DPP - Daily Practice Problems

Name :

Date :

Start Time :

End Time :

PHYSICS 42

SYLLABUS : MAGNETISM AND MATTER - 1 (Bar magnet as an equivalent solenoid, Magnetic field lines, Earth's magnetic field and magnetic elements)

Max. Marks : 120 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.21) : There are 21 mul1tiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 A north pole of strength 50 Am and south pole of strength 100 Am are separated by a distance of 10 cm in air. Find the force between them.
(a) 50×10^{-3} N (b) 25×10^{-3} N
(c) 20×10^{-6} N (d) 30×10^{-18} N

Q.2 Calculate magnetic induction at a distance of 20 cm from a pole of strength 40 Am in air.
(a) 10^{-4} wb/m^2 (b) 10^{-8} wb/m^2
(c) 10^{-1} wb/m^2 (d) 10^{-12} wb/m^2

Q.3 A bar magnet of length 0.2 m and pole strength 5 Am is kept in a uniform magnetic induction field of strength 15 wb/m^{-2} making an angle of 30° with the field. Find the couple acting on it.
(a) 2.5 Nm (b) 5.5 Nm (c) 7.5 Nm (d) 9.0 Nm

Q.4 The force experienced by a pole of strength 100 Am at a distance of 0.2 m from a short magnet of length 5 cm and pole strength of 200 Am on its axial line will be
(a) 2.5×10^{-2} N (b) 2.5×10^{-3} N
(c) 5.0×10^{-2} N (d) 5.0×10^{-3} N

Q.5 A magnet of moment M is lying in a magnetic field of induction B. W_1 is the work done in turning it from 0º to 60º and W_2 is the work done in turning it from 30º to 90º. Then
(a) $W_2 = W_1$ (b) $W_2 = \frac{W_1}{2}$
(c) $W_2 = 2W_1$ (d) $W_2 = \sqrt{3}\, W_1$

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

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Q.6 A bar magnet of magnetic moment 4.0 A-m^2 is free to rotate about a vertical axis through its centre. The magnet is released from rest from east-west position. Kinetic energy of the magnet in north-south position will be (Horizontal component of earth's magnetic field $B_H = 25\mu T$)
(a) 10^{-2} J (b) 10^{-4} J (c) 10^{-6} J (d) 0

Q.7 The length of a bar magnet is 10 cm and its pole strength is 10^{-3} Weber. It is placed in a magnetic field of induction $4\pi \times 10^{-3}$ Tesla in a direction making an angle 30º with the field direction. The value of torque acting on the magnet will be –
(a) $2\pi \times 10^{-7}$ N-m (b) $2\pi \times 10^{-5}$ N-m
(c) 0.5×10^2 N-m (d) None of these

Q.8 At magnetic poles of earth, angle of dip is
(a) zero (b) 45° (c) 90° (d) 180°

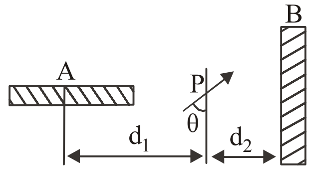
Q.9 A short bar magnet is placed with its north pole pointing south. The neutral point is 10 cm away from the centre of the magnet. If H = 0.4 gauss, calculate magnetic moment of the magnet.
(a) 2 Am^2 (b) 1 A m^2 (c) 0.1 A m^2 (d) 0.2 Am^2

Q.10 A bar magnet with its poles 25 cm apart and of pole strength 24.0 A-m rests with its centre on a frictionless pivot. A force F is applied on the magnet at a distance of 12 cm from the pivot, so that it is held in equilibrium at an angle of 30º with respect to a magnetic field of induction 0.25 T. The value of force F is
(a) 65.62 N (b) 2.56 N (c) 6.52 N (d) 6.25 N

Q.11 A small magnet of magnetic moment 4A-m^2 is placed on a deflection magnetometer in tan-B position at a distance of 20 cm from the compass needle. At what distance from compass needle should another small magnet of moment 0.5 A-m^2 be placed such that the deflection of the needle remains zero ?
(a) 12 cm (b) 10 cm (c) 20 cm (d) 30 cm

