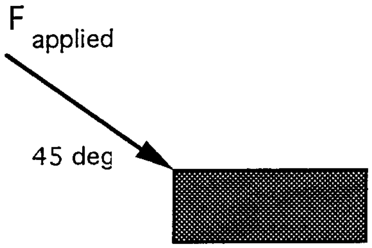
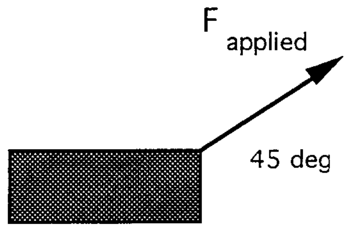
Work Sheet Problems for Friction

Problems 1 & 2: A heavy box rests on the floor. In order to move it you have the option of either pushing it or pulling it. Compare the forces necessary to keep it sliding in each case





Assume a mass of 100 kg (corresponding to 220 lb) and coefficient of friction $\mu_K = 0.5$.

Problem 3:

5–50 A block with mass 10.0 kg is placed on an inclined plane with slope angle 30° and is connected to a second hanging block that has mass m by a cord passing over a small, frictionless pulley (Fig. 5–45). The coefficient of static friction is 0.45, and the coef-

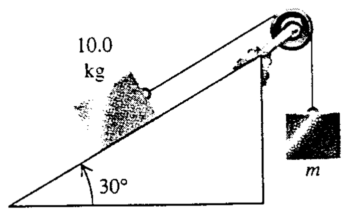


FIGURE 5–45

ficient of kinetic friction is 0.35. a) Find the mass m for which the 10.0-kg block moves up the plane at constant speed once it has been set in motion. b) Find the mass m for which it moves down the plane at constant speed once it has been set in motion. c) For what range of values of m will the block remain at rest if it is released from rest?

5–50 A block with mass 10.0 kg is placed on an inclined plane with slope angle 30° and is connected to a second hanging block that has mass m by a cord passing over a small, frictionless pulley (Fig. 5–45). The coefficient of static friction is 0.45, and the coefficient of kinetic friction is 0.35. a) Find the mass m for which the 10.0-kg block moves up the plane at constant speed once it has been set in motion. b) Find the mass m for which it moves down the plane at constant speed once it has been set in motion. [redacted]?

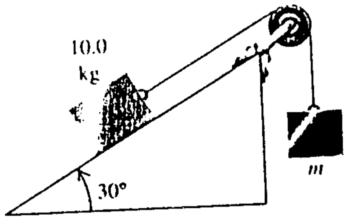


FIGURE 5–45

5–60 Two blocks connected by a cord passing over a small, frictionless pulley rest on frictionless planes (Fig. 5–51). a) Which way will the system move when the blocks are released from rest? b) What is the acceleration of the blocks? c) What is the tension in the cord?

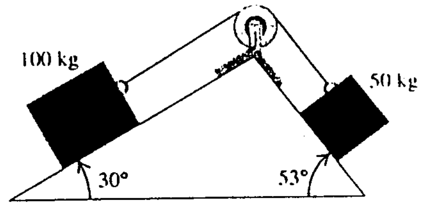


FIGURE 5–51

5–65 What acceleration must the cart in Fig. 5–54 have in order that block A does not fall? The coefficient of static friction between the block and the cart is μ_s. [redacted]?

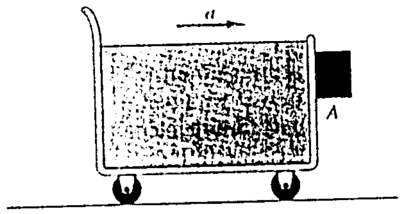


FIGURE 5–54

5–82 Block A, with weight $2w$, slides down an inclined plane S of slope angle 37.0° at a constant speed while the plank B, with weight w, rests on top of A. The plank is attached by a cord to the top of the plane (Fig. 5–61). [redacted] b) If the coefficient of friction is the same between A and B and between S and A, determine its value.

