Investigate the relationship between varying the initial height of a marble rolling down a ramp and the maximum compressed distance of a horizontal spring at the bottom upon collision with the marble

IB Physics IA

Contents

1 Introduction

The inspiration for this experiment came from a childhood game with my brother. We used to play a game where we drop a marble down a ramp with a spring at the bottom, and when the marble hits the spring it will bounce back up the ramp, and whoever's marble reaches the highest point wins. I have always been fascinated by this, and now I want to actually see how much the spring is compressed when the marble is dropped onto it and observe its behavior.

2 Research Question

What is the relationship between varying initial height of a marble rolling down a ramp and the maximum compressed distance of a horizontal spring at the bottom upon collision with the marble?

3 Theory & Background Knowledge

The law of conservation of energy states that the total energy of an isolated system will always be constant

$$E_i = E_f \tag{1}$$

Where E_i is the initial energy and E_f is the final energy.
Now consider the system of the marble and spring, its initial energy will be the potential energy when the marble is on top of the ramp.

$$E_i = mgh_0 \tag{2}$$

Where m is the mass of the marble, g is the gravitational acceleration of the Earth, and h_0 is the initial height of the marble.
The final energy at the moment when the spring is compressed the most will be the potential energy of the spring and the marble

$$E_f = \frac{1}{2}kx^2 \tag{3}$$

Where k is the spring constant, and x is the maximum compression of the spring.
Note there is no kinetic energy here because the velocity of the marble is 0

when the spring reaches maximum compression.
Combining (1), (2) and (3)

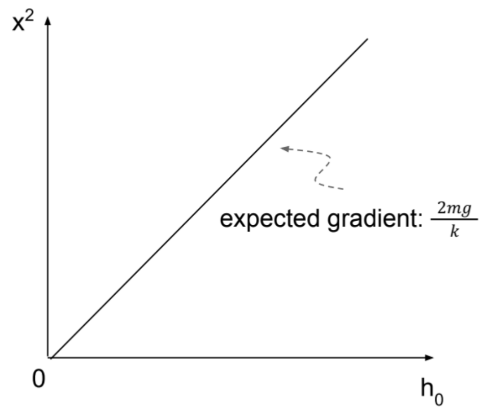
$$mgh_0 = \frac{1}{2}kx^2 \tag{4}$$

Isolating x^2 we get:

$$x^2 = \frac{2mg}{k}h_0 \tag{5}$$

4 Hypothesis

From the linearised equation $x^2 = \frac{2mg}{k} \cdot h_0$, we can plot x^2 against h_0 and obtain a linear line passing through the origin with an expected gradient of $\frac{2mg}{k}$. By comparing this against a directly calculated value of $\frac{2mg}{k}$ through direct measurement and literature value, we can determine the experimental error.



5 Variables

Independent variable: height of drop
Dependent variable: compression of spring
Controlled variables: mass of marble, spring constant, location of experiment (for g constant)

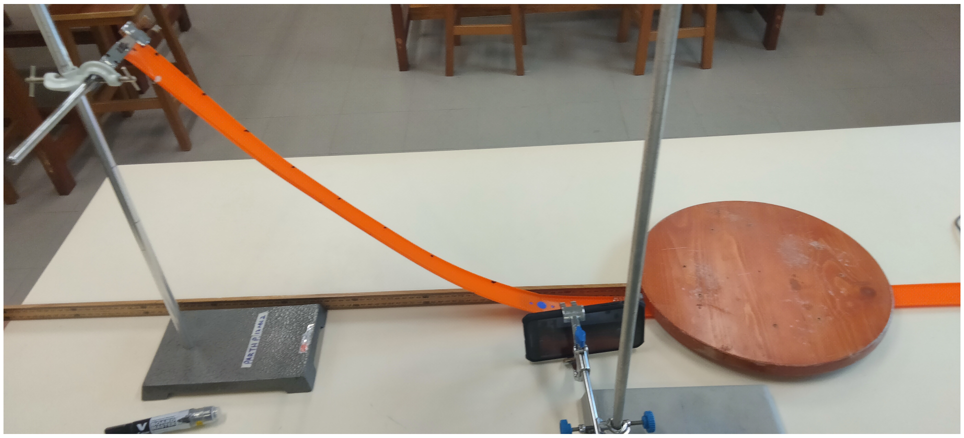


Figure 1: General set up

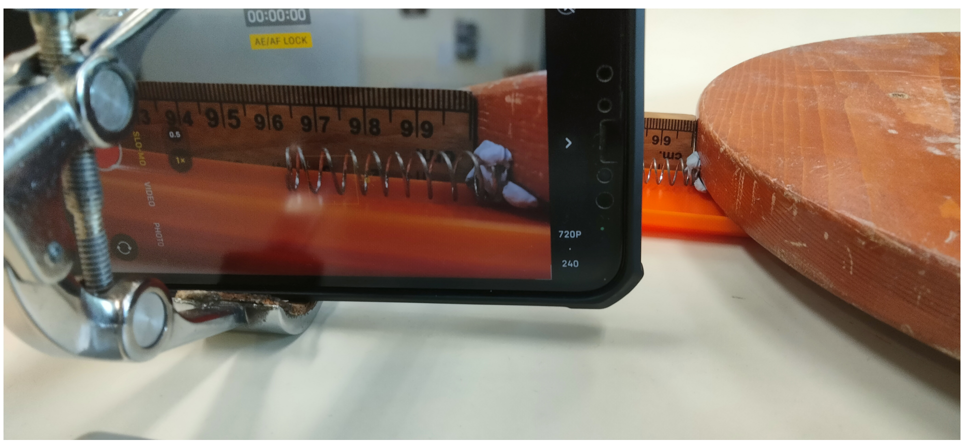


Figure 2: Set up of high speed camera & spring

6 Experimental Setup

6.1 Apparatus

6.2 Method

6.3 Risk Assessment

7 Raw Data Table

8 Processed Data Table

9 Example Calculations

10 Processing & Graphs

11 Calculations

12 Conclusion