Momentum and Impulse Problems

1. An ostrich with a mass of 146kg is running to the right with a velocity of 17m/s. Find the momentum of the ostrich.

2. A 21kg child is riding a 5.9kg bike with a velocity of 4.5m/s to the northwest.
   a. What is the total momentum of the child and the bike together?

   b. What is the momentum of the child?

   c. What is the momentum of the bike?

3. A 0.50kg football is thrown with a velocity of 15m/s to the right. A stationary receiver catches the ball and brings it to rest in .020s. What is the force exerted on the receiver?

4. An 82kg man drops from rest on a diving board 3m above the surface of the water and comes to rest .55s after reaching the water. What force does the water exert on him?

5. A 0.40kg soccer ball approaches a player horizontally with a velocity of 18m/s to the north. The player strikes the ball and causes it to move in the opposite direction with a velocity of 22m/s. What impulse was delivered to the ball by the player?

6. A 0.50kg object is at rest. A 3N force to the right acts on the object during a time interval of 1.5s.
   a. What is the velocity of the object at the end of this interval?

   b. At the end of this interval, a constant force of 4N to the left is applied for 3s. What is the velocity at the end of the 3s.

7. A 2500 kg car traveling to the north is slowed down uniformly from an initial velocity of 20m/s by a 6250N braking force acting opposite the car's motion. Use the impulse-momentum theorem to answer the following questions.
   a. What is the car's velocity after 2.5 s?
   b. How far does the car move during 2.5s?
   c. How long doe sit take the car to come to a complete stop?
8. The speed of a particle is doubled.
   a. By what factor is its momentum changed?
   b. What happens to its kinetic energy?
9. Tyler claims he can throw a 0.145kg baseball with as much momentum as a speeding bullet. Assume that a 3g bullet moves at a speed of 1500m/s.
   a. What must the baseball's speed be if Tyler's claim is valid?
   b. Which has greater kinetic energy, the ball or the bullet?
10. A 0.42kg soccer ball is moving downfield with a velocity of 12m/s. Palmer kicks the ball so that it has a final velocity of 18m/s downfield.
   a. What is the change in the ball's momentum?

Momentum and Impulse Problems

1. An ostrich with a mass of 146kg is running to the right with a velocity of 17m/s. Find the momentum of the ostrich.
   a. Given:
      i. m=146kg, v=17m/s to the right, p=????
   b. Formula to use
      i. p=mv
   c. p=(146kg)(17m/s)
      i. p=2500kg m/s to the right

2. A 21kg child is riding a 5.9kg bike with a velocity of 4.5m/s to the northwest.

Given: m_1=21kg, m_2=5.9kg, v=4.5m/s to the northwest

   a. What is the total momentum of the child and the bike together?
      i. Formulas to use
         1. $p_{tot}=m_{tot}v=(m_1+m_2)v$
      ii. t_{tot}=(21kg+5.9kg)(4.5m/s)
      iii. p_{tot}=(27kg)(4.5m/s)
      iv. p_{tot}=120kg m/s to the northwest

   b. What is the momentum of the child?
      i. Formulas to use
         1. $p_1=m_1v$
      ii. p_1=21(kg)(4.5m/s)
      iii. p_1=94kg m/s to the northwest

   c. What is the momentum of the bike?
      i. Formulas to use
         1. $p_2=m_2v$
      ii. p_2=(5.9kg)(4.5m/s)
      iii. p_2=27kg m/s to the northwest

3. A 0.50kg football is thrown with a velocity of 15m/s to the right. A stationary receiver catches the ball and brings it to rest in .020s. What is the force exerted on the receiver?
   a. Given
      i. m=.50kg, v_i=15m/s to the right, Δt=.020s, v_f=0m/s
   b. Formulas to use
      i. $$F_{onball}=\frac{mv_f-mv_i}{\Delta t}=\frac{(0.50kg)(0m/s)-(0.50kg)(15m/s)}{0.020s}$$
      ii. $F_{on\ ball}$=-380N or 380N to the left
      iii. $F_{on\ receiver}=-F_{on\ ball}$=-(-380N)=380N to the right

4. An 82kg man drops from rest on a diving board 3m above the surface of the water and comes to rest 0.55s after reaching the water. What force does the water exert on him?
   a. Given

i. m=82kg, Δy=-3.0m, Δt=0.55s, v_i=0m/s, a=-9.81m/s^2

b. Formulas to use

i. $v_f = \pm\sqrt{2a\Delta y} = \pm\sqrt{(2)(-9.81m/s^2)(-3.0m)} = \pm 7.7m/s = -7.7m/s$

c. Now let's calculate the force during the time the man is in the water.

i. Given

1. v_i=7.7m/s downward = -7.7m/s, v_f=0m/s

ii. Formulas to use

1. $F = \frac{mv_f - mv_i}{\Delta t}$

iii. $F = \frac{(82kg)(0m/s)-(82kg)(-7.7m/s}{0.55s}$

iv. F=1100N upward

5. A 0.40kg soccer ball approaches a player horizontally with a velocity of 18m/s to the north. The player strikes the ball and causes it to move in the opposite direction with a velocity of 22m/s. What impulse was delivered to the ball by the player?

