“The nation that controls magnetism will control the universe” – Dick Tracy (1935)

1) Jackson 5.27 [10 points]

2) Jackson 5.33 [10 points] (a)–5, (b)–5.

3) Jackson 5.34 [20 points] (a)–3: Use the formula given in Problem 5.10b as the start. (b)–7; (c)–7; (d)–3: No discussion of Prob. 5.18 is needed.

4) Jackson 6.8 [20 points]
   The hard part of this problem is the start. \( \vec{P} \) always follows \( \vec{E} \), so \( \vec{P} \) points along \( \hat{x} \). You need the surface magnetic pole density \( \sigma_M = \vec{M} \cdot \hat{n} \) to source \( \Phi_M \). Once you have it, the problem comes apart in your hands.
   There are (at least) three ways to begin. First, you could use the surface current density \( \vec{K}_M \) and surface magnetization \( \vec{M} \), \( \vec{K}_M = \vec{M} \times \hat{n} \) where \( \hat{n} \) is an outward normal to the surface. The surface current density comes from the surface polarization density \( \vec{K} = \sigma_P \vec{v} \) where \( \sigma_P \) is the surface polarization charge density, and \( \vec{v} = \vec{\omega} \times \vec{r} \). \( \vec{K} = \vec{M} \times \hat{n} \) so \( \vec{M} = \hat{k} \omega P_0 \hat{x} \) where \( P_0 \) is the magnitude of the polarization vector.
   Second, you could look at the volume magnetization \( M \) and find the volume current \( \vec{J}_M = \vec{\nabla} \times \vec{M} \). You imagine a little dipole whose head and tail are separated by a small difference, so \( \vec{J} = N q (\vec{v}_+ - \vec{v}_-) \). This is nice, but wrong by a sign – the dipole remains oriented along \( \hat{x} \), so the charge hops from dipole to dipole in the opposite direction to what you have found. You can find \( \vec{M} \) from \( \vec{J}_M = \vec{\nabla} \times \vec{M} \), you discover \( \vec{\nabla} \cdot \vec{M} = 0 \) and construct \( \sigma_M \).
   The third way is to look around Jackson Eq. 6.100: a material in bulk motion acquires an effective magnetization \( \vec{M}_{ff} = \vec{P} \times \vec{v} \). The derivation is awful, it is fiddling along the lines of Eqs. 6.93-6.96.