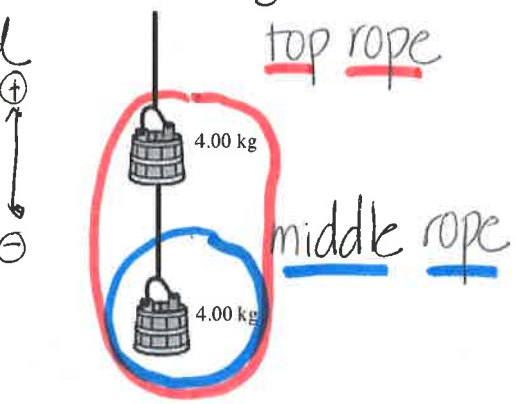
Two body problems

1. Two buckets are hanging motionless from ropes as shown.. What is the tension in the top rope? The middle rope? What would change, if anything, if they moved upwards at a constant speed?

There would be no change in tension at a constant speed because $\vec{a} = 0 \frac{m}{s^2}$ and $\Sigma F = ma = 0 N$.

Use $g = -10 \frac{m}{s^2}$



Top rope: $F_T = |F_g| = |mg| = |(8.0kg)(-10\frac{m}{s^2})|$

$= \boxed{80N}$

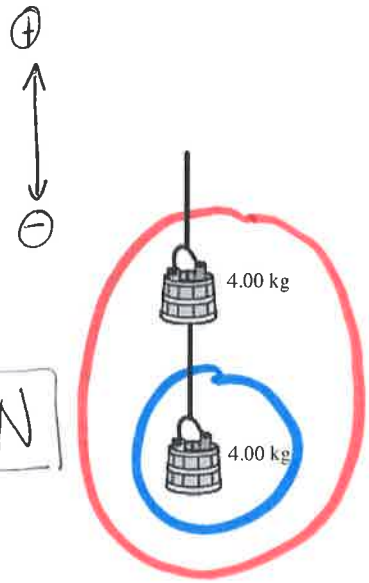
Middle rope: $\Sigma F = F_T + F_g = 0N$

$F_T = -F_g = -(4.0kg)(-10\frac{m}{s^2}) = \boxed{40N}$

2. The two buckets are now accelerated upwards at a rate of 5 m/s^2. What is the tension in each rope?

$\Sigma F = ma$

$F_g + F_T = ma$



Top rope: $F_T = ma - F_g$

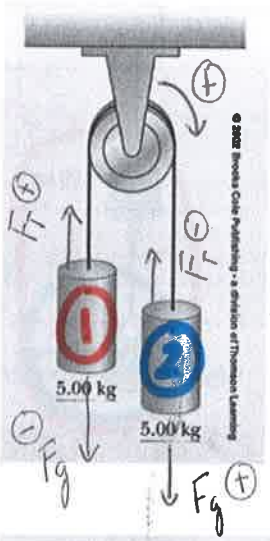
$F_T = (8.0kg)(5m/s^2) - -80N = \boxed{120N}$

Middle rope: $F_T = ma - F_g$

$F_T = (4.0kg)(5\frac{m}{s^2}) - -40N = \boxed{60N}$

3. Determine the tension in the string and the acceleration of each of the two objects connected by a light string over a light, frictionless pulley, as shown in each diagram.

a)



Reduce to a single object with combined mass and treat as though object is in a straight line.

1) $F_T = 50N$

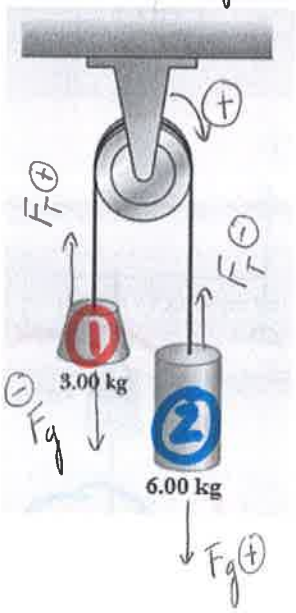
2) $F_T = -50N$

→ FBD Free Body Diagram

$F_g = -50N$ ← $m_T = 10.0kg$ → $F_g = 50N$

$\Sigma F = 0N$ ⊖ ⟷ ⊕ no $\vec{a}$

b)