Q.12 The ratio of intensities of magnetic field, at distances x and 2x from the centre of magnet of length 2cm on its axis, will be
(a) 4 : 1 (b) 4 : 1 approx
(c) 8 : 1 (d) 8 : 1 approx

Q.13 Two magnets A and B are identical and these are arranged as shown in the figure. Their length is negligible in comparison to the separation between them. A magnetic needle is placed between the magnets at point P which gets deflected through an angle θ under the influence of magnets. The ratio of distances d_1 and d_2 will be
(a) $(2 \tan \theta)^{1/3}$
(b) $(2 \tan \theta)^{-1/3}$
(c) $(2 \cot \theta)^{1/3}$
(d) $(2 \cot \theta)^{-1/3}$



Q.14 The period of oscillation of a freely suspended bar magnet is 4 second. If it is cut into two equal parts length wise then the time period of each part will be
(a) 4 sec (b) 2 sec (c) 0.5 sec (d) 0.25 sec

Q.15 The length, breadth and mass of two bar magnets are same but their magnetic moments are 3M and 2M respectively. These are joined pole to pole and are suspended by a string. When oscillated in a magnetic field of strength B, the time period obtained is 5s. If the poles of either of the magnets are reverse then the time period of the combination in the same magnetic field will be –
(a) $3\sqrt{3}$ s (b) $2\sqrt{2}$ s (c) $5\sqrt{5}$ s (d) 1 s

Q.16 A thin magnetic needle oscillates in a horizontal plane with a period T. It is broken into n equals parts. The time period of each part will be
(a) T (b) $\frac{T}{n}$ (c) Tn^2 (d) $\frac{T}{n^2}$

Q.17 A bar magnet made of steel has a magnetic moment of 2.5 A-m^2 and a mass of 6.6×10^3 kg. If the density of steel is 7.9×10^9 kg/m^3, find the intensity of magnetization of the magnet.
(a) 3.0×10^6 A/m (b) 2.0×10^6 A/m
(c) 5.0×10^6 A/m (d) 1.2×10^6 A/m

Q.18 A short magnet of length 4 cm is kept at a distance of 20 cm to the east of a compass box such that is axis is perpendicular to the magnetic meridian. If the deflection produced is 45°, find the pole strength (H = 30 Am^{-1})
(a) 17.7 Am (b) 44.2 Am
(c) 27.7 Am (d) 37.7 Am

RESPONSE GRID					
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ		

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Q.19 A 10 cm long bar magnet of magnetic moment 1.34 Am^2 is placed in the magnetic meridian with its south pole pointing geographical south. The neutral point is obtained at a distance of 15 cm from the centre of the magnet. Calculate the horizontal component of earth's magnetic field.
(a) 0.12×10^{-4} T (b) 0.21×10^{-4} T
(c) 0.34×10^{-4} T (d) 0.87×10^{-7} T

Q.20 A 30 cm long bar magnet is placed in the magnetic meridian with its north pole pointing south. The neutral point is obtained at a distance of 40 cm from the centre of the magnet. Pole strength of the magnet is (The horizontal component of earth's magnetic field is 0.34 Gauss)
(a) 26.7 Am (b) 16.7 Am (c) 12.7 Am (d) 15.2 Am

Q.21 A long straight horizontal cable carries a current of 2.5 A in the direction 10° south of west to 10° north of east. The magnetic meridian of the place happens to be 10° west of the geographic meridian. The earth's magnetic field at the location is 0.33 Gauss, and the angle of dip is zero. Distance of the line of neutral points from the cable is (Ignore the thickness of the cable).
(a) 1.5 cm (b) 2.5 cm (c) 3.5 cm (d) 2.0 cm

DIRECTIONS (Q.22-Q.24) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :
(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct
(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.22 Which of the following is/are not the main difference between electric lines of force and magnetic lines of force ?
(1) Electric lines of force are closed curves whereas magnetic lines of force are open curves.
(2) Magnetic lines of force cut each other whereas electric lines of force do not cut.
(3) Electric lines of force cut each other whereas magnetic lines of force do not cut.
(4) Electric lines of force are open curves whereas magnetic lines of force are closed curves.

