**Pre-Lab: Elastic Collision [5 pts]**

Directions: Read this sheet carefully and answer the questions to the best of your ability. It is essential that you understand the theory discussed here before you begin the associated experiment. Use your answers in the Theory section of your formal report.

A ball bearing of mass \( m_1 \) starts at rest at height \( h \) along a curved track. When released, mass \( m_1 \) rolls down that track and undergoes a perfect elastic collision with a ball bearing of mass \( m_2 \), also initially at rest.

Use kinematics formulas, conservation of energy, conservation of momentum, and error propagation formulas to answer the following questions:

1. Show that the speed of mass \( m_1 \) just before colliding with mass \( m_2 \) is given by
   \[
   v_1 = \sqrt{2gh}
   \]

2. Show that the final *dynamical* speed of mass \( m_1 \) after the collision is given by
   \[
   V_1 = \left( \frac{m_1 - m_2}{m_1 + m_2} \right) \cdot \sqrt{2gh}
   \]

3. Show that the final *dynamical* speed of mass \( m_2 \) after the collision is given by
   \[
   V_2 = \left( \frac{2m_1}{m_1 + m_2} \right) \cdot \sqrt{2gh}
   \]

4. Given that the error in \( h \) is \( \delta h \) and the error in both \( m_1 \) and \( m_2 \) is \( \delta m \), derive an expression for the propagated error in \( V_1 \) from Question 2.

5. Given that the error in \( h \) is \( \delta h \) and the error in both \( m_1 \) and \( m_2 \) is \( \delta m \), derive an expression for the propagated error in \( V_2 \) from Question 3.
Each ball bearing rolls horizontally off the track after the collision. Their speeds are $V_1$ and $V_2$ when they leave the track. They land at horizontal distances $R_1$ and $R_2$ along the floor.

6. Show that the time it takes either ball bearing to land on the floor is given by
   $$ t = \sqrt{\frac{2H}{g}} $$

7. Show that the initial *kinematical* horizontal speeds of the ball bearings are given by
   $$ V_1 = R_1 \cdot \sqrt{\frac{g}{2H}} \quad \text{and} \quad V_2 = R_2 \cdot \sqrt{\frac{g}{2H}} $$

8. Given the errors in measuring $H$ and $R$ are $\delta H$ and $\delta R$, respectively, derive expressions for the propagated errors in $V_1$ and $V_2$. 