SRIGAYATRI EDUCATIONAL INSTITUTIONS
INDIA

SR MPC JEE MAINS (UT1) – QUESTION BANK
MAGNETISM AND MATTER

1. The pole strength of 12 cm long bar magnet is 20Am. The magnetic induction at a point 10 cm away from the centre of the magnet on its axial line is $\left(\frac{\mu_0}{4\pi} = 10^{-7} Hm^{-1}\right)$

1) $1.17\times10^{-3}T$ 2) $2.20\times10^{-3}T$ 3) $1.17\times10^{-2}T$ 4) $2.20\times10^{-2}T$

Sol: $B = \frac{\mu_0}{4\pi}\left(\frac{2Md}{\left(d^2 - l^2\right)^2}\right)$

$= 1.17\times10^{-3}T$

2. A circular coil of 300 turns and diameter 14cm carries a current of 15A. The magnitude of magnetic moment associated with the loop is

1) $51.7 JT^{-1}$ 2) $69.2 JT^{-1}$ 3) $38.6 JT^{-1}$ 4) $19.5 JT^{-1}$

Sol: $M = NIA$

$= NI\pi R^2$

$= 69.2 JT^{-1}$

3. A dipole of magnetic moment $\overline{M} = 30\, jAm^2$ is placed along the y-axis in a uniform magnetic field $B = \left(2\hat{i} + 5j\right)T$ .The forque acting on it is

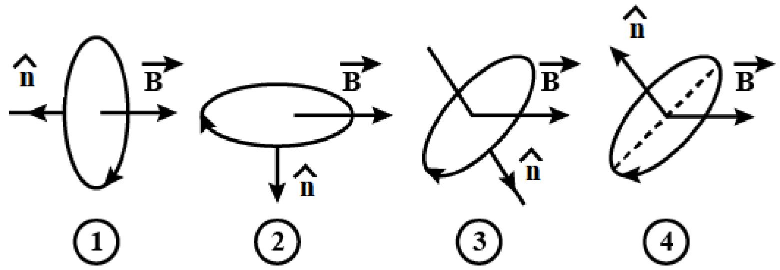
1) $-40kNm$ **2)** $-50kNm$ **3)** $-60kNm$ **4)** $-70kNm$

Sol: $\vec{T} = \vec{M}\times\vec{B}$

$= 60(-k) + 150\times 0$ $\left(\begin{matrix} j\times\hat{i} = -k \\ j\times\hat{i} = 0 \end{matrix}\right)$

$= -60kNm$

4. A current carrying loop is placed in a uniform maqnetic field in four different orientations as shown in fig. Arrange them in the decreasing order of potential energy



1) 4, 2, 3, 1 2) 1, 4, 2, 3 3) 4, 3, 2, 1 4) 1, 2, 3, 4

Sol: $P.E=-\vec{M}.\vec{B}=-MB\cos\theta$

1) $U=-MB\cos180^0=MB$

2) $U=-MB\cos90^0=0$

3) $U=-MB\cos\theta$

$U=+MB\cos\theta$

5. **The net magnetic flux through any closed surface, kept in a magnetic field is**

1) zero 2) $\dfrac{\mu_0}{4\pi}$ **3)** $4\pi\,\mu_0$ **4)** $\dfrac{4\mu_0}{\pi}$

Sol: **The net magnetic flux through a closed surface will be zero. i.e** $\oint\overline{B}.d\overline{s}=0$ **because there are no magnetic monopoles**

6. **The horizontal and vertical components of earth's magnetic field at a place are 0.3G and 0.52G. The earth's magnetic field and the angle of dip are**

1) 0.3G & $\delta=30^0$ **2) 0.4G &** $\delta=40^0$

3) 0.5G & $\delta=50^0$ **4) 0.6G &** $\delta=60^0$

Sol: $B_H=0.3G$ $B_v=0.52G$

$B=\sqrt{B_H^2+B_v^2}$

$=0.6G$

Tan $\delta=\dfrac{B_v}{B_H}=1.734$

$\delta=\tan^{-1}(1.734)=60^0$

7. **At a given place on earths surface the horizontal component of earth's magnetic field is** $2\times10^{-5}T$ **and resultant magnetic field is** $4\times10^{-5}T$ **. The angle of dip at this place is**

