Impulse & Momentum Calculations

IB PHYSICS | ENERGY & MOMENTUM

Impulse Review

Work → Change in Energy

Impulse → Change in Momentum

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

Impulse Slowing Down

Same Mass

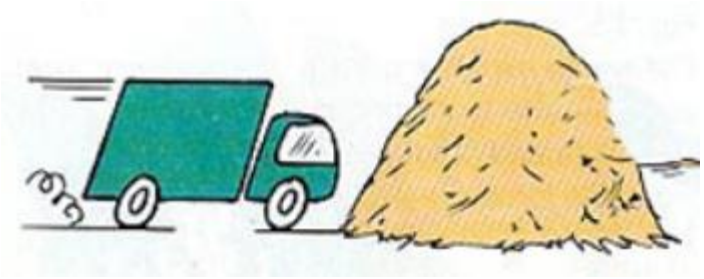
Same Momentum

Short Time

Large Force

$F \times \Delta t$

Same Impulse

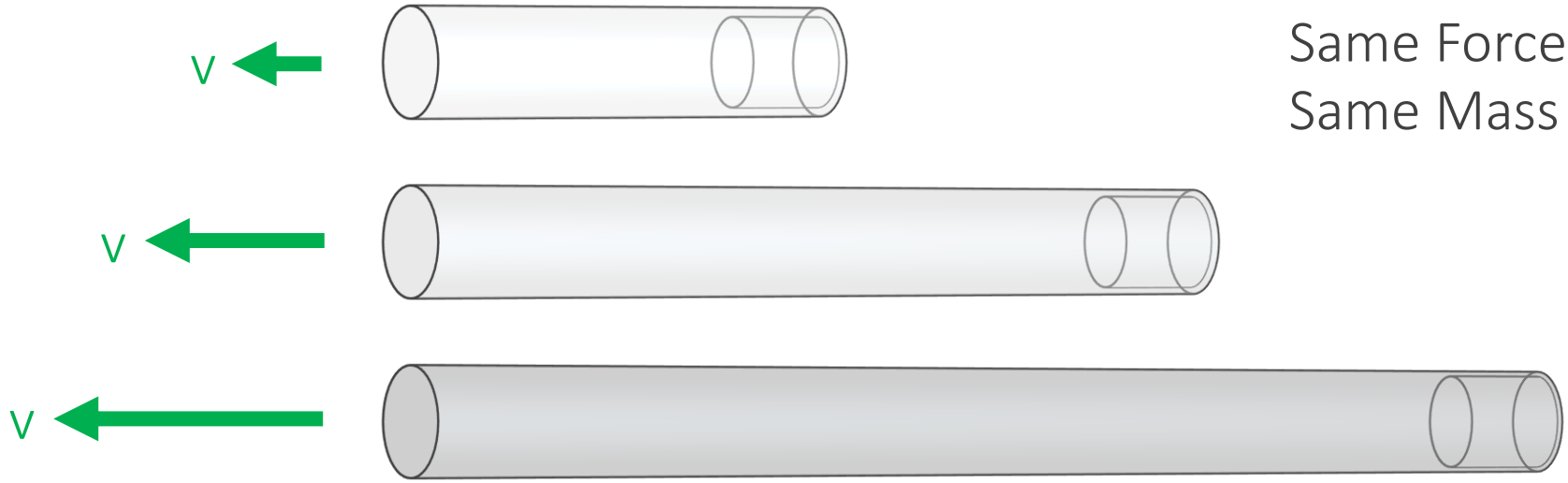


Long Time

Small Force

Impulse Speeding Up

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



More Time → More Velocity

Slapshot!

A hockey puck has a mass of 0.115 kg. A player takes a slap shot which exerts a force of 31.0 N for 0.15 sec. How fast will the puck be moving?

Initial Momentum → Impulse Added → Final Momentum

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

Impulse = FΔt = (31 N)(0.15 s) = 4.65 kg m s^{-1}

Final Momentum = 4.65 kg m s^{-1} = mv = (0.115 kg)v

Final Velocity = v = **40.4 m s^{-1}**

Impulse and Momentum

The 440 newton Liquid Apogee Motor (LAM) of India's Mars Orbiter Spacecraft, was successfully fired for a duration of 3.968 seconds on September 22, 2014. This operation of the spacecraft's main liquid engine was also used for the spacecraft's trajectory correction and changed its velocity by 2.18 m s^{-1}. What was the mass of the spacecraft at the time of this engine firing?

