THE UNIVERSITY OF HONG KONG
Department of Physics

PHYS2250 Introductory mechanics

Laboratory report 2250-2: Projectile and ballistic pendulum

Full name : ____________________

UID : ____________________

Group No. : ____________________

Date : ____________________

* This semi-full report is for reference only. Students are welcome to write their own full report as long as marking standard is met, e.g. appropriate sectioning, statements written in full sentence, and all the questions asked in manual have been answered.
Blanks are provided here for making quick drafts. When submitting the report, students are strongly suggested to type on a computer and print out the hard copies.

1 Objectives

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2 Background

Projectile motion, along with wedge problems and simple pendulum, has always been a popular topic to be introduced in introductory mechanics. Its pedagogical advantage is hard to be overstated when we have been accummulating so many related life experiences ranging from basketball games to the *Angry Birds*. Most often, students' first encounter with physics analysis of projectile motion took place in high schools, but only the theoretical derivation - typically includes decomposition of velocity vector and kinematic equations concerning uniformly accelerated motion - was emphasized. In this laboratory session, students will be asked to review these concepts from an experimental perspective. All formulae are derived by assuming the absence of air resistance.

3 Apparatus

- Projectile launcher
- Measuring tape
- Plumb bob
- ________________________________
- ________________________________
- ________________________________
- ________________________________
- ________________________________

[May include more if not sufficient.]

4 Measurements and results

[Make sure you include error analysis for every single measurement.]

In order to predict the projectile motion, it is important to know the launching velocity that our apparatus can reach. Two methods will be used here for the same purpose.

[Task 1: Determining initial velocity by shooting off horizontally]

Suppose we set up the laucher at some height h point at $\theta = 0^\circ$, then the horizontal range is given by

$$x = v_0 t \ ,$$

where t is the time of flight. This allows us to obtain v_0 by knowing x and t. The horizontal range x is measured from the edge of ____

To reduce the uncertainty, we have repeated the measurements for ____________________________

The following table summarizes the results:

[Task 2: Determining initial velocity by ballisitic pendulum]

The second method is simply an application of ballistic pendulum. Right after the metal ball leaves projectile launcher, it carries an angular momentum of $L_b = m_b R_b v_0$ with respect to the pivot, where m_b is the mass of metal ball and R_b measures the distance from the pivot to the metal ball. Conservation of angular momentum then yields

$$L_{cm} = L_b = m_b R_b v_0 \ ,$$

where L_{cm} is the angular momentum of the pendulum-ball system. Denote E as the total energy, then we have

$$E = \frac{L_{cm}^2}{2I} \implies v_0 = \frac{1}{m_b R_b}\sqrt{2IE} \ ,$$

where I is the moment of inertia of the pendulum-ball system. Suppose we assume that there is no energy loss after the ball is trapper into the pendulum, then E can simply be given by the final potential energy

In order to obtain the moment of inertia of the pendulum-ball system I, we first write down the force component of $(m_b + m_p)\,g$ directed towards the center of oscillation:

Hence, the torque acting upon the pendulum is

We would assume that $\theta \ll 1$, hence $\sin\theta \approx \theta$. Therefore, the angular acceleration $\ddot{\theta}$ can be expressed as

This is exactly the equation for harmonic oscillator, and the angular frequency is simply

[Task 3: Projectile angle and horizontal range]

Having known the launching velocity, we may return to the study of projectile motion. In particular, we will be focusing on the relation between projectile angle and horizontal range. Two settings will be investigated:

1. Shooting on a level surface ($h = 0$)
2. Shooting off a table ($h > 0$)

In this experiment, the table has a height of __________

All measurements are summarized in the following table:

We shall compare our results against theoretical calculations. To derive the theoretical prediction, we begin with $x = v_0 t\cos\theta$, where t is the time of flight which can be solely determined by analyzing the vertical component of motion, i.e. __________

5 Discussion

6 References