Topic: Momentum

PHYSICS 231
Current Assignments

• Set 4 will be due this Thursday, Feb 10, 11 pm
• Set 5 open but due week after exam
• Midterm exam on Thursday 2/17
Reading Quiz

• What is Impulse:
  A. a force that is applied at a random time.
  B. a force that is applied very suddenly.
  C. Force multiplied with the time its applied
  D. the interval of time that a force lasts.

•
Reading Quiz

• What is momentum
  A: Mass times speed
  **B: Mass times velocity**
  C: Mass of a moving object
  D: Mass times acceleration
Key Concepts

• Momentum (Vector)
• Change of momentum is caused by a force applied for a time:
• Impulse
• Collision
• Momentum conservation and application to problem solving (pre- and post collision)
• Completely inelastic collisions
• Elastic collisions
Momentum

• Definition: $\vec{p} = m\vec{v}$

• Note:
  – Vector: magnitude $mv$, same direction as velocity
  – Components have sign! ($p_x > 0$ for motion in positive $x$-direction, $p_x < 0$ for motion in negative $x$-direction)
  – Definition is different from everyday use of word
Impulse

• Momentum is changed by force applied over time (here for x-component)
  \[ \Delta p_x = p_{xf} - p_{xi} = F_x \Delta t \]

• \( F_x \Delta t \) is also called impulse \( J_x \)

• Impulse is momentum change (vector!)

• Impulse approximation: often in collisions \( \Delta t \) is very small and \( F \) very large. Other forces can then be neglected.
Clicker quiz

• Which ball generates a larger force on the block when colliding:

A: Happy ball (bounces back)
B: Sad ball (sticks to block)
C: They generate the same force
Momentum conservation

• Isolated system: no force from the OUTSIDE acts on the system
• For isolated system $\vec{p}$ is constant
• This means $p_x$, $p_y$, and $p_z$ are constant
• Particularly useful for collisions: solve problems by setting equal total momentum of the system before and after the collision
Collisions

- Completely inelastic collision: colliding objects stick together.
  - Momentum is conserved, Kinetic energy not
- Elastic collision: objects bounce back
  - Momentum and kinetic energy are conserved
- Most collisions are not perfectly elastic (some energy is converted into heat) but often it’s a good approximation (for example a high quality bouncing ball)
Elastic collision

• Mass $m_1$ moves with velocity $v_{x1i}$ and hits mass $m_2$, which was at rest.

\[
v_{1xf} = \frac{m_1 - m_2}{m_1 + m_2} v_{1xi}
\]

\[
v_{2xf} = \frac{2m_1}{m_1 + m_2} v_{1xi}
\]

Where

$V_{1xf} = \text{final velocity of } m_1$

$V_{2xf} = \text{final velocity of } m_2$
Clicker Quiz

• What is the velocity of \( m_1 \) after the collision if \( m_1 = m_2 \)

A: \(-v_{x1i}\)
B: 0
C: \( \frac{1}{2} v_{x1i} \)
D: \( v_{x1i} \)
Clicker Quiz

• What is the velocity of $m_2$ after the collision if $m_1=m_2$

A: $-v_{x1i}$
B: 0
C: $v_{x1i}$
D: $\frac{1}{2} v_{x1i}$
E: $2 v_{x1i}$
Baron Muenchhausen

1720-1797