Name: KEY

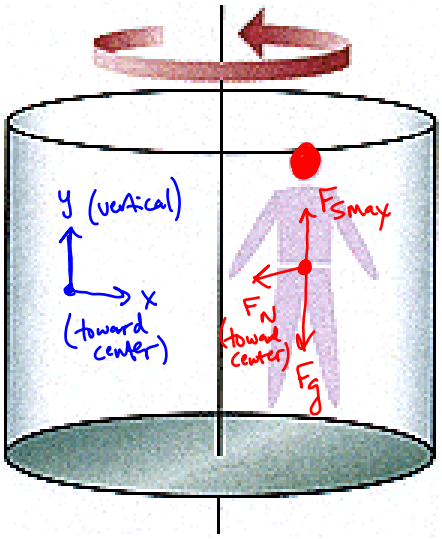
Date:

Section C D F

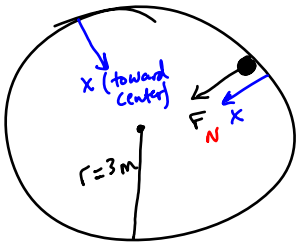
The Masters School
Mr. Alex Rawson
Physics

Rotational Motion IV

1. In a popular amusement-park ride, a cylinder of radius 3.00 m is set in rotation at an angular speed of 5.00 rad/s, as shown in Figure 7-20. The floor then drops away, leaving the riders suspended against the wall in a vertical position. What minimum coefficient of friction between a rider's clothing and the wall of the cylinder is needed to keep the rider from slipping? (*Hint*: Recall that $F_s = \mu_s F_n$, where the normal force is the force that maintains circular motion. Your answer should be between 0.1 and 0.2)



Overhead View



Given

$r = 3$ m

$\omega = 5$ rad/s

$\mu_s = ?$

$F_{net\,y} = F_{s\,max} - F_g = 0$

$F_g = F_{s\,max} = mg$

$F_{net\,x} = F_N \neq 0$ (b/c accelerating toward center)

$F_{net\,x} = ma_c$

$\therefore F_N = ma_c$

$$\mu_s = \frac{F_{s\,max}}{F_N}$$

$$\mu_s = \frac{mg}{ma_c}$$

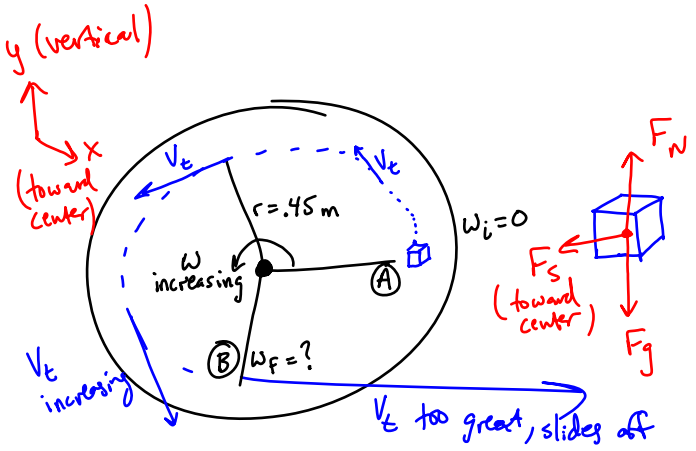
substitute $a_c = r\omega^2$

$$\mu_s = \frac{g}{r\omega^2}$$

$$\mu_s = \frac{9.81}{3(5)^2}$$

$$\boxed{\mu_s = .1308}$$

2. A copper block rests 45.0 cm from the center of a steel turntable. The coefficient of static friction between the block and the surface is 0.44. The turntable starts from rest and rotates with a constant angular acceleration of 0.40 rad/s^2. After what time interval will the block start to slip on the turntable? (*Hint*: first find ω_f, then find Δt. Your answer should be between 6 and 9 seconds.)



Initially, we are at point A, with no velocity. As the turntable rotates and accelerates, the tangential velocity Vt increases, as well as the angular velocity ω. As the turntable speeds up, it becomes harder and harder for the copper block to stay on the turntable, held there by friction. At some point B, the coefficient of static friction is not strong enough to hold on to the copper block, so the copper block flies off. Lets consider that as the final point, with a final velocity. How much time passes before reaching that ωf?

Given

$r = .45$ m

$\Delta\theta =$

$\omega_i = 0$ (1)

$\omega_f = ?$

$\alpha = .4$ rad/s^2

$\Delta t = ?$ (2)

$\mu_s = .44$

$F_{net_x} = F_s \neq 0$

$F_{net_x} = ma_c = F_c$

$\therefore F_s = ma_c$

$F_{net_y} = F_N - F_g = 0$

$F_g = F_N = mg$

(1)

$$\mu_s = \frac{F_{s,max}}{F_N} = \frac{ma_c}{mg}$$

substitute $a_c = r\omega^2$

$$\mu_s = \frac{mr\omega_f^2}{mg}$$

isolate ω_f

$$\omega_f^2 = \frac{g\mu_s}{r}$$

$$\omega_f^2 = \frac{(9.81)(.44)}{(.45)}$$

$$\omega_f^2 = 9.592 \text{ rad/s}$$

$\omega_f = 3.097$ rad/s

(2) $\omega_f = \omega_i + \alpha\Delta t$

$$\frac{\omega_f}{\alpha} = \Delta t = \frac{3.097}{.4}$$

$\Delta t = 7.743$ seconds