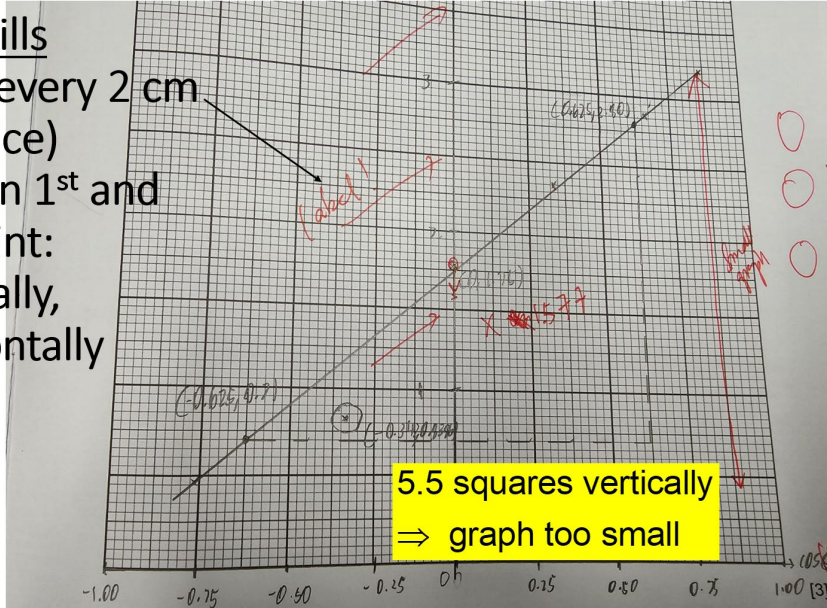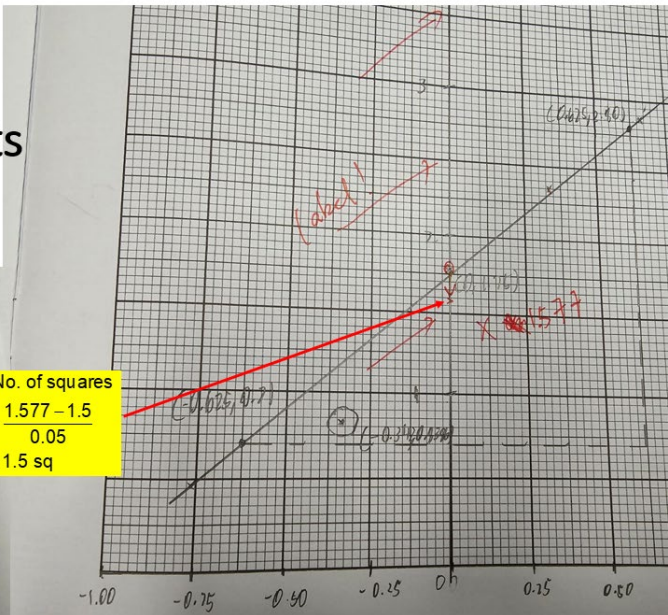| No	Marking Instructions	Mark
1(a)(i)	• Total mass of at least 5 paper clips measured. Average mass of each paper clip to be computed from total mass.	1
	• Value of each paper clip < 1.20 g • Value of each paper clip stated to the correct precision and recorded with an appropriate unit.	1
1(a)(ii)	• Average of at least 2 readings. • Must be whole number if the average of 2 consecutive numbers given.	1
1(b)(i)	• Average of at least 2 measurements. • $125° \leq \theta \leq 155°$. • θ recorded to the correct precision (nearest degree) with unit (degree °)	1
1(b)(ii)	• $2° \leq \Delta\theta \leq 8°$. • Correct calculation. • % uncertainty to 2 s.f. • If repeated readings have been taken, then absolute uncertainty can be computed as follows with full working clearly shown: $\Delta\theta = \left(\theta_{max} - \theta_{min}\right) / 2$. This method is not valid if the computed value $\Delta\theta = 0$, or $\Delta\theta \leq$ precision of instrument.	1
1(c)(i)	• Value of M calculated correctly with appropriate s.f. (2 or 3) and units. 	1
1(c)(ii)	• Clear explanation or working showing how the maximum value of M can be obtained. • Values of **(a)(ii)** and **(b)(ii)** to be explicitly used • Maximum value of M correctly calculated with appropriate s.f. (2 or 3) and units. 	1