Q.23 The correct statements regarding the lines of force of the magnetic field B are
(1) Magnetic intensity is a measure of lines of force passing through unit area held normal to it
(2) Magnetic lines of force form a closed curve
(3) Due to a magnet magnetic lines of force never cut each other
(4) Inside a magnet, its magnetic lines of force move from north pole of a magnet towards its south pole

Q.24 A short bar magnet of magnetic moment 5.25×10^{-2} JT^{-1} is placed with its axis perpendicular to the earth's field direction. Magnitude of the earth's field at the place is given to be 0.42 G. Ignore the length of the magnet in comparison to the distance involved. Then
(1) the distance from the centre of the magnet on its normal bisector at which the resultant field is inclined at 45° with the earth's field is 5 cm
(2) the distance from the centre of the magnet on its axis at which the resultant field inclined at 45° with the earth's field is 6.3 cm
(3) the distance from the centre of the magnet on its normal bisector at which the resultant field inclined at 45° with the earth's field is 8.3 cm
(4) the distance from the centre of the magnet on its axis at which the resultant field inclined at 45° with the earth's field is 8 cm

DIRECTIONS (Q.25-Q.27) : Read the passage given below and answer the questions that follows :

A telephone cable at a place has four long, straight horizontal wires carrying a current of 1.0 A in the same direction east to west. The earth's magnetic field at the place is 0.39 Gauss, and the angle of dip is 35°. The magnetic declination is nearly zero. (cos 35° = 0.82, sin 35° = 0.57)

Q.25 The magnetic field produced by four current carrying straight cable wires at a distance 4 cm is
(a) 0.2 Gauss (b) 0.3 Gauss
(c) 0.4 Gauss (d) 0.5 Gauss

Q.26 The resultant magnetic field below at points 4cm and above the cable are
(a) 0.25, 0.56 Gauss (b) 0.14, 0.32 Gauss
(c) 0.23, 0.34 Gauss (d) 0.52, 0.62 Gauss

RESPONSE GRID					
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ
	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ		

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Q.27 The angle that resultant makes with horizontal in case below and above the cable respectively, are

(a) 30°, 45° (b) $\tan^{-1} 1.8, \tan^{-1} 0.43$

(c) $\tan^{-1} 2, \tan^{-1}\sqrt{2}$ (d) $\sin^{-1} 0.7, \sin^{-1} 0.9$

DIRECTIONS (Q. 28-Q.30) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.

(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.

(c) Statement-1 is False, Statement-2 is True.

(d) Statement-1 is True, Statement-2 is False.

Q.28 **Statement-1 :** Gauss theorem is not applicable in magnetism.

Statement-2 : Mono magnetic pole does not exist.

Q.29 **Statement-1 :** A compass needle when placed on the magnetic north pole of the earth cannot rotate in vertical direction.

Statement-2 : The earth has only horizontal component of its magnetic field at the north poles.

Q.30 **Statement-1 :** We cannot think of magnetic field configuration with three poles.

Statement-2 : A bar magnet does not exert a torque on itself due to its own field.

RESPONSE GRID	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 42 - PHYSICS			
Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	30	Qualifying Score	50
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

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DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS 42

1. **(a).** Force between magnetic poles in air is given by

$$F=\frac{\mu_0}{4\pi}\times\frac{m_1 m_2}{r^2}$$

Given that $m_1 = 50$ Am, $m_2 = 100$Am,
r = 10 cm = 0.1 m and
μ_0 = permeability of air = $4\pi \times 10^{-7}$ Hm^{-1}.

$$\therefore F=\frac{4\pi\times10^{-7}}{4\pi}.\frac{50\times100}{0.1\times0.1}=50\times10^{-3}\text{ N}$$

2. **(a)** Strength of a magnetic field due to a pole of strength m is given by

$$H=\frac{1}{4\pi}.\frac{m}{r^2}$$

Given that m = 40 Am, r = 20 cm = 20×10^{-2} m.