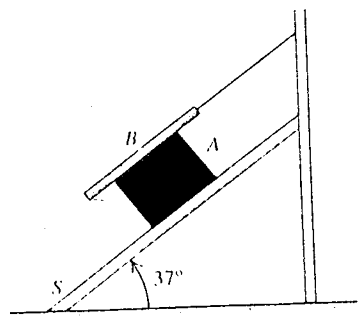
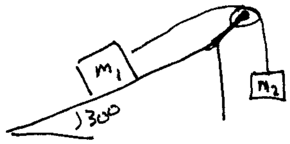


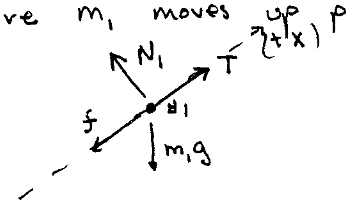
FIGURE 5–61

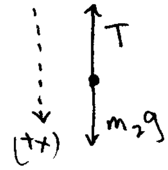
5-50.



$\mu_s = 0.45$ $\mu_k = 0.35$

a) #1 where m_1 moves up plane.





$m_1 a_x = T - f - m_1 g \sin\theta$ $\quad m_1 \cancel{a_y}^{0} = N - m_1 g \cos\theta$

$= T - \mu_k N - m_1 g \sin\theta$ $\quad N = m_1 g \cos\theta$

$m_1 a_x = T - \mu_k m_1 g \cos\theta - m_1 g \sin\theta$

$m_2 a_x = m_2 g - T$

If const speed, then $a_x = 0$

$0 = T - \mu_k m_1 g \cos\theta - m_1 g \sin\theta$

$0 = m_2 g - T$

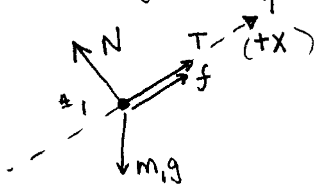
$T = m_2 g$

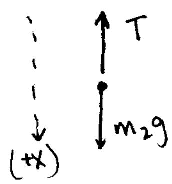
$0 = m_2 \cancel{g} - \mu_k m_1 \cancel{g} \cos\theta - m_1 \cancel{g} \sin\theta$

So: $m_2 = [\mu_k \cos\theta + \sin\theta]\, m_1$

$= [0.35 \cos 30° + \sin 30°](10\ \text{kg}) = 8.03\ \text{kg}$

b) CASE #2 - where m_1 moves down incline at constant speed





$m_1 a_x = T + f - m_1 g \sin\theta$ $\quad m_1 \cancel{a_y}^{0} = N - m_1 g \cos\theta$

$= T + \mu_k N - m_1 g \sin\theta$ $\quad N = m_1 g \cos\theta$

$m_2 a_x = m_2 g - T$

$= T + \mu_k m_1 g \cos\theta - m_1 g \sin\theta$

If constant speed, then $a_x = 0$

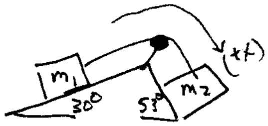
$0 = T + \mu_k m_1 g \cos\theta - m_1 g \sin\theta$

$0 = m_2 g - T$

$T = m_2 g$

$0 = m_2 \cancel{g} + \mu_k m_1 \cancel{g} \cos\theta - m_1 \cancel{g} \sin\theta$

So: $m_2 = m_1 [\sin\theta - \mu_k \cos\theta] = 1.97\ \text{kg}$

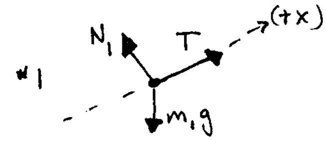
5-60 

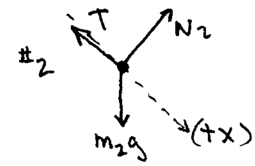
$m_1 = 100$ kg $m_2 = 50$ kg

No friction

a) There's no reason we have to answer this question now - let's put it off until we work the problem

b)





$m_1 a_x = T - m_1 g \sin 30^\circ$

$m_1 \cancel{a_y}^{0} = N_1 - m_1 g\cos\theta$

$N_1 = m_1 g \cos\theta$

don't need this eqn

$m_2 a_x = m_2 g \sin 53^\circ - T$

$m_2 \cancel{a_y}^{0} = N_2 - m_2 g \cos 53^\circ$

$N_2 = m_2 g \cos 53^\circ$

don't need this

$m_1 a_x = T - m_1 g \sin 30^\circ$

$m_2 a_x = m_2 g \sin 53^\circ - T$

Have 2 eqns - 2 unknowns

$T = m_2 g \sin 53^\circ - m_2 a_x$

$m_1 a_x = (m_2 g \sin 53^\circ - m_2 a_x) - m_1 g \sin 30^\circ$

$(m_1 + m_2) a_x = m_2 g \sin 53^\circ - m_1 g \sin 30^\circ$

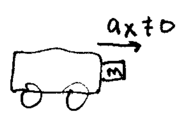
$150 \quad a_x = 50(9.8)\sin 53^\circ - 100(9.8)\sin 30^\circ$