$F_g = -30N$ ← $m_T = 9.00kg$ → $F_g = 60N$

$\Sigma F = ma$ $\quad a = \frac{\Sigma F}{m_T} = \frac{F_g + F_g}{m_T}$

$\frac{60N + -30N}{9kg} = 3.3\frac{m}{s^2}$

$F_T + F_g = ma$

1) $F_T = ma - F_g = (3.00kg)(3.3\frac{m}{s^2}) - -30N = 40N$

2) $F_T = ma - F_g = (6.00kg)(3.3\frac{m}{s^2}) - 60N = -40N$

1) Find $\vec{a}$ for the system with mass total.
2) Find F_T using a single mass.

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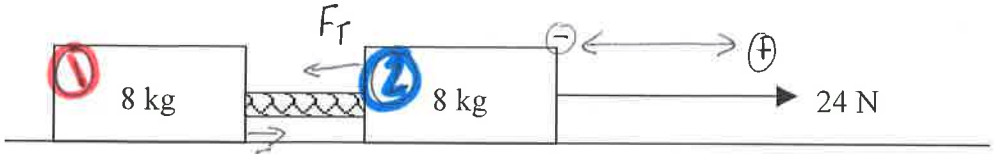
4. In each case below, two boxes connected by ropes are pulled across a frictionless floor by a horizontal force of 24 newtons. Find the tension in each inner rope and the acceleration of each box.

a)

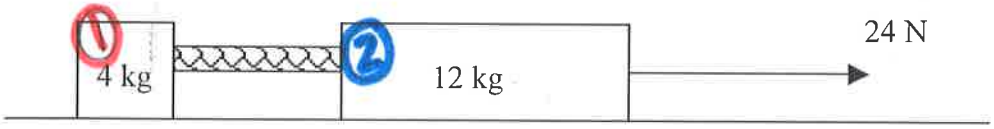


$\Sigma F = ma$ $\quad 24N = 16kg\,\vec{a}$ $\quad \vec{a} = \frac{24N}{16kg} = 1.5\,m/s^2$

① $(8kg)(1.5\,m/s^2) = \boxed{12N = F_T}$ $\qquad \boxed{F_T = -12N}$

② $\Sigma F = F_T + F_A = ma$ $\quad F_T = ma - F_A = (8kg)(1.5\,m/s^2) - 24N$

b)



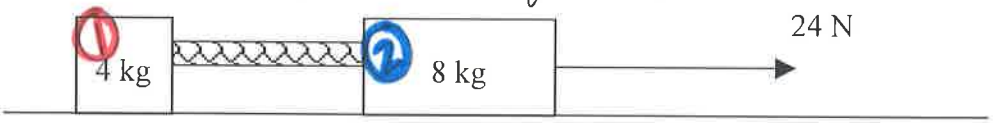
$\vec{a} = 1.5\,m/s^2$

① $\Sigma F = ma = (4kg)(1.5\,m/s^2) = \boxed{6N}$

② $\Sigma F = F_T + F_A = ma$

$F_T = ma - F_A = (12kg)(1.5\,m/s^2) - 24N = \boxed{-6N}$

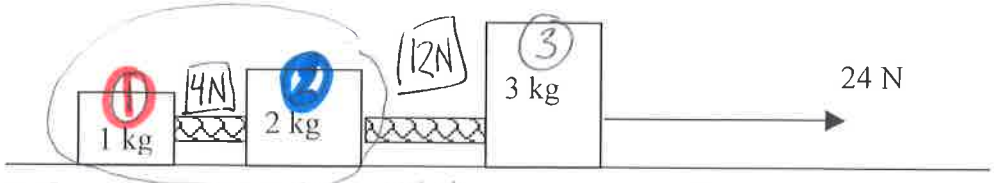
c)



