CEE 271 APPLIED MECHANICS II

Lecture 16: Conservation of Linear Momentum

Department of Civil & Environmental Engineering
University of Hawaiʻi at Mānoa

Today's Objectives

- Apply the principle of linear impulse and momentum to a system of particles.
- Understand the conditions for conservation of momentum.

Outline
(Pre-Job Brief)

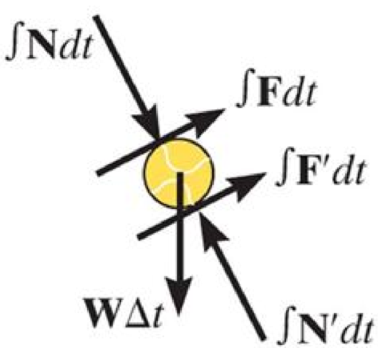
- Linear Impulse and Momentum for a System of Particles
- Conservation of Linear Momentum
- Examples and Questions
- Summary and Feedback

Conservation of Linear Momentum

Applications

As the wheels of this pitching machine rotate, they apply frictional impulses to the ball, thereby giving it linear momentum in the direction of ***F***dt and ***F '***dt.

The weight impulse, **W**Δt is very small since the time the ball is in contact with the wheels is very small.



Does the release velocity of the ball depend on the mass of the ball?

Applications (continued)

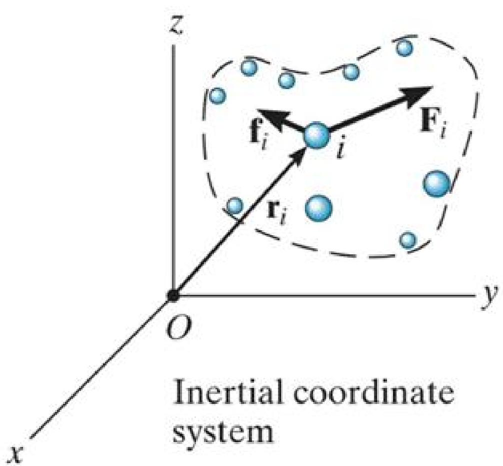
This large crane-mounted hammer is used to drive piles into the ground.

Conservation of momentum can be used to find the velocity of the pile just after impact, assuming the hammer does not rebound off the pile.

If the hammer rebounds, does the pile velocity change from the case when the hammer doesn't rebound ? Why ?

In the impulse-momentum analysis, do we have to consider the impulses of the weights of the hammer and pile and the resistance force ? Why or why not ?

System of Particles



For the system of particles shown, the internal forces f_i between particles always occur in pairs with equal magnitude and opposite directions. Thus the internal impulses sum to zero.

The linear impulse and momentum equation for this system only includes the impulse of external forces.

$$\sum m_i(\mathbf{v}_i)_1 + \sum \int_{t_1}^{t_2} \mathbf{F}_i \, dt = \sum m_i(\mathbf{v}_i)_2$$

Motion of the Center of Mass

For a system of particles, we can define a "fictitious" center of mass of an aggregate particle of mass m_{tot}, where m_{tot} is the sum ($\sum m_i$) of all the particles. This system of particles then has an aggregate velocity of $\mathbf{v}_G = (\sum m_i \mathbf{v}_i) / m_{tot}$.

The motion of this fictitious mass is based on motion of the center of mass for the system.

The position vector $\mathbf{r}_G = (\sum m_i \mathbf{r}_i) / m_{tot}$ describes the motion of the center of mass.

System of Particles

When the sum of external impulses acting on a system of objects is zero, the linear impulse-momentum equation simplifies to

$$\sum m_i(\mathbf{v}_i)_1 = \sum m_i(\mathbf{v}_i)_2$$

This equation is referred to as the conservation of linear momentum. Conservation of linear momentum is often applied when particles collide or interact. When particles impact, only impulsive forces cause a change of linear momentum.

The sledgehammer applies an impulsive force to the stake. The weight of the stake is considered negligible, or non-impulsive, as compared to the force of the sledgehammer. Also, provided the stake is driven into soft ground with little resistance, the impulse of the ground acting on the stake is considered non-impulsive.

Examples & Questions

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