction. The magnetic field in tesla at the centre is

1) $5\mu_o/4$ 2) $\mu_o/80$ 3) $7\mu_o/80$ 4) $3\mu_o/4$

2007

33. Two long straight wires are set parallel to each other at separation r and each carries a current I in the same direction. The strength of the magnetic field at any point midway between the two wires is

1) $\frac{\mu_o I}{\pi r}$ 2) $\frac{2\mu_o I}{\pi r}$ 3) $\frac{\mu_o I}{2\pi r}$ 4) zero

34. A long solenoid has $20\,\text{turns}\,\text{cm}^{-1}$. The current necessary to produce a magnetic field of 20mT inside the solenoid is approximately

1) 1A 2) 2A 3) 4A 4) 8A

35. A long solenoid carrying a current produces a magnetic field B along its axis. If the current is doubled and the number of turns per cm is halved, the new value of the magnetic field is

1) 2B 2) 4B 3) $B/2$ 4) B

36. Two identical coils having same number of turns and carrying equal current have common centre and their planes are at right angles to each other. What is the ratio of magnitude of the resultant magnetic field at the centre and magnetic field due to one of the coils at the centre?

1) $1:\sqrt{2}$ 2) $\sqrt{2}:1$ 3) 1 : 1 4) 2 : 1

37. A straight wire of mass 200g and length 1.5m carries a current of 2A. It is suspended in mid – air by a uniform horizontal magnetic field B. The magnitude of B (in tesla) is (Assume $g = 9.8\,ms^{-2}$)

1) 2 2) 1.5 3) 0.55 4) 0.65

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

1) $6.28\times10^{-3}T$ 2) $5\times10^{3}T$ 3) $3.2\times10^{-2}T$ 4) $1.5\times10^{-5}T$

39. For the magnetic field to be maximum due to a small element of current carrying conductor at a point, the angle between the element and the line joining the element to the given point must be

1) $0°$ 2) $90°$ 3) $180°$ 4) $45°$

Biot – Savart's Law and Ampere's Circuital Law

KEY

1) **c**	2) **d**	3) **c**	4) **d**	5) **a**	6) **b**	7) **b**	8) **a**	9) **c**	
10) **b**	11) **a**	12) **c**	13) **c**	14) **c**	15) **b**	16) **b**	17) **c**	18) **a**	19) **c**
20) **d**	21) **a**	22) **c**	23) **b**	24) **a**	25) **a**	26) **c**	27) **c**	**28**) **b**	29) **b**
30) **c**	31) **b**	32) **d**	33) **d**	34) **d**	35) **d**	36) **b**	**37**) **d**	38) **a**	39) **b**

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SOLUTIONS

1. $R = R_1 + R_2 = 5 + 5 = 10\Omega$

$i = \frac{V}{R} = \frac{10}{10} = 1A$

3. $B_1 = \frac{\mu_o}{4\pi}.\frac{2i}{R}$ and $B_2 = \frac{\mu_o}{4\pi}.\frac{4i}{R}$

$B_2 - B_1 = \frac{\mu_o}{4\pi}.\frac{2i}{r} = B$

$B_2 = 2B_1$

$2B_1 - B_1 = B$

$\therefore\ B_1 = B$

4. $B_{\text{axis}} = \frac{\mu_o}{4\pi}\frac{2\pi IR^2}{\left(x^2 + R^2\right)^{3/2}}$

At centre

$$B_{\text{centre}} = \frac{\mu_o I}{2R}$$

Dividing , $\frac{B_{axis}}{B_{centre}} = \frac{\mu_o IR^2}{2\left(x^2 + R^2\right)^{3/2}} \times \frac{2R}{\mu_o I}$

$\frac{R^3}{\left(x^2 + R^2\right)^{3/2}} = \frac{1}{8}$

Or $\frac{R}{\left(x^2 + R^2\right)^{1/2}} = \frac{1}{2}$

$\Rightarrow x = \sqrt{3}R$

5. $B = \frac{\mu_o}{4\pi} \times \frac{2i}{a}$

$\Rightarrow 10^{-6} = \frac{10^{-7} \times 2 \times i}{0.02} \Rightarrow\ i = 0.1A$

6. $B = \frac{\mu_o i}{2\pi r}$ or $B \propto \frac{1}{2}$ or $\frac{B_2}{B_1} = \frac{r_1}{r_2}$

$\therefore \quad \frac{B_2}{B} = \frac{5}{20} = \frac{1}{4}$ or $B_2 = \frac{B}{4}$

7. $dB = \frac{\mu_o}{4\pi}\frac{idl\sin\theta}{r^2}$

This is maximum when $\sin\theta = 1 = \sin 90°$

$\theta = 90°$

8. $B = \mu_o ni = 4\pi\times10^{-7}\times5\times1000 = 2\pi\times10^{-3}T$

9. $B_1 = \frac{\mu_o}{4\pi}\times\frac{i}{(L/2)}[\sin 45° + \sin 45°]$

$= \frac{\mu_o}{4\pi}\times\frac{2\sqrt{2}i}{L}$

Field at centre due to the four arms of the square

$B = 4B_1 = \frac{\mu_o}{\pi}\times\frac{2\sqrt{2}i}{L}$

$\therefore B \propto \frac{1}{L}$

10. $B = \mu_o ni$

Here $\mu_o = 4\pi\times10^{-7} T\,mA^{-1}$

$n = \frac{1000}{50\times10^{-2}},\ i = 5A$

$B = 4\pi\times10^{-7}\times\frac{1000}{50\times10^{-2}}\times5$

$B = 1.26\times10^{-2}T$

12. The magnetic field at the centre of a circle is given by

$$B = \frac{\mu_o i}{2r}$$

where, i is current and r the radius of circle

Also, $i = \frac{q}{t}$

For helium nucleus, q = 2e

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$\therefore\ i = \frac{2e}{t}$

Or $B = \frac{\mu_o .2e}{2rt} = \frac{\mu_o \times 2 \times 1.6 \times 10^{-19}}{2 \times 0.8 \times 2} = 10^{-19}\mu_o$

13. $B = \frac{\mu_o Ni}{l}$, where N = total number of turns, l = length of the solenoid

$\Rightarrow 0.2 = \frac{4\pi \times 10^{-7} \times N \times 10}{0.8}$

$\Rightarrow N = \frac{4 \times 10^4}{\pi}$

Since N turns are made from the winding wire, so length of the wire $(L) = 2\pi r \times N$ [$2\pi r$ = length of each turns]

$\Rightarrow L = 2\pi \times 3 \times 10^{-2}\frac{4 \times 10^4}{\pi} = 2.4 \times 10^3 m$

