GIANCOLI HOMEWORK SOLUTIONS

Section 4-8 to4-9, #36-57

36. $\mu_K = 0.30$

$m = 35kg$

$F_f = F_N\mu$

$F_N = mg$

$F = F_f = mg\mu_K = (35)(9.81)(0.30) = 103N$

37. $F_A = 48.0N$

$m = 5.0kg$

a. *Since it is the force to get the box to start to move, use static friction and there is no acceleration. The applied force equals the maximum static friction force.*

$F_f = F_N\mu_S$

$F_N = mg$

$F_A = F_f = mg\mu_S$

$$\frac{F_A}{mg} = \mu_S = \frac{48}{(5)(9.81)} = 0.979$$

b. $a = 0.70\,m/s^2$

$F_A - F_f = ma$

$F_A - mg\mu_K = ma$

$F_A - ma = mg\mu_K$

$$\frac{F_A - ma}{mg} = \mu_K = \frac{48 - (5)(0.7)}{(5)(9.81)} = 0.907$$

38. $a = 0.20g = (0.2)(9.81) = 1.96\,m/s^2$

$F_f = ma$

$F_f = F_N\mu$

$F_N = mg$

$F_f = mg\mu_S$

$\cancel{m}g\mu_S = \cancel{m}a$

$$\mu_S = \frac{a}{g} = \frac{1.96}{9.81} = 0.20$$

39. $\mu_S = 0.80$

$F_f = ma$

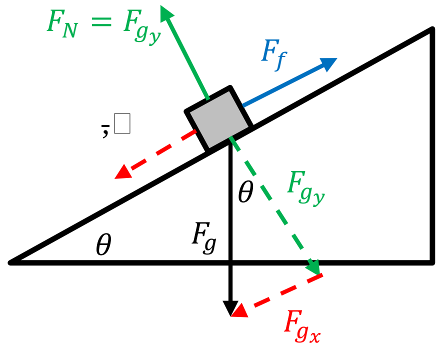
$F_f = F_N\mu$

$F_N = mg$

$F_f = mg\mu_S$

$\cancel{m}g\mu_S = \cancel{m}a$

$g\mu_S = a = (9.81)(0.8) = 7.85\,m/s^2$



40.

$\mu_S = 0.80$

You are looking for the largest angle at which the x-component of gravity will equal the maximum force of static friction.

$F_{g_x} = F_f$

$F_{g_x} = mg\sin\theta$

$F_f = F_N\mu_S$

$F_N = F_{g_y} = mg\cos\theta$

$F_f = mg\cos\theta\,\mu_S$

$F_{g_x} = F_f$

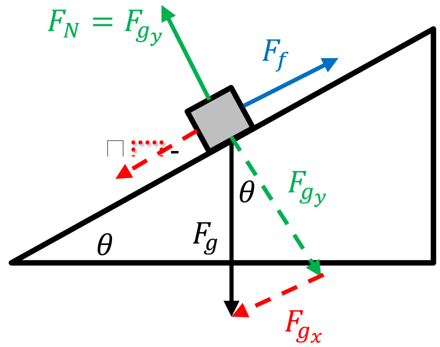
$\cancel{mg}\sin\theta = \cancel{mg}\cos\theta\,\mu_S$

$$\frac{\sin\theta}{\cos\theta} = \mu_S$$

$$\frac{\sin\theta}{\cos\theta} = \frac{\left(\frac{opp}{hyp}\right)}{\left(\frac{adj}{hyp}\right)} = \frac{opp}{adj} = \tan\theta$$

$\tan\theta = \mu_S$

$\theta = \tan^{-1}\mu_S = \tan^{-1}(0.8) = 38.7°$



41. .

The x-component of the gravity force is greater than the kinetic friction force by an amount that causes the box to accelerate.

$m = 15.0kg$

$\theta = 32°$

$a = 0.30\,m/s^2$

$F_{g_x} - F_f = ma$

$F_{g_x} = mg\sin\theta$

$mg\sin\theta - F_f = ma$

$mg\sin\theta - ma = F_f$

$(15)(9.81)\sin(32) - (15)(0.3) = F_f = 73.5\ N$

$F_f = F_N\mu_K$

$F_N = F_{g_y} = mg\cos\theta$

$F_f = mg\cos\theta\,\mu_K$

$$\frac{F_f}{mg\cos\theta} = \mu_K = \frac{(73.5)}{(15)(9.81)\cos(32)} = 0.589$$

42. $a = -4.80\,m/s^2$

$F_f = ma$

$\cancel{m}g\mu_K = \cancel{m}a$

$$\mu_K = \frac{a}{g} = \frac{4.8}{9.8} = 0.490$$

On the incline, both gravity and friction are working in the same direction to slow the car.

