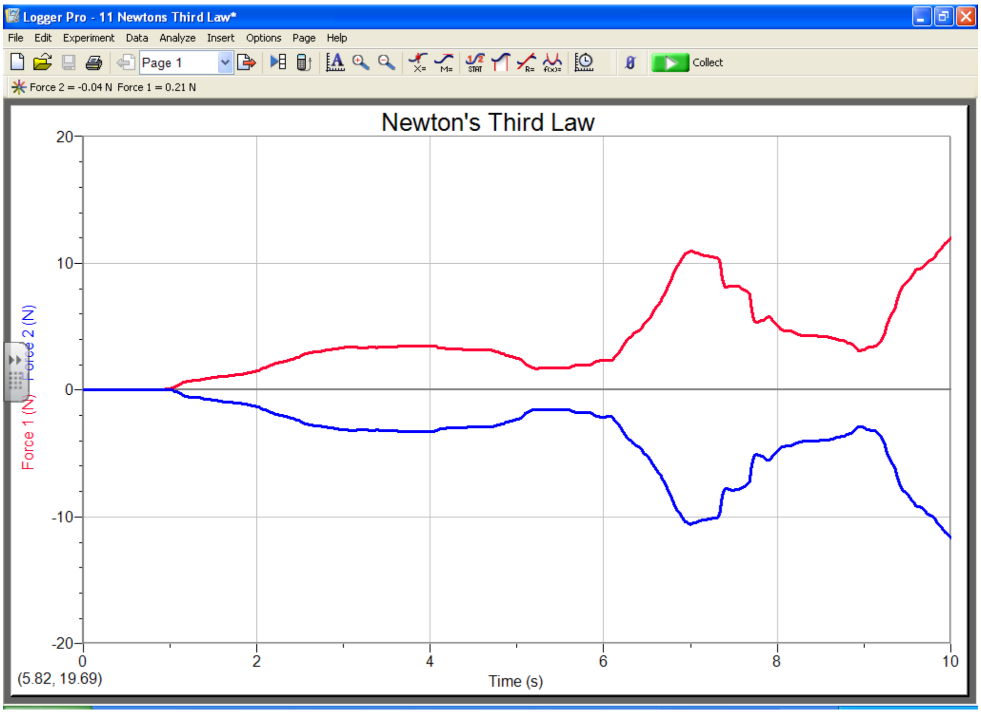

Logger Pro - 11 Newtons Third Law*
File Edit Experiment Data Analyze Insert Options Page Help
Page 1
Collect
Force 2 = -0.04 N Force 1 = 0.21 N
Newton's Third Law
20
10
0
-10
-20
Force 1 (N) Force 2 (N)
0
2
4
6
8
10
Time (s)
(5.82, 19.69)

Newton's Third Law of Motion

Consider two bodies, A and B, which collide:

Momentum is conserved in an isolated system:

$$\vec{p}_{total(before)} = \vec{p}_{total(after)}$$

$$\vec{p}_{A_i} + \vec{p}_{B_i} = \vec{p}_{A_f} + \vec{p}_{B_f}$$

$$-\vec{p}_{A_f} + \vec{p}_{A_i} = \vec{p}_{B_f} - \vec{p}_{B_i}$$

$$-(\vec{p}_{A_f} - \vec{p}_{A_i}) = \vec{p}_{B_f} - \vec{p}_{B_i}$$

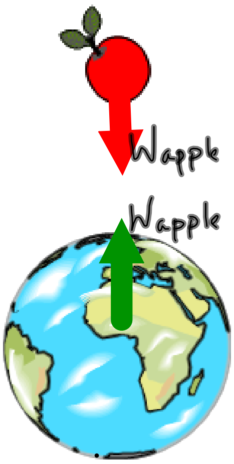
equal but opposite changes in mom → $-\Delta\vec{p}_A = \Delta\vec{p}_B$ ← Another way to write the Law of Conservation of momentum

equal but opposite impulses → $-\vec{F}_A \Delta t = \vec{F}_B \Delta t$

equal but opposite forces → $-\vec{F}_A = \vec{F}_B$ ← Newton's Third Law

Newton's Third Law

When two bodies A and B interact, the force A exerts on B is equal and opposite to the force that B exerts on A.



Consider the apple and the earth:

$$\vec{F}_{net} = m\vec{a}$$

$$m_{apple}\,\vec{g} = m_{apple}\,\vec{a}_{apple}$$

$$\vec{a}_{apple} = g$$

That same force ($W_{apple} = m_{apple}\,g$) is acting on the Earth.

for the Earth: $\vec{F}_{net} = m\vec{a}$

$$m_{apple}\,\vec{g} = m_{earth}\,\vec{a}_{earth}$$

$$\vec{a}_{earth} = \frac{m_{apple}}{m_{earth}}\,\vec{g}$$

$m_{earth} >>>> m_{apple}$

so the acceleration is negligible.

