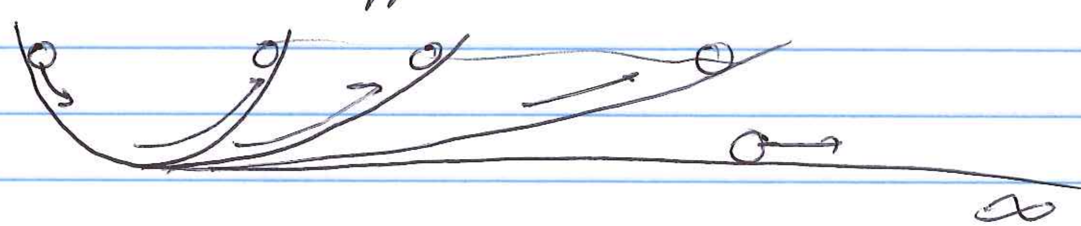
kinematics : description of motion, without consideration of the causes

dynamics : causes of motion = <u>forces</u>

force : "push" or "pull" action on an object
↳ vector quantity : magnitude and direction

Aristotle : ~~- natural state of an object is at rest~~
~~- any motion requires a force,~~
~~if no force is applied → motion will come to rest~~

Galileo (1609) : - objects in motion will stay in motion <u>unless</u> there is a force applied

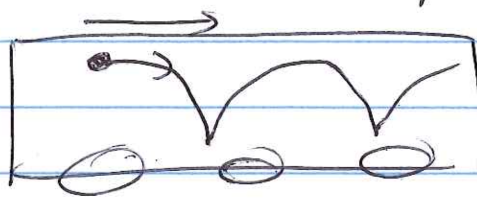


Newton (1685-1686) : <u>3 laws of motion</u>

Newton's first law < Galileo

$\boxed{\text{Objects have a constant velocity unless acted upon by a net force}}$

$\vec{v} = 0$ is not a special case



Moving reference frames → laws of motion are valid in these frames when $\vec{v}$ of reference frame is constant

Newton's second law

$\boxed{\text{Acceleration of an object that is acted upon by a net external force } \vec{F}_{net} \text{ is directly proportional to the force } \vec{F}_{net}\text{, is inversely proportional to the mass of the object, } m.}$

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

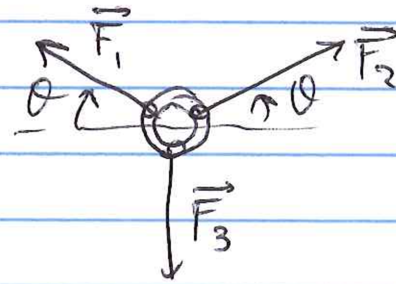
$\vec{F}_{net}$ ← cause (dynamics)

m inertial mass

$\vec{a}$ ← effect (kinematics)

↳ $\vec{F}_{net} = m\vec{a}$

$$\vec{F}_{net} = \sum_i \vec{F}_i$$



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

$kg \cdot m/s^2$ = units of force

N , Newton

$$1\,N = 1\,kg\,m/s^2$$

<u>mg</u> : $(0.1\,kg)(10\,m/s^2) \approx 1\,N$

$\mu N, mN$

kN

<u>Mass</u> m versus <u>weight</u> W

<u>mass</u> = measure of the inertia of an object

reluctance of an object to change its velocity

- scalar quantity
- intrinsic to the object, depends on numbers and type of atoms

