Answer on Question 56361, Physics, Other

Question:

A $25kg$ box of textbooks rests on a loading ramp that makes an angle of θ with the horizontal. The coefficient of kinetic friction is 0.25, and the coefficient of static friction is 0.35.

a) Find the minimum angle at which the box is about to move if the angle of the ramp increaces gradually.

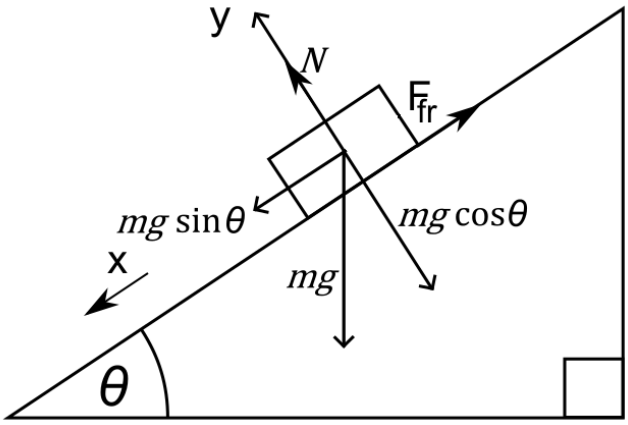
b) At this angle, find the acceleration of the box.

c) At this angle, how fast will the box be moving after it has slide $5m$ along the loading ramp?

Specify the given completely, required (what is being asked), complete solution and the final answer for each question.

Solution:

a)



First, we need to find the minimum angle at which the box is about to move if the angle of the ramp increaces gradually. Let's write all forces, that act on the box:

$$m\vec{g} + \vec{N} + \overrightarrow{F_{fr}} = 0.$$

Then projected the forces on axis x and y we get:

$$mgsin\theta - F_{fr} = 0, (1)$$

$$N - mgcos\theta = 0. \quad (2)$$

Let's write the friction force that act on the box (since the box is at rest, we use the coefficient of static friction):

$$F_{fr} = \mu_s N = \mu_s mgcos\theta$$

Substituting the friction force into the first equation we get:

$$mgsin\theta - \mu_s mgcos\theta = 0,$$

$$sin\theta = \mu_s cos\theta,$$

$$tan\theta = \mu_s = 0.35,$$

$$\theta = \arctan(0.35) = 19.29^{\circ}$$

b) Let's write the projections of the forces on axis x (since the box is moving, we use the coefficient of kinetic friction):

$$mgsin\theta - F_{fr} = ma,$$

$$mgsin\theta - \mu_k mgcos\theta = ma.$$

From the last equation we can find the acceleration of the box:

$$a = g(sin\theta - \mu_k cos\theta) = 9.8\frac{m}{s^2} \cdot (sin19.29^{\circ} - 0.25 \cdot cos19.29^{\circ}) = 0.931\frac{m}{s^2}.$$

c) In order to find the velocity of the box after it has slide $5m$ along the loading ramp, we use the kinematic equation:

$$v^2 = v_0^2 + 2as,$$

here, v is the velocity of the box after it has slide $5m$ along the loading ramp, $v_0 = 0ms^{-1}$ is the initial velocity of the box (initially the box is at rest), a is the acceleration of the box and s is the sliding distance.

Therefore, we get:

$$v = \sqrt{2as} = \sqrt{2 \cdot 0.931\frac{m}{s^2} \cdot 5m} = 3.05\frac{m}{s}.$$

Answer:

a) $\theta = 19.29^{\circ}$.

b) $a = 0.931\frac{m}{s^2}$.

c) $v = 3.05\frac{m}{s}$.