EA3 – Week 4

Momentum & Conservation of Momentum

Spring 2018

Note: QUIZ 1 is this week!
RQ 3  (Which are True?)

1. The symbol for momentum is P

2. Momentum of a mass in motion is mV

3. A force F applied for a time T yields a momentum change FT

4. Conservation of momentum is an approximation, like $F=kx$ or $F=\mu N$

5. Momentum is not useful for problems with friction
6. Momentum conservation for objects 1 and 2 can be written
   A. \( m_1v_1 + m_2v_2 = \text{force} \)   C. \( m_1gh_1 + m_2gh_2 = 0 \)
   B. \( m_1v_1 + m_2v_2 = \text{constant} \)   D. \( m_1gh_1 + m_2gh_2 = \text{constant} \)

7. After a perfectly plastic collision, two objects
   A. will move at the same velocity
   B. will move at different velocities
   C. will stop moving

8. In a perfectly elastic collision
   A. kinetic energy is conserved
   B. there is energy loss to heat
   C. momentum is not conserved
Today’s Outline: Momentum

- Definition
- Conservation of momentum
- Relative velocities
- Types of Collisions
- CQ’s
Momentum

- Linear momentum: \( P = mv \)
- Conservation of Momentum
  - External forces negligible
    (so \( \sum F_{\text{ext}} = m_{\text{tot}} \cdot a_{\text{CM}} = 0 \) too)
  - \( m_A v_{A1} + m_B v_{B1} = m_A v_{A2} + m_B v_{B2} \)
  - Velocities have direction (sign)
- Relative velocity
  - \( v_{A/B} = v_A - v_B \)
  - Careful with signs - do sanity check on values
Two shopping carts are initially at rest. They are frictionless and otherwise identical, *except* that one of them holds an additional giant watermelon so its mass is greater. The child in one cart heaves the watermelon to the child in the other cart. As a consequence the carts move apart. Afterwards:

(A) The "catching" cart (on the left) is moving faster.
(B) The "throwing" cart (on the right) is moving faster
(C) The carts have the same speed.
The hippo and the barge each weigh 1 ton. Initially the hippo is in the middle of the barge (both are stationary), which has length L. The hippo walks to the front of the barge and stops, and...

(A) He can now walk right onto the shore
(B) The barge is still moving toward the shore
(C) The barge is still moving away from the shore
(D) The barge is L/2 from the shore and stationary
(E) The barge is L/4 from the shore and stationary
The hippo, being near sighted and never having taken EA3, runs to the front of the barge at 2 m/sec (wrt barge) and falls off into the water, splashing quickly to a stop.

(A) The barge stops when the hippo falls off
(B) The barge stops when the hippo splashes to a stop
(C) The barge continues to move at 1 m/s
(D) The barge continues to move at 2 m/s
(E) This can’t happen
(F) It’s the rhinoceros that is famously nearsighted, not the hippopotamus!
Momentum and Collisions

- Conservation of Momentum
- Collisions: **Elastic vs Inelastic**
  - Apply conservation of momentum
    \[ m_A v_A + m_B v_B = m_A v'_A + m_B v'_B \]
  - Perfectly inelastic collision (plastic collision):
    \[ v'_A = v'_B \]
  - Elastic collision: KE conserved
  - General collisions:
    \[
    \frac{v'_B - v'_A}{v_A - v_B} = e
    \]
    e...coefficient of restitution \((0 \leq e \leq 1)\)

plastic

elastic
If all three collisions in the figure shown here are perfectly inelastic, which bring(s) the car on the left to a halt?
CQ 5

Suppose you are on a cart, initially at rest on a track with very little friction. You throw balls at a partition that is rigidly mounted on the cart. If the balls bounce straight back as shown in the figure, is the cart put in motion?

(A) yes, it moves to the right
(B) yes, it moves to the left
(C) no, it stays in place
(D) it depends
Two massless bumper boats float with negligible friction in a pool, and carry three children, as shown. Each child has mass, M.

The boats are initially moving towards each other but Boat #1 has a speed of V and Boat #2 has a speed of 1.5V.

The boats collide head-on and afterwards Boat #2 is stopped.

- What is the speed of Boat #1 after the collision? _______
- Deduce the coefficient of restitution of this collision.  e = ____
- What percentage of energy is lost during the collision? _____%