a. Given

i. m=0.40kg, v_i=18m/s to the north (positive), v_f=22m/s to the south (negative)

b. Formulas to use

i. $\Delta p = mv_f - mv_i$

ii. Δp=(0.40kg)(-22m/s)-(0.40g)(18m/s)

iii. Δp=-8.8kg m/s - 7.2kg m/s

iv. Δp=16kg m/s to the south

6. A 0.50kg object is at rest. A 3N force to the right acts on the object during a time interval of 1.5s.

Given: m=0.50kg, F_1=3N to the right, Δt_1=1.50s, $v_{i,1}$ = 0m/s, F_2=4N to the left (negative), Δt_2=3s, $v_{i,2}$=9m/s to the right (positive)

a. What is the velocity of the object at the end of this interval?

i. Formulas to use

1. $v_{f,1} = \frac{F_1\Delta t_1 + mv_{i,1}}{m} = \frac{(3N)(1.5s)+(0.50kg)(0m/s)}{.50kg}$

2. $v_{f,1}$=9m/s to the right

b. At the end of this interval, a constant force of 4N to the left is applied for 3s. What is the velocity at the end of the 3s?

i. Formulas to use

1. $v_{f,2} = \frac{F_2\Delta t_2 + mv_{i,2}}{m} = \frac{(-4N)(3s)+(0.50kg)(9m/s)}{.50kg}$

2. $v_{f,2} = \frac{-12kg\bullet m/s + 4.5kg\bullet m/s}{0.50kg} = \frac{-7.5kg\bullet m/s}{0.50kg} = -15m/s$

3. $v_{f,2}$=15m/s to the left

7. A 2500 kg car traveling to the north is slowed down uniformly from an initial velocity of 20m/s by a 6250N braking force acting opposite the car's motion. Use the impulse-momentum theorem to answer the following questions.

Given: m=2500kg, v_i=20m/s to the north (positive), F=6250N to the south (Negative), Δt=2.50s

a. What is the car's velocity after 2.5 s?
   i. Formulas to use
      1. $$v_f = \frac{F\Delta t + mv_i}{m} = \frac{(-6250N)(2.5s) + (2500kg)(20m/s)}{2500kg}$$
      2. $$v_f = \frac{(-1.56\times10^4 kg \bullet m/s) + (5\times10^4 kg \bullet m/s}{2500kg} = \frac{3.4\times10^4 kg \bullet m/s}{2500kg}$$
      3. v_f=14m/s to the north

b. How far does the car move during 2.5s?
   i. Formulas to use
      1. $$\Delta x = \frac{1}{2}(v_i + v_f)(\Delta t) = \frac{1}{2}(20m/s + 14m/s)(2.5s)$$
      2. $$\Delta x = \frac{1}{2}(34m/s)(2.5s)$$
      3. Δx=42m to the north

c. How long does it take the car to come to a complete stop?
   i. Formulas to use
      1. $$\Delta t = \frac{mv_f - mv_i}{F} = \frac{(2500kg)(0m/s) - (2500kg)(20m/s)}{-6250N} = 8s$$

8. The speed of a particle is doubled.
   a. By what factor is its momentum changed?
      i. Momentum increases by a factor of two
   b. What happens to its kinetic energy?
      i. kinetic energy increases by a factor of four

9. Tyler claims he can throw a 0.145kg baseball with as much momentum as a speeding bullet. Assume that a 3g bullet moves at a speed of 1500m/s.

Given: m_1=0.145kg, m_2=3g, v_2=1500m/s

a. What must the baseball's speed be if Tyler's claim is valid?
   i. Formulas to use
      1. $m_1v_1=m_2v_2$
   ii. Solving for v_1, rearrange formula
      1. $$v_1 = \frac{m_2v_2}{m_1} = \frac{(0.003kg)(1500m/s)}{0.145kg}$$
      2. v_1=31m/s

b. Which has greater kinetic energy, the ball or the bullet?
   i. Formulas to use

1. $KE_1 = \frac{1}{2}m_1v_1^2 = \frac{1}{2}(0.145kg)(31m/s)^2 = 69.7J$
2. $KE_2 = \frac{1}{2}m_2v_2^2 = \frac{1}{2}(0.003kg)(1500m/s)^2 = 3380J$

ii. $KE_2 > KE_1$ Bullet has greater kinetic energy

10. A 0.42kg soccer ball is moving downfield with a velocity of 12m/s. Palmer kicks the ball so that it has a final velocity of 18m/s downfield.
    a. What is the change in the ball's momentum?
        i. Given:
            1. m=0.42kg, v_i=12m/s downfield, v_f=18m/s downfield, Δt=0.020s
        ii. Formulas to use
            1. $\Delta p = mv_f - mv_i$
            2. Δp=(0.42kg)(18m/s)-(0.42kg)(12m/s)
            3. Δp=7.6kg m/s-5kg m/s
            4. Δp=2.6kg m/s downfield