Physics
Quiz # 9

Date Given: June 9, 2022
Date Due: June 16, 2022

Q1. (2 points) If the 2-kg block passes over the top B of the circular portion of the path with a speed of 3.5m/s, calculate the magnitude N_B of the normal force exerted by the path on the block. Determine the maximum speed v which the block can have at A without losing contact with the path.

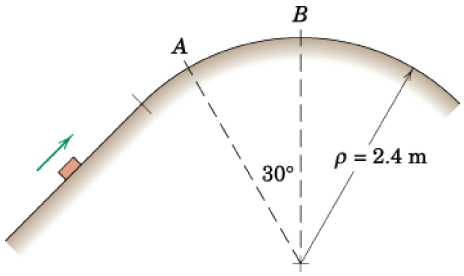

Figure 1: Illustration to Problem 1.

Answer:

Figure 2: Illustration to Problem 1.

(a) At point B we have, $\sum F_n = ma_n \Longrightarrow mg - N_B = mv^2/\rho$, where $m = 2\text{kg}, v = 3.5\text{m/s}, \rho = 2.4\text{m}$. Therefore, $N_B = mg - mv^2/\rho \approx 9.41\text{N}.$

(b) At point A we have, $\sum F_n = ma_n \Longrightarrow mg\cos 30^\text{o} - N_A = mv^2/\rho \Longrightarrow$ (since loss of contact at A implies $N_A = 0$) $mg\cos 30^\text{o} = mv^2/\rho \Longrightarrow v^2 = g\rho\cos 30^\text{o}) \Longrightarrow v = \sqrt{g\rho\cos 30^\text{o}} \approx 4.52\text{m/s}.$

Q2. (2 points) Set up the n, t axes and write the equations of motion for the 10-kg block shown in Figure 3 along each of these axes.

Answer:

(a) First, $\sum F_t = ma_t \Longrightarrow -\mu_k N = ma_t \Longrightarrow -0.3N = 10a_t$. Next $\sum F_n = ma_n \Longrightarrow mg - N = m\frac{v^2}{\rho} \Longrightarrow 98.1 - N = 10\frac{6^2}{10} = 36.$

(b) First, $\sum F_t = ma_t \Longrightarrow mg\sin 30^\text{o} - \mu_k N = ma_t \Longrightarrow 98.1\sin 30^\text{o} - 0.2N = 10a_t$. Next $\sum F_n = ma_n \Longrightarrow N - mg\cos 30^\text{o} = m\frac{v^2}{\rho} \Longrightarrow N - 98.1\cos 30^\text{o} = 10\frac{4^2}{5} = 32.$

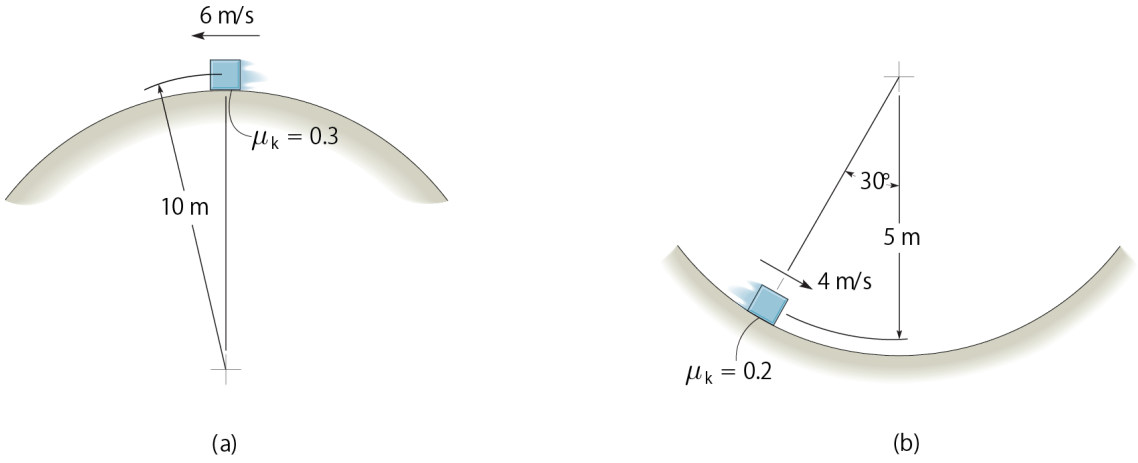

Figure 3: Illustration to Question 2.

