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the examination. It shows the basis on which Examiners were instructed to award marks. It does not
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Mark schemes should be read in conjunction with the question paper and the Principal Examiner
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1 Planning (15 marks)

Defining the problem (3 marks)

P (cos) \( \theta \) is the independent variable, or vary (cos) \( \theta \). \[1\]

P \( P \) is the dependent variable, or measure \( P \). \[1\]

P Keep the speed of the air constant.
Allow keep power to the fan/hairdryer constant. \[1\]

Methods of data collection (5 marks)

M Labelled diagram showing method to produce air flow in line with turbine. Method of producing “wind” must be labelled. \[1\]

M Circuit connecting turbine to lamp with ammeter and voltmeter connected correctly. No additional power supplies in the lamp circuit. \[1\]

M \( P = IV \). Do not allow \( I^2R \) or \( V^2/R \) unless it is clear that \( R \) is determined from \( V/I \). Allow wattmeter or joule meter and stopwatch. \[1\]

M Measure angle with protractor or use rule to measure appropriate distances. \[1\]

M Ensure that there are no other draughts or airflows. \[1\]

Method of analysis (2 marks)

A Plot a graph of \( P \) against \( \cos \theta \). \[1\]

A \( k = \) gradient. \[1\]

Safety considerations (1 mark)

S Precaution linked to avoiding air flow entering eyes or avoid moving blades. \[1\]

Additional detail (4 marks)

D Relevant points might include \[4\]

1 Use of large wind speed to gain measurable readings.
2 Use of low wattage/low resistance lamp or turbine with low friction.
3 Additional detail on measuring (cos) \( \theta \) – correct angle must be determined.
4 Wait until airflow/turbine/meter readings constant.
5 Avoid turbulence or reflection of air flow.
6 Ensure distance from fan to turbine is constant.
7 Relationship is valid if the graph is a straight line passing through the origin.
8 Method to check that wind speed is constant.

Do not allow vague computer methods.

[Total: 15]
# Analysis, conclusions and evaluation (15 marks)

<table>
<thead>
<tr>
<th>Mark</th>
<th>Expected Answer</th>
<th>Additional Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(a)</strong></td>
<td>A1</td>
<td>$\text{gradient} = \frac{1}{4\pi^2 L}$</td>
</tr>
<tr>
<td><strong>(b)</strong></td>
<td>T1 T2</td>
<td>4.0 or 4.00 22.2 or 22.20 3.3 or 3.33 18.0 or 17.96 2.9 or 2.86 15.1 or 15.13 2.3 or 2.27 11.4 or 11.45 1.5 or 1.52 6.7 or 6.72 1.1 or 1.14 4.2 or 4.23</td>
</tr>
<tr>
<td><strong>U1</strong></td>
<td>From $\pm 0.4$ (or $\pm 0.5$) to $\pm 0.1$ (or $\pm 0.2$)</td>
<td>Allow more than one significant figure.</td>
</tr>
<tr>
<td><strong>(c) (i)</strong></td>
<td>G1</td>
<td>Six points plotted correctly</td>
</tr>
<tr>
<td><strong>(c) (ii)</strong></td>
<td>G2</td>
<td>Line of best fit</td>
</tr>
<tr>
<td><strong>(c) (iii)</strong></td>
<td>C1</td>
<td>Gradient of best fit line</td>
</tr>
<tr>
<td><strong>U3</strong></td>
<td>Uncertainty in gradient correctly determined</td>
<td>Method of determining absolute uncertainty: difference in worst gradient and gradient.</td>
</tr>
<tr>
<td><strong>(d)</strong></td>
<td>C2</td>
<td>$L = \frac{1}{4\pi^2 \times \text{gradient}}$</td>
</tr>
</tbody>
</table>
Uncertainties in Question 2

(c) (iii) Gradient [U3]

Uncertainty = gradient of line of best fit – gradient of worst acceptable line

Uncertainty = $\frac{1}{2}$ (steepest worst line gradient – shallowest worst line gradient)

(d) [U4]

\[
\text{absolute uncertainty in } L = \left(\frac{\Delta \text{gradient}}{\text{gradient}} \times L\right)
\]

\[
\text{max } L = \frac{1}{4\pi^2 \times \text{min gradient}}
\]

\[
\text{min } L = \frac{1}{4\pi^2 \times \text{max gradient}}
\]

(e) (ii) [U5]

\[
\% \text{ uncertainty} = \frac{1}{2} \left(\frac{\Delta L}{L} \times 100 + 10\right) = \frac{1}{2} \left(\frac{\Delta \text{gradient}}{\text{gradient}} \times 100 + 10\right)
\]

\[
\text{max } f = \frac{1}{2\pi\sqrt{L_{\text{min}}C_{\text{min}}}} = \sqrt{\frac{\text{max gradient}}{\text{min C}}}
\]

\[
\text{min } f = \frac{1}{2\pi\sqrt{L_{\text{max}}C_{\text{max}}}} = \sqrt{\frac{\text{min gradient}}{\text{max C}}}
\]