Answer on Question #54213-Physics-Mechanics-Kinematics-Dynamics

A 1200 kg car can roll up and down a ramp at an angle of θ = 45° to the ground. It is connected, by a massless tow-rope that runs over a frictionless pulley, to a heavy spring of spring constant k = 50 kN/m, as shown in the figure. The car handbrake is released when the car is at rest, with the spring in its unstretched state. Assume the rolling motion of the car is frictionless and that the mass of the wheels is negligible compared to the main body.

a. What is the speed of the car when it has moved 10 cm down the ramp?

b. How far down the ramp from its point of release does the car roll before momentarily stopping?

c. What is the direction (up or down the incline) of the car's acceleration at the instant the car momentarily stops?

Solution

a. According to the conservation of energy law:

$$mgx\sin\theta = \frac{mv^2}{2} + \frac{kx^2}{2}.$$

The speed of the car when it has moved 10 cm down the ramp is

$$v = \sqrt{2gx\sin\theta - \frac{\mathrm{k}}{\mathrm{m}}x^2} = \sqrt{2\cdot 9.8\cdot 0.1\sin 45 - \frac{50000}{1200}0.1^2} = 0.98\frac{m}{s}.$$

b. We have an equation

$$mgl\sin\theta = \frac{m\cdot 0^2}{2} + \frac{kl^2}{2} \rightarrow mgl\sin\theta = \frac{kl^2}{2}.$$

$$l = \frac{2mg\sin\theta}{k} = \frac{2\cdot 9.8\cdot 1200\sin 45}{50000} = 0.33\ m = 33\ cm.$$

c. The direction of the car's acceleration at the instant the car momentarily stops is up the incline. It is because the velocity's direction is down the incline and for stop the direction of the car's acceleration should be directed oppositely to it.