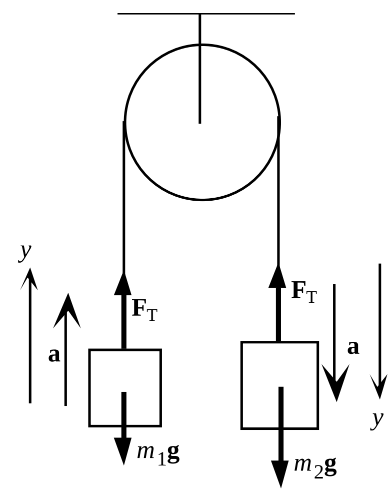
Answers to Some Sample Review Problems from Chapters 1 – 12

2) Forces are drawn for each of the blocks. Because the string doesn't stretch, the tension is the same at each end of the string, and the accelerations of the blocks have the same magnitude. Note that we take the positive direction in the direction of the acceleration for each block.



We write $\sum \mathbf{F} = m\mathbf{a}$ from the force diagram for each block:

y-component (block 1): $F_T - m_1g = m_1a$;

y-component (block 2): $m_2g - F_T = m_2a$.

By adding the equations, we find the acceleration:

$a = (m_2 - m_1)g/(m_1 + m_2)$

$= (3.2 \text{ kg} - 2.2 \text{ kg})(9.80 \text{ m/s}^2)/(3.2 \text{ kg} + 2.2 \text{ kg})$

$= 1.81 \text{ m/s}^2$ for both blocks.

For the motion of block 1 we take the origin at the ground and up positive. When block 2 hits the ground, we have

$v_1^2 = v_{01}^2 + 2a(y_1 - y_{01})$

$= 0 + 2(1.81 \text{ m/s}^2)(3.60 \text{ m} - 1.80 \text{ m})$, which gives

$v_1 = 2.56 \text{ m/s}$.

Once block 2 hits the ground, $F_T \to 0$ and block 1 will have the downward acceleration of g.

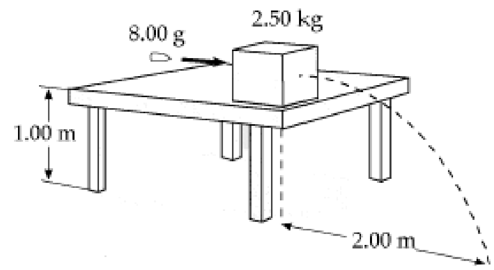
For this motion of block 1 up to the highest point reached, we have

$v^2 = v_1^2 + 2a(h - y_1)$

$0 = (2.56 \text{ m/s})^2 + 2(-9.80 \text{ m/s}^2)(h - 3.60 \text{ m})$, which gives $h = 3.93 \text{ m}$.

3)

8.50 Since no other force acts along the horizontal direction on the bullet-block system before and after impact,



$\Delta p = 0$ or $(8.00 \times 10^{-3})v_i = (2.508)v_f$

We can find v_f using the kinematic equations:

$\Delta x = v_f t$ or $2.00 = v_f t$

and $\Delta y = \frac{1}{2}a_y t^2$

or $-1.00 \text{ m} = \frac{1}{2}(-9.80 \text{ m/s}^2)\left(\frac{2.00}{v_f}\right)^2$

$v_f = 4.43 \text{ m/s}$

$v_i = \frac{2.508(4.43)}{8.00 \times 10^{-3}} = \boxed{1.39 \text{ km/s}}$

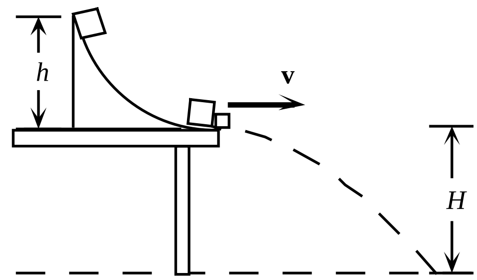
4)

66 ·· The system in Figure 9-47 is released from rest. The 30-kg block is 2 m above the ledge. The pulley is a uniform disk with a radius of 10 cm and mass of 5 kg. Find (*a*) the speed of the 30-kg block just before it hits the ledge, (*b*) the angular speed of the pulley at that time, (*c*) the tensions in the strings, and (*d*) the time it takes for the 30-kg block to reach the ledge. Assume that the string does not slip on the pulley.