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

When r = 5 cm

$\therefore\ B = \frac{\mu_o 2I}{4\pi(5)}$ ………… (i)

When r = 20 cm

$B' = \frac{\mu_o 2I}{4\pi(20)}$ ……….. (ii)

From Equations, (i) and (ii), $B' = \frac{B}{4}$

18. At the midpoint , $BB_{net} = B_{AB} + B_{CD}$

$= \frac{\mu_o i}{2r} + \frac{\mu_o i}{2r} = \frac{\mu_o i}{r}$

19. $B_1 = \frac{\mu_o \times 2i}{2 \times R}$ and $B_2 = \frac{\mu_o i}{4R}$

$$B_{\text{net}} = \frac{\mu_o i}{R} - \frac{\mu_o i}{4R} = \frac{3\mu_o i}{4R}$$

21. $B_{\text{centre}} = \frac{4 \times \mu_o}{4\pi} \times \frac{1}{(a/2)}(\sin 45 + \sin 45°)$

$$= 4 \times \frac{\mu_o}{4\pi} \times \frac{2I}{a} \times \frac{2}{\sqrt{2}}$$

$$= \frac{4\pi \times 10^{-7} \times 1.414 \times 2 \times \sqrt{2}}{\pi \times 2 \times 10^{-2}}$$

$$= 8 \times 10^{-5} T$$

25. $B = \mu_o nI$

Here $n = 10 \text{ turns cm}^{-1} = 1000 \text{ turns m}^{-1}, I = 5A$

$$B = 4\pi \times 10^{-7} \times 1000 \times 5$$

$$= 2\pi \times 10^{-3} T$$

26. Current density $J = \frac{1}{\pi a^2}$

From Ampere's circuital law

$$\oint B.dl = \mu.I_{\text{enclosed}}$$

For r < a

$$B \times 2\pi r = \mu_o \times J \times \pi r^2$$

$$\Rightarrow B = \frac{\mu_o I}{\pi a^2} \times \frac{r}{2}$$

At $r = a/2$

$$B_1 = \frac{\mu_o I}{4\pi a}$$

For r > a

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

At r = 2a $\quad B_2 = \frac{\mu_o i}{4\pi a}$

So, $\frac{B_1}{B_2} = 1$

27. $B_P = \frac{\mu_o I_2}{2R}$

$= \frac{4\pi \times 10^{-7} \times 4}{2 \times 0.02\pi} = 4 \times 10^{-5} Wb\, m^{-2}$

$B_Q = \frac{\mu_o I_1}{2R}$

$= \frac{4\pi \times 10^{-7} \times 3}{2 \times 0.02\pi} = 3 \times 10^{-5} Wb\, m^{-2}$

$\therefore\ B = \sqrt{B_P^2 + B_Q^2}$

$= \sqrt{\left(4 \times 10^{-5}\right)^2 + \left(3 \times 10^{-5}\right)^2}$

$= 5 \times 10^{-5} Wb\, m^{-2}$

29. $B_1 = \frac{\mu_o}{4\pi} \times \frac{2\pi I}{R}$

$= \frac{\mu_o}{4\pi} \times \frac{2\pi I \times 2\pi}{L}$

($\because\ L = 2\pi R$, for circular loop)

$B_2 = \frac{\mu_o}{4\pi} \times \frac{I}{(a/2)} \left[\sin 45^\circ + \sin 45^\circ\right] \times 4$

where $\quad a = L/4$

$\therefore\ B_2 = \frac{\mu_o I}{4\pi L} \times 8 \times 4 \times \left[\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right]$

$$\frac{\mu_o I}{4\pi L}\times\frac{64}{\sqrt{2}}$$

Hence, $\frac{B_1}{B_2}=\left(\frac{\mu_o}{4\pi}\right)\times\frac{4\pi^2 I}{L}\bigg/\frac{\mu_o I}{4\pi L}\times\frac{64}{\sqrt{2}}$

or $\frac{B_1}{B_2}=\frac{\pi^2}{8\sqrt{2}}$

30. Magnetic induction at the centre of the coil of radius r is

$$B_c=\frac{\mu_o nI}{2r}$$

Magnetic induction on the axial line of a circular coil at a distance x from the centre is

$$B_a=\frac{\mu_o nr^2 I}{2\left(r^2+x^2\right)^{3/2}}$$

Given $x=r$

$$\therefore\ B_a=\frac{\mu_o nr^2 I}{2(2r2)^{3/2}}$$

From Equations (i) and (ii), we get

$$\frac{B_c}{B_a}=\frac{2\sqrt{2}}{1}$$

32. $B=\frac{\mu_o nI}{2r}$

For first coil, $B_1=\frac{\mu_o nI_1}{2r_1}$

For second coil, $B_2=\frac{\mu_o nI_2}{2r_2}$

Resultant magnetic field at the centre of concentric loop is

$$B=\frac{\mu_o nI_1}{2r_1}-\frac{\mu_o nI_2}{2r_2}$$

But , $n=10,\ I_1=0.2,\ r_1=20\,cm=0.20\,m$

$I_2 = 0.3A,\ r_2 = 40\,cm = 0.40\,m$

$$\therefore\ B = \mu_o\left[\frac{10\times0.2}{2\times0.2} - \frac{10\times0.3}{2\times0.4}\right] = \frac{5}{4}\mu_o$$

34. $B = \mu_o nI$

or $20\times10^{-3} = 4\pi\times10^{-7}\times2000\times I$

or $I = \dfrac{20\times10^{-3}}{4\pi\times10^{-7}\times2000}$

$\Rightarrow\ I \approx 8A$

35. $B \propto nI$

$$\therefore \frac{B_1}{B_2} = \frac{n_1I_1}{n_2I_2}$$

Here $n_1 = n,\ n_2 = \dfrac{n}{2},\ I_1 = I,\ I_2 = 2I,\ B_1 = B$

$$\therefore\ \frac{B}{B_2} = \frac{n}{n/2}\times\frac{I}{2I} = 1$$

or $B_2 = B$

36. $B_r = \sqrt{B^2 + B^2} = \sqrt{2}B$

Hence, the required ratio will be

$$\frac{B_r}{B} = \sqrt{2}$$

37. Magnetic force on straight wire

$$F = BIl\sin\theta = BIl\sin90^\circ = B_H$$

For equilibrium of wire in mid – air

F = mg

$BIl = mg$

$$\therefore\ B = \frac{mg}{Il} = \frac{200\times10^{-3}\times9.8}{2\times1.5} = 0.65T$$

38. Number of turns per unit length

$$n = \frac{500}{0.5} = 1000\,\text{turns}\,\text{m}^{-1}$$

Given $l = 0.5m,\ r = 0.01m$

Since $\frac{l}{a} = 50$, i.e., $l >> a$

Therefore, $B = \mu_o ni = 4\pi \times 10^{-7} \times 10^3 \times 5$

$$B = 6.28 \times 10^{-3} T$$

MOTION OF A CHARGED PARTICLE IN A MAGNETIC FIELD

2011

1. The total energy of electron in the second excited state is -2E. What is its potential energy in the same state with proper sign?

