Rockslide

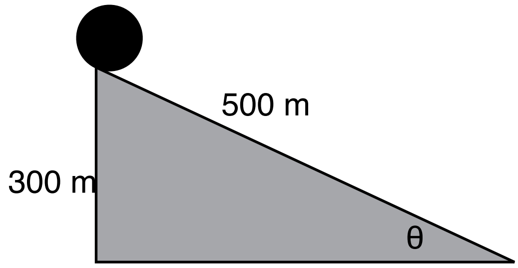
During a rockslide, a 520kg rock slides from rest down a hillside 500m long and 300m high. Coefficient of kinetic friction between the rock and the hill surface is 0.25.

(a) If the gravitational potential energy of the rock-Earth system is set to zero at the bottom of the hill, what is the value of U just before the slide?

(b) How much work is done by frictional forces during the slide?

(c) What is the kinetic energy of the rock as it reaches the bottom of the hill?

(d) What is its speed then?



Solution:

(a) $U_i = mgh = 520 \times 9.8 \times 300 = 1.53 \times 10^6$ J

(b) The work done by friction is given by

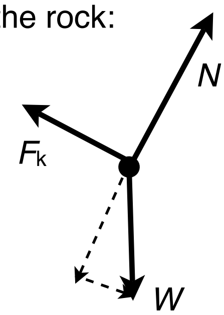
$W = (\text{force}) \times (\text{distance})$

$= -F_k\, d$

(negative because friction is acting in the opposite direction to the distance the rock is moving)

Now $F_k = \mu_k N$

so we need to find the strength of the normal force. Draw the FBD for the rock:



Resolving W into components parallel and perpendicular to the surface, and noting that there is no net force perpendicular to the surface, we get

$N - W\cos\theta = 0$

so

$N = W\cos\theta = 0.8\, mg = 4077$ N

so $F_k = \mu_k N = 1019$ N

Hence the work done by friction is

$W = -F_k d = -1019 \times 500 = -5.1 \times 10^5$ J

(c) Now conservation of energy tells us that ΔE_{th} = W. Hence

$U_i + K_i = U_f + K_f + \Delta E_{th}$

$U_f = 0$, $K_i = 0$ so

$K_f = U_i - \Delta E_{th}$

$= 1.53 \times 10^6 \text{ J} - 5.1 \times 10^5 \text{ J} = 1.02 \times 10^6$ J

(d) From (c), $K_f = 1.02 \times 10^6 \text{ J} = \frac{1}{2} m v_f^2$

so

$v_f = \sqrt{(2K_f/m)} = \sqrt{(2 \times 1.02 \times 10^6/520)}$

$= 63 \text{ ms}^{-1}$