(*a*) 1. m_1=20 kg, m_2=30 kg; use energy conservation	$m_2gh = m_1gh + 1/2(m_1v^2 + m_2v^2 + I\omega^2)$
2. $I = 1/2mr^2$; $\omega^2 = v^2/r^2$; so $I\omega^2 = 1/2mv^2$; m = 5 kg	$v = [2gh(m_2-m_1)/(m_1+m_2+1/2m)]^{1/2}$ = 2.73 m/s
(*b*) Use $\omega = v/r$	ω = (2.73/0.1) rad/s = 27.3 rad/s
(*c*) 1. Find acceleration; $a = v^2/2h$	a = 1.87 m/s^2
2. $T_1 = m_1(g + a)$; $T_2 = m_2(g - a)$	T_1 = 234 N; T_2 = 238 N
(*d*) Use $t = h/v_{av} = 2h/v$	t = (4/2.73) s = 1.47 s

5) We find the speed after falling a height h from energy conservation:

$\frac{1}{2}Mv^2 = Mgh$, or $v = (2gh)^{1/2}$.



The speed of the first cube after sliding down the incline and just before the collision is

$v_1 = [2(9.80\ m/s^2)(0.20\ m)]^{1/2} = 1.98$ m/s.

For the elastic collision of the two cubes, we use momentum and energy conservation:

$v_{1f} = (m_1 - m_2)/(m_1 + m_2)\ v_{1i}$

$v_{2f} = (2m_1/(m_1 + m_2)\ v_{1i}$

With $m_2 = \frac{1}{2}\ m_1$ and v_{1i} = 1.98 m/s we get:

v_{1f} = 0.660 m/s, and v_{2f} = 2.64 m/s.

Because both cubes leave the table with a horizontal velocity, they will fall to the floor in the same time, which we find from

$H = \frac{1}{2}gt^2$;

0.90 m = ½ (9.80 m/s^2)t^2, which gives t = 0.429 s.

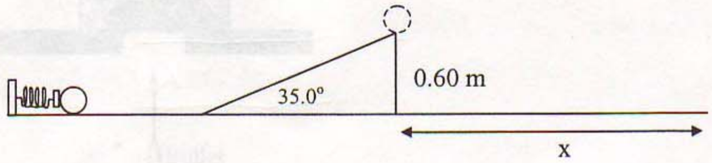
Because the horizontal motion has constant velocity, we have

$x_1 = v_1t$ = (0.660 m/s)(0.429 s) = 0.28 m;

$x_2 = v_2t$ = (2.64 m/s)(0.429 s) = 1.1 m.

Problem 7

A solid steel ball of mass 0.50 kg and diameter 20 cm is held in place against a spring with spring constant k = 250 N/m, compressing the spring a distance x = 20 cm. The ball is then released from rest and rolls without slipping along a horizontal floor. It then makes a smooth transition to an inclined plane and rolls without slipping up a 0.60 m high inclined plane as shown in the figure below.



a) What is the speed of the ball just as it leaves the inclined plane? (5 points)

$K_i + U_i = K_f + U_f$, with $K_i = 0$

$\frac{1}{2}Kx^2 = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + mgy$ $\quad I = \frac{2}{5}mr^2$, $\omega = v/r$

$\frac{1}{2}Kx^2 = \frac{1}{2}mv^2 + \frac{1}{2}(\frac{2}{5}mr^2)(\frac{v^2}{r^2}) + mgy$

$\frac{1}{2}Kx^2 - mgy = \frac{7}{10}mv^2$

$$v = \left[\frac{10(\frac{1}{2}Kx^2 - mgy)}{7m}\right]^{1/2} = \left[\frac{10[\frac{1}{2}(250 N/m)(0.20 m)^2 - (0.50 Kg)(9.8 m/s^2)(0.60 m)]}{7(0.50 Kg)}\right]^{\frac{1}{2}}$$

v = 2.43 m/s

b) How far from the inclined plane (i.e. what is x in the figure) will the ball land? (5 points)

$V_{ox} = (2.43 m/s)\cos 35° = 1.99 m/s$

$V_{oy} = (2.43 m/s)\sin 35° = 1.39 m/s$

$y_o = 0.60 m$

$y = 0 m$

$x_o = 0 m$

$x = ?$

$y = y_o + V_{oy}t + \frac{1}{2}a_y t^2$

$0 = 0.60 m + (1.39 m/s)t - 4.9 m/s^2\, t^2$

$4.9 m/s^2\, t^2 - 1.39 m/s\, t - 0.60 m = 0$

$a = 4.9$, $b = -1.39$, $c = -0.60$

$$t = \frac{1.39 \pm \sqrt{(-1.39)^2 - 4(4.9)(-0.60)}}{2(4.9)}$$

$t = 0.519 s$

$X = V_{ox}t = (1.99 m/s)(0.519 s)$

X = 1.63 m