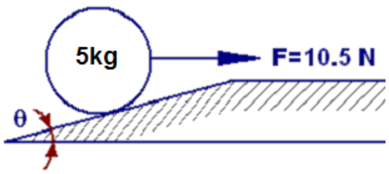
Classical Mechanics

Inclines

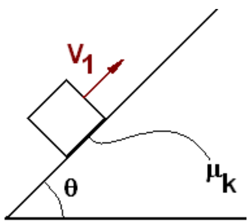
Problem 1.- Calculate the angle θ, knowing that the horizontal force necessary to keep the sphere from moving is 10.5 N.
Consider the friction between the sphere and the inclined surface to be zero.



Solution: As you can demonstrate, the tension in the string is the weight of the sphere times the tangent of the angle θ. So, knowing that the horizontal force is 10.5 N we get:

$$10.5 = mg\tan\theta \rightarrow \theta = \tan^{-1}\left(\frac{10.5}{5\times 9.8}\right) = \mathbf{12.1^o}$$

Problem 2.- The box in the figure was pushed, so it is moving with an initial velocity $v_1 = 2\text{m/s}$ on a rough incline plane of coefficient of friction $\mu_k = 0.2$ and angle $\theta = 40^\circ$.
Calculate the time it will take for the box to come back to the same place.



Solution: On the way up the acceleration on the box is:

$$a = -g(\sin\theta + \mu_k\cos\theta) = \text{-7.8 m/s}^2$$

It will take the box $t_{UP} = \frac{v_2 - v_1}{a} = \frac{0-2}{-7.8} = 0.256s$ to get to the top.

And the distance covered is $x = v_1 t + \frac{1}{2}at^2 = 0.256m$

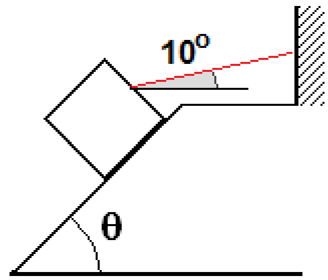
On the way down the acceleration on the box is:

$$a = -g(\sin\theta - \mu_k\cos\theta) = \text{-6.27 m/s}^2$$

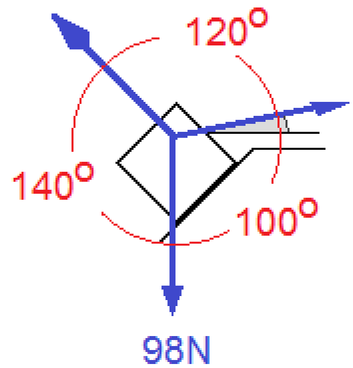
So it will take the box $t_{DOWN} = \sqrt{\frac{2x}{a}} = 0.286s$ to get from the top to the initial position.

The total time is: $t_{DOWN} + t_{UP} = 0.256s + 0.286s =$ **0.542 s**

Problem 2.- The box in the figure is in equilibrium, has a mass of 10kg and we can ignore friction. Calculate the tension force in the cable if the angle $\theta = 40^\circ$



Solution: We can use the law of sines to solve this problem. The angles between the forces can be found using geometric rules and they are as follows



To find the force on the cable we have: $\dfrac{98}{\sin 120^\circ} = \dfrac{F}{\sin 140^\circ} \rightarrow F = \mathbf{73\ N}$