Momentum

(Chapter 5 - Page 195)

Momentum - "quantity of motion"

- measure of an object's ability to resist a change in its motion
- how much "oomph" an object has
- the product of an object's mass and its velocity

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

p -> momentum (kgm/s)

m -> mass (kg)

v -> velocity (m/s)

Momentum is a vector quantity. It has the same direction as the velocity of the object.

Model Problem - Page 197

Determine the momentum of a 0.300 kg hockey puck travelling across the ice at a velocity of 5.55 m/s, north. (1.67 kgm/s, north)

Example:

Determine the mass of an object that has a momentum of 8.39×10^7 kgm/s [S] and a velocity of 755 km/h south.

(4.00×10^5 kg)

Impulse
(Page 198)

Starting with Newton's second law of motion, we can derive a formula for impulse which is the product of the force exerted on an object and the time interval over which the force acts.

$$\mathbf{F} = m\mathbf{a}$$

Remember: $\mathbf{a} = \frac{\mathbf{v}_f - \mathbf{v}_0}{t}$

Impulse is a vector quantity and has the same direction as the force that causes it.

Average forces are used for short intense interactions.

Textbook: Page 200, PP #30-32

Impulse - Momentum Theorem

Textbook: Page 203, PP #33-35

Using this form of the equation, impulse has the same direction as the change in momentum of the object.

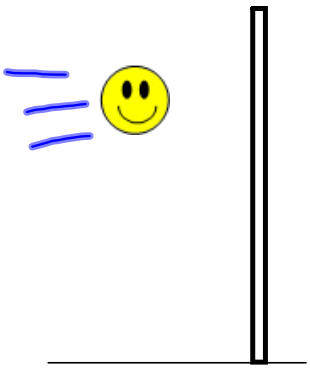
30. A sledgehammer strikes a spike with an average force of 2125 N[down] over a time interval of 0.0205 s. Calculate the impulse of the interaction.

31. In a crash test, a car strikes a wall with an average force of 1.23×10^7 N[S] over an interval of 21.0 ms. Calculate the impulse.

32. In a crash test similar to the one described in problem 31, another car, with the same mass and velocity as the first car, experiences an impulse identical to the value you calculated in problem 31. However, the second car was designed to crumple more slowly than the first. As a result, the duration of the interaction was 57.1 ms. Determine the average force exerted on the second car.

Model Problem - Page 201

A student practices her tennis volleys by hitting a tennis ball against a wall.
a) If the 0.060 kg ball travels 48 m/s before hitting the wall and then bounces directly backward at 35 m/s, what is the impulse of the interaction? (-5.0 kgm/s)
b) If the duration of the interaction is 25 ms, what is the average force exerted on the ball by the wall? (-2.0×10^2 N)



Textbook: Page 208, #37-45

Conservation of Momentum

For any collision between objects in a closed and isolated system, the total momentum before the collision is equal to the total momentum after the collision.

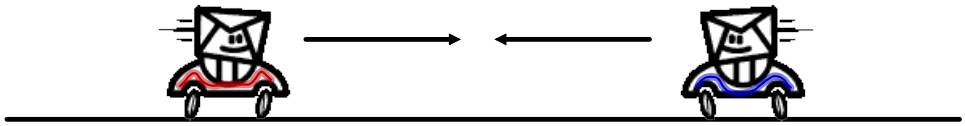
The Law of Conservation of Momentum

$$\vec{p}_A + \vec{p}_B = \vec{p}_A' + \vec{p}_B'$$

$$m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v}_A' + m_B\vec{v}_B'$$

1D Collisions

Example: When a car of mass 2.0×10^3 kg moving at 9.0 m/s collides head on with a second car having a mass of 1.5×10^3 kg, the cars lock and come to rest at the point of collision. What was the velocity of the second car before the collision?