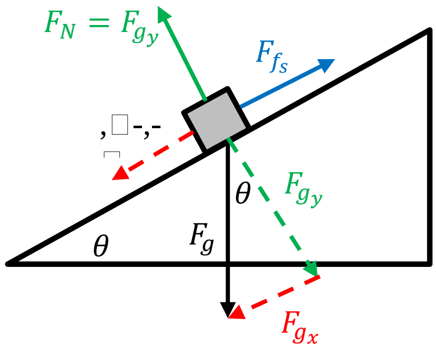
$F_{g_x} + F_f = ma$

$\cancel{m}g\sin\theta + \cancel{m}g\cos\theta\,\mu_S = \cancel{m}a$

$(9.81)\sin(13) + (9.81)\cos(13)\,(0.490) = a$

$a = 6.89\,m/s^2$

43. $\theta = 32°$



a.

b. The static friction would change to kinetic friction.

c. If the box were sliding up the ramp, the friction force would be in the opposite direction to oppose the upward motion.

44. $x = 1.0km = 1000m$

$t = 12s$

$x = \cancel{x_0} + \cancel{v_0 t} + \frac{1}{2}at^2$

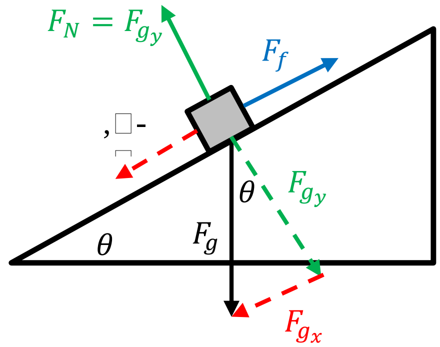
$\frac{2x}{t^2} = a = \frac{2(1000)}{(12)^2} = 13.9\, m/s^2$

With no slippage, the applied force equals the friction force which in turn equals mass times acceleration.

$F_f = ma$

$\cancel{m}g\mu_S = \cancel{m}a$

$\frac{a}{g} = \mu_S = \frac{13.9}{(9.81)} = 1.42$



45.

$m = 22kg$

$\mu_K = 0.10$

$\theta = 6°$

$v = 60\, km/h = 16.7\, m/s$

$x = 75m$

$v^2 = \cancel{v_0^2 +} 2ax$

$\frac{v^2}{2x} = a = \frac{(16.7)^2}{2(75)} = 1.85\, m/s^2$

$F_A + F_{g_x} - F_f = ma$

$F_{g_x} = mg\sin\theta$

$F_f = F_N\mu_K$

$F_N = F_{g_y} = mg\cos\theta$

$F_f = mg\cos\theta\,\mu_K$

$F_A = ma + mg\cos\theta\,\mu_K - mg\sin\theta$

$F_A = (22)(1.85) + (22)(9.81)\cos(6)\,(0.1) - (22)(9.81)\sin(6)$

$F_A = 39.6N$

46. $\mu_S = 0.30$

$F_T = F_{g-B} = mg = (2)(9.81) = 19.6N$

To prevent movement, the friction force must equal the tension force.

