Each problem is worth 10 points.

1. A ball is thrown from the ground into the air, reaching a maximum height of 115 m, and traveling a horizontal distance of 245 m before it hits the ground. Determine the speed and direction with which the ball was thrown, and the amount of time it was in the air.

2. A car and a bus travel along two intersecting roads, as shown here. The car is traveling at 30 m/s due north, and the bus is traveling at 20 m/s at 35° north of east. At t = 0, the bus is at the intersection, while the car is 75 m to the south of the intersection. (a) Find the velocity of the car relative to the bus, expressed in unit-vector notation. (You should take north to be the direction of the +y axis, and east to be the direction of the +x axis.) (b) Find the position of the car relative to the bus as a function of time, expressed in unit-vector notation.

3. In the diagram, \( m_1 = 2.0 \text{ kg} \) and \( m_2 = 3.0 \text{ kg} \). A coefficient of kinetic friction \( \mu_k = 0.30 \) exists between both blocks and the surfaces. The pulley is massless and frictionless. Find the acceleration of the masses, and the tension in the rope.

4. (a) A roller coaster car travels at 25.0 m/s at the bottom of a loop, where the radius of curvature is 65.0 m. An 85.0 kg man is in the car, and sitting on a scale. What does the scale read? (b) Suppose the car slows to 15.0 m/s at the top, and the scale now reads an amount equal to the man's weight. What must be the radius of curvature of the track at the top?
1. First find the time.

Time on way down can be found from:

\[ Y - y_0 = v_0 t - \frac{1}{2} g t^2 \]

\[ -11.5 = 0 - \frac{1}{2} (9.81) t^2 \]

\[ t = 4.84 \text{ s} \]

This is also time to go up:

\[ t_{up} = t = 4.84 \text{ s} \]

so total time \( t = 2 t = 9.68 \text{ s} \).

Now find \( v_{0x} \):

\[ x - x_0 = v_{0x} t \]

\[ 24.5 = v_{0x} (9.68) \]

\[ v_{0x} = 2.53 \text{ m/s} \]

To find \( v_{0y} \):

\[ v_{0y} = v_{0y} - g t_{up} \]

\[ 0 = v_{0y} - (9.81)(4.84) \]

\[ v_{0y} = 47.4 \text{ m/s} \]

\[ v = \sqrt{v_{0x}^2 + v_{0y}^2} = 53.7 \text{ m/s} \]

\[ \tan \theta = \frac{v_{0y}}{v_{0x}} = 1.87 \]

\[ \theta = 61.9^\circ \]
3.

\[ F_{\text{net}, x} = T - F_k = m_1 a_x = m_1 a \]
\[ F_{\text{net}, y} = F_N - m_1 g = m_1 a_y = 0 \]
\[ F_N = m_1 g \]
\[ F_k = \mu_k F_N = \mu_k m_1 g \]

\[ T - \mu_k m_1 g = m_1 a \]

\[ F_{\text{net}, x} = m_2 g \sin 30^\circ - T - F_k = m_2 a_x = m_2 a \]
\[ F_{\text{net}, y} = F_N - m_2 g \cos 30^\circ = m_2 a_y = 0 \]
\[ F_N = m_2 g \cos 30^\circ \]
\[ F_k = \mu_k F_N = \mu_k m_2 g \cos 30^\circ \]

\[ m_2 g \sin 30^\circ - T - \mu_k m_2 g \cos 30^\circ = m_2 a \]

Add equations:

\[ m_2 g \sin 30^\circ - \mu_k m_1 g - \mu_k m_2 g \cos 30^\circ = m_1 a + m_2 a \]

\[ a = \frac{(m_2 \sin 30^\circ - \mu_k m_1 - \mu_k m_2 \cos 30^\circ) g}{m_1 + m_2} \]

\[ = \frac{(3.0 \sin 30^\circ - 0.30)(2.0) - (0.30)(7.0) \cos 30^\circ}{2.0 + 7.0} \]

\[ = 0.24 \text{ m/s}^2 \]

\[ T = m_1 a + \mu_k m_1 g = m_1 (a + \mu_k g) \]

\[ = (2.0) [0.24 + (0.30)(9.8)] \]

\[ = 6.4 \text{ N} \]
4. (a) Scale reads the normal force.

\[ \overrightarrow{F_N} = \overrightarrow{F_N} - mg = \frac{mv^2}{V} \]

\[ F_N = mg + \frac{mv^2}{V} \]

\[ = m(g + \frac{v^2}{V}) \]

\[ = (85.0)(9.8 + \frac{25.0^2}{65.0}) \]

\[ = 1650 \text{ N} \]

(b)

\[ \overrightarrow{F_N} = \overrightarrow{F_N} + mg = \frac{mv^2}{V} \]

\[ F_N = mg \]

\[ mg + mg = \frac{mv^2}{V} \]

\[ 2mg = \frac{mv^2}{V} \]

\[ v = \sqrt{\frac{v^2}{2g}} = \frac{15.0^2}{2(9.8)} \approx 11.8 \text{ m} \]