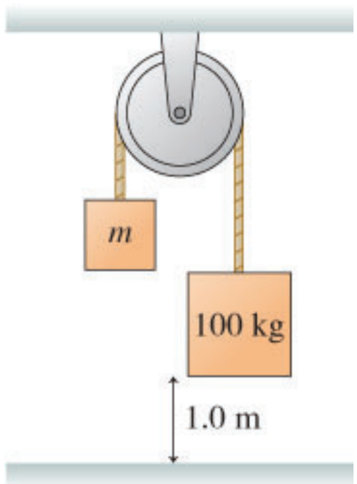
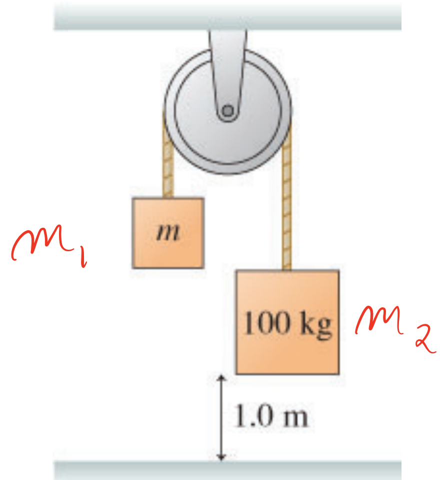
5.84 ||| **INT** The 100 kg block in Figure P5.84 takes 6.0 s to reach the floor after being released from rest. What is the mass of the block on the left?

Figure P5.84



5.84 ||| **INT** The 100 kg block in Figure P5.84 takes 6.0 s to reach the floor after being released from rest. What is the mass of the block on the left?

Figure P5.84



What principle can we use to find m_1?

The only one we have so far is $\sum \vec{F} = m\vec{a}$.

First, though, we need to find a.

Look at the motion of m_2: (Call up positive.)

$y_{2i} = 1.0\text{ m}$ $\quad v_{2i} = 0.$

$y_{2f} = 0.0\text{ m}$ (floor)

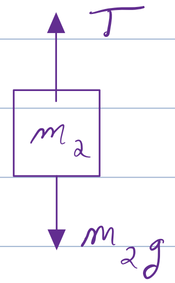
Use motion with constant acceleration

$$y_{2f} = y_{2i} + v_{2i}t + \frac{1}{2}a_2 t^2$$

$$0 = 1.0\text{ m} + 0 + \frac{1}{2}a_2(6.0\text{ s})^2$$

$$a_2 = \frac{-2(1.0\text{ m})}{36.0\text{ s}^2} = \frac{-1}{18}\text{ m/s}^2 \simeq -0.0556\text{ m/s}^2$$

Look at m_2.
Next: what are the forces: Draw a free body diagram. Note we already chose up as positive in the acceleration calculation, so we have to call up positive here too.

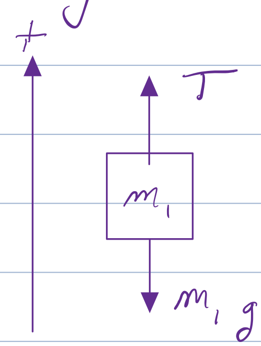


$$\Sigma F = m_2 a_2$$
$$T - m_2 g = m_2 a_2$$
$$T = m_2 (g + a_2)$$

$$T = (100\,kg)(9.8 - 0.0556)\,m/s^2$$
$$T = 974.4\,N$$

(Note this is slightly less than the weight — the mass accelerates down.)

Finally — look at mass m_1. Draw a free body diagram. Again, we pick a direction for positive — pick up since that is the direction the mass accelerates.



$$\Sigma F = m_1 a_1$$
$$T - m_1 g = m_1 a_1$$
$$T = m_1 (g + a_1)$$

Key
Note $a_1 = -a_2$
$= +0.0554\ \frac{m}{s^2}$

$$m_1 = \frac{T}{g + a_1} = \frac{974.4\,N}{(9.8 + 0.0554)\,m/s^2} = \boxed{98.9\,kg}$$

Note this is slightly less than $m_2 = 100\ kg$, so it makes sense that m_2 goes down.

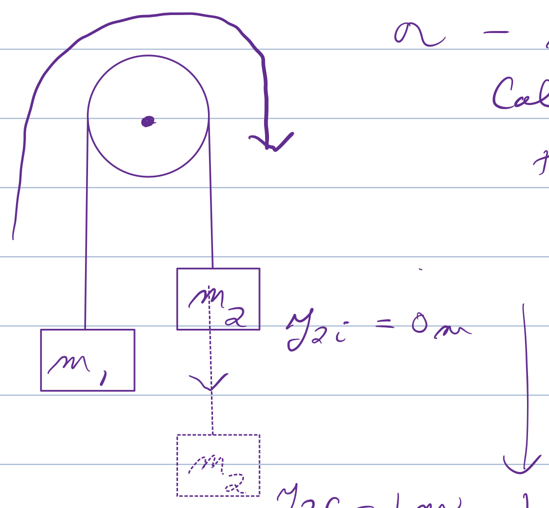
Key observations

1) Tensions are the same (assuming a massless frictionless pulley)
2) accelerations have the same magnitude.

More about signs: We are free to pick + or − signs.

Motion goes this way:

Call down + on the right



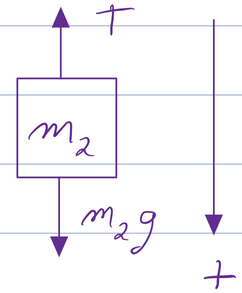
$$y_{2f} = y_{2i} + v_{2i}t + \frac{1}{2}a_2 t^2$$

$$1m = 0 + 0 + \frac{1}{2}a_2 t^2$$

$$a_2 = \frac{2(1.0m)}{(6.0s)^2} = +\frac{1}{18}m^2 = +0.0554\frac{m}{s^2}$$

(Positive because I called down positive.)

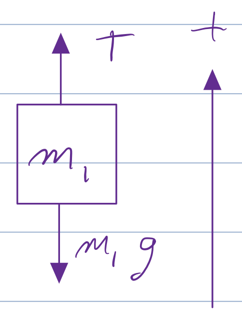
Free body diagram for m_2



$$\Sigma F = m_2 a_2$$
$$m_2 g - T = m_2 a_2$$
$$m_2 (g - a_2) = T$$

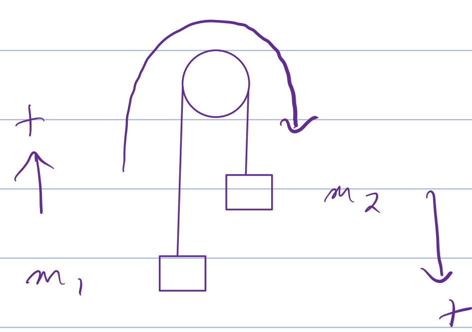
$$T = m_2 (g - a_2)$$
$$= (100\ kg)(9.8 - 0.0554)\,m/s^2 = 974.4\,N$$

Free body diagram for m_1. Pick up as positive.



$$\Sigma F = m_1 a_1$$
$$T - m_1 g = m_1 a_1$$
$$T = m_1 (g + a_1)$$
$$m_1 = \frac{T}{g + a_1}$$

What is a_1? Look at figure:



a_1 and a_2 are both positive

$a_1 = a_2 = 0.0554\,m/s^2$

$$m_1 = \frac{T}{g + a_1} = \frac{974.4\,N}{(9.8 + 0.0554)\,m/s^2} = 98.9\,kg$$

Key idea: you choose the direction for positive, but have to apply it consistently.