Cambridge International AS & A Level

PHYSICS **9702/54**

Paper 5 Planning, Analysis and Evaluation **May/June 2026**

MARK SCHEME

Maximum Mark: 30

Published

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

General marking principles

All examiners must apply these marking principles when marking candidate responses.

1	Examiners must award marks for each response in line with: • the specific **content** defined in the mark scheme • the specific **skills** defined in the mark scheme or in the level descriptions • the **standard of response** required as exemplified by the standardisation scripts.
2	Examiners must award **whole marks** (not half marks, or other fractions).
3	Examiners must award marks **positively**. This means that: • marks are not deducted for errors or omissions • marks are awarded for correct/valid answers as defined in the mark scheme and also for **other valid answers** which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate • the quality of spelling, punctuation and grammar are judged **only** when the mark scheme indicates that these features are **specifically assessed** in the question. However, the meaning of all responses must be unambiguous.
4	Examiners must **consistently** apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly.
5	Examiners must use the **full range of marks** defined in the mark scheme, unless limited by the quality of the candidate responses seen.
6	Examiners must award marks according to the mark scheme and **must not** award marks with grade thresholds or grade descriptions in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states ‘show your working’.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
BOD	benefit of the doubt given
✓ 1	correct awarding one mark from additional detail 1. similar numbered ticks are used for additional detail 2, 3, 4 etc.
✓	correct point or mark awarded
P	defining the problem mark
ECF	error carried forward applied
SF	error in number of significant figures
I	incorrect or insufficient point ignored while marking the rest of the response
✗	incorrect point or mark not awarded
U	incorrect unit
^	information missing or insufficient for credit

Annotation	Meaning
MO	methods of data collection mark
SEEN	point has been noted, but no credit has been given or blank page seen
REP	repeat of point previously awarded mark

Abbreviations

ECF	error carried forward
SF	significant figures
POT	power of ten

Question	Answer	Marks	Guidance
1	**Defining the problem**		Annotate with P.
	Vary *r* and measure *c* **or** *r* is the independent variable and *c* is the dependent variable	1	This mark could be awarded having read the candidate's script all the way through. **Not** *r* or *c* constant.
	Keep *v* <u>constant</u>	1	**Allow** same for constant **Allow** speed or v^2 for *v* **Ignore** keep distance ball falls constant see D2
	Methods of data collection		Annotate with M0.
	Labelled diagram of workable experiment including: • cardboard on springs • springs on bench • rule (to measure *c*) clamped vertically near to cardboard • stand on bench • two labels from bench, spring(s), cardboard, clamp / stand, rule	1	**Note** D2, D5, D7 **Allow** ruler for rule
	Method to determine *c*, e.g. measure initial height (of cardboard / spring) and new height **and** *c* = original height – new height	1	**Allow** difference in heights or new height – original height
	Method to determine *r* e.g. use micrometer / calipers to measure diameter *d* **and** *r* = *d* / 2	1	**Not** rule(r) **Allow** rule(r) **and** use of set squares / blocks
	Measure height (*h*) ball <u>falls</u> (from release point to cardboard) with rule (to determine *v*)	1	**Allow** ruler for rule **Not** micrometer / calipers

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>Method of Analysis</td><td></td><td>Annotate with ✓.</td></tr>
<tr><td></td><td>Plot a graph of $\frac{1}{c^2}$ against $\frac{1}{r^3}$
or
plot a graph of $\frac{1}{r^3}$ against $\frac{1}{c^2}$ or equivalent.
Do not accept logarithms.</td><td>1</td><td>Note drawn axes take priority.</td></tr>
<tr><td></td><td><table><tr><td>$\frac{1}{c^2}$ against $\frac{1}{r^3}$</td><td>$\frac{1}{r^3}$ against $\frac{1}{c^2}$</td></tr><tr><td>$\alpha = \pi\rho v^2 \times \text{gradient}$</td><td>$\alpha = \frac{\pi\rho v^2}{\text{gradient}}$</td></tr></table></td><td>1</td><td>Note Must be consistent with drawn graph.</td></tr>
<tr><td></td><td><table><tr><td>$\frac{1}{c^2}$ against $\frac{1}{r^3}$</td><td>$\frac{1}{r^3}$ against $\frac{1}{c^2}$</td></tr><tr><td>$Z = y\text{-intercept} \times v^2$</td><td>$Z = -\frac{\alpha \times y\text{-intercept}}{\pi\rho}$
or $Z = -\frac{v^2 \times y\text{-intercept}}{\text{gradient}}$</td></tr></table></td><td>1</td><td>Note Must be consistent with drawn graph.</td></tr>
</table>

