Problem I.2 . . . philodendron on its way 3 points; průměr 2,62; řešilo 159 studentů

Jarda is bringing Viktor a new philodendron in the trunk of his car. It is planted in a flowerpot with a circular base with a radius of 6 cm *and the center of gravity of the philodendron and the flowerpot is at a height of* 7 cm*. Jarda is driving at a speed of* $90\,\mathrm{km\cdot h^{-1}}$*, but he is approaching a turn with a radius of curvature of* 10 m*. To ensure that the philodendron prospers, it cannot even tilt along the journey. What is the shortest distance from the turn that Jarda has to start braking? He wants to drive through the turn at a constant speed.*

Jarda is a large-scale grower.

So that our flower does not even tilt, the torque of the gravitational force for the corner of the flowerpot has always to be greater than the torque of the inertial force in the frame of reference of the car. The boundary situation happens when the torques equal. Because the problem statement also asks for the shortest distance, the highest possible acceleration is necessary.

The maximal possible acceleration is derived from the mentioned equality of torques

$$rmg = hma \quad \Rightarrow \quad a = \frac{rg}{h}\,,$$

where m is the weight of the philodendron with the flowerpot, r is the radius of the flowerpot and h is the height of the center of gravity.

With this maximal acceleration, it can go through the turn. From the relation for the centrifugal acceleration $a = v_\mathrm{z}^2/R$ we can therefore calculate the velocity in the turn as

$$v_\mathrm{z} = \sqrt{aR}\,,$$

where R is the radius of the turn.

For this velocity, the car must decelerate before the turn and do that on a sought distance x. Even here it can only move with a maximal acceleration a. For the car to decelerate with this acceleration, a decelerating force ma must act on it. On the sought distance x, it does work of xma. The car's kinetic energy has to decrease by this amount before the turn. From the law of conservation of energy, we can therefore express x as

$$\frac{1}{2}mv_0^2 = max + \frac{1}{2}mv_\mathrm{z}^2 \quad \Rightarrow \quad x = \frac{v_0^2 - v_\mathrm{z}^2}{2a} = \frac{hv_0^2 - rgR}{2rg} \doteq 32\,\mathrm{m}\,.$$

Therefore, the minimal deceleration distance is approximately 32 m.

Jaroslav Herman
jardah@fykos.org

FYKOS is organized by students of Faculty of Mathematics and Physics of Charles University. It's part of Media Communications and PR Office and is supported by Institute of Theoretical Physics of CUNI MFF, his employees and The Union of Czech Mathematicians and Physicists. The realization of this project was supported by Ministry of Education, Youth and Sports of the Czech Republic.