The rope in the system is getting shorter, so both bodies are moving up.
Man and Dumbwaiter are in contact so both have some accel.

We need two free-body diagrams.

\[
\begin{align*}
\text{m}_1: \quad & +T -m_1g -F_3 \\
\text{m}_2: \quad & +T +F_3 -m_2g
\end{align*}
\]

Applying NTH to the net force on each.

\[
\begin{align*}
\text{m}_1a &= T -F_3 -m_1g \\
\text{m}_2a &= T +F_3 -m_2g
\end{align*}
\]

We want \(a\), so eliminate \(T\) by subtraction (or solve one for \(T\) and substitute into the other).

\[
\begin{align*}
\text{m}_1a -\text{m}_2a &= T -T -F_3 -F_3 -m_1g +m_2g \\
a &= \frac{2F_3 + (m_1 - m_2)g}{m_2 - m_1} = 0.2 \text{ m/s}^2 \text{ up}
\end{align*}
\]
Sanity check: Suppose the man freezes on the rope. Then $a=0$ and the combined mass of man and dumbbell is suspended from the two cables. So we expect

$$2T = (m_1 + m_2)g \quad (a=0)$$

If $a=0$, the two equations of motion are

$$0 = T - F_S - m_1g$$
$$0 = T + F_S - m_2g$$

Eliminate $F_S$ by adding

$$0 = 2T - (m_1 + m_2)g$$
$$2T = (m_1 + m_2)g \quad \text{OK!}$$
Free-body diagrams

\[ \sum F = ma \]

\[ m_1a = T - mg \]

\[ m_2a = -T + mg \]

\[ (m_1 + m_2)g = 0 + (-m_1 + m_2)g \]

\[ a = \frac{m_2 - m_1}{m_1 + m_2} \cdot g \]

To eliminate \( a \) but keep \( T \), derive top again by \( m_1 \) bottom again by \( m_2 \) and substitute

\[ a = \frac{T}{m_1} - g \]

\[ a = \frac{T}{m_2} + g \]

\[ 0 = T\left(\frac{1}{m_1} - \frac{1}{m_2}\right) - 2g \]

\[ T = \frac{2 \cdot m_1 \cdot m_2}{m_1 + m_2} \cdot g \]
If \( m_2 = 2m_1 \),

\[
a = \frac{2m_1 - m_1}{m_1 + 2m_1} \ g = \frac{1}{3} \ g
\]

To make \( a = 0 \), \( m_1 = m_2 \).

This is "balanced." Note that \( a = 0 \) does not mean \( v = 0 \!! \) It doesn't necessarily sit there stationary.

If \( m_2 > 2m_1 \), then \( \frac{m_1}{m_2} < 1 \rightarrow 0 \)

\[
a = \frac{m_2 - m_1}{m_1 + m_2} \ g \ \rightarrow 0
\]

\[
= \frac{m_2 (1 - \frac{m_1}{m_2})}{m_2 (1 + \frac{m_1}{m_2})} \ g \ \rightarrow 0
\]

\approx \ g

Not surprisingly, in this case \( m_2 \) just falls!
The tensions may be found directly from the first and third equations.

\[ T_1 = m_1 g - m_1 a \]  
\[ = m_1 g - \frac{m_1 (m_1 - m_3)}{m_1 + m_2 + m_3} g \]  
\[ = \frac{m_1 (m_2 + 2m_3)}{m_1 + m_2 + m_3} g = 3.0 \text{ kg} \cdot g = 29 \text{ N} \]

\[ T_2 = m_2 g + m_3 a \]  
\[ = m_3 g + \frac{m_3 (m_3 - m_1)}{m_1 + m_2 + m_3} g \]  
\[ = \frac{m_3 (m_2 + 2m_1)}{m_1 + m_2 + m_3} g = 2.5 \text{ kg} \cdot g = 25 \text{ N} \]

The tensions are external; the weights are external.
91. \[ F = \mu_s N = \mu_s mg \]

92. \[ F = \mu_k (m_1 + m_2)g = 94 N \]
The frictional force $F_f$ is the only force acting, so it provides the acceleration:

$$-ma = F_f = \mu_k mg$$

$$-a = \mu_k g$$

If you remember $v_f^2 - v_0^2 = 2as$ then

$$v_0^2 = -2\mu_k g s$$

$$\mu_k = \frac{v_0^2}{2gs}$$

Or, if you don't remember (like me),

$$v_f = v_0 + at$$

$$v_0 = -at$$

$$t = -\frac{v_0}{a}$$

but also

$$s = -\frac{1}{2}at^2$$
$s_0 \quad s = -\frac{1}{2} a \left( \frac{v_0}{a} \right)^2$

$= \frac{-v_0^2}{2a}$

$s = \frac{v_0^2}{2\mu_k g}$

$\mu_k = \frac{v_0^2}{2g} \quad \text{OK}$