Class 3-5-1B

Tuesday, October 18, 2022 1:15 PM

Collisions

EF 151, Class 3-5

Summary

Type of Collision	Final Relative Velocity	Solution Strategy	e
Perfectly Inelastic	Zero; Objects move together	COM	0
Inelastic	Ratio between 0 and 1; defined by coefficient of restitution	COM and Coefficient of Restitution	0<e<1
Perfectly Elastic	Same magnitude as original relative velocity; opposite sign	COM and Relative Velocities	1

Real world

Bounciness

Conservation of Momentum (COM)

$$m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$$

Coefficient of Restitution

$$e = \frac{-(v_1' - v_2')}{v_1 - v_2}$$

e=1 perfectly elastic

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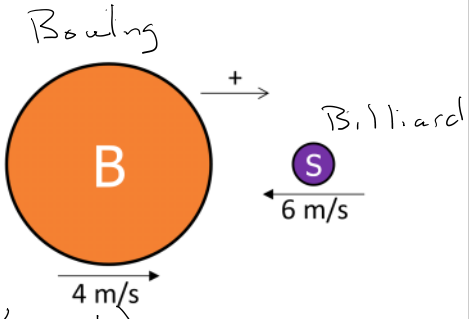
Coefficient of Resitiution

- The coefficient of restitution is the ratio of:
  - A. momentum
  - B. kinetic energy
  - C. relative velocity

Perfectly Elastic Collision

The big orange ball collides with the small purple ball in a perfectly elastic collision.

- **Determine $v'_{B,orange}$.** $4\ m/s$



- **Determine $v'_{S,purple}$.**

$$1.0 = \frac{-(V_1' - V_2')}{V_1 - V_2}$$

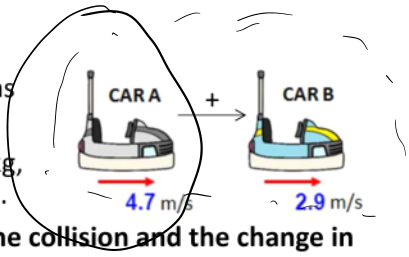
$$1.0 = \frac{-(4\ m/s - V_2')}{4\ m/s - (-6\ m/s)} = \frac{-4\ m/s + V_2'}{10\ m/s} = 1.0$$

$$V_2' = 14\ m/s$$

Practice 3-5-1

The bumper cars at an amusement park collide as one approaches the other directly from the rear.

The masses of Cars A and B are 420 kg and 478 kg, respectively. The coefficient of restitution is 0.65.



We want to find the velocity of each car after the collision and the change in momentum in each car.

- What two equations will we use to solve this problem? COM & COR
- What is the change in momentum of the system of Car A and Car B? No net external force COM
- What is the change in momentum of Car A? Negative

Practice 3-5-2

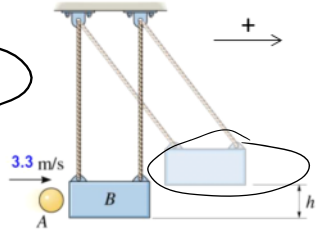
Tony throws a 2.3 kg ball at the suspended 16.6 kg block with a velocity of 3.3 m/s. The coefficient of restitution between the ball and the block is e = 0.73.

We want to find

(a) the velocity of the ball after the impact,

(b) the maximum height, h, to which the block will swing, and

(c) the percentage of kinetic energy lost during the collision.



State 1: Before ball hits block
State 2: Just after collision
State 3: Block at highest point

- What is conserved between state 1 and state 2? Only momentum
- What is conserved between state 2 and state 3? Energy

Two Minute Exam Drill

A 145 gram baseball is thrown at a speed of 41 m/s. The batter hits the ball so that it leaves the bat with a speed of 37 m/s. If the bat and ball are in contact for 0.0030 seconds, **determine the magnitude of the average force on the ball.** Assume the ball is moving horizontally just before and just after the collision.

Impulse Momentum

$F_{avg} \cdot t = mv_f - mv_i$

$F_{avg}(0.0035ec) = 0.145kg(-37 m/s) - 0.145kg(+41 m/s)$

$F_{avg} = 3770N = 847 lb$

Two Minute Exam Drill

perfectly inelastic

A 2 kg object at rest is struck by a 3 kg object moving at 8 m/s. The objects stick together after the collision. **Determine the amount of mechanical energy that was lost in the collision.**

COM $m_1v_1 + m_2v_2 = (m_1+m_2)v'$

$3kg(8 m/s) = (5kg)v'$

$\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 = \frac{1}{2}(m_1+m_2)(v')^2 + E_{loss}$

$\frac{1}{2}(3kg)(8 m/s)^2 = \frac{1}{2}(5kg)(v')^2 + E_{loss}$

$v' = 4.8 m/s \quad E_{loss} = 38.4J$

$4v_2 - 4v_2' = 6(5) - 6(7)$

$0.7v_2 + 1v_2' = 5 - 4.9$

Two Minute Exam Drill

$0.7v_2 + 1v_2' = 5 - 4.9$

Two Minute Exam Drill

A 6 kg object is moving at 7 m/s and strikes a 4 kg object that is moving at an unknown velocity. After the collision, the 6 kg object is moving at 5 m/s. The coefficient of restitution is 0.7. **Determine the initial and final velocity of the 4 kg object.**

COM $m_1 v_1 + m_2 v_2 = m_1 v_1' + m_2 v_2'$

$6kg(7 m/s) + 4kg(v_2) = 6kg(5 m/s) + 4kg(v_2')$

COR $e = \frac{-(v_1' - v_2')}{v_1 - v_2}$ $\quad 0.7 = \frac{-(5 m/s - v_2')}{7 m/s - v_2}$

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$0.7(7 - v_2) = 5 m/s + v_2'$

$4.9 - 0.7v_2 - 5 m/s = v_2'$