Initial Momentum → Impulse Added → Final Momentum

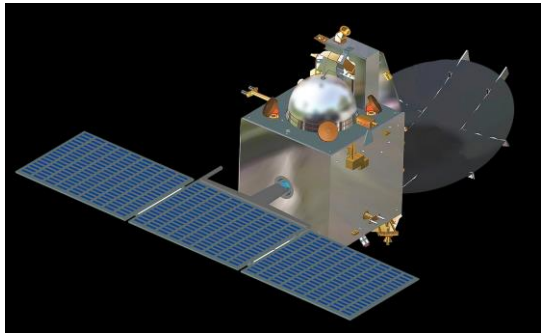
$$\text{Impulse} = F\Delta t = \Delta p$$

$$\text{Impulse} = F\Delta t = (440\ \text{N})(3.968\ \text{s}) = 1746\ \text{kg m s}^{-1}$$

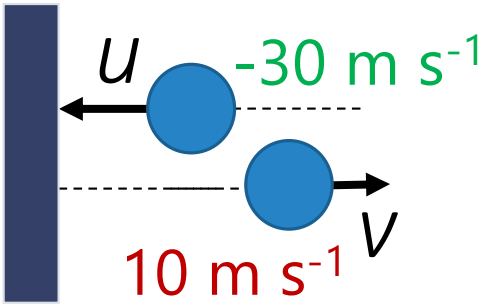
$$\text{Change in Momentum} = 1746\ \text{kg m s}^{-1} = (m)(\Delta v)$$

$$1746\ \text{kg m s}^{-1} = (m)(2.18)$$

$$\mathbf{m = 801\ kg}$$



Direction Matters

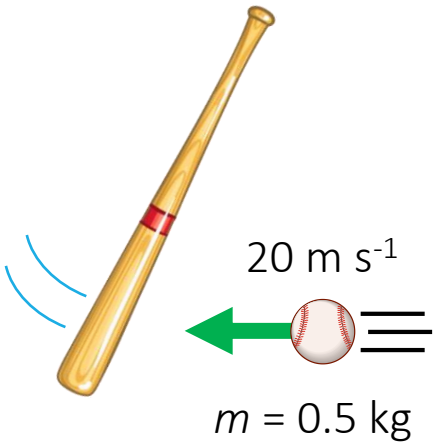


Assume u is 30 m s^{-1} to the left and v is 10 m s^{-1} to the right.
What is the change in velocity?

Change in Velocity = 40 m s^{-1}

Try This…

A **500 g** baseball moves to the left at **20 m s^{-1}** striking a bat. The bat is in contact with the ball for **0.002 s**, and it leaves in the opposite direction at **40 m s^{-1}**. What was average force on ball?



Initial Momentum → Final Momentum

Impulse Added

p = (0.5)(-20)

-10 kg m s^{-1}

Δp

30 kg m s^{-1}

p = (0.5)(40)

