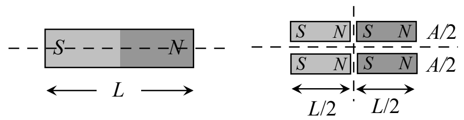
6. (d) For a magnet $B = \frac{\mu_0}{4\pi}.\frac{2M}{x^3}$ (Nearly)

$\Rightarrow \frac{B_1}{B_2} = \left(\frac{x_1}{x_2}\right)^3 = \left(\frac{x}{2x}\right)^3 = \frac{1}{8}$ (Approx.)

7. (b) For each part $m' = \frac{m}{2}$



8. (c) $\frac{B_1}{B_2} = \frac{d_1}{d_2}\left(\frac{d_2^2 - l^2}{d_1^2 - l^2}\right)^2 \Rightarrow \frac{12.5}{1} = \frac{10}{20}\left(\frac{400 - l^2}{100 - l^2}\right)^2$

$\Rightarrow l = 5\ cm$

Hence length of magnet $= 2l = 10\ cm$

9. (c) $B_1 = \frac{2M}{d^3}. B_2 = \frac{M}{d^3}$; $\therefore \frac{B_1}{B_2} = 2:1$

10. (a)

11. (c) $\tau = MB\sin\theta = 48 \times 25 \times 10^{-2} \times 0.15 \times \frac{1}{2} = 0.9\ N \times m$

12. (d) $B_1 = \frac{2M}{x^3}$ and $B_2 = \frac{M}{y^3}$

As $B_1 = B_2$

Hence $\frac{2M}{x^3} = \frac{M}{y^3}$ or $\frac{x^3}{y^3} = 2$ or $\frac{x}{y} = 2^{1/3}$

13. (c) Work done $W = MB_H(1 - \cos\theta)$

$= 20 \times 0.3(1 - \cos 30°) = 6\left(1 - \frac{\sqrt{3}}{2}\right) = 3(2 - \sqrt{3})$

14. (b) Magnetic intensity on end side-on position is twice than broad side on position.

15. (a) Along the axis of magnet $B_a = \frac{2M}{X^3} = 200\ guass$

$\Rightarrow B_a = \frac{M}{X^3} = 100\ guass$

16. (a)

17. (b)

18. (c)

19. (d) Provided length of magnet is <<the distance.

20. (b) Permeability of soft iron is maximum, so maximum lines of force tries to pass through the soft iron.

21. (a) Plane of coil is having angle θ with the magnetic field.

$\therefore \tau = MB\sin(90 - \theta)$ or $\tau = niAB\cos\theta$ [As $M = niA$]

22. (c) $B \propto \frac{1}{x^3} \Rightarrow \frac{B_1}{B_2} = \left(\frac{x_2}{x_1}\right)^3 = \left(\frac{3x}{x}\right)^3 = \frac{27}{1}$

23. (c) For null deflection $\frac{M_1}{M_2} = \left(\frac{d_1}{d_2}\right)^3 = \left(\frac{40}{50}\right)^3 = \frac{64}{125}$

24. (d)

25. (d) $F = \frac{\mu_0}{4\pi}\left(\frac{6MM'}{d^4}\right)$ in end-on position.

26. (d) Work done $MB(\cos\theta_1 - \cos\theta_2)$

$\theta_1 = 0^o$ and $\theta_2 = 180^o$

$\Rightarrow W = MB(\cos 0 - \cos 180) = 2MB$

27. (a) Pole strength doesn't depend upon the length.

28. (a) Torque $\tau = MB_H \sin\theta$

$= 0.1 \times 10^{-3} \times 4\pi \times 10^{-3} \times \sin 30^o = 10^{-7} \times 4\pi \times \frac{1}{2}$

$= 2\pi \times 10^{-7}\ N \times m$

29. (b) Number of lines of force passing through per unit area normally is intensity of magnetic field, hence option (c) is incorrect. The correct option is (b).

30. (a) Flux $= B \times A$; $\therefore B = \frac{Flux}{A} = Weber/m^2$

31. (a)

32. (b) $B = \frac{m}{d^2}$ in C.G.S. system.

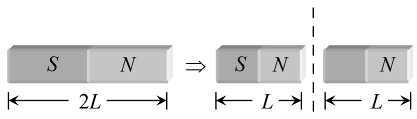
33. (a) $W = MB(\cos\theta_1 - \cos\theta_2) = MB(\cos 0^o - \cos 60^o)$

$= MB\left(1 - \frac{1}{2}\right) = \frac{MB}{2}$

and $\tau = MB\sin\theta = MB\sin 60^o = MB\frac{\sqrt{3}}{2}$

$\therefore \tau = \left(\frac{MB}{2}\right)\sqrt{3} \Rightarrow \tau = \sqrt{3}\ W$

34. (c)

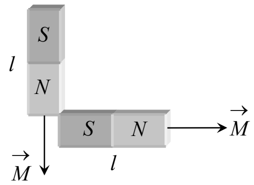


Pole strength of each part $= m$

Magnetic moment of each part

$= M' = m'L' = mL = \frac{M}{2}$

35. (c)



$M_{net} = \sqrt{2}M = \sqrt{2}ml.$

36. (b)

37. (b) $F \propto \frac{m_1 m_2}{r^2}$

38. (c) $F = 10^{-7} \times \frac{m^2}{r^2} = \frac{10^{-7}(1)^2}{(1)^2} = 10^{-7}\ N$

39. (b) $\tau = MH\sin\theta = MH\sin 30^o = \frac{MH}{2}$

40. (c)

41. (c) $F = \frac{\mu_0}{4\pi}\left(\frac{6MM'}{d^4}\right)$ in end-on position between two small magnets.

$\therefore F = 10^{-7}\left(\frac{6\times 10\times 10}{(0.1)^4}\right) = 0.6\,N$

42. (b)

43. (a) $\tau = MB_H\sin\theta$ or $\frac{d\tau}{d\theta} = MB_H\cos\theta$

This will be maximum. when $\theta = 0^o$.

44. (d) $W = MB(\cos\theta_1 - \cos\theta_2)$, $\theta_1 = 0^o$ and $\theta_2 = 360^o \Rightarrow W = 0$

45. (d)

46. (b) $W_1 = MB(\cos 0^o - \cos 90^o) = MB(1-0) = MB$

$W_2 = MB(\cos 0^o - \cos 60^o) = MB\left(1 - \frac{1}{2}\right) = \frac{MB}{2}$

$\therefore W_1 = 2W_2 \Rightarrow n = 2$

47. (d) In magnetic dipole, force $\propto \frac{1}{r^4}$

Hence new force $= \frac{4.8}{2^4} = \frac{4.8}{16} = 0.3\ N$

48. (a) Magnetic moment of bar $M = 10^4\ J/T$

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

Hence work done $W = \vec{M}.\vec{B}$

$= 10^4 \times 4\times 10^{-5} \times \cos 60^o = 0.2\ J$

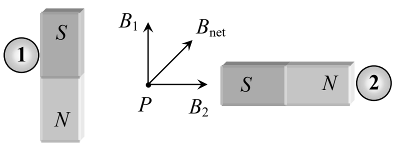
49. (a)

50. (d)

51. (c) $B = \frac{\mu_0}{4\pi}\frac{2M}{d^3} = 10^{-7}\times\frac{2\times 1.25}{(0.5)^3} = 2\times 10^{-6}\ N/A-m$

52. (b)

53. (b)



54. (c)

55. (b) $\tau = MB_H\sin\theta \Rightarrow 0.032 = M\times 0.16\times\sin 30^o$

$\Rightarrow M = 0.4\ J/\ tesla$

56. (b) $B_{equatorial} = \frac{\mu_0}{4\pi}\frac{M}{r^3}$

57. (c) Inside a magnet, magnetic lines of force move form south pole to north pole.

58. (b) Magnetic moment of circular loop carrying current

$M = IA = I(\pi R^2) = I\pi\left(\frac{L}{2\pi}\right)^2 = \frac{IL^2}{4\pi} \Rightarrow L = \sqrt{\frac{4\pi M}{I}}$

59. (c)

60. (b) Concept of magnetic screening.

61. (b) Repulsion is the sure test of magnetism.

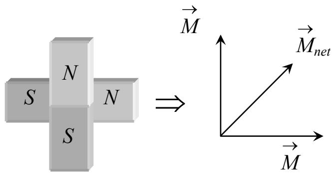
62. (d)

63. (a)

64. (a) $C_{max} = MB \Rightarrow 4\times 10^{-5} = M\times 10^{-4} \Rightarrow M = 0.4\ A\times m^2$

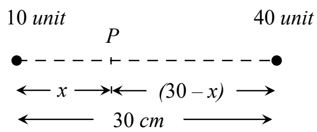
65. (c) Magnetic flux $\phi = BA \Rightarrow B = \frac{\phi}{A} = \frac{Weber}{m^2} = Tesla$

66. (b)



$\Rightarrow M_{net} = \sqrt{M^2 + M^2} = \sqrt{2}M$

67. (b) Suppose magnetic field is zero at point P. Which lies at a distance x from 10 unit pole. Hence at P



$\frac{\mu_0}{4\pi}.\frac{10}{x^2} = \frac{\mu_0}{4\pi}.\frac{40}{(30-x)^2} \Rightarrow x = 10cm$

So from stronger pole distance is 20 *cm*.