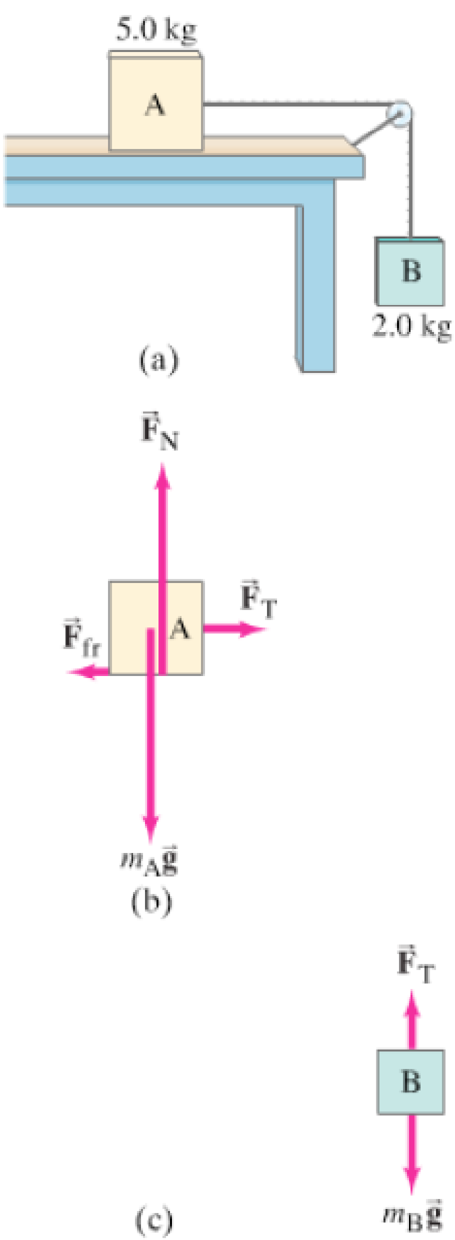
$F_f = F_T$

$mg\mu_S = F_T$

$$m = \frac{F_T}{(g)(\mu_S)}$$

$$m = \frac{19.6}{(9.81)(0.3)} = 6.67kg$$

FIGURE 4–32 Example 4–20.



47. $\mu_K = 0.20$

$v_0 = 4.0\,m/s$

$F_f = ma$

$\cancel{m}g\mu_K = \cancel{m}a$

$g\mu_K = a = (9.81)(0.2) = 1.962\,m/s^2$

$\cancel{v^2} = {v_0}^2 + 2ax$

$2ax = {v_0}^2$

$$x = \frac{{v_0}^2}{2a} = \frac{(4)^2}{2(1.962)} = 4.08m$$

48. $\mu_K = 0.15$

$m_1 = 75kg$

$m_2 = 110g$

$F_A = 620N$

a. *Since the question asks for acceleration of the system, the two blocks can be treated as one.*

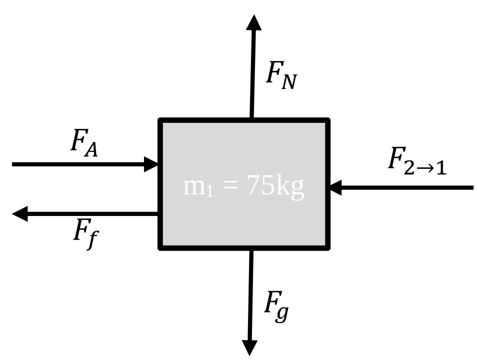
$F_A - F_f = ma$

$F_A - (m_1 + m_2)g\mu_K = (m_1 + m_2)a$

$$\frac{F_A - (m_1 + m_2)g\mu_K}{(m_1 + m_2)} = a$$

$$\frac{620 - (75 + 110)(9.81)(0.15)}{(75 + 110)} = a$$

$1.88\,m/s^2 = a$



b.

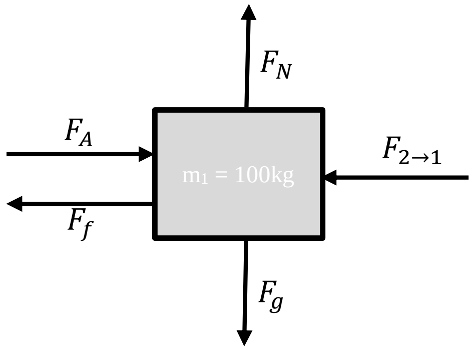
$\sum F = m_1 a$

$F_A - F_f - F_{2\to1} = m_1 a$

$F_A - m_1 g\mu_K - m_1 a = F_{2\to1}$

$620 - (75)(9.81)(0.15) - (75)(1.88) = F_{2\to1}$

$369N = F_{2\to1}$



c.

$$\sum F = m_1 a$$

$$F_A - F_f - F_{2\to1} = m_1 a$$

$$F_A - m_1 g \mu_K - m_1 a = F_{2\to1}$$

$$620 - (100)(9.81)(0.15) - (100)(1.88) = F_{2\to1}$$

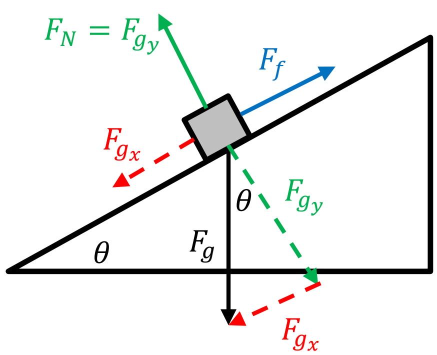
$$285N = F_{2\to1}$$

49. $\mu_S = 0.75$

$$F_f = ma$$

$$\cancel{m} g \mu_S = \cancel{m} a$$

$$(9.81)(0.75) = a = -7.36\, m/s^2$$



50.

