Physics 50 workshop problems Chapter 8: Momentum, impulse and Collisions.

The most important concept of this chapter is the conservation of momentum. Momentum is . It is a vector, which means it has magnitude and direction, x and y components. Conservation of momentum in a collision means that , so the total of its x components have to be the same before and after the collision. The same goes for the y components. This will allow you to have two equations to solve for two unknowns, often the magnitude and direction of an object’s velocity after the collision.

In certain kinds of collisions, the kinetic energy is also conserved because none of it gets converted into other forms of energy. These idealized collisions are called “elastic.” In most realistic collisions, the kinetic energy goes into deforming the objects, making noise, etc. There is another kind of collision in which the objects stick together after they collide. This is called an inelastic collision. Here, the post-collision velocities of the two colliding objects are equal, because they now move together as one big object.

Force is related to momentum: Remember what  means? Now you can replace the ma with m’s change in momentum: , or if you’re talking about an average force over a discrete amount of time, you can use .

This week’s problems:

1. A soccer ball with a mass of 442 grams hits the top of the goal and is deflected upward at an angle of 58 degrees with respect to horizontal. Immediately after the collision, the kinetic energy of the ball is 49.5 J. What are the vertical and horizontal components of the ball's momentum immediately after the collision?

2. Lois Lane falls from a building and is then caught by Superman. Lois has a mass of 50.0 kg and at the moment she is caught, she is moving downward at 60.0 m/s. How much force much Superman exert on her if it takes him 0.100 to slow her to a stop? If the average human can only survive a force of 7g's (meaning, 7 times the acceleration due to gravity), what is the minimum amount of time that Superman should take to slow her down?

3. Imagine that there is an asteroid that will collide with earth unless we take dramatic action. This asteroid has a mass of 2.10x1010 kg and is heading toward earth at a speed of 12.0 m/s. The plan is to crash a rocket into it to stop its forward motion.

A) how fast would the rocket have to be going in order to stop the asteroid completely, if the collision is head-on?

B) given that the speed of light is 3x108 m/s, this approach may not work very well. An alternate plan is to deflect the asteroid's path by a tiny bit when it is far from the earth, which will cause the asteroid to miss the earth by the time it would have gotten here. If the rocket is traveling perpendicular to the asteroid's path at the moment of collision, how fast would the rocket have to be traveling to divert the asteroid's velocity vector by 1 degree?

4. A sled is sitting at rest on a flat ice rink (which can be considered frictionless). The sled's mass is 38.5 kg. Initially, it is carrying a 13.5 kg block which it then fires horizontally to the left with a speed of 13.6 m/s. What is the speed of the sled after it fires the block?

5. Two blocks, A and B, are connected by a spring. The blocks have masses 1.00 and 3.00 kg respectively. The blocks rest on a frictionless surface. The spring has a spring constant of 2500 N/m and is compressed by 3.00 cm from its equilibrium position. The blocks are not fastened to the spring so they are free to continue on their way after the spring does its thing. What are the speeds of block A and block B after the spring is released?

6. A 1439-kg railroad car is traveling at a speed of 12.0 m/s and strikes an identical car which is originally at rest. If they lock together as a result of the collision, what is their new speed?

7. A 2000.0-kg Cadillac and a 1000.0 kg Volkswagen crash into each other in an intersection. The Cadillac was originally moving north at 30.0 m/s and the Volkswagen was moving east at an unknown speed. The officer notices that the skid marks from the entangled mess of cars make an angle of 55.0 degrees north of east. How fast was the Volkswagen going before impact?

8. A 0.150-kg frame, when suspended from a coil spring, stretches the spring 0.07m. A 0.200-kg lump of putty is dropped from rest onto the frame from a height of 30.0 cm. Find the maximum distance the frame moves downward from its initial position.



Solutions to Chapter 8 problems

1. The x component of the momentum is 3.51 kg.m/s and the y component is 5.61 kg.m/s
2. The force that Superman exerts is 30,000 N which is 61 g’s. Ouch! The delta-t should be more like 0.875 second.
3. The rocket’s velocity would have to be 3.15x109 m/s to stop the asteroid in a head-on collision. This is kind of difficult because the speed of light is 3x108 m/s. If the rocket were to strike the asteroid at right angles and deflect it, the speed would only have to be 5.5x107 m/s, still kind of high but not violating the laws of physics!
4. Use conservation of momentum. The sled will move 4.77 m/s to the right.
5. The energy in the spring goes into the KE of the two masses. B moves at 0.433 m/s and A moves at 1.3 m/s.
6. Momentum is conserved: the final velocity after the collision is 6 m/s.
7. Conservation of momentum! This time you have both x and y components. This will give you two equations (one for each component) and two unknowns. One is the speed of the two cars stuck together (which comes out to be 24.41 m/s) and the other is the initial velocity of the volkswagen, which is 42 m/s toward the east.
8. You will have to use conservation of energy (where the energy is elastic, potential and kinetic), and the two times you’re comparing are before the putty falls and after the spring extends its furthest amount) and also conservation of momentum (where the two times are right before the putty hits and right after it sticks to the tray. The important thing is that gravity doesn’t have time to do anything). The answer is 0.295 meter