<u>Unit 4: Newton's Laws</u>

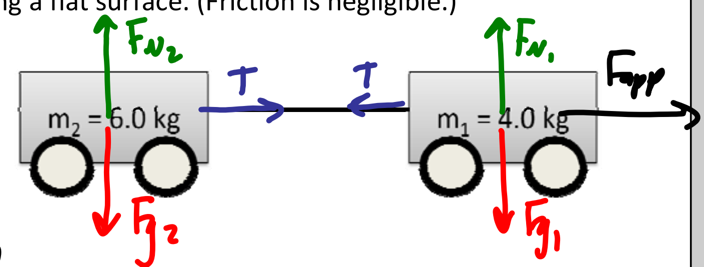
Tension

Tension occurs within a material that is being…pulled or stretched.

It is an internal force that acts at all points along a rope (string, chain, etc) in both directions.

Consider two carts attached by a rope being pulled along a flat surface. (Friction is negligible.)

If m_1 is pulled to the right by a force of 40.0 N find:



a) The acceleration of the carts.

$F_{net} = F_{app} + \cancel{T} - \cancel{T} = m_T a$

$F_{app} = m_T a \qquad a = \frac{F_{app}}{m_T} = \frac{40.0\ N}{(6.0+4.0)\ kg} = 4.00\ m/s^2$

NOTE: tension…cancels out of the total F_{net} equation,

b) The tension in the string connecting them.

m_2

$F_{net} = T = m_2 a$

$= (6.0\ kg)(4.00\ m/s^2) = 24\ N$

m_1

$F_{net} = F_{app} - T = m_1 a$

$T = F_{app} - m_1 a = 40.0\ N - (4.0\ kg)(4.00\ m/s^2) = 24\ N$

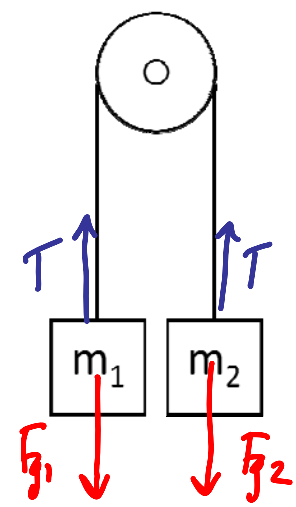
NOTE: Since it cancels out of the total F_{net} equation, we will only consider the forces acting…on one mass.

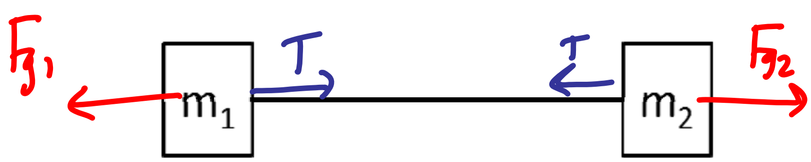
NOTE: Since tension acts on both masses equally we can use…either mass.

Consider two equal masses hanging from a pulley.

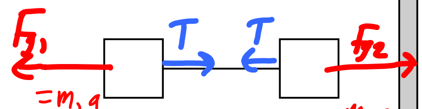
Diagram the forces acting on the entire system.

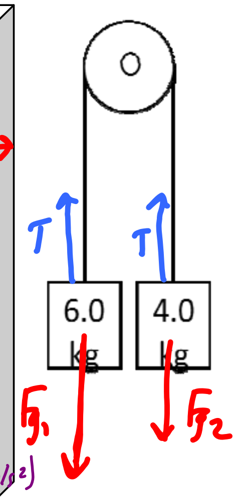
With pulley problems it is sometime easier to "*unfold*" the rope as shown.





Ex: The two masses shown hanging from a frictionless pulley are released at rest. Find





a) The acceleration of the system.

$F_{net} = F_{g1} + T - T - F_{g2} = m_T a$ ($F_{g1} = m_1 g = 58.8\ N$, $F_{g2} = m_2 g = 39.2\ N$)

$F_{g1} - F_{g2} = m_T a \qquad a = \frac{F_{g1} - F_{g2}}{m_T} = \frac{(58.8 - 39.2)\ N}{(6.0 + 4.0)\ kg} = \boxed{1.96\ m/s^2}$

b) The tension in the string.

m_1

$F_{net} = F_{g1} - T = m_1 a$

$T = F_{g1} - m_1 a = 58.8\ N - (6.0\ kg)(1.96\ m/s^2) = 47\ N$

m_2

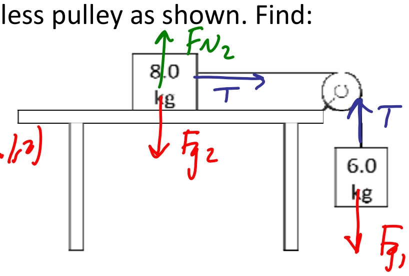
$F_{net} = T - F_{g2} = m_2 a$

$T = F_{g2} + m_2 a = 39.2\ N + (4.0\ kg)(1.96\ m/s^2) = 47\ N$

NOTES: 1. When solving for acceleration of the whole system we consider _total mass_

2. When finding T we only use _one_ _mass_.

Ex: A mass on a frictionless table is attached to a hanging mass over a frictionless pulley as shown. Find:



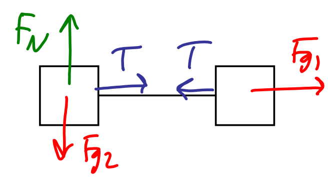
a) The acceleration of the masses.

$F_{g1} = m_1 g = (6.0\ kg)(9.80\ m/s^2) = 58.8\ N$

$F_{net} = F_{g1} + T - T = m_T a$

$F_{g1} = m_T a \qquad a = \frac{F_{g1}}{m_T} = \frac{58.8\ N}{(8.0 + 6.0)\ kg} = \boxed{4.2\ m/s^2}$

b) The tension in the rope.



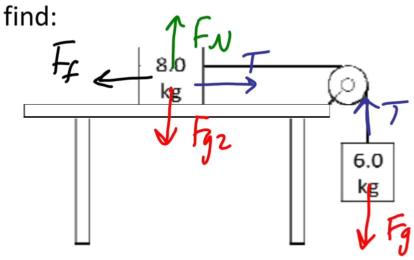
m_2

$F_{net} = T = m_2 a$

$= (8.0\ kg)(4.2\ m/s^2)$

$= \boxed{34\ N}$

Ex2: If the same system has a friction force of 25 N acting on the 8.0 kg mass find:

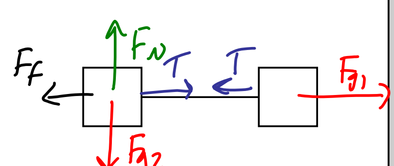


a) The acceleration of the masses.

$F_{net} = F_{g1} - F_f = m_T a$

$a = \frac{F_{g1} - F_f}{m_T} = \frac{(58.8 - 25)\ N}{(6.0 + 8.0)\ kg} = 2.414\ m/s^2 = \boxed{2.4\ m/s^2}$

b) The tension in the rope.



m_2

$F_{net} = T - F_f = m_2 a$

$T = m_2 a + F_f = (8.0\ kg)(2.414\ m/s^2) + 25\ N$

$= \boxed{44\ N}$