1) 30^0 **2)** 60^0 **3)** 90^0 **4)** 45^0

Sol: $B_H=B\cos\delta$

$B=4\times10^{-5}T$ $B_H=2\times10^{-5}T$

$\delta=60^0$

8. **A permanent magnet in the shape of a thin cylinder of length 10cm has magnetisation** $(M)=10^6\,Am^{-1}$**. It's magnetization current** I_M **is**

1) 10^5A **2)** 10^6A **3)** 10^7A **4)** 10^8A

Sol: $Bl=\mu_0Ml=\mu_0\left(I+I_M\right)$

$I=0$

$\mu_0MI=\mu_0\left(I_M\right)$

$I_M=MI$

$=10^6\times0.1=10^5A$

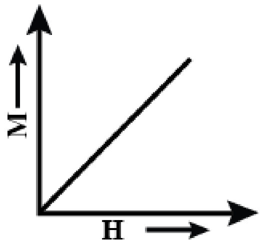
9. **The relation connecting magnetic susceptihility** χ_m **& relative permeability** μ_r **is**

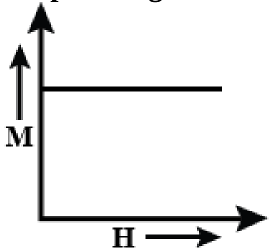
1) $\chi_m=\mu_r+1$ **2)** $\chi_m=\mu_r-1$ **3)** $\chi_m=\dfrac{1}{\mu_r}$ **4)** $\chi_m=3(1+\mu_r)$

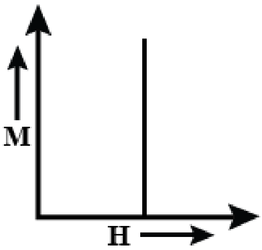
Sol: $\mu_r = 1 + \chi_m$

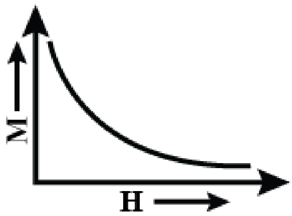
$\chi_m = \mu_r - 1$

10. **The correct M-H curve for a paramagnetic material at a constant temperature (T) is represented by**

1) 

2) 

3) 

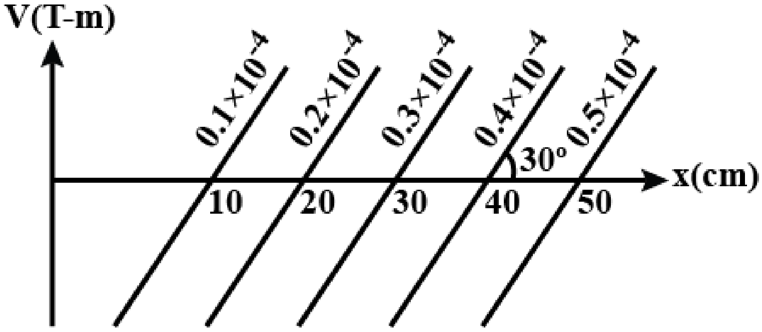
4) 

Sol: $M = c\frac{B}{T} = c\mu_0 \frac{H}{T}$ $\left(\therefore \frac{c\mu_0}{T} is\, const \right)$

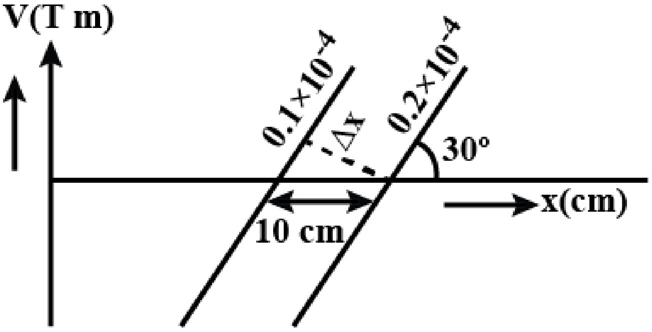
$M \propto H$

11. **Which of the following materinl is used in making the core of a moving coil galvanometer?**
1) Copper 2) Nickel 3) Iron 4) Both (1) & (2)
Sol: **soft iron is used in making the core of moving coil galvanometer, because it has high initial permeability & low hysteresis loss**

