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?

Review Questions and Problems:

1. State the Law of Conservation of Momentum.

2. When does the Law of Conservation of Momentum apply? When does it not apply?

3. The law of conservation of momentum applies to *closed* systems. With regard to momentum, what is a closed system?

4. When is mechanical energy conserved? When is it not conserved?

5. Define impulse and tell how the impulse experienced by an object relates to that object’s momentum.

6. Many protective devices reduce the impact force during collisions. Some examples include ski helmets, airbags, pools of water, and haystacks. Use the concepts of impulse and momentum to explain how these devices stop a moving object without damaging the object.

7. Explain the difference between an elastic collision and an inelastic collision.

8. Two objects collide with perfect **elasticity**. What does that tell us about their velocities before and after the collision?

9. Two objects collide with perfect **inelasticity**. What does that tell us about their velocities before and after the collision?

10. Why does the law of conservation of momentum apply to all collisions, whether they are elastic or inelastic?

11. Provide a quick description of each of the equations (top three rows) in the box on the right. Paraphrase what each equation is telling us.

**Good Stuff**

pA + pB = pA‛ + pB‛

F∆t = ∆p = m∆v

e = (vB‛ – vA‛)/(vA-vB)

e = 1 means perfectly elastic

e = 0 means perfectly inelastic

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. The collision lasts for 0.1 second, and after the bounce, boat B has a velocity of 1.4m/s.

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

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

 c. What impact force is felt by boat A?

 d. What impulse is experienced by boat B?

 e. What impact force is felt by boat B?

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

 g. Is the collision elastic or inelastic? How do you know?

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)?

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?