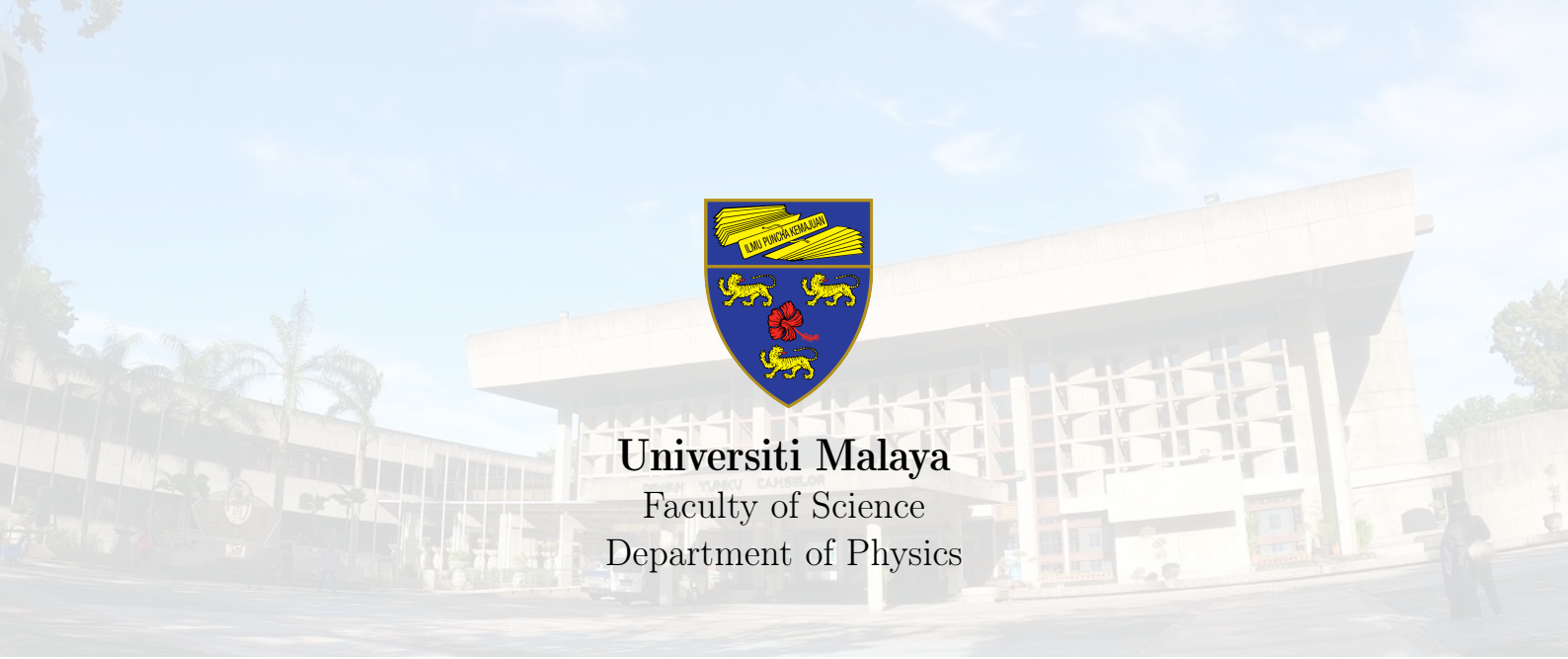


Universiti Malaya
Faculty of Science
Department of Physics

XXX0000 - Course Title
Laboratory Report XXX

Experiment Title

Student Name
Invincible

Matric Number
123456789

Lecturer(s) in charge:

Dr. Markiplier
Dr. Omniman

March 25 - April 6, 2025

Contents

1 Objectives

Write the objectives of the experiment here.

- Objective 1.
- Objective 2.

2 Instruments & Components

Make use of `\tabular` and `\minipage` for nicer layout.

Instruments : DC Power Supply, Multimeter
Components : Resistors — $91\,\Omega\,(\times 1), 220\,\Omega\,(\times 1), 1.0\,\mathrm{k}\Omega\,(\times 3), 4.7\,\mathrm{k}\Omega\,(\times 2), 6.8\,\mathrm{k}\Omega\,(\times 1)$

3 Introduction

Include an introduction of the experiment's theory.

