20.

Problem 12.16P (HRW)

A bowler throws a bowling ball of radius $R = 11\text{cm}$ *down a lane. The ball slides on the lane, with initial speed* $v_0 = 8.5\ \text{m s}^{-1}$ *and initial angular speed* $\omega_0 = 0$. *The coefficient of kinetic friction between the ball and the lane is* 0.21. *The kinetic frictional force* f_k *acting on the ball causes a linear acceleration of the ball while producing a torque that causes an angular acceleration of the ball. When the speed of the centre of mass v has decreased enough and angular speed* ω *has increased enough, the ball stops sliding and then rolls smoothly.*

We have to answer

a) What then is v in terms of ω*?*

b) What is the linear acceleration of the ball during sliding?

c) What is the angular acceleration of the ball during sliding?

d) How long does the ball slide?

e) How far does the ball slide?

f) What is the speed of the ball when smooth rolling begins?

Solution:

We will use the results of the problem **19**, 12.35 (HR), in calculating the numerical answers. Note, the normal force is Mg and the coefficient of kinetic friction is 0.21. Therefore, the force of friction will be $f_k = 0.21Mg$. Substituting this expression for f_k in the formulas for a, α, t', v and ω at t', we find the following answers:

a) $v = \omega R.$

b) $a = 0.21g = 2.06 \text{ m s}^{-2}.$

c) $\alpha = \frac{5}{2} \times \frac{0.21g}{R} = 46.8 \text{ rad s}^{-2}.$

d) $t' = \frac{2}{7} \frac{v_0}{0.21g} = 1.18 \text{ s.}$

f) $v' = 8.5 - 0.21 \times 1.18 \times g = 6.07 \text{ m s}^{-1}.$

e) $s = \frac{8.5^2 - 6.07^2}{2 \times 0.21 \times 9.8} = 8.6 \text{ m.}$