UNIVERSITY OF LEIPZIG
INSTITUTE FOR THEORETICAL PHYSICS
Department: Theory of Elementary Particles

TP2 2017

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List of problems 11 (last sheet)

33. A circular wire loop of radius R is rotating uniformly with angular velocity ω about a diameter PQ. At its center, and lying along this diameter, is a small magnet of total magnetic moment $\mathbf{m}$.
What is the induced electromotive force (emf) between the point P (or Q) and a point on the loop mid-way between P and Q?

34. Consider a square loop of wire, of side length l, lying in the x,y-plane at $z=0$ [corners $(0,0,0)$, $(l,0,0)$, $(0,l,0)$, $(l,l,0)$].
Suppose a particle of charge q is moving with a constant velocity v, where $v \ll c$, in the x,z-plane at a constant distance z_0 from the x,y-plane. (Assume the particle is moving in the positive x direction with $y=0$.)
At $t=0$ the particle cross the z-axis. Thus, at time t the position of q is $(vt,0,z_0)$.
Give the induced electromotive force (emf) in the loop as a function of time.
Hint: To get the magnetic field at an observation point (x,y,z), use the Biot and Savart law with the current $\mathbf{I} = q\mathbf{v} = qv\,\mathbf{e}_x$. Thus, the time dependence in the magnetic field is a result of the changing distance between the moving charge and the observation point.

35. Voluntary!

Consider a spherical cavity of radius a(magnetic permeability μ_0) in a diamagnetic medium with permeability constant μ and an applied uniform magnetic field $\mathbf{B}_0$.
Introducing a magnetic scalar potential for $\mathbf{H}$, calculate that potential inside and outside the sphere.
Give the resultant magnetic fields $\mathbf{H}$ and $\mathbf{B}$ vectors inside and outside and sketch the field lines.
What is the vector of magnetization in the medium?
Find the effective current density and effective magnetic charge density on the surface of the cavity (normal vector from medium to cavity).