3.1 | Sub Section Heading

This is a subsection under the main section[1].

- Item 1
- Item 2
  - ◇ Subitem 1
  - ◇ Subitem 2
    - □ Subsubitem 1
    - □ Subsubitem 2
  - ◇ Subitem 3
- Item 3

3.1.1 | Sub Sub Section Heading

This is a subsubsection under the subsection.

1. Item 1
2. Item 2
   [a] Subitem 1
   [b] Subitem 2
      i. Subsubitem 1
      ii. Subsubitem 2
   [c] Subitem 3
3. Item 3

[1] This is a footnote. It is custom coloured.

4 Procedure

This design was done by using `\minipage` alongside `\tcolorbox`.

Steps:

1. List out the steps of experiment.
2. You may use `\tblue` and `\tbluebf` to colour text like this — blue and **blue bold**.
3. You may also use `\mblue` and `\mbluebf` to colour mathematics like this — 100% and $\mathbf{100\%}$.
4. Then you can reference figures like this. Figure 4.1.

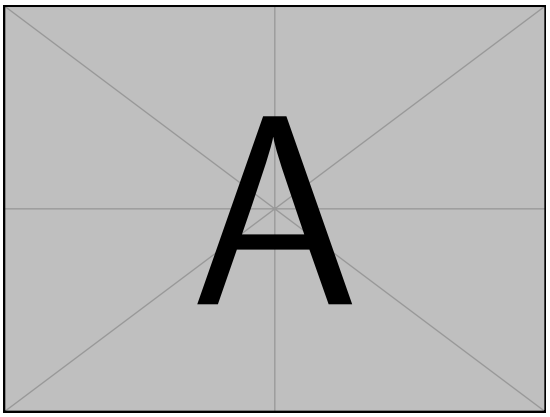


Figure 4.1: Description of the figure.

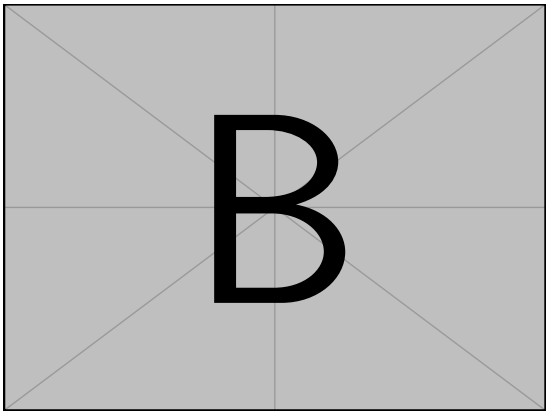
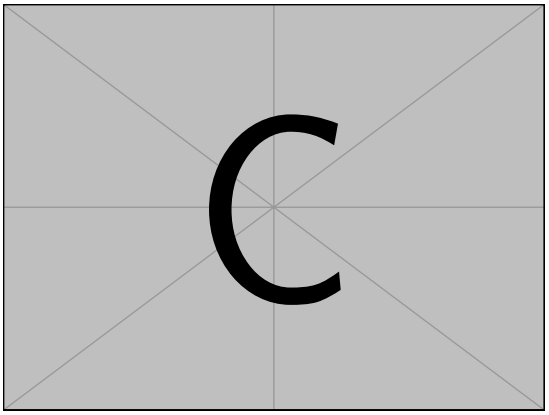


Figure 4.2: Description of the figure.

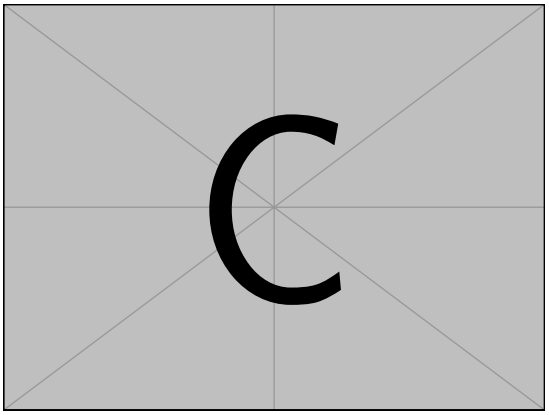
Steps:

1. Spice up the design by switching the image sides.
2. You can't use `\footnote{}` within `minipage` environment because the text will be rendered right below it.
3. Luckily, you can use `\footnotemark[]` within `minipage` like this.[2]
4. The downside is that, `\footnotemark[]` does not follow the numbering of `\footnote{}`. Thus, I always use `\footnotemark[]` even though it's tedious.

