Announcements 8 Apr 09

- **Exam 2**
  - **Answers will be posted later today**
- **Homework #9**
  - **Will be due on Tuesday next week**

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Momentum Recap

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

This equation expresses the momentum of a single particle or a collection of them.

For more than one particle the total momentum is the sum of the momentum of individual particles.

$$\vec{p} = \vec{p}_1 + \vec{p}_2 + \vec{p}_3 + \ldots = \sum_i \vec{p}_i$$

The SI units of momentum: kg m/s

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Conservation of Momentum

Consider a collision btw two balls

Impulse-momentum thm:

$\Delta p_{1x} = J_{1x}$ and $\Delta p_{2x} = J_{2x}$

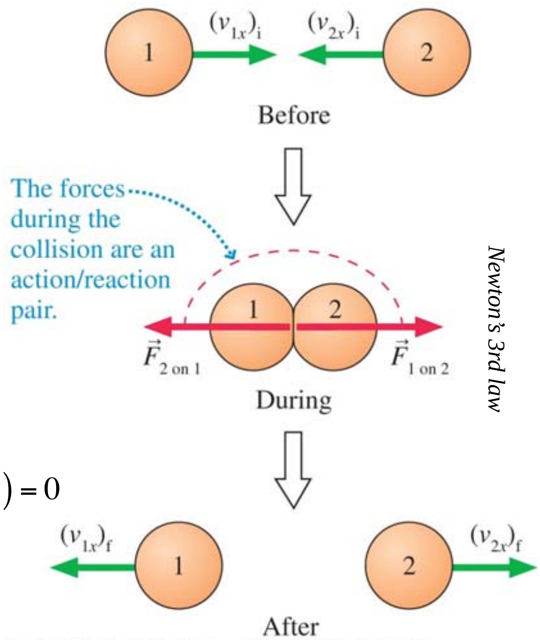
Since $(F_{2on1})_x = -(F_{1on2})_x$, we have $J_{1x} = - J_{2x}$, and thus

$\Delta p_{1x} = -\Delta p_{2x}$

i.e., $\Delta p_{1x} + \Delta p_{2x} = \Delta\left(p_{1x} + p_{2x}\right) = 0$

The sum of the momenta does not change

$\left(p_{1x}\right)_f + \left(p_{2x}\right)_f = \left(p_{1x}\right)_i + \left(p_{2x}\right)_i$



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Conservation of Momentum

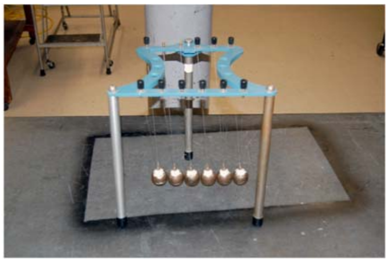
The total momentum before the collision is equal to the total momentum after the collision

This can be generalized to any *isolated* system consisting of any number of particles

➔ Law of momentum conservation

One of the most general and important Laws of Nature

DEMOS:
- spring-apart carts
- rocket propulsion
- Newton's cradle



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Momentum and collision question

PRS

You seek to knock down a heavy bowling pin by throwing a ball at it. You have two balls of equal size and mass, one of rubber and the other of putty. The rubber ball bounces back, while the putty sticks to the pin. Which is most likely to topple the bowling pin?

A. Rubber ball
B. Putty
C. No difference
D. Insufficient information

DEMO: Bouncy vs. "unbouncy" balls rolling down ramp with same velocity and hitting a stationary block

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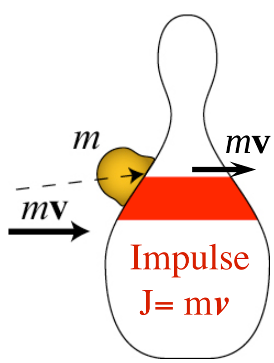

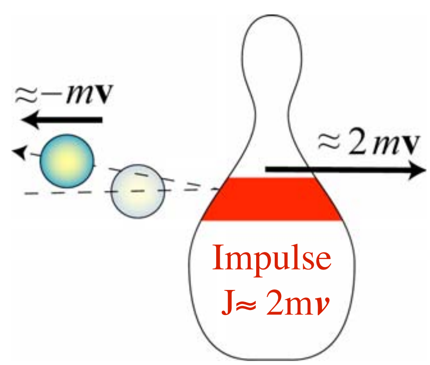

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Solving momentum conservation problems

PROBLEM-SOLVING STRATEGY 9.1 Conservation of momentum problems

PREPARE Clearly define *the system.*

- If possible, choose a system that is isolated ($\vec{F}_{net} = \vec{0}$) or within which the interactions are sufficiently short and intense that you can ignore external forces for the duration of the interaction (the impulse approximation). Momentum is then conserved.
- If it's not possible to choose an isolated system, try to divide the problem into parts such that momentum is conserved during one segment of the motion. Other segments of the motion can be analyzed using Newton's laws or, as you'll learn in Chapter 10, conservation of energy.

