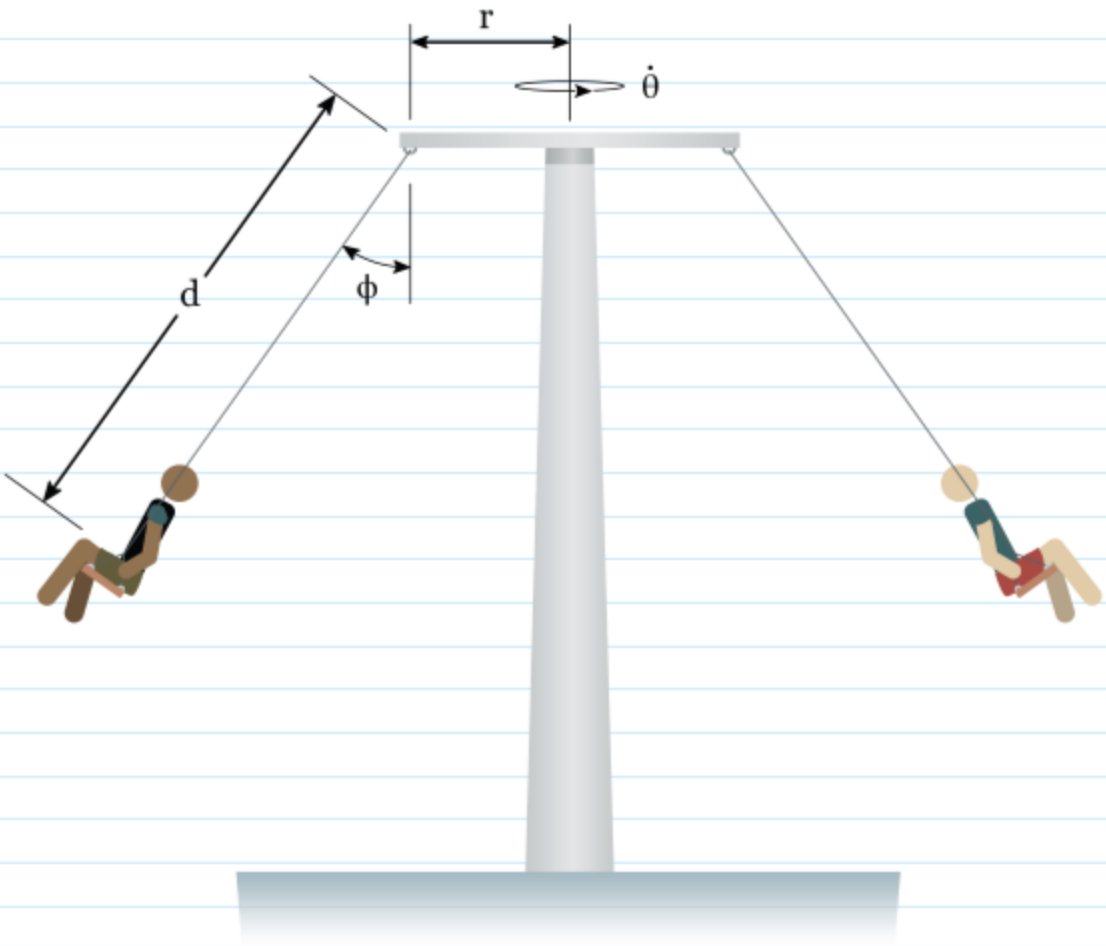
21-P-FA-GD-007



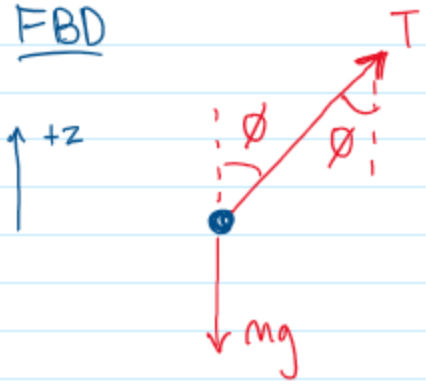
A new amusement park ride has opened near your house and you are eager to try it with one of your friends.

Your friend is scared of rollercoasters, but they agree to ride it with you if they do not exceed $V_{\equiv}$ m/s.

The maximum angle of the seat from the vertical is $\emptyset_{\equiv}$, the arm supporting the seat extends $r_{\equiv}$ from the center, and the cable supporting the seat is $d_{\equiv}$ long.

What is the angular velocity of the center pillar?
What is your friend's velocity?
Will your friend forgive you if they're convinced to go on?

FBD



given r, d, ϕ, g, v_{max}

find $\dot{\theta}$

radial (r)

$a_r = \ddot{r} - r\dot{\theta}^2$ general formula

$= \cancel{\ddot{r}}^{0} - (r + d\sin\phi)\dot{\theta}^2$

$\Sigma F_r = ma_r$

$m\cancel{a_r}^{0} = T\sin\phi - m(r + d\sin\phi)\dot{\theta}^2$

vertical (z)

$\Sigma F_z = m\cancel{a_z}^{0} = T\cos\phi - mg$

$T = \frac{mg}{\cos\phi}$

$\frac{\cancel{m}g}{\cos\phi}\sin\phi = \cancel{m}(r + d\sin\phi)\dot{\theta}^2$

$g\tan\phi = (r + d\sin\phi)\dot{\theta}^2$

$\dot{\theta} = \sqrt{\frac{g\tan\phi}{r + d\sin\phi}}$

$v = (r + d\sin\phi)\dot{\theta}$

if $v < v_{max}$, your friend will forgive you

otherwise, they will not.