68. (b) $\tau = MB\sin\theta = (mL)B\sin\theta$

$= (40\times 10\times 10^{-2})\times 2\times 10^{-4}\times\sin 45°$

$= 0.565\times 10^{-3}\ N-m$

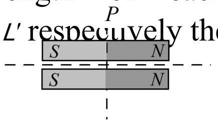
69. (a) Potential energy $U = -MB\cos\theta$

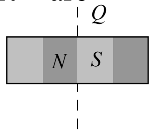
$\Rightarrow U_{max} = MH(\text{at}\,\theta = 180^o)$

70. (b) $\tau = MB\sin\theta$

$\tau = 200 \times 0.25 \times \sin 30^\circ = 25\ N \times m.$

71. (c) If pole strength, magnetic moment and length of each part are m', M' and L' respectively then





$m' = \frac{m}{2}$ $\quad\quad$ $m' = m$

$L' = L$ $\quad\quad$ $L' = \frac{L}{2}$

$\Rightarrow M' = \frac{M}{2}$ $\quad\quad$ $\Rightarrow M' = \frac{M}{2}$

72. (b) $\vec{\tau} = \vec{M} \times \vec{B} \Rightarrow \vec{\tau} = 50\hat{i} \times (0.5\hat{i} + 3\hat{j})$

$= 150(\hat{i} \times \hat{j}) = 150\hat{k} N \times m.$

73. (c) $\tau = MB\sin\theta \Rightarrow \tau \propto \sin\theta$

$\Rightarrow \frac{\tau_1}{\tau_2} = \frac{\sin\theta_1}{\sin\theta_2} \Rightarrow \frac{\tau}{\tau/2} = \frac{\sin 90}{\sin\theta_2}$

$\Rightarrow \sin\theta_2 = \frac{1}{2} \Rightarrow \theta_2 = 30^o$

$\Rightarrow$ angle of rotation $= 0\mathring{A} - 30 = 60^\circ$

74. (d)

75. (d) $F = mB \Rightarrow F = \frac{M}{L} \times B$

$\Rightarrow 6 \times 10^{-4} = \frac{3}{L} \times 2 \times 10^{-5} \Rightarrow L = 0.1\ m.$

76. (a) $\tau = MB\sin\theta \Rightarrow \tau = (mL)B\sin\theta$

$\Rightarrow 25 \times 10^{-6} = (m \times 5 \times 10^{-2}) \times 5 \times 10^{-2} \times \sin 30$

$\Rightarrow m = 2 \times 10^{-2}\ A - m.$

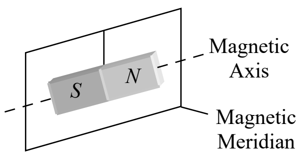
77. (d)

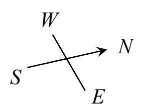
78. (c) Monopole do not exists.

79. (d)

80. (a)

81. (a)





82. (b) $W = MB(1 - \cos\theta)$; where $\theta = 180^o$

$\Rightarrow W = 2MB \Rightarrow W = 2 \times 2 \times 5 \times 10^{-3} = 2 \times 10^{-2}\ J$

83. (a) Torque on a bar magnet in earths magnetic field (B_H) is $\tau = MB_H \sin\theta$. τ will be maximum if sin θ = maximum *i.e.* $\theta = 90^o$. Hence axis of the magnet is perpendicular to the field of earth.

84. (b)

85. (a) Both points *A* and *B* lying on the axis of the magnet and on axial position

$B \propto \frac{1}{d^3} \Rightarrow \frac{B_A}{B_B} = \left(\frac{d_B}{d_A}\right)^3 = \left(\frac{48}{24}\right)^3 = \frac{8}{1}$

86. (b) $W = MB(1 - \cos\theta) = 2 \times 0.1 \times (1 - \cos 90^o) = 0.2 J$

87. (a) $M = mL = 4 \times 10 \times 10^{-2} = 0.4\ A \times m^2$

88. (a) Similar to solution (1)

New magnetic moment

$M' = \frac{2M}{\pi} = \frac{2mL}{\pi} = \frac{2 \times 0.5 \times 31.4 \times 10^{-2}}{3.14} = 0.1\ amp \times m^2$

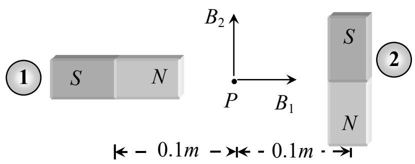
89. (d) Magnetic potential at a distance *d* from the bar magnet on it's axial line is given by

$V = \frac{\mu_0}{4\pi}.\frac{M}{d^2} \Rightarrow V \propto M \Rightarrow \frac{V_1}{V_2} = \frac{M_1}{M_2}$

$\Rightarrow \frac{V}{V_2} = \frac{M}{M/4} \Rightarrow V_2 = \frac{V}{4}$

90. (b) $B = \frac{\mu_0}{4\pi}.\frac{2M}{d^3} \Rightarrow B = 10^{-7} \times \frac{2 \times 1.2}{(0.1)^3} = 2.4 \times 10^{-4}\ T$

91. (d)



From figure $B_{net} = \sqrt{B_a^{\ 2} + B_e^{\ 2}}$

$= \sqrt{\left(\frac{\mu_0}{4\pi}.\frac{2M}{d^3}\right)^2 + \left(\frac{\mu_0}{4\pi}.\frac{M}{d^3}\right)^2}$

$= \sqrt{5}.\frac{\mu_0}{4\pi}.\frac{M}{d^3} = \sqrt{5} \times 10^{-7} \times \frac{10}{(0.1)^3} =$

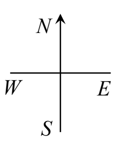
$\sqrt{5} \times 10^{-3}$ *Tesla.*

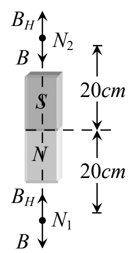
92. (c) $\tau = MB\sin\theta = m \times (2l) \times B\sin\theta$

$= 10^{-4} \times 0.1 \times 30 \sin 30^\circ = 1.5 \times 10^{-4}\ Nm$

Earth Magnetism

1. (b)





At neutral point

$|B| = |B_H| \Rightarrow \frac{2M}{(20)^3} = 0.3 \Rightarrow M = 1.2 \times 10^3\ emu$

2. (d) No magnetic lines of force passes through the steel box.

3. (b) At magnetic poles, the angle of dip is 90°. Hence the horizontal component $B_H = B\cos\theta = 0$.

4. (a)

5. (c)

6. (c)

7. (d) $B_H = \sqrt{3}\ B_V$, also $\tan\theta = \frac{B_V}{B_H} = \frac{1}{\sqrt{3}} \Rightarrow \theta = 30^o$

8. (d) At magnetic equator, the angle of dip is 0°. Hence the vertical component $V = I\sin\phi = 0$.

9. (b)

10. (a)

11. (c) $B_V = H_H \tan\phi$; If $B_V = B_{H,}$ then $\tan\phi = 1$ or $\phi = 45^o$

12. (a) The horizontal components are $(B_H)_1 = B\cos\phi_1$ and $(B_H)_2 = B\cos\phi_2$

$\therefore \frac{(B_H)_1}{(B_H)_2} = \frac{\cos\phi_1}{\cos\phi_2} = \frac{\cos 30^o}{\cos 45^o} = \frac{\sqrt{3}}{2} \times \sqrt{2} = \frac{\sqrt{3}}{\sqrt{2}}$

13. (d) From the relation $B_H = B\cos\phi$ and $B_V = B\sin\phi$

$\frac{B_V}{B_H} = \tan\phi$ or $B_V = B_H \tan\phi$

$= 0.36 \times 10^{-4} \times \tan 60^o = 0.623 \times 10^{-4}\ Wb/m^2$

14. (d) From the relation $B_V = I\sin\phi$

$I = \frac{V}{\sin\phi} = \frac{6 \times 10^{-5}}{\sin 40.6^o} = \frac{6 \times 10^{-5}}{0.65} = 9.2 \times 10^{-5}$ *tesla*

15. (c)

16. (c) $B_H = B\cos\phi; \therefore B = \frac{B_H}{\cos\phi} = \frac{0.5}{\cos 30^o} = \frac{0.5}{\sqrt{3}/2} = \frac{1}{\sqrt{3}}$

17. (a)

18. (d)

19. (b)

20. (e)

21. (b)

22. (d)

23. (a) $\tan\phi = \frac{B_V}{B_H} = \frac{0.173}{0.30} = \frac{1.73}{3.0} = \frac{\sqrt{3}}{3} = \frac{1}{\sqrt{3}} \Rightarrow \phi = 30^o$

