Newton's laws of motion

Force causes change in motion.

Force is a vector: magnitude & direction

Experiments show that what matters is the net force or unbalanced force => meaning the vector sum of all individual forces acting on an object.

1st Newton's law of motion or Law of inertia

Every object continues in its state of rest or state of uniform velocity in a straight line as long as no net force acts on it.

$$\Sigma \vec{F} = 0$$

The tendency of an object to maintain its state of rest or uniform velocity is called INERTIA

— note! only in inertial reference frames does the 1st N. law hold!

inertial reference frame – nonaccelerating reference frame

noninertial r. frame – accelerating

– note: mass / weight

2nd Newton's law of motion

The acceleration of an object is directly proportional to the NET force acting on it, and it is inversly proportional to the object's mass. The direction of the acceleration is in the direction of the net force acting on the object.

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

F [N]

$$\hookrightarrow [kg\ m\ s^{-2}] = [N]$$

$$\vec{F} = F_x \hat{i} + F_y \hat{j} + F_z \hat{k}$$

x $\quad \sum F_x = ma_x$

y $\quad \sum F_y = ma_y$

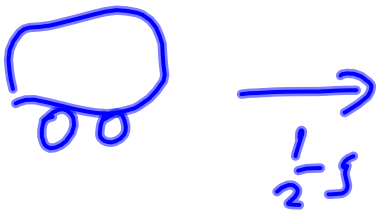
z $\quad \sum F_z = ma_z$

Ex

Estimate a net force needed to accelerate

a) 1000 kg car at $\frac{1}{2}g$

b) 200 g apple at the same rate

a) 

$\Sigma F_x = m a_x$

$a_x = \frac{1}{2}g$ $\quad g \sim 10\ m/s^2$

$m = 1000\ kg$

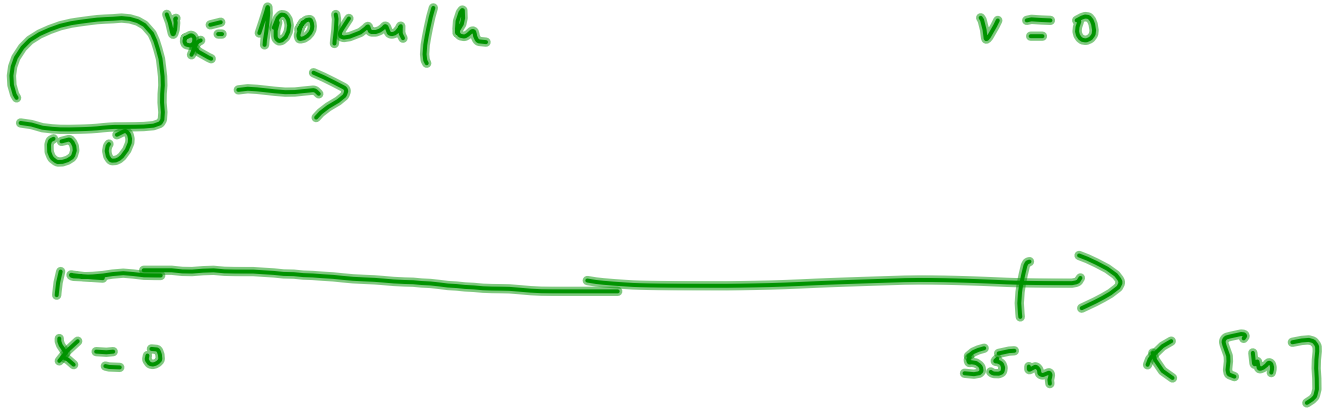
$\Sigma F_x = 500\ N$

b) 

$\Sigma F_x = 0.2\ kg \cdot \frac{1}{2}g = 1\ N$

Ex 2

What average net force is required to bring a 1500 kg car to rest from a speed of 100 km/h within a distance of 55 m?