12. **Some equipotential surfaces of the magnetic scalar potential are shown in figure. Magnetic field at a point in the region is**



1) $10^{-4}T$ 2) $0.5\times10^{-4}T$ 3) $2\times10^{-4}T$ **4) None of these**



Sol:

$\Delta V = (0.2.01)10^{-4}Tm$

$\Delta x = x\sin 30^0 = 0.1\times\frac{1}{2}$

$$|B| = \frac{\Delta v}{\Delta x} = \frac{1\times10^{-4}}{0.1/2} = 2\times10^{-4}T$$

13. **A solenoid has core of a material with relative permeability 500 and its windings carry a current of 1A. The number of turns of the solenoid is 500 per metre. The magnetization of the material is nearly**

1) $2.5\times10^{3}Am^{-1}$ **2)** $2.5\times10^{5}Am^{-1}$ **3)** $2.0\times10^{3}Am^{-1}$ **4)** $2.0\times10^{5}Am^{-1}$

Sol: $n = 500\,turns/m$

$I = 1A,\ \mu_r = 500$

$H = nI = 500Am^{-1}$

$\mu_r = 1+\chi$

$\chi = (\mu_r - 1)$

$M = xH = (\mu_r - 1)$

$H = (500-1)500$

$= 2.495\times10^{5}Am^{-1}$

$\simeq 2.5\times10^{5}Am^{-1}$

14. **A bar magnet of magnetic moment M and moment of inertia I is freely suspended such that the magnetic axial line is in the direction of magnetic meridian. If the magnet is displace of by a very small angle θ, angular acceleration is (magnetic induction of earths horizontal field is B_H**

1) $\frac{MB_H\theta}{I}$ **2)** $\frac{IB_H\theta}{M}$ **3)** $\frac{M\theta}{IB_H}$ **4)** $\frac{I\theta}{MB_H}$

Sol: **Restoring torque on the magnet**

$T = -2mB_H l\sin\theta$

$= -MB_H\sin\theta$

If θ **is small** $\sin\theta \approx \theta \Rightarrow I\propto = -MB_H\theta$

$$\propto = \frac{MB_H\theta}{I}$$

15. **A magnetic compass needle oscillates 30 times per minute at a place where the dip is 45^0 ansd 40 times per minute where the dip is 30^0. If $B_1\ and\ B_2$ respectively the total magnetic field due to the earth at the two places, then the ratio B_1/B_2 is best given by**

1) 0.7 2) 3.6 3) 1.8 4) 2.2

Sol: **Frequency of oscillation** $\propto\sqrt{magnetic\ field}$

$$\frac{30}{40} = \sqrt{\frac{B_1\cos45^0}{B_2\cos30^0}}$$

$$\frac{B_1}{B_2} = 0.7$$

16. **A magnetic dipole in a constant magnetic filed has**

1) zero potential energy when the torque is maximum

2) minimum potential energy when the torque is maximum

3) maximum potential energy when the torque is maximum

4) zero potential energy when the torque is minimum

Sol: **When a magnetic dipole of dipole moment is placed in a uniform magnetic field, it will experience a torque**

$$T = mB\sin\theta$$

$$\theta = 90^0$$

$$T_{\max} = MB\sin 90^0 = MB$$

17. **A hoop and a solid cylinder of same mass & radius are made of a permanent magnetic material with their magnetic moment parallel to their respective axes. But the magnetic moment of hoop is twice of solid cylinder. They are placed in a uniform magnetic field such a manner that their magnetic moments make a small angle with the field. If the oscillation periods of hoop and cylinder are T_h & T_c respectively, then**

