

Unit 4: Newton's Laws

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.

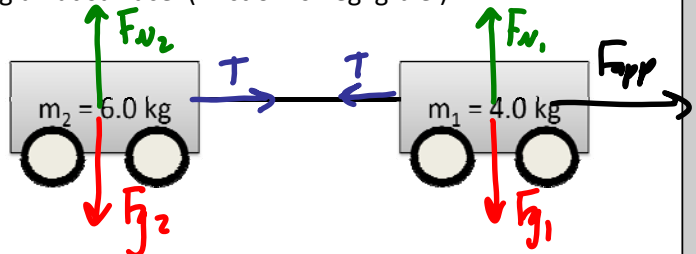
Consider two carts attached by a rope being pulled along a flat surface. (Friction is negligible.)

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

a) The acceleration of the carts.

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

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



NOTE: tension... *cancel out of the total Fnet equation,*

b) The tension in the string connecting them.

$$F_{net} = T = m_2 a = (6.0 \text{ kg})(4.00 \text{ m/s}^2) = 24 \text{ N}$$

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

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

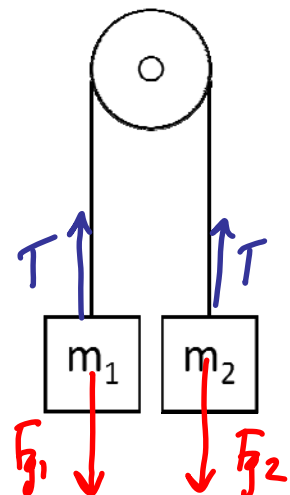
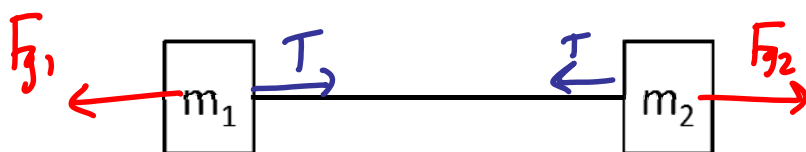
NOTE: Since it cancels out of the total F_{net} equation, we will only consider the forces acting... *on one mass.*

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.

$$F_{\text{net}} = F_{g1} + \cancel{T} - \cancel{T} - F_{g2} = m_+ a$$

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

b) The tension in the string.

m_1

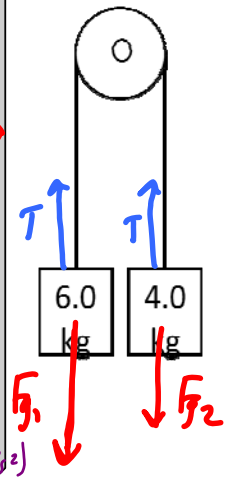
$$F_{\text{net}} = F_{g1} - T = m_1 a$$

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

m_2

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

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



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.

$$F_{\text{net}} = F_{g1} + \cancel{T} - \cancel{T} = m_+ a$$

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

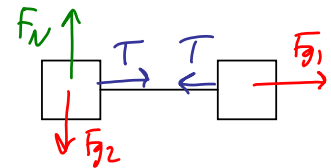
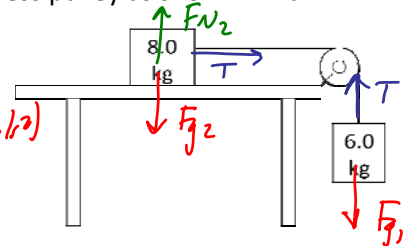
b) The tension in the rope.

m_2

$$F_{\text{net}} = T = m_2 a$$

$$= (8.0 \text{ kg})(4.2 \text{ m/s}^2) = \boxed{34 \text{ N}}$$

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



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.

$$F_{\text{net}} = F_{g1} - F_f = m_+ a$$

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

b) The tension in the rope.

m_2

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

$$T = m_2 a + F_f = (8.0 \text{ kg})(2.4 \text{ m/s}^2) + 25 \text{ N}$$

$$= \boxed{44 \text{ N}}$$

