If you are in a car that is accelerating or decelerating, then you are in a non-inertial frame of reference. If you apply Newton's laws they give wrong answers (don't hold).

Mass: a measure of an objects resistance to motion (measure of the inertia of an object).

large mass → large inertia
small mass → small inertia

<u>Note</u> A large force is needed to move a large mass or stop it.

Comparison between mass and weight.

Mass (measure of resistance to motion)	Weight (Gravitational force acting on an object)
- Scalar	- Vector [Force]
- Does NOT change with location	- Depends on location. A 1kg on earth has a different weight on the moon.

On earth's surface $g_E = 9.81\ m/s^2$ ‖ On moon's surface $g_M = \frac{9.81}{6}\ m/s^2$

Newton's Second Law

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

sigma (sum) → Σ; $\sum \vec{F}$ = net force

[For a constant mass].

Gives the relation between the net force acting on an object, its mass and its acceleration.

$$\therefore \vec{a} = \frac{1}{m} \Sigma \vec{F}$$

$\overrightarrow{\text{vector}}$ equation

Gravitational acc. g is ALWAYS vertically downwards parallel the net force (weight) (for free fall)

NOTE: - A net force is needed to cause acceleration.
- $\vec{a}$ is ALWAYS parallel to the net force
- $\vec{a}$ is propoitional to $\Sigma \vec{F}$
- $\vec{a}$ is inversely proportional to m.

We can write

net force along x-axis

$\Sigma F_x = m a_x$ (along x-axis)

$\Sigma F_y = m a_y$ (along y-axis)

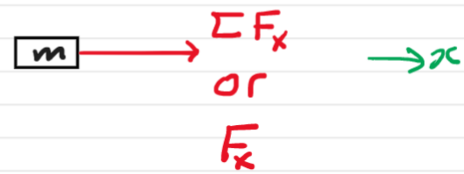
$\Sigma F_z = m a_z$ (along z-axis)

Unit of force: Newton (N). (in mks international system) — m: meter, k: kg, s: second

Is N a basic unit? No. N is a derived unit. i.e expressed in terms of meter, kg and second

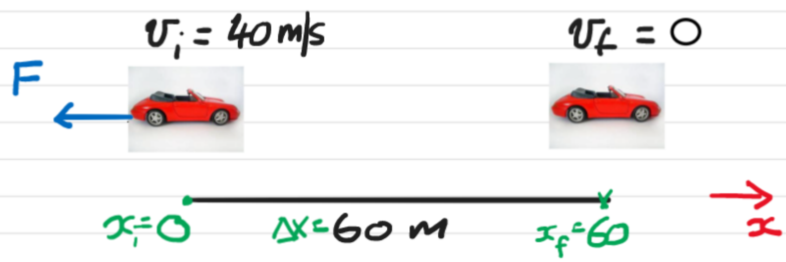
$1\ N \equiv 1\ kg \cdot 1 \frac{m}{s^2} = 1 kg \frac{m}{s^2}$ $F = ma$

Example: Find the net force required to give a 3 kg mass an acceleration of $a = 2\ m/s^2$ in the positive x-axis.



$$\Sigma F_x = (3)(2) = 6\ kg\frac{m}{s^2} \equiv 6\ N.$$

Example: Find the net force required to stop a 1000 kg car moving at 40 m/s in 60 m.



$F = ma$?

Use equations of motion to find the acceleration.

$$v_f^2 - v_i^2 = 2a\Delta x$$ ← displacement

$$0 - (40)^2 = 2a(60)$$

$a = -\frac{1600}{120} \approx -13.3 \ m/s^2.$

$a < 0$, $v > 0$ } ⇒ deceleration since the signs of a and v are different.

net force ↓ ΣF_x

$F = 1000(-13.3)$

$= -13300$ N

↑ the force is in the negative x-direction.

Newton's Third Law

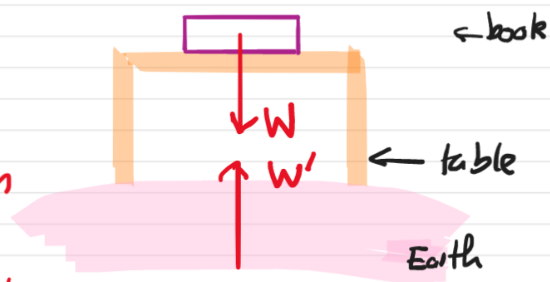
Each action has a reaction equals to it in magnitude and opposite to it in direction.

(action reaction forces are equal and opposite)

It is very important to identify the correct pair of action-reaction forces.

Exmple A book on a tabe which rests on the ground.

Find the pairs of action reaction forces.



W: force of earth on book. Call it action (weight).

W': force of book on earth. Call it reaction.

$$W' = -W$$ (equal in magnitude and opposite in direction.

NOTE: action (W) acts on the book, while the reaction (W') acts on the earth.

W and W' are action-reaction pair and act on different objects.