WHAT ARE MOMENTUM AND IMPULSE?

WHAT IS MOMENTUM?

Momentum is a word that we hear used colloquially in everyday life. We are often told that sports teams and political candidates have "a lot of momentum". In this context, the speaker usually means to imply that the team or candidate has had a lot of recent success and that it would be difficult for an opponent to change their trajectory. This is also the essence of the meaning in physics, though in physics we need to be much more precise.

Momentum is a measurement of mass in motion: how much mass is in how much motion. It is usually given the symbol **p**.

By definition, $\boxed{\mathbf{p} = m \cdot \mathbf{v}}$.

Where *m* is the mass and **v** is the velocity. The standard units for momentum are $kg \cdot ms^{-1}$, and momentum is always a vector quantity. This simple relationship means that doubling either the mass or velocity of an object will simply double the momentum.

The useful thing about momentum is its relationship to force. You might recall from the kinematic equations that change in velocity Δv can also be written as $a \cdot \Delta t$

We can then see that any change in momentum following an acceleration can be written as

$$\begin{aligned}\Delta\mathbf{p} &= m \cdot \Delta v \\ &= m \cdot \mathbf{a} \cdot \Delta t \\ &= \mathbf{F} \cdot \Delta t\end{aligned}$$

WHAT IS IMPULSE?

Impulse is a term that quantifies the overall effect of a force acting over time. It is conventionally given the symbol J and expressed in Newton-seconds.

For a constant force, $\mathbf{J} = \mathbf{F} \cdot \Delta t$.

As we saw earlier, this is exactly equivalent to a change in momentum $\Delta\mathbf{p}$. This equivalence is known as the **impulse-momentum theorem**. Because of the impulse-momentum theorem, we can make a direct connection between how a force acts on an object over time and the motion of the object.

One of the reasons why impulse is important and useful is that in the real world, forces are often not constant. Forces due to things like people and engines tend to build up from zero over time and may vary depending on many factors. Working out the overall effect of all these forces directly would be quite difficult.

When we calculate impulse, we are multiplying force by time. This is equivalent to finding the area under a force time curve. This is useful because the area can just as easily be found for a complicated shape variable force as for a simple rectangle constant force. It is only the overall **net impulse** that matters for understanding the motion of an object following an impulse.
The concept of impulse that is both external and internal to a system is also fundamental to understanding conservation of momentum.