$m = 1500\ kg$

$v_0 = 100\ km/h = 27.8\ m/s$

the force acts in opposite direction than initial velocity

$v = 0$

$x = 55\ m$

$\Sigma F_x = ?$

$\Sigma F_x = m a_x$

$a_x = ?$

$\Sigma F_x = 1500 \cdot (-7) = -1.1 \cdot 10^4\ N$

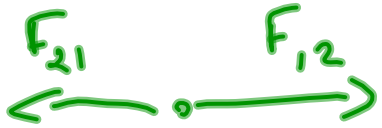
$$a = \frac{v^2 - v_0^2}{2(x - x_0)}$$

$$= \frac{0 - 27.8^2\ m^2/s^2}{2 \cdot 55\ m}$$

$$= -7\ m/s^2$$

Newton's 3rd law of motion

Whenever one object exerts a force on a second object, the second object exerts an equal force in the opposite direction on the first object



Forces

Gravitational force or force of gravity

$\vec{F}_G = m\vec{g}$ toward center of earth

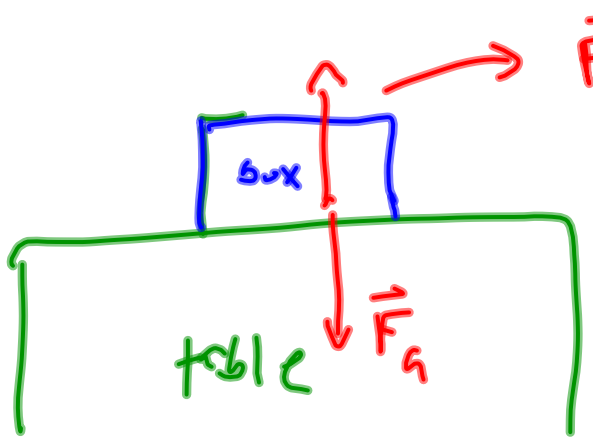
note F_G is also called weight

Normal force

Tension force

Normal force

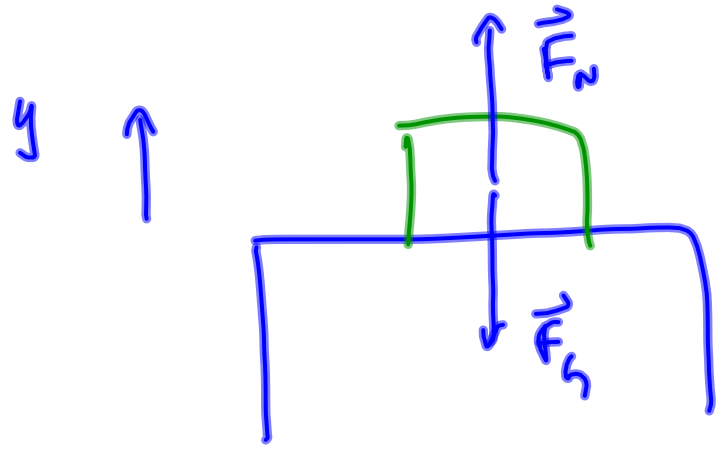
- when a contact force acts ⊥ to the common surface of the conduct it is referred to as the normal force



$\vec{F}_N \neq \vec{F}_g$ in all cases

A box of 10 kg mass rests on frictionless horizontal surface

a) determine the weight of the box & normal force exerted by the table



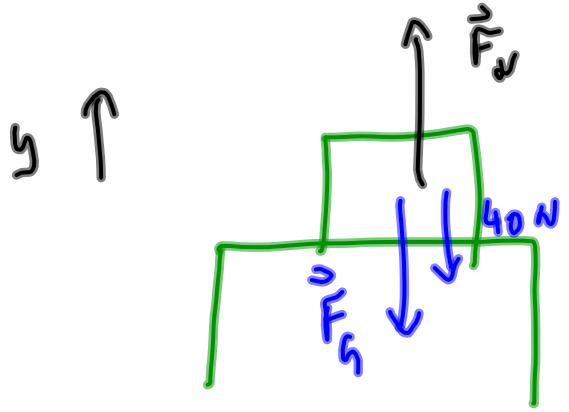
$\Sigma F_y = F_N - F_g$

$a_y = 0$

$\Sigma F_y = 0$

$F_N = F_g = 98\,N$

b) your friend pushes down on the box with a force of 40 N



$\Sigma F_y = F_N - F_g - 40N$

c) $a_y = 2 m/s$

$\Sigma F_y \neq 0$

ΣF_y is a sum

$\Sigma F_y = F_N + (-F_g)$!