1) -2E 2) -4E 3) 4E 4) –E

2. Two particles A and B having equal charges +6C, after being accelerated through the same potential difference, enter a region of uniform magnetic field and describe circular paths of radii 2cm and 3cm respectively. The ratio of mass of A to that of B is

1) $4/9$ 2) $9/5$ 3) $1/2$ 4) $1/3$

3. A metallic rod of length R is rotated through with an angular frequency ω with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius R, about an axis passing through the centre and perpendicular to the plane of the ring. There is a magnetic field B, perpendicular to the plane of the ring. The emf induced between the centre and the metallic ring is

1) $B\sin\omega t$ 2) $\frac{BR^2\omega}{2}$ 3) $2BR^2\omega$ 4) $BR^2\omega$

4. The path of a charged particle in a uniform magnetic field, when the velocity and the magnetic field are perpendicular to each other is a

1) circle 2) parabola 3) helix 4) straight line

5. A proton travelling at $23°$ w.r.t the direction of a magnetic field of strength 2.6mT experiences a magnetic force of $6.5 \times 10^{-17} N$. What is the speed of the proton?

1) $2\times10^5 ms^{-1}$ 2) $4\times10^5 ms^{-1}$ 3) $6\times10^5 ms^{-1}$ 4) $6\times10^{-5} ms^{-1}$

6. What uniform magnetic field applied perpendicular to a beam of electrons moving at $1.3\times10^6 ms^{-1}$, is required to make the electrons travel in a circular arc of radius 0.35m ?

1) $2.1\times10^{-5}G$ 2) $6\times10^{-5}T$ 3) $2.1\times10^{-5}T$ 4) $6\times10^{-5}G$

7. A uniform electric field and a uniform magnetic field are acting along the same direction in a certain region. If an electron is projected in the region such that its velocity is pointed along the direction of fields, then the electron

1) speed will decrease 2) speed will increase

3) will turn towards left of direction of motion

4) will turn towards right of direction of a motion

2010

8. A deuteron of kinetic energy 50keV is describing a circular orbit of radius 0.5m, in a plane perpendicular to magnetic field B. The kinetic energy of a proton that describes circular orbit of radius 0.5m in the same plane with the same magnetic field is

1) 200 keV 2) 50 keV 3) 100 keV 4) 25 keV

9. A charged particle enters a magnetic field H with its initial velocity making an angle of $45°$ with H. The path of the particle will be

1) straight wire 2) a circle 3) an ellipse 4) a helix

10. A charged particle moving with velocity $4\times10^{6}ms^{-1}$ enters perpendicular to a magnetic field $B = 2Wbm^{-2}$. It moves in a circular path of radius 2cm, and then charge per unit mass is

1) $10^{2}C\,kg^{-1}$ 2) $10^{3}C\,kg^{-1}$ 3) $10^{4}C\,kg^{-1}$ 4) $10^{8}C\,kg^{-1}$

11. An electron of mass m and charge q is travelling with a speed v along a circular path of radius r at right angles to a uniform magnetic field B. If speed of the electron is doubled and the magnetic field is halved, then resulting path would have a radius of

1) $\frac{r}{4}$ 2) $\frac{r}{2}$ 3) 2r 4) 4r

12. A charged particle moves along a circle under the action of magnetic and electric fields, then the region of space may have

1) E = 0, B = 0 2) E = 0, B ≠ 0 3) E ≠ 0, B = 0 4) E ≠ 0, B ≠ 0

13. An electric field of $1500Vm^{-1}$ and a magnetic field of $0.40Wbm^{-2}$ act on a moving electron. The minimum uniform speed along a straight line, the electron could have is

1) $1.5\times10^{15}ms^{-1}$ 2) $6\times10^{-16}ms^{-1}$ 3) $3.75\times10^{3}ms^{-1}$ 4) $3.75\times10^{2}ms^{-1}$

14. Two particles of masses m_a and m_b same charge are projected in a perpendicular magnetic field. They travel along circular paths of radius r_a and r_b such that $r_a > r_b$. Then which is true?

1) $m_a v_a > m_b v_b$ 2) $m_a > m_b$ and $v_a > v_b$ 3) $m_a = m_b$ and $v_a = v_b$ 4) $m_b v_b > m_a v_a$

15. A charge +Q is moving upwards vertically. It enters a magnetic field direction to north. The force on the charge will be towards

1) north 2) south 3) east 4) west

16. A proton enters a magnetic field of flux density $1.5Wbm^{-2}$ with a speed of $2\times10^{7}ms^{-1}$ at angle of $30°$ with the field. The force on a proton will be

1) $0.24\times10^{-12}N$ 2) $2.4\times10^{-12}N$ 3) $24\times10^{-12}N$ 4) $0.024\times10^{-12}N$

2009

17. The magnetic force acting on a charged particle of charge $-2\mu C$ in a magnetic field of 2T acting in y – direction, when the particle velocity is $(2i+3j)\times 10^{6} ms^{-1}$ is

1) 8N in – z direction 2) 4N in z direction 3) 8N in y direction 4) 8N in z direction

18. In a mass spectrometer used for measuring the masses of ions, the ions are initially accelerated by an electric potential V and then made to describe semicircular paths of radius R using a magnetic field B. If V and B are kept constant, the ratio $\left(\frac{\text{charge on the ion}}{\text{mass of the ion}}\right)$ will be proportional to

1) $\frac{1}{R}$ 2) $\frac{1}{R^2}$ 3) R^2 4) R

19. A beam of electrons is moving with constant velocity in a region having electric and magnetic fields of strength $20\ Vm^{-1}$ and 0.5 T at right angles to the direction of motion of the electrons. What is the velocity of the electrons?

