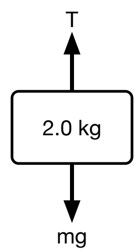
Group Work 10.A.3 Solution

A)

We begin by drawing a free body diagram of the block:



Taking up to represent the positive y-axis, summing the forces in the y-direction gives:

$$\sum F_y = T - Mg = M(0). \tag{1}$$

Where $a = 0$ since the wheel is being held still. Equation 1 then gives:

$$T = Mg = (2.0kg)\left(10\frac{m}{s^2}\right) = 20N$$

B)

For this part, we need to recognize that if the mass is moving at $2\frac{m}{s}$, the string must also be moving at $2\frac{m}{s}$.

C)

In this case, a point on the edge of the circle would also be moving at $2\frac{m}{s}$. As such we have:

$$\omega = \frac{v}{r} = \frac{2\frac{m}{s}}{0.5m} = \frac{4}{s}$$

D)

For this, we must first find the combined moment of inertia of the disc and masses. To do this, we recall that:

$$I_{TOT} = I_{disc} + \sum_i I_i, \tag{2}$$

and that the moment of inertia for a point mass is given by:

$$I = mr^2. \tag{3}$$

Since the disc is "light" we are to assume $I_{disc} \approx 0$. Thus, equations subbing equation 3 into equation 2 gives:

$$I_{TOT} = (2)(1.0kg)(0.25m)^2 + (2)(1.0kg)(0.5m)^2 = 0.625kg * m^2 \tag{4}$$

The total energy is then given by:

$$KE_{TOT} = KE_{trans} + KE_{rot} = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2.$$

Plugging in values gives:

$$KE_{TOT} = \frac{1}{2}(2.0kg)\left(2\frac{m}{s}\right)^2 + \frac{1}{2}(0.625kg * m^2)\left(\frac{4}{s}\right) = 9J$$

E)

For this part we use the work energy theorem. Our equation:

$$\Delta KE = W_C + w_{NC},$$

and since there are no non-conservative forces at work, this becomes:

$$\Delta KE = W_C = -\Delta PE \tag{5}$$

By setting $y = 0$ to the initial height of the block, equation 5 becomes:

$$9J = Mg(0) - Mgy_{final}, \tag{6}$$

Equation 6 implies:

$$y_{final} = \frac{-9J}{Mg} = \frac{-9J}{(2kg)\left(10\frac{m}{s^2}\right)} = -0.45m$$

F)

If the angular acceleration is limited to $-1.0\frac{1}{s}$, then the linear acceleration of the block would be limited to:

$$a = r\alpha = (0.5m)\left(-1.0\frac{1}{s}\right) = -0.5\frac{m}{s^2}.$$

Referring once again to our free-body diagram from part A, we once again take the sum of the forces in the y-direction, giving:

$$\sum F_y = T - Mg = Ma. \tag{7}$$

Equation 7 implies that:

$$T = M(g + a) = (2.0kg)\left(10\frac{m}{s} - 0.5\frac{m}{s}\right) = 19N$$