Momentum and Impulse

Another Conservation Law...

Momentum and Impulse

- I. Momentum and Impulse - concepts and definition

 - relation to force
- II. Conservation of Momentum
 - internal and external force

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- elasticity

	The student will be able to:	HW:
1	Define and calculate momentum using appropriate SI units.	1
2	Define and calculate impulse and solve problems relating impulse, momentum, and force.	2-6
3	State and apply the law of conservation of momentum with proper consideration to internal and external forces. Define and analyze center of mass position and velocity.	7 – 10
4	Use conservation of momentum to solve related problems.	11 – 21
5	Define elastic and inelastic collisions and use the definitions to solve related problems.	22–27 W. Milliga

What is Momentum?

Momentum is the product of mass and velocity.

$$\vec{p} = m\vec{v}$$

Momentum is a vector that points in the same direction as velocity.

Its magnitude has SI units of: kg m/s

(Note: there is no special defined unit for measuring and quantifying momentum.)

Momentum – Numerical Example

A car of mass 1000 kg is traveling with velocity 20.0 m/s, 0.0°. Find its momentum.



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$$\vec{p} = m\vec{v}$$
$$p = (1000 \text{ kg}) \cdot (20 \frac{\text{m}}{\text{s}})$$
$$p = 20000 \frac{\text{kg} \cdot \text{m}}{\text{s}}$$

Momentum – Numerical Example

A car of mass 1000 kg is traveling with velocity 20.0 m/s, 0.0°. Find its momentum.







245 lbs, 40 yd = 4.9 s

210 lbs, 40 yd = 4.5 s

Whom would you rather tackle – a tight end or a tailback?





m = 111 kg, v = 7.46 m/s m = 95.3 kg, v = 8.31 m/s

Which player has more momentum?

Which player has more inertia?



More inertia and more momentum!





m = 111 kg, v = 7.46 m/s m = 95.3 kg, v = ?

At what speed would the tailback have momentum equal to that of the tight end? Would inertia change?



The greater the momentum of an object the greater the force and time required to stop it.

This leads to the concept of **impulse**...

Impulse is the product of force and time.

$$\vec{J} = \vec{F}(\Delta t)$$

where: J = impulse F = force $\Delta t = amount of time$ that the force acts

Understanding Impulse

A force of 1580 N, 0.0° is required to bring the tailback to a stop in 0.500 s (if he has momentum equal to 790 kg m/s). Find the impulse.



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$$J = \left(1580 \text{ N} \right) \cdot \left(0.5 \text{ s} \right)$$

 $\vec{J} = 790 \text{ N} \cdot \text{s}, 0.0^{\circ}$



Would the same impulse stop a player with more momentum? © Matthew W. Milligan

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Force, Momentum, Impulse

Starting with Newton' s 2nd Law it can be shown that net force equals rate of change in momentum...

$$\vec{F}_{net} = \frac{\Delta \vec{p}}{\Delta t}$$
$$\vec{F}_{net} \left(\Delta t\right) = \Delta \vec{p}$$
$$\vec{J}_{net} = \Delta \vec{p}$$

...which leads to a formula that equates net impulse with change in momentum.