Karlsruhe Institute of Technology - International Department GmbH

Pre-Semester 2010 - Physics Course - Extra Tutorial

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1. Travelling Point

Consider the following journey of a point mass with charge $q = 1.6 \cdot 10^{-19}\,\mathrm{C}$:

(1) Initially at rest, it is accelerated in passing a parallel-plate capacitor with voltage U_1.

(2) Afterwards, it flies through a velocity selector with crossed electric and magnetic fields ($E_2 = 5.93 \cdot 10^4\,\mathrm{V/m}$, $B_2 = 100\,\mathrm{mT}$) without being deflected.

(3) Finally, it enters a region with constant magnetic field $B_3 = 10^{-4}\mathrm{T}$. Since its velocity is not perpendicular to $\vec{B}_3$ it performs a helical motion ("winding around the magnetic field lines") with angular frequency $\omega = 17.56 \cdot 10^6\,\mathrm{s}^{-1}$.

Assuming that the point's velocity does not change *between* the 3 regions, calculate U_1!

2. Another Generator

Consider the generator drawn on the blackboard: In a magnetic field B, a conducting "open rectangle" with edge lengthes l (parallel to rotation axis) and d (perpendicular to rotation axis) is rotated with constant angular velocity ω. The two perpendicular edges are connected via a resistor R. Initially, the rectangle is perpendicular to the magnetic field, say, such that the enclosed flux is minimal. Neglect self-inductance effects (that means neglect the field which the current through the rectangle produces).

(a) What is the induced current $I(t)$ as a function of time t?

(b) What power $P_{\mathrm{el}}(t)$ is dissipated in the resistor?

(c) What moment of torque $M(t)$ is needed to keep the rectangle rotating with constant angular velocity?

(d) With what mechanical power $P_{\mathrm{mech}}(t)$ does the generator, hence, have to be supplied?

3. Crossbar on Rails

Two parallel conducting rails with distance d make an angle α with the horizontal and are connected via a resistor R. A conducting crossbar with mass m lies perpendicular on both rails and may slide along them without friction. Because of gravity (acting downwards, in vertical direction) the crossbar moves downwards. But because there is a constant vertical magnetic field B which exerts the Lorentz force, the crossbar moves with constant velocity v. Neglecting self-inductance, determine v!