KIT - International Department GmbH

Pre-Semester Physics - Exercises Summer 2010

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1. Exercise:

A point charge $q = 50\,\text{mC}$ with mass $m = 20\,\text{g}$ is moving with velocity $v = 8.0\,\frac{\text{m}}{\text{s}}$ (perpendicularly) towards the edge of a large quadratic region where a homogeneous magnetic field $B = 0.25\,\text{T}$ is present. Consider a velocity perpendicular to the magnetic field at first.

(a) At what distance d to the entry point will the point charge leave the region?

(b) How long does it remain in the region?

(c) State the electric field $\mathcal{E}$ perpendicular to the magnetic one (and in the region) so that the point charge is not deviated from its course.

(d) What kind of motion does the point charge perform if its velocity is at an angle $\alpha = 60°$ to the magnetic field (with no electric field present)?

(e) Calculate the time $\tilde{t}$ it spends inside the region for the non-perpendicular velocity of (d).

(f) Find again the distance $\tilde{d}$ to the entry point when it leaves the region for this case.

2. Exercise:

Consider a coil with $N = 100$ turns, length $\ell = 12.6\,\text{cm}$ and radius $r = 1.0\,\text{cm}$ through which a current of $I = 1.0\,\text{A}$ flows. A frame is moving towards the coil with velocity $v = 1.0\,\frac{\text{m}}{\text{s}}$ parallel to two of its edges. At $t = 0\,\text{s}$ its first edge passes the turns. The metallic, quadratic frame with edge length $a = 1.0\,\text{mm}$ is oriented perpendicular to the axis of the coil. (Neglect the curvature of the turns, the effects of self induction as well as the magnetic field outside the coil.)

(a) Calculate the magnetic field of the coil.

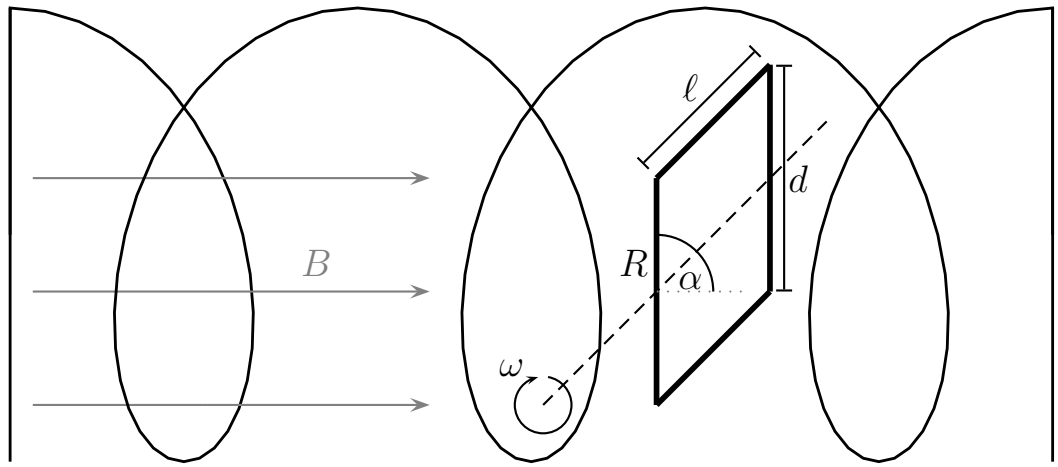
(b) How would this quantity change when iron ($\mu_r = 1000$) is inserted into the coil?

(c) Sketch the magnetic flux $\Phi(t)$ through the frame in the case of the empty coil.

(d) What is the maximal induced voltage $\hat{U}_{\text{ind}}$ in the frame in this case?

(e) When can this value be measured?

3. Exercise:



Inside a coil, which produces a magnetic field B a metal frame is rotated at constant angular velocity ω. The edges of the rectangular frame consist of a wire with length ℓ and d where the edge with length ℓ is always perpendicular to the magnetic field inside the coil. The frame has a total resistance of R. Initially, the frame is parallel to the turns of the coil.

(a) State the time-dependence of the angle α between the frame and the magnetic field.

(b) Find the magnetic flux Φ through the frame as function of time t.

(c) Determine the induced voltage $U_{\text{ind}}(t)$ inside the frame.

(d) What is the current $I(t)$ in the frame?

(e) Calculate the moment of torque $M(t)$ necessary to keep the frame at constant angular velocity.

(f) What power $P(t)$ is put into the system by this moment of torque?

Note:
The vacuum permeability is given by $\mu_0 = 1.26 \cdot 10^{-6} \, \frac{\text{J}}{\text{A}^2\text{m}}$