Answer on Question 74927, Physics, Other

Question:

In an amusement park ride called "drop out", riders are spun in a horizontal circles of radius 7.5 m, which pins their backs against an outer wall. When they are spinning quickly enough, the floor drops out, and they are suspended by friction. If the coefficient of static friction between the riders and the wall is as small as 0.28, how many revolutions per second must the ride achieve before the floor is allowed to drop out?

Solution:

There are four forces acting on the rider when he is spun: the force of gravity $W = mg$ (or the weight of the rider) directed downward, the friction force F_{fr} directed upward, the normal force N from the wall directed inward and the centripetal force F_c also directed inward.

Since, the friction force must balance the force of gravity, we can write:

$$F_{fr} = W = mg,$$

here, m is the mass of the rider, g is the acceleration due to gravity.

Also, the normal force provides the centripetal force:

$$N = F_c = m\omega^2 r,$$

here, ω is the angular velocity of the ride, r is the radius of the circle.

From the other hand, we can write:

$$F_{fr} = \mu N = mg,$$

$$\mu m\omega^2 r = mg,$$

here, μ is the coefficient of friction between the rider and the wall.

From this formula we can find the angular velocity of the ride:

$$\omega = \sqrt{\frac{g}{\mu r}}.$$

Finally, we can find the frequency of rotation of the ride before the floor is allowed to drop out from the formula:

$$\omega = 2\pi f,$$

$$f = \frac{\omega}{2\pi}.$$

Substituting ω into the formula, we get:

$$f = \frac{\omega}{2\pi} = \frac{\sqrt{\frac{g}{\mu r}}}{2\pi} = \frac{\sqrt{\frac{9.8\ \frac{m}{s^2}}{0.28 \cdot 7.5\ m}}}{2\pi} = 0.34\ \frac{rev}{s}.$$

Answer:

$f = 0.34\ \frac{rev}{s}.$