AP Physics 1
5.1 – The Impulse-Momentum Theorem
5.2 – The Principle of Conservation of Linear Momentum
Assessment

Name: _____ Period: _____

Concepts

1) Six runners have the mass (in multiples of m_o), speed (in multiples of v_o), and direction of travel that are indicated in the table. Which two runners have identical momentum? Why?

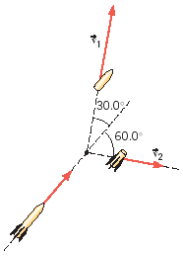
Runner	Mass	Speed	Direction of Travel
A	$\frac{1}{2}m_0$	v_0	Due north
B	m_0	v_0	Due east
C	m_0	$2v_0$	Due south
D	$2m_0$	v_0	Due west
E	m_0	$\frac{1}{2}v_0$	Due north
F	$2m_0$	$2v_0$	Due west

2) As we discussed in class, Conservation of Linear Momentum only applies when the system of objects is an isolated system. Consider the five systems below and indicate whether each is an isolated or nonisolated system:
   a. A ball is dropped from the top of a building. The system is the ball.
   b. A ball is dropped from the top of a building. The system is the ball and Earth.
   c. A billiard ball collides with a stationary billiard ball on a frictionless pool table. The system is the moving ball.
   d. A car slides to a halt in an emergency. The system is the car.
   e. A space probe is moving in deep space where gravitational and other forces are negligible. The system is the space probe.

Problems

3) Consider two forces, each producing the same impulse. However, $\mathbf{F_2}$ has a magnitude that is 1/3 that of $\mathbf{F_1}$. You may consider both forces to be average forces, meaning you do not need to consider changes that act within the impulse. $\mathbf{F_1}$ acts for a time interval of 3.2 ms. What is the time interval in which $\mathbf{F_2}$ acts?
4) Cars are often rated by their performance, usually determined by outside companies. In these tests, engineers not only check for safety but also verify the manufacturer's claims, such as acceleration and braking. Consider two cars in a performance test. The first car, Car A, has a mass of 1400 kg, while Car B is 500 kg more massive. Both cars take 9.0 s to accelerate to 27 m/s from rest. Find the net average force that acts on each car during the test.
5) In this problem you may neglect the effects of gravity and air resistance. A popular hobby, especially here in Florida where NASA is located, is the building of model rockets. The average mass of a constructed model rocket is 0.175 kg. Most store-bought rocket motors for such kits produce an impulse of 29.0 N-s. If a model rocket were constructed using these specifications, what is its final speed when launched from rest?
6) The Jet Propulsion Laboratory in California is responsible for the trajectory of a planetary probe designed to explore the outer planets in our solar system. For much of its journey, it is traveling with a momentum that has a magnitude of 7.5×10^7 kg-m/s. At the appropriate time, it is programmed to fire a retrorocket to slow it down so that it may achieve orbit around a planet. The force of this retrorocket has a magnitude of 2.0×10^6 N and fires for 12 s. What is the momentum of the probe after the retrorocket ceases to fire?

7) Athletes and coaches alike know that serious injury can occur if you try to run or jump stiff-legged. You now have the understanding to apply physics to the body to reduce the possibility of injury: By bending your knees upon landing in any kind of physical activity (thus reducing the force of the impact). Let us consider the case of a pole-vaulter (m = 75.0 kg) just before making contact with the ground after his jump (v_i = 6.4 m/s).
    a. In a stiff-leg landing, the pole-vaulter comes to rest in 2.0 ms. What average force acted on him during?
    b. If the same pole-vaulter bent his knees upon landing, he comes to a halt in 0.10 s. What is the average force that acted upon him when he bent his knees upon landing?
    c. The net force acting on the pole-vaulter includes both gravity and the normal force when he lands, find the force of the ground on the pole-vaulter in parts (a) and (b).
8) A 63.0 kg branch falls from a tree and strikes the ground, coming to rest in 0.040 s. The average force exerted on it by the ground is +18,000 N (let up be positive). Assuming that the only force acting on the branch is the ground, from what height did it fall?
9) After being dropped from a height of 1.20 m above a floor, a 0.500 kg ball rebounds to a height of 0.700 m. What is the impulse (magnitude and direction) of the net force applied to the ball during the collision with the floor?
10) An airtrack can provide a frictionless surface. Consider a 2.3 kg puck sliding across a horizontal airtrack toward a second puck of mass1.5 kg. Both pucks are equipped with magnets that cause them to attract and accelerate toward each other, causing each puck to undergo an acceleration toward the other. Just before the two pucks collide, the first puck has a velocity of +4.5 m/s, while the second puck, initially at rest, has accelerated to a velocity of -1.9 m/s. The two pucks collide.
    a. What is the total momentum of the system of the two pucks at the instant of collision?
    b. What was the velocity of the first puck when the second puck was still at rest?
11) During a Jaguars football game, a receiver just caught a pass (it can happen!). However, being a Jaguars player, he just stands there before being grabbed by a tackler (m = 115 kg) moving at a velocity of +4.5 m/s. The tackler holds onto the receiver, and the two move with a velocity of +2.6 m/s. Assuming that momentum is conserved, find the mass of the receiver.
12) Little Johnny got a wagon for Christmas and, with the beautiful Florida weather, is excited to go outside to play with it. He climbs into the wagon with his new softball and his father gives him a push along level ground with a speed of 0.500 m/s. The total mass of the system, which includes the wagon, Johnny, and the softball, is 95.0 kg, of which 0.300 kg is the softball. Relative to the ground (watch your reference frames!), Johnny throws his softball with a speed of 16.0 m/s. Find the final speed of Johnny and the wagon when
    a. the softball is thrown directly forward; and b. when the softball is thrown directly backward.
13) Some of the more advanced model rocket kits can break into pieces to simulate the dropping of stages, like the real Apollo rockets of the 1960s and 1970s. Consider one such model rocket moving at a speed, relative to the ground, of 45.0 m/s. It breaks into two pieces, each of equal mass. These two pieces fly off with velocities $\mathbf{v_1}$ and $\mathbf{v_2}$, as indicated below. Find the magnitudes (speeds) of each piece.



14) Let's reconsider the case of two skaters, facing each other and initially at rest, pushing against each other and moving away in opposite directions. During the period of time when the skaters are pushing on each other, you may ignore any friction acting on the skates. Once the skaters separate, however, kinetic friction can no longer be ignored and the two skaters will eventually come to rest. While the magnitudes of their accelerations are equal, skater 1 glides twice as far as skater 2. What is the ratio, m_1/m_2, of their masses?