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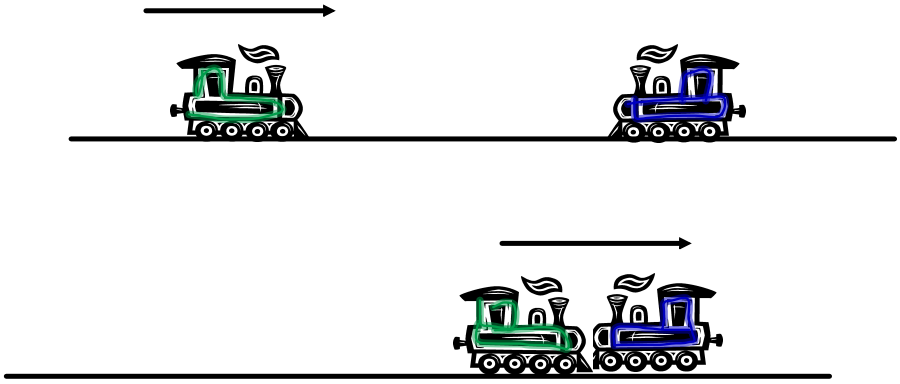
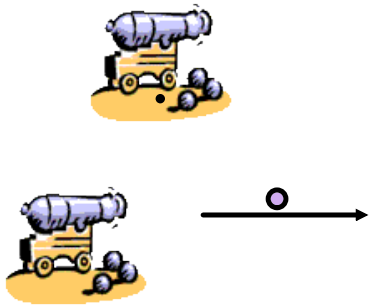
Example: A 6500 kg train travelling at 2.5 m/s collides with a stationary 8000 kg train. If they interlock upon collision, find their velocity after the collision.



Example: A shell having a mass of 25.0 kg is fired horizontally eastward from a cannon with a velocity of 500 m/s. If the mass of the cannon is 1000 kg, what is the magnitude and direction of the recoil velocity?



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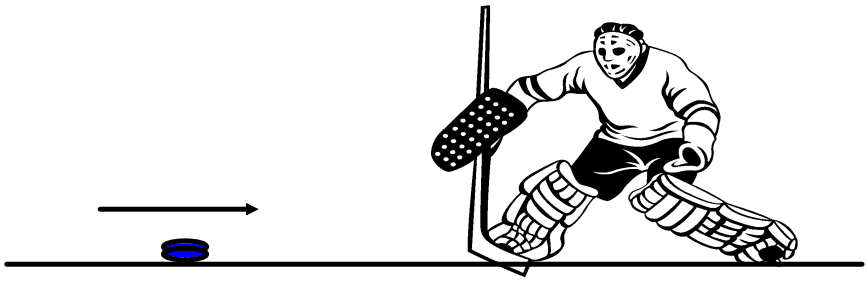
Example: A 0.105 kg hockey puck moving at 48 m/s is caught by a 75 kg goalie at rest. With what velocity does the goalie slide on the ice after the puck is caught?



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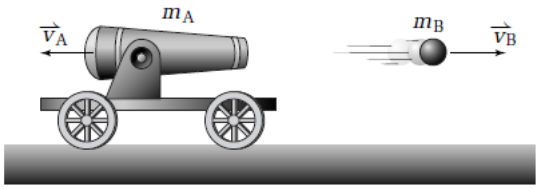
25. Claude and Heather are practising pairs skating for a competition. Heather (47 kg) is skating with a velocity of 2.2 m/s. Claude (72 kg) is directly behind her, skating with a velocity of 3.1 m/s. When he reaches her, he holds her waist and they skate together. At the instant after he takes hold of her waist, what is their velocity?

26. Two amusement park "wrecker cars" are heading directly toward each other. The combined mass of car A plus driver is 375 kg and it is moving with a velocity of +1.8 m/s. The combined mass of car B plus driver is 422 kg and it is moving with a velocity of –1.4 m/s. When they collide, they attach and continue moving along the same straight line. What is their velocity immediately after they collide?

27. A 1385 kg cannon containing a 58.5 kg cannon ball is on wheels. The cannon fires the cannon ball, giving it a velocity of 49.8 m/s north. What is the initial velocity of the cannon the instant after it fires the cannon ball?



28. While you are wearing in-line skates, you are standing still and holding a 1.7 kg rock. Assume that your mass is 57 kg. If you throw the rock directly west with a velocity of 3.8 m/s, what will be your recoil velocity?

29. The mass of a uranium-238 atom is 3.95×10^{-25} kg. A stationary uranium atom emits an alpha particle with a mass of 6.64×10^{-27} kg. If the alpha particle has a velocity of 1.42×10^{4} m/s, what is the recoil velocity of the uranium atom?

Attachments

Song - Momentum.jpg