($a_{earth} <<<< a_{apple}$)

Example

Suppose the weight of an apple on a tree is 1.0N. The apple falls from the tree. Calculate the acceleration of the Earth towards the apple. Mass of Earth 6.0×10^{24} kg

$$F = ma$$

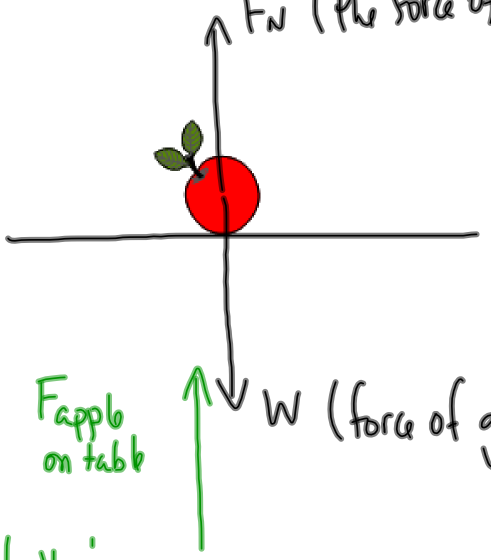
$$a = \frac{F}{m}$$

$$a = \frac{1.0\,N}{6.0 \times 10^{24}\,kg}$$

$$a = 1.7 \times 10^{-25}\,ms^{-2}$$

$$\vec{a} = 1.7 \times 10^{-25}\,ms^{-2}\ [\text{towards the apple}]$$

Consider an apple resting on a table:



Equal but opposite due to Newton's First Law. (at rest)

Example

A man pushes on a trolley and the forces are equal an opposite

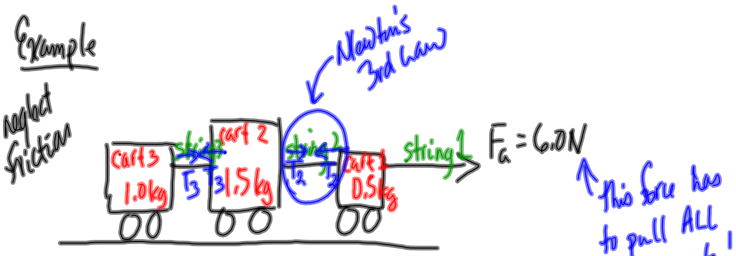
equal b/c of Newton's third Law

Since F_{push} and F_f are equal and opposite, the trolley has a constant velocity

Newton's 2nd Law ($F_{net} = 0$, $a = 0$)

If we took the friction out, then there would be acceleration.

Example



What is the acceleration of the train?

What is the tension in each string?

Consider all 3 carts together:

$\vec{F}_{net} = m\vec{a}$

$\vec{F}_a = m\vec{a}$

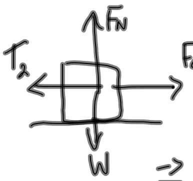
$\vec{a} = \frac{\vec{F}_a}{m}$

$\vec{a} = \frac{6.0N\ [right]}{(1.0kg + 1.5kg + 0.5kg)}$

$\vec{a} = 2.0\ m/s^2\ [right]$

Consider Cart 1:

$\vec{a} = 2.0m/s^2$



$F_a = 6.0N = T_1$

$\vec{F}_{net} = m\vec{a}$

$F_a - T_2 = ma$

$-T_2 = ma - F_a$

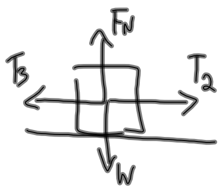
$T_2 = -ma + F_a$

$T_2 = -(0.5kg)(2.0m/s^2) + 6.0N$

$T_2 = 5.0N$

Consider Cart 2:

$\vec{a} = 2.0m/s^2$



$T_2 = 5.0N$

$\vec{F}_{net} = m\vec{a}$

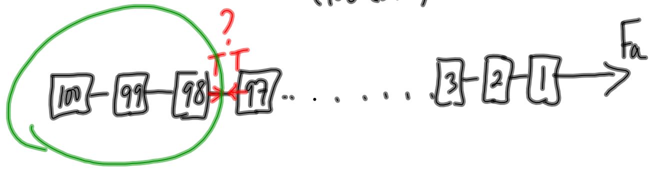
$T_2 - T_3 = ma$

$T_3 = T_2 - ma$

$T_3 = 5.0N - (1.5kg)(2.0\ m/s^2)$

$T_3 = 2.0N$

What if you had a very long train (100 cars)?



Consider all 3 cars as one.