24. (d) $B_H = B\cos\phi = 0.64 \times \cos 60^o = 0.64 \times \frac{1}{2} = 0.32$ units

25. (b)

26. (d)

27. (a)

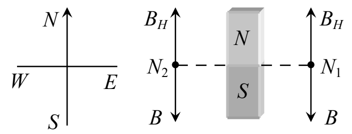
28. (a) $B_H = 0.3$ *Oersted*, $I = 0.6$ *Oersted*

We have $B_H = I\cos\phi \Rightarrow \cos\phi = \frac{B_H}{I} = \frac{0.3}{0.6} = \frac{1}{2}$

$\therefore \phi = 60^o$

29. (d)

30. (b)



31. (d) At broad side-on position $B = \frac{M}{d^3}$

$\therefore \frac{M_1}{d_1^3} = \frac{M_2}{d_2^3}$ or $\frac{M_1}{r^3} = \frac{M_2}{8r^3}$ or $\frac{M_1}{M_2} = \frac{r^3}{8r^3} = \frac{1}{8}$

32. (a)

33. (c) $B^2 = B_V^2 + B_H^2 \Rightarrow B_V = \sqrt{B^2 - B_H^2} = \sqrt{(0.5)^2 - (0.3)^2} = 0.4$

Now $\tan\phi = \frac{B_V}{B_H} = \frac{0.4}{0.3} = \frac{4}{3} \Rightarrow \phi = \tan^{-1}\left(\frac{4}{3}\right)$.

34. (a) Horizontal component $B_H = B\cos\phi$

Total intensity of earth magnetic field $B = \frac{B_H}{\cos\phi}$

$= \frac{1.8 \times 10^5}{\cos 30^o} = \frac{1.8 \times 10^{-5}}{\sqrt{3}/2} = 2.08 \times 10^{-5}\ Wb/m^2$

35. (a)

36. (c)

37. (a) The vertical component of earth's magnetic field is zero at equator where angle of dip is also zero.

38. (d) $B_0 = V_0$ also total intensity $B = \sqrt{B_0^2 + V_0^2}$

$\Rightarrow B = \sqrt{2} B_0$

39. (a) At poles magnetic field is perpendicular to the surface of earth.

40. (a)

41. (a)

42. (c) At neutral point

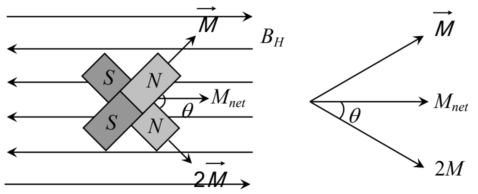
$$\left|\begin{matrix}\text{Magnetic field due}\\ \text{to magnet}\end{matrix}\right| = \left|\begin{matrix}\text{Magnetic field due}\\ \text{to earth}\end{matrix}\right|$$

$$\frac{\mu_0}{4\pi}.\frac{2M}{d^3} = 5\times10^{-5} \Rightarrow 10^{-7}\times\frac{2\times6.75}{d^3} = 5\times10^{-5}$$

$$\Rightarrow d = 0.3\ m = 30\ cm$$

43. (c) As they enter the magnetic field of the earth, they are deflected away from the equator.

44. (c)



$$\Rightarrow \tan\theta = \frac{M}{2M} = \frac{1}{2} \Rightarrow \theta = \tan^{-1} = \frac{1}{2}$$

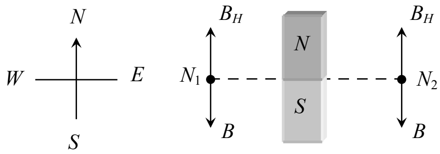
45. (a)

46. (b) $B_H = B\sin\phi \Rightarrow B = \frac{B_H}{\sin\phi} \Rightarrow B = \frac{B_o}{\sin 45^o} = \sqrt{2}B_0$

47. (c)

48. (a)

49. (a)



N_1 and N_2 are two null points. And

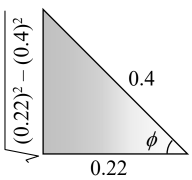
B_H = Horizontal component of earth's magnetic field

B = Magnetic field due to bar magnet.

50. (c)

51. (b) $B_H = B\cos\phi \Rightarrow B = \frac{B_H}{\cos\phi} \Rightarrow B = \frac{B_H}{\cos 30^o} = \frac{2B_H}{\sqrt{3}}$

52. (c) By using $B_H = B\cos\phi$



$$\Rightarrow \cos\phi = \frac{B_H}{B} = \frac{0.22}{0.4}$$

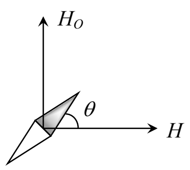
$$\Rightarrow \tan\phi = \frac{\sqrt{(0.4)^2-(0.22)^2}}{0.22}$$

$$\Rightarrow \phi = \tan^{-1}(1.518)$$

53. (b)

54. (d) At equator angle of dip is zero.

55. (c)



56. (a) In given case H and H_0 are perpendicular to each other.

From figure $\tan\theta = \frac{H_0}{H}$

$$\Rightarrow \theta = \tan^{-1}\left(\frac{H_0}{H}\right)$$

57. (a)

58. (b)

59. (a)

Magnetic Equipments

1. (d)

2. (c)

3. (a)

4. (b) In sum position : $T_S = 2\pi\sqrt{\frac{I_s}{(M_1+M_2)B_H}}$

In difference position : $T_d = 2\pi\sqrt{\frac{I_d}{(M_1-M_2)B_H}}$

It is clear that $T_d > T_s$

5. (d) $T = 2\pi\sqrt{\frac{I}{MB_H}}; \therefore \frac{T_1}{T_2} = \sqrt{\frac{(B_H)_2}{(B_H)_1}} \Rightarrow T_2 = T_1\sqrt{\frac{(B_H)_1}{(B_H)_2}}$

Here n_1=30 *oscillation /min* $= \frac{1}{2}$ *oscillation/sec*

$$\therefore T_1 = \frac{1}{n_1} = 2\,\text{sec}$$

$$\therefore T_2 = 2\sqrt{\frac{B_H}{2B_H}} = 2\times\frac{1}{\sqrt{2}} = \sqrt{2}\,\text{sec}$$

6. (d)

7. (a) $T = 2\pi\sqrt{\frac{1}{MB_H}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{M_2}{M_1}}$

$$\Rightarrow \frac{M_1}{M_2} = \frac{T_2^2}{T_1^2} = \frac{(60/15)^2}{(60/10)^2} = \frac{4}{9}$$

8. (c) When magnet of length l is cut into four equal parts. then $m' = \frac{m}{2}$ and $l' = \frac{l}{2}$; $\therefore M' = \frac{m}{2}\times\frac{l}{2} = \frac{ml}{4} = \frac{M}{4}$

New moment of inertia

$$I' = \frac{wl^2}{12} = \frac{\frac{w}{4}.\left(\frac{1}{2}\right)^2}{12} = \frac{1}{16}.\frac{wl^2}{12}$$

Here w is the mass of magnet.

$\therefore I' = \frac{1}{16} I$; Time period of each part

$T' = 2\pi\sqrt{\frac{I'}{M'B_H}}$

$= 2\pi\sqrt{\frac{I/16}{(M/4)B_H}} = 2\pi\sqrt{\frac{I}{4MB_H}} = \frac{T}{2}$

9. (c) $T = 2\pi\sqrt{\frac{I_1 + I_2}{(M_1 - M_2)B_H}}$

Here $M_1 = M_2 = M, \therefore T = \infty$

10. (b) Time period in vibration magnetometer

$T = 2\pi\sqrt{\frac{I}{MB_H}}$, At poles $B_H = 0$ so $T = \infty$

11. (c)

12. (a) $\frac{T_1}{T_2} = \sqrt{\frac{M_2}{M_1}} = \sqrt{\frac{4M}{M}} = 2 \Rightarrow \frac{2}{T_2} = 2 \Rightarrow T_2 = 1 \sec$

13. (a) $T = 2\pi\sqrt{\frac{I}{MB_H}}$

$I = 40 gm - cm^2 = 400 \times 10^{-8} kg - m^2$

$\therefore 3 = 2\pi\sqrt{\frac{400 \times 10^{-8}}{36 \times 10^{-6} \times M}}$

$\Rightarrow \frac{1}{M} = \frac{9}{4\pi^2} \times \frac{36}{4} \Rightarrow M = 0.5\ A \times m^2$

14. (a)

15. (b) Because moment of inertia increases i.e. $T \propto \sqrt{I}$

16. (b) $T = 2\pi\sqrt{\frac{I}{MB_H}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{(B_H)_2}{(B_H)_1}}$

$\Rightarrow T_2 = T\sqrt{\frac{(BH)_1}{(BH)_2}} = \frac{T}{2} \quad (\because (B_H)_2 = 4(B_H)_1)$

17. (b) In sum position $T \propto \frac{1}{\sqrt{M_1 + M_2}}$ and in difference position $T \propto \frac{1}{\sqrt{M_1 - M_2}}$

$\Rightarrow \frac{3^2}{T^2} = \frac{2M - M}{2M + M} \Rightarrow T^2 = 9 \times 3 \sec^2$

$\therefore T = 3\sqrt{3} \sec$

18. (d)

19. (b) Given $\nu_1 = \frac{20}{60} = \frac{1}{3} \sec^{-1}$ and $\nu_2 = \frac{15}{60} = \frac{1}{4} \sec^{-1}$

Now

$\nu = \frac{1}{2\pi}\sqrt{\frac{MB_H}{I}} = \frac{1}{2\pi}\sqrt{\frac{MB\cos\phi}{I}} \quad (\because B_H = B\cos\phi)$

$\therefore \frac{\nu_1}{\nu_2} = \sqrt{\frac{B_1\cos\phi_1}{B_2\cos\phi_2}} \Rightarrow \frac{B_1}{B_2} = \left(\frac{\nu_1}{\nu_2}\right)^2\left(\frac{\cos\phi_2}{\cos\phi_1}\right)^2$

$\Rightarrow \frac{B_1}{B_2} = \left(\frac{1/3}{1/4}\right)^2 \frac{\cos 60°}{\cos 30°} = \frac{16}{9} \times \frac{1/2}{\sqrt{3}/2} = \frac{16}{9\sqrt{3}}$.

