A student investigates the power dissipated by a lamp connected to a model wind turbine as shown in Fig. 1.1.

![Fig. 1.1](image)

The power $P$ dissipated in the lamp depends on the angle $\theta$ between the axis of the turbine and the direction of the wind, as shown by the top view in Fig. 1.2.

![Fig. 1.2](image)

It is suggested that

$$P = k \cos \theta$$

where $k$ is a constant.

Design a laboratory experiment to test the relationship between $P$ and $\theta$ and determine a value for $k$. You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

(a) the procedure to be followed,
(b) the measurements to be taken,
(c) the control of variables,
(d) the analysis of the data,
(e) the safety precautions to be taken.
A student investigates electrical resonance in a circuit containing a capacitor and a coil connected in parallel.

The circuit is set up as shown in Fig. 2.1.

![Diagram of a circuit with a signal generator, coil, and capacitor](image)

**Fig. 2.1**

The resonant frequency \( f \) is the frequency at which the current measured by the ammeter is a minimum.

An experiment is carried out to investigate how \( f \) varies with the capacitance \( C \) of the capacitor.

It is suggested that \( f \) and \( C \) are related by the equation

\[
f = \frac{1}{2\pi\sqrt{LC}}
\]

where \( L \) is a constant for the circuit.

(a) A graph is plotted of \( f^2 \) on the y-axis against \( \frac{1}{C} \) on the x-axis. Determine an expression for the gradient in terms of \( L \).

\[
\text{gradient} = \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots [1]
\]
(b) Values of \( f \) and \( C \) are given in Fig. 2.2.

<table>
<thead>
<tr>
<th>( C/10^{-4} ) F</th>
<th>( f/) Hz</th>
<th>( 1/C/10^3 ) F(^{-1} )</th>
<th>( f^2/10^3 ) Hz(^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5 ± 10%</td>
<td>149</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0 ± 10%</td>
<td>134</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5 ± 10%</td>
<td>123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.4 ± 10%</td>
<td>107</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.6 ± 10%</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.8 ± 10%</td>
<td>65</td>
<td></td>
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</tr>
</tbody>
</table>

Fig. 2.2

Calculate and record values of \( 1/C/10^3 \) F\(^{-1} \) and \( f^2/10^3 \) Hz\(^2 \) in Fig. 2.2.

Include the absolute uncertainties in \( 1/C \). [3]

(c) (i) Plot a graph of \( f^2/10^3 \) Hz\(^2 \) against \( 1/C/10^3 \) F\(^{-1} \). Include error bars for \( 1/C \). [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]

(iii) Determine the gradient of the line of best fit. Include the uncertainty in your answer.

gradient = ................................................. [2]
(d) Using your answer to (c)(iii), determine the value of $L$. Include the absolute uncertainty in your value and an appropriate unit.

$L = \underline{\hspace{2cm}}$ \[3\]

(e) The experiment is repeated using a capacitor of capacitance $10\mu F \pm 10\%$.

(i) Using the relationship given and your answer to (d), determine the value of $f$.

$f = \underline{\hspace{2cm}}$ Hz \[1\]

(ii) Determine the percentage uncertainty in the value of $f$.

percentage uncertainty = $\underline{\hspace{2cm}}$ \% \[1\]