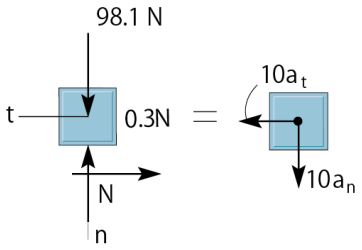

Figure 4: Illustration to Question 2 (a).

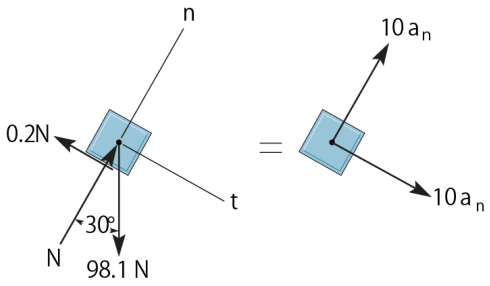

Figure 5: Illustration to Question 2 (b).

Q3. (2 points) A child twirls a small 50 gram ball attached to the end of a 1m string so that the ball traces a circle in a vertical plane as shown. What is the minimum speed v which the ball must have when in position 1? If this speed is maintained throughout the circle, calculate the tension T in the string when the ball is in position 2. Neglect any small motion of the child's hand.

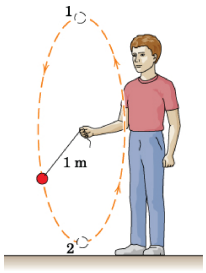

Figure 6: Illustration to Question 3.

Answer:

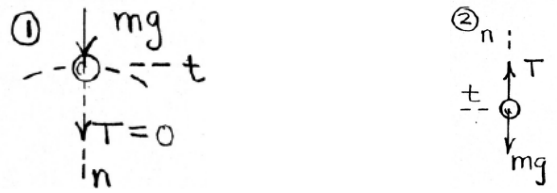

Figure 7: Illustration to Question 3.

(a) The minimal speed corresponds to zero tension in the string. At the lowest point we have, $\sum F_n = ma_n \implies mg + T = mv^2/\rho$, and (since $T = 0$) $\implies v^2 = \rho g \implies v = \sqrt{\rho g} = \sqrt{g} \approx 3.13\text{m/s}$.

(b) At the highest point, $\sum F_n = ma_n \implies T - mg = mv^2/\rho \implies$ (since we established $v = \sqrt{\rho g}$) we have $T - mg = mg \implies T = 2mg = 2 \times 0.05 \times 9.81 = 0.981\text{N}$.

Q4. (1 point) The hollow tube is pivoted about a horizontal axis through point O and is made to rotate in the vertical plane with a constant counterclockwise angular velocity $\dot{\theta} = 3\text{rad/s}$. If a 0.1kg particle is sliding in the tube toward O with a velocity of 1.2m/s relative to the tube when the position $\theta = 30^\circ$ is passed, calculate the magnitude N of the normal force exerted by the wall of the tube on the particle at this instant.

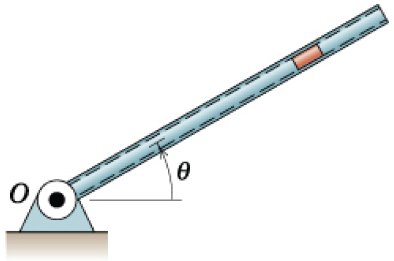

Figure 8: Illustration to Problem 4.

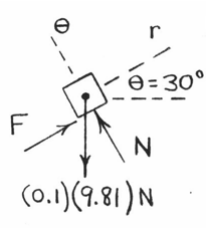

Figure 9: Illustration to Problem 4.

Answer:

To find N, it suffice to consider motion equation corresponding to θ direction. Here we have, $\sum F_\theta = ma_\theta \Longrightarrow N - mg\cos 30^\circ = m(r\ddot{\theta} + 2\dot{r}\dot{\theta}) \Longrightarrow$ (since $\ddot{\theta} = 0$)

$N = mg\cos 30^\circ + 2m\dot{r}\dot{\theta} \approx 0.1296\text{N}.$