

Week 11 Worksheet

Magnets!

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Exercise 1. Suppose a magnetized object has a *uniform* magnetization \mathbf{M} .

- What does $\int \mathbf{M} dV$ calculate, where the integral is taken over the volume of the object?
- Suppose a little current loop creates one of the infinitesimal dipole moments. Let it have area a and thickness t . What is m for this loop?
- Since $m = Ia$, find an equation for the current I , and hence for the bound surface current K_b .
Hint: You can write K_b in terms of I and the dimension(s) of the loop; then, you can eliminate the dimensions using the previous results.
- Deduce that

$$\mathbf{K}_b = \mathbf{M} \times \hat{n}.$$

Exercise 2. Suppose a magnetized object has a *non-uniform* magnetization \mathbf{M} . We already know how to calculate the surface current density, so we would now like to calculate the volume current density.

- Consider two adjacent infinitesimal chunks of magnetized material, one at (x, y, z) and the other at $(x, y + dy, z)$. On the surface where the chunks touch, which way does the net current **due only to** M_z point? Show that its magnitude is

$$\frac{\partial M_z}{\partial y} dy dz.$$

- What is the net bound current density due to the touching surface for the chunks considered in (a)?
- Now, consider two chunks situated at (x, y, z) and $(x, y, z + dz)$, and consider M_y . Obtain that the net bound current density due to the chunks in (a) and the new chunks is

$$(J_b)_x = (\nabla \times \mathbf{M})_x.$$