1) $20\ ms^{-1}$ 2) $40\ ms^{-1}$ 3) $8\ ms^{-1}$ 4) $5.5\ ms^{-1}$

20. A charged particle with velocity $v = xi + yj$ moves in a magnetic field $B = yi + xj$. Magnitude of the force acting on the particle is F. The correct option for F is

i) No force will act on particle if $x = y$ ii) Force will act along y – axis if $y < x$

iii) Force is proportional to $(x^2 - y^2)$ if $x > y$ iv) Force is proportional to $(x^2 + y^2)$ if $y > x$

1) I and ii are true 2) I and iii are true 3) ii and iv are true 4) iii and iv are true

21. A charged particle enters in a strong perpendicular magnetic field. Then its kinetic energy

1) increases 2) decreases

3) remains constant 4) first increases and then becomes constant

22. A cyclotron can accelerate

1) β - particles 2) α - particles

3) high velocity gamma rays 4) high velocity X – rays

23. An α - particle and a deuteron projected with equal kinetic energies describe circular paths of radii r_1 and r_2 respectively in a uniform magnetic field. The ratio r_1/r_2 is

1) 1 2) 2 3) $\frac{1}{\sqrt{2}}$ 4) $\sqrt{2}$

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

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

1) i only 2) i or ii

3) i or ii 4) any one of i, ii and iii

25. Proton and α - particle are projected perpendicularly in a magnetic field, if both move in a circular path with same speed. Then the ratio of their radii is

1) 1: 2 2) 2: 1 3) 1: 4 4) 1: 1

2008

26. A particle mass m, charge Q and kinetic energy T enters a transverse uniform magnetic field of induction B. After 3s the kinetic energy of the particle will be
1) 3T 2) 2T 3) T 4) 4T

27. A proton, a deuteron and an α - particle with the same kinetic energy enter a region of uniform magnetic field, moving at right angles to B. What is the ratio of the radii of their circular paths?
1) $1:\sqrt{2}:1$ 2) $1:\sqrt{2}:\sqrt{2}$ 3) $\sqrt{2}:1:1$ 4) $\sqrt{2}:\sqrt{2}:1$

28. Frequency of cyclotron does not depend upon
1) charge 2) mass 3) velocity 4) $\frac{q}{m}$

29. Under the influence of a uniform magnetic field a charged particle is moving in a circle of radius R with constant speed v. The time period of the motion
1) depends on v and not on R 2) depends on both R and v
3) is independent of both R and v 4) depends on R and not on v

30. Which of the following while in motion cannot be deflected by magnetic field?
1) Protons 2) Cathode rays 3) Alpha particles 4) Neutrons

31. A proton is moving in a magnetic field B is a circular path of radius a in a direction perpendicular to z – axis along which field B exists. Calculate the angular momentum, if the radius is a charge on proton is e
1) $\frac{Be}{a^2}$ 2) eB^2a 3) a^2eB 4) aeB

32. The magnetic force on a charged particle moving in the field does no work, because
1) kinetic energy of the charged particle does not change
2) the charge of the particle remains same
3) the magnetic force is parallel to velocity of the particle
4) the magnetic force is parallel to magnetic field

2007

33. A charged particle (charge q) is moving in a circle of radius R with uniform speed v. The associated magnetic moment μ is given by
1) $\frac{qvR}{2}$ 2) qvR^2 3) $\frac{qvR^2}{2}$ 4) qvR

34. The path of an electron in a uniform magnetic field may be
1) circular but not helical 2) helical but not circular
3) neither circular nor circular 4) either helical or circular

35. The figure shows three situations when an electron with velocity v travels through a uniform magnetic field B. In each case, what is the direction of magnetic force on the electron?
1) +ve z – axis, -ve x – axis, +ve y – axis 2) –ve z – axis, -ve x – axis and zero
3) +ve z – axis, +ve y – axis and zero 4) –ve z – axis, +ve x – axis and zero

36. A beam of protons with velocity $4\times10^5 ms^{-1}$ enters a magnetic field of 0.3T at an angle of $60°$ to the magnetic field. Find the radius of the helical path taken by the proton beam
1) 0.2 cm 2) 1.2 cm 3) 2.2 cm 4) 0.122 cm

37. A charged particle moves through a magnetic field in a direction perpendicular to it. Then the
1) acceleration remains unchanged
2) velocity remains unchanged
3) speed of the particle remains unchanged
4) direction of the particle remains unchanged

38. An electron is travelling along the x – direction. It encounters a magnetic field in the y – direction. Its subsequent motion will be
1) straight line along the x – direction
2) a circle in the xz – plane
3) a circle in the yz – plane
4) a circle in xy – plane

39. An electron and proton enter a magnetic field perpendicularly. Both have same kinetic energy. Which of the following is true?
1) Trajectory of electron is less curved
2) Trajectory of proton is less curved
3) Both trajectories are equally curved
4) Both move on straight line path

2006

40. When a charged particle moving with velocity v is subjected to a magnetic field of induction B, the force on it is non – zero. This implies that
1) angle between v and B is necessarily $90°$
2) angle between v and B can have any value other than $90°$
3) angle between v and B can have any value other than zero and $180°$
4) angle between v and B is either zero or $180°$

41. When deuterium and helium are subjected to an accelerating field simultaneously then
1) both acquire same energy
2) deuterium accelerates faster
3) helium accelerates faster
4) neither of them is accelerated

42. An electron revolves in a circle of radius $0.4\overset{o}{A}$ with a speed of$10^5\ ms^{-1}$. The magnitude of the magnetic field, produced at the centre of the circular path due to the motion of the electron, in $Wb\,m^{-2}$ is
1) 0.01 2) 10 3) 1 4) 0.005 5) 5

43. A plane metallic sheet is placed with its face parallel to lines of magnetic induction B of a uniform field. A particle of mass m and charge q is projected with a velocity v from a distance d from the plane normal to the lines of induction. Then, the maximum velocity of projection for which the particle does not hit the plate is
1) $\frac{2Bqd}{m}$
2) $\frac{Bqd}{m}$
3) $\frac{Bqd}{2m}$
4) $\frac{Bqm}{d}$

44. An electron moves at right angle to a magnetic field of $1.5\times10^{-2}T$ with a speed of $6\times10^7\ ms^{-1}$. If the specific charge of the electron is $1.7\times10^{11}C\,kg^{-1}$, the radius of the circular path will be
1) 2.9 cm 2) 3.9 cm 3) 2.35 cm 4) 2 cm

45. If velocity of a charged particle is doubled and strength of magnetic field is halved, then radius becomes
1) 8 times 2) 2 times 3) 4 times 4) 3 times

46. A charged particle enters a uniform magnetic field with a certain speed at right angles to it. In the magnetic field a change could occur in its
1) Kinetic energy 2) angular momentum 3) linear momentum 4) speed

2005

47. Cyclotron is a device which is used to

1) Measure the charge 2) measure the voltage
3) accelerate protons 4) accelerate electrons

48. In a cyclotron, if a deuteron can gain energy of 40 MeV, then a proton can gain energy of

1) 40 MeV 2) 80 MeV 3) 20 MeV 4) 60 MeV

49. An electron, moving in a uniform magnetic field of induction of intensity B, has its radius directly proportional to

1) its charge 2) magnetic field 3) speed 4) None of these

50. An electron projected in a perpendicular uniform magnetic field of $3\times10^{-3}T$, moves in a circle of radius 4mm. The linear momentum of electron (in $kg-ms^{-1}$) is

