## Impulse

IB PHYSICS | ENERGY \& MOMENTUM

## IB Physics Data Booklet

$$
\begin{aligned}
& \text { Sub-topic } 2.4 \text { - Momentum and impulse } \\
& \hline p=m v \\
& F=\frac{\Delta p}{\Delta t} \\
& E_{\mathrm{K}}=\frac{p^{2}}{2 m} \\
& \text { Impulse }=F \Delta t=\Delta p
\end{aligned}
$$

## Remember Work?

## Work $=$ Force $\times$ Distance

## 2,000 kg



Initial Energy $=0 \mathrm{~J}$
Work $=(\mathbf{5 , 0 0 0} \mathbf{N})(100 \mathrm{~m})=\mathbf{5 0 0 , 0 0 0} \mathbf{J} \longleftarrow$ Energy added to system
Final Energy $=500,000 \mathrm{~J}=1 / 2 \mathrm{mv}^{2}=1 / 2(2,000 \mathrm{~kg}) \mathrm{v}^{2}$
Final Velocity $=v=22.36 \mathrm{~m} \mathrm{~s}^{-1}$

## Introducing Impulse

## Impulse $=$ Force $\times \underline{\text { Time }}^{8.94 \mathrm{~s}}$

## 2,000 kg

5,000 N
$0 \mathrm{~m} \mathrm{~s}^{-1}$ 100 m

$$
v=?
$$

Initial Momentum $=0 \mathrm{~kg} \mathrm{~m} \mathrm{~s}^{-1}$
Impulse $=\mathbf{( 5 , 0 0 0} \mathbf{N})(8.94 \mathbf{s})=\mathbf{4 4 , 7 0 0} \mathbf{~ k g ~ m ~ s}^{\mathbf{- 1}} \longleftarrow$ Momentum added to system
Final Momentum $=44,700 \mathrm{~kg} \mathrm{~m} \mathrm{~s}^{-1}=\mathrm{mv}=(2,000 \mathrm{~kg}) \mathrm{v}$
Final Velocity $=\mathrm{v}=22.35 \mathrm{~m} \mathrm{~s}^{-1}$

## Impulse

## Work $\rightarrow$ Change in Energy

 Impulse $\rightarrow$ Change in MomentumWhat about Units? $[\mathrm{N}]=[\mathrm{kg}]\left[\mathrm{m} \mathrm{s} \mathrm{s}^{2}\right]$
Impulse $=\mathrm{F} \times \mathrm{t}=[\mathrm{N}][\mathrm{s}]=[\mathrm{kg}][\mathrm{m} \mathrm{s}-2][\mathrm{s}]$
Impulse $=[\mathbf{N ~ s}]$ or $\left[\mathbf{k g ~ m ~ s} \mathbf{~ s}^{-1}\right]^{\star}$
*same unit as momentum

## IB Physics Data Booklet

## Sub-topic 2.4 - Momentum and impulse

$$
\begin{aligned}
& p=m v \\
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\end{aligned}
$$

## Impulse and Momentum

## Impulse can act to increase or decrease an object's momentum



Initial Velocity $0 \mathrm{~m} / \mathrm{s}$

## Impulse $\rightarrow$ Slowing Down



## Impulse and Momentum

## Impulse $=F \Delta t=\Delta p$



Short Time


Large Force


$$
F x_{\Delta t}=F \times \Delta t
$$

Same Impulse
Same Momentum


Long Time
Small Force


## Impulse to Speed Up



> Should a cannon have a long or short barrel to produce to largest final velocity? Why?

Both designs will experience the same force but the long barrel experiences that force for more time and creates a larger impulse / change in momentum

## Marshmallow Shooter

## Impulse $=F \Delta t=\Delta p=m \Delta v$



Same Force
Same Mass


More Time $\rightarrow$ More Velocity

## What if the force isn't constant?



Remember how we found
work done by a varying force?


Area $=(y$-axis) $(x$-axis $)$
Work $=$ (force)(displacement)

$$
\mathrm{W}=\mathrm{Fs}
$$

## Which impulse is larger?



## Same

Twice the time Half the force

## The force matters!



## Lesson Takeaways

$\square$ I can describe the meaning of impulse and how it is related to momentum change
$\square$ I can conceptually describe how to decrease the force experienced in a collision
$\square$ I can determine the impulse of a collision from a force vs time graph