$$\therefore\quad H=\frac{1}{4\pi}\times\frac{40}{(20\times10^{-2})^2}=79.57\text{ Am}^{-1}$$

Now, magnetic induction at the same point :
$B = \mu_0 H = 4\pi \times 10^{-7} \times 79.57 = 10^{-4}$ wb/m^2

3. **(c)** Couple acting on a bar magnet of dipole moment M when placed in a magnetic field, is given by
$\tau = MB \sin\theta$
where θ is the angle made by the axis of magnet with the direction of field.
Given that m = 5 Am, $2\ell = 0.2$ m, θ = 30°
and B = 15 Wbm^{-2}
∴ $\tau = MB\sin\theta = (m \times 2\ell) B \sin\theta$

$$=5\times0.2\times15\times\frac{1}{2}=7.5\text{ Nm.}$$

4. **(a)** $F = mB = \frac{\mu_0}{4\pi}\frac{2m'\ell}{x^3}m$

$$=\frac{10^{-7}\times2\times200\times0.05\times100}{8\times10^{-3}}$$

$= 2.5 \times 10^{-2}$ N

5. **(d).** $W = MB(\cos\theta_1 - \cos\theta_2)$

$$\therefore W_1 = MB(\cos 0^\circ-\cos 60^\circ)=\frac{MB}{2}$$

$$W_2 = MB(\cos 30^\circ-\cos 90^\circ)=\frac{\sqrt{3}\,MB}{2}$$

$\therefore W_2 = \sqrt{3}\,W_1$.

6. **(b).** Loss in P.E. = gain in K.E.
$\therefore E_k = U_i - U_j = -MB\cos 90^\circ - (-MB\cos 0^\circ)$
$= 4 \times 25 \times 10^{-6} = 10^{-4}$ J

7. **(a).** $\tau = MB\sin\theta = m\ell B\sin\theta$
$= 10^{-3} \times 0.1 \times 4\pi \times 10^{-3} \times 0.5$
$= 2\pi \times 10^{-7}$ N-m

8. **(c)**

9. **(d)** Here, d = 10 cm = 0.1 m,
H = 0.4 gauss = 0.4 x 10^{-4} T, M = ?
Neutral points in this case, lie on axial line of magnet, such that

$$\frac{\mu_0}{4\pi}\frac{2M}{d^3}=H$$

$$\therefore 10^{-7}\times\frac{2M}{(0.1)^3}=0.4\times10^{-4}$$

$M = 0.2$ A m^2

10. **(d).** $\tau = F \times r = MB\sin 30$

$$F=\frac{\ell\times mB\sin30}{r}$$

$$=\frac{25\times10^{-2}\times24\times0.25}{12\times10^{-2}}\times\frac{1}{2}=6.25\text{ N}$$

11. **(b).** $B=\frac{\mu_0}{4\pi}\times\frac{2M}{x^3}$ = constant

$$\therefore x_2=x_1\left(\frac{M_2}{M_1}\right)^{1/3}=20\times\left(\frac{1}{2\times4}\right)^{1/3}=10\text{ cm}$$

12. **(d).** $B=\frac{\mu_0}{4\pi}=\frac{2M}{(\ell^2+x^2)^{3/2}}=\frac{\mu_0}{4\pi}\frac{2M}{x^3}$

$$\therefore\frac{B_1}{B_2}=\left(\frac{x_2}{x_1}\right)^3=8:1\text{ approximately.}$$

13. **(c).** According to tangent law
$B_A = B_B\tan\theta$

$$\text{or}\quad\frac{\mu_0}{4\pi}\frac{2M}{d_1^3}=\frac{\mu_0}{4\pi}\frac{M}{d_1^3}\tan\theta$$

$$\therefore\frac{d_1}{d_2}=(2\cot\theta)^{1/3}$$

14. **(a).** $T=2\pi\sqrt{\frac{I}{MB}}=2\pi\sqrt{\frac{m\ell^2}{12\times m_p\ell B}}=4\text{ sec}$

$$T'=2\pi\sqrt{\frac{\frac{m}{2}\ell^2}{12\times\frac{m_p}{2}\ell B}}=4\text{ sec}$$

