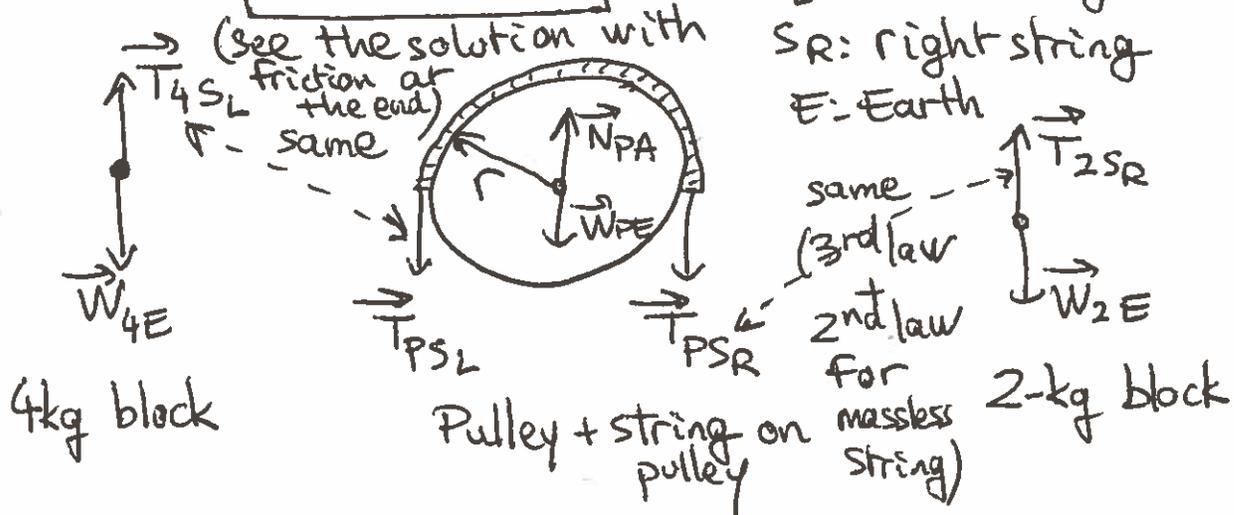


1)

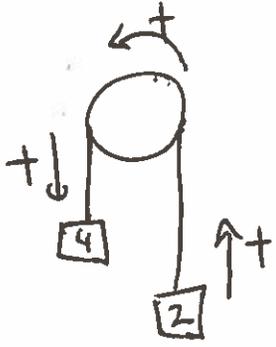
Rotation. Example #5.

FBD's Assume No friction



A: axis of pulley
 P: pulley + string on pulley
 4: 4 kg block
 2: 2 kg block
 SL: left string
 SR: right string
 E: Earth

Positive direction



$\vec{F}_{net} = m\vec{a}$

4 kg $\rightarrow \vec{W}_{4E} + \vec{T}_{4SL} = 4\vec{a}_4 \rightarrow \boxed{4g - T_{4SL} = 4a_4}$

2 kg $\rightarrow \vec{W}_{2E} + \vec{T}_{2SR} = 2\vec{a}_2 \rightarrow \boxed{-2g + T_{2SR} = 2a_2}$

Applying $\vec{F}_{net} = m\vec{a}$ to the pulley would give

$\vec{T}_{PSL} + \vec{T}_{PSR} + \vec{N}_{PA} + \vec{W}_{PE} = 0$

\rightarrow not a useful equation to answer the question of the exercise

$\vec{\tau}_{net} = I\alpha$

pulley radius

$\rightarrow \boxed{T_{PSL} \cdot r - T_{PSR} \cdot r = I\alpha}$

2)

Unknowns:

$$T_{4SL} = T_{PSL} = T_L$$

$$T_{2SR} = T_{PSR} = T_R$$

$$a_4 = a_2 = a$$

α

→ 4 unknowns

Need a 4th equation:

The string doesn't slip on the pulley:

$a_{\text{string}} = a_{\text{tangential of a point on the rim of the pulley}}$

$$\rightarrow a = r\alpha$$

Solve

$$\left\{ \begin{array}{l} 4g - T_L = 4a \quad (1) \\ -2g + T_R = 2a \quad (2) \\ T_L \cdot r - T_R \cdot r = I\alpha \quad (3) \\ a = r\alpha \quad (4) \end{array} \right.$$

$$(1) + (2) \rightarrow 2g + T_R - T_L = 6a.$$

so $T_L - T_R = 2g - 6a.$

Plug in (3): $r(T_L - T_R) = I\alpha.$

$$r(2g - 6a) = I\alpha$$

since from (4): $a = r\alpha$

$$r(2g - 6a) = \frac{I}{r}a.$$

so $a = \frac{2gr}{\frac{I}{r} + 6r}$

3)

$$a = \frac{2 \times 9.8 \times \cancel{0.06}}{\frac{\frac{1}{2} \times 2 \times \cancel{0.06^2}}{\cancel{0.06}} + 6 \times \cancel{0.06}} = \frac{2 \times 9.8}{7}$$

$$a = 2.8 \text{ m/s}^2.$$

The 4-kg block reaches the floor at t such that

$$h = 1 \text{ m} = \frac{1}{2} a t^2$$

$$t = \sqrt{\frac{2}{2.8}}$$

$$t = 0.85 \text{ s}$$

With Friction

add a torque on the axis of the pulley

③ becomes

$$T_{PSL} r - T_{PSR} r - 0.5 = I \alpha$$

That is $(T_L - T_R) \cdot r = I \alpha + 0.5$.

But $T_L - T_R = 2g - 6a$ (as derived before)

$$(2g - 6a) r = I \alpha + 0.5$$

and

$$a = r \alpha \rightarrow (2g - 6a) r = \frac{I}{r} a + 0.5$$

$$a = \frac{2gr - 0.5}{\frac{I}{r} + 6r}$$

$$a = \frac{2 \times 9.8 \times 0.06 - 0.5}{\frac{\frac{1}{2} \times 2 \times 0.06^2}{0.06} + 6 \times 0.06} = 1.61 \text{ m/s}^2$$

$$\rightarrow t = \sqrt{\frac{2}{1.61}} = 1.11 \text{ s}$$