20. (c) $T \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{M_2}{M_1}} \Rightarrow \frac{1.5}{T_2} = \sqrt{\frac{M_1/4}{M_1}} = \frac{1}{2}$

$\Rightarrow T_2 = 3 \sec$

21. (c) $\nu = \frac{1}{2\pi}\sqrt{\frac{MB_H}{I}} \Rightarrow \nu \propto \sqrt{M}$

$\Rightarrow \frac{\nu_A}{\nu_B} = \sqrt{\frac{M_A}{M_B}} \Rightarrow \frac{2}{1} = \sqrt{\frac{M_A}{M_B}} \Rightarrow M_A = 4M_B$

22. (c) $T = 2\pi\sqrt{\frac{I}{MB_H}} \Rightarrow T \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{M_A}{M_B} = \left(\frac{T_B}{T_A}\right)^2 = \frac{4}{1}$

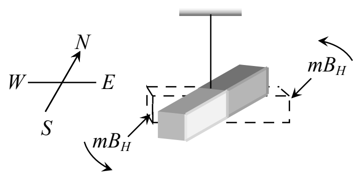
23. (c) No. of oscillation per minute $= \frac{1}{2\pi}\sqrt{\frac{MB_H}{I}}$

$\Rightarrow n \propto \sqrt{MB_H}$; $M \to 4$ *times*

$B_H \to 2$ *times*

So $\nu \to \sqrt{8}$ *times i.e.* $\nu' = \sqrt{8}\nu = 2\sqrt{2}n$

24. (c)



25. (a) $T = 2\pi\sqrt{\frac{I}{MH}} \Rightarrow T \propto \frac{1}{\sqrt{H}} \Rightarrow \frac{T_A}{T_B} = \sqrt{\frac{H_B}{H_A}}$

$\Rightarrow \frac{H_A}{H_B} = \left(\frac{T_B}{T_A}\right)^2 = \left(\frac{3}{2}\right)^2 = \frac{9}{4}$.

26. (a) $T = 2\pi\sqrt{\frac{I}{MB_H}}$ and $I = \frac{w(l^2 + b^2)}{12}$; $\therefore T \propto \sqrt{w}$

(w = Mass of the magnet)

27. (c) $T_{Sum} = 2\pi\sqrt{\frac{(I_1 + I_2)}{(M_1 + M_2)B_H}}$

$T_{diff} = 2\pi\sqrt{\frac{I_1 + I_2}{(M_1 - M_2)B_H}}$

$\Rightarrow \frac{T_s}{T_d} = \frac{T_1}{T_2} = \sqrt{\frac{M_1 - M_2}{M_1 + M_2}} = \sqrt{\frac{2M - M}{2M + M}} = \frac{1}{\sqrt{3}}$

28. (a) $T = 2\pi\sqrt{\frac{I}{MB}} \Rightarrow \frac{T}{T'} = \sqrt{\frac{B}{B}} = \sqrt{\frac{B}{B_H}}$

$\Rightarrow \frac{T}{T'} = \sqrt{\frac{1}{\cos\phi}} = \sqrt{\frac{1}{\cos 60^o}} = \sqrt{2} \Rightarrow T' = \frac{T}{\sqrt{2}}$

29. (a)

30. (a)

31. (b) For tangent galvanometer $I = \frac{2rB}{\mu_0 n}\tan\theta$

$\therefore \tan\theta = \frac{I\mu_0 n}{2rB} = \frac{0.1\times 4\pi\times 10^{-7}\times 50}{0.04\times 7\times 10^{-5}\times 2} = 1.12$

or $\theta = \tan^{-1}(1.12) = 48.2^o$

32. (d) Time period of a magnet $T = 2\pi\sqrt{\frac{I}{MB}}$

or $I = \frac{T^2 MB}{4\pi^2} = \frac{225\times 5\times 10^{-5}\times 8\pi\times 10^{-4}}{4\pi^2}$

$\therefore I = 7.16\times 10^{-7}\, kg - m^2$

33. (b) $T = 2\pi\sqrt{\frac{I}{MB_H}} = 4\,\sec$

When magnet is cut into two equal halves, then New magnetic moment $M' = \frac{M}{2}$

New moment of inertia $I' = \frac{(w/2)(l/2)^2}{12} = \frac{1}{8}\cdot\frac{wl^2}{12}$

Where w is the initial mass of the magnet

But $I = \frac{wl^2}{12}$; $\therefore I' = \frac{I}{8}$

$\therefore$ New time period $T' = 2\pi\sqrt{\frac{I'}{M'B_H}}$

$= 2\pi\sqrt{\frac{I/8}{(M/2)B_H}} = \frac{1}{2}2\pi\sqrt{\frac{I}{M_H}}$

$= \frac{1}{2}\times T = \frac{1}{2}\times 4 = 2\,\sec$

34. (d)

35. (a) $K = \frac{2RB_H}{\mu_0 N}$ (R = radius, N= number of turns)

36. (c) $T \propto \frac{1}{\sqrt{M}}$. Since magnetic moment decreases with increase in temperature hence time period T increases.

37. (b) Sensitivity $S = \frac{\theta}{i} = \frac{\theta}{K\tan\theta}$ where $K = \frac{2RB_H}{\mu_0 N}$

For increasing sensitivity K should be decreased and hence number of turns should be increased.

38. (d) In the first galvanometer

$i_1 = K_1\tan\theta_1 = K_1\tan 60^o = K_1\sqrt{3}$

In the second galvanometer

$i_2 = K_2\tan\theta_2 = K_2\tan 45^o = K_2$

In series $i_1 = i_2 \Rightarrow K_1\sqrt{3} = K_2 \Rightarrow \frac{K_1}{K_2} = \frac{1}{\sqrt{3}}$

But $K \propto \frac{1}{n} \Rightarrow \frac{K_1}{K_2} = \frac{n_2}{n_1}$ $\therefore$ $\frac{n_1}{n_2} = \frac{\sqrt{3}}{1}$.

39. (b) $T = 2\pi\sqrt{\frac{I}{MB_H}}$. If Q is an identical bar magnet then time period of system will be $T' = 2\pi\sqrt{\frac{2I}{(2M)B_H}} = T$

40. (a) Frequency $\nu \propto \sqrt{B_H}$

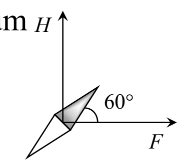
41. (b) In tangent galvanometer, $I \propto \tan\theta$

$\therefore \frac{I_1}{I_2} = \frac{\tan\theta_1}{\tan\theta_2} \Rightarrow \frac{I_1}{I_1/\sqrt{3}} = \frac{\tan 45^0}{\tan\theta_2}$

$\Rightarrow \sqrt{3}\tan\theta_2 = 1 \Rightarrow \tan\theta_2 = \frac{1}{\sqrt{3}} \Rightarrow \theta_2 = 30^o$

So deflection will decrease by 45°- 30° = 15°.

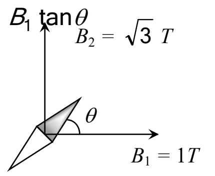
42. (d) From figure at equilibrium



$\tan 60° = \frac{H}{F}$

$\Rightarrow \sqrt{3} = \frac{H}{F} \Rightarrow \frac{F}{H} = \frac{1}{\sqrt{3}}$

43. (d) In balance condition $B_2 = B_1\tan\theta$



$\Rightarrow \tan\theta = \frac{\sqrt{3}}{1}$

$\Rightarrow \theta = 60^o$

44. (d) In the sum and difference method of vibration magnetometer

$\frac{M_1}{M_2} = \frac{T_2^2 + T_1^2}{T_2^2 - T_1^2}$

Here $T_1 = \frac{1}{n_1} = \frac{60}{12} = 5\,\text{sec}.\ T_2 = \frac{1}{n_2} = \frac{60}{4} = 15\,\text{sec}$

$\therefore \frac{M_1}{M_2} = \frac{15^2 + 5^2}{15^2 - 5^2} = \frac{225 + 25}{225 - 25} = \frac{5}{4}$

45. (c)

46. (b) $i \propto \tan\theta \Rightarrow \frac{i_1}{i_2} = \frac{\tan\theta_1}{\tan\theta_2} \Rightarrow \frac{\sqrt{3}}{3} = \frac{\tan 30^o}{\tan\theta_2} \Rightarrow \theta = 45^o$

47. (b) $T = 2\pi\sqrt{\frac{I}{MB}} = 2\pi\sqrt{\frac{wl^2/12}{\text{Pole strength} \times 2l \times B}}$

$\therefore T \propto \sqrt{Wl}$

$\therefore \frac{T_2}{T_1} = \sqrt{\frac{w_2}{w_1} \times \frac{l_2}{l_1}} = \sqrt{\frac{w_1/2}{w_1} \times \frac{l_1/2}{l_1}} = \frac{1}{2}$

$\Rightarrow T_2 = \frac{T_1}{2} = 0.5\ sec$

48. (d) $T' = \frac{T}{n} \Rightarrow T' = \frac{2}{2} = 1 sec$

49. (c) It is due to the magnetic field produced by coil.

50. (d)

51. (c) $T = 2\pi\sqrt{\frac{I}{MB_H}} \Rightarrow T \propto \sqrt{I} \propto \sqrt{w} \Rightarrow T' = \sqrt{2}\ T_0$

52. (d) $\frac{M_1}{M_2} = \left(\frac{d_1}{d_2}\right)^3 \Rightarrow \frac{27}{8} = \left(\frac{d_1}{0.12}\right)^3$

$\Rightarrow \frac{3}{2} = \frac{d_1}{0.12} \Rightarrow 0.18\ m$

53. (c) $T = 2\pi\sqrt{\frac{I}{MB_H}} \Rightarrow T \propto \frac{1}{\sqrt{M}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{M_2}{M_1}}$

If M_1 =100 than M_2 (100 – 19) = 81

So $\frac{T_1}{T_2} = \sqrt{\frac{81}{100}} = \frac{9}{10} \Rightarrow T_2 = \frac{10}{9} T_1 = 1.11\ T_1$

$\Rightarrow$ Time period increases by 11%

54. (b) $T = 2\pi\sqrt{\frac{I}{M \times B_H}} \Rightarrow T \propto \frac{1}{\sqrt{B_H}}$

$\Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{(B_H)_2}{(B_H)_1}} \Rightarrow \frac{60/40}{2.5} = \sqrt{\frac{(B_H)_2}{0.1 \times 10^{-5}}}$

$\Rightarrow (B_H)_2 = 0.36 \times 10^{-6}\ T$

55. (a) $i = \frac{2rB_H}{\mu_0 N}\tan\theta$

$\Rightarrow i = \frac{2 \times 15 \times 10^{-2} \times 3 \times 10^{-5}}{4\pi \times 10^{-7} \times 25} \times \tan 45^o \Rightarrow i = 0.29\ A$

56. (a) $T = 2\pi\sqrt{\frac{I}{MB_H}}$; $I \to 3$ times and $M \to \frac{1}{3}$ times

So $T \to 3$ times *i.e.* $T' = 3T_0$

57. (c) In case of tangent galvanometer as

$i = k\tan\phi$

Differentiating both side *w.r.t.* ϕ

$\frac{di}{d\phi} = k\sec^2\phi \Rightarrow di = k\sec^2 d\phi$

$\Rightarrow \frac{di}{i} = \frac{d\phi}{\sin\phi\cos\phi} = \frac{2d\phi}{\sin 2\phi}$

Hence the error in the measurement will be least when

$\sin 2\phi = \max = 1 \Rightarrow 2\phi = 90^o \Rightarrow \phi = 45^o$

58. (a)

59. (a) $T' = \frac{T}{n}$

60. (c) $\frac{T_A}{T_B} = \sqrt{\frac{(B_H)_B}{(B_H)_A}} \Rightarrow \frac{60/10}{60/20} = \sqrt{\frac{(B_H)_B}{36 \times 10^{-6}}}$

$\Rightarrow (B_H)_B = 144 \times 10^{-6}\ T$

61. (d) $i \propto \tan\phi \Rightarrow \frac{i_1}{i_2} = \frac{\tan\phi_1}{\tan\phi_2}$

$\Rightarrow \frac{2}{i_2} = \frac{\tan 30}{\tan 60} \Rightarrow i_2 = 6\ amp$

62. (a) In tangent galvanometer experiment. The plane of the coil firstly set in the magnetic meridian.

63. (c) $T \propto \frac{1}{\sqrt{M}} \Rightarrow T \propto \frac{1}{\sqrt{m}}$; If $m \to 4$ times.

$T \to \frac{1}{2}$ times i.*e.* $T' = \frac{T}{2} = \frac{2}{2} = 1\,\text{sec}$

64. (d) $\frac{M_1}{M_2} = \frac{\tan\theta_1}{\tan\theta_2} \Rightarrow \frac{m_1 L_1}{m_2 L_2} = \frac{\tan\theta_1}{\tan\theta_2}$

$\Rightarrow \frac{m_1}{m_2} = \frac{2}{1} \times \frac{\tan 45°}{\tan 30°} = \frac{2\sqrt{3}}{1}$

65. (b) $B = B_H \tan\theta = 0.34 \times 10^{-4} \tan 30° = 1.96 \times 10^{-5}\ T$

66. (b) $i \propto \tan\phi \Rightarrow \frac{i_1}{i_2} = \frac{\tan\phi_1}{\tan\phi_2}$

$\Rightarrow \frac{0.1}{i_2} = \frac{\tan 30°}{\tan 60°} = \frac{1}{3} \Rightarrow i_2 = 0.3A$

67. (a) As $T \propto \sqrt{I}$; where I = moment of inertia

$= \frac{wL^2}{12} \Rightarrow T \propto \sqrt{w}$ (w = Mass of magnet. If $w \to$ quadrupled, then $T \to$ doubled *i.e.* $T' = 2T$

68. (c) Oscillation of n^{th} part of magnet $T' = \frac{T}{n}$

$\Rightarrow \frac{T'}{T} = \frac{1}{n}$; here $n = 2$ so $\frac{T'}{T} = \frac{1}{2}$.

69. (b) $T = 2\pi\sqrt{\frac{I}{M\,B_H}}$; where $I = \frac{w(L^2+b^2)}{12}$ (w =Mass of magnet)

$\Rightarrow T \propto \sqrt{w}$, If $w \to$ four times then $T \to$ Two times

70. (b) Initially, the time period of the magnet

$T = 2 = 2\pi\sqrt{\frac{I}{MB}}$ ..... (i)

For each part, it's moment of inertia $= \frac{I}{27}$ and magnetic moment $= \frac{M}{3}$

$\therefore$ Moment of inertia of system $I_s = \frac{I}{27} \times 3 = \frac{I}{9}$

Magnetic moment of system $M_s = \frac{M}{3} \times 3 = M$

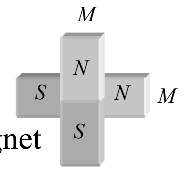
Time period of system

$T_s = 2\pi\sqrt{\frac{I_s}{M_s B}} = \frac{1}{3} \times 2\pi\sqrt{\frac{I}{MB}} = \frac{T}{3} = \frac{2}{3}\text{sec}$

71. (c) $T \propto \frac{1}{\sqrt{B_H}} = \frac{1}{\sqrt{B\cos\phi}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{B_2\cos\phi_2}{B_1\cos\phi_1}}$

$\Rightarrow \frac{B_1}{B_2} = \frac{T_2^2}{T_1^2} \times \frac{\cos\phi_2}{\cos\phi_1} = \left(\frac{3}{2}\right)^2 \times \frac{\cos 60^\circ}{\cos 30^\circ} \Rightarrow \frac{B_1}{B_2} = \frac{9}{4\sqrt{3}}$

72. (c) Time period of combination



$T = 2\pi\sqrt{\frac{2I}{\sqrt{2}\,M.H}}$ .....(i)

and time period of each magnet

$T' = 2\pi\sqrt{\frac{I}{MH}}$ ......(ii)

from (i) and (ii) we get

$T' = \frac{T}{2^{1/4}} = 2^{-1/4}\,T$

73. (b) $B = B_H\tan\theta \Rightarrow \frac{\mu_0 ni}{2r} = B_H\tan\theta$

$\Rightarrow i = \frac{2r.\,B_H\tan\theta}{\mu_0 n} = \frac{2\times 0.1\times 4\times 10^{-5}}{10\times 4\pi\times 10^{-7}} = 1.1A$

Magnetic Materials

1. (c)

2. (a) Neon atom is diamagnetic, hence it's net magnetic moment is zero.

3. (a) Soft iron is highly ferromagnetic.

4. (d)

5. (b) On heating, different domains have net magnetisation in them which are randomly distributes. Thus the net magnetisastion of the substance due to various domains decreases to minimum.

6. (b) Repelled due to induction of similar poles.

7. (d) From the characteristic of *B-H* curve.

8. (c)

9. (d)

10. (b)

11. (a)

12. (c) The property of paramagnetism is found in these substances whose atoms have an excess of electrons spinning in the same direction. Hence atoms of paramagnetic substances have a net non-zero magnetic moment of their own.

13. (c)

14. (a)

15. (a, b)

16. (d) $\chi_m = (\mu_r - 1) \Rightarrow \chi_m = (5500 - 1) = 5499$

17. (b)

18. (b)

19. (c)

20. (b) Because, diamagnetic substance, moves from stronger magnetic field to weaker field.

21. (d)

22. (b) With rise in temperature their magnetic susceptibility decreases *i.e.* $\chi_m \propto \frac{1}{T}$

23. (c)

24. (b)

25. (c) Diamagnetic substances are repelled by magnetic field.

26. (b) As we know for circulating electron magnetic moment

$M = \frac{1}{2}evr$ ...... (i)

and angular momentum $J = mvr$ ...... (ii)

From equation (i) and (ii) $M = \frac{eJ}{2m}$

27. (b)

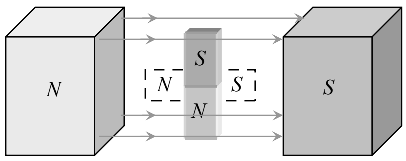
28. (a)

29. (c) The energy lost per unit volume of a substance in a complete cycle of magnetisation is equal to the area of the hysteresis loop.

30. (c)

31. (d)

32. (a) A diamagnetic rod set itself perpendicular to the field if free to rotate between the poles of a magnet as in this situation the field is strongest near the poles.



33. (c)

34. (b)

35. (b) Diamagnetic substances are repelled by the magnetic field.

36. (d)

37. (b)

38. (b)

39. (c)

40. (b)

41. (d) Net magnetic induction $B = B_0 + B_m$ $= \mu_0 H + \mu_0 M$

42. (c)

43. (d) $\mu_r = \frac{B}{B_0} = 4$

44. (d)

45. (a)

46. (b)

47. (c)

48. (c) Susceptibility of diamagnetic substance is negative and it does not change with temperature.

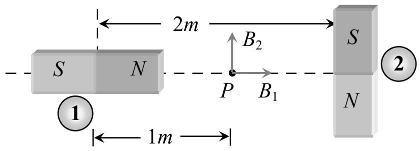
49. (a)

50. (d) When a ferromagnetic material in heated above its curie temperature then it behaves like paramagnetic material.

Critical Thinking Questions

1. (b) With respect to 1st magnet, P lies in end side-on position

$\therefore B_1 = \frac{\mu_0}{4\pi}\left(\frac{2M}{d^3}\right)$ (RHS)



With respect to 2nd magnet. P lies in broad side on position.

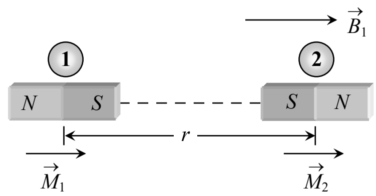
$\therefore B_2 = \frac{\mu_0}{4\pi}\left(\frac{M}{d^3}\right)$ (Upward)

$B_1 = 10^{-7} \times \frac{2 \times 1}{1} = 2 \times 10^{-7}\, T,\ B_2 = \frac{B_1}{2} = 10^{-7}\, T$

As B_1 and B_2 are mutually perpendicular, hence the resultant magnetic field

$B_R = \sqrt{B_1^2 + B_2^2} = \sqrt{(2 \times 10^{-7})^2 + (10^{-7})^2} = \sqrt{5} \times 10^{-7}\, T$

2. (d)



Both the magnets are placed in the field of one another, hence potential energy of dipole (2) is

$U_2 = -M_2 B_1 \cos 0 = -M_2 B_1 = M_2 \times \frac{\mu_0}{4\pi}.\frac{2M_1}{r^3}$

By using $F = -\frac{dU}{dr}$, Force on magnet (2) is

$F_2 = -\frac{dU_2}{dr} = -\frac{d}{dr}\left(\frac{\mu_0}{4\pi}.\frac{2M_1M_2}{r^3}\right) = -\frac{\mu_0}{4\pi}.6\frac{M_1M_2}{r^4}$

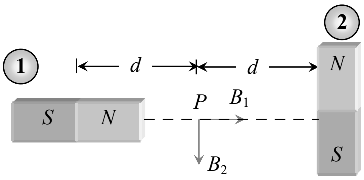
It can be proved $|F_1| = |F_2| = F = \frac{\mu_0}{4\pi}.\frac{6M_1M_2}{r^4}$

$\Rightarrow F \propto \frac{1}{r^4}$

3. (d) At point P net magnetic field $B_{net} = \sqrt{B_1^2 + B_2^2}$

where $B_1 = \frac{\mu_0}{4\pi}.\frac{2M}{d^3}$ and $B_2 = \frac{\mu_0}{4\pi}.\frac{M}{d^3}$

$\Rightarrow B_{net} = \frac{\mu_0}{4\pi}.\frac{\sqrt{5}M}{d^3}$



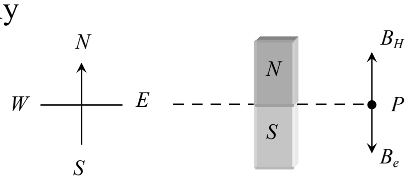
4. (a) Let the real dip be ϕ, then $\tan\phi = \frac{B_V}{B_H}$

For apparent dip,

$\tan\phi' = \frac{B_V}{B_H \cos\beta} = \frac{B_V}{B_H \cos 30^o} = \frac{2B_V}{\sqrt{3}B_H}$

or $\tan 45^o = \frac{2}{\sqrt{3}}.\tan\phi$ or $\phi = \tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

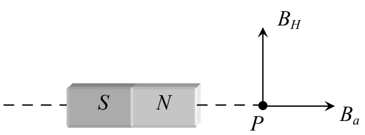
5. (d) Initially



Neutral point obtained on equatorial line and at neutral point $|B_H| = |B_e|$

where B_H = Horizontal component of earth's magnetic field, B_e = Magnetic field due to bar magnet on it's equatorial line

Finally



Point P comes on axial line of the magnet and at P, net magnetic field $B = \sqrt{B_a^2 + B_H^2}$

$= \sqrt{(2B_e)^2 + (B_H)^2} = \sqrt{(2B_H)^2 + B_H^2} = \sqrt{5}\ B_H$

6. (b) $\tan\phi' = \frac{\tan\phi}{\cos\beta}$; where ϕ'=Apparent angle of dip,

ϕ= True angle of dip, β=Angle made by vertical plane with magnetic meridian.

$\Rightarrow \tan\phi' = \frac{\tan 60^o}{\cos 30^o} = 2 \Rightarrow \phi' = \tan^{-1}(2)$

7. (c) Initially magnetic moment of system

$M_1 = \sqrt{M^2 + M^2} = 2M$ and moment of inertia

$I_1 = I + I = 2I.$

Finally when one of the magnet is removed then

$M_2 = M$ and $I_2 = I$

So $T = 2\pi\sqrt{\frac{I}{M\ B_H}}$

$\frac{T_1}{T_2} = \sqrt{\frac{I_1}{I_2} \times \frac{M_2}{M_1}} = \sqrt{\frac{2I}{I} \times \frac{M}{\sqrt{2}M}} \Rightarrow T_2 = \frac{2^{5/4}}{2^{1/4}} = 2$ sec.

8. (b) $T \propto \frac{1}{\sqrt{H}} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{H_2}{H_1}} \Rightarrow \frac{2}{1} = \sqrt{\frac{H+F}{H}} \Rightarrow F = 3H$

or $\frac{H}{F} = \frac{1}{3}$

9. (b) Relation for dipole moment is, $M = I \times V$. Volume of the cylinder $V = \pi r^2 l$, Where r is the radius and l is the length of the cylinder, then dipole moment,

$M = I\pi r^2 l = (5.30 \times 10^3) \times \frac{22}{7} \times (0.5 \times 10^{-2})^2 (5 \times 10^{-2})$

$= 2.08 \times 10^{-2}\ J/T$

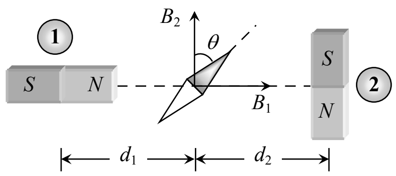
10. (b) For equilibrium of the system torques on M_1 and M_2 due to B_H must counter balance each other *i.e.* $M_1 \times B_H = M_2 \times B_H$. If θ is the angle between M_1 and B_H will be $(90 - \theta)$; so

$M_1 B_H \sin\theta = M_2 B_H \sin(90 - \theta)$

$\Rightarrow \tan\theta = \frac{M_2}{M_1} = \frac{M}{3M} = \frac{1}{3} \Rightarrow \theta = \tan^{-1}\left(\frac{1}{3}\right)$

11. (a) $I = \frac{M}{V} = \frac{\mu N}{V} = \frac{1.5 \times 10^{-23} \times 2 \times 10^{26}}{1} = 3 \times 10^3\ Amp/m$

12. (c) In equilibrium $B_1 = B_2 \tan\theta$

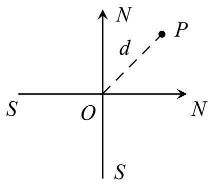


$\Rightarrow \frac{\mu_0}{4\pi} \cdot \frac{2M}{d_1^3} = \frac{\mu_0}{4\pi} \cdot \frac{M}{d_2^3} \tan\theta$

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

13. (c) Resultant magnetic moment of the two magnets is

$M_{net} = \sqrt{M^2 + M^2} = \sqrt{2}M$



Imagine a short magnet lying along *OP* with magnetic moment equal to $M\sqrt{2}$. Thus point *P* lies on the axial line of the magnet.

$\therefore$ Magnitude of magnetic field at *P* is given by $B = \frac{\mu_0}{4\pi} \cdot \frac{2\sqrt{2}M}{d^3}$

14. (a) On passing current through the coil, it acts as a magnetic dipole. Torque acting on magnetic dipole is counter balanced by the moment of additional weight about position *O*. Torque acting on a magnetic dipole

$\tau = MB\sin\theta = (NiA)B\sin 90^o = NiAB.$

Again $\tau = Force \times Lever\ arm = \Delta mg \times l$

$\Rightarrow NiAB = \Delta mgl$

$\Rightarrow B = \frac{\Delta mgl}{NiA} = \frac{60 \times 10^{-3} \times 9.8 \times 30 \times 10^{-2}}{200 \times 22 \times 10^{-3} \times 1 \times 10^{-4}} = 0.4\ T$

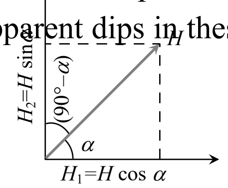
15. (a) The weight of upper magnet should be balanced by the repulsion between the two magnet

$\therefore \frac{\mu}{4\pi} \cdot \frac{m^2}{r^2} = 50\, gm - wt$

$\Rightarrow 10^{-7} \times \frac{m^2}{(9 \times 10^{-6})} = 50 \times 10^{-3} \times 9.8$

$\Rightarrow m = 6.64\, amp \times m$

16. (d) Let α be the angle which one of the planes make with the magnetic meridian the other plane makes an angle $(90^o - \alpha)$ with it. The components of *H* in these planes will be $H\cos\alpha$ and $H\sin\alpha$ respectively. If ϕ_1 and ϕ_2 are the apparent dips in these two planes, then



$\tan\phi_1 = \frac{V}{H\cos\alpha}$ *i.e.* $\cos\alpha = \frac{V}{H\tan\phi_1}$ ..... (i)

$\tan\phi_2 = \frac{V}{H\sin\alpha}$ *i.e.* $\sin\alpha = \frac{V}{H\tan\phi_2}$ ..... (ii)

Squaring and adding (i) and (ii), we get

$\cos^2\alpha + \sin^2\alpha = \left(\frac{V}{H}\right)^2 \left(\frac{1}{\tan^2\phi_1} + \frac{1}{\tan^2\phi_2}\right)$

i.e. $1 = \frac{V^2}{H^2}(\cot^2\phi_1 + \cot^2\phi_2)$

or $\frac{H^2}{V^2} = \cot^2\phi_1 + \cot^2\phi_2$ *i.e.* $\cot^2\phi = \cot^2\phi_1 + \cot^2\phi_2$

This is the required result.

17. (c) The number of atoms per unit volume in a specimen,

$n = \frac{\rho N_A}{A}$

For iron, $\rho = 7.8 \times 10^{-3}\, kgm^{-3}$,

$N_A = 6.02 \times 10^{26}\, / kgmol$, $A = 56$

$\Rightarrow n = \frac{7.8 \times 10^3 \times 6.02 \times 10^{26}}{56} = 8.38 \times 10^{28}\, m^{-3}$

Total number of atoms in the bar is

$N_0 = nV = 8.38 \times 10^{28} \times (5 \times 10^{-2} \times 1 \times 10^{-2} \times 1 \times 10^{-2})$

$N_0 = 4.19\times10^{23}$

The saturated magnetic moment of bar

$= 4.19\times10^{23}\times1.8\times10^{-23} = 7.54\ Am^2$

18. (d) We have, $B = \mu_0 H + \mu_0 I$

or $I = \frac{B-\mu_0 H}{\mu_0}$ or $I = \frac{\mu H - \mu_0 H}{\mu_0} = \left(\frac{\mu}{\mu_0} - 1\right)H$

$I = (\mu_r - 1)H$

For a solenoid of n-turns per unit length and current i

$H = ni$

$\therefore\ I = (\mu_r - 1)ni = (1000-1)\times500\times0.5$

$I = 2.5\times10^5\ Am^{-1}$

$\therefore$ Magnetic moment $M = IV$

$M = 2.5\times10^5\times10^{-4} = 25\ Am^2$

19. (d) The bar magnet coercivity $4\times10^3\ Am^{-1}$ *i.e.*, it requires a magnetic intensity $H = 4\times10^3\ Am^{-1}$ to get demagnetised. Let i be the current carried by solenoid having n number of turns per metre length, then by definition $H = ni$. Here $H = 4\times10^3$ *Amp turn metre*$^{-1}$

$n = \frac{N}{l} = \frac{60}{0.12} = 500$ *turn metre*$^{-1}$

$\Rightarrow i = \frac{H}{n} = \frac{4\times10^3}{500} = 8.0\ A$

20. (c) Let M_1 and M_2 be the magnetic moments of magnets and H the horizontal component of earth's field.

We have $\tau = MH\sin\theta$. If ϕ is the twist of wire, then $\tau = C\phi$, C being restoring couple per unit twist of wire

$\Rightarrow C\phi = MH\sin\theta$

Here $\phi_1 = (180^o - 30^o) = 150^o = 150\times\frac{\pi}{180}$ *rad*

$\phi_2 = (270^o - 30^o) = 240^o = 240\times\frac{\pi}{180}$ *rad*

So, $C\phi_1 = M_1 H\sin\theta$ (For deflection $\theta = 30^o$ of I magnet)

$C\phi_2 = M_2 H\sin\theta$ (For deflection $\theta = 30^o$ of II magnet)

Dividing $\frac{\phi_1}{\phi_2} = \frac{M_1}{M_2}$

$\Rightarrow \frac{M_1}{M_2} = \frac{\phi_1}{\phi_2} = \frac{150\times\left(\frac{\pi}{180}\right)}{240\times\left(\frac{\pi}{180}\right)} = \frac{15}{24} = \frac{5}{8}$

$\Rightarrow M_1 : M_2 = 5:8$

21. (c) In vertical plane perpendicular to magnetic meridian.

$T = 2\pi\sqrt{\frac{I}{MB_V}}$ ..... (i)

In horizontal plane $T = 2\pi\sqrt{\frac{I}{MB_H}}$ ..... (ii)

Equation (i) and (ii) gives $B_V = B_H$

Hence by using $\tan\phi = \frac{B_V}{B_H} \Rightarrow \tan\phi = 1 \Rightarrow \phi = 45^o$

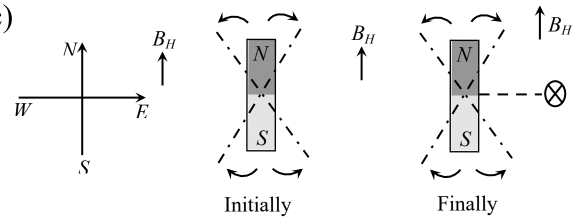
22. (a) Molar susceptibility

$= \frac{\text{Volume susceptibility}}{\text{Density of material}}\times\text{molecular weight}$

$= \frac{I/H}{\rho}\times M = \frac{I/H}{M/V}\times M$

So it's unit is m^3.

