1. Textbook exercise 9.1
2. Textbook exercise 9.10
4. Textbook exercise 9.15

5. If \( \mathbf{J}_f = 0 \) everywhere, the curl of \( \mathbf{H} \) vanishes, and we can express \( \mathbf{H} \) as the gradient of a scalar potential \( \phi_m \), where \( \mathbf{H} = -\nabla \phi_m \). Thus, \( \nabla^2 \phi_m = \nabla \cdot \mathbf{M} \), and \( \phi_m \) obeys Poisson’s equation with \( \nabla \cdot \mathbf{M} \) as the “source”. This enables us to use the mathematical tools from electrostatics (and the potential) to find \( \phi_m \). For example, find the magnetic field inside of a uniformly magnetized (uniform magnetization \( \mathbf{M}(\mathbf{x}) = M \hat{\mathbf{k}} \)) sphere of radius \( R \) by separation of variables. Note that \( \mathbf{M} \) is divergenceless everywhere except at the surface so Laplace’s equation is satisfied inside and outside the sphere. You may use our result

\[
V(r, \theta) = \sum_{l=0}^{\infty} \left( A_l r^l + B_l r^{-l-1} \right) P_l(\cos \theta)
\]

which is the general solution for separation of variables in spherical polar coordinates with azimuthal symmetry. Use the equation

\[
H_\perp^{\text{Above}} - H_\perp^{\text{Below}} = -(M_\perp^{\text{Above}} - M_\perp^{\text{Below}})
\]

to figure out the appropriate boundary condition on \( \phi_m \) at the sphere’s surface. (Example 7 in the text is similar and may be helpful.)