1) 1.92×10^{-21} 2) 1.2×10^{-24} 3) 1.92×10^{-24} 4) 1.2×10^{-21}

MOTION OF A CHARGED PARTICLE IN A MAGNETIC FIELD

KEY

1) **b**	2) **a**	3) **b**	4) **c**	5) **b**	6) **c**	7) **a**	8) **c**	9) **d**	10) **d**
11) **d**	12) **b**	13) **a**	14) **a**	15) **d**	16) **b**	17) **b**	18) **a**	19) **a**	20) **b**
21) **c**	22) **b**	23) **c**	24) **d**	25) **c**	26) **c**	**27**) **a**	28) **c**	29) **c**	30) **a**
31) **c**	32) **a**	33) **a**	34) **d**	35) **d**	**36)** **b**	37) **c**	38) **d**	39) **a**	40) **b**
41) **d**	42) **c**	43) **b**	44) **c**	45) **c**	**46**) **c**	47) **c**	48) **b**	49) **c**	50) **c**

SOLUTIONS

1. $E = E_i - E_f$

$-2E + x = 2E$

$x = 4E$

$x = -4E$

2, $r = \dfrac{\sqrt{2mqV}}{qB} = \sqrt{\dfrac{2mV}{aB^2}}$

$\dfrac{r_1}{r_2} = \sqrt{\dfrac{m_1}{m_2}}$

$\dfrac{m_1}{m_2} = \dfrac{r_1^2}{r_2^2}$

Hence, $\frac{m_1}{m_2}=\frac{(2)^2}{(3)^2}=\frac{4}{9}$

3. The emf induced between the centre and the metallic ring = $\frac{1}{2}BR^2\omega$

5. $\theta = 23°,\ B = 2.6\,mT = 2.6\times10^{-6}T$ and $F = 6.5\times10^{-17}N$

But, $F = qvB\sin\theta$

$6.5\times10^{-17} = 1.6\times10^{-19}\times v\times2.6\times10^{-6}\times\sin 23°$

$v=\frac{6.5\times10^{-17}}{2.6\times10^{-6}\times1.6\times10^{-19}\times0.39}$

$v = 4\times10^{5}\,ms^{-1}$

6. $r=\frac{mv}{qB}$ or

$B=\frac{mv}{qr}=\frac{9.1\times10^{-31}\times1.3\times10^{6}}{1/6\times10^{-19}\times0.35}=2.1\times10^{-5}T$

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

$r=\frac{mv}{Bq}=\frac{2mE}{qB}$

$r=\frac{\sqrt{2mE}}{Bq}=\frac{\sqrt{2m_1E_1}}{Bq}$

or $E_1=\frac{mE}{m_1}=\frac{(2m_1)}{m_1}\times50\,keV$ $[\because m=2m_1]$ = 100 keV

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

$\therefore\ \frac{r_1}{r_2}=\frac{v_1}{v_2}\times\frac{B_2}{B_1}$

$\frac{r_1}{r_2}=\frac{1}{2}\times\frac{1}{2}$

$r_2=4r_1\Rightarrow r_2=4r$

13. $qE = qvB$

$$v = \frac{E}{B} = \frac{1500}{0.40}$$

$$= 3750\, ms^{-1}$$

$$v = 3.75 \times 10^{-3} ms^{-1}$$

14. $r_a = \frac{m_a v_a}{qB}$

And $r_b = \frac{m_b v_b}{qB}$

But, $r_a > r_b$

$$\therefore \frac{m_a v_a}{qB} > \frac{m_b v_b}{qB}$$

or $m_a v_a > m_b v_b$

16. $F = qvB\sin\theta$

$$\therefore F = \left(1.6 \times 10^{-19}\right) \times \left(2 \times 10^{7}\right) \times 1.5 \sin 30^\circ$$

$$F = 1.6 \times 10^{-12} \times 2 \times 1.5 \times \frac{1}{2}$$

$$F = 2.4 \times 10^{-2} N$$

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

$$r = \frac{mv}{qB} = \sqrt{\frac{2mE}{q^2 B^2}}$$

Here, E = kinetic energy of the particle

$$r_p = \sqrt{\frac{2mE}{e^2 B^2}}$$

$$r_d = \sqrt{\frac{2 \times 2m \times E}{e^2 B^2}}$$

and $r_a = \sqrt{\frac{2 \times 4m \times E}{(2e)^2 B^2}}$

$\therefore\ r_p : r_d : r_a = 1 : \sqrt{2} : 1$

29. $\frac{mv^2}{R} = Bqv$ or $R = \frac{mv}{Bq}$

$$T = \frac{2\pi R}{v}$$

$$= \frac{2\pi\left(\frac{mv}{Bq}\right)}{v} \quad \text{or} \quad T = \frac{2\pi m}{Bq}$$

It is independent of both R and v.

31. Under uniform magnetic field, force evB acts on proton and provides the necessary centripetal force mv^2/a

$$\therefore\ \frac{mv^2}{a} = evB$$

or $c = \frac{aeB}{m}$ …….. (i)

Angular momentum

$$J = r \times p$$

Here $J = a \times mv$

$$\therefore J = a \times m\left(\frac{qeB}{m}\right) = a^2 eB$$

33. $I = qf = q \times \frac{\omega}{2\pi}$

But $\omega = \frac{v}{R}$

where R is radius of circle and v is uniform speed of charged particle

Therefore, $I = \frac{qv}{2\pi R}$

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Now, $\mu = IA = I \times \pi R^2$

or $\mu = \frac{qv}{2\pi R} \times \pi R^2 \quad = \frac{1}{2} qvR$

36. Radius of the helical path $r = \frac{m(v \sin\theta)}{qB}$

Here $m = 1.67 \times 10^{-27}\, kg$

$v = 4 \times 10^5\, ms^{-1}$

$\theta = 60°$

$q = 1.6 \times 10^{-19}\, C$

B = 0.3T

$\therefore \; r = \frac{1.67 \times 10^{-27} \times 4 \times 10^5 \times \left(\sqrt{3}/2\right)}{1.6 \times 10^{-19} \times 0.3}$ = 1.2 cm

38. $F = qv \times B$

Here $v = v_x i$ and $B - = B_y j$

$\therefore \; R = ev_x B_y (i \times j) = ev_x B_y k$

Hence, subsequent motion of the charged particle will be a circle in the xy - plane.

