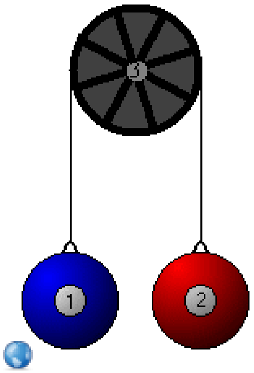
Multiple Masses and Finding Net Force

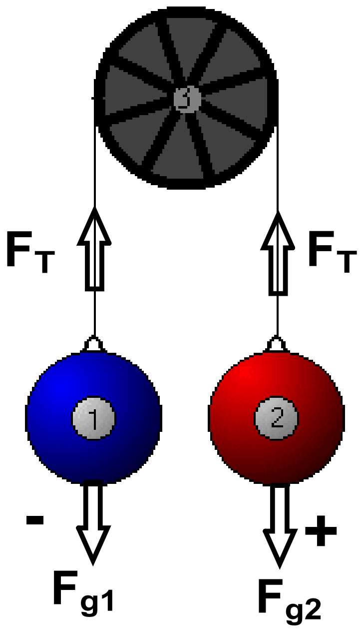
Chapter 10.2 of text:
Read Pg 478 - 489
Problems Pg 485 #s 19 - 22, Pg 488 #s 24 - 28



This is an example of a system where there are multiple masses, the Atwood machine.

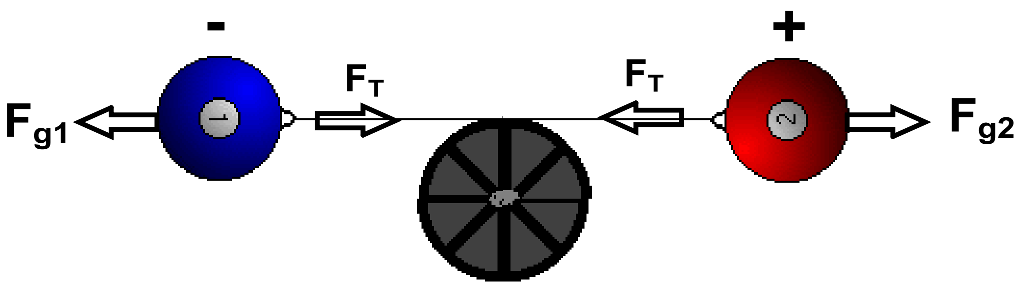
We will apply the concept of forces to determine the resulting acceleration.

Define the Direction of Forces

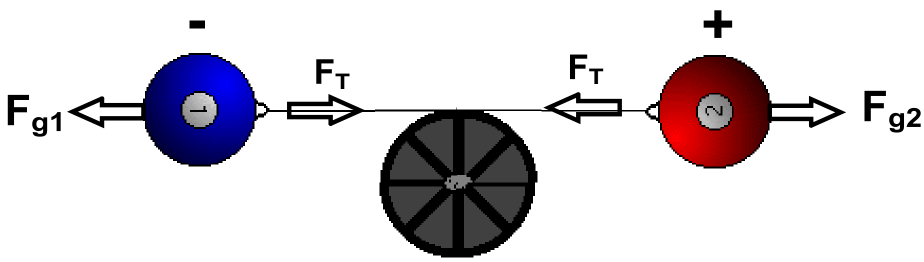


Our problems will not include friction and the pulley will be massless.

You may find it easier to picture, or draw, the system horizontally.



