GCE A LEVEL MARKING SCHEME

SUMMER 2023

A LEVEL
PHYSICS – COMPONENT 1
A420U10-1

INTRODUCTION

This marking scheme was used by WJEC for the 2023 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

GCE A LEVEL PHYSICS

COMPONENT 1 – NEWTONIAN PHYSICS

SUMMER 2023 MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response question).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

SECTION A

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)		Measure vertical distance from bench to ruler / use a [spirit] level Accept sensible alternatives e.g. ruler and threads checked to be 90^{o}			1	1		1
	(b)		[Point at which] the weight of an object is considered to act (1) CoG in correct position roughly (by eye) (1)	2			2		1
	(c)	(i)	When a system is in equilibrium (1) Sum of clockwise moments is equal to the sum of the anticlockwise moments [about the same point] [**or** resultant moment about any point is zero] (1)	2			2		
		(ii)	$(0.60gx) + (W \times 0.4) = T \times 0.80$ (1) Convincing algebra to give $T = 7.36\ [\text{N m}^{-1}] + \frac{W}{2}$ (1)		2		2	2	2
	(d)	(i)	Suitable line of best fit (1) T intercept recorded accept gradient calculated and use of point on the line (1) W determined i.e. $2 \times T$ intercept (1) No unit or sig figs penalty		3		3	2	3

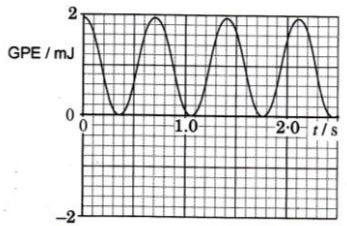
Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	**Any 2 × (1) from:** • Evan's method is more accurate / is closer to the known value OR (if anomaly is missed) Lily's method is more accurate / is closer to the known value. • Evan's method allowed for the anomaly to be spotted and hence omitted • Lily's method allowed for an uncertainty in her result / actual value lies within these bounds • The position of the best fit straight line in Evan's method has a considerable effect on the intercept and hence value for W.			2	2		2
			Question 1 total	**4**	**5**	**3**	**12**	**5**	**9**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		Substitution into $R = \frac{\rho l}{A}$ (1) even if slips in factors of 2 or 10 R = 4.5 [Ω] (1) Use of $P = \frac{V^2}{R}$ or alternatives (1) P = 22.4 [W] **ecf** on R (1)	1 1	1 1		4	3	
	(b)	(i)	The energy required to raise [the temperature of] 1 kg (1) by 1 °C or K (1)	2			2		2
		(ii)	$E = Pt = 22.4 \times 5 \times 60 = 6\,720$ [J] **and** $M = \rho V = 0.997 \times 190 = 189.4$ [g] (1) $E_{\text{delivered}} = E_{\text{into copper container}} + E_{\text{into water}}$ i.e. $6\,720 = (0.08 \times 380 \times 8) + (0.1894 \times c_w \times 8)$ (1) **ecf** for slips in E and M $c_w = 4\,275$ [J kg^{-1} °C^{-1}] (1) **Alternatively, if 20 W is used** $E = Pt = 20 \times 5 \times 60 = 6\,000$ [J] **and** $M = \rho V = 0.997 \times 190 = 189.4$ [g] (1) $E_{\text{delivered}} = E_{\text{into copper container}} + E_{\text{into water}}$ i.e. $6\,000 = (0.08 \times 380 \times 8) + (0.1894 \times c_w \times 8)$ (1) **ecf** for slips in E and M $c_w = 3\,800$ [J kg^{-1} °C^{-1}] (1)		3		3	3	3
		(iii)	[During the heating process below 16 °C] heat will be absorbed from surrounding air / room (1) and above 16 °C heat will be emitted to surrounding air so balanced, method minimises heat losses so good practice (1)			2	2		2
			Question 2 total	**4**	**5**	**2**	**11**	**6**	**7**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)		As skydiver accelerates the {air resistance / resistive / drag} force increases (1) due to greater collision rate with air molecules (1) This decreases the resultant force until ΣF becomes zero [and constant velocity is achieved] (1)		3		3		
	(b)		Suitable tangent drawn and calculated to be 2.1 ± 0.4 [$m\,s^{-2}$] (1) Substitution into $\Sigma F = ma$ = 68 × tangent value [e.g. = 142.8 [N]] (1) $\Sigma F = ma = mg - F_{AR}$ (1) Correctly calculated value for F_{AR} e.g. = 524.3 [N] (1)	1	1 1 1		4	3	
	(c)		**Any 2 × good points:** e.g. Unethical – money can be spent elsewhere e.g. tackling poverty / homelessness / medicine / spaceflight adds to pollution hence global warming e.g. Ethical - creates jobs / new technology useful to humans / extra-terrestrial resources could prove to be useful / reducing aircraft debris / reusable aircraft / useful if colonising planets Accept sensible alternatives.			2	2		
			Question 3 total	**1**	**6**	**2**	**9**	**3**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		ΔU - Increase (accept change) in internal energy (1) W – Work done <u>by</u> the system (1) Q – Heat [flow] <u>into</u> the system (1)	3			3		
	(b)	(i)	Use of pV = constant **OR** internal energy calculated **OR** temperatures calculated (1) Showing that two or more values are constant (1)		2		2	2	
		(ii)	**Any ×(1) from:** • Counting squares method • Single trapezium method • Multiple trapezia method Value = (333 ± 20) [J] (1)		2		2	2	
		(iii)	$\Delta U = 0$ for A → B → C → A (1) $Q = \Delta U + W$ therefore $Q = W$ (1) Net W = + 330 – 180 = +150 [J] therefore Joseph is correct (1)			3	3	1	
			Question 4 total	**3**	**4**	**3**	**10**	**5**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)		Rate of doing work **or** rate of transfer of energy Accept $\frac{\text{work}}{\text{time}}$ or $\frac{\text{energy}}{\text{time}}$	1			1		
	(b)	(i)	Rate of gain of GPE = 0.15 [kg s^{-1}] × 9.81 [N kg^{-1}] × 1.3 [m] (1) = 1.9 W **unit mark** (accept J s^{-1}) (1)	1	1		2	1	
		(ii)	KE given per second = $\frac{1}{2} \times 0.15 \times 3.5^2$ [W] = 0.92 [W] (1) Significant as a fraction of rate of gain of GPE (or total power or similar) [so Leo is correct] (1)			2	2	1	
		(iii)	Input power = 12 × 0.65 (1) [= 7.8 W] (1) Substitution: efficiency = $\frac{(1.9+0.9[2])[\text{W}]}{7.8\ [\text{W}]}$ [× 100] (1) or by implication = 0.36 **or** 36 % [**ecf** on PE, KE] (1)	1 1	1		3	2	
			Question 5 total	**4**	**2**	**2**	**8**	**4**	**0**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
6	(a)			Component of bob's weight at right angles to thread = $mg\sin\theta$ (1) $\sin\theta \approx \theta$ [since θ small] (1) Acceleration at right angles to thread = $\frac{mg\,[\sin]\,\theta}{m} = g\theta$ (1)		3		3	2	
	(b)	(i)		$l = \frac{T^2 g}{4\pi^2}$ i.e. rearrangement of the equation at any time (1) T = 1.4 [s] (1) l = 0.49 [m] (1) **Alternative:** $l = \frac{g}{\omega^2}$ (1) T = 1.4 [s] (1) l = 0.49 [m] (1)		3		3	2	
		(ii)	I.	$E_{k\,max} = \frac{1}{2} 0.12 \times 0.18^2$ [J] (1) = 1.94 m[J] (1)	1	1		2	1	
			II.	 Period (1) Phase (1) Shape non-pointy and maximum value correct to within a small square (1) If graph is negative then only the period mark can be awarded.	1 1	1		3	2	
		(iii)	I.	$a = \frac{0.18^2}{0.487}$ [m s^{-2}] (1) = 0.067 m s^{-2} (1) **unit mark** Accept use of 0.5 m leading to 0.065 m s^{-2}	1	1		2	1	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
			II.	[Centripetal acceleration requires] resultant force on bob **/** $T - mg = ma$ (1) which must be upwards (1) Award 1 mark only for acceleration upwards	1	1		2		
	(c)			**Indicative content:** **Demonstrating forced oscillations** • With signal generator off, time 10 (say) oscillations to determine *T* and hence natural frequency $\left[\frac{1}{T}\right]$. • Set signal generator to a known frequency and read amplitude of oscillations of mass on ruler • Repeat over a range of frequencies [from near zero to well above system's natural frequency] • Additional detail, e.g. wait for steady oscillations **or** read limits of oscillations and divide by 2 (or equivalent) **or** do not adjust voltage output of signal generator between frequencies **or** use of mobile phone / recording device to record oscillations and use playback to determine amplitude. **Amplitude of the forced oscillations** • Low [but not zero] at very low frequencies • As frequency is increased, rises to a peak and then drops, approaching zero. • Peak occurs when signal generator frequency equals natural frequency • Known as resonance N.B. A sketched graph might be presented to support answer	3		3	6		6