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

$\therefore \; r = \frac{mv}{qB}$ ……… (i)

Now kinetic energy of the particle

$K = \frac{1}{2} mv^2 \Rightarrow mv = \sqrt{2mK}$

Therefore, Equation (i) becomes

$r = \frac{\sqrt{2mK}}{qB}$ or $r \propto \sqrt{m}$

$$\therefore \ \frac{r_e}{r_p} = \sqrt{\frac{m_e}{m_p}}$$

As $m_e < m_p$, so $r_e < r_p$

Hence, trajectory of electron is less curved.

40. $F = qvB\sin\theta$

If $\theta = 90^\circ$ or 180°, then $\sin\theta = 0$

$\therefore \ R = qvB\sin\theta = 0$

Since, force on charged particle is non – zero, so angle between v and B can have any value other than zero and 180°.

42. $B = \frac{\mu_o}{4\pi}\frac{qv}{r^2}$

$\frac{\mu_o}{4\pi} = 10^{-7}$, $q = 1.6\times10^{-19} C$

$v = 10^5 ms^{-1}$

$r = 0.4\overset{o}{A} = 0.4\times10^{-10} m$

$$\therefore \ B = 10^{-7}\times\frac{1.6\times10^{-19}\times10^5}{\left(0.4\times10^{-10}\right)^2} = 1 Wb\, m^{-2}$$

43. $\therefore \ Bqv\sin\frac{\pi}{2} = \frac{mv^2}{r}$

$\Rightarrow r = \frac{mv}{Bq}$

The particle does not hit the plate if

$r \le d$

or $\frac{mv}{Bq} \le d$

or $v \le \frac{Bqd}{m}$

$$\therefore \ v_{\max} = \frac{Bqd}{m}$$

44. $r = \frac{mv}{eB} = \frac{v}{\left(\frac{e}{m}\right)B}$ .... (i)

$$\therefore \ r = \frac{6\times10^{7}}{1.7\times10^{11}\times1.5\times10^{-2}} = 2.35 \text{ cm}$$

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

$$\Rightarrow \ r = \frac{mv}{qB}$$

$$\therefore \ r^1 = \frac{m\times2v}{q\times\frac{B}{2}} = 4r$$

46. $F = qv\times B$ .... (i)

and centripetal force

$F = \frac{mv^2}{r}$ .... (ii)

From Eqs. (i) and (ii), $B = \frac{mv}{rq} = \frac{\text{linear momentum}}{\text{charge}}$

48. $F = qvB = \frac{mv^2}{r}$ = centripetal force

Maximum energy $E = \frac{1}{2}\frac{B^2q^2r^2}{m}$

$$\frac{E_d}{E_p} = \left(\frac{q_d}{q_p}\right)\left(\frac{m_p}{m_d}\right)$$

$$\frac{40}{E_p} = \left(\frac{q}{q}\right)^2\left(\frac{m}{2m}\right)$$

$$E_p = 80\,MeV$$

49. $F = evB$ ……… (i)

The centripetal force is given by

$$F = \frac{mv^2}{r} \text{ ………. (ii)}$$

where, r is radius of circular path.

Equating Eq. (i) with Eq. (ii), we get

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

$$\Rightarrow r = \frac{mv}{qB}$$

$$\Rightarrow r \propto v$$

50. $\frac{mv^2}{r} = evB$

i.e., $r = \frac{mv}{eB}$

$p = mv$

$$\therefore r = \frac{mv}{eB} = \frac{p}{eB} \Rightarrow p = eBr$$

$$\therefore p = 1.6\times10^{-19}\times3\times10^{-3}\times4\times10^{-3} = 1.92\times10^{-24} kg - ms^{-1}$$

FORCE AND TORQUE ON A CURRENT CARRYING CONDUCTOR

2011

1. An electron is accelerated under a potential difference of 182V. The maximum velocity of electron will be (Charge of electron is $1.6\times10^{-19}C$ and its mass is $9.1\times10^{-31}kg$)

   1) $5.65\times10^{6}\,ms^{-1}$ 2) $4\times10^{6}\,ms^{-1}$ 3) $8\times10^{6}\,ms^{-1}$ 4) $16\times10^{-6}\,ms^{-1}$

2. Magnetic flux of $10\mu Wb$ is linked with a coil, when a current of 2mA flows through it. What is the self inductance of the coil?

   1) 10 mH 2) 5 mH 3) 15 mH 4) 20 mH

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3. Pick out the true statement from the following

1) The direction of eddy current is given by Fleming's right hand rule

2) A choke coil is a pure inductor used for controlling current in an AC circuit

3) The energy stored in a conductor of capacitance C having a charge q is $\frac{1}{2}Cq^2$

4) The magnetic energy stored in a coil of self – inductance L carrying current I is $\frac{1}{2}LI^2$

5) Induction coil is powerful equipment used for generating high voltages

4. The torque required to hold a small circular coil of 10 turns, area $1mm^2$ and carrying a current of $(21/44)A$ in the middle of a long solenoid of 10^3 turns m^{-1} carrying a current of 2.5A, with its axis perpendicular to the axis of the solenoid is

1) $1.5\times10^{-6}N-m$ 2) $1.5\times10^{-8}N-m$ 3) $1.5\times10^{+6}N-m$ 4) $1.5\times10^{+8}N-m$

2010

5. Magnetic field at the centre of a circular loop of area A is B. The magnetic moment of the loop will be

1) $\frac{BA^2}{\mu_o\pi}$ 2) $\frac{BA^{3/2}}{\mu_o\pi}$ 3) $\frac{BA^{3/2}}{\mu_o\pi^{1/2}}$ 4) $\frac{2BA^{3/2}}{\mu_o\pi^{1/2}}$

6. 3A of current is flowing in a linear conductor having a length of 40mc. The conductor is placed in a magnetic field of strength 500 gauss and makes an angle of $30°$ with direction of the field. It experiences a force of magnitude

1) 3×10^4N 2) 3×10^2N 3) $3\times10^{-2}N$ 4) $3\times10^{-4}N$

7. Two thin long parallel wires separated by a distance b are carrying a current i ampere each. The magnitude of the force per unit length exerted by one wire on the other, is

1) $\frac{\mu_o i^2}{b^2}$ 2) $\frac{\mu_o i}{2\pi b^2}$ 3) $\frac{\mu_o i}{2\pi b}$ 4) $\frac{\mu_o i^2}{2\pi b}$

8. A coil in the shape of an equilateral triangle of side 0.02m is suspended from its vertex such that it is hanging in a vertical plane between the pole pieces of permanent magnet producing a uniform field of $5\times10^{-2}T$. If a current of 0.1A is passed through the coil, what is the couple acting ?

1) $5\sqrt{3}\times10^{-7}N-m$ 2) $5\sqrt{3}\times10^{-10}N-m$ 3) $\frac{\sqrt{3}}{5}\times10^{-7}N-m$ 4) None of these

9. Assertion (A): Torque on the coil is the maximum, when coil is suspended in a radial magnetic field

Reason (R): The torque tends to rotate the coil on its own axis

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

2) Both A and R are correct. R is not the correct explanation of A.