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15. **(c).** $T = 2\pi\sqrt{\frac{I}{MB}}$ or $T \propto \frac{1}{\sqrt{M}}$

$$\frac{T_1}{T_2} = \sqrt{\frac{3M - 2M}{3M + 2M}} \text{ or } T_2 = 5\sqrt{5}\ s$$

16. **(b).** $T = 2\pi\sqrt{\frac{I}{MB}}$

$$= 2\pi\sqrt{\frac{m\ell^2/12}{m_p \ell B}} \text{ or } T \propto m\ell$$

$$\frac{T'}{T} = \left(\frac{\frac{m}{n}\frac{\ell}{n}}{m\ell}\right)^{1/2} \text{ or } T' = \frac{T}{n}$$

17. **(a).** The volume of the bar magnet is

$$V = \frac{\text{mass}}{\text{density}}$$

$$= \frac{6.6 \times 10^{-3}\,kg}{7.9 \times 10^3\,kg/m^3} = 8.3 \times 10^{-7}\,m^3.$$

The intensity of magnetization is

$$I = \frac{M}{V} = \frac{2.5\ A - m^2}{8.3 \times 10^{-7}\ m^2}$$

$$= 3.0 \times 10^6\ A/m$$

18. **(d).** The compass box will be on the axial line of the magnet,

Hence, $\frac{1}{4\pi}\cdot\frac{2M}{r^3} = \frac{1}{4\pi}\cdot\frac{2 \times 2\ell m}{r^3} = H \tan\theta$

Given that H = horizontal component of the earth's magnetic field = $30\ Am^{-1}$, $\theta = 45°$,

$r = 20\ cm = 0.02\ m$,

$M = 2\ \ell\ m = 4 \times 10^{-2}\ m$

Hence, $\frac{2 \times 4 \times 10^{-2}\,m}{4\pi\,(0.2)^3} = 30 \times \tan 45° = 30 \times 1;$

$$\therefore m = \frac{30 \times 4\pi \times (0.2)^3}{2 \times 4 \times 10^{-2}} = 37.7\ Am$$

19. **(c).** As the magnet is placed with its south pole pointing south, hence the neutral point lies on the equatorial line. At the neutral point, the magnetic field B due to the magnet becomes equal and opposite to horizontal component of earth's magnetic field i.e., B_H.
Hence, if M be magnetic dipole moment of the magnet of length 2ℓ and r the distance of the neutral point from its centre, then

$$B = \frac{\mu_0}{4\pi}\frac{M}{(r^2 + \ell^2)^{3/2}} = B_H$$

Given that $\mu_0 = 4\pi \times 10^{-1}\ T\ mA^{-1}$,
$M = 13.4\ Am^2$,
$r = 15\ cm = 0.15\ m$ and $\ell = 5.0\ cm = 0.05\ m$

$$\therefore B_H = 10^{-7} \times \frac{1.34}{[(0.15)^2 + (0.5)^2]^{3/2}}$$

$$= 10^{-7} \times \frac{1.34}{0.025\sqrt{0.025}} = 0.34 \times 10^{-4}\ T$$

20. **(a).** As the magnet is placed with its north pole pointing south, the neutral points are obtained on the axial line. At the neutral points the magnetic field B due to the magnet becomes equal and opposite to the horizontal component of earth's magnetic field i.e., B_H.
Hence, if M be the magnetic dipole moment of the magnet of length 2ℓ and r the distance of neutral point from the centre of the magnet, then we have

$$B = \frac{\mu_0}{4\pi}\cdot\frac{2Mr}{(r^2 - \ell^2)^2} = B_H$$

Given that $\mu_0 = 4\pi \times 10^{-7}\ TmA^{-1}$,
$r = 40\ cm = 0.40\ m$, $\ell = 15\ cm = 0.15\ m$ and
$H_H = 0.34$ Gauss $= 0.34 \times 10^{-4}\ T$

