Mark Scheme (Results)

June 2021

Pearson Edexcel International Advanced Level
In Physics (WPH16)
Paper 1 Practical Skills in Physics II

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Summer 2021
Question Paper Log Number P67822A
Publications Code WPH16_01_2106_MS

Erratum Notice WPH16 Mark Scheme

There was a printing error in Q4 (c) (iii). In the command sentence, 0.11 cm was printed instead of 0.11 cm^2.

This may have confused some candidates who might have thought that they had to take the square root of their uncertainty value (so that the units of their answer would be cm). This could affect the awarding of MP4, although MP1, MP2, and MP3 are all process marks and so would be unaffected.

For candidates who sat the uncorrected QP, otherwise correct responses in which the square root of final value is taken should be awarded full credit.

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] (1) **1**
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'

1.2 Bold lower case will be used for emphasis.

1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".

1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.

2.2 Incorrect use of case e.g. 'Watt' or 'w' will not be penalised.

2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in ePen).

2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.

2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.

3.2 The use of $g = 10 \text{ m s}^{-2}$ or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use o**f the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H	(1)	
Substitution into density equation with a volume and density	(1)	
Correct answer [49.4 (N)] to at least 3 sig fig. [No ue]	(1)	**3**

[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark]
[Bald answer scores 0, reverse calculation 2/3]

<u>Example of calculation</u>
80 cm × 50 cm × 1.8 cm = 7200 cm^3
7200 cm^3 × 0.70 g cm^{-3} = 5040 g
5040 × 10^{-3} kg × 9.81 N/kg= 49.4 N

5. Graphs

5.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

5.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

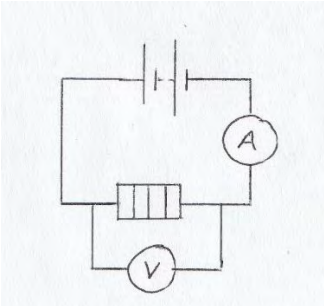
5.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 4, 7 etc.

5.4 Points should be plotted to within 1 mm.
- Check the two points furthest from the best line. If both are OK award the mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these are OK, otherwise no mark.

5.5 For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question number	Answer		Mark
1(a)	Measure (the number of divisions) between the same points on the pulses [Accept clearly labelled on diagram]	(1)	
	Multiply the number of divisions by the time per division.	(1)	
	Measure between the first and last pulse and divide by two **Or** Measure between successive pulses and determine a mean	(1)	**3**
	[Accept distance for number of divisions]		
1(b)	Use of $T = 2\pi/\omega$ **and** $v = \omega r$	(1)	
	T = 35.9 ms [Accept 36 ms]	(1)	
	Correct value of time per division calculated from time period and screen width **Or** Correct value of (maximum) time period on screen calculated using time scale and screen width	(1)	
	Valid time scale based on comparison of values	(1)	**4**
	[Accept calculation based on a screen width of between 5 and 10 divisions, or 2T]		
	<u>Example of calculation</u>		
	$\omega = v / r = 22.2 \text{ m s}^{-1} / 0.127 \text{ m} = 175 \text{ rad s}^{-1}$		
	$T = 2\pi / \omega = 2\pi / 175 \text{ rad s}^{-1} = 35.9 \times 10^{-3} \text{ s} = 35.9 \text{ ms}$		
	The screen is 10 divisions wide, so each division would need to be at least 3.59 ms		
	Therefore use setting of 5 ms per division as 2 ms per division is too small		
			Total mark for Question 1 = 7

<table>
<tr><th>Question number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>2(a)</td><td>Correct circuit diagram including a d.c. power supply, voltmeter and ammeter [Accept joulemeter or wattmeter in series for voltmeter and ammeter]

<u>Example of circuit diagram</u>


[Accept circuit drawn on diagram]

Wait until the water begins to boil
Record values of mass m

at times t with a stopwatch
Or
at energies E with a joulemeter

Plot appropriate graph for the measurements made
Correct gradient for the graph to obtain L
[Accept a labelled sketch graph]

