

MSci 4261 ELECTROMAGNETISM EXERCISES

Week 2

1. Consider the definitions of the energy density and Poynting vector in the presence of sources:

$$\mathcal{E} = \frac{1}{2}(\mathbf{E} \cdot \mathbf{D} + \mathbf{B} \cdot \mathbf{H}),$$
$$\mathcal{P} = \mathbf{E} \times \mathbf{H}.$$

Show that Maxwell's equations imply that these satisfy the conservation equation

$$\nabla \cdot \mathcal{P} + \frac{\partial \mathcal{E}}{\partial t} = -\mathbf{J} \cdot \mathbf{E}.$$

Explain the physical significance of the term on the right-hand side of this equation.

2. Using Maxwell's equations and the Lorentz force law, prove the result given in the lectures that

$$\frac{d}{dt}(\mathbf{P}_m + \mathbf{P}_{em})_a = \oint_S T_{ab} n_b dS.$$

3. Show that a charged particle in a uniform static magnetic field \mathbf{B} moves in a helix.