Pearson Edexcel

Mark Scheme (Results)

January 2023

Pearson Edexcel International Advanced Level in Physics (WPH16)
Paper 01 Practical Skills in Physics II

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

January 2023
Question Paper Log Number: P71949RA
Publications Code: WPH16_01_MS_2301

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 $g = 10\ m\ s^{-2}$ 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 $9.8\ N\ kg^{-1}$

3.3 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

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>
$80\ cm \times 50\ cm \times 1.8\ cm = 7200\ cm^3$
$7200\ cm^3 \times 0.70\ g\ cm^{-3} = 5040\ g$
$5040 \times 10^{-3}\ kg \times 9.81\ N/kg = 49.4\ N$

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.

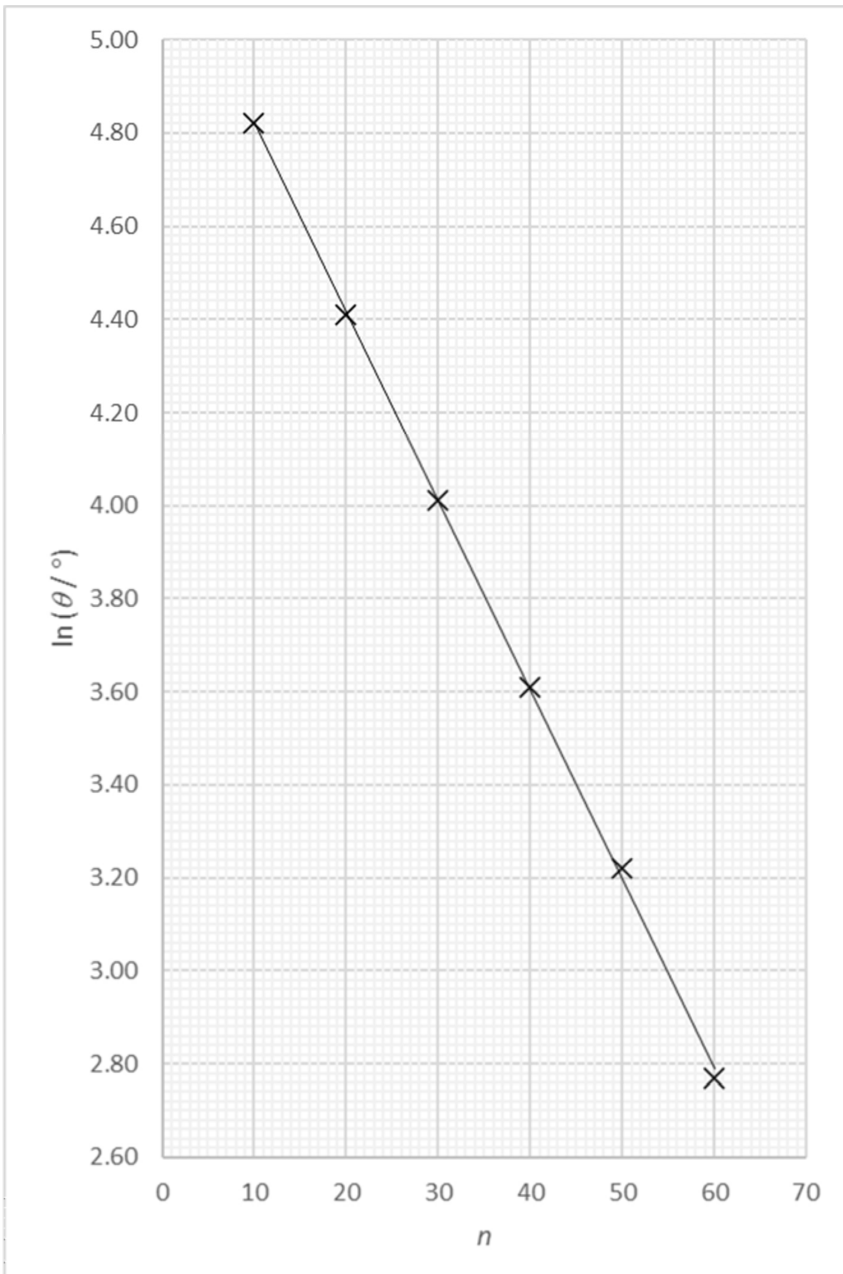
5.5 For a line mark there must be a thin continuous line which is the best-fit line for the candidate’s results.

