According to this law, “the rate of change of momentum (mass × velocity) of a body is proportional to the impressed force and it takes place in the direction of the force”.

Mathematically $\vec{F} \propto \frac{d\vec{p}}{dt} \Rightarrow \vec{F} = k\frac{d\vec{p}}{dt} = \frac{d\vec{p}}{dt}$

$$\vec{F} = \frac{d\vec{p}}{dt}$$ (Defining force such a way that k =1)

$$\vec{F} = \frac{d}{dt}(m\vec{v}) = m\frac{d\vec{v}}{dt}$$ (consider mass m is constant)

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

In scalar form, $F = ma$

This equation is valid only if mass of the body is constant.

(i) Force is a vector quantity, whose unit is Newton or $\frac{Kg.m}{sec^2}$ *(In MKS)* and Dyne or $\frac{gm \times cm}{sec^2}$ *(In C. G. S.)*

(ii) The dimension of force is (MLT^{-2})

(iii) The second law of motion gives the magnitude and unit of force.

(iv) If m is not constant, then

$$\vec{F} = \frac{d}{dt}(m\vec{v}) = m.\frac{d\vec{v}}{dt} + \vec{v}\,\frac{dm}{dt}$$

As in case of rocket propulsion, the mass of the fuel varies with respect to time.