Acceleration of the Masses: Newton's 2nd Law



$$F_{net} = ma$$

$$F_{net} = \sum Forces$$

$$m = \sum masses\ that\ accelerate$$

$$F_{g1} + F_T + F_T + F_{g2} = (m_1 + m_2)a$$

$$-m_1 g + F_T + (-F_T) + m_2 g = (m_1 + m_2)a$$

$$m_2 g - m_1 g = (m_1 + m_2)a$$

$$(m_2 - m_1)g = (m_1 + m_2)a$$

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

To Find Tension:

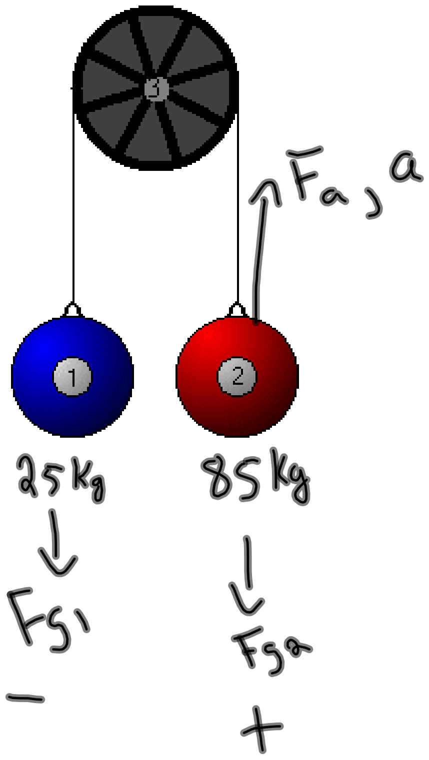
$$F_{g1} + F_T = m_1 a$$

or

$$F_{g2} + F_T = m_2 a$$

☆ How would the formula for acceleration change if positive was to the left?

A counter weight of 25 kg is used to help a person of mass 85 kg to do chin ups. What is the force applied by the person if he accelerates at 1.2 m/s^2?



$|a| = 1.2\ m/s^2$

$\{F = ma\}_{net}$

$F = \sum$ Forces

$m = \sum$ masses

$a = -1.2\ m/s^2$ ← negative direction

F_T → equal and opposite

$$F_{g1} + F_{g2} + F_a = (m_1 + m_2)\,a$$

$$-(25)(9.81) + (85)(9.81) + F_a = (25 + 85)(-1.2)$$

$$-245 + 834 + F_a = -132$$

$$F_a = -721\ N$$

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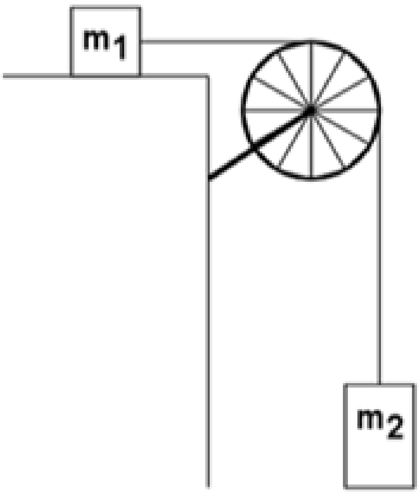
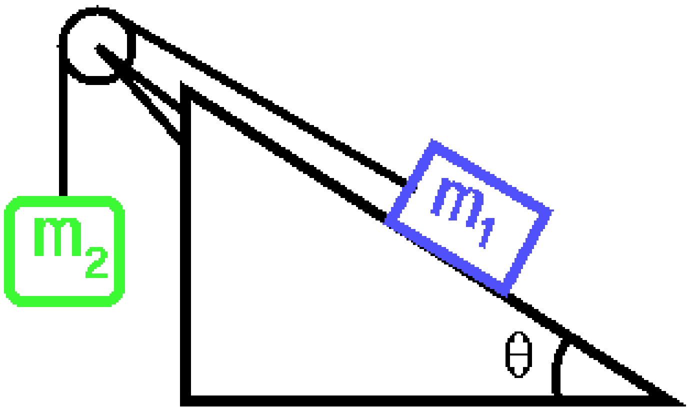
Objects Connected at an Angle

