# 11 Physics SAC Practical Investigation

## Scope of Assessment Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Unit 2 Outcome 3

### In this area of study you will design and conduct a practical investigation related to knowledge and skills developed in Area of Study 1 and/or Area of Study 2.

### Task Outline

### The investigation requires you to develop a question, plan a course of action that attempts to answer the question, undertake an investigation to collect the appropriate primary qualitative and/or quantitative data, organise and interpret the data, and reach a conclusion in response to the question. You need to design and undertakes an investigation involving two independent variables one of which should be a continuous variable. You will need to use a logbook for recording, authentication and assessment purposes.

The task is divided into three phases:

* Planning the experiment
* Conducting the experiment
* Communicating your findings on a poster

### Task 1: Planning and Design - Rubric 1

Your background research, investigation design and introduction will be assessed prior to you conducting your experiment.

### Task 2: Results and Findings - Rubric 2

The presentation of your results and discussion of your findings will be assessed at the end of the investigation.

### Topic Areas

There are three topics to choose from and you will complete an individual practical investigation.

1. Crumple zones
2. Safety barriers
3. Protective air bags

### Required Poster Layout and Sections

* The centre of the poster will occupy between 20 to 25 per cent of the poster space and will be a one-sentence summary of the major finding of the investigation that answers the investigation question.
* The poster may only include 600 words. Poster title, student name/identification number, tables, graphs, flowcharts, figure captions, references and acknowledgements are not included in the poster word count.
* Posters are generally written in past tense, as they report on what has been done. They are also written in an impersonal style with no pronouns such as ‘we’, ‘you’, or ‘I’ included.

 

 The presentation format of the poster will include the following sections:

|  |  |
| --- | --- |
| **Poster section** | **Content**  |
| Title | Question under investigation  |
| Introduction | Brief explanation or reason for undertaking the investigation, including a clear aim, a hypothesis and/or prediction and relevant background biological concepts  |
| Methodology and methods | * Brief outline of the selected methodology used to address the investigation question
* Summary of data generation method/s and data analysis method
 |
| Results | Presentation of generated data/evidence in appropriate format to illustrate trends, patterns and/or relationships  |
| Discussion | * Interpretation and evaluation of analysed primary data
* Identification of limitations in data and methods, and suggested improvements
* Cross-referencing of results to relevant chemical concepts
* Linking of results to investigation question and to the aim to explain whether or not the investigation data and findings support the hypothesis
* Implications of the investigation and/or suggestions as to further investigations that may be undertaken
 |
| Conclusion | * Conclusion that provides a response to the investigation question
* Identification of the extent to which the analysis has answered the investigation question, with no new information being introduced
 |
| References and acknowledgements | Referencing and acknowledgement of all quotations and sourced content relevant to the investigation  |

##

## Timeline

|  |  |  |
| --- | --- | --- |
| **Lesson** | **Content** | **Dates** |
| 1 wk 2 | Topic Selection and answer background questions | ­11 Oct |
| 2 wk 2 | Research question, aim, variables and hypothesis | 14 Oct |
| 3 wk 2 | Introduction plan  | 17 Oct\* |
| 4, 5 wk 2 | Materials and procedure, risk assessment, design results table**Rubric 1 due** | 18 Oct – 2 lessons |
| 6 wk 3 | Conduct experiment - Experimental log | 21 Oct |
| 7 wk 3 | Conduct experiment - Experimental log | 24 Oct |
| 8, 9 wk 3 | Conduct experiment - Experimental logAnalyse data and draw graph | 25 Oct – 2 lessons |
| 10 wk 4 | Discussion and Conclusion Plan | 28 Oct |
| 11 wk 4 | Complete discussion under test conditions and collating poster**Rubric 2 due** | 31 Oct |

## Assessment Rubric - planning

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **1** | **2** | **3** | **4** |
| **Log book** | lists materials and method | identifies hazards and devises safety precautions | writes a list of instructions | creates reproducible procedure |
| **Designs investigation** | distinguishes between factors to control, measure and change | designs a fair test with at least 5 controls | creates a hypothesis to predict outcome | hypothesis links independent and dependent variables |
| **Introduces investigation** | identifies aim and hypothesis | describes context or problem with in-text citations | describes relevant background chemical concepts | evaluates how project extends understanding |

## Assessment rubric - discussion and poster

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 |
| **Represents data** | uses graph that follows some set conventions | designs graph which follows set conventions | creates graph which shows patterns and/or relationships |  |
| **Reports data** | includes relevant data | summarises data | describes the quality of the data using measurement terms | elaborates on the terms used to describe the quality of data |
| **Analyses data** | devises key finding related to the aim | explains key finding using a science theory with in-text citations | applies understanding of science theories to explain key finding | makes links to hypothesis and other science studies |
| **Evaluates method** | identifies limitations in data and methods | categorises errors as random or systematic | explains why errors occurred | evaluates how errors affect quality of data |
| **Modifies method** | identifies steps or equipment which can be modified | explains how modifications improve design | predicts the effect of modifications on the quality of data |  |
| **Makes conclusions** | summarises key finding | describes extent to which investigation answered research question  | makes recommendations to broaden application of key finding | evaluates the implications of the investigation to the wider community |
| **Communicates ideas** | follows required format for poster and meets 600 word limit | uses scientific conventions for units, labelling of figures and tenses | uses graphics to convey ideas | uses clear, coherent and concise expression  |
| **Bibliography** | includes references | uses required referencing style |  |  |

