Physics 200 Name: _____

Momentum & Impulse: wrap-up and review

Coefficient of Restitution: tells how elastic a collision is; is a ratio of the separation speed of objects after a collision to their approach speed before the collision.

Coefficient of Restitution = $\frac{Separation\ Speed}{Closing\ speed}$

When e =1...

- objects separate as fast as they came together
- collision is **perfectly elastic.**
- No kinetic energy is lost.
- Example: A perfectly bouncy ball approaches the ground at 2m/s (closing speed) and then bounces back up with a speed of 2m/s (separation speed). e = 2/2

When e=0...

- objects do not separate
- the collision is **perfectly inelastic.**
- Kinetic energy is lost to friction.
- Example: a bullet approaches a ballistic pendulum at 500m/s (closing speed) and the bullet and pendulum then swing upward together (separation speed = 0; no separation). e =0/2

Coefficient of Restitution Formula = $e = \frac{V_b' - V_a'}{V_a - V_b}$ ...where Va = initial velocity of object A, Vb = initial velocity of object B, and Va' and Vb' = their final velocities.

When e=1, $V_b' - V_a' = V_a - V_b$

Example Problem:

Cart A has a mass of 4kg and an initial velocity of -2m/s. Cart B has a mass of 3kg and an initial velocity of 0m/s. If the carts collide with perfect elasticity (e=1), what are the carts' velocities after the collision?

$V_B' - V_A' = V_A - V_B$ $\quad V_B' - V_A' = -2m/s - 0m/s = -2m/s$

$V_B' = V_A' - 2m/s$

Using Cons of P:

$4kg(-2m/s) + 3kg(0m/s) = 4kg(V_A') + 3kg(V_B')$

$-8kg\,m/s = 4kg\,V_A' + 3kg(V_A' - 2m/s)$

$-8kg\,m/s = 4kg\,V_A' + 3kg\,V_A' - 6kg\,m/s$

$-2kg\,m/s = 7kg\,V_A'$

$V_A' = -0.29m/s$

$V_B' = -0.29m/s - 2m/s = -2.29m/s$

12. Boat A has a mass of 10kg and a velocity of 3m/s. Boat B has a mass of 15kg and a velocity of -1m/s. The two boats collide and bounce away from one another. After the bounce, boat B has a velocity of 1.4m/s.

a. What is the velocity of boat A after the bounce?

$-0.6\ m/s$

b. What impulse is experienced by boat A during the collision?

$F\Delta t = \Delta p = p_{Final} - p_{initial} = (-0.6\ m/s)(10\ kg) - (10\ kg)(3\ m/s) = -36\ kg\ m/s$

c. What impact force is felt by boat B?

$F(0.1\ s) = -36\ kg\ m/s$ $\quad F = 360N$

d. What impulse is experienced by boat B?

$36\ kg\ m/s$

e. What impact force is felt by boat A?

$F = -360N$

f. What is the coefficient of restitution for this collision?

$e = \frac{V_B' - V_A'}{V_A - V_B} = \frac{1.4\ m/s - (-0.6\ m/s)}{(3\ m/s) - (-1\ m/s)} = \frac{2\ m/s}{4\ m/s} = 0.5$

g. Is the collision elastic or inelastic?

$e < 1$

13. A 0.2kg projectile is fired at a 1kg ballistic pendulum. After the projectile embeds in the target, the pendulum and projectile swing upward a height of 0.4m. What was the initial velocity of the projectile (just before it hit the pendulum)?

$16.8\ m/s$

14. A catcher catches 0.145kg baseball traveling at 35m/s. If the catcher applies a stopping force of 500N to the ball, over what length of time does the catcher feel the ball's impact?

$F\Delta t = \Delta p = m\Delta v$

$-500N\ (t) = 0.145\ kg\ (-35\ m/s)$

$t = 0.01\ s$