$$\therefore M = \frac{4\pi}{\mu_0}\cdot\frac{B_H(r^2 - \ell^2)^2}{2r}$$

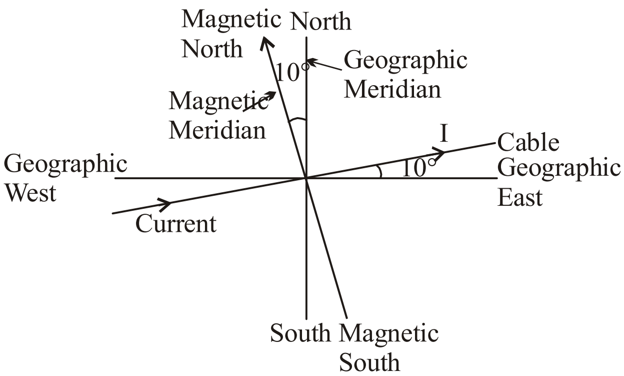
$$= 10^{-7} \times \frac{(0.34 \times 10^{-4}) - [(0.40)^2 - (0.15)^2]^2}{2 \times 0.40}$$

$= 8.0\ Am^2$

The pole strength of the magnet is,

$$m = \frac{M}{2\ell} = \frac{8.0}{0.30} = 26.7\ Am$$

21. **(a).** The situation is shown in figure. The horizontal component of earth's magnetic field at the location of the cable (angle of dip $\theta = 0$ is)



$B_H = B\cos\theta = B\cos 0 = B = 0.33$ Gauss
$= 0.33 \times 10^{-4}$ Tesla
B_H is directed horizontally in the magnetic meridian.
The magnetic field produced by the cable at a distance of R meter is given by

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

$$= 2 \times 10^{-7} \times \frac{2.5}{R} = \frac{5.0 \times 10^{-7}}{R} T$$

According to right-hand-palm rule no, 1, the field B is directed horizontally along B_H at a point below the cable, and opposite to B_H at a point above the cable. Therefore, neutral points will be obtained above the cable. At these points, will be equal and opposite to B_H. Thus

$$\frac{5.0 \times 10^{-7}}{R} = B_H = 0.33 \times 10^{-4}.$$

$$\text{or } R = \frac{5.0 \times 10^{-7}}{0.33 \times 10^{-4}} = 15 \times 10^{-3} \text{ m} = 1.5 \text{ cm}$$

Thus, the line of neutral points lies above and parallel to the cable at a distance of 1.5 cm from it.

22. **(a)** The magnetic lines of force are in the form of closed curves whereas electric lines of force are open curves.

23. **(a)** Inside a magnet, magnetic lines of force move from south pole to north pole.

24. **(b)** Given that pole strength, $m = 5.25 \times 10^{-2}$ JT^{-1}, $\theta = 45°$

and $B = 0.42$ G $= 0.42 \times 10^{-4}$ T.

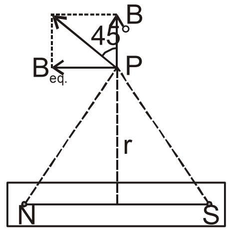

Figure shows a point P on the normal bisector of a short bar magnet lying at a distance r from the centre O of the magnet. It is given that resultant magnetic field at P makes an angle of 45° w.r.t. earth's field B.

From the figure, it is clear that

$B_{eq} = B \tan 45° = B.$

Now, for a short bar magnet in this position

$$B_{eq} = B = \frac{\mu_0}{4\pi} \cdot \frac{M}{r^3}$$

$$\text{or } r^3 = \frac{\mu_0}{4\pi} \cdot \frac{M}{B}$$

$$= 10^{-7} \times \frac{5.25 \times 10^{-2}}{0.42 \times 10^{-4}} = 125 \times 10^{-7}.$$

$\therefore r = 5 \times 10^{-2}$ m $= 5$ cm.