3) A is true, but R is false

4) Both A and R are false

10. A square current carrying loop is suspended in uniform magnetic field acting in the plane of the loop. If the force on one arm of the loop is F, the net force on the remaining three arms of the loop is

1) 3F 2) – F 3) – 3F 4) F

11. A wire of length L is bent in the form of a circular coil and current i is passed through it. If this coil is placed in a magnetic field then the torque acting on the coil will be maximum when the number of turns is

1) as large as possible 2) any number 3) 2 4) 1

12. A coil of 100 turns and area $2\times10^{-2}m^2$ is pivoted about a vertical diameter in a uniform magnetic filed and carries a current of 5A. When the coil is held with its plane in north – south direction, it experiences a couple of 0.33 Nm. When the plane is east – west, the corresponding couple is 0.4Nm, the value of magnetic induction is (Neglect earth's magnetic field)

1) 0.2 T 2) 0.3 T 3) 0.4 T 4) 0.05 T

13. Two long straight wires are set parallel to each other at separation r and each carries a current i in the same direction. The strength of the magnetic field at any point midway between the two wires is

1) $\frac{\mu_o i}{\pi r}$ 2) $\frac{2\mu_o i}{\pi r}$ 3) $\frac{\mu_o i}{2\pi r}$ 4) zero

14. The ratio of magnetic field and magnetic moment at the centre of a current carrying circular loop is x. When both the current and radius is doubled the ratio will be

1) $x/8$ 2) $x/4$ 3) $x/2$ 4) $2x$

2009

15. In moving coil galvanometer, the magnetic field used is

1) Non – uniform 2) radial 3) uniform 4) None of these

16. What is shape of magnet in moving coil galvanometer to make the radial magnet field?

1) Concave 2) Horse shoe magnet 3) Convex 4) None of these

17. Calculate the current which will produce a deflection of $30°$ in a tangent galvanometer, if its reduction factor is 3A

1) 1.732 A 2) 0.732 A 3) 3.732 A 4) 2.732 A

18. A copper rod is suspended in a non homogeneous magnetic field region. The rod when in equilibrium with align itself

1) in the region where magnetic field is strongest

2) in the region where magnetic field is weaker and parallel to direction of magnetic field there

3) in the direction in which it was originally suspended

4) in the region where magnetic field is weakest and perpendicular to the direction of magnetic field there

19. In a moving coil galvanometer, to make the field radial

1) coil is wound on wooden frame 2) magnetic poles are cylindrically cut

3) a horse – shoe magnet is used 4) the number of windings in the coil is decreased

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20. A wire of length l carrying a current I A is bent into a circle. The magnitude of the magnetic moment is

1) $\frac{lI^2}{2\pi}$ 2) $\frac{lI^2}{4\pi}$ 3) $\frac{l^2 I}{2\pi}$ 4) $\frac{l^2 I}{4\pi}$

21. The magnetic dipole moment of current loop i, independent of

1) magnetic field in which it is lying 2) number of turns
3) area of the loop 4) current in the loop

2008

22. A straight wire of mass 200g and length 1.5m carries a current of 2A. It is suspended in mid – air by a uniform horizontal field B. The magnitude of B (in tesla) is (assume $g = 9.8\,ms^{-2}$)

1) 2 2) 1.5 3) 0.55 4) 0.65

23. Two streams of protons move parallel to each other in the same direction. Then these

1) do not interact at all 2) attract each other
3) repel each other 4) get rotated to be perpendicular to each other

24. Consider two straight parallel conductors A and B separated by a distance x and carrying individual currents I_A and I_B respectively. If the two conductors attract each other, it indicates that

1) the two currents are parallel in direction
2) the two currents are anti – parallel in direction
3) the magnetic lines of induction are parallel
4) the magnetic lines of induction are parallel to length of conductors

2007

25. A proton with energy of 2MeV enters a uniform magnetic field of 2.5T normally. The magnetic force on the proton is (Take mass of proton to be $1.6\times10^{-27}\,kg$)

1) $3\times10^{-12}\,N$ 2) $8\times10^{-10}\,N$ 3) $8\times10^{-12}\,N$ 4) $2\times10^{-10}\,N$

26. Currents of 10A and 2A are passed through two parallel wires A and B respectively in opposite directions. If the wire A is infinitely long and length of the wire B is 2m, the force acting on the conductor B which is situated at 10cm distance from A will be

1) $5\times10^{-5}\,N$ 2) $4\pi\times10^{-7}\,N$ 3) $8\times10^{-5}\,N$ 4) $8\pi\times10^{-7}\,N$

27. Two free parallel wires carrying currents in the opposite directions

1) attract each other 2) repel each other
3) do not effect each other 4) get rotated to be perpendicular to each other

2006

28. A conducting circular loop of radius r carries a constant current I. It is placed in a uniform magnetic field B_o such that B_o is perpendicular to the plane of the loop. The magnetic force acting on the loop is

1) IrB_o 2) $2\pi IrB_o$ 3) πIrB_o 4) zero

29. A proton moving vertically downward enters a magnetic field pointing towards north. In which direction proton will deflect ?

1) East 2) West 3) North 4) South

30. Graph of force per unit length between two long parallel currents carrying conductor and the distance between them is

1) straight line 2) parabola 3) ellipse 4)rectangular hyperbola

2005

31. A coil in the shape of an equilateral triangle of side l is suspended between the pole pieces of a permanent magnet such that B is in plane of the coil. If due to a current i in the triangle a torque τ acts on it, the side l of the triangle is

1) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bi}\right)^{1/2}$ 2) $\frac{2}{\sqrt{3}}\left(\frac{\tau}{Bi}\right)$ 3) $2\left(\frac{\tau}{\sqrt{3}Bi}\right)^{1/2}$ 4) $\frac{1}{\sqrt{3}}\frac{\tau}{Bi}$

32. Two parallel wires carrying currents in the same direction attract each other because of

1) Potential difference between them 2) mutual inductance between them

3) electric force between them 4) magnetic force between them

33. The force on a conductor of length l placed in a magnetic field of magnitude B and carrying a current i is given by (θ is the angle, the conductor makes with the direction of B)

1) $F = ilB\sin\theta$ 2) $F = i^2lB^2\sin\theta$ 3) $F = ilB\cos\theta$ 4) $F = \frac{i^2l}{B}\sin\theta$

