12 Physics **Scientific Investigation Reports**

A scientist writes a report of a scientific investigation in order to communicate their work to others. In a scientific report, a scientist must explain what was done, report the observations obtained and clearly explain the conclusions reached based on the observations. A report should be written with enough detail so that other scientists could repeat the experiment and develop further experiments based on the reported work.

Report components:

Title Page:

- Report Title, Name, Partners' Names, Date Experiment Performed, Due Date, Teacher's Name

Part I: Abstract

- A brief summary of the experiment. It includes **three** parts:
  1) A statement of what was investigated
  2) A very brief general description of how this was done (omitting specific experimental details)
  3) The conclusions reached.

Part II: Introduction

a) Purpose

- A brief statement of why the experiment is being performed.

b) Hypothesis * (Not always included)

- In some cases, an experiment is being performed to test a specific prediction based on prior knowledge. The prediction with reasons (theoretical analysis) should be presented in the hypothesis.

c) Method

- An explanation of how the experiment was performed. It includes the materials list, a schematic diagram and the procedure.

Materials:

- List the materials and measuring devices used.
- Record **experimental uncertainties** for the measuring devices. The uncertainties are generally assumed to be ± ½ of the size of the smallest scale division on the instrument, or ± 1 in the last digit of a digital instrument. In some cases, the stated instrumental uncertainty will also include the uncertainties due to other sources (e.g. human reaction time when using a stopwatch).

Diagram:

- A **schematic diagram** (line diagram) of the **experimental set-up** drawn with a ruler and pencil or computer drawing program.
- Indicate how quantities were measured where possible.
- **Do not** include everyday devices (e.g. rulers, stopwatches, etc.) in the diagram.

Procedure:

- A brief description of the experimental steps written in the **past tense** and in the **passive voice** (e.g. "*The current was adjusted using the rheostat*").
- Do not describe how the data was analyzed.

Part III. Observations

- Record all data, observations and physical constants used.
- Describe qualitative observations in sentence form.
- State individual observations in a sentence. (e.g. "*The length of the wire was determined to be L=3.0 m*")
- If data has been recorded in rough form during the experiment, the rough sheets must be included at the end of the report.
- Record repeated observations/measurements in **table form**.

Table Format:

- Each table must have a table **number** and **title**. The table **MUST** be referred to in the written part of the report.
- Variables held constant should be described in the table description (e.g. *"The data in table 3 was obtained with the temperature held constant at 30°C and the current varied."*)
- The **units** of the measurements and the **experimental uncertainties** are shown ONLY in the column headings.
- The precision of the measurements should match the stated experimental uncertainties. (e.g. *d = 5.4 cm for length measurement uncertainty ± 0.1 cm)*

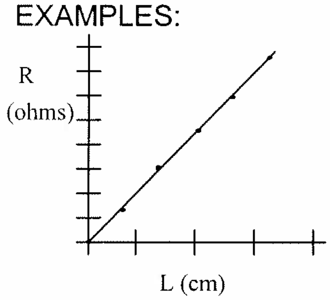
Part IV: Data Analysis and Discussion

- Show sample calculations, analysis tables and graph analysis here.
- **ALL TABLES , GRAPHS AND SAMPLE CALCULATIONS MUST BE INTRODUCED AND EXPLAINED!!**
- Show only ONE set of sample calculations for repeated calculations.
- Results should have the appropriate number of **significant digits**. In general, average values should be rounded to the same precision as individual measurements.

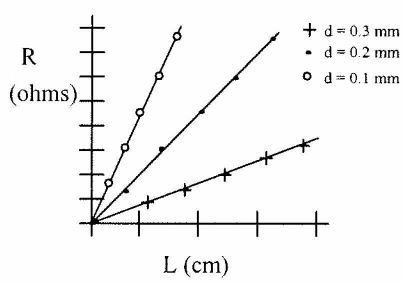
Graphs

- Hand drawn graphs **must** be on graph paper. If plotted on computer, best-fit curves/lines should be hand-drawn.
- Graphs must have a **graph number** and **title** (reading "*y-axis* vs. *x-axis*"),
- Axes scales should be based on multiples of 1, 2 or 5. Show axes labels and units.
- Do not use breaks in axes. Include (0,0) on the graph if there is a clear reason to do so.
- If the data points clearly suggest a **linear trend**, draw a line-of-best-fit.
- If points on the graph follow a **non-linear trend**, a smooth curve should be drawn which best fits the trend of the data points

EXAMPLES:



Graph 1. Resistance (R) vs. Length (L) for a copper wire



Graph 2. Resistance (R) vs. Length (L) for various diameters (d) of copper wire

V) Conclusions and Sources of Error

- Discuss what can be concluded from the observations and analysis.
- **Do not** conclude what you think you are supposed to if your data does not support it.
- The conclusions should reflect what you wrote as the purpose of the investigation. If your introduction included a hypothesis, discuss whether your hypothesis is supported by the results.
- If possible, this section should also show how the results agree with known theories. If one of the conclusions is a numerical value for a known quantity, the experimental value should be compared with the known value based on a percent error calculation.
- You should also discuss aspects of the experiment that could potentially have produced errors in yours results. These sources include known problems or extraneous influences that may have influenced the data collection These sources of error do not include "misreading the instrument" or "human error.

References: List any references (books, journal articles, etc.) that were used in completing the report.

