

Pre-Lab Question 3

Topic: Momentum and Energy

Learning Outcomes:

To enable the students to

- state the physics principles used in ballistic pendulum problem,
- apply the conservation of momentum and conservation of energy to derive the expression to calculate the initial velocity of the projectile,
- identify the variables to be measured in an experiment to determine the velocity of the projectile,
- produce an appropriate data table, for the experiment.
- state the expression to calculate the uncertainty of the velocity of the projectile

Pre-Lab Questions 3

- What is a ballistic pendulum?

(Refer to Example 9.6 The Ballistic Pendulum – Serway & Jewett, Physics for Scientists & Engineers with Modern Physics, 7th Edition, p.239)

- A bullet of mass m is fired from a gun with velocity u and it strikes and embedded in a wooden pendulum of mass M which was initially at rest. Just after hitting the pendulum, the bullet and pendulum moved together with velocity v . Both the bullet and the pendulum then moved a maximum vertical distance h as shown in **Figure 1**.

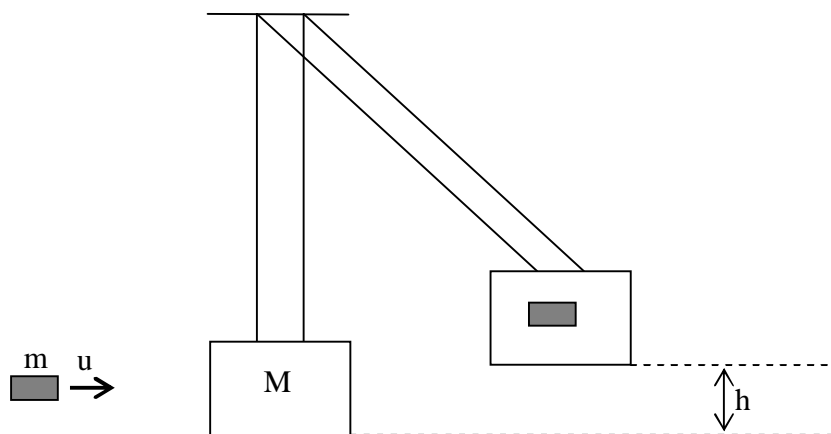


Figure 1

- By applying the conservation of momentum before and immediately after the bullet hits the pendulum, write down an equation for v in terms of m , u and M .

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- (b) By applying the conservation of energy just after the bullet hits the pendulum until it moved a maximum vertical distance h , write down an equation v in terms of m , M , h and g (acceleration due to gravity).
- (c) Write down u in terms of m , M , h and g by substituting the equation in part (a) into the equation in part (b).
3. In an experiment to determine u , state the quantities that must be measured in order to get the value of u ? Hint: Look at the equation derived in 2(c).
 4. Produce a table to tabulate the quantities measured in the above experiment to determine u .
 5. Write down the expression to determine the uncertainty in u based on the equation in 2(c).

Experiment 3

Topic: Momentum and Energy

Objective: To determine the velocity of a horizontally projected object (a metal ball) fired from a spring gun

Learning Outcomes

After doing the experiment, the students will be able to

1. determine the initial velocity (u) of a horizontally projected object by using a ballistic pendulum.
2. calculate the uncertainty of u .
3. write a report on the experiment.

Apparatus: Ballistic pendulum apparatus in the lab which consists of spring gun designed to project a metal ball in a horizontal direction with a hollow pendulum able to catch the ball in a completely inelastic collision.

Introduction:

Conservation laws play a central role in physics. . . . Nothing we can do – in fact, nothing that occurs in nature – can change the total energy and total momentum of the universe. As with conservation of energy, we shall see that the conservation of momentum provides a powerful way of approaching a variety of problems that would be extremely difficult to solve using Newton's laws directly. (Walker 2004)

Indeed, most of our understanding of the subatomic world – electrons, protons, neutrons, muons, quarks, and the like – comes from experiments involving collisions and explosions. (Cummings, Laws et al. 2004)

The study of conservation of momentum and energy are very important in physics since both are fundamental concepts in Physics.

The *ballistic pendulum* was used to measure the speeds of bullets before electronics timing devices were developed. Since real bullets are not practical to be used in an introductory physics lab therefore the staple bullet from the staple gun is a reasonable replacement and this experiment can be set up as shown in Figure 1.

Instructions

1. Discuss the quantities to be measured and the procedure for this experiment and proceed with the measurement using the available instruments. Refer to the above Pre Lab Activities for Experiment 2.
2. Set up the ballistic pendulum apparatus available in the lab.
3. Tabulate your data.
4. Calculate u and its uncertainties.
5. Hand in your group report at the end of the lab period.

What should be in your report:

1. Objective :
2. Apparatus : Equipments that you use in the experiment
3. Theory : State the physics principles and the equations used in this experiment
4. Data and Results:
Organize your data into tables. Be consistent and correct in the use of significant figures. Give the quantity its units. Calculate the results and its uncertainties.
5. Conclusions : State the results and its uncertainties. Include the sources of uncertainties in this experiment.

Post-Lab Questions:

1. State two physics principles used to determine the initial velocity of the ball.
2. Is kinetic energy conserved in this collision? Explain.
3. Do you think this experiment can be improved? Describe the improvement.
4. Which measurement do you think contribute most to the uncertainty of the result in this experiment?
5. Can you think of any other way to determine the initial velocity of the staple bullet?

References

- Cummings, K., P. W. Laws, et al. (2004). Understanding Physics, John Wiley & Sons, Inc.
- Walker, J. S. (2004). Physics. New Jersey, Pearson Education, Inc.