04-02 Conservation of Momentum Lab **Name: _____**

Adapted from Take-Home Physics by Michael Horton

Objective

- What affects the velocity of objects that push off each other?

Materials

- 2 Glass marbles
- Metal marble
- Grooved ruler
- Stiff playing card
- Balance

Procedure

In this lab, you will be having two marbles push off each other. To measure velocity, you will let the marbles roll for the same amount of time. $x = vt$ is an equation you have used before. The equation shows that velocity is directly proportional to distance. If two marbles roll for the same time, then their distance can be used for their velocity in units of cm/time.

1. Find a flat surface by placing the ruler on the surface and putting a marble in the groove. If it does not move, then the surface is flat. You may be able to rotate the ruler to find an orientation that is horizontal.
2. Gently fold the playing card in half so that it springs back when released. This will be used to launch the marbles.
3. To verify that you are operating the launcher correctly, use two of the same marbles and launch them from the center of the ruler. Since they have the same mass and force, they should reach the ends of the ruler at the same time.
4. Practice using the launcher several times. Squeeze the card in the middle, put one marble on each side, and release the card. The marbles should take off in opposite directions.
    a. Do not hold the card in your hand; release it. The marbles must push off each other, not your hand.
    b. The strength of the launcher does not really matter as long as both marbles reach the ends of the ruler.
    c. Try to make the marbles touch the card before releasing it. Do not let one marble get a head start.
5. Put the card in the middle of the ruler with a metal marble on one side and glass marble on the other side. Which marble reaches the end first? _____
6. Put the card at the 5 cm mark with the glass marble on the short side and the metal marble on the long side. Which marble reaches the end first? _____
7. Put the card at the 25 cm mark with the metal marble on the short side and the glass marble on the long side. Which marble reaches the end first? _____
8. Now move the card back and forth until you find the point at which the two marble hit the ends of the ruler at the same time.
    a. How far did the metal marble go? _____ cm
    b. How far did the glass marble go? _____ cm
    c. What is the ratio of distances of the metal marble to the glass marble? _____
    d. Since velocity is directly proportional to distance, what is the ratio of velocities? _____
9. What is the momentum before the marbles were launched? _____ kg m/s
10. What do you know about the forces between the marbles from Newton's 3rd Law of Motion? _____
11. Since the time of the forces are the same, what do you know about the impulse applied to each marble? _____
12. What is the total momentum of the marbles after being launched? _____
13. This implies that $m_m v_m + m_g v_g = 0$ for the marbles after being launched. Solve the equation for $\frac{v_g}{v_m}$. _____
14. What is the ratio of the masses of the marbles $\frac{m_m}{m_g}$? _____
15. Use the balance to find the masses of the marbles. m_m = _____ kg, m_g = _____ kg
16. What is the actual ratio of the masses of the marbles $\frac{m_m}{m_g}$? _____
17. Find the percent error between the actual and experimental ratios of masses. _____

$$\%\ error = \frac{theoretical - experimental}{theoretical} \times 100\%$$

18. Explain why if a person standing of frictionless ice shoots a bullet at 200 m/s does not move backwards are 200 m/s.

    _____

19. A 100 kg person pushes off from a 50 kg person on frictionless ice. If the 100 kg person moves at 3 m/s, what speed will the 50 kg person move at? _____ m/s