SAMPLE REPORT

An Investigation of Falling Objects

Abstract: In this investigation the effects of two variables, drop height and mass, on how long it takes a dropped object to reach the ground were examined. This was done by dropping objects of various masses from various heights and measuring the time required for the object to hit the ground. It was found that the time required increased as the height increased and that the two were related by $T = k\sqrt{h}$ where the constant k = 0.45 $s/m^{1/2}$. It was also found that the mass had no effect on the time.

Introduction:

Purpose: To investigate how the time for a dropped object to fall depends upon release height and the mass of the object.

Method

Equipment: tape measure (±0.01 m), ladder, stopwatch (±0.1 s including reaction time), mass set (±1 g)

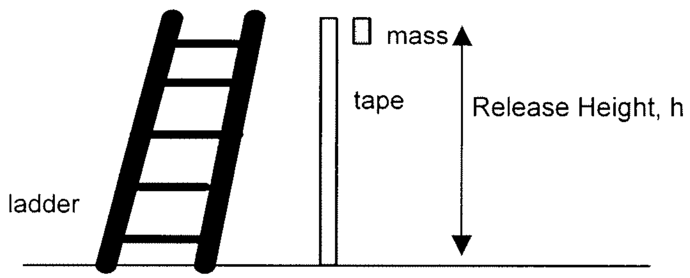


Figure 1: Experimental Set-up

Procedure

1. The ladder was set up leaning against a wall with the tape measure attached to the ground and running up the wall beside the ladder as shown in Figure 1. The height from which the masses were released was read from the tape measure.
2. A 200 g mass was released at a height of 6.00 m by a person standing on the ladder. The time taken for the mass to reach the ground after being released was measured using the stopwatch. . Each trial was performed three times.
3. The 200 g mass was then released from different heights and the time to fall determined in each case.
4. A height of 8.00 m was selected and a 100 g mass was released from this height and the time to fall was again determined.
5. Different masses were released from the same height of 8.00 m and their times to fall were measured.

Data

The data obtained in the first part of the experiment are summarized below in Table 1. In this case the mass was kept constant at 200 g and the height was varied. The three trials at each height were used to find an average time in each case.

Table 1: Time of fall (T) for various release heights (h) and constant mass (200 g)

Release Height	Time To Fall (T)			
h (±0.01 m)	Trial 1	Trial 2	Trial 3	Average(±0.1 s)
6.00	1.03	1.19	1.20	1.1
8.00	1.24	1.30	1.39	1.3
10.00	1.36	1.52	1.41	1.4
12.00	1.61	1.57	1.53	1.6
14.00	1.69	1.71	1.82	1.7

The data obtained in the second part of the experiment are summarized below in Table 2. In this case the height was kept constant at 8.0 m and the mass of the object was varied. The three trials at each mass were used to find an average time in each case.

Table 2: Time of fall (T) for varying mass (m) and constant release height (4.0 m)

Mass	Time to fall (T)			
m (±1 g)	Trial 1	Trial 2	Trial 3	Average(±0.1 s)
100	1.38	1.29	1.39	1.4
200	1.28	1.27	1.35	1.3
300	1.37	1.35	1.38	1.4
400	1.34	1.29	1.32	1.3
500	1.33	1.26	1.38	1.3

Analysis & Discussion

Table 1 shows that time to drop increased as release height increased. A plot of the average time vs. height from the data in Table 1 is drawn in Graph 1. The shape of this graph (rising but with decreasing slope) suggests that the time is proportional to some root of the height.

From Table 2 it can be seen that changing the mass had very little or no effect on the time. This can also be seen in Graph 2 where the time is plotted against the mass. The graph is a straight horizontal line which indicates that the mass has no effect on the time.

We can further analyze the data in Table 1 to determine the specific relationship between time to drop and release height. Table 3 shows the values of T and $\sqrt{h}$ as obtained from Table 1.

(TABLE 3 WOULD BE SHOWN HERE.)

A plot of T versus $\sqrt{h}$ is shown in Graph 3. The linear relationship demonstrated in Graph 3, verifies that time to drop is directly proportional to the square root of release height. This relationship can be represented by the equation $T = k\sqrt{h}$ where k is the slope of the linear plot in Graph 3. The calculation of the slope of the best fit line of this plot is shown below.

(CALCULATIONS WOULD BE SHOWN HERE.)

The slope value of 0.45 $s/m^{1/2}$ shows that the equation relating dropping time and release height is $T = 0.45\ s/m^{1/2}\ \sqrt{h}$.

{ NOTE: TABLE, GRAPHS AND SLOPE ANALYSIS ARE NOT SHOWN IN THIS SAMPLE REPORT}

Conclusion

From the first part of the experiment it can be concluded that the height from which an object is dropped does affect the amount of time it takes to reach the ground. Furthermore, the data shows that the time (T) is related to the height (h) by the equation $T = k\sqrt{h}$ where the constant $k = 0.45\ s/m^{1/2}$.

It can also be concluded from the second part of the experiment that the mass of an object does not affect how long it will take to fall.

One factor that may have affected the reliability of these results is that the experiment was done outdoors and it was windy. This may have caused the dropping masses to fall at an angle from the vertical which may have affected the length of time they required to reach the ground. This could be eliminated by doing the experiment indoors. Another problem was ensuring that the masses were consistently dropped from the same height during repeated trials. A movable pointer to indicate the release position could have helped with this problem. It was also noted that the masses did not make much sound when they hit the ground since it was soft dirt. This made it difficult to determine when the mass hit the ground. This could be remedied by having the mass strike a board on the ground.