Physics Unit 4: Momentum Review

1. Know about impulse, momentum, Law of Conservation of Momentum, elastic, inelastic, kinetic energy, right-hand rule, angular momentum, moment of inertia
2. Know how to minimize force during a collision
3. What does changing the radius where the mass is located, change the angular momentum of an object?
4. Why is the total momentum of a system conserved when there is no net force on the system?
5. A 500-kg car runs into a tree. If it was traveling at 8 m/s right before it hit and the collision lasted 0.01 s, what was the average force between the car and the tree?
6. A 0.5-kg ball traveling at 20 m/s is hit by a baseball bat. After it is hit, it is traveling at 5 m/s in the opposite direction. What impulse was delivered to the ball?
7. A penguin is waddling at 0.5 m/s. If the penguin weighs 50 N, what is the magnitude of its momentum?
8. A 10-kg pitching machine at rest contains a 0.5-kg ball. When pitched, the ball leaves the machine with a speed of 40 m/s. What is the recoil speed of the machine?
9. A 1500-kg car traveling east at 10 m/s collides with a 1000-kg car traveling west at 12 m/s. The cars stick together after the collision. What is their common speed after the collision?
10. A 0.2-kg bird is flying 50 m above the ground at 15 m/s. What is the bird's kinetic energy?
11. Two identical marbles bounce off each other. The first marble's mass is 0.02 kg, its initial velocity was 3 m/s, and its final velocity was –2 m/s. The second marble's mass is 0.02 kg, its initial velocity was –1 m/s and its final velocity was 4 m/s. What type of collision occurred?
12. A 1200-kg car is stopped at a stop sign when it is hit in the back by a 2500-kg van. The two vehicles stick together after the accident. From the skid marks and measured coefficient of friction you calculate that the speed of both cars combined after the collision is 11 m/s. What was the speed of the van before the collision?
13. A ring is spinning on its central axis. Its mass is 2 kg, internal radius 0.8 m, and external radius is 1 m. What is its angular momentum when it is spinning at π rad/s?
14. A 5-kg solid disk is rotating around its axis at 13 rad/s when a second nonrotating solid disk with mass 2 kg is dropped on top so that they share the same axis. The first disk has radius 1 m and the second disk has radius 0.7 m. What is the final angular speed of disks?

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Answers

2. $F\Delta t = mv_2 - mv_1$: Increase the time of the collision or decrease the final speed by not letting it rebound
3. The angular momentum is related to the moment of inertia by $L = I\omega$. The moment of inertia is directly proportional to R^2. Increasing the radius increases the moment of inertia which increases the angular momentum.
4. $F\Delta t = mv_2 - mv_1$ If $F = 0$, then the change in momentum = 0.
5. $F\Delta t = mv_2 - mv_1$

   $F(0.01\ s) = (500\ kg)\left(0\frac{m}{s}\right) - (500\ kg)\left(8\frac{m}{s}\right)$

   $F = \mathbf{-400{,}000\ N}$
6. $F\Delta t = mv_2 - mv_1$

   $J = F\Delta t$

   $J = mv_2 - mv_1$

   $J = (0.5\ kg)\left(-5\frac{m}{s}\right) - (0.5\ kg)\left(20\frac{m}{s}\right)$

   $J = \mathbf{12.5\ kg\ m/s}$
7. $p = mv$

   $w = mg$

   $50\ N = m\left(9.8\frac{m}{s^2}\right)$

   $5.1\ kg = m$

   $p = (5.1\ kg)\left(0.5\frac{m}{s}\right) = \mathbf{2.55\frac{m}{s}}$
8. $m_b v_{b1} + m_m v_{m1} = m_b v_{b2} + m_m v_{m2}$

   $(0.5\ kg)\left(0\frac{m}{s}\right) + (10\ kg)\left(0\frac{m}{s}\right) = (0.5\ kg)\left(40\frac{m}{s}\right) + (10kg)v_{m2}$

   $0 = 20\ kg\frac{m}{s} + (10\ kg)v_{m2}$

   $-20\ kg\frac{m}{s} = (10\ kg)v_{m2}$

   $\mathbf{-2\frac{m}{s}} = v_{m2}$
9. $m_1 v_{11} + m_2 v_{21} = m_1 v_{12} + m_2 v_{22}$

   $(1500\ kg)\left(10\frac{m}{s}\right) + (1000\ kg)\left(-12\frac{m}{s}\right) = (1500\ kg)v_f + (1000\ kg)v_f$

   $3000\ kg\frac{m}{s} = (2500\ kg)v_f$

   $\mathbf{1.2\frac{m}{s}} = v_f$
10. $KE = \frac{1}{2}mv^2$

    $KE = \frac{1}{2}(0.2\ kg)\left(15\frac{m}{s}\right)^2 = \mathbf{22.5\ J}$
11. Check for conservation of KE

    $\frac{1}{2}m_1 v_{11}^2 + \frac{1}{2}m_2 v_{21}^2 = \frac{1}{2}m_1 v_{12}^2 + \frac{1}{2}m_2 v_{22}^2$

    $\frac{1}{2}(0.02\ kg)\left(3\frac{m}{s}\right)^2 + \frac{1}{2}(0.02\ kg)\left(-2\frac{m}{s}\right)^2 = \frac{1}{2}(0.02\ kg)\left(-1\frac{m}{s}\right)^2 + \frac{1}{2}(0.02\ kg)\left(4\frac{m}{s}\right)^2$

    $0.13\ J \neq 0.17\ J$

    KE is not conserved, so the collision is **inelastic**.
12. $m_c v_{c1} + m_v v_{v1} = m_c v_{c2} + m_v v_{v2}$

    $(1200\ kg)\left(0\frac{m}{s}\right) + (2500\ kg)v_{v1} = (1200\ kg)\left(11\frac{m}{s}\right) + (2500\ kg)\left(11\frac{m}{s}\right)$

    $(2500\ kg)v_{v1} = 40700\ kg\ m/s$

    $v_{v1} = \mathbf{16.3\frac{m}{s}}$
13. $L = I\omega$

    $I = \frac{M}{2}(R_1^2 + R_2^2)$

    $I = \frac{2\ kg}{2}((0.8\ m)^2 + (1\ m)^2) = 1.64\ kg\ m^2$

    $L = (1.64\ kg\ m^2)\left(\pi\frac{rad}{s}\right) = \mathbf{5.15\ kg\frac{m^2}{s}}$
14. $I_1\omega_{11} + I_2\omega_{21} = I_1\omega_{12} + I_2\omega_{22}$

    $I_1 = \frac{MR^2}{2} = \frac{(5\ kg)(1\ m)^2}{2} = 2.5\ kg\ m^2$

    $I_2 = \frac{MR^2}{2} = \frac{(2\ kg)(0.7\ m)^2}{2} = 0.49\ kg\ m^2$

    $(2.5\ kg\ m^2)\left(13\frac{rad}{s}\right) + (0.49\ kg\ m^2)\left(0\frac{m}{s}\right) = (2.5\ kg\ m^2)\omega_f + (0.49\ kg\ m^2)\omega_f$

    $32.5\ kg\frac{m^2}{s} = (2.99\ kg\ m^2)\omega_f$

    $\mathbf{10.9\frac{rad}{s}} = \omega_f$