Question	Answer	Marks	Guidance
1	**Additional detail including safety considerations**	**6**	Annotate with numbered tick
	D1 Precaution linked to stop ball (leaving bench), e.g. screens around apparatus to stop the ball or cushions / sand tray on bench to stop the ball		**Ignore** goggles **Ignore** reference to floor **Ignore** collisions with equipment / people
	D2 Method to keep *v* constant, by keeping distance ball falls constant, e.g. electromagnet fixed between the springs to release (steel) ball		**Note** from diagram **Allow** fixed release point between springs e.g. clamp / rule fixed
	D3 Method to determine *v* using height *h* ball falls to cardboard e.g. $v = \sqrt{2gh}$ or $v^2 = 2gh$		**Ignore** timing methods **Note** *h* must be defined **Note** must use *g*
	D4 Measure mass *m* of ball using a balance **and** $\rho = \dfrac{m}{\frac{4}{3}\pi r^3}$ or $\rho = \dfrac{6m}{\pi d^3}$ **or** $\rho = \dfrac{m}{V}$ **and** $V = \dfrac{4}{3}\pi r^3$ or $\dfrac{1}{6}\pi d^3$		**Ignore** displacement methods **Allow** scales **Ignore** scale
	D5 Description of method to ensure stability of the cardboard e.g. tape / adhesive putty at end of the spring(s) **or** position springs at the edges / corners of the cardboard or symmetrically		**Allow** from diagram **Allow** glue at top of springs **Ignore** clamped springs **Allow** springs fixed to base or rods clamped to bench
	D6 Method to ensure that *c* is the same for all springs, e.g. ball needs to hit centre of cardboard **or** use springs each with the same spring constant		**Ignore** symmetrical (D5) **Ignore** *k* is constant **Ignore** springs are the same
	D7 Description of method to determine accurate value of *h* and/or *c* e.g. measure from the bottom of the ball to the top of the cardboard **or** use of plumb line / set square to ensure rule is vertical		**Allow** on diagram **Note** reason required

Question	Answer	Marks	Guidance
1	D8 Use springs with small value of spring constant / longer springs / springs with more turns / larger h <u>to increase c</u> **or** Use of video and slow-motion playback / frame by frame (with rule in view) to observe (minimum) new height (of spring/cardboard)		**Ignore** reference to pointer since there is the edge of the cardboard **Allow** determine c for new height
	D9 Repeat determination of c for the same value of r **and** average c		**Allow** same ball or r or d **Allow** each for same
	D10 Relationship valid <u>if</u> a straight line is produced (with y-intercept = $\frac{Z}{v^2}$). Do not accept through the origin.		**Note** Must be consistent with drawn graph. **Ignore** ‘data’ / ‘graph’ / ‘experiment’ / ‘results’ / ‘correlation’ valid.

Question	Answer	Marks	Guidance
2(a)	Gradient = $\dfrac{16\pi^2 ML^3}{Ed^3}$	1	
2(b)	<table><tr><th>T / s</th><th>T^2 / s^2</th></tr><tr><td>0.400</td><td>0.160 or 0.1600</td></tr><tr><td>0.371</td><td>0.138 or 0.1376</td></tr><tr><td>0.339</td><td>0.115 or 0.1149</td></tr><tr><td>0.310</td><td>0.0961 or 0.09610</td></tr><tr><td>0.289</td><td>0.0835 or 0.08352</td></tr><tr><td>0.271</td><td>0.0734 or 0.07344</td></tr></table>		
	Values of T^2 as shown in table above.	1	**Allow** mixture of sf in T^2
	Uncertainties in T and T^2: T: ± 0.004 **and** T^2: from ± 0.003 to ± 0.002	1	**Allow** more than 1 sf **Allow** more than 1 sf
2(c)(i)	Six points from **(b)** plotted correctly. Must be within half a small square. Diameter of points must be less than half a small square.	1	Check second and fifth plots from the left. **Allow** ecf from **2(b)**
	Error bars in T^2 plotted correctly. All error bars to be plotted. Total length of bar must be accurate to less than half a small square and symmetrical.	1	Check second and fifth plots from the left. **Allow** ecf from **2(b)**

Question	Answer	Marks	Guidance
2(c)(ii)	Straight line of best fit drawn. Do not accept line from top point to bottom point. Thickness of the line should be less than half a small square. Line must pass between (65.0, 0.090) and (67.0, 0.090) **and** between (103.0, 0.140) and (104.0, 0.140)	1	**Note** no ecf
	Worst acceptable line drawn. Steepest or shallowest possible line that passes through all the error bars. Thickness of the line should be less than half a small square. All error bars must be plotted.	1	**Allow** ecf from points/error bars plotted incorrectly. **Note** wal may be constrained by an intermediate error bar.
2(c)(iii)	Gradient determined with clear substitution of data points into $\Delta y / \Delta x$; distance between data points must be greater than half the length of the drawn line.	1	Check the read offs. Work to less than half a small square in each direction. **Ignore** POT. **Expect** ≈ 0.0011 to 0.0015 **Expect** $\Delta x \geqslant 35$
	Gradient determined of worst acceptable line with clear substitution of data points into $\Delta y / \Delta x$ uncertainty = (gradient of line of best fit – gradient of worst acceptable line) **or** uncertainty = ½ (steepest worst line gradient – shallowest worst line gradient)	1	Method of determining absolute uncertainty. Check read-offs are not used in the bfl gradient unless on wal. Check subtraction.
2(d)	0.97 ± 0.03 (mm)	1	**Allow** 0.970 and / or 0.030 **Allow** 0.98 ± 0.01 (mm)