[2] Footnotes can also be called inside minipage this way.



(a) Description of the subfigure.



(b) Description of the subfigure.

Figure 4.3: Description of the figure.

Steps:

1. Typical design for LaTeX.
2. You can also cite some sources. [1]
3. Refer to `biblatex` on how to automatically change citation style. (i.e. APA, IEEE, Harvard, etc)
4. Lorem ipsum dolor sit amet, consectetuer adipiscing elit.
5. Nam dui ligula, fringilla a, euismod sodales, sollicitudin vel, wisi.
6. Nulla malesuada porttitor diam.
7. Quisque ullamcorper placerat ipsum.
8. Fusce mauris.

5 Results

5.1 | Observations

In this section, display the data that you have obtained.

Table 5.1: A table without vertical lines.

Column 1	Column 2	Column 3	Column 4	Column 5
Entry 1	1	2	3	4
Entry 2	1	2	3	4
Entry 3	1	2	3	4
Entry 4	1	2	3	4

5.2 | Data Analysis

In this section, display any relevant figures, tables or equations after you have analysed them.

Table 5.2: A table with vertical lines.

Column 1	Column 2	Column 3	Column 4	Column 5
Entry 1	1	2	3	4
Entry 2	1	2	3	4
Entry 3	1	2	3	4
Entry 4	1	2	3	4

`Block` equations are automatically coloured blue, however `inline` equations are not because it will mess up some paragraph spacing.

$$i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t) = \hat{H}\Psi(\mathbf{r},t) \tag{5.1}$$

You can also create a blue horizontal line using `\lblue`.

6 Discussion

6.1 | Analysis

Part 1

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris.

Part 2

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6.2 | Sources of Error

Suspendisse vel felis. Ut lorem lorem, interdum eu, tincidunt sit amet, laoreet vitae, arcu. Aenean faucibus pede eu ante.

6.3 | Challenges and Steps to Overcome

Sed commodo posuere pede. Mauris ut est. Ut quis purus.

6.4 | Suggestions for Improvement

Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Donec odio elit, dictum in, hendrerit sit amet, egestas sed, leo. Praesent feugiat sapien aliquet odio.

7 Conclusion

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum.

References

[1] John Smith and Jane Doe, eds. *Proceedings of the International Conference on Physics*. Berlin, Germany: Springer, 2025.

A Calculations

Show all the calculations you have made for this experiment.

A.1 | Matrix Equation

Simultaneous equation can be written as:

$$A\mathbf{x} = \mathbf{b}; \quad \text{where } A = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}, \quad \mathbf{x} = \begin{bmatrix} x \\ y \\ z \end{bmatrix}, \quad \mathbf{b} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}.$$

To solve for $\mathbf{x}$, matrix multiply A^{-1} on both sides:

$$\mathbf{x} = A^{-1}\mathbf{b}. \tag{A.1}$$

A.2 | Kirchhoff's Laws

Kirchhoff's Voltage Law (**KVL**) and Current Law (**KCL**) at the junction:

$$\sum_{i=1}^{n} V_i = 0, \quad \text{and} \quad \sum_{i=1}^{n} I_i = 0 \tag{A.2}$$

A.3 | Branch-Current Analysis Calculations

Referring to Figure 4.1, applying **KCL**:

$$I_1 + I_2 - I_3 = 0 \tag{1}$$

Now applying **KVL**:

$$20 - V_1 - V_3 = 0 \longrightarrow (1.9\,\text{k})I_1 + (6.8\,\text{k})I_3 = 20 \tag{2}$$
$$10 - V_2 - V_3 = 0 \longrightarrow (4.7\,\text{k})I_2 + (6.8\,\text{k})I_3 = 10 \tag{3}$$

Putting the three equations together, we obtain simultaneous equations:

$$\left.\begin{aligned} I_1 + I_2 - I_3 &= 0 \\ (1.9\,\text{k})I_1 + (6.8\,\text{k})I_3 &= 20 \\ (4.7\,\text{k})I_2 + (6.8\,\text{k})I_3 &= 10 \end{aligned}\right\}$$