$$\mu_S = 0.15$$

$$F_{g_x} = F_f$$

$$F_{g_x} = mg \sin\theta$$

$$F_f = F_N \mu_S$$

$$F_N = F_{g_y} = mg\cos\theta$$

$$F_f = mg\cos\theta\,\mu_S$$

$$F_{g_x} = F_f$$

$$\cancel{mg}\sin\theta = \cancel{mg}\cos\theta\,\mu_S$$

$$\frac{\sin\theta}{\cos\theta} = \mu_S$$

$$\frac{\sin\theta}{\cos\theta} = \frac{\left(\frac{opp}{hyp}\right)}{\left(\frac{adj}{hyp}\right)} = \frac{opp}{adj} = \tan\theta$$

$$\tan\theta = \mu_S$$

$$\theta = \tan^{-1}\mu_S = \tan^{-1}(0.15) = 8.5°$$

Only the 6° driveway will work.

51. $\theta = 28°$

$$F_{g_x} = ma$$

$$\cancel{m} g\sin\theta = \cancel{m} a$$

$$g\sin\theta = a = (9.81)\sin 28° = 4.61\, m/s^2$$

$$v^2 = \cancel{v_0^2 +} 2ax$$

$$\left(\frac{v}{2}\right)^2 = \cancel{v_0^2 +} 2\frac{a}{4}x$$

If the velocity at the bottom with friction is half as much, that means the acceleration is one-fourth that of frictionless.

$$F_{g_x} - F_f = ma$$

$$\cancel{m} g\sin\theta + \cancel{m} g\cos\theta\,\mu_S = \cancel{m} a$$

$$g\cos\theta\,\mu_S = a - g\sin\theta$$

$$\mu_S = \frac{a - g\sin\theta}{g\cos\theta}$$

$$\mu_S = \frac{\frac{4.61}{4} - (9.81)\sin 28°}{(9.81)\cos 28°} = 0.40$$

52. $\theta = 22°$

$\mu_K = 0.12$

$x = 9.30m$

a. $F_{g_x} - F_f = ma$

$\cancel{m}g \sin\theta - \cancel{m}g \cos\theta\, \mu_S = \cancel{m}a$

$(9.81)\sin(22°) - (9.81)\cos(22°)(0.12) = a$

$2.58\, m/s^2 = a$

b. $v^2 = \cancel{v_0{}^2 +} 2ax$

$v = \sqrt{2ax}$

$v = \sqrt{2(2.58)(9.30)}$

$v = 6.93\, m/s$

53. *With no friction, only gravity slows it down*

$\theta = 22°$

$v_0 = 3.0\, m/s$

a. $F_{g_x} = ma$

$\cancel{m}g \sin\theta = \cancel{m}a$

$(9.81)\sin(22°) = a$

$3.67\, m/s^2 = a$

$\cancel{v^2} = v_0{}^2 + 2ax$

$2ax = v_0{}^2$

$x = \frac{v_0{}^2}{2a} = \frac{(3)^2}{2(3.67)} = 1.22m$

b. *We know the initial velocity is 3 m/s and if we use the fact that the final velocity will be the same magnitude but in the opposite direction (-3 m/s) we can use,*