<u>Examples of appropriate graphs</u>
<table>
<tr><th>y</th><th>x</th><th>gradient</th></tr>
<tr><td>m</td><td>t</td><td>VI/L or P/L</td></tr>
<tr><td>m</td><td>VIt or Pt or E</td><td>1/L</td></tr>
<tr><td>m</td><td>Vt</td><td>I/L</td></tr>
<tr><td>m</td><td>It</td><td>V/L</td></tr>
</table></td><td>(1)

(1)
(1)

(1)

(1)
(1)</td><td>6</td></tr>
<tr><td>2(b)</td><td>A significant source of error is energy transfer to the surroundings
Decreases the energy transferred to the water (per second)
Hence the value of L will be too large [dependent MP1 or MP2]
[Accept a reasonable source of error related to the experiment]</td><td>(1)

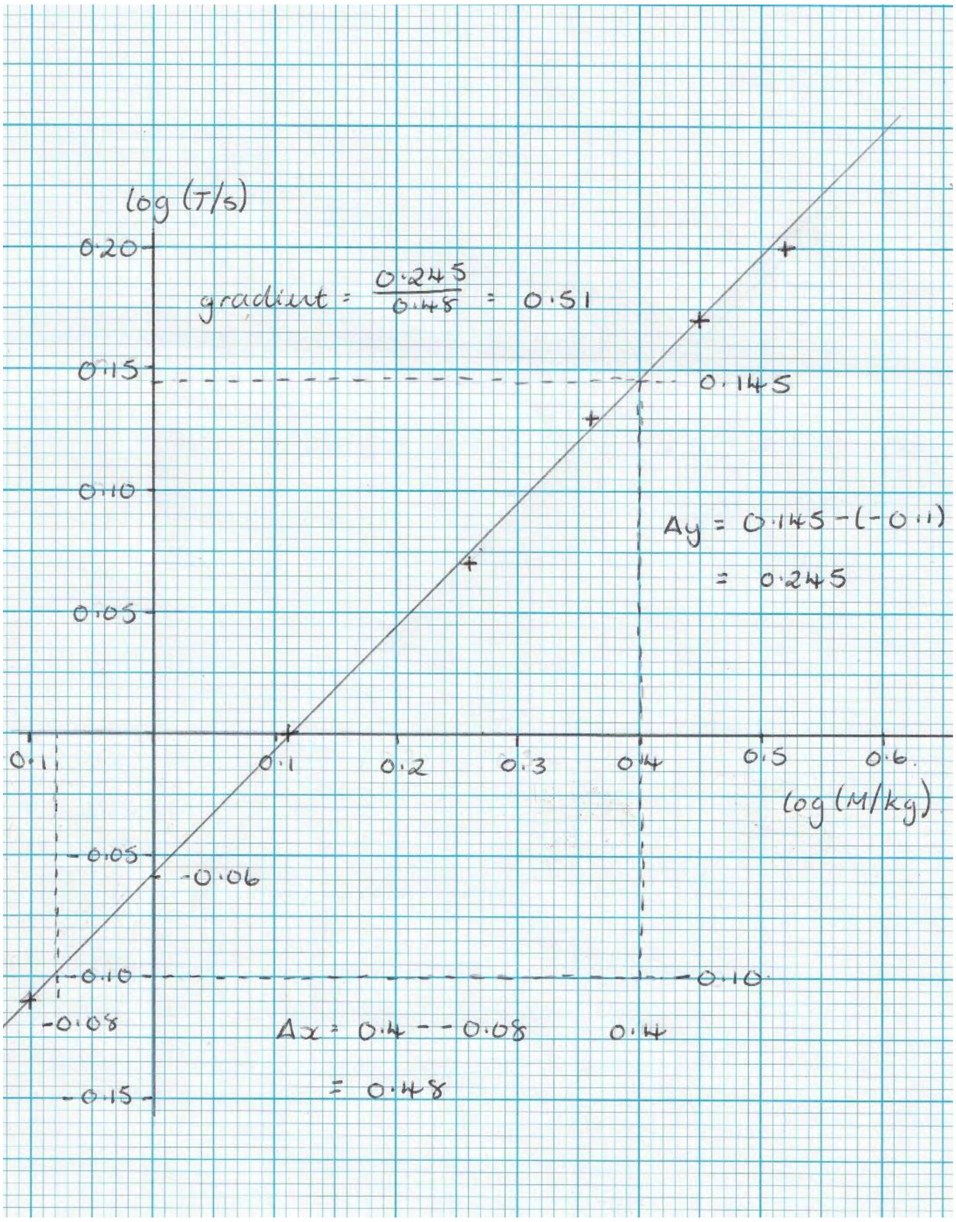
(1)
(1)</td><td>3</td></tr>
<tr><td colspan="4">Total mark for Question 2 = 9</td></tr>
</table>

