

Linear Momentum

Linear Momentum and Impulse

Syllabus Statement 2.2.10-2.2.13 due next
Thursday (12/15)

- What is momentum?

Property of a moving object that describes how "hard" it is to stop the object.

- What does momentum depend on?

Mass and velocity. Momentum is a vector in the direction of the velocity.

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Definition of Linear Momentum

The linear momentum of an object is the product of its mass and velocity

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

Unit: kg*m/s

Practice:

A 50-g bullet is moving at a velocity of 300 m/s. What is its linear momentum?

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Practice:

Find out how the momentum form of Newton's second law relate to the form we are all familiar with : $F=ma$

Newton's Second Law (in momentum form)

The average net force acting on an object is equal to the time rate of change of its linear momentum

$$\mathbf{F}_{net} = \frac{\Delta \mathbf{p}}{\Delta t}$$

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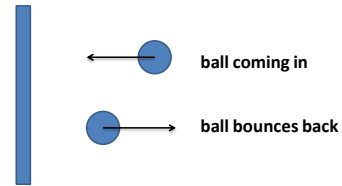
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$$F_{net} = \frac{\Delta p}{\Delta t}$$

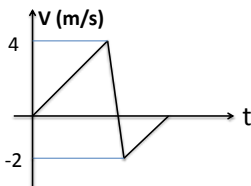
$$= \frac{\Delta(mV)}{\Delta t} = m \frac{\Delta V}{\Delta t} = ma$$

Practice:

A 0.1 kg ball moving at 5 m/s bounces off a vertical wall without a change in its speed (see figure below). If the collision with the wall lasted for 0.1 s, what force was exerted on the ball?

**Practice:**

A 0.50 kg ball bounces off a hard surface. A graph of velocity vs. time is shown in the figure below. Find the magnitude of the momentum change of the ball during the bounce. The ball stayed in contact with floor for 0.15 s. What average force did the ball exert on the floor?

**Warm Up:**

Why do we need to bend our knees before we land when we jump from a high place ?

Newton's second law in terms of momentum:

$$F_{net} = \frac{\Delta p}{\Delta t}$$

Δt infinitesimally small ----- instantaneous force

Otherwise ----- average force \bar{F}

Definition of Impulse

$$\Delta p = \bar{F} \Delta t$$

ΔP is the magnitude of the impulse delivered and equals the product of the magnitude of the average force times the interval of time for which contact lasts.

Discussion: Given a force-time graph, how do we find the impulse?

Impulse is the area under the curve of a force-time graph and equals the total momentum change of the mass.

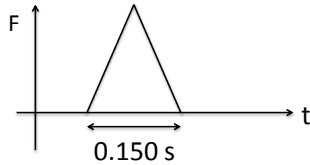
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Practice:

A ball of mass 0.250 kg moves on a frictionless horizontal floor and hits a vertical wall with speed 5.0 m/s. The ball rebounds with speed 4.0 m/s. If the ball was in contact with the wall for 0.150 s.

- Find the average force that acted on the ball.**
- The force is assumed to vary with time as shown in the figure, find the maximum force that acted on the ball.**



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Practice

- If the average force is doubled and the contact time is cut in half, the change of momentum will
 - double.
 - be cut in half.
 - stay the same.
- And the impulse delivered by the force will
 - double.
 - be cut in half.
 - stay the same.