1(c)(iii)	• Average of at least 2 measurements.
	• Value of θ in **(c)(iii)** less than the value of θ in **(b)(i).**
	• θ is recorded to the correct precision (nearest degree) with unit (degree $^\circ$)
	
	Examiner's Comments
	Common errors:
	    • only one reading taken (MUST take repeated reading!),
	    • expressing the angle measured to 0.1 degree (MUST give to whole number!)
	    • omtting the unit for the angle measured (MUST give units!)
		1

1(d)(i)	• k_1 & k_2 calculated correctly and given to appropriate s.f.
	• k_1 & k_2 given correct units.
	
	Examiner's Comments
	Common errors:
	    • omitting the unit for k
	    • taking m = 50 g for both θ measured.
		1
		1

1(d)(ii)	• Percentage difference in the two k values calculated correctly and given to 2 s.f. • Correct conclusion given with reasoning. **Examiner's Comments** Minority of scripts did not apply the formula for percentage difference correctly or failed to compare the percentage difference in k with percentage uncertainty in θ as required.	1 1
1(e)(i)	***Accepted sources of error*** **Usually expect problem + quantity for sources of error. But in this case, the quantity is given, so stating θ becomes a good practice rather than a requirement.** i) Difficult to measure θ accurately, using a protractor held in one's hand, because of unsteady hands ii) Friction present in the ball bearings of the pulley causes the setup to be stable over a range of θ. iii) The hook of the hanger makes it impossible to place the protractor close to the setup. This affects the measurement of θ. iv) Difficult to gauge where the vertical axis is. This makes it difficult to ensure that θ is symmetrical about the vertical axis. **Examiner's Comments** 1. Many students thought that the height of the 2 ends of the strings must be the same. This is not the case. 2. Answers like difficult to measure angle θ will not be accepted if the difficulty is not elaborated correctly. 3. Some students also wrote answers like wind/parallax error and no mark was awarded as well.	Max 1

1(e)(ii)	***Corresponding improvement***
	
	i) Clamp the protractor with a retort stand, so that it is stable.
	ii) Lubricate the axle of the pulley.
	iii) Tie the hanger to a string loop, and hang the loop through the string in Fig 1.2
	iv) Use a plumb line to indicate the vertical axis as a fiducial marker.
	            or
	   Measure the horizontal distance to ensure the mass is hung at the mid-point. (This is not entirely true because the height of the 2 ends of the strings are not the same.)
	   BOD – You may have kept the height the same.
	
	Do not accept:
	1. Use trigo to calculate angle θ because most assumptions are wrong. Using metre rule to measure the length will incur error as well.
	2. Many students used video/photograph to ensure the angle is symmetrical. This is also not accepted because the camera is not aligned and will incur more error.
		Max 1

		[Total: 14 Marks]

No	Marking Instructions	Mark

2(a)(iii)	• Average of at least 2 measurements.
	• $130° \leq \theta \leq 150°$.
	• θ recorded to the correct precision (nearest degree) with unit (degree °)
	
	Examiner's Comments
	Common errors:
	   • Units and evidence of repeated readings were often missed out.
	   • Precision was wrong (Correct: 1°, Wrong: 0.1°)
		1

2(b)(iii)	• Number of oscillations stated. BOD given if not defined but can be inferred from calculation
	• Evidence of repeated measurements of t.
	  BOD given if main table has repeated measurement of the same reading.
	• t recorded with the *correct* precision (2 d.p.) and unit.
	• $t \geq 15$ s
	• T calculated correctly and given to the correct s.f. (4 SF) with an appropriate unit.
	