Question number	Answer		Mark
3(a)(i)	Place a (timing) marker on the bench [Accept labelled diagram] (Marker) directly below a specific point on the trolley when (undisplaced from) the equilibrium	(1) (1)	2
3(a)(ii)	Max **TWO** from Time multiple oscillations **and** divide by the number of oscillations Repeat **and** calculate a mean Start timing after several oscillations have completed [Credit reference to a stationary timing marker in (a)(i)]	(1) (1) (1)	2
3(b)(i)	log T values correct and consistent to 2 d.p. [Accept 3 d.p] log M values correct and consistent to 2 d.p. [Accept 3 d.p] Axes labelled: y as log(T / s) and x as log(M / kg) Most appropriate scales for both axes Plots accurate to ± 1mm Best fit line with even spread of plots	(1) (1) (1) (1) (1) (1)	6
3 (b)(ii)	$\log T = \log (2\pi/\sqrt{k}) + ½\log M$ is in the form $y = c + mx$ with a gradient of 0.5 [dependent MP1] Correct calculation of gradient using large triangle shown Value of gradient in range 0.47 to 0.54, to 2 or 3 s.f., no unit Valid conclusion based on gradient value <u>Example of calculation</u> *gradient* = (0.145 – –0.10)/ (0.4 – –0.08) = 0.245 / 0.48 = 0.51 As the gradient is approximately 0.5 the prediction is valid [Credit gradient calculation given in (b)(iii) or on graph]	(1) (1) (1) (1) (1)	5

