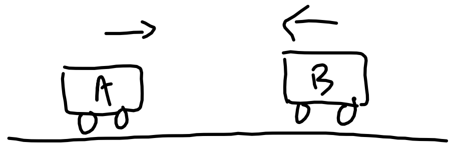
Newton's Third Law of Motion

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 →

$$-\vec{F}_A \Delta t = \vec{F}_B \Delta t$$

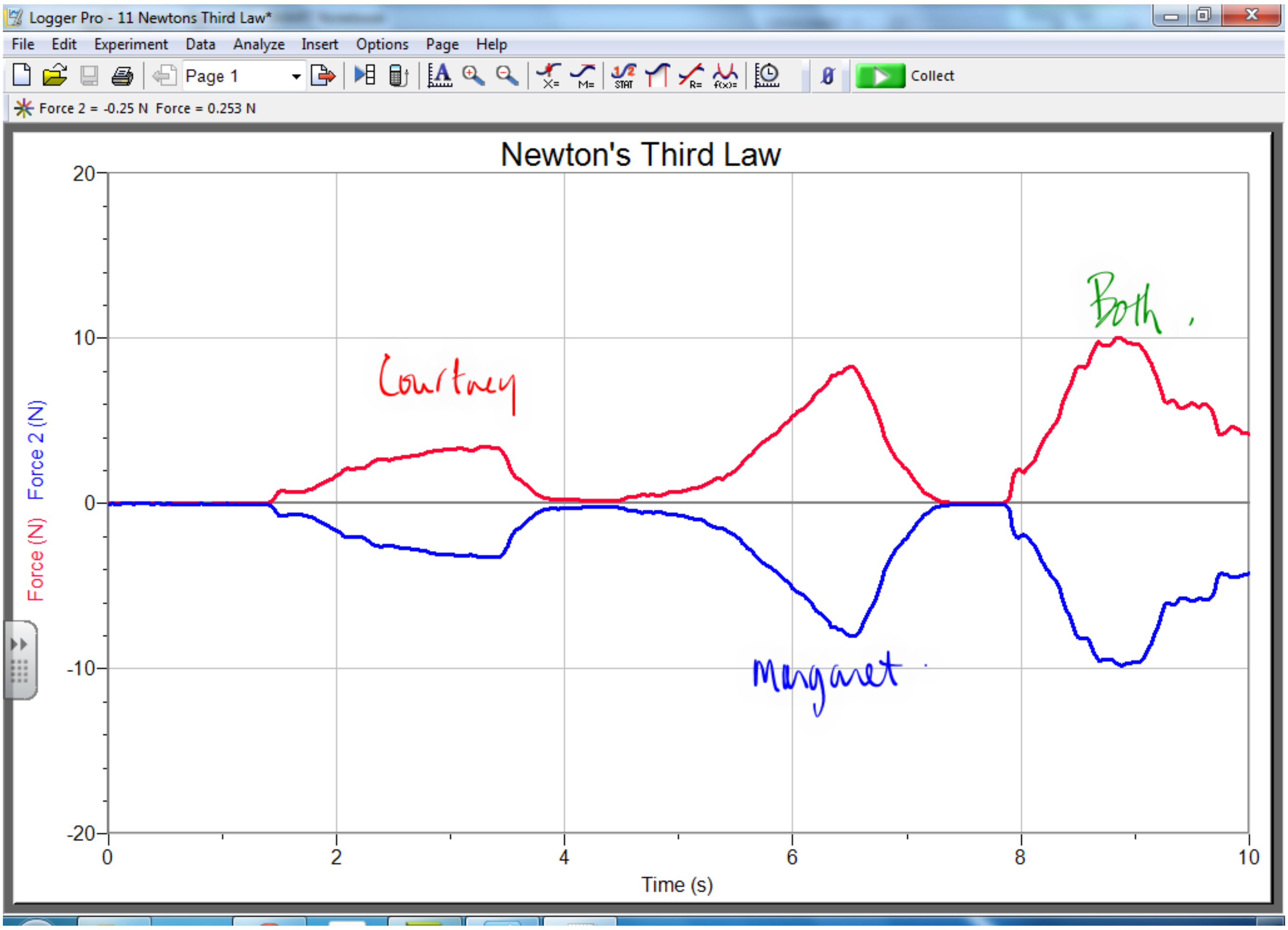
equal but opposite forces →

$$-\vec{F}_A = \vec{F}_B$$

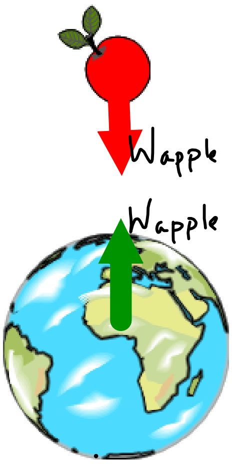
← Newton's Third Law

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.



Logger Pro - 11 Newtons Third Law*
File Edit Experiment Data Analyze Insert Options Page Help
Page 1
Collect
Force 2 = -0.25 N Force = 0.253 N
Newton's Third Law
Force (N) Force 2 (N)
20
10
0
-10
-20
0
2
4
6
8
10
Time (s)
Courtney
Margaret
Both



