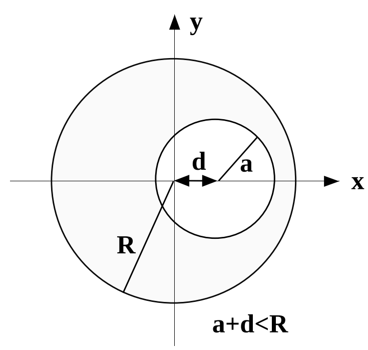
Electrodynamics, spring 2008
Exercise 5 (21.2., 22.2.; Friday group in English)

1. Charge Q is uniformly distributed at the surface of a sphere (radius R). The sphere is rotating around its axis at a constant angular velocity ω. Calculate the vector potential and the magnetic flux density inside and outside of the sphere.

2. There is an electric current flowing in an infinite disc (thickness L). The current density is everywhere parallel to the x-axis and increases linearly across the disc from $-J_0$ to J_0. Determine the magnetic flux density everywhere.

3. There is a cylindrical cavity (radius a) inside a long conducting cylinder (radius R). The distance between the axes of the cylinders is d. In the remaining conductor, there is a uniformly distributed total current I flowing parallel to the axis. Determine the magnetic flux density a) inside the cavity, b) far away from the cylinder.



4. Electric currents in the melted core of the Earth produce the geomagnetic field. Estimate their amplitude assuming that the current is a circular loop at the equatorial plane at a depth of 2900 km. Estimate also the magnitude of the Earth's dipole moment. The magnetic flux density at the magnetic poles is about 60000 nT and the radius of the Earth is about 6400 km.

5. Go through the details of the calculation outlined in the lecture notes starting from Eq. 6.12:
$$\mathbf{A}(\mathbf{r}) = \frac{\mu_0}{4\pi} \int_V \frac{\mathbf{M}(\mathbf{r}') \times (\mathbf{r} - \mathbf{r}')}{|\mathbf{r} - \mathbf{r}'|^3} \, dV'$$
and ending to Eq. 6.16: $\mathbf{B}(\mathbf{r}) = -\mu_0 \nabla\psi(\mathbf{r}) + \mu_0 \mathbf{M}(\mathbf{r})$, where ψ is the magnetic scalar potential and $\mathbf{M}$ is magnetization.

6. Extra problem (one point): There are two similar metal rods made of the same material. One is a permanent magnet and the other is unmagnetised. How can you find out which one is the magnet without using any other tools?

Return the answers until Tuesday 19.2. 12 o'clock.