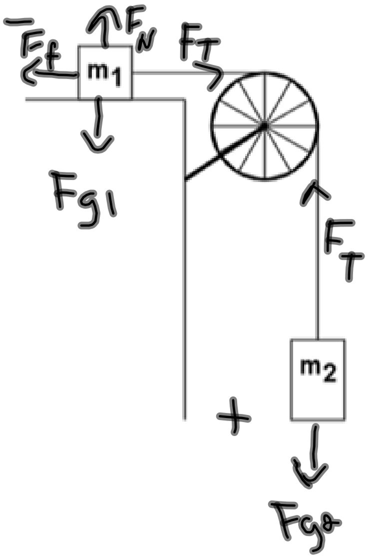




We approach this problem like the others:

- Picture the motion in one dimension.
- Apply Newton's second law.

In the diagram below m_1 = 425 g, m_2 = 735 g, the coefficient of kinetic friction is 0.34, and there is not friction from the pulley and string. What is the acceleration of the masses?



$a = ?$

$\mu = 0.34$ $\quad m_2 = 0.735\ kg$

$m_1 = 0.425\ kg$

$$\sum Forces = \sum masses \times a$$

$$F_f = \mu F_N = \mu F_{g1}$$

$$F_f + F_{g2} + F_T + F_T = (m_1 + m_2)a$$

$$-\mu(m_1)(g) + m_2 g = (m_1 + m_2)a$$

$$(-0.34)(.425)(9.81) + (0.735)(9.81) = (0.425 + .735)a$$

$$-1.42 + 7.21 = 1.16a$$

$$5.79 = 1.16a$$

$$\boxed{5.0\ m/s^2 = a}$$

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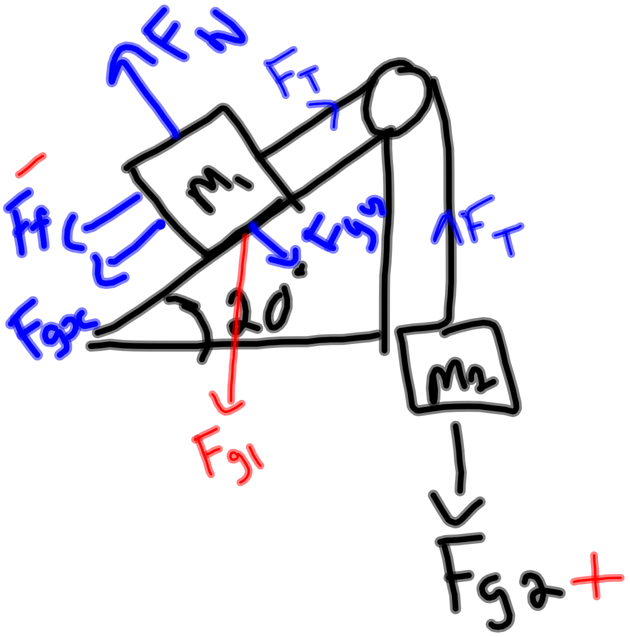
A counterweight is used to slide an object up an inclined plane of 20°. The counterweight has a mass of 25 kg and is suspended with a massless string and a friction less pulley. The coefficient of friction on the plane is 0.19. What is the acceleration of a 16 kg object?



$m_1 = 16\text{ kg}$ $\theta = 20°$

$m_2 = 25\text{ kg}$

$\mu = 0.19$

$$\sum \text{Forces} = \sum \text{masses} \times a$$

$$F_{gx} + F_f + F_{g2} = (m_1 + m_2)a$$

$$F_{gx} = F_g \sin\theta \; ; \; F_f = \mu F_N = \mu F_g \cos\theta$$

$$F_{g2} = m_2 g$$

$$-(16)(9.81)\sin 20 + \left[-(0.19)(16)(9.81)\cos 20°\right] + (25)(9.81) = (16+25)a$$

$$-53.7 - 28.0 + 245 = (41)a$$

$$163.55 = 41a$$

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$$\boxed{4.0\text{ m/s}^2 = a}$$