	Examiner's Comments
	Common errors:
	   • wrong units (s^{-1})
	   • $t < 15$ s
	   • T not in 4 sf.
		1

2(c)	• 6 or more sets of data without assistance/ intervention.	1
	• **Range** of $\theta > 80°$	1
	• **Correct trend:** as θ decreases, T decreases	1
	• Each **column heading** must contain a quantity with an appropriate unit. (minimally must have θ, t, $\dfrac{1}{T^4}$ and cos θ) **Examiner's Comments** Most students could not write correctly the column heading $\cos(\theta \, / \, °)$.	1
	All **raw measurements** are recorded to the correct precision • t to the nearest 0.01 s • θ to the nearest degree	1
	• All **processed data** are correctly calculated and given to the correct s.f.	1
	Number of oscillations shown AND evidence of repeated measurements of t for each value of θ AND $t \geq 15$ s	1
	[minus 1] Split table	
	Examiner's Comments Quite a number of students did not draw in the table lines. Many recorded their readings in pencil instead of using a pen. Note that doing all these reduce the readability of the table, and candidates might be penalised in the A-level Exam. Students who did not do well for this section obviously have not studied the Practical Guide notes, or the many past Sample reports.	

2(d)(i)		
Graph Axes	• Sensible scales must be used, no awkward scales (e.g. 3:10). • Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. • Scales must be labelled with the quantity and units which are being plotted. • Scale markings should be no more than 4 cm apart. **Examiner's Comments** Please approach tutor for clarification if you do not know what is considered a small graph (see point 2 above). Graphing Skills Axes Label: every 2 cm (good practice) Dist between 1st and last data point: > 6sq vertically, > 4sq horizontally 5.5 squares vertically ⇒ graph too small	1
Graph Plotting of points	• All observations must be plotted on the grid. • Plots must be accurate to within half a small square in both x and y directions. **Examiner's Comments** • Learn how to calculate how many squares a certain point is. (See below) • Do NOT put a cross for gradient coordinates or y-intercept. Graphing Skills Plotting of points No. of squares $= \dfrac{1.577 - 1.5}{0.05}$ $= 1.5$ sq	1

Graph
Line of best fit
	• Judged by balance of all points on the grid about the line. There must be an even distribution of points either side of the line along the full length.
	• One anomalous point is allowed only if clearly indicated (i.e. circled and labelled).
	• Lines must not be kinked or thicker than half a small square.
	
	Examiner's Comments
	Marker's judgement is final. Use the following pointers to check your line.
	   • Sum the perpendicular distance of the points above and below the line. They should be equal. Else shift the line.
	   • The points above and below should be scattered throughout the line. For example if 1st 3 points are below the line and next 3 points are above the line, it means the best fit line should be rotated.
		1

Linearising equation and statement	• Linearizing equation and statement. **Examiner's Comments** Linearizing statement missing or missing words "to give a straight line graph"	1

gradient	• The hypotenuse of the triangle or lines (must draw) must be greater than half the length of the drawn line.
	• Label the coordinates correctly to half a small square in both the x and y directions (can drop off trailing zeros)
	
	Examiner's Comments
	Common errors:
	   • missing gradient triangle and coordinates.
	   • coordinates read wrongly
		1

finding A	• correct calculation for gradient; do not allow $\Delta x / \Delta y$. • correct unit (s^{-4}) • accept 2 to 4 sf **Examiner's Comments** Units often missing	1
y-intercept / finding B	Either: • Correct read-offs from a point on the line substituted into $y = mx + c$ or an equivalent expression. • Correct calculation. • Read-off must be accurate to half a small square in both x and y directions. OR: • Intercept read directly from the graph, with read-off accurate to half a small square. • value of B correctly computed and stated with correct s.f. (2 – 4 s.f.) and units. **Examiner's Comments** Units often missing and reading the y-intercept from the wrong y-axis.	1
2(d)(ii)	Correct justification of anomalous point • State coordinates of anomalous point or comment on absence • Follow/does not follow trend of best fit line • (Significantly) far/ not far from best fit line **relative to other points** • **Examiner's Comments** Please learn from the model answer and provide all the key words. Each word / phrase is there for a reason.	1

2(e)	• Average of at least 2 measurements. • $37.5 \le L \le 42.5$ cm. • L recorded to the correct precision (0.1 cm) with unit. **Examiner's Comments** Mostly well done.	1
	• Value of g calculated correctly with appropriate s.f. (3 or 4) and units. **Examiner's Comments** Mostly well done. Errors include the lack of units or wrong units.	1
		[Total: 19 Marks]