Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

PHYSICS **9702/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2019**

MARK SCHEME

Maximum Mark: 30

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Question	Answer	Marks
1	**Defining the problem**	
	L is the independent variable and *s* is the dependent variable **or** vary *L* and measure *s*	**1**
	keep mass of load or *M* constant	**1**
	Methods of data collection	
	labelled diagram of workable experiment including: • method of fixing strip at one end, e.g. with a G-clamp or (heavy) mass placed on top of strip over bench • load shown touching at point P • load and G-clamp or (heavy) mass labelled	**1**
	method of attaching load to strip, e.g. use glue/tape/attach with a hook and string	**1**
	use a rule to measure *L* and *s*	**1**
	use a balance to measure *M*	**1**
	Method of analysis	
	plot a graph of *s* against L^3 (allow lg *s* against lg *L*, or log)	**1**
	relationship valid if a straight line through (0,0) (for lg *s* against lg *L* gradient of straight line = 3)	**1**
	$E = \dfrac{4Mg}{bt^3 \times \text{gradient}}$ (for lg *s* against lg *L*, $E = \dfrac{4Mg}{bt^3} \div 10^{y-\text{intercept}}$)	**1**

Question	Answer		Marks
1	**Additional detail including safety considerations**		**Max. 6**
	D1	use cushion/foam/sandbox in case mass/load falls **or** wear goggles in case strip snaps or recoils	
	D2	use same wooden strip or keep *b* and *t* constant	
	D3	clamp rule vertically to measure *s*	
	D4	method to ensure clamped rule to measure *s* is vertical, e.g. correctly positioned set square indicated at right angles to the horizontal surface or plumb line shown in appropriate position	
	D5	*s* = reading of vertical rule with loaded strip – reading of vertical rule with no load	
	D6	repeat *s* measurement for each *L* (unloading and loading strip) and average *s*	
	D7	use a micrometer/calipers to determine *t*	
	D8	repeat readings for *b* and/or *t* at different points along/across the strip and average	
	D9	method to ensure strip is perpendicular to the bench, e.g. repeat measurements of *L* on each side of strip to check that *L* is constant or set square correctly indicated on diagram	
	D10	wait until block is stationary/in equilibrium or measure *s* after a fixed time	

Question	Answer	Marks
2(a)	gradient = $\dfrac{K}{E}$	**1**
2(b)	<table><tr><td>$\dfrac{1}{I}$ / A^{-1}</td></tr><tr><td>180 or 175</td></tr><tr><td>210 or 213</td></tr><tr><td>250</td></tr><tr><td>290 or 286</td></tr><tr><td>320 or 323</td></tr><tr><td>370</td></tr></table>	**1**
	uncertainties in $\dfrac{1}{I}$ from ±3 or ±4 to ±10–15	**1**
2(c)(i)	Six points plotted correctly. Must be accurate to the nearest half small square. Diameter of points must be less than half a small square.	**1**
	Error bars in $\dfrac{1}{I}$ plotted correctly. All error bars to be plotted. Length of bar must be accurate to less than half a small square and symmetrical.	**1**

Question	Answer	Marks
2(c)(ii)	Line of best fit drawn. Do not allow line from top point to bottom point. If points are plotted correctly then lower end of line should pass between (122, 230) and (126, 230) **and** upper end of line should pass between (186, 350) and (190, 350).	**1**
	Worst acceptable line drawn (steepest or shallowest possible line that passes through all the error bars). All error bars must be plotted.	**1**
2(c)(iii)	Gradient determined with clear substitution of points from the line into $\Delta y/\Delta x$. Distance between points must be at least half the length of the drawn line.	**1**
	uncertainty = gradient of line of best fit – gradient of worst acceptable line **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	**1**
2(d)	9.4 ± 0.2 (V)	**1**
2(e)(i)	*K* determined from gradient **and** given to 2 or 3 significant figures. $K = E \times$ gradient $= 9.4 \times$ **(c)(iii)**.	**1**
	K determined from gradient with correct unit (Ω / °).	**1**
2(e)(ii)	% uncertainty in $K = \left(\left(\frac{\Delta\text{gradient}}{\text{gradient}}\right) + \left(\frac{\Delta E}{E}\right)\right) \times 100$	**1**

Question	Answer	Marks
2(f)	θ calculated. Correct substitution of numbers required. $\theta = \dfrac{E}{IK} = \dfrac{9.4}{0.01 \times \textbf{(e)(i)}}$ **or** $\theta = \dfrac{1}{I \times \text{gradient}} = \dfrac{1}{0.01 \times \textbf{(c)(iii)}}$	**1**
	Absolute uncertainty in θ. Correct substitution of numbers required. Use of ΔI not required but allow if included by the candidate. Using *E* and *K*: $\text{uncertainty in}\,\theta = \left(\dfrac{\Delta E}{E} + \dfrac{\Delta K}{K}\left(+\dfrac{\Delta I}{I}\right)\right) \times \theta$ $\text{uncertainty in}\,\theta = \left(\dfrac{0.2}{9.4} + \dfrac{\textbf{(e)(ii)}}{100}\right) \times \theta$ $\max\theta = \dfrac{\max E}{0.01 \times \min K}$ **or** $\min\theta = \dfrac{\min E}{0.01 \times \max K}$ Using gradient: $\text{uncertainty in}\,\theta = \left(\dfrac{\Delta\text{gradient}}{\text{gradient}}\left(+\dfrac{\Delta I}{I}\right)\right) \times \theta$ $\max\theta = \dfrac{1}{0.01 \times \min\text{gradient}}$ **or** $\min\theta = \dfrac{1}{0.01 \times \max\text{gradient}}$	**1**