Question	Answer	Marks	Guidance
2(e)(i)	*E* determined using gradient **and** *E* given to 2 or 3 sf $E = \dfrac{16\pi^2 ML^3}{\text{gradient} \times d^3} = \dfrac{0.284}{\text{gradient} \times d^3}$	1	**Ignore** POT **Allow** ecf from **2(c)(iii)** and **2(d)** **Note** expect to see evidence of use of gradient
	E determined using gradient **and** *E* given with SI units with appropriate power of ten Unit of *E*: N m^{-2} or Pa or $\text{kg m}^{-1}\text{s}^{-2}$	1	**Allow** ecf from **2(c)(iii)** and **2(d)** **Expect** ≈ 2.4×10^{11} (N m^{-2}) 2.4×10^{9} ($\text{kg cm}^{-1}\text{s}^{-2}$) 2.4×10^{14} ($\text{g m}^{-1}\text{s}^{-2}$) 2.4×10^{12} ($\text{g cm}^{-1}\text{s}^{-2}$) **Allow** unit for gradient substituted into correct expression with values but incorrectly calculated **Ignore** $\text{kg cm}^{3}\text{m}^{-1}\text{mm}^{-3}\text{s}^{-2}$
2(e)(ii)	Percentage uncertainty in *E* with method shown. $\%\text{uncertainty} = \left(\dfrac{\Delta M}{M} + \dfrac{3\Delta L}{L} + \dfrac{\Delta\text{gradient}}{\text{gradient}} + \dfrac{3\Delta d}{d}\right) \times 100$ $\%\text{uncertainty} = \left(5\% + 3 \times 0.7\% + \dfrac{\Delta\text{gradient}}{\text{gradient}}\% + \dfrac{3\Delta d}{d}\%\right)$ **or** Correct substitution for max/min methods.	1	**Allow** ecf from **2(c)(iii)**, **2(d)** and **2(e)(i)** **Allow** 1sf if working clear **Note** must be greater than 7% (16% with correct **2(d)**)

Question	Answer	Marks	Guidance
2(f)	w determined to a minimum of 2 sf from **2(c)(iii)** or **2(d)** and **2(e)(i)** with clear method **and** correct power of ten. $w = \dfrac{\text{gradient}}{T^2} = \dfrac{\text{gradient}}{0.500^2} = 4 \times \text{gradient}$ **or** $w = \dfrac{16\pi^2 ML^3}{Ed^3T^2} = \dfrac{1.136}{Ed^3}$	1	**Allow** ecf from **2(c)(iii)**, **2(d)** and **2(e)(i)** **Expect** ≈ 5×10^{-3} (m) **Note** $d = 9.7 \times 10^{-3}$ (m) from **2(d)** – possible ecf **Allow** 1 sf answer if uncertainty justifies it (from 2nd method)
	Absolute uncertainty determined with correct substitution. For use of gradient from **2(c)(iii)**: $\Delta w = \left(\dfrac{\Delta\text{gradient}}{\text{gradient}} + \dfrac{2 \times 0.004}{0.500}\right) \times w$ **or** Correct substitution for max/min methods. $\Delta w = \dfrac{\text{max gradient}}{0.496^2} - w$ **or** $\Delta w = w - \dfrac{\text{min gradient}}{0.504^2}$ **or** For use of d and E from **2(d)** and **2(e)(i)** $\Delta w = \left(\dfrac{\Delta M}{M} + \dfrac{3\Delta L}{L} + \dfrac{\Delta E}{E} + \dfrac{3\Delta d}{d} + \dfrac{2\Delta T}{T}\right) \times w$ **or** Correct substitution for max/min methods. $\Delta w = \left(\dfrac{16\pi^2 \times \max M \times (\max L)^3}{\min E \times (\min d)^3 \times (\min T)^2}\right) - w$ **or** $\Delta w = w - \left(\dfrac{16\pi^2 \times \min M \times (\min L)^3}{\max E \times (\max d)^3 \times (\max T)^2}\right)$	1	**Allow** max / min methods **Allow** clear method **Note** substitution needed **Allow** clear method **Note** substitution needed **Note** substitution needed