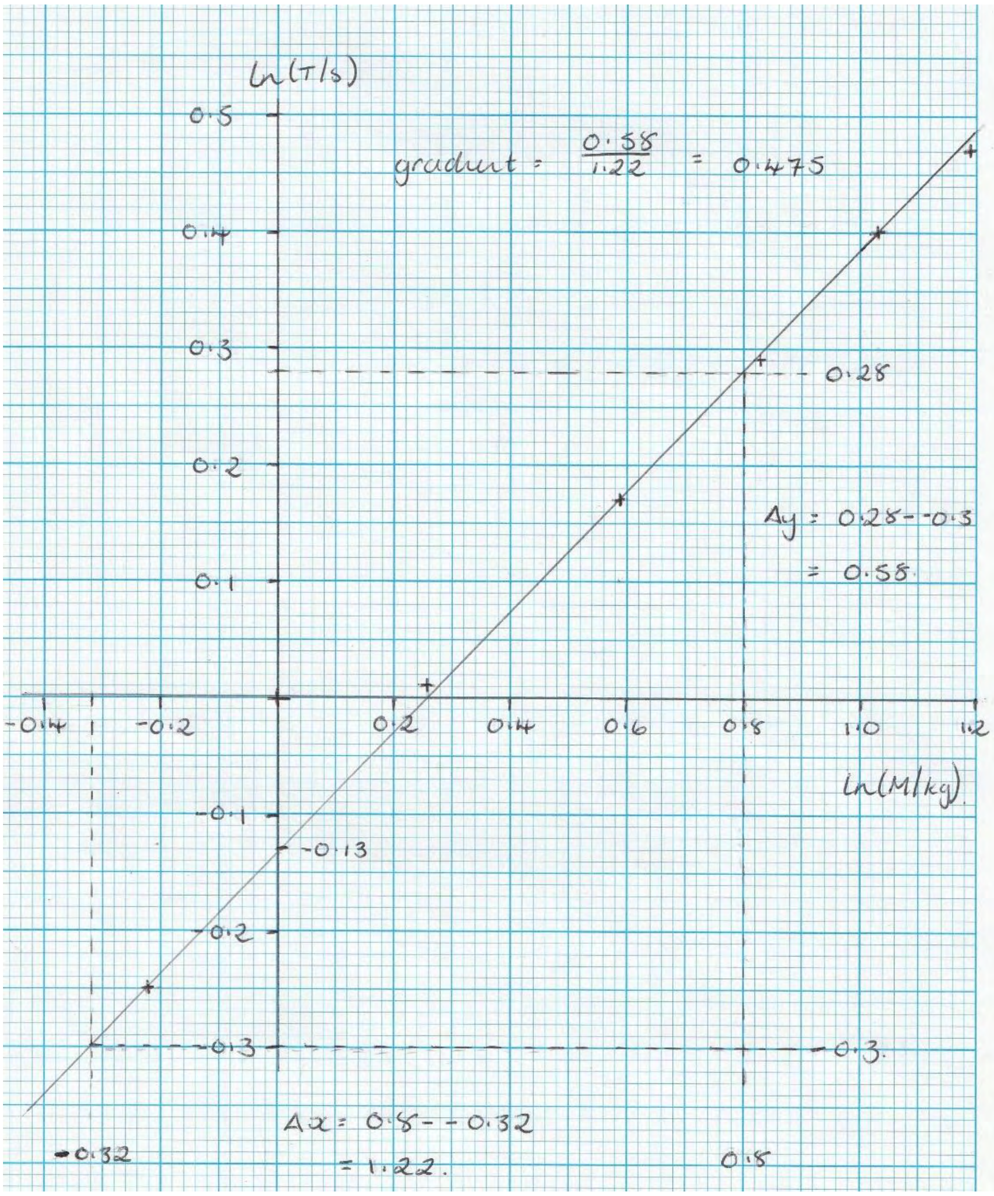
3 (b)(iii)	Correct value of *y*-intercept read from graph shown	(1)	
	Calculation using antilog to determine 2π/√*k* shown	(1)	
	Value of *k* in range 50 to 54 to 2 or 3 s.f. with unit of kg s^{-2}	(1)	
	[Accept N m^{-1}]		
	<u>Example of calculation</u>		
	c = –0.06 = log (2π/√*k*)		
	(2π/√*k*) = $10^{-0.06}$ = 0.87		
	k = $(2\pi/0.87)^2$ = 52 kg s^{-2}		
	Or		
	Correct value of *y*-intercept using coordinates from point on best fit line with gradient shown [e.c.f. (b)(ii)]	(1)	
	Calculation using antilog to determine 2π√*k* shown	(1)	
	Value of *k* in range 50 to 54 to 2 or 3 s.f. with unit of kg s^{-2}	(1)	
	[Accept N m^{-1}]		
	<u>Example of calculation</u>		
	From best fit line, *y* = 0.095, *x* = 0.3		
	c = *y* – *mx* = 0.095 – (0.51 ´ 0.3) = 0.095 – 0.153 = –0.058		
	(2π/√*k*) = $10^{-0.058}$ = 0.875		
	k = $(2\pi/0.875)^2$ = 52 kg s^{-2}		
	Or		
	Correct antilog of coordinates from point on best fit line shown	(1)	
	Use of *T* = 2π√(*M*/*k*) shown	(1)	
	Value of *k* in range 50 to 54 to 2 or 3 s.f. with unit of kg s^{-2}	(1)	**3**
	[Accept N m^{-1}]		
	<u>Example of calculation</u>		
	From best fit line, *y* = 0.095, *x* = 0.3		
	T = $10^{0.095}$ = 1.24, *M* = $10^{0.3}$ = 2.00		
	k = $4\pi^2$ *M* / T^2 = $4\pi^2$ ´ 2 / 1.24^2 = 79 / 1.54 = 51 kg s^{-2}		
			Total mark for Question 3 = 18

Examples of completed tables and graphs

M **/ kg**	***T*** **/ s**	**log (*M*/kg)**	**log (*T*/s)**
0.800	0.78	–0.10	–0.11
1.300	1.01	0.11	0.00
1.800	1.18	0.26	0.07
2.300	1.34	0.36	0.13
2.800	1.49	0.45	0.17
3.300	1.60	0.52	0.20



