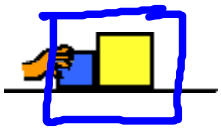
Solving Two (+) Body Problems

So far we have analyzed the motion of single bodies under the influence of Newton's laws. But what happens when there are two (or more) objects connected to each other (i.e. a tow truck hauling a car, a stack of textbooks, or a three toboggans linked together)?

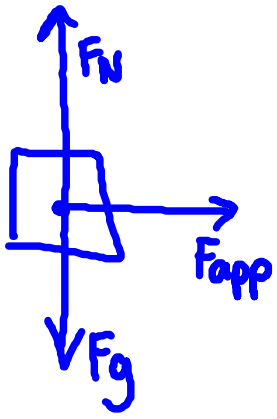
To solve two (or more) body problems, we will take a systems approach and an individual analysis approach.

The systems approach is usually used to determine the acceleration of the system.

Ex: 1. A 5.0-kg and a 10.0-kg box are touching each other. A 45.0-N horizontal force is applied to the 5.0-kg box in order to accelerate both boxes across the floor. Ignore friction forces.



(a) Determine the acceleration of the boxes.



Need $\cdot a$

$\Rightarrow F_{net_x} = ma$

$F_{app} = ma$

$a = \frac{F_{app}}{m_T}$

$= \frac{45\,N}{m_1 + m_2}$

$= \frac{45\,N}{15\,kg}$

$\vec{a} = 3.0\,m/s^2\,[fwd]$

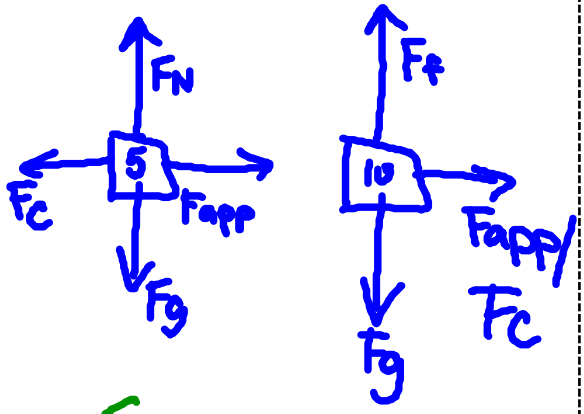
In the individual object analysis, either one of the objects is isolated and considered as an independent, separate object. This can help us solve for any force acting between the objects (i.e. <u>contact</u> forces or <u>tension</u> forces).

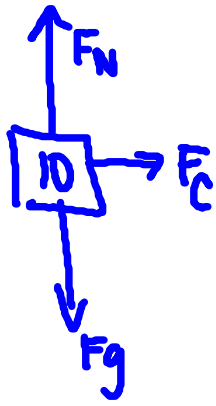
Ex: 1. A 5.0-kg and a 10.0-kg box are touching each other. A 45.0-N horizontal force is applied to the 5.0-kg box in order to accelerate both boxes across the floor. Ignore friction forces.

(b) Determine the force acting between the objects.

* it does NOT matter which object we analyze *

let's choose the 10kg object b/c there are less forces acting in the x





$F_{net_x} = ma$

$F_c = ma$

$= 10kg\left(3.0\frac{m}{s^2}\right)$

$= 30\,N$

$= 3.0 \times 10^1\,N\,[fwd]$

$F_{net_x} = ma$

$F_{app} - F_c = ma$

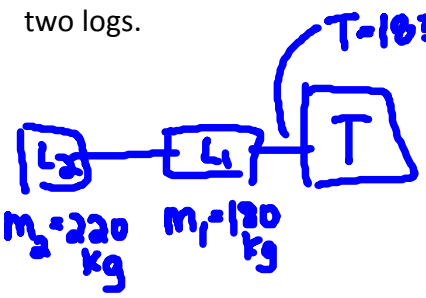
$-F_c = -F_{app} + ma$

$F_c = F_{app} - ma$

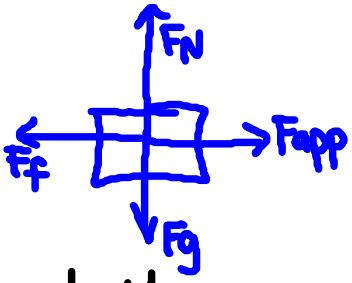
$= 45N - 5(3)$

$= 30\,N\,[back]$

Ex: 2. A tractor is being used to pull two large logs across a field. A chain connects the logs to each other; the front log is connected to the tractor by a separate chain. The mass of the front log is 180 kg. The mass of the back log is 220 kg. The coefficient of friction between the logs and the field is approximately 0.45. The tension in the chain connecting the tractor to the front log is 1850 N. Determine the acceleration of the logs and the tension in the chain that connects the two logs.



(a) Need: $\vec{a}$ use system approach



$F_f = \mu \cdot F_N$

$Fnet_x = ma$

$F_{app} - F_f = ma$

$a = \frac{F_{app} - F_f}{m_T}$

$= \frac{F_{app} - \mu F_N}{m_T}$

$= \frac{F_{app} - \mu mg}{m_T}$

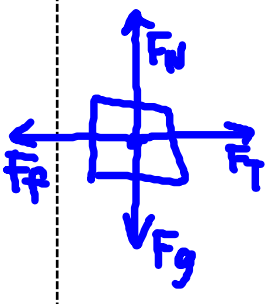
$= \frac{1850\,N - (0.45)(400\,kg)(9.8\,m/s^2)}{400\,kg}$

$= 0.215\,m/s^2\,[fwd]$

$\vec{a} = 0.22\,m/s^2\,[fwd]$

(b) Need: T between $L_1 + L_2$

use individual analysis



$Fnet_x = ma$

$F_T - F_f = ma$

$F_T = F_f + ma$

$= \mu F_N + ma$

$= \mu mg + ma$

$F_T = 0.45(220\,kg)(9.8\,m/s^2) + 220\,kg(0.215\,m/s^2)$

$= 1017.5\,N$

$= 1.0 \times 10^3\,N$

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