20 kg m s^{-1}

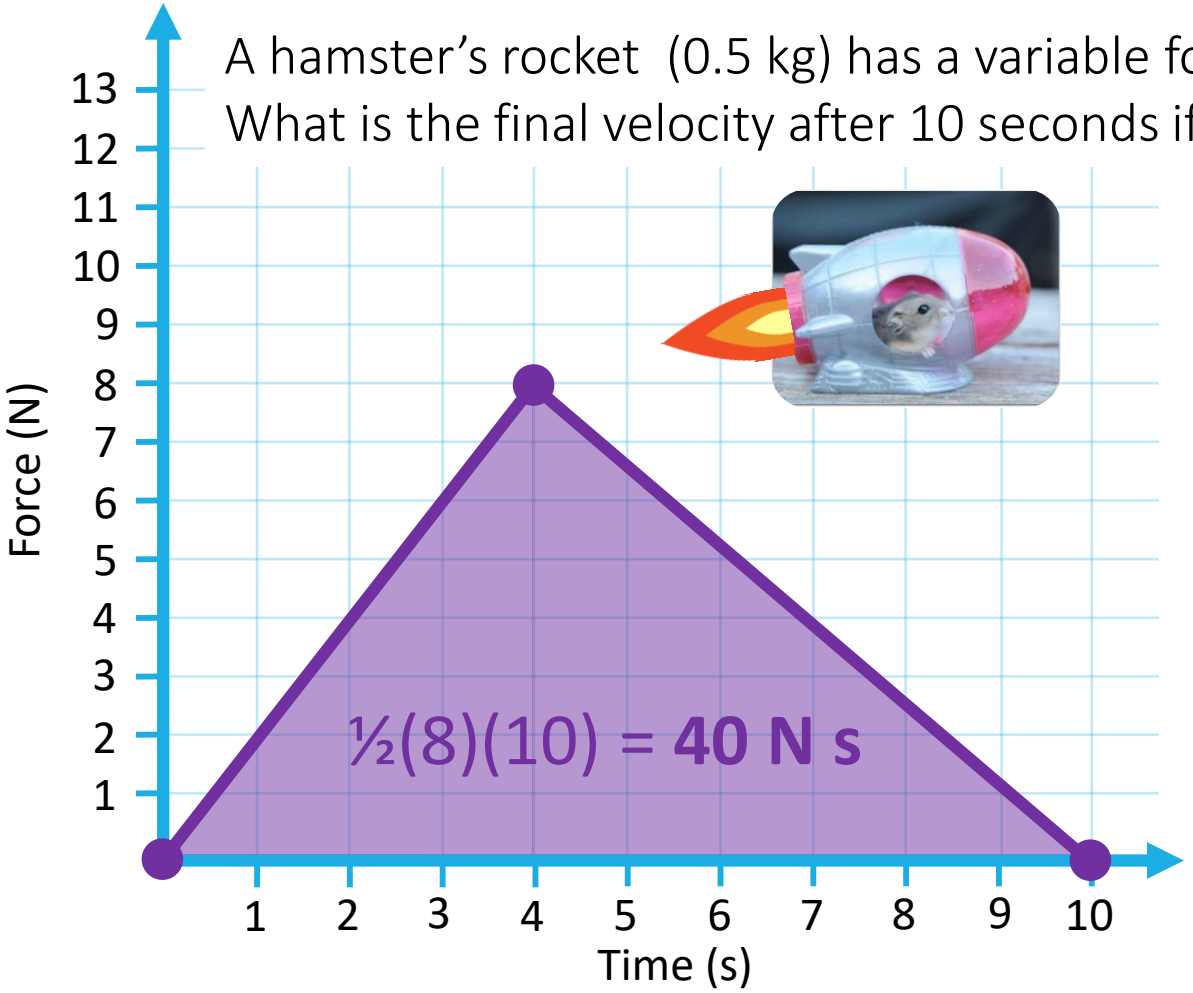
Impulse = FΔt = Δp

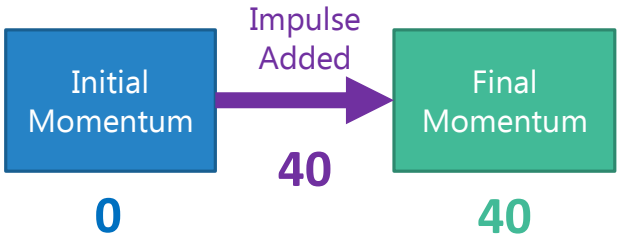
Impulse = F(0.002 s) = 30 kg m s^{-1}

F = 15,000 N

Impulse from a Graph

A hamster's rocket (0.5 kg) has a variable force as shown in the graph. What is the final velocity after 10 seconds if it starts from rest?





$p = mv$

$40 = (0.5)v$

$v = 80$ m/s

Try This...

Kara Less was applying her makeup when she drove into South's busy parking lot last Friday morning. Unaware that Lisa Ford was stopped in her lane, Kara rear-ended Lisa's rental car. Kara's 1300-kg car was moving at 5 m s^{-1} and stopped in 0.4 seconds. What was the force?

Initial Momentum = mv = (1,300)(5) = 6,500 kg m s^{-1}

Final Momentum = 0 kg m s^{-1}

Impulse = 6,500 kg m s^{-1} = (F)(0.4 s)

Force = F = **16,250 N**

Lesson Takeaways

- ❑ I can use impulse and momentum to solve for an unknown **force**
- ❑ I can use impulse and momentum to solve for an unknown **velocity**
- ❑ I can calculate the change in velocity when there is a direction change
- ❑ I can calculate change in momentum from a Force vs Time graph