Momentum
Worksheet 1

1. Two objects, A & B, have identical velocities. Object A has 3 times the mass of object B. Compare the momentum of each object. Justify your answer.

3mv vs mv
Object A has 3 times the momentum

2. Two other objects, C and D, have identical masses. Object C has twice the velocity of object D. Compare the momentum of each object. Justify your answer.

m2v vs mv
Object C has 2 times the momentum

3. While being thrown, a net force of 132 N acts on a baseball (mass = 140g) for a period of 4.5×10^{-2}sec. What is the magnitude of the change in momentum of the ball?

$Ft = \Delta p$

So $132 \times (4.5 \times 10^{-2}) = 5.94 \text{ kg ms}^{-1}$

4. If the initial speed of the baseball in question 3 is $v_0 = 0.0$ m/s, what will its speed be when it leaves the pitcher's hand?

$5.94 = m\Delta v$

$\Delta v = \frac{5.94}{0.14} = 42.43 \text{ m/s}$

5. When the batter hits the ball, a net force of 1320 N, opposite to the direction of the ball's initial motion, acts on the ball for 9.0×10^{-3} s during the hit. What is the change in momentum of the ball? What is the final velocity of the ball?

$\Delta p = Ft = 1320(9 \times 10^{-3}) = 11.9 \text{ kg m s}^{-1}$

Assuming zero air resistance

$11.9 - 5.94 = 5.94$ back towards pitcher.

$mv = 5.94$

$v = \frac{5.94}{0.14}$

$v = 42.43 \text{ m/s}$

6. What force does the ball exert on the bat in the question above? Explain.

By Newtons 3rd law, 1320 N

7. A golf ball that weighs 0.45 N is dropped from a height of 1.0 m. Assume that the golf ball has a perfectly elastic collision with the floor.

a. Determine the time required for the ball to reach the floor.

$u = 0$ $\quad s = ut^0 + \frac{1}{2}at^2$

$a = -9.8$ $\quad t = \sqrt{\frac{2s}{a}} = \sqrt{\frac{2(-1)}{-9.8}} = 0.451\,s$

$s = -1$

b. What will the instantaneous momentum of the golf ball be immediately *before* it strikes the floor?

$v = u + at$

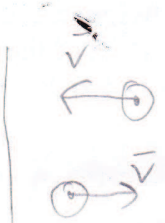
$v = 0 - 9.8(0.451)$

$v = -4.42\ ms^{-1}$

$\Delta p = Ft = 0.45(0.451)$

$p = 0.203\ kg\ ms^{-1}$

c. What will be the change in momentum, (Δ**p**) from the instant before the ball collides with the floor until the instant after it rebounds from the floor? (Illustrate with a vector diagram.)



Elastic = no loss of k.E = Same speed

So all momentum one way → momentum other way

$\Delta p = 2 \times 0.203 = 0.406\ kg\ ms^{-1}$

d. Suppose that the golf ball was in contact with the floor for 4.0×10^{-4} s. What was the average force on the ball while it was in contact with the floor?

$\Delta p = Ft$

$0.406 = \bar{F}(4 \times 10^{-4})$

$\bar{F} = 1015\ N$

Name_____

Date _____ Pd____

Worksheet 2

1. Kim holds a 2.0 kg air rifle loosely and fires a bullet of mass 1.0 g. The muzzle velocity of the bullet is 150 m/s. What is the recoil speed of the rifle?

$(m_1v_1 + m_2v_2)_{before} = m_1v_1 + m_2v_2$ after

$0 = 2v_1 + 0.001(150)$

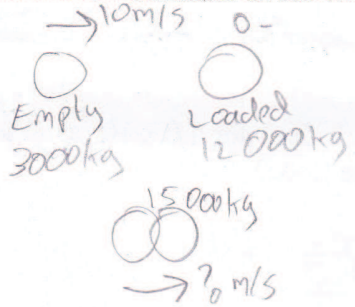
$v_1 = \frac{0.001(150)}{2} = 0.075\ ms^{-1}$

2. If the girl in the previous question holds the rifle tightly against her body, the recoil speed is less. Explain. Calculate the new recoil speed assuming the girl has a mass of 48 kg.

$v_1 = \frac{(0.001)(150)}{(2+48)} = 0.003\ ms^{-1}$

The mass of the object recoiling is greater.

3. In a freight yard a train is being put together from freight cars. An empty freight car, coasting at 10 m/s, strikes a loaded car that is stationary and the cars couple together. Each of the cars has a mass of 3000 kg when empty, and the loaded car contains 12,000 kg of canned soda. With what speed does the combination of the two cars start to move?



