Exercises Electrodynamics	**Sheet 5**

[Tutorial 26.10.]

Exercise 1: In the lecture we determined the magnetic induction for a ring current (centered at $\vec{x} = \vec{0}$, placed in the (x, y)-plane, with the current I and radius R) along the z-axis, finding

$$\vec{B}(0, 0, z) = \frac{I}{c} \frac{2\pi R^2}{(R^2 + z^2)^{3/2}} \vec{e}_z \ .$$

Consider now a coil, of radius R and length L, with N windings through which a current I flows. We consider the limit $N \to \infty$, with NI kept fixed. Determine the magnetic induction along the cylinder axis. How much smaller is the magnetic induction at the far ends of the coil, compared with the middle?

[Hint: the sum over windings can be replaced by an integral in the limit mentioned.]

Exercise 2: A small permanent magnetic dipole $\vec{\mu}$ is placed at position $\vec{d} = d\,\vec{e}_x$, and can rotate in the $(x, y)-$plane. There is a homogeneous magnetic field $\vec{B} = B_0\,\vec{e}_x$ present.

(a) In which direction does $\vec{\mu}$ point in a static "equilibrium" situation?

(b) We now switch on a current in a wire running along the z-axis, so that the current density becomes $\vec{j} = I\,\delta(x)\,\delta(y)\,\vec{e}_z$. How does the direction of the dipole change?

[Note: such an arrangement can be viewed as a current measurement device.]

Exercise 3: A charged particle (charge q, mass m) moves in simultaneous homogeneous electric and magnetic fields $\vec{E}$ and $\vec{B}$. Only the Lorentz force is considered.

(a) What is the general solution of the equation of motion?

[Hint: Landau & Lifshitz, *The classical theory of fields*, §22.]

(b) Demonstrate that if $\vec{E}$ and $\vec{B}$ are orthogonal to each other, then there are solutions with a constant velocity $\vec{v}$.