Question Number	Answer	Mark
1(a)	The screw will get hot **Or** Risk of burns **(1)** (So) use tongs whilst heating **(1)**	2
1(b)(i)	Any **TWO** from: No repeats recorded **Or** Not enough sets of data — Do not accept reference to range **(1)** Inconsistent number of significant figures **Or** Inconsistent number of decimal places **Or** Not all values recorded to resolution of instrument **(1)** No units for temperature (increase) **(1)** Actual temperatures (of water) not recorded **(1)**	2
1(b)(ii)	Any **ONE** from Time for heating the screw **(1)** Position of screw in flame **(1)** Flame setting **(1)** **Do not accept mass or volume**	1
1(b)(iii)	Use of $\Delta E = mc\Delta\theta$ using pair of values from table of results **(1)** Use of energy lost by screw in cooling down = energy gained by water in heating up **(1)** Correct value of $\Delta\theta$ to 3 sig figs **(1)** <u>Example of calculation</u> For water $\Delta E = mc\Delta\theta = 9.9 \times 10^{-3} \times 4180 \times 62 = 2570$ J For screw $\Delta\theta = \frac{\Delta E}{mc} = \frac{2570}{4.11\times10^{-3}\times420} = 1490$ (°C) 2nd data line: $\Delta\theta = 1510$ (°C) — 3rd data line $\Delta\theta = 1500$ (°C) Reverse working can score 2 marks	3
	Total for question 1	**8**

Question Number	Answer		Mark
2(a)(i)	Substitution using $T = \frac{2\pi}{\omega}$	(1)	
	Clear algebra leading to relationship	(1)	2
	<u>Example of derivation</u> $T = \frac{2\pi}{\omega} \Rightarrow \omega = \frac{2\pi}{T} \Rightarrow \omega^2 = \frac{4\pi^2}{T^2}$ $Mg = mx\omega^2 = mx\frac{4\pi^2}{T^2}$ $\therefore T^2 = \frac{4\pi^2 mx}{Mg}$		
2(a)(ii)	1 Use a timing marker (to mark the start and end of a rotation)	(1)	
	2 Start timing after a few rotations	(1)	
	3 Time a number of rotations and divide by the number of rotations **Or** Repeat the measurement of T and calculate a mean	(1)	
	4 (Vary M to) obtain at least 5 sets of measurements	(1)	
	5 Keep x constant (for each value of M)	(1)	
	6 Plot a graph of T^2 against $\frac{1}{M}$ to check it is a straight line **Or** Plot a graph of T^2 against $\frac{1}{M}$ to check the gradient is constant	(1)	6
	Accept alternative graphs: T against $\sqrt{\frac{1}{M}}$ or log T against log M or variations with correct use of constants		
2(b)	Any **TWO** from		
	The video recording will help to judge when a rotation is complete	(1)	
	The video recording can be used to view the motion more slowly	(1)	
	The time for a rotation will be long so any improvement will be small	(1)	2
	Total for question 2		**10**

