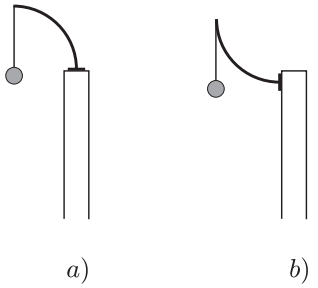
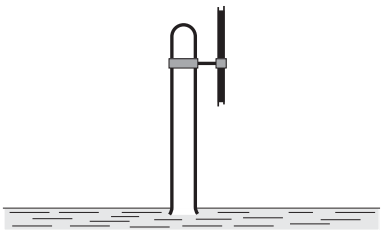
Eötvös 2004

1) A home decorator designs two versions of a standing coat rack. He attaches a thin, but strong, flexible metal wire in the shape of a quarter circle to a rigid body at one end, once in arrangement a), and once in arrangement b). He is surprised to find that if he hangs the same load on the hangers, the end of the metal wire does not sink by the same amount in both cases.



Use simple considerations to figure out which case has a greater end point drop.

2) A test tube, fixed vertically with its opening facing downwards, is about to be immersed in a large bowl of water. The temperature of the water and the environment is slowly increased from the initial 0 °C. After a while, the heating is stopped and the temperature is allowed to return to the original value. We find that the test tube is half full of water. The external air pressure was 10^5 Pa throughout.



Approximately what temperature (in °C) did we heat the system to? (*Note: for this question, you are expected to have a table of the vapour pressure of water at different temperatures. You can use the one on Wikipedia.*)

3) In this task, we examine the motion of electrons in a homogeneous magnetic field B, in a plane perpendicular to the magnetic field lines. (The electron is considered a classical point mass with mass m and charge $-e$, on which only electric and magnetic forces act.). Assume that the electrons always move at a nonrelativistic speed.
   a) Two electrons are initially at rest at a distance d apart. Under certain conditions, we can give them initial velocities in opposite directions so that their distance does not change during the motion. Find the initial speed v of the electrons, and find the minimum distance $d_{\min}$ for such motion to be possible.
   b) Show that the distance d can remain constant even if only one of the electrons is given an initial velocity. In this case, what is the minimum distance $d_{\min}$ at which such a motion can still occur? When $d = d_{\min}$, sketch the motion of the electrons, and find when the electron with the initial velocity first comes to rest momentarily.