# Problems

**1.** Given the Lagrangian

$$L = \dot{x}\dot{y} + \dot{x}y + x\dot{y} + x^2 \ ,$$

- find the constants of motion,
- write down and solve the equations of motion.

**2.** An electric current $I_1$ flows in a thin, long linear wire. At a distance $d$ from this wire there is a small conducting loop of area $A$, so that the plane of the loop is parallel with the wire. There is a current $I_2$ flowing in the loop. Find the net force acting on the loop.

**3.** What can be the total angular momentum of the hydrogen atom in its $2p$ excited state (principal quantum number $n = 2$, azimuthal quantum number $\ell = 1$)? Take into account the spins of the nucleus and the electron!

**4.** The hydrogen ground state energy is $-13.6\ eV$. The energy of the first excited state is $-3.4\ eV$. What is the ratio of atoms in the first excited state compared to those in the ground state in atomic hydrogen gas at temperature $T = 30\,000\ K$ ($kT = 2.6\ eV$)?