$m_1v_1 + m_2v_2 = (m_1 + m_2)v$

$3000(10) + 12000(0) = (15000)v$

$v = \frac{3000(10)}{15000} = 2\ ms^{-1}$

5. A tennis player returns a 30. m/s serve straight back at 25. m/s, after making contact with the ball for 0.50 s. If the ball has a mass of 0.20 kg, what is the force she exerted on the ball?

$Ft = \Delta mv \left(= m(v_f - v_i)\right)$

$F = \frac{\Delta mv}{t} = \frac{0.2(25 - -30)}{0.5} = \frac{0.2(55)}{0.5} = 22\ N$

6. A 50. kg cart is moving across a frictionless floor at 2.0 m/s. A 70. kg boy, riding in the cart, jumps off so that he hits the floor with zero velocity.

   a. What impulse did the boy give to the cart?

$I = \Delta mv = 70(2) = 140 \text{ kg ms}^{-1}$

OR

$(m_1+m_2)v_i = m_1 v_f$

$(50+70)2 = 50 v_f$

$v_f = 4.8 \text{ ms}^{-1}$

$I = m\Delta v$

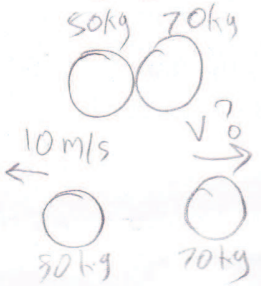
$= 50(4.8-2)$

$I = 140 \text{ kg ms}^{-1}$

   b. What was the velocity of the cart after the boy jumped?

$v_f = 4.8 \text{ ms}^{-1}$

7. Two girls with masses of 50.0 kg and 70.0 kg are at rest on frictionless skates. The larger girl pushes the smaller girl so that the latter rolls away at a speed of 10.0 m/s. What is the effect of the action on the larger girl? What is the impulse that each girl exerts on the other?



Larger girl moves in the opposite direction

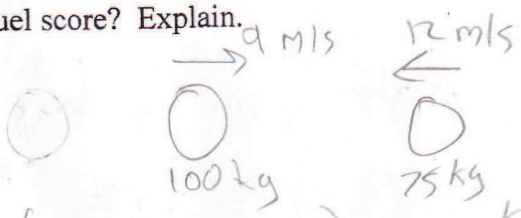
$0 = 50(10) + 70v$

$v = \frac{50(10)}{70} = 7.14 \text{ m/s}$

$I = \Delta mv = 70(7.14)$

$= 500 \text{ kg ms}^{-1}$

9. Mighty Miguel has a mass of 100. kg and is running towards the end zone at 9.0 m/s. Joey Gonzales (mass of 75.0 kg), runs at 12.0 m/s towards Miguel. They collide at the 2-yard line. Does Miguel score? Explain.



$(m_1v_1 + m_2v_2)_{\text{before}} = (m_1+m_2)v$

$v = \frac{100(9) + 75(-12)}{(175)} = 0$

No remaining momentum (or velocity) so no

Energy and Momentum Test Practice

__ 1. A car moving at 15 m/s skids to a stop in 20m. If the car travels at 45 m/s, how far will it skid, assuming the same constant braking force?

a. 20 m.
b. 50 m.
c. 90 m.
d. 120 m.
e. 180 m.

$W = Fd = \frac{1}{2}mv^2$

$F = \frac{mv^2}{2d}$ $\quad \frac{m(15^2)}{2(20)} = \frac{m(45^2)}{2d}$

$d = \frac{2(20)(45^2)}{2(15^2)} = 180\text{m}$

__ 3. A crate is dragged across a floor at constant speed. The work done on the system can be accounted for by

a. Elastic Potential Energy
b. Kinetic Energy
c. GPE
d. Dissipated energy (heat energy lost)
e. both b and d

4. A 30 kg box sits at the top of a 30° incline, 5.0 m above the floor. How fast will it be moving at the bottom of the ramp if the surface is *frictionless*?

Longer way:
1. Use $F_{net} = ma$ to get a.
2. use const. accel equations to get v_f

Shorter way:

$mgh = \frac{1}{2}mv^2$

$v = \sqrt{2gh}$

$v = \sqrt{2(9.8)(5)}$

$v = 9.9\ \text{m/s}$

5. How much energy will be dissipated if $F_f = 25$ N?

$W = F_f d = 25(10) = 250\text{J}$

Work done by friction

$\sin 30 = \frac{5}{h}$

$h = \frac{5}{\sin 30} = 10\text{m}$

6. How fast will it be going at the bottom of the hill?

$mgh = \frac{1}{2}mv^2 + W_{friction}$

$30(9.8)5 = \frac{1}{2}(30)v^2 + 250$

$v = \sqrt{\frac{30(9.8)(5) - 250}{15}} = 9.02\ \text{m/s}$