Following Tactics Box 9.1, draw a before-and-after visual overview. Define symbols that will be used in the problem, list known values, and identify what you're trying to find.

SOLVE The mathematical representation is based on the law of conservation of momentum: $\vec{P}_f = \vec{P}_i$. In component form, this is

$$(p_{1x})_f + (p_{2x})_f + (p_{3x})_f + \cdots = (p_{1x})_i + (p_{2x})_i + (p_{3x})_i + \cdots$$
$$(p_{1y})_f + (p_{2y})_f + (p_{3y})_f + \cdots = (p_{1y})_i + (p_{2y})_i + (p_{3y})_i + \cdots$$

ASSESS Check that your result has the correct units, is reasonable, and answers the question.

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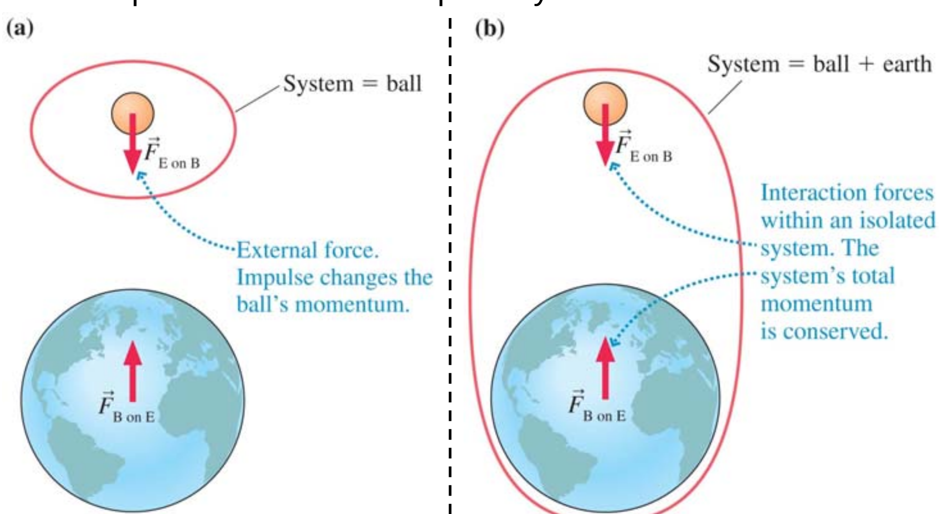
Isolated system

Isolated system: no forces from agents outside the system act on the "particles" that make up the system



System not isolated *Isolated system*

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Momentum problem 1

A 100 g bullet is fired horizontally into a 14.9 kg block of wood resting on a horizontal surface, and the bullet becomes embedded in the block. If the muzzle velocity of the bullet is 250 m/s, what is the speed of the block immediately after the impact? (neglect surface friction)

Know:
m_1 = 100g= 0.1kg
m_2 = 14.9kg
v_b = 250m/s
v_{block}= 0m/s

If we use conservation of momentum we can solve this problem (without knowing the rather complex details of the forces involved)

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Momentum problem 1

$$p_i = p_f$$

$$p_{bullet} + p_{block} = p_{bullet\ and\ block}$$

$$m_1 v_b + m_2 v_{block} = (m_1 + m_2) v_{final}$$

$$\frac{m_1 v_b + m_2 v_{block}}{(m_1 + m_2)} = v_{final}$$

$$v_{final} = \frac{0.1\ \text{kg}\ (250\ \text{m/s}) + (14.9\ \text{kg})(0\ \text{m/s})}{(0.1\ \text{kg} + 14.9\ \text{kg})}$$

$$v_{final} = 1.7\ \text{m/s}$$

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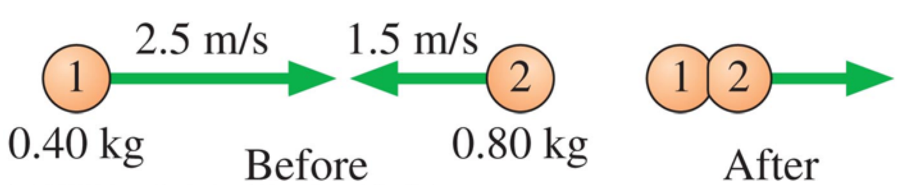
Momentum and collision question 2

PRS

The two particles shown collide and stick together. After the collision, the combined particles



A. Move to the right as shown above

B. Move to the left

C. Are at rest

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