Momentum and Impulse Problem Set

1) In one dimension, object 1, a 10 kg mass moving at 5 m/s, collides elastically with object 2, another 10 kg mass, which is moving at -1 m/s. After the collision, object 1 is moving at 3 m/s. What is the final velocity of object 2?

   a. -2 m/s
   b. 1 m/s
   c. 2 m/s
   d. collision is impossible as stated

2) A woman standing on a frictionless surface throws a ball of mass 1 kg to the left with velocity 10 m/s. Her mass is 50 kg. What is her final velocity?

   a. .2 m/s to the right
   b. 5 m/s to the left
   c. 5 m/s to the right
   d. 2 m/s to the right

3) Which of the following units would apply to a quantity of momentum?

   a. $N \cdot s$
   b. $N \cdot \frac{s}{m^1}$
   c. $kg\frac{m}{s}$
   d. more than one of the above

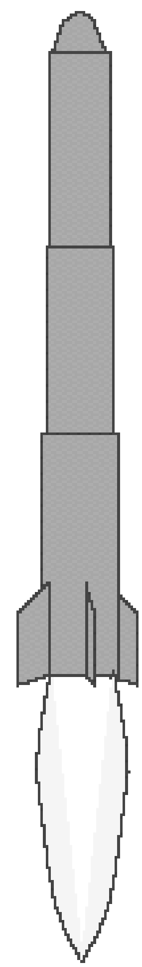
4) A physicist working with sub-atomic particles carries out the collision of a neutron with a helium nucleus (alpha particle). He subsequently notices the emission of gamma radiation. What can he conclude about the collision?

   a. the collision was elastic
   b. the collision was inelastic
   c. the collision was superelastic
   d. not enough information to determine

5) Which of the following scientific principles does the law of conservation of momentum directly follow from?

   a. Newton's third law of motion
   b. the law of conservation of mechanical energy
   c. the law of inertia for single bodies
   d. more than one of the above

The following passage pertains to questions 6-10



Rocket propulsion may be understood in terms of conservation of momentum. The gaseous products of combustion ejected from the engine are in possession a certain momentum. This matter (the fuel), prior to combustion, had been in motion with the entire rocket. Now these gases move with a velocity different than that of the center of mass of the entire system (rocket and all fuel, before and after combustion). A compensation occurs so that the total momentum of the system remains constant. The rocket accelerates in a direction opposite to the motion of the gaseous exhaust.

Conservation of momentum implies that the center of mass of the entire system maintains constant velocity. As the rocket accelerates in the forward direction it loses mass as combusted fuel in the opposite direction. For short time intervals, this relationship may be approximated, becoming true at $\lim \Delta t \to 0$:

$$M \, \Delta v_r = v_e \, m$$

M = mass of rocket + fuel prior to interval
v_r = speed of rocket
v_e = speed of expelled gases
m = mass of fuel combusted during interval

From the above equation may be derived an exact expression that relates the initial and final speed of the rocket to its initial and final mass (before and after combustion of all fuel):

$$v_f - v_i = 2.303 \, v_e \log\left(\frac{M_i}{M_f}\right)$$

6. The system described in the above passage consists of:

a. the rocket and its fuel both prior to and after combustion
b. the rocket
c. the rocket and its fuel only before combustion, not after
d. the rocket, its fuel before combustion, and the universe

7. Which of the following statements is true?

a. after engines are fired, the center of mass of a rocket moves with constant velocity
b. the velocity of the rocket must equal the velocity of the expelled gases
c. in all cases, the center of mass of the system maintains constant position
d. none of the above

8. A rocket undergoes lift-off from earth. Its initial mass (rocket + uncombusted fuel) equals 400,000 kg. Combusted fuel is expelled at a rate of 6 X 10^3 m/s. After 5 seconds, 10,000 kg of fuel have been consumed. Ignoring air friction, which of the following expressions best describes the motion of the rocket at this time?

a. $$v = \frac{(6 \times 10^3\ \frac{m}{s})\ (1 \times 10^4\ kg)}{4 \times 10^5\ kg}$$

b. $$v = \frac{(6 \times 10^4\ \frac{m}{s})\ (1 \times 10^3\ kg)}{4 \times 10^5\ kg}$$

c. $$v = 2.303\ (6 \times 10^3\ \frac{m}{s})\ \log\left(\frac{4 \times 10^5}{3.9 \times 10^5}\right) - 50\ \frac{m}{s}$$

d. $$v = 2.303\ (6 \times 10^3\ \frac{m}{s})\ \log\left(\frac{4 \times 10^5}{3.9 \times 10^5}\right)$$

9. The rocket engines of an interplanetary probe at rest in outer space are fired. If the mass of probes machinery is 1/9 the mass of its fuel, after all of the fuel has been consumed:

a. the speed of the probe will 9 times greater than the speed at which combusted gases were expelled
b. the speed of the probe will be 1/9 the speed at which combusted gases were expelled.
c. the speed of the probe will be a little more than twice the speed at which combusted gases were expelled.
d. it is necessary to know the length of time the rockets were fired.