Problems

1. Given the Lagrangian

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

- 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 perpendicular to the wire. There is a current I_2 flowing in the loop. Find the net torque acting on the loop.

3. What can be the total angular momentum of the deuterium 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! (Note that the spin of the deuteron is unity.)

4. The hydrogen ground state energy (doubly degenerated) is $-13.6 \ eV$. The energy of the first excited state (eightfold degeneracy) is $-3.4 \ eV$. What is the temperature at which the ratio of atoms in the first excited state compared to those in the ground state in atomic hydrogen gas becomes 50%?