Consider the apple and the earth:

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

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

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

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

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

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

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

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

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

$$F = ma$$

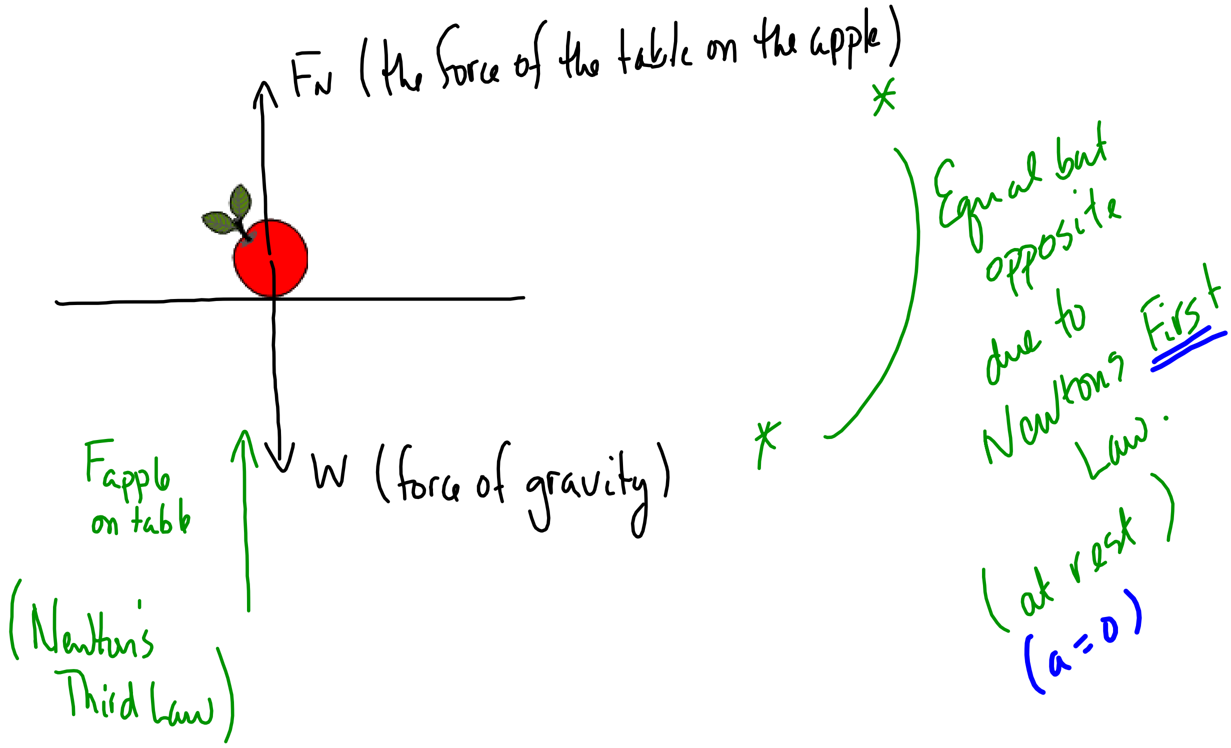
$$a = \frac{F}{m}$$ ← the force of the apple on the Earth.

