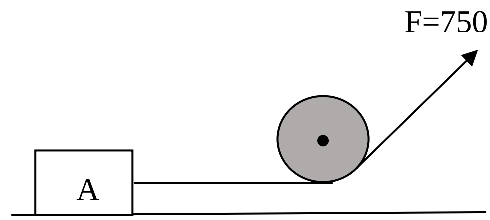
Q- A light cable is used to pull a block of mass 10 kg on a rough horizontal surface and the coefficient of friction between them is 0.2. The cable is passed through a fixed pulley of radius 0.25 m and moment of inertia 1.2 kg-m^2, which is free to rotate about its horizontal axis. The cable is horizontal between the pulley and the block. If a force of 750 N is applied to the cable and the cable does not slip on pulley, determine the velocity of block A at t= 0.155 second.

If the cable is not slipping on the roller thus 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.

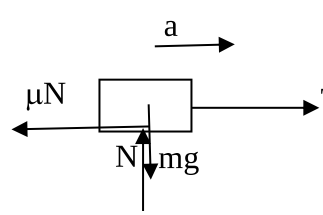


The reactionary friction on the cable will change the tension in the cable and hence if the tension in the string between the block and the roller is T then the equation for the horizontal motion of the block will be [F = ma]

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

Where g is the acceleration due to gravity

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

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

Where α is the angular acceleration of the pulley given by $\alpha = a/R$, Hence

$(F-T)*R = I_B*(a/R)$

Substituting T from equation 2 we get

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

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

Rearranging we get

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

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 = 0.155 s will be

$V = 0 + 25.0*0.155 = 3.88$ m/s.