## Topic selection

**Crumple Zones**

Crumple zones were first introduced into passenger cars in 1952. The main purpose of the crumple zone is to absorb the energy from the crash which in turn reduces the amount of force transferred to the occupants of the car.

### Background questions

1. When were crumple zones introduced in vehicles and why?
2. Which aspect of a crumple zone makes the vehicle safer in a collision?
3. What types of materials are used in crumple zone and how do materials increase the time of impact?
4. How does increasing the collision time lead to fewer injuries in impact collisions?

**Safety barriers**

The design of safety barriers is important in preventing severe injuries when cars run off the road. The main aim of safety barriers is to slow down the impact time of cars during collisions.

**Background questions**

1. When were safety barriers introduced in vehicles and why?
2. Which aspect of a safety barrier makes vehicle collisions safer?
3. What types of materials are used in safety barriers and how do these materials increase the time of impact?
4. How does increasing the collision time lead to fewer injuries in impact collisions?

**Protective air bags**

Air bags were first installed in a passenger car in 1980. They have contributed to a reduction in fatalities in car collisions with estimates that along with seat belts they reduce the risk of death in frontal clashes by almost 60%.

**Background questions**

1. When were protective air bags introduced in vehicles and why?
2. Which aspect of a protective air bag makes the vehicle safer in a collision?
3. What types of materials are used in air bags and how does using these materials increase the time of impact?
4. How does increasing the collision time lead to fewer injuries in impact collisions?

|  |  |
| --- | --- |
| **Background questions** | **Reference** |
|  |  |

**Research Question**

**Research Question Checklist**

|  |  |
| --- | --- |
| Includes the variable(s) that will be changed.  |   |
| States what will be effected  |   |

A research question is used to guide all parts of the investigation. It is important that your research question is not too broad or too generalised. For example, "What is the effect of the mass of the person on the force of impact on the person at the lowest point of a bungy jump?"

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### Variables

Identify the independent, dependent and controlled variables. Use the table below as a guide.

You need to include one continuous independent variable.

|  |  |  |
| --- | --- | --- |
| **Independent Variable**(what will you be changing?) | **Dependent variable**(what change will you be measuring? Include units) | **Controlled variables**(What will you keep constant? – You will need at least 5 controlled variables) |
|  |  |   |

**Aim Checklist**

|  |  |
| --- | --- |
| States what will be done and measured  |   |
|  Uses a verb to begin sentence |   |

### Aim

The aim states the purpose of the experiment. In the aim, you need to explain what will be done, and how it will be measured. The sentence should also start with a verb, such as “to investigate, to measure, to verify, to determine, to compare or to calculate.”

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### Hypothesis

A hypothesis is a prediction about the relationship that you expect to occur between your IV and DV. It must be written using the following sentence structure.   If independent variable *increases/decreases* then dependent variable *increases/decreases* because….insert theory to justify your hypothesis

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### Hypothesis Checklist

|  |  |
| --- | --- |
|    | Show the link between independent and dependent variables  |
|    | Includes theory to justify your hypothesis  |

## Introduction

Use the information from your background and variables research to complete your introduction plan below by:

* describing the problem and the importance of your investigation and explaining what scientists already know about the topic
* identifying the current gaps in scientific knowledge or understanding that need to be addressed.
* stating your aim and stating your hypothesis with a justification for your prediction. Usually written using the 'If… then… because' sentence structure
1. Describe the problem (include at least one piece of data/statistic)

2 - 3 sentences

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What is already known (include key scientific information/data related to your research question)

3 sentences

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Gaps in knowledge (link what we don’t know to your experiment)

1-2 sentences

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Aim

1 sentence

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Hypothesis

 1 sentence

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Materials and Procedure

### Materials

**Procedure Checklist**

|  |  |
| --- | --- |
|  Numerical steps are used |   |
|  The steps are in correct order |   |
|  Quantity of each item included |   |
|  Is written in instructional tense  |   |

### Procedure

The procedure outlines how you will conduct your experimental work. It is a set of instruction that should be written as a clear and correctly ordered steps. The procedure should also include how much of each item you plan to use and be written in instructional tense like a recipe.

\*\*Remember that you need at least five replicates for your independent variable.

### Visualise your procedure

Draw an A3 diagram to show the steps you will follow in your experiment.

## Risk Assessment

### Hazard Assessment

Whenever conducting an experiment, it is important to identify the hazards and then state what precautions will be taken to prevent injury. This section must be completed before the experiment is conducted.

|  |  |  |
| --- | --- | --- |
| **Equipment or Process**  | **Hazard**  | **Safety Precaution**  |
|    |    |      |
|    |    |      |
|    |    |      |

**Table Checklist**

|  |  |
| --- | --- |
|  Includes a descriptive title and three replicates |   |
|  Units are included |   |
|  The independent variable is in the left column |   |

## Results Table

**Instructions**

You need to include a MINIMUM of 5 replicates

Title:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |
| --- |
| **Dependent Variable (unit):**  |
| **Independent Variable:** | **Replicate 1** | **Replicate 2** | **Replicate 3** | **Replicate 4** | **Replicate 5** |
|   |   |   |   |  |  |
|   |   |   |   |  |  |
|   |   |   |   |  |  |
|   |   |   |   |  |  |

## Experimental Log

### Instructions

1. During each experiment session, list the tasks that you were able to complete.
2. Insert observations and notes regarding the changes you are observing, any unexpected results, difficulties or ways to improve the experiment. Include any raw data from the session.
3. Remember to take photographs of your experimental work for your poster.
4. Make any required alterations in your proposed tasks for the following experimental session.

Note: This section MUST be completed as it is required for authentication of your work and forms part of your assessment.

###  Experimental Session - Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

###  Experimental Session - Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

###  Experimental Session - Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Graph**

**Instructions**

1. Use the instructions below to create an electronic graph of your results using Excel.
2. Insert your graph in the space provided.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  The choice of graph needs to be suitable for the data that is collected. Generally, line graphs are used for continuous data, while bar graphs are used for data for separate categories. Graphs need to include a title that describes the data, labels on the axes with units and an appropriate scale. The independent variable should be on the x axis. The graph needs to be drawn electronically.  | **Graph Checklist**

|  |  |
| --- | --- |
|    | Is a suitable graph for the data  |
|    | Includes a title and axes are labelled |
|    | Units are included and appropriate scale |
|    | The independent variable is on the x axis  |
|    | 95% CI included  |

 |

## Discussion and Conclusion Plan

Only use dot points as you will write the discussion and conclusion in class under test conditions.

### Reporting Data

### Summarise the data (1-2 sentences)

Compare the important results and include numbers, e.g. the highest and lowest averages. DO NOT LIST YOUR VALUES. Describe any trends or patterns you may observe. Do not discuss key findings.

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Evaluates the quality of the data - accuracy and precision (2-3 sentences)

Use selected measurement terms, such as precision and accuracy to evaluate the quality of the data.

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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### Key finding - related to aim (1 sentence)

Simply state what you found out by looking at your data or your observations.

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Theory to explain key finding with in-text citations (3-4 sentences)

Use science theories to explain your key finding. Insert an intext citation to reference where you obtained the scientific information. Include the reference in your bibliography.

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### Links key findings to hypothesis and other science studies (2 sentences)

Remember to include intext citations.

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

## Errors in method

### Random error (2 sentences)

Identify an error in the measurement which causes the values to vary.

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Effect on quality of data (1 -2 sentences)**

Explain how the error affected your collected data. Did the error result in the values being more variable (data points are further apart)? Random errors affect the reliability of the experiment.

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### Modification to address random error (1-2 sentences)

Identify a modification that could be made to the method/equipment to overcome the random error.

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**Effect of modification on quality of data (1 sentence)**

Explain how the modification would affect the reliability of your data.

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### Systematic error (2 sentences)

Identify an error which created bias in the data. That is, the practical value differed from the true value by the same amount each time.

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**Effect of error on quality of data (1 sentence)**

Explain how the error affected your data. Would the error make the data higher (overestimation) or lower (underestimation) than the theoretical value? Systematic errors affect the validity of the experiment.

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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### Modification to address systematic error (1-2 sentences)

Identify a modification that could be made to the method/equipment to overcome the systematic error and ensure the practical value is closer to the theoretical value.

###  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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### Effect on modification quality of data (1 sentence)

Explain how the modification would the quality of your collected data.

### \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### Conclusion (4 sentences)

### Summarise key finding

Clearly state the overall finding as a bold confident sentence.

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**Describes extent to which analysis answered research question**

In what contexts might the overall findings not apply or be true? However…..

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**Recommendations**

What should other scientists study/investigate next? Therefore….

###  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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### Implications

What does the overall finding mean for the scientific community or wider general population. Link this to the context of the aim and your generalisation.

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**Bibliography**

Use the numbered referencing style where references are indicated in-text by superscript numbers, or numbers in brackets. Each number corresponds to a particular source and refers to the bibliography list and provides full details of the sources used, arranged in the order they first appear in the text.

**Number– author (date) title of article, book title, web address, date accessed.**

eg. 1. Williams (2016) Multiple Myeloma, Encyclopaedia Britannica, www.school.eb.com.au, [date accessed 11th February 2017]

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