JIGYAS BARUAH
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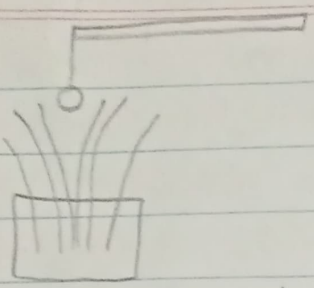

In the given setup we have a paramagnetic ball of volume V attracted to a pole of ~~et~~ an electromagnet. The magnetic induction at the axis of the pole is given by $B = B_0 e^{-ay^2}$, where y is the height from the base level, B_0 is the magnetic induction at base level and a is some constant. Given that X is the magnetic susceptibility of the paramagnet find the maximum attractive force and its position.

Sol^n We have, $F_y = p_m \cdot \vec{\nabla} B = \frac{XBV}{\mu_0} \cdot \frac{dB}{dy}$

$$= \frac{XV}{\mu_0} B_0 e^{-ay^2} \frac{d}{dy} B_0 e^{-ay^2}$$

$$= -2ay e^{-2ay^2} \frac{X B_0^2 V}{\mu_0}$$

For F_{max}, $\frac{dF}{dy} = 0$

$$\Rightarrow -\frac{2aXVB_0^2}{\mu_0} \left(e^{-2ay^2} - 4ay^2 e^{-2ay^2} \right) = 0$$

$$\Rightarrow e^{-2ay^2} - 4ay^2 e^{-2ay^2} = 0$$

$$\Rightarrow e^{-2ay^2} = 4ay^2 e^{-2ay^2}$$

$$\Rightarrow 4ay^2 = 1$$

$$\Rightarrow y = \frac{1}{2\sqrt{a}}$$

Now $F_{max} = -2a \frac{1}{2\sqrt{a}} e^{\frac{-2a}{4a}} \frac{X V B_0^2}{\mu_0}$

$= -\frac{X V B_0^2}{\mu_0} \sqrt{\frac{a}{e}}$

∴ the maximum attractive force is $\frac{X V B_0^2}{\mu_0} \sqrt{\frac{a}{e}}$ at a height of $\frac{1}{2\sqrt{a}}$