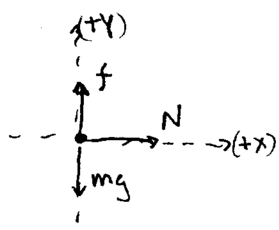
$a_x = -0.66$ - the system moves CCW.

$T = m_2 g \sin 53^\circ - m_2 a_x$

$= 50(9.8)\sin 53^\circ - 50(-0.66)$

$= 424$ N

5-65 



$m a_x = N$

$m a_y = f - mg$

$= \mu_s N - mg$

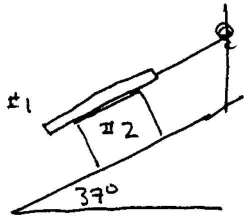
Want $a_y = 0$

$m a_x = N \longrightarrow 0 = \mu_s N - mg$

$0 = \mu_s m a_x - mg$

So $a_x = \frac{g}{\mu_s}$

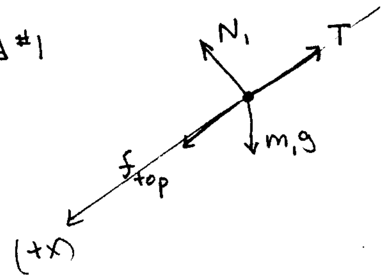
5-82



$m_1 g = W \qquad m_2 g = 2W$

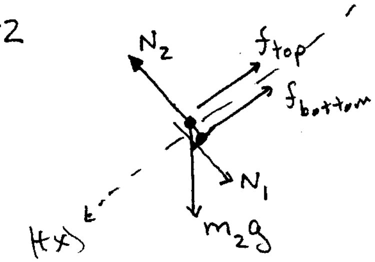
both surfaces have same coefficent of friction.

fbd #1



f_{top} is the action-reaction counterpart to the [illegible] force in fbd #2

fbd #2



N_1 is the action-reaction counterpart to the Normal force in fbd #1

$m_1 a_{1x} = -T + f_{top} + m_1 g \sin\theta \qquad m_1 a_{1y} = N_1 - m_1 g \cos\theta$

Block #1 is stationary ∴ $a_{1x} = 0 \quad a_{1y} = 0$

$0 = -T + f_{top} + m_1 g \sin\theta \qquad 0 = N_1 - m_1 g \cos\theta$

$0 = -T + \mu N_1 + m_1 g \sin\theta \qquad N_1 = m_1 g \cos\theta$

Note $f_{top} = \mu N_1 = \mu m_1 g \cos\theta$

$m_2 a_{2x} = m_2 g \sin\theta - f_{top} - f_{bot} \qquad m_2 a_{2y} = N_2 - N_1 - m_2 g \cos\theta$

Block #2 has constant speed, ∴ no accel.

$0 = m_2 g \sin\theta - f_{top} - f_{bot} \qquad 0 = N_2 - N_1 - m_2 g \cos\theta$

$= m_2 g \sin\theta - f_{top} - \mu N_2 \qquad N_2 = N_1 + m_2 g \cos\theta$

subst N_1

$N_2 = (m_1 + m_2) g \cos\theta$

subst f_{top} N_2

$0 = \underline{m_2 g} \sin\theta - \mu \underline{m_1 g} \cos\theta - \mu \underline{(m_1 + m_2) g} \cos\theta$

$0 = 2W \sin\theta - \mu W \cos\theta - \mu\, 3W \cos\theta$

$0 = 2W \sin\theta - \mu 4W \cos\theta$

$\mu 4W \cos\theta = 2W \sin\theta$

$\mu = \frac{1}{2} \tan\theta = \frac{1}{2} \tan 37° = 0.377$