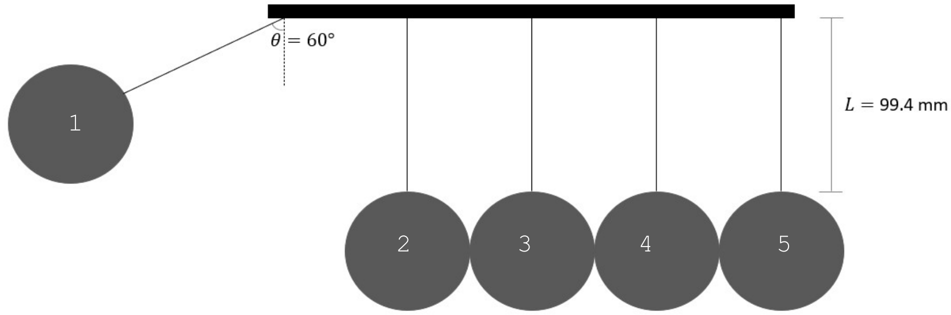
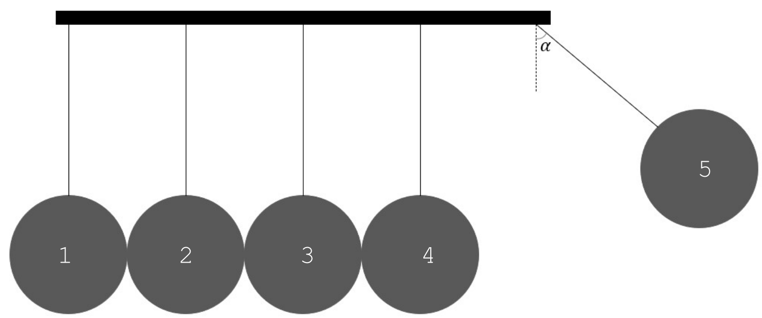
In this document, we will calculate the angle at which the ball at the right end will be deflected. The Newton's Cradle setup can be seen below.



In addition, the mass of each ball is determined to be 483.89 grams, and the coefficient of restitution between the balls are set to 0.9. Using these known values, we're able to calculate the angle of deflection of ball 5 as shown below.



In order to solve this problem, we'll need 3 theories: **Conservation of Energy**, **Conservation of Momentum**, & **Coefficient of Restitution**. Below, we see the known values accompanied by the equations that are derived from these 3 principles.

$\theta := 60\ \text{deg}$ $\quad m := 0.48389\ \text{kg}$ $\quad g := 9.81\ \frac{\text{m}}{\text{s}^2}$

$L := 0.0994\ \text{m}$ $\quad e := 0.9$

Conservation of Energy

$$v_{1i} := \sqrt{2 \cdot g \cdot (L - L \cdot \cos(\theta))}$$ <1>

$$\alpha := \text{acos}\left(1 - \frac{{v_5}^2}{2 \cdot g \cdot L}\right)$$ <2>

Conservation of Momentum

$$v_{1i} := v_{1f} + v_{2i}$$ <3>

$$v_{2i} := v_{2f} + v_{3i}$$ <4>

$$v_{3i} := v_{3f} + v_{4i}$$ <5>

$$v_{4i} := v_{4f} + v_5$$ <6>

Coefficient of Restitution

$$0.9 := \frac{v_{2i} - v_{1f}}{v_{1i}}$$ <7>

$$0.9 := \frac{v_{3i} - v_{2f}}{v_{2i}}$$ <8>

$$0.9 := \frac{v_{4i} - v_{3f}}{v_{3i}}$$ <9>

$$0.9 := \frac{v_5 - v_{4f}}{v_{4i}}$$ <10>

First, we'll start with ball 1. Using equation <1>, we can calculate the inital velocity of ball 1.

$$v_{1i} = 0.9875 \ \frac{\text{m}}{\text{s}}$$

Now, we will implement the momentum calculations between balls 1 & 2. Using equations <3> & <7>, we find that:

$$v_{1f} := 0.049375 \ \frac{\text{m}}{\text{s}}$$

$$v_{2i} := 0.9381 \ \frac{\text{m}}{\text{s}}$$

Repeating this process for balls 2&3, 3&4, then 4&5, we're able to find the velocity of ball 5.

$$v_5 := 0.8043 \ \frac{\text{m}}{\text{s}}$$

Finally, we're able to find the angle of deflection using equation <2>:

$$\alpha = 0.8389 \ \text{rad} := 48.07 \ \text{deg}$$