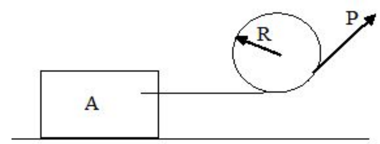
Q- Block A of mass m = 10 kg is pulled from rest, on a horizontal surface by a rope passing over a fixed pulley of same mass m = 10 kg and radius R = 0.25 m and moment of inertia I = 1.2 kg m^2. The force applied at the end of the string is P = 750 N. If the coefficient of friction between the block and the surface is μ = 0.2 and the rope does not slide over the pully find the velocity of the block after time t = 0.15 s.

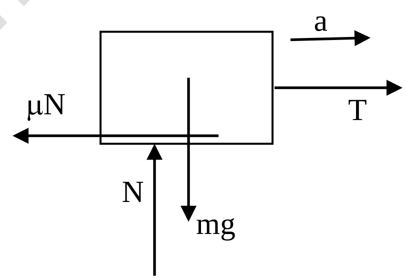


If the cable is not slipping on the roller, there will be a friction force F between the cable and the roller (not limiting friction). This force is tangential to the roller and creates a torque to make the roller periphery move with the same tangential acceleration 'a' as that of cable and block A.

The reactionary friction on the cable will change the tension in the cable and hence if the tension in the string between the block and the roller is T then the equation for the horizontal motion of the block will be [F = ma]

$T - \mu N = ma$ -------------- (1)

Now consider vertically, as in the free body diagram, the forces are the weight of the block mg downward and the normal force N of the surface upward and as the block is not moving vertically, we have



$N - mg = 0$

Substituting this value of N in equation 1 we have

$T - \mu mg = ma$

Or $T = m(a + \mu g)$ -------------- (2)

Here g is the acceleration due to gravity

Now considering the rotation of the roller, the net tangential force acting on the roller will be P - T and hence the torque on the roller is given by

$\tau = (P - T) * R = I_B * \alpha$

Where α is the angular acceleration of the roller given as

$\alpha = a/R$

Hence $(P - T) * R = I_B * (a/R)$

Substituting T from equation 2 we get

$P - m(a + \mu g) = (I_B/R^2) * a$

Or $P - \mu mg = ma + (I_B/R^2) * a$

Or $$a = \frac{P - \mu mg}{m + \frac{I_B}{R^2}} = \frac{750 - 0.2*10*9.8}{10 + \frac{1.2}{0.25^2}} = \frac{730.4}{29.2} = 25.0 \quad m/s^2$$

Hence the block will move with an acceleration of 25.0 m/s^2.

According to the first equation of motion v = u + at we get the velocity of the block after t = 0.15 s will be

V = 0 + 25.0*0.15 = **3.75 m/s.**