

Problem Set 8

Work and energy

PHYS-101(en)

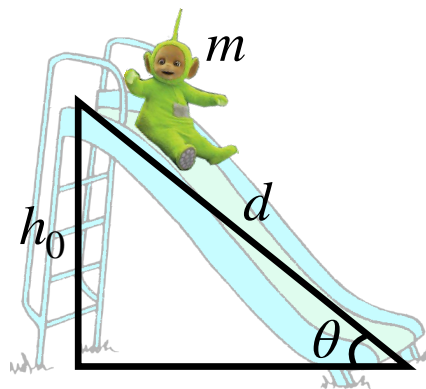
1. Throwing a ball in the wind

A ball is thrown straight upwards in a strong but steady wind, blowing towards the east. It rises a height H , during which time it moves eastward by a distance D . Assume that the wind exerts a steady force on the ball of magnitude F . How much work does the wind do on the ball, from the time it is thrown to when it reaches its maximum height?

2. Slide

A child's playground slide is $d = 5$ m in length and makes an angle of $\theta = 20$ degrees with respect to the horizontal ground. A child with mass $m = 20$ kg starts from rest at the top of the slide. The coefficient of kinetic friction between the child and the slide is $\mu_k = 0.2$.

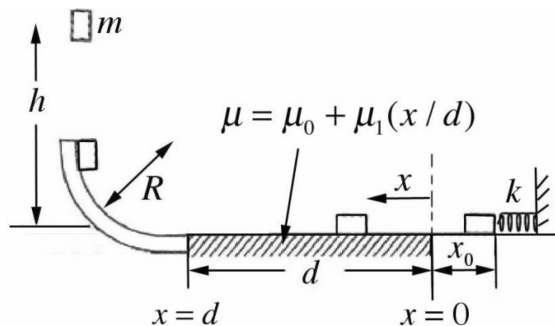
- What is the total work done by the friction force on the child?
- What is the speed of the child at the bottom of the slide?
- How long does the child take to slide down the slide?
- To get to the top of the slide, one must climb a ladder of height h_0 . Two children who have the exact same mass climb the ladder. The first child climbs up in t seconds and the other climbs up 5 times faster. Who does more work? Justify your answer mathematically.



3. Travel on surface/loop

An object of mass m is released from rest and is pushed by a spring (with a spring constant k) that has been compressed by a distance x_0 . After losing contact with the spring at $x = 0$ (which is the equilibrium position of the spring), the object travels a distance d along a horizontal track with a coefficient of friction that varies with position according to $\mu(x) = \mu_0 + \mu_1(x/d)$.

Following the horizontal track, the object enters a quarter turn of a frictionless loop with radius R . Finally, after exiting the quarter turn of the loop, the object travels vertically upwards to a maximum height h (as measured from the horizontal surface). Find the maximum height h that the object attains in terms of the constants: $m, k, x_0, \mu_0, \mu_1, d, R$, and the acceleration due to gravity g (not all may be needed).



4. Tetherball

A ball of mass m is whirling around on a string that passes through a fixed ring located at the center of the circular motion. Initially, the ball is at a radial distance ρ_0 and has an angular speed ω_0 . Then, a person grabs the string and pulls it downwards, with a constant speed V , until the ball is a distance ρ_f from the fixed ring. You may neglect the effect of gravity. Show that the work done in pulling the string equals the increase in kinetic energy of the ball.

