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

TP2 2015

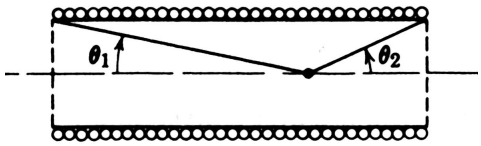
Lecturer: PD Dr. A. Schiller

List of problems 12
voluntary, to collect additional points

34. A right-circular solenoid of finite length $L$ and radius $a$ has $N$ turns per unit length and carries a current $I$.
Show that the magnetic induction on the cylinder axis in the limit $NL \to \infty$ is

$$B_z = \frac{\mu_0 N I}{2} \left(\cos\theta_1 + \cos\theta_2\right)$$

where the angles are defined in the figure.




35. The Lorentz force law for a particle of mass $m$ and charge $q$ is

$$\mathbf{F} = q\left(\mathbf{E} + \mathbf{v} \times \mathbf{B}\right) .$$

(a) Show that if the particle moves in a time-independent electric field $\mathbf{E} = -\boldsymbol{\nabla}\Phi(\mathbf{r})$ and any magnetic field, then the energy $\frac{1}{2}m\mathbf{v}^2 + q\Phi$ is a constant.
(b) Suppose the particle moves along the $x$-axis in the electric field

$$\mathbf{E} = A\mathrm{e}^{-t/\tau}\mathbf{e}_x ,$$

where $A$ and $\tau$ are constants. Suppose that the magnetic field is zero along the $x$-axis and $x(0) = \dot{x}(0) = 0$. Find $x(t)$.

36. A particle with charge $q$ is traveling with velocity $\mathbf{v}$ parallel to a wire with a uniform linear charge distribution $\lambda$ per unit length. The wire also carries a current $I$ (parallel to the velocity).
What must be the velocity for the particle to travel in a straight line parallel to the wire, a distance $r$ away?