$v = v_0 + at$

$\frac{v - v_0}{a} = t = \frac{(-3) - (3)}{(-3.67)} = 1.63s$

54. $\theta = 45°$

$v_0 = 6.0\, km/h = 1.67 m/s$

$x = 45.0m$

$\mu_K = 0.18$

$F_{g_x} - F_f = ma$

$\cancel{m}g \sin\theta - \cancel{m}g \cos\theta\, \mu_S = \cancel{m}a$

$(9.81)\sin(45°) - (9.81)\cos(45°)(0.18) = a$

$5.69\, m/s^2 = a$

$v^2 = v_0{}^2 + 2ax$

$v = \sqrt{v_0{}^2 + 2ax}$

$v = \sqrt{(1.67)^2 + 2(5.69)(45.0)}$

$v = 22.7\, m/s$

55. $m = 18.0kg$

$\theta = 37.0°$

$a = 0.270\, m/s^2$

$F_{g_x} - F_f = ma$

$mg \sin\theta - F_f = ma$

$mg \sin\theta - ma = F_f$

$(18.0)(9.81)\sin(37°) - (18.0)(0.270) = F_f$

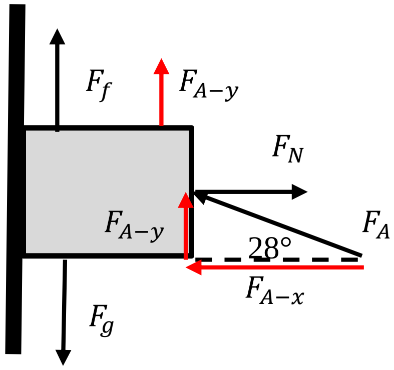
$101N = F_f$

$F_f = mg \cos\theta\, \mu_K$

$\frac{F_f}{mg \cos\theta} = \mu_K = \frac{101}{(18)(9.81)\cos(37)}$

$\mu_K = 0.716$

56.



The most important thing is to draw a picture to figure out where the angle of the applied force is. The y-component of the minimum applied force (13N) plus the force of static friction must equal the weight. The normal force needed for the friction force is equal to the x-component of the applied force.

$F_A = 13N$

$\theta = 28°$

$\mu_S = 0.40$

$F_{A_y} + F_f = F_g$

$F_{A_y} = F_A \sin 28°$

$F_f = F_N \mu_S$

$F_N = F_A \cos 28°$

$F_f = F_A \cos 28° \, \mu_S$

$F_g = mg$

$F_{A_y} + F_f = F_g$

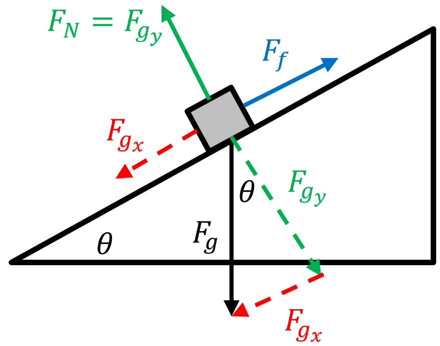
$F_A \sin 28° + F_A \cos 28° \, \mu_S = mg$

$$\frac{F_A \sin 28° + F_A \cos 28° \, \mu_S}{g} = m$$

$$\frac{(13)\sin 28° + (13)\cos 28° \,(0.4)}{(9.81)} = m$$

$1.09kg = m$

57.



$\theta = 30°$

a.

$F_{g_x} - F_f = ma = 0$

$F_{g_x} = F_f$

$F_{g_x} = mg \sin\theta$

$F_f = mg \cos\theta \, \mu_S$

$mg \sin\theta = mg \cos\theta \, \mu_S$

$$\frac{\cancel{mg}\sin\theta}{\cancel{mg}\cos\theta} = \mu_S = \tan\theta = \tan 30° = 0.577$$

b. $\mu_K = 0.20$

$x = 5.0m$

$F_{g_x} - F_f = ma$

$\cancel{m}g \sin\theta - \cancel{m}g \cos\theta \, \mu_K = \cancel{m}a$

$(9.81)\sin(30) - (9.81)\cos(30)\,(0.20) = a$

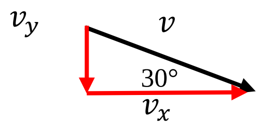
$3.21 \, m/s^2 = a$

$v^2 = \cancel{v_0^2} + 2ax$

$v = \sqrt{2ax} = \sqrt{2(3.21)(5)} = 5.67 \, m/s$

c. $h = 10.0m$

We now have a projectile motion problem with a velocity of 5.67 m/s at 30° below the horizon. We need to find the x-component (which will stay the same) and the y-component which will increase due to gravity.



$v_x = v\cos 30 = 5.67\cos 30 = 4.91\, m/s$

$v_y = v\sin 30 = 5.67\sin 30 = 2.83\, m/s$

$v_y{}^2 = v_{y-0}{}^2 + 2ah$

$v_y = \sqrt{(2.83)^2 + 2(9.81)(10)} = 14.3\, m/s$

$v_R = \sqrt{v_x{}^2 + v_y{}^2}$

$v_R = \sqrt{(4.91)^2 + (14.3)^2}$

$v_R = 15.1\, m/s$