FORCE AND TORQUE ON A CURRENT CARRYING CONDUCTOR

KEY

1) **c**	2) **b**	3) **b**	4) **b**	5) **d**	6) **c**	7) **d**	8) **a**	9) **b**	10) **b**
11) **d**	12) **d**	13) **d**	14) **a**	15) **b**	16) **a**	17) **a**	18) **d**	19) **b**	20) **d**
21) **a**	22) **d**	23) **c**	24) **a**	25) **c**	26) **c**	27) **b**	28) **d**	29) **a**	30) **a**
31) **c**	32) **d**	**33)** **a**							

SOLUTIONS

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

$\frac{1}{2}\times 9\times 10^{-31}\times v^2 = 1.6\times 10^{-19}\times 182$

$v^2 = \frac{1.6\times 10^{-19}\times 182\times 2}{9.1\times 10^{-31}} = 64\times 10^{12}$

$v = 8\times 10^6\, ms^{-1}$

2. $\phi = Li$

$L = \frac{\phi}{i} = \frac{10\times 10^{-6}}{2\times 10^{-3}} = 5\times 10^{-3} = 5mH$

3. Energy = $\frac{1}{2}\frac{q^2}{C}$

4. We have M = NIA

$B = \mu_o nI$

Torque, C = MB

Here, $C = (n_1 I_1 A)(\mu_o n_1 I_2)$

$= \left(10\times\frac{21}{44}\times10^{-6}\right)\left(4\times\frac{22}{7}\times10^{-7}\times10^{3}{}_{t2.5}\right) = 1.5\times10^{-8}N-m$

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

$I = \frac{2Br}{\mu_o}$

Also, $A = \pi r^2$ or $r = \left(\frac{A}{\pi}\right)^{1/2}$

Magnetic moment, $M = IA = \frac{2Br}{\mu_o}A = \frac{2BA}{\mu_o}\times\left(\frac{A}{\pi}\right)^{1/2} = \frac{2BA^{3/2}}{\mu_o\pi^{1/2}}$

6. $F = Bil\sin\theta$

$= 500\times10^{-4}\times3\times\left(40\times10^{-2}\right)\times\frac{1}{2}$

$= 3\times10^{-2}N$

7. The magnitude of magnetic field B at any point on Y due to current i_1 in X is given by

$B = \frac{\mu_o}{2\pi}\frac{i_1}{b}$

$F = i_2 Bl = i_2\left(\frac{\mu_o}{2\pi}\frac{i_1}{b}\right)l$

Force per unit length is

$\frac{F}{l} = \frac{\mu_o}{2\pi}\frac{i_1 i_2}{b}$

Given, $i_1 = i_2 = i$, therefore,

$$\frac{F}{l} = \frac{\mu_o}{2\pi}\frac{i^2}{b}$$

8. Torque $\tau = iAB\sin\theta,\ i = 0.1A,\ \theta = 90°$

$$A = \frac{1}{2}\times \text{base}\times\text{height}$$

or $$A = \frac{1}{2}a\times\frac{a\sqrt{3}}{2}$$

$$= \frac{\sqrt{3}a^2}{4} = \frac{\sqrt{3}\times(0.02)^2}{4}$$

$$= \sqrt{3}\times10^{-4}m^2\ ;\ \theta = 90°$$

$$\tau = 0.1\times\sqrt{3}\times10^{-4}\times5\times10^{-2}\sin 90°$$

$$= 5\sqrt{3}\times10^{-7}\,N-m$$

11. $\tau_{\max} = MB$

or $\tau_{\max} = ni\pi r^2 B$

Let number of turns in length l is n so $l = n(2\pi r)$

or $r = \frac{1}{2\pi n}$

$$\Rightarrow\ \tau_{\max} = \frac{ni\pi Bl^2}{4\pi^2 n^2} = \frac{l^2 iB}{4\pi n_{\min}}$$

$$\Rightarrow \tau_{\max} \propto \frac{1}{n_{\min}}$$

$$\Rightarrow n_{\min} = 1$$

12. $NBiA\sin\theta = \tau$

N, B, i and A are constants

$\therefore\ \sin\theta \propto 0.3$

$\cos\theta \propto 0.4$

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$\tan\theta = \frac{3}{4}$ and $\sin\theta = \frac{3}{5}$

$$B = \frac{\tau}{NiA\sin\theta}$$

$$B = \frac{0.3\times 5}{100\times 5\times 2\times 10^{-2}\times 3} = 0.05T$$

13. $$B_1 = \frac{\mu_o i}{2\pi\left(\frac{r}{2}\right)}$$

$$B_2 = \frac{\mu_o i}{2\pi\left(\frac{r}{2}\right)}$$

So, $B_{\text{net}} = 0$

14. $$B = \frac{\mu_o}{4\pi}\left(\frac{2\pi i}{a}\right) = \frac{\mu_o i}{2a}$$

$$M = i\left(\pi a^2\right)$$

$$\therefore \frac{B}{M} = \frac{\mu_o i}{2a}\times\frac{1}{i\pi a^2} = \frac{\mu_o}{2\pi a^3} = x \text{ (given)}$$

When both the current and the radius are doubled, the ratio becomes

$$\frac{\mu_o}{2\pi(2a)^3} = \frac{\mu_o}{8\left(2\pi a^3\right)} = \frac{x}{8}$$

20. $$2\pi r = l$$

Area = $\pi r^2 = \frac{l^2}{4\pi}$

Magnetic moment = $IA = \frac{Il^2}{4\pi}$

22. Magnetic force on straight wire

$$F = BIl\sin\theta = BIl\sin 90° = BIl$$

For equilibrium of wire in mid – air

F = mg

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$$BIl = mg$$

$$\therefore\ B = \frac{mg}{Il} = \frac{200\times10^{-3}\times9.8}{2\times1.5} = 0.65T$$

25. Energy of proton = 2MeV

$$= 2\times1.6\times10^{-19}\times10^{6}\,J$$

$$= 3.2\times10^{-13}\,J$$

Magnetic field (B) = 2.5 T

Mass of proton $(m) = 1.6\times10^{-27}\,kg$

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

$$\therefore\ v = \sqrt{\frac{2E}{m}}\ \text{.........}\ \text{(i)}$$

Magnetic force on proton

$$F = Bqv\sin 90^\circ = \text{Bqv}$$

$$\therefore F = Bq\sqrt{\frac{2E}{m}} = 2.5\times1.6\times10^{-19}\sqrt{\frac{2\times3.2\times10^{-13}}{1.6\times10^{-27}}} = 8\times10^{-12}\,N$$

26. $F = \frac{\mu_o}{4\pi}.\frac{2I_1I_2}{r}l$

$I_1 = 10A,\ I_2 = 2A,\ l = 2m$

R = 10 cm = 0.1 m

$$\therefore\ F = 10^{-7}\times\frac{2\times10\times2\times2}{0.1} = 8\times10^{-5}\,N$$