Problem 1

A robot going into a high-radiation environment uses a special kind of magnetic data
storage. 2.88 MB of data are stored in a square area with edge $L = 10\, cm$. The thickness
of the magnetic material is $20\, \mu m$. The bits are rectangular boxes and are arranged in a
square array. The thickness is one bit. 1 Byte = 8 bits.

When a bit is set, the magnitude of the magnetization is $10^6 A/m$ and the direction is
either up or down (perpendicular to the plane of the square). Let $B$ denote the magnitude
of the magnetic field a distance $h = 5\, cm$ above the center of the square.

(a) Find an approximate value for $B$ for the case in which all of the bits have the same
value.

(b) Considering just two neighboring bits in the center of the square, find the value of $B$,
assuming opposite values are stored in these bits.

Problem 2

A cube with vertices $(\pm d, \pm d, \pm d)$ is uniformly magnetized in the $z$ direction.

(a) Find the bound volume current density and the bound surface current density.

(b) Set up the integral for the vector potential at the point $(2d, 0, 0)$ using Eq. (6.15).

(c) Compute the magnetic dipole moment from the bound current density and compare
with what you expect based on the volume and the magnetization.

Problem 3

Repeat the previous problem with magnetization $\mathbf{M} = k x^2 \hat{z}$, where $k$ is a constant. You
may use the formula $\mathbf{m} = \frac{1}{2} \int (\mathbf{r} \times \mathbf{J}) d\tau$ presented at the end of Chapter 5.

Problem 4

Using what we have learned about linear magnetic media, fill in the missing parts in
Example 6.2, that is, compute the bound current and the magnetic field everywhere.
Problem 5

The interior of a certain electron microscope contains a region in which the potential is $V(x, y, z) = \beta(2z^2 - x^2 - y^2)$, where $\beta$ is a constant. A tiny dielectric sphere of radius $R$ is placed at the origin. Its dielectric constant is $\epsilon_r$. The sphere is tiny in the sense that the electron microscope is not affected by it, and we use the unperturbed far-field form for the potential.

(a) Find the electric field inside and outside the sphere.

(b) Using the transcription described in Problem 6.25 on page 293, write out the magnetic field inside and outside the sphere in the corresponding magnetic problem with a linear magnetic material. The relative permeability is $\mu_r$.

(c) For the sphere in part (b), find the bound surface current and verify the boundary conditions for $\mathbf{B}$ and $\mathbf{H}$. For both fields, verify both the normal and tangential boundary conditions.