M98E.2

Solution to M98.E.2

Group 3

Problem:
A cylindrical magnet has a cross-section area A, length $L$and uniform magnetization M parallel to L. The magnet is very long, $L \gg A^{1/2}$. It is placed on end against a steel sheet, with the axis of the cylinder perpendicular to the surface of the steel sheet. The steel has infinite magnetic permeability. What force F is necessary to pull the magnet from the sheet? Neglect gravity.

\section{Solution:}

Given the magnetization of a magnet, we first calculate the volume and surface bound current.
Since $\vec{M} = M \cdot \hat{z}$:

$$\overrightarrow{J_b} = \vec{\nabla} \times \vec{M} = 0 \tag{1}$$

and

$$\overrightarrow{K_b} = \vec{M} \times \hat{n} = M \cdot \hat{\phi} \tag{2}$$

Notice that magnet field of this surface current should resemble that of a solenoid. According to Ampere's Law, the magnetic field near the end of the magnet should be:

$$\vec{B} = \mu_0 K_b \cdot \hat{z} = \mu_0 M \cdot \hat{z} \tag{3}$$

Now when there is a small gap, ϵ, between the magnet and the sheet, the energy stored in the "air gap"

comes all from the magnetic field:

$$E = \frac{B^2 \epsilon A}{2\mu_0} = \frac{1}{2}\mu_0 M^2 \epsilon A \tag{4}$$

Thus the force applied to do this amount of work is:

$$F = \frac{dE}{d\epsilon} = \frac{1}{2}\mu_0 M^2 A \tag{5}$$

| Assigned groups: ssgubser_classes_F2013

One thought on “M98E.2”

December 13, 2013 at 1:42 am

Good solution.