# Impulse

IB PHYSICS | ENERGY & MOMENTUM

#### **IB** Physics Data Booklet



# Remember Work?

# Work = Force × Distance



Initial Energy = 0 J

Work = (5,000 N)(100 m) = 500,000 J - Energy added to system

Final Energy = 500,000 J =  $\frac{1}{2}$ mv<sup>2</sup> =  $\frac{1}{2}(2,000 \text{ kg})v^2$ 

Final Velocity =  $v = 22.36 \text{ m s}^{-1}$ 

# Introducing Impulse



Initial Momentum =  $0 \text{ kg m s}^{-1}$ 

Impulse = (5,000 N)(8.94 s) = 44,700 kg m s<sup>-1</sup> - Momentum added to system

Final Momentum =  $44,700 \text{ kg m s}^{-1} = \text{mv} = (2,000 \text{ kg})\text{v}$ 

Final Velocity =  $v = 22.35 \text{ m s}^{-1}$ 

# Impulse

# Work $\rightarrow$ Change in Energy Impulse $\rightarrow$ Change in <u>Momentum</u>

# What about Units? $[N] = [kg][m s^{-2}]$ Impulse = F × t = $[N][s] = [kg][m s^{-2}][s]$ Impulse = [N s] or $[kg m s^{-1}]^*$

\*same unit as momentum

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### Impulse and Momentum

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

Final Velocity 0 *m/s*  Initial Velocity 0 m/s

Initial Velocity 0 m/s







# How are these the same? different?



# Impulse → Slowing Down



# How can we decrease the force acting on an object?



# Impulse and Momentum

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



Same Mass Same Momentum Short Time Large Force

 $F \times \Delta t$ 





#### Same Impulse



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



# Marshmallow Shooter

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



#### More Time $\rightarrow$ More Velocity

# What if the force isn't constant?



Remember how we found work done by a varying force?



# Which impulse is larger?



# Same

Twice the time Half the force

# The force matters!



Increase time to decrease force below a dangerous threshold

F

# Lesson Takeaways

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