

# Problems

1. Given the Lagrangian

$$L = \dot{x}\dot{y} + 2xy\dot{x} + x^2\dot{y} - x^3 ,$$

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

2. There are two identical loops of wire, each carrying a current  $I$ . The area of the loops is  $A$ . They are a distance  $d$  apart from each other, which is much larger than the size of the loops. The planes of the loops are perpendicular to the line connecting them. Find the force acting on each loop.

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

4. The hydrogen ground state energy (twofold degeneracy) is  $-13.6 \text{ eV}$ . The energy of the first excited state (eightfold degeneracy) is  $-3.4 \text{ eV}$ . What is the ratio between the number of atoms in the first excited state and those in the ground state in atomic hydrogen gas at temperature  $T = 30\,000 \text{ K}$  ( $kT = 2.6 \text{ eV}$ )?