Lab Design Assignment: Work-Energy Investigation

Steel Ball Drop

Physics 11 - Mr. Gullo

Overview

This experimental investigation has been structured to fit an 80-minute lab period, with an additional 40-minute design period the week before. Students will use a timer-controlled dropping mechanism and photo-gate to study concepts from Chapter 9 on work, energy, and conservation principles.

Schedule

Week 1: Design Period (40 minutes)
Week 2: Lab Implementation (80 minutes)

Required Equipment

- Timer-controlled dropping mechanism
- Steel ball
- Photo-gate timing system
- Electronic balance
- Calculator
- Laptop with spreadsheet software (optional)
- Lab notebook

Pre-Lab Design Requirements (Week 1)

During the 40-minute design period, students should:

1. Review textbook sections 9.1 and 9.2 to identify relevant equations
2. Design a systematic approach for data collection
3. Create a data table template
4. Develop a hypothesis about the relationship between drop height and ball velocity
5. Prepare prediction calculations for at least three different drop heights
6. Identify potential sources of experimental error

Experimental Procedure (Week 2)

Setup Phase (15 minutes)

1. Measure and record the mass of the steel ball
2. Mount the dropping mechanism securely above the photo-gate
3. Test the timing system and dropping mechanism
4. Establish a consistent method for measuring drop heights

Data Collection Phase (30 minutes)

1. Select 5 different drop heights between 0.2m and 1.0m
2. For each height:
   - Record the height measurement precisely
   - Calculate the theoretical gravitational potential energy
   - Predict the velocity at the photo-gate using conservation of energy
   - Perform 3 trial drops, recording the photo-gate time measurements
   - Calculate the actual velocity from the photo-gate data

Analysis Phase (20 minutes)

1. Calculate for each trial:
   - Initial gravitational potential energy (mgh)
   - Theoretical final kinetic energy ($\frac{1}{2}mv^2$) based on energy conservation
   - Actual final kinetic energy based on measured velocity
   - Percentage of energy conserved
   - Work done by gravity
   - Average power during the fall (work/time)
2. Create a graph of potential energy vs. measured kinetic energy
3. Determine the slope of the best-fit line and its physical meaning

Discussion Phase (10 minutes)

1. Compare theoretical predictions to experimental results
2. Analyze discrepancies and potential energy losses
3. Discuss experimental uncertainties and their impact
4. Relate findings to the work-energy theorem and conservation principles

Submission Requirements

By end of design period (Week 1):

- Completed experimental design
- Prediction calculations for at least three heights

By end of lab period (Week 2):

- Completed data tables
- Preliminary graphs
- Initial analysis of results

Final report (due one week after lab):

- Introduction with hypothesis
- Methods section with detailed procedure
- Results with data tables and graphs
- Analysis connecting to work-energy theorem and conservation principles
- Discussion of error sources
- Conclusion evaluating the hypothesis

Safety Considerations

- Secure all equipment properly to prevent falling objects
- Ensure clear space around the drop zone
- Handle equipment with care to prevent damage