M / kg	T / s	ln (M/kg)	ln (T/s)
0.800	0.78	–0.22	–0.25
1.300	1.01	0.26	0.01
1.800	1.18	0.59	0.17
2.300	1.34	0.83	0.29
2.800	1.49	1.03	0.40
3.300	1.60	1.19	0.47



<table>
<tr><th>Question number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>4(a)(i)</td><td>Vernier calipers as the range of the micrometer is too small
[Accept clear reference to range of micrometer as 25 mm]</td><td>(1)</td><td>1</td></tr>
<tr><td>4(a)(ii)</td><td>There may be a <u>systematic error</u>
Or
there may be zero error (on the Vernier calipers)
(Therefore) the values may not be close to the true value
Or
(therefore) there may be a constant value added to the measurements</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>4(b)</td><td>Mean x = <u>2.12</u> (mm)
Uncertainty of <u>0.02</u> (mm) from calculation of half range
[Accept furthest from the mean]

<u>Example of calculation</u>
mean x = (2.11+2.10+2.13+2.14+2.11) mm/5 = 2.118 = 2.12 mm
Uncertainty = (2.14–2.10) mm/2 = 0.02 mm</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>4(c)(i)</td><td>Use of $n = 1 + \frac{d^2+(t-x)^2}{8f(t-x)}$
Correct value of n to 2 or 3 s.f. [e.c.f (b)]

<u>Example of calculation</u>
$n = 1 + \frac{d^2+(t-x)^2}{8f(t-x)} = 1 + \frac{5.10^2+(0.830-0.212)^2}{8\times9.8\times(0.830-0.212)} = 1 + \frac{26.01+0.618^2}{48.45}$
= 1.54</td><td>(1)
(1)</td><td>2</td></tr>
<tr><td>4(c)(ii)</td><td>Addition of U in t and U in x shown
Conversion to %U to minimum 2 s.f. [e.c.f (b)]

<u>Example of calculation</u>
U = 0.01 + 0.02 = 0.03
%U = 0.03 / (8.30 – 2.12) × 100% = 0.49 %</td><td>(1)
(1)</td><td>2</td></tr>
</table>

4(c)(iii)	Use of 2× %U in d **or** 2× %U (t–x) shown [e.c.f (b)] Calculation of U in d^2 **or** U in $(t–x)^2$ shown Addition of U in d^2 and U in $(t–x)^2$ shown Correct value of U to minimum 3 s.f. [do not penalise if square root of final value is taken] <u>Example of calculation</u> %U in $d^2 = 2 \times (0.01/5.1 \times 100) = 0.392\%$ U in $d^2 = 5.1^2 \times 0.392/100 = 0.102$ %U in $(t – x)^2 = 2 \times 0.49 = 0.98\%$ U in $(t – x)^2 = 0.618^2 \times 0.98/100 = 0.004$ U = 0.102 + 0.004 = 0.106	(1) (1) (1) (1)	4
4(c)(iv)	Correct calculation of %U in n shown [e.c.f. (c)(ii) and (iii)] Calculation of relevant limit shown [e.c.f (c)(i)] Valid conclusion based on comparison of calculated values [MP3 dependent on MP2] <u>Example of calculation</u> %U = (0.106/26.4 × 100) + 0.485 + (0.3/9.8 × 100) = 0.402 + 0.485 + 3.06 = 3.95% Upper limit = 1.54 × 1.04 = 1.60 Lower limit = 1.54 × 0.96 = 1.48 The lens is most likely to be made of crown glass as it is the only value to fall within the range **Or** Correct calculation of %U in n shown [e.c.f. (c)(ii) and (iii)] Correct calculation of relevant %D shown [e.c.f (c)(i)] Valid conclusion based on comparison of calculated values [MP3 dependent on MP2]	(1) (1) (1) (1) (1) (1)	3

	Example of calculation %U = (0.106/26.4 × 100) + 0.485 + (0.3/9.8 × 100) = 0.402 + 0.485 + 3.06 = 3.95% Crown glass %D = (1.54–1.52)/1.52 × 100 = 1.32 % Flint glass %D = (1.66–1.54)/1.66 × 100 = 7.23 % The lens is most likely to be made of crown glass as the %D is less than the %U whereas %D is larger than %U for flint glass.		
	Total mark for Question 4 = 16		

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