Question Number	Answer		Mark
3(a)	Any **PAIR** from $\ln \theta = \ln \theta_0 - \lambda n$ Is in the form $y = c + mx$ where $-\lambda$ is the <u>gradient</u> **Or** $\ln \theta = - \lambda n + \ln \theta_0$ Is in the form $y = mx + c$ where $-\lambda$ is the <u>gradient</u> MP2 dependent on MP1	 **(1)** **(1)** **(1)** **(1)**	**2**
3(b)(i)	Values of $\ln \theta$ correct to 2 d.p. Accept 3 d.p. Axes labelled: y as $\ln (\theta / °)$ and x as n Accept degrees for ° Appropriate scales chosen Values plotted accurately Best fit line drawn	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
3(b)(ii)	Calculation of gradient using large triangle shown Value of λ in range (–)0.038 to (–)0.042 Value of λ given to 2 or 3 s.f, positive, no unit <u>Example of calculation</u> $-\lambda = (4.82 - 3.20) / (10 - -50) = -1.62 / 40 = -0.0405$ $-\lambda = -0.0405$ $\lambda = 0.041$	**(1)** **(1)** **(1)**	**3**
3(b)(iii)	Correct value of $\ln \theta_0$ obtained using value of λ and data point from best fit line **Or** Correct value of $\ln \theta_0$ obtained using y-intercept Conversion of $\ln \theta_0$ to θ_0 Valid conclusion based on calculated value of θ_0 <u>Example of calculation</u> $\ln \theta = \ln \theta_0 - \lambda n$ $\ln \theta_0 = \ln \theta + \lambda n = 3.2 + (0.041 \times 50) = 5.25$ $\theta_0 = e^{5.25} = 191°$ As this is greater than 180° the claim is correct	 **(1)** **(1)** **(1)**	**3**
	Total for question 3		**13**

n	θ / °	ln (θ / °)
10	124	4.82
20	82	4.41
30	55	4.01
40	37	3.61
50	25	3.22
60	16	2.77



Question Number	Answer	Mark
4(a)(i)	Any **PAIR** from: Repeat at different orientations and calculate a mean **(1)** To reduce (the effect of) random error **(1)** **Or** Check and correct for zero error Accept suitable method **(1)** To eliminate systematic error **(1)** MP2 dependent MP1	2
4(a)(ii)	Mean d = 8.54 (mm) **(1)** Calculation using half range shown **Or** Calculation of furthest from mean **(1)** Uncertainty in d = 0.02 (mm) d.p. consistent with mean **(1)** Example of calculation Mean d = (8.53 + 8.56 + 8.55 + 8.53) / 4 = 34.17 / 4 = 8.54 (mm) Uncertainty = (8.56 – 8.53) / 2 = 0.03 / 2 = 0.015 = 0.02 (mm)	3
4(b)(i)	Use of 2 × %U in d shown **Or** Use of $2 \times \frac{\Delta d}{d}$ shown **(1)** Calculation of U in d^2 shown **(1)** U in d^2= 1.3 (mm^2) Accept 3 sig figs **(1)** Example of calculation %U in $d^2 = 2 \times \frac{0.06}{10.70} \times 100 = 1.1$ % U in d^2= (10.70)^2 mm^2 × 1.1 % = 1.26 (mm^2) **Or** Uses uncertainty in d to calculate minimum or maximum d^2 **(1)** Calculation of U in d^2 using half range shown **(1)** U in d^2= 1.3 (mm^2) Accept 3 sig figs **(1)** Example of calculation Maximum d^2 = (10.70 + 0.06)^2 = 10.76^2 = 115.8 (mm^2) Minimum d^2 = (10.70 – 0.06)^2 = 10.64^2 = 113.2 (mm^2) U in $d^2 = \frac{115.8-113.2}{2} = \frac{2.6}{2}$ = 1.3 (mm^2)	3