1) $T_h = 0.5T_c$ **2)** $T_h = 2T_c$ **3)** $T_h = 1.5T_c$ **4)** $T_h = T_c$

Sol: $T = 2\pi\sqrt{\dfrac{I}{\mu B}}$

$$T_C = 2\pi\sqrt{\frac{\left(\frac{1}{2}\right)MR^2}{\mu B}}$$

$$T_h = 2\pi\sqrt{\frac{MR^2}{(2\mu)B}}$$

$$T_h = T_c$$

18. **core of electromagnets are made of ferromagnetic materials which have**

1) low permeability and low retentivity

2) high permeability and high retentivity

3) high permeability and low retentivity

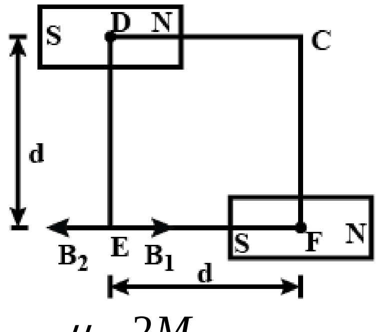
4) low permeability and high retentivity

Sol: **Conceptual**

19. **Two short bar magnets of magnetic moments m each are arranged at the opposite corners of a square of side d such that their centres coincide with the corners and their axes are parallel. If the like poles are in the same direction, the magnetic induction at any of the other corners of the square is**

1) $\dfrac{\mu_0}{4\pi}.\dfrac{M}{d^3}$ **2)** $\dfrac{\mu_0}{4\pi}.\dfrac{2M}{d^3}$ **3)** $\dfrac{\mu_0}{4\pi}.\dfrac{M}{2d^3}$ **4)** $\dfrac{\mu_0}{4\pi}.\dfrac{M^3}{2d^3}$

Sol:



$$B_{1amial} = \frac{\mu_0}{4\pi}.\frac{2M}{d^3}$$

$$B_2 equ = \frac{\mu_0}{4\pi}\frac{M}{d^3}$$

$$B = B_1 - B_2$$

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

20. **Super conductors are**

1) Ferromagnetism **2) dia magnetism**

3) para magnetism **4) Anti-ferromagnetism**

21. **The magnetic needle has magnetic moment $6.28\times10^{-2}\,Am^2$ & Moment of inertia $I = 6.4\times10^{-6}\,Kgm^2$. It performs 30 complete Oscillations in 9.60s. what is the magnitude of the magnetic field?**

Ans: **0.039T**

Sol: **The time period of oscillation is**

$$T = \frac{9.60}{30} = 0.32s$$

$$B = \frac{4\pi^2 I}{MT^2}$$

$$= \frac{4\times(3.14)^2\times6.4\times10^{-6}}{6.28\times10^{-2}\times(0.32)^2} = 0.039T$$

22. **What is the magnitude of the equatorial and axial fields due to a bar magnet of length 15.0 cm at distance of 150 cm from its mid-point? The magnetic moment of the bar magnet is 0.80 Am^2**

Ans: $0.23\times10^{-7}T, 0.47\times10^{-7}T$

Sol: $$B_E = \frac{\mu_0 m}{4\pi r^3} = \frac{10^{-7}\times0.80}{(1.5)^3} = \frac{0.80}{3.375}\times10^{-7} = 0.237\times10^{-7}T$$

$$B_A = \frac{\mu_0 2m}{4\pi r^3} = \frac{10^{-7}\times2\times0.80}{(1.5)^3} = \frac{1.6\times10^{-7}}{3.375} = 0.47\times10^{-7}T$$

23. **In the magnetic meridian of a certain place, the horizontal component of the earths magnetic field is 1.732G and the dip angle is 30^0. What is the magnetic field of the earth at this location?**

Ans: **2G**

Sol: $H_E = 1.732G$

$$\cos30^0 = \frac{H_E}{B_E} \Rightarrow B_E = \frac{H_E}{\cos30^0} = \frac{1.732}{\frac{\sqrt{3}}{2}} = 2G$$

24. **A solenoid has a core of a material with relative permeability 1600. The windings of the solenoid are insulated from the core and carry a current of 4A. If the number of turns is 10000per metre. Calculate a) H b) B**

Ans: $4\times10^4\,A/m, 80.384T$

Sol: **a) The field H is depeudeut of the material of the core and is**

$$H = nI$$

$$= 10000\times4$$

$= 4 \times 10^4 A/m$

b) $B = \mu_r \mu_o H$

$= 1600 \times 4\pi \times 10^{-7} \left(N / A^2\right) \times 4 \times 10^4$

$= \dfrac{80384}{1000} = 80.384T$

25. **A Rowland ring of mean radius 36 cm has 3200 turns wire wound on a ferromagnetic core of relative permeability 600. What is the magnetic field B in the core for a magnetizing current of 1.8A?**

Ans: **1.92T**

Sol: $B = \dfrac{\mu_r \mu_0 IN}{2\pi r}$

$\mu_r = 600$

$i = 1.8A$

$N = 3200$

$r = 36cm = 0.6m$

$B = 1.92T$

26. **A magnetizing field of** $1600Am^{-1}$ **produces a magnetic flux of** 2.4×10^{-5} **wb in an iron bar of cross-sectional area** $0.2cm^2$**. The susceptibility of an iron bar is**

Ans: **596**

Sol: $H = 1600Am^{-1}$

$\phi = 2.4 \times 10^{-5} wb$

$A = 0.2cm^2 = 0.2 \times 10^{-4}$

$B = \dfrac{\phi}{A} = 1.2wbm^{-2}$

$\mu = \dfrac{B}{H} = 7.5 \times 10^{-4} NA^{-2}$

$x = \dfrac{\mu}{\mu_0} - 1 = \dfrac{7.5 \times 10^{-4}}{4\pi \times 10^{-7}} - 1 = 596$

27. **A domain in ferromagnetic substance is in the form of a cube of side length** $1\mu m$**. If it contains** 8×10^{10} **atoms and each atomic dipole has a dipole moment of** $9 \times 10^{-24} Am^2$**, then the magnetization of the domain is** $n \times 70^5 Am^{-1}$ **Then the value of n is**

Sol: $v = \left(10^{-6} m\right)^3 = 10^{-18} m^3$

$m_{net} = 8 \times 10^{10} \times 9 \times 10^{-24} Am^2$

$= 72 \times 10^{-14} Am^2$

$M = \dfrac{m_{net}}{domain\, volume}$

$= \dfrac{72 \times 10^{-14} Am^2}{10^{-18} m^3} = 7.2 \times 10^5 Am^{-1}$

28. **The magnetic field due to a dipole of magnetic moment $1.2Am^2$ at a point 1m away from it in a direction making an angle 60^0 with the dipole axis is $P\times10^{-7}$. The value of P is**

Ans: 1.6

Sol: The magnetic field $=\dfrac{\mu_0}{4\pi}\dfrac{M}{r^3}\sqrt{1+3\cos^2\theta}$

$$=\left(10^{-7}\frac{Tm}{A}\right)\frac{1.2Am^2}{1m^3}\sqrt{1+3\cos^2 60^0}=1.6\times10^{-7}T$$

29. **Magnetic permeability of a certain terromagnetic a alloy is $1.1\times10^{-2}T\,MA^{-1}$. The value of relative permeability of the given alloy is 88×10^n. Then the value of n is**

Ans: 2

Sol: $\mu=1.1\times10^{-2}T\,MA^{-1}$

$$\mu_r=\frac{\mu}{\mu_0}=\frac{1.1\times10^{-2}}{4\pi\times10^{-1}}=88\times1$$

$$88\times10^n=88\times10^2$$

$$n=2$$

30. **A coil of a long solenoid per metre and magnetic intensity H at the centre of soleuoid is $2500Am^{-1}$. Then the current (in A) passing in the coil is**

Ans: 3.12

Sol: $H=2500Am^{-1}$

$$n=800m^{-1}$$

$$I=\frac{H}{n}=3.125A$$

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