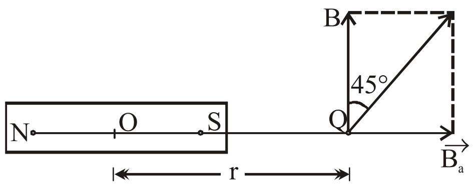

Figure shows a point Q on the axis of a short bar magnet lying at a distance r from the centre of the magnet. It is given that resultant magnetic field at Q is inclined at an angle of 45° w.r.t. earth's field B.

From the figure, it is clear that

$B_a = B \tan 45° = B$

Now for a short bar magnet in this position,

$$B_a = B = \frac{\mu_0}{4\pi} \cdot \frac{2M}{r^3}$$

$$\text{or } r^3 = \frac{\mu_0}{4\pi} \cdot \frac{2M}{B} = 2 \times 125 \times 10^{-6}$$

$$\therefore r = (2 \times 125 \times 10^{-6})^{1/3} = 6.3 \text{ cm}$$

25-27

Given that earth's magnetic field, B = 0.39 G and angle of dip, $\theta = 35°$

Horizontal and vertical components of earth's magnetic field B at the location of the cable are

$B_H = B \cos\theta = 0.39 \cos 35°$

$= 0.39 \times 0.82 = 0.32$ Gauss and

$B_V = B \sin\theta = 0.39 \sin 35°$

$= 0.39 \times 0.57 = 0.22$ Gauss

The magnetic field produced by four current carrying straight cable wires at a distance R is

$$B' = \frac{\mu_0 I}{2\pi R} \times 4 = 2 \times 10^{-7} \times \frac{1.0}{0.04} \times 4$$

$= 0.2 \times 10^{-4}$ T $= 0.2$ Gauss

Resultant magnetic field below the cable

According to right - hand, palm rule no. 1, the direction of B′ below the cable will be opposite to that of B_H. Therefore, at a point 4 cm below the cable, resultant horizontal component of earth's magnetic field

$R_H = B_H - B' = 0.32 - 0.2 = 0.12$ Gauss.

Resultant vertical component of earth's magnetic field

$R_V = B_V = 0.22$ Gauss (unchanged)

∴ Resultant magnetic field below the cable is

$$R = \sqrt{[R_H^2 + R_V^2]}$$

$$= \sqrt{[(0.12)^2 + (0.22)^2]}$$

$= 0.25$ Gauss

The angle that R makes with the horizontal is given by

$$\theta = \tan^{-1}\frac{R_V}{R_H}$$

$$= \tan^{-1}\frac{0.22}{0.12} = \tan^{-1}(1.8) \cong 62°$$

Resultant magnetic field above the cable

Again, according to right - hand - palm no. 1, the direction of B′ at a point above the cable is the same as that of B_H.

Therefore, at a point 4 cm below the cable, the horizontal component of resultant magnetic field will be

$R_H = B_H + B' = 0.32 + 0.20 = 0.52$ Gauss

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Vertical component of resultant magnetic field will be $R_V = B_V - 0.22$ Gauss (unchanged)
Hence, magnitude of resultant magnetic field below the cable

$$R = \sqrt{[R^2{}_H + R^2{}_V]}$$

$$= \sqrt{[(0.52)^2 + (0.52)^2]}$$

$$= 0.56 \text{ Gauss}$$

The angle that R makes with the horizontal is given by

$$\theta = \tan^{-1}\left(\frac{R_V}{R_H}\right) = \tan^{-1}\left(\frac{0.22}{0.52}\right)$$

$$= \tan^{-1}(0.43) \cong 23°$$

25. **(a)** **26. (a)** **27. (b)**

28. **(a)**

29. **(d)** The earth has only vertical component of its magnetic field at the magnetic poles. Since compass needle is only free to rotate in horizontal plane. At north pole the vertical component of earth's field will exert torque on the magnetic needle so as to aligh it along its direction. As the compass needle can not rotate in vertical plane, it will rest horizontally, when placed ont he magnetic pole of the earth.

30. **(c)** It is quite clear that magnetic poles always exists in pairs. Since, one can imagine magnetic field configuration with three poles. When north poles or south poles of two magnets are glued together. They provide a three pole field configuration. It is also known that a bar magnet does not exert a torque on itself due to own its field.

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