Rewriting the above in matrix form:

$$\begin{bmatrix} 1 & 1 & -1 \\ 1.9\,\text{k} & 0 & 6.8\,\text{k} \\ 0 & 4.7\,\text{k} & 6.8\,\text{k} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 20 \\ 10 \end{bmatrix} \equiv A\mathbf{x} = \mathbf{b}$$

The inverse of matrix A is:

$$A^{-1} = \begin{bmatrix} {}^{1598}/_{2173} & {}^{23}/_{86920} & {}^{-17}/_{108650} \\ {}^{340}/_{2173} & {}^{-17}/_{108650} & {}^{39}/_{217300} \\ {}^{-235}/_{2173} & {}^{47}/_{434600} & {}^{1}/_{43460} \end{bmatrix}$$

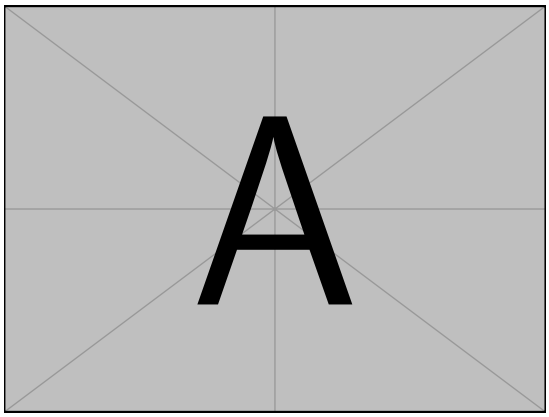
Therefore, we obtain the value of $\mathbf{x}$:

$$\begin{aligned} \mathbf{x} &= A^{-1}\mathbf{b} \\ \mathbf{x} &= \begin{bmatrix} {}^{1598}/_{2173} & {}^{23}/_{86920} & {}^{-17}/_{108650} \\ {}^{340}/_{2173} & {}^{-17}/_{108650} & {}^{39}/_{217300} \\ {}^{-235}/_{2173} & {}^{47}/_{434600} & {}^{1}/_{43460} \end{bmatrix} \begin{bmatrix} 0 \\ 20 \\ 10 \end{bmatrix} \\ \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} &\approx \begin{bmatrix} 3.728\,\text{mA} \\ -1.335\,\text{mA} \\ 2.793\,\text{mA} \end{bmatrix} \end{aligned} \tag{A.3}$$

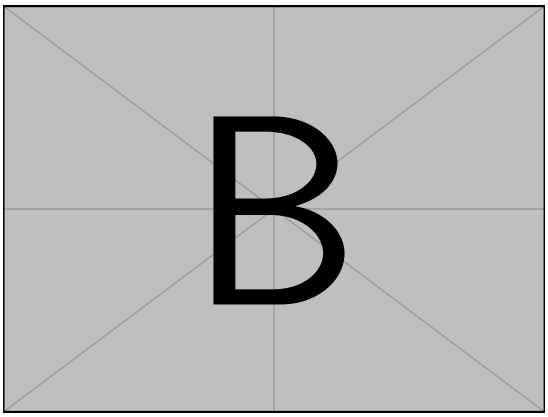
B Gallery

Include any fun photos you have taken during the experiment!

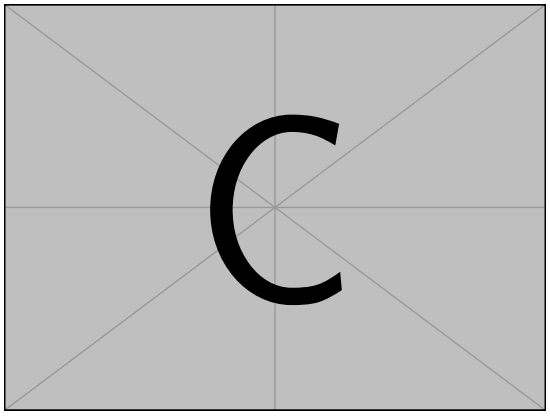
B.1 | Part 1



(a) Subcaption 1.



(b) Subcaption 2.



(c) Subcaption 3.

Figure B.1: Caption.

C Code

Include any code you have written for this experiment.

C.1 | Least-square Gradients

```
import pandas as pd

data = {'A': [10, 20], 'B': [30, 40]}
df = pd.DataFrame(data)
print(df.head())
```

Output

```
    A   B
0  10  30
1  20  40
```