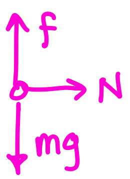
ABRHS PHYSICS (H) NAME: KEY

Force Problems IV

Include a correctly labeled free body diagram in each problem.

1. The Turkish Twist is a classic amusement park ride in which the riders stand in a tube. The tube spins around, and then the floor drops down, leaving the riders stuck to the wall. If the radius of the tube is 3 meters, and the coefficient of friction between the rider and the wall is 0.4, what is the minimum rotation speed (in rpm) of the ride?



$\Sigma F_x = \frac{mv^2}{r}$

$N = \frac{mv^2}{r}$

$\Sigma F_y = 0$

$f - mg = 0$

min speed → max f_s

$f = \mu N$

So $f = mg$

$\mu N = mg$

$\mu\left(\frac{mv^2}{r}\right) = mg$

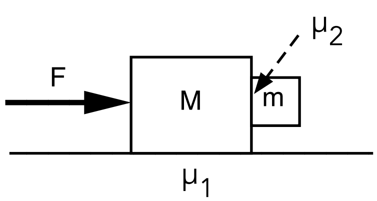
$v^2 = \frac{rg}{\mu} = \frac{(3)(10)}{0.4}$

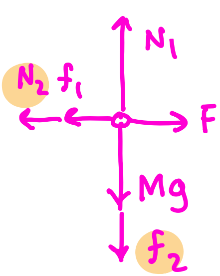
$v^2 = 75$ $\quad$ $v = 8.66$ m/s

So $\left(\frac{8.66\ \cancel{m}}{\cancel{s}}\right)\left(\frac{60\ \cancel{s}}{1\ \text{min}}\right)\left(\frac{1\ \text{rev}}{2\pi(3)\ \cancel{m}}\right)$

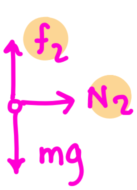
$\boxed{= 27.6\ \text{rpm}}$

2. A force F is pushing a big box M, which in turn is pushing a little box m, as shown in the diagram. The coefficients of friction are as shown. What is the minimum force F so that m stays suspended?





N3L pairs



M) $\Sigma F_x = Ma$ $\qquad$ $\Sigma F_y = 0$

$F - f_1 - N_2 = Ma$ $\qquad$ $N_1 - Mg - f_2 = 0$

m) $\Sigma F_x = ma$ $\qquad$ $\Sigma F_y = 0$

$N_2 = ma$ $\qquad$ $f_2 - mg = 0$

friction) $f_1 = \mu_1 N_1$ $\qquad$ $f_2 = \mu_2 N_2$

system) $\Sigma F_x = (m+M)a$ $\qquad$ $\Sigma F_y = 0$

$F - f_1 = (m+M)a$ $\qquad$ $N_1 - (m+M)g = 0$

So $\mu_2 N_2 = mg \rightarrow \mu_2(ma) = mg$ $\qquad$ $a = \frac{g}{\mu_2}$

And $F = (m+M)a + f_1 = (m+M)a + \mu_1 N_1$

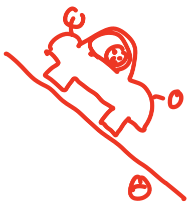
$$\boxed{F = (m+M)\frac{g}{\mu_2} + \mu_1(m+M)g}$$

could say $F = \left(\frac{1}{\mu_2} + \mu_1\right)(m+M)g$

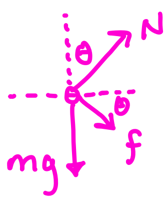
Force Problems IV

3. A car is driving around a curved, banked road, base angle θ and radius r. If the coefficient of friction between the tires and the road is μ, what is the fastest the car can travel around the curve without sliding.

↳ So friction helps to keep it from sliding up the hill...



$\Sigma F_x = \frac{mv^2}{r}$ $\Sigma F_y = 0$ NOT // & ⊥ (but see below)



$N\sin\theta + f\cos\theta = \frac{mv^2}{r}$ $N\cos\theta - f\sin\theta - mg = 0$ $f = \mu N$

$N\sin\theta + \mu N\cos\theta = \frac{mv^2}{r}$ $N\cos\theta - \mu N\sin\theta - mg = 0$

$N = \frac{mg}{\cos\theta - \mu\sin\theta}$

So $N(\sin\theta + \mu\cos\theta) = \frac{mv^2}{r}$

$\left(\frac{\cancel{m}g}{\cos\theta - \mu\sin\theta}\right)(\sin\theta + \mu\cos\theta) = \frac{\cancel{m}v^2}{r}$

$v^2 = rg\,\frac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta}$

$\boxed{\text{So } v = \sqrt{rg\,\frac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta}}}$

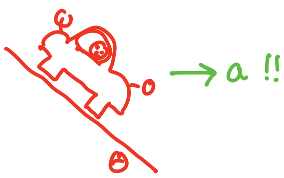
Answers

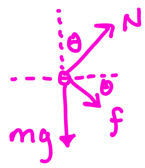
1) *27.6 rpm*

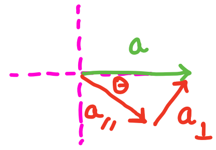
2) *$F = (\mu_1 + 1/\mu_2)(m_1 + m_2)g$*

3) *$v^2 = rg[(\sin\theta + \mu\cos\theta)/(\cos\theta - \mu\sin\theta)]$*

3) You can do this problem with $\parallel$ & $\perp$ components, it's just a little harder. The tricky part is realizing that the acceleration has both $\parallel$ and $\perp$ components.







$a = \frac{v^2}{r}$

So $\qquad \Sigma F_\perp = m a_\perp \quad$ & $\quad \Sigma F_\parallel = m a_\parallel$

$$N - mg\cos\theta = \frac{mv^2}{r}\sin\theta \quad \& \quad f + mg\sin\theta = \frac{mv^2}{r}\cos\theta$$

In addition $\quad f = \mu N \quad$ (Since the limits on the velocity would correspond to the most friction possible.)

Therefore we can say $\quad N = mg\cos\theta + \frac{mv^2}{r}\sin\theta$

So that $\qquad \mu N + mg\sin\theta = \frac{mv^2}{r}\cos\theta$

$$\mu\left(\cancel{m}g\cos\theta + \frac{\cancel{m}v^2}{r}\sin\theta\right) + \cancel{m}g\sin\theta = \frac{\cancel{m}v^2}{r}\cos\theta$$

Now just solve for V

$$\mu g\cos\theta + g\sin\theta = \frac{v^2}{r}\cos\theta - \mu\frac{v^2}{r}\sin\theta$$

$$g(\sin\theta + \mu\cos\theta) = \frac{v^2}{r}(\cos\theta - \mu\sin\theta)$$

So That $\quad \boxed{v^2 = rg\,\frac{\sin\theta + \mu\cos\theta}{\cos\theta - \mu\sin\theta}}$