University Karlsruhe - International Department

**Physics Course - Exercises Summer 2009**

**Stefan Kremer** (kremer@tkm.uni-karlsruhe.de)
**Holger Schmidt** (hschmidt@tkm.uni-karlsruhe.de)

**Extra Tutorial**
**26.9.2009**

---

## 1. Exercise

(i) State Ohm's law.

(ii) What is the content of Kirchhoff's rules?

(iii) What is the equivalent resistance of two parallel resistors with resistance $R_1$ and $R_2$?

(iv) What is the equivalent resistance of two serial connected resistors with resistance $R_1$ and $R_2$?

(v) How can a battery with voltage $U_0$ and internal resistance $r$ be expressed in a equivalent circuit?

(vi) How is the magnetic field of a wire connected to the current flowing inside it?

(vii) State the magnetic field of a coil, with length $\ell$ and turns $N$ surrounding a volume $V = \ell \cdot A$, through which flows a current $I$.

(viii) What is the Lorentz-Force of a magnetic field $\vec{B}$ on a charge $q$, that moves with velocity $\vec{v}$? Give the vectorial and the scalar expression!

(ix) Find the force $\vec{F}$ on a charge $q$ that moves with a velocity $\vec{v}$ in a capacity, charged by a voltage $U$, and where a magnetic field $\vec{B}$ is present.

(x) How can one calculate the force of a magnetic field $\vec{B}$ on a wire of length $\ell$ which carries a current $I$.

(xi) What kind of path describes a charged particle in homogeneous magnetic field $\vec{B}$.

(xii) What is a velocity selector and how does it work?

(xiii) How is the magnetic flux $\Phi$ defined?

(xiv) What is the content of Faraday's induction law, i.e. how is the magnetic flux $\Phi$ related to the induced voltage $U_{ind}$?

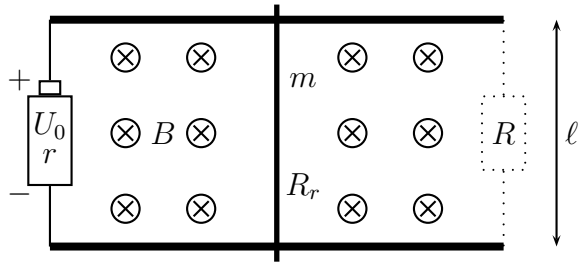
(xv) State and explain Lenz's law as equation.

(xvi) How is the self-inductance of a coil related to its geometric quantities?

(xvii) What kind of voltage is provided by an electric generator in contrast to a battery?

**2. Exercise**

A metallic rod with resistance $R_r = 1.5\,\Omega$ and mass $m = 150\,\mathrm{g}$ lies on two rails placed at a distance $\ell = 1\,\mathrm{m}$ where a perpendicular magnetic field $B = 200\,\mathrm{mT}$ into the ground is applied. The rails are connected at one end by a battery with voltage $U_0 = 3\,\mathrm{V}$ and inner resistance $r = 500\,\mathrm{m}\Omega$.




At first neglect self-induction effects:

(i) Draw the equivalent circuit.

(ii) State the equivalent resistance $R_{eq}$ of the circuit.

(iii) What is the current $I$ through the rod?

(iv) Calculate the force $F$ on the rod.

(v) In which direction does the rod moves?

(vi) State the position depending on time.

Let now be a resistance of $R = 3\,\Omega$ between the ends of the rails opposite to the battery.

(vii) Draw the equivalent circuit.

(viii) What is now the equivalent resistance $R'_{eq}$ which lies at the battery?

(ix) What current $I'$ flows now through the rod?

(x) What would be the velocity after $t = 3\,\mathrm{ms}$?

Now consider again the original situation with only the battery and the rod but look at the terminal situation with self-induction effects.

(xi) How large has to be the induced current $I_{ind}$ to compensate the force $F$ in (iv)?

(xii) Compare this current with the one flowing in the circuit without self-induction effects, calculated in (iii). What would be the total current $I_{tot}$?

(xiii) How depend the induced voltage $U_{ind}$ in the rod from its velocity $v$?

(xiv) Use Kirchhoff's voltage law (and Lenz's law) to determine the terminal velocity.