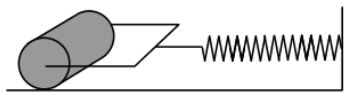
2. Roller (8 points) — *Lasse Frantti (iv,v: Jaan Kalda).* A roller consists of a solid homogeneous cylinder of mass M and radius r; it rests on a horizontal table and is attached to a wall via a helical spring of spring constant k (see figure). The spring can be assumed to be of a negligible mass and ideal, i.e. the Hooke's law remains valid for arbitrarily large deformations.



i) *(1 point)* At first, let as assume that there is no friction between the cylinder and the table. The roller is pushed aside and released; find the period of oscillations T_0.

ii) *(1 point)* From now on, the coefficient of friction between the roller and the table μ is no longer neglected. The roller is pushed aside and starts to roll back and forth. For small oscillation amplitudes, there is no slipping between the roller and the surface. Find the new period of oscillations T_r.

iii) *(2 points)* If the initial oscillation amplitude (measured as the deformation x of the spring) is larger than a certain critical value $A_\star$, the amplitude of oscillations starts decreasing in time. Express $A_\star$ in terms of k, M, r, the free fall acceleration g, and.

iv) *(2 points)* Assuming that the initial amplitude A_0 is much larger than $A_\star$, what is the maximal angular speed of the cylinder during $0 \le t \le T/2$, where t is the time elapsed since releasing the roller?

v) *(2 points)* Assuming that $A_0 \gg A_\star$, sketch a qualitative graph showing the dependance of εr and a as functions of time; here ε and a denote the angular acceleration and linear acceleration of the roller, respectively.