<u>weight</u> = <u>force</u> due to gravity

- vector quantity → downwards

$\vec{W} = \vec{F}_{net} = m\vec{a} = -mg$, downwards

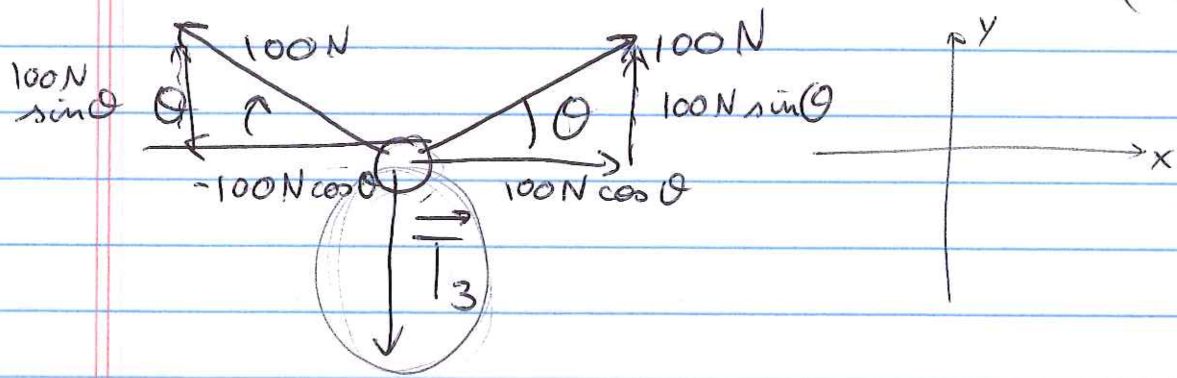
$\vec{a} = -g$

* Newton's Third law:

> If an object A exerts a force on object B, then object exerts a force on object A that is equal in magnitude, opposite in direction

$$\vec{F}_{BA} = -\vec{F}_{AB}$$

Force is a vector $\quad \vec{F}_{net} = m\vec{a} \rightarrow$
$F_x = ma_x$
$F_y = ma_y$
$(F_z = ma_z)$

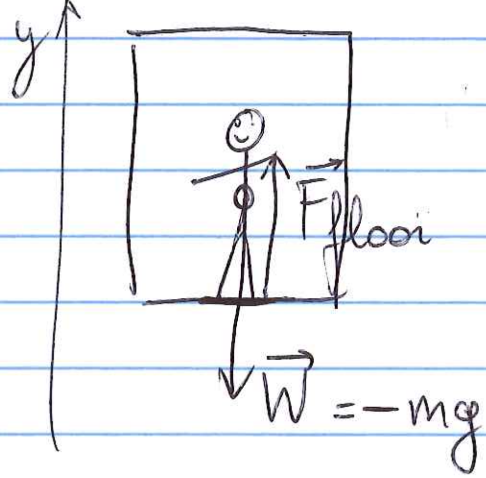


$$T_{3,y} + T_{1,y} + T_{2,y} = 0$$

$$T_{3,y} + 2(100N)\sin\theta = 0$$

$$\hookrightarrow T_3 = -2(100N)\sin\theta$$

Elevator standing still (moving at constant velocity)
(person inside) ↳ $\vec{a} = 0$



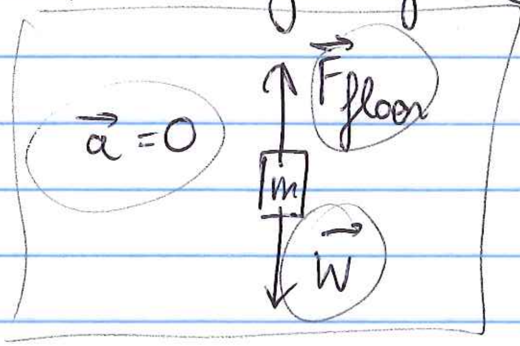
$$\vec{F}_{net} = m\vec{a} = 0$$

↳ $\vec{W} + \vec{F}_{floor} = 0$

$-mg + F_{floor} = 0$

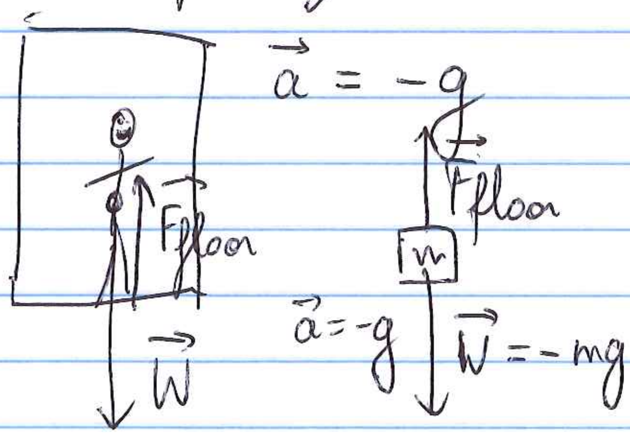
$\vec{F}_{floor} = +mg$, upwards

Free-body diagram



$\rightarrow \vec{F}_{floor} + \vec{W} = m\vec{a}$

Elevator falling



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

$\vec{F}_{floor} + \vec{W} = -mg$

$F_{floor} - mg = -mg$

⇓

$F_{floor} = 0$