Answer on Question#39726, Physics, Mechanics

Question:

A heavy solid sphere is thrown on a horizontal rough surface with initial velocity 7 m/s without rolling. When it starts pure rolling motion, then its speed will be??

Solution:

For translational motion we have

$$ma = -\mu mg$$

where μ is the coefficient of friction

So

$$a = -\mu g$$

After time t velocity is

$$v = v_0 + at = v_0 - \mu gt$$

For rotational motion about centre a net torque acting upon an object will produce an angular acceleration of the object according to

$$\tau = I\alpha$$

$$\mu mgr = I\alpha$$

where *r* is radius of sphere, *I* is moment of inertia, α is angular accleration

The moment of inertia of solid sphere of radius r and mass m is

$$I = \frac{2mr^2}{5}$$

So

$$\mu mgr = \frac{2mr^2}{5}\alpha$$

$$\alpha = \frac{5\mu g}{2r}$$

The angular velocity is

$$\omega = 0 + \alpha t$$

$$\omega = \frac{5\mu g}{2r}t$$

For pure rolling motion

$$v = r\omega$$

So

$$v_0 - \mu gt = r\frac{5\mu g}{2r}t$$

$$v_0 = \mu gt + \frac{5\mu gt}{2} = \frac{7\mu gt}{2}$$

From this equation

$$t = \frac{2v_0}{7\mu g}$$

Now we put t in equation for v

$$v = v_0 - \mu gt = v_0 - \frac{\mu g 2v_0}{7\mu g} = v_0 - \frac{2v_0}{7} = \frac{5v_0}{7}$$

$$v = \frac{5 \cdot 7}{7} = 5 \text{ m/s}$$

Answer. $v = 5$ m/s.