$\Sigma F = m_T a = \frac{24N}{12kg} = \vec{a} = 2\,m/s^2$

① $\Sigma F = ma = (4kg)(2\,m/s^2) = 8N$

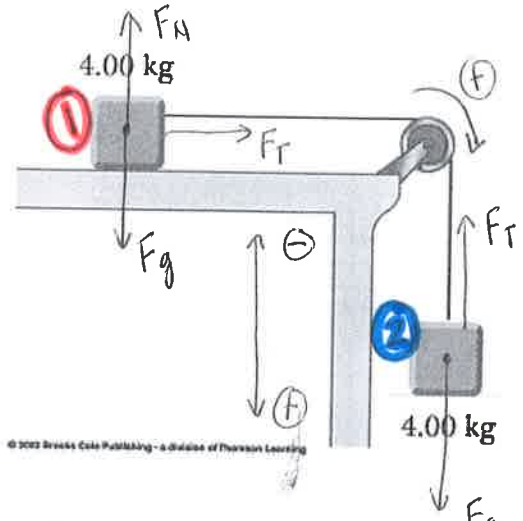
d)



$\Sigma F = m_T a$ $\quad \Sigma F = \frac{24N}{6kg} = 4\,m/s^2 = \vec{a}$

① $F_T = (1kg)(4\,m/s^2) = \boxed{4N}$ $\qquad$ ② $F_T = (3kg)(4\,m/s^2) = \boxed{12N}$

5. Find the acceleration of these two objects and the tension in the string as the block slides across a frictionless table.



$\Sigma F = m_T a$

$\Sigma F = (8.00kg)\vec{a}$

$\frac{40N}{8.00kg} = 5.0\frac{m}{s^2} = \vec{a}$

$F_g = 40N$

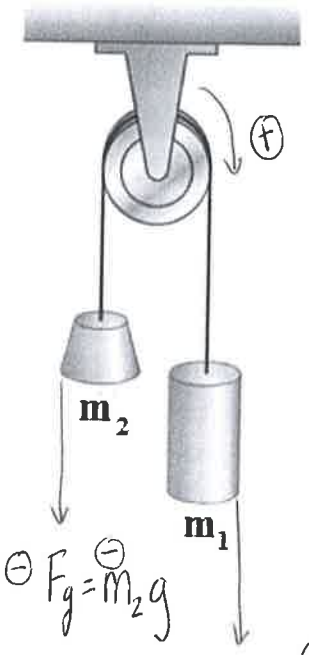
① $F_T = ma = (4.00kg)(5\frac{m}{s^2}) = \boxed{20N}$

② $\Sigma F = ma = F_T + F_g = ma$

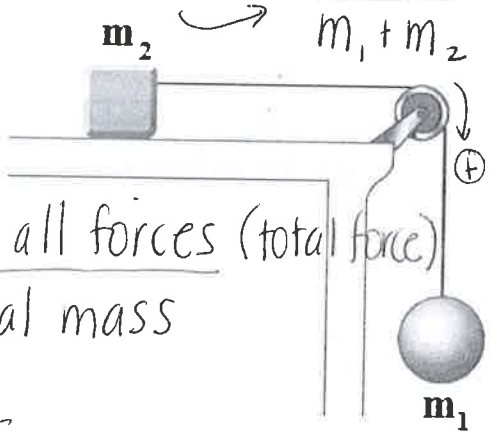
$F_T = ma - F_g = (4.00kg)(5\frac{m}{s^2}) - 40N = \boxed{-20N}$

6. Determine the acceleration of each system.

a)



b)



$\vec{a} = \frac{\vec{F}}{m_T} = \frac{\text{sum of all forces (total force)}}{\text{total mass}}$

$\Sigma F = \oplus F_g + \ominus F_g$

$\Sigma F = m_1 g + \ominus m_2 g$

$m_T = m_1 + m_2$

$\boxed{\vec{a}} = \frac{m_1 g + -m_2 g}{m_1 + m_2} = \boxed{\frac{g(m_1 - m_2)}{m_1 + m_2}}$ ⓐ

ⓑ $\boxed{\vec{a}} = \frac{m_1 g}{m_1 + m_2}$ →