

# Impulse – Detailed Explanation

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## 1. Definition of Impulse

**Impulse** is the measure of the effect of a large force acting for a short time, producing a finite change in momentum.

$$\text{Impulse} = \text{Average Force} \times \text{Time Interval}$$

- Denoted by:  $\vec{I}$
  - Vector quantity (same direction as force)
  - SI unit: Newton-second (N·s)
  - Dimensional formula:  $[MLT^{-1}]$
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## 2. Mathematical Expression

For a constant force  $\vec{F}$  acting over a small time interval  $dt$ :

$$d\vec{I} = \vec{F} dt$$

For a force acting over time interval from  $t_1$  to  $t_2$ :

$$\vec{I} = \int_{t_1}^{t_2} \vec{F} dt$$

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## 3. Impulse with Average Force

If  $F_{\text{av}}$  is the average force over  $\Delta t = t_2 - t_1$ , then:

$$\vec{I} = F_{\text{av}} \int_{t_1}^{t_2} dt = F_{\text{av}}(t_2 - t_1) \Rightarrow \vec{I} = F_{\text{av}}\Delta t$$

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## 4. Relation to Momentum

From Newton's Second Law:

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

Integrating both sides:

$$\int_{t_1}^{t_2} \vec{F} dt = \int_{\vec{p}_1}^{\vec{p}_2} d\vec{p}$$

$$\Rightarrow \vec{I} = \vec{p}_2 - \vec{p}_1$$

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## 5. Final Result - Impulse-Momentum Theorem

$$\boxed{\vec{I} = \vec{p}_2 - \vec{p}_1}$$

### Conclusion:

The **impulse of a force** is equal to the **change in momentum** produced by that force.

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