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

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

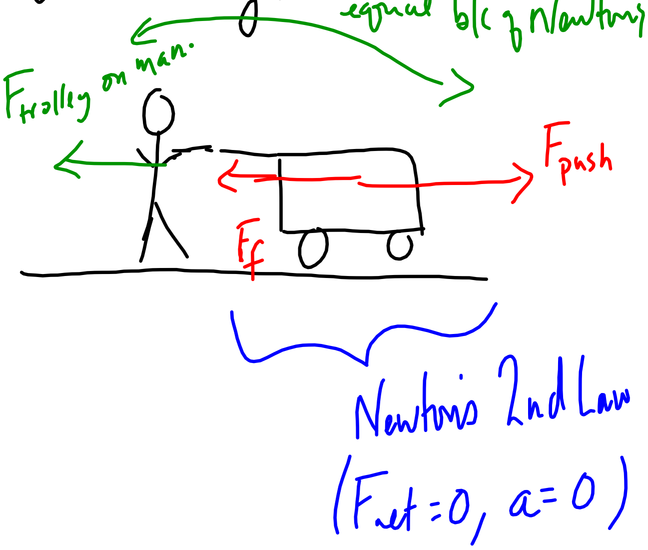
$$\vec{a} = 1.7 \times 10^{-25}\ ms^{-2}$$ [towards the apple]

Consider an apple resting on a table:



Example

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

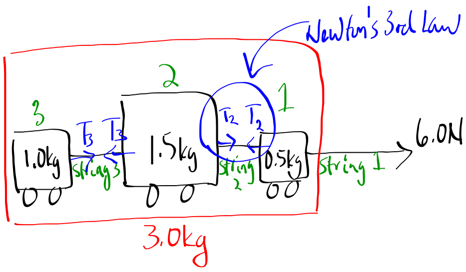


Since Fpush and F_f are equal and opposite, the trolley has a constant velocity

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

Example

Find the tension in each string. (frictionless)



Consider all 3 carts together $(m = 3.0\,kg)$

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

$$T_1 = ma$$

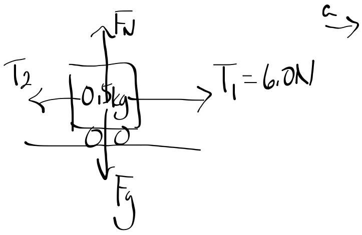
$$a = \frac{T_1}{m}$$

$$a = \frac{6.0\,N}{3.0\,kg}$$

$$a = 2.0\,m\,s^{-2}$$

each cart has an acceleration of $2.0\,ms^{-2}$ since they are connected.

Consider only cart 1:



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

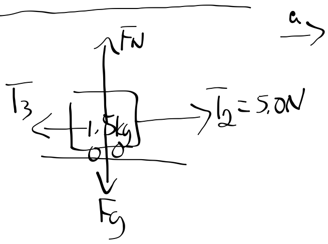
$$T_1 - T_2 = m_1 a$$

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

$$6.0\,N - T_2 = 1.0\,N$$

$$\boxed{T_2 = 5.0\,N}$$

Consider ONLY cart 2:



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

$$T_2 - T_3 = m_2 a$$

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

$$5.0\,N - T_3 = 3.0\,N$$

$$\boxed{T_3 = 2.0\,N}$$

What if you had a train with 100 cars and you wanted to find the force in the connection between car 75 and car 76?