6. Truck (7 pts)

1) A rope is put over a pole so that the plane of the rope is perpendicular to the axes of the pole, and the length of that segment of the rope, which touches the pole is l, much shorter than the radius of the pole R, see figure (a). To the one end of the rope, a force T is applied; the sliding of the rope can be prevented by applying a force T_1 to the other end of the rope. Express the ratio T_1/T via l, R, and μ, where μ is the coefficient of friction between the rope and the pole.

2) Answer the first question, if l is not small (i.e. without the assumption $l \ll R$).

Remark: you may use equality

$$\lim_{x\to 0}(1+nx)^{1/x} = e^n.$$

3) The rope makes exactly $n = 2$ winds around the pole. One end of the rope is attached to a truck standing on a slope (slanting angle $\phi = 10°$); the mass of the truck $m = 20\,\mathrm{t}$, see figure (b). Find the force F, needed to apply to the other end of the rope, in order to keep the truck at rest. Use the numerical value $\mu = 0{,}3$. All the other friction forces acting upon the truck can be neglected.

4) How does the answer change, if the cross-section of the pole is not circular, but instead, egg-shaped? Motivate your answer.



