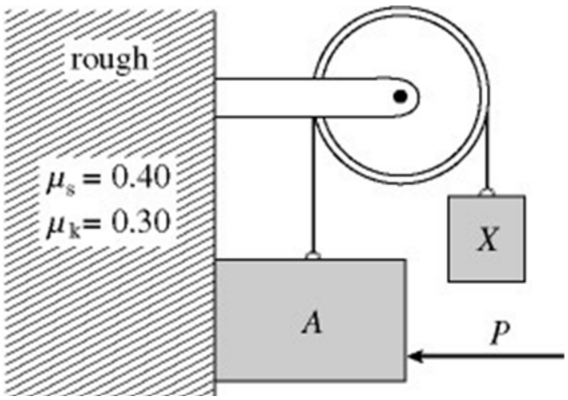
General Physics B 1- Homework Set 2 Solution

1 points for each problem. Total:5 points.

1.Newton's law on Multiple Objects

Block A of mass 8.00 kg and block X are attached to a rope that passes over a pulley. A 50.00N force P is applied horizontally to block A, keeping it in contact with a rough vertical face. The coefficients of static and kinetic friction between the wall and block A are $\mu_s = 0.40$ and $\mu_k = 0.30$. The pulley is light and frictionless. In the figure, the mass of block X is adjusted until block A descends at constant velocity of 5.00 cm/s when it is set into motion. What is the mass of block X? (1point)



Solution Since the block A descends at constant velocity, the net force acting on block A is 0. Thus we have:

$$m_A g = \mu_k F_N + T$$

in vertical dirction and

$$P = F_N$$

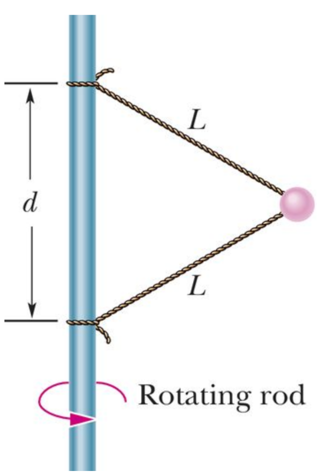
in horizontal direction for block A. For block X, we have $m_B g = T$ in vertical dirction.
Thus we can have

$$m_A g = \mu_k P + m_B g$$

and$m_B = \frac{m_A g - \mu_k P}{g} = 6.47kg$

2.Force for an Uniform Circular Motion

In the following figure, a 1.34 kg ball is connected by means of two massless strings, each of length L = 1.70 m, to a vertical, rotating rod. The strings are tied to the rod with separation d = 1.70 m and are taut. The tension in the upper string is 35.00 N. What are the (a) tension in the lower string (0.5point) (b) speed of the ball?(0.5point)



Solution (a)The net force in vertical direction is zero so that the strings are taut. Therefore, we have $T_{upper} sin\theta = mg + T_{lower} sin\theta$, where $sin\theta = (d/2)/L = 0.5$

Thus $T_{lower} = \frac{Tsin\theta - mg}{sin\theta} = 8.74N$.

(b)The net force is only in horizontal direction and is provided by the two strings. Thus the magnitude of the force is $F = T_{upper} cos\theta + T_{lower} cos\theta = 37.88N$.

The speed of the ball satisfies the condition of uniform circular motion, where the net force profide the acceleration. Thus, $v = \sqrt{ar} = \sqrt{\frac{F}{m}(Lcos\theta)} = 6.45m/s$.

3. Work Done by a Variational Force

A force on a particle depends on position such that $F(x) = [3.00(N/m^2)x^2 + 6.00(N/m)x)]\hat{i} + 5.00(N)\hat{j}$ for a particle constrained to move along the x-axis. There is no motion in y-axis. What work is done by this force on a particle that moves from x = 0.00 m to x = 2.00 m? (1point)

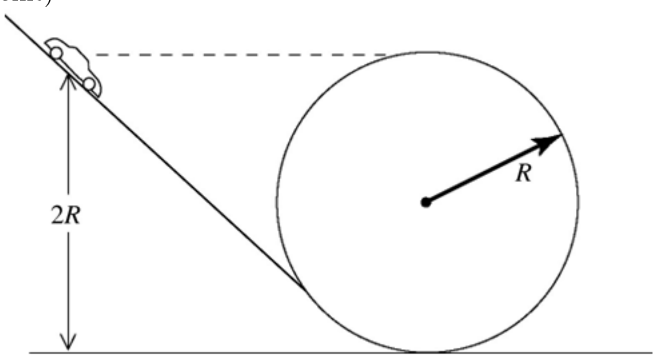
Solution Following the definition of work and we have:

$$W = \int \overrightarrow{F(x)} \cdot d\overrightarrow{x} = \int_{x=0}^{x=2} \{[3.00(N/m^2)x^2 + 6.00(N/m)x)]\hat{i} + 5.00(N)\hat{j}\} \cdot d\overrightarrow{x} = \int_{x=0}^{x=2} [3.00(N/m^2)x^2 + 6.00(N/m)x)]dx$$

$$= [3.00(N/m^2)(\frac{1}{3}x^3) + 6.00(N/m)(\frac{1}{2}x^2)]_{x=0}^{x=2} = 8(N \cdot m) + 12(N \cdot m) = 20(j)$$

4.Conservation of energy in a Looping-Loop

In the figure, a toy race car of mass m=0.1kg is released from rest on the loop-the-loop track. If it is released at a height 2R=2.00m above the floor, how high is it above the floor when it leaves the track, neglecting friction? (1point)



Solution Let the height from the lowest point to the position of the car is h. During the whole process, only graviational force is doing work. From conservation of mechanical energy, assuming the magnitude of toy car's velocity at positon h is v, thus we have:

$$mg2R = mgh + \frac{1}{2}mv^2 \tag{1}$$

Note that the velocity on the loop-the-loop track is in the tangential direction of the loop. During the toy car traveling on looping track, the centripical acceleration is provided by net force of normal force and gravitational force. The toy car leaves the track when the centripal acceleration is only provide by the components of gravitational force and the normal force is zero. The centripical acceleration is provided by a component of graviational force pointing to the ceter of the circle and the magnitude of this force is:

$$mgsin\theta = mg\frac{h-R}{R} = m\frac{v^2}{R} \tag{2}$$

From (1), we have $v^2 = 2g(2R - h)$. Plug into (2) and we have $h - R = 2(2R - h)$. Thus, we can get $h = \frac{5}{3}R$.

5.Circular Motion around the Moon

During the Apollo Moon landings, one astronaut remained with the command module in lunar orbit, about 130km above the moon survace. For half of each orbit, this astronaut was completely cut off from the rest of humanity as the spacecraft rounded the far side of the Moon. How long did this period last? (1point) Given the radius of the Moon is $R_M = 1.74 \times 10^6 m$ and the mass of the Moon is $M = 7.35 \times 10^{22} kg$. The gravitational constant $G = 6.67 \times 10^{-11} N \cdot m^2/kg^2$.

Solution Since the spacecraft is doing a circular motion surroundin the moon with a radius $d + R_M = 1.30 \times 10^5 + 1.74 \times 10^6 = 1.87 \times 10^6(m)$. The time for the spacecraft to surround half of the orbit is:

$$\frac{T}{2} = \frac{2\pi(d + R_M)}{2(v)} = \frac{2\pi(d + R_M)}{2(\sqrt{\frac{GM}{d+R_M}})} = \pi\sqrt{\frac{(d + R_M)^3}{GM}} = 3.63 \times 10^3(s)$$

So the period of totally silence is $3.63 \times 10^3 sec = 60.5 minutes$.