4(b)(ii)	Use of $A = \frac{\pi}{4}(s^2 - d^2)$ Addition of uncertainties in s^2 and d^2 e.c.f. 4(b)(i) Calculation of U in A using factor of $\frac{\pi}{4}$ shown %U in A = 0.43 % Accept 3 sig figs Accept use of U in d^2 of 1mm² to give 0.39% <u>Example of calculation</u> $A = \frac{\pi}{4}(s^2 - d^2) = \frac{\pi}{4}(881 - 114) = \frac{\pi}{4} \times 766 = 602$ mm² U in $A = \frac{\pi}{4}(2 + 1.3) = \frac{\pi}{4} \times 3.3 = 2.6$ mm² %U in $A = \frac{2.6}{602} \times 100 = 0.43$ % **Or** Use of $A = \frac{\pi}{4}(s^2 - d^2)$ Correct use of uncertainties to calculate maximum or minimum A e.c.f. 4(b)(i) Calculation of U in A from half range shown %U in A = 0.42 % Accept 3 sig figs <u>Example of calculation</u> $A = \frac{\pi}{4}(s^2 - d^2) = \frac{\pi}{4}(881 - 114) = \frac{\pi}{4} \times 767 = 602$ mm² Max $A = \frac{\pi}{4}(s^2 - d^2) = \frac{\pi}{4}((881 + 2) - (114 - 1)) = \frac{\pi}{4} \times 770 = 605$ mm² Min $A = \frac{\pi}{4}(s^2 - d^2) = \frac{\pi}{4}((881 - 2) - (114 + 1)) = \frac{\pi}{4} \times 763 = 600$ mm² U in $A = \frac{605 - 600}{2} = 2.5$ mm² %U in $A = \frac{2.5}{602} \times 100 = 0.42$ %	(1) (1) (1) (1) (1) (1) (1) (1)	4
4(c)	Both readings would have the same uncertainty (So) the percentage uncertainty (in the mass) is reduced **Or** %U for mass of 10 rings = 0.8% and %U for mass of one ring = 8%	(1) (1)	2
4(d)(i)	Use of $\rho = \frac{m}{xA}$ $\rho = \underline{7.46}$ (g cm^{-3}) <u>Example of calculation</u> $\rho = \frac{63}{1.403 \times 6.02} = 7.46$ (g cm^{-3})	(1) (1)	2

4(d)(ii)	%U in ρ = 1.5 % Accept 1, 2 or 3 sig figs **(1)** Correct calculation of relevant limit using %U shown e.c.f. (d)(i) **(1)** Conclusion based on comparison of limit and range **(1)** MP3 dependent MP2 <u>Example of calculation</u> %U in $\rho = \frac{0.5}{63} \times 100 + \frac{0.04}{14.03} \times 100 + 0.4$ = 0.8 % + 0.3 % + 0.4 % = 1.5 % Upper limit of ρ = 7.46 × (1 + 0.015) = 7.57 (g cm^{-3}) As the upper limit is higher than 7.48 g cm^{-3} then the ring could be made from stainless steel. **Or** %U in ρ = 1.5 % Accept 1, 2 or 3 sig figs **(1)** Correct calculation of relevant %D shown e.c.f. (d)(i) **(1)** Conclusion based on comparison of %D and %U **(1)** MP3 dependent MP2 <u>Example of calculation</u> %U in $\rho = \frac{0.5}{63} \times 100 + \frac{0.04}{14.03} \times 100 + 0.4$ = 0.8 % + 0.3 % + 0.4 % = 1.5 % %D = $\frac{7.48-7.46}{7.48} \times 100$ = 0.3 % As % D for the lower value is less than the %U then the ring could be made from stainless steel. **Or** Use of $\rho = \frac{m}{xA}$ and uncertainties to calculate maximum or minimum ρ **(1)** Correct calculation of relevant limit shown e.c.f. (d)(i) **(1)** Conclusion based on comparison of relevant limit and range **(1)** MP3 dependent MP2 <u>Example of calculation</u> Maximum $\rho = \frac{63+0.5}{(1.403-0.004)\times(6.02-0.4\%)} = \frac{63.5}{1.399\times 6.00} = \frac{63.5}{8.39}$ = 7.56 (g cm^{-3}) As the maximum ρ is higher than 7.48 g cm^{-3} then the ring could be made from stainless steel. Note minimum ρ = 7.35 (g cm^{-3})		3
	Total for question 4		**19**

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom