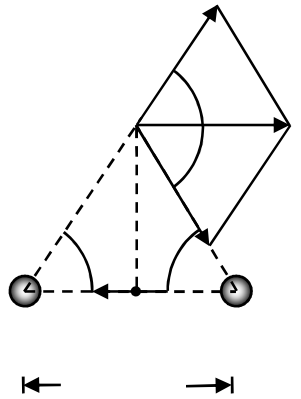
Magnetic field intensity due to a magnetic dipole (bar magnet) along perpendicular to its axis

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 05
CHAPTER NAME : MAGNETISM AND MATTER

MAGNETIC FIELD INTENSITY DUE TO A MAGNETIC DIPOLE (BAR MAGNET) ALONG PERPENDICULAR TO ITS AXIS

Magnetic charge (or pole strength) of the north pole and the south poles are respectively q_m and $-q_m$.



MAGNETIC FIELD INTENSITY DUE TO A MAGNETIC DIPOLE (BAR MAGNET) ALONG PERPENDICULAR TO ITS AXIS

Magnetic charge (or pole strength) of the north pole and the south poles are respectively q_m and $-q_m$. The magnitudes of magnetic field intensities at P due to north and south poles are respectively and are equal

$$B_N = \frac{\mu_0}{4\pi}\frac{q_m}{(r^2+a^2)}$$

$$B_S = \frac{\mu_0}{4\pi}\frac{q_m}{(r^2+a^2)}$$

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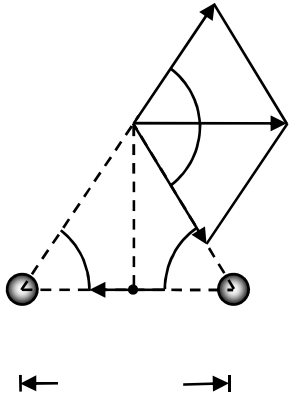

The directions of $\vec{\boldsymbol{B}}_N$ and $\vec{\boldsymbol{B}}_S$ are as shown in fig.(1). The components normal to the dipole axis cancel away. The components along the dipole axis add up. The total magnetic field is opposite to the unit vector $\hat{\boldsymbol{m}}$ along the dipole axis from south pole to north pole.

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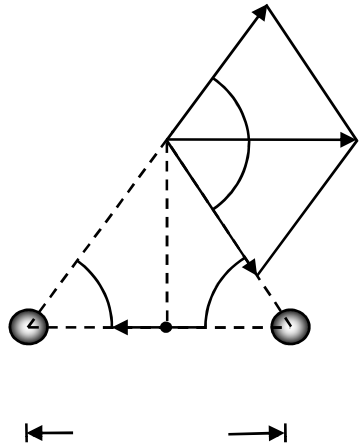
So the total field at P is

$$\vec{\boldsymbol{B}} = -(B_N + B_S)\cos\theta\,\hat{\boldsymbol{m}}$$

$$= -\frac{\mu_0}{4\pi}\frac{2aq_m}{(r^2+a^2)^{3/2}}\hat{\boldsymbol{m}}$$

$$= -\frac{\mu_0}{4\pi}\frac{\vec{\boldsymbol{m}}}{(r^2+a^2)^{3/2}}$$



where, $\vec{\boldsymbol{m}} = 2aq_m\hat{\boldsymbol{m}}$ is the magnetic moment of a bar magnet.

For $r \gg a$,

$$\vec{\boldsymbol{B}} \approx -\frac{\mu_0}{4\pi}\frac{\vec{\boldsymbol{m}}}{r^3}$$

Numerical

Question: What is the magnitude of the equatorial field due to a bar magnet of length 5.0 cm at a distance of 50 cm from its mid-point? The magnetic moment of the bar magnet is 0.40 $A \cdot m^2$.(NCERT)

Solution:

$$B \approx \frac{\mu_0}{4\pi}\frac{m}{r^3} = 3.2 \times 10^{-7} T$$

Numerical

Question: Two magnetic poles (north and south) ±10 μAm are placed 5.0 mm apart. Determine the magnetic field at a point 15 cm away from its centre on a line passing through the centre and normal to the axis of the dipole.

THANKING YOU

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