23. (c)



Initially $T = 2\pi\sqrt{\frac{I}{mB_H}}$, Finally $T' = 2\pi\sqrt{\frac{I}{m(B+B_H)}}$

Where B = Magnetic field due to down ward conductor

$= \frac{\mu_0}{4\pi}.\frac{2i}{a} = 18\mu T$

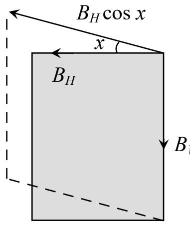
$\therefore\ \frac{T'}{T} = \sqrt{\frac{B_H}{B+B_H}} \Rightarrow \frac{T'}{0.1} = \frac{24}{18+24} \Rightarrow$

$T' = 0.076\ s$

24. (a) In first case $\tan\theta = \frac{B_V}{B_H}$ ..... (i)

Second case $\tan\theta' = \frac{B_V}{B_H \cos x}$ ..... (ii)

From equation (i) and (ii), $\frac{\tan\theta'}{\tan\theta} = \frac{1}{\cos x}$



25. (c) $\tan\theta = \frac{B_V}{B_H}$ ... (i)

If apparent dip is θ' then

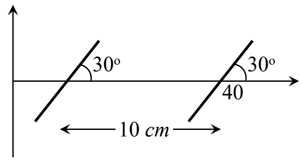
$$\tan\theta' = \frac{B_V}{B_H} = \frac{B_V}{B_H \cos 30^\circ} = \frac{B_V}{B_H \times \frac{\sqrt{3}}{2}}$$

$$\Rightarrow \tan\theta' = \left(\frac{2}{\sqrt{3}}\right)\tan\theta \Rightarrow \tan\theta' > \tan\theta \Rightarrow \theta' > \theta$$

Graphical Questions

1. (d) For a temporary magnet the hysteresis loop should be long and narrow.
2. (c) Magnetism of a magnet falls with rise of temperature and becomes practically zero above curie temperature.
3. (b) For a diamagnetic substance χ is small, negative and independent of temperature.
4. (a) Susceptibility of a paramagnetic substance is independent of magnetising field.
5. (a) Susceptibility of a ferromagnetic substance falls with rise of temperature $\left(\chi = \frac{c}{T - T_c}\right)$ and the substance becomes paramagnetic above curie temperature, so magnetic susceptibility becomes very small above curie temperature.
6. (c)
7. (b) $B = \mu_0 \mu_r H \Rightarrow \mu_r \propto \frac{B}{H}$ = slope of B- H curve

   According to the given graph, slope of the graph is highest point Q.
8. (b) $i \propto \tan\theta$
9. (b) $|B| = \frac{\Delta V}{\Delta x} = \frac{0.1 \times 10^{-4}}{0.1 \sin 30^o} = 2 \times 10^{-4}\ T$



10. (a) $X = C \times \frac{1}{T} = \frac{0.4}{7 \times 10^{-3}} = 57K$
11. (b) In the given figure OQ refers to retentivity while OR refers to corecivity, for permanents both retentivity and corecivity should be high.
12. (b) Intensity of magnetisation of diamagnetic substance is very small and negative.
13. (d) $\mu_r = 1 + \frac{I}{H}$; as we know I dependent on H, initially value of $\frac{I}{H}$ is smaller so value of μ_r increases with H but slowly but with further increases of H value of $\frac{I}{H}$ also increases *i.e.* μ_r increases speedily. When material fully magnetised I becomes constant then with the increase of H ($\frac{I}{H}$ decreases) μ_r decreases. This is confirm with the option (d).
14. (a) For paramagnetic substance magnetization M proportional to magnetising field H, and M is positive.

Assertion and Reason

1. (d) 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.
2. (b) As we know every atom of a magnet acts as a dipole, So poles cannot be separated. When magnet is broken into two equal

pieces, magnetic moment of each part will be half of the original magnet.

3. (a) In case of the electric field of an electric dipole, the electric lines of force originate from positive charge and end at negative charge. Since isolated magnetic lines are closed continuous loops extending through out the body of the magnet.

4. (c) In an atom, electrons revolve around the nucleus and as such the circular orbits of electrons may be considered as the small current loops. In addition to orbital motion, an electron has got spin motion also. So the total magnetic moment of electron is the vector sum of its magnetic moments due to orbital and spin motion. Charge particles at rest do not produce electric field.

5. (b) Magnetic dipole moment of the current loop

= Ampere turns × Area of the coil

Initially magnetic moment $M = i\pi r^2$, new magnetic moment $M' = i\pi(2r)^2 = 4i(\pi r^2) = 4M$.

So magnetic moment becomes four times when radius is doubled.

6. (e) The temperature inside the earth is so high that it is impossible for iron core to behave as magnet and act as a source of magnetic field. The magnetic field of earth is considered to be due to circulating electric current in the iron (In molten state) and other conducting materials inside the earth.

7. (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 align it along its direction. As the compass needle can not rotate in vertical plane, it will rest horizontally, when placed on the magnetic pole of the earth.

8. (b) In tangent galvanometer the current through the coil is given by $I = \frac{2r}{n\mu_0}.B_H \tan\theta \Rightarrow$

$\tan\theta \propto n/r$

i.e. by reducing its radius or by increasing number of turns of coil we can increase the sensitivity of tangent galvanometer.

9. (b) The susceptibility of ferromagnetic substance decreases with the rise of temperature in a complicated manner. After Curies point the susceptibility of ferromagnetic substance varies inversely with its absolute temperature. Ferromagnetic substance obey's Curies law only above its Curie point.

10. (e) The properties of substance is due to alignment of molecules in it. When these substance are heated, molecules acquire some kinetic energy. Some of molecules may get back to the closed chain arrangement (produce zero resultant). So they lose their magnetic property or magnetism. Therefor the properties of both ferromagnetic and paramagnetic are effected by heating.

11. (a) The core of a transformer undergoes cycles of magnetisation again and again. During each cycle of magnetisation, energy numerically equal to the area of the hysteresis loop is spent per unit volume of the core. Therefore, for high efficiency of transformer, the energy loss will be lesser if the hystersis loop is of lesser area, i.e. narrow. That's why the soft iron is used as core, which has narrow hysteresis loop (or area of $B-H$ curve is very small). Also soft iron (ferromegnetic substance) has high permeability, high retentivity, low coercivity and low hystersis loss.

12. (a) A magnetic field is produced by the motion of electric charge. Since motion is relative, the magnetic field is also relative.

13. (a) In a moving coil galvanometer, the coil is suspended in a very strong uniform magnetic field created by two magnetic pole pieces. The earth's magnetic field is quite weak as compared to that field, therefore, it does not effect the working of magnetic field.

14. (c) A paramagnetic sample display greater magnetisation when cooled, this is because at lower temperature, the tendency to disrupt the alignment of dipoles (due to magnetising field) decreases on account of reduced random thermal motion.

15. (a) Electromagnets are magnets, which can be turned on and off by switching the current on and off. As the material in electromagnets is subjected to cyclic change (magnification and demagentisation), the hysteresis loss of the material must be small. The material should attain high value of I and B with low value of magnetising field intensity H. As soft iron has small coercivity, so it is a best choice for this purpose.

16. (a) Since iron is ferromagnetic in nature, therefore, lines of force due to external magnetic field prefer to pass through iron.

17. (d) In general, the field due to a magnet is non-uniform. Therefore, it exerts both, a net force and a torque on the nails which will translate and also rotate the nails before striking to north pole of magnet with their induced south poles and vice-versa.

18. (d) In a non-uniform magnetic field, both a torque and a net force acts on the dipole. If magnetic field were uniform, net force on dipole would be zero.

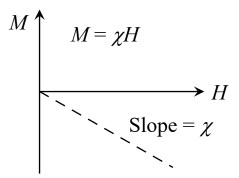
19. (c) The reduction factor of tangent galvanometer is

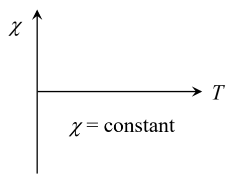
$$K = \frac{B_H}{G} = B_H \times \frac{2r}{n\mu_0}$$

Thus reduction factor of a tangent galvanometer depends upon the geometry of its coil. It increases with increase of radius and decreases with increase in number of turn of the coil of the galvanometer.

20. (c) Diamagnetism is non-cooperative behaviour of orbiting electrons when exposed to an applied magnetic field. Diamagnetic substance are composed of atom which have no net magnetic moment (*i.e.*, all the orbital shells are filled and there are no unpaired electrons). When exposed to a field, a negative magnetization is produced and thus the susceptibility is negative.

Behaviour of diamagnetic material is that the susceptibility is temperature independent.





21. (d) The permeability of a ferromagnetic material is not independent of magnetic field, $\vec{B} = K_m \vec{B}_0$.

B_0 is applied field. The total magnetic field $\vec{B}$ inside a ferromagnet may be 10^3 or 10^4 times the applied field B_0. The permeability K_m of a ferromagnetic material is not constant, neither the field $\vec{B}$ nor the magnetization $\vec{M}$ increases linearly with $\vec{B}$. Even at small value of B_0. From the hysteresis curve, magnetic permeability is greater for lower field.

22. (e) For a perfectly diamagnetic substance,

$B = \mu_0(H + I) = 0 \qquad \therefore I = -H.$

Therefore, $\chi_m = \frac{I}{H} = -1$

Therefore relative permeability

$\mu_r = 1 + \chi_m = 1 - 1 = 0. \quad \therefore \mu = \mu_0 \mu_r =$ zero.

i.e. for a perfectly diamagnetic material permeability is zero.

23. (a)

24. (a) Helium atom has paired electrons so their electron spin are opposite to each other and hence it's net magnetic moment is zero.

25. (b) Steel is preferred over soft iron for making permanent magnets, because coercivity of steel is larger.