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks Comprehensive description of both the method and the analysis. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description of either the method or the analysis or a limited description of both. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited description of either the method or the analysis. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** No attempt made or no response worthy of credit.						
				Question 6 total	**8**	**10**	**3**	**21**	**8**	**6**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
7	(a)		Molecules hit {walls / container} (1) Momentum change of molecule that occurs [is away from wall], so molecule exerts an [outward] force on the wall (1) Such forces over an area give rise to the pressure (1) accept reference to $p = \frac{F}{A}$	3			3		
	(b)		Division of ($394^2 + 453^2 + 527^2$) by 3 and square-rooting **or by implication** [$638174 \div 3 = 212\,725$; $\sqrt{212725} = 461$] Tolerate slips if correct procedure apparent, for this mark only (1) $c_{\text{rms}} = 461 [\text{m s}^{-1}] (1)$		2		2	2	
	(c)		c_{rms} evaluated at one temperature (1 mark method, 1 mark answer) At 100 K, $c_{\text{rms}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 100}{28 \times 1.66 \times 10^{-27}}}$ **or** $\sqrt{\frac{3 \times 8.31 \times 100}{0.028}} = 298\ [\text{m s}^{-1}]$ **or**, at 200 K, $c_{\text{rms}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 200}{28 \times 1.66 \times 10^{-27}}}$ **or** $\sqrt{\frac{3 \times 8.31 \times 200}{0.028}} = 422\ [\text{m s}^{-1}]$ **or**, at 300 K $c_{\text{rms}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 300}{28 \times 1.66 \times 10^{-27}}}$ **or** $\sqrt{\frac{3 \times 8.31 \times 300}{0.028}} = 517\ [\text{m s}^{-1}]$ Ratios v_s / c_{rms} or c_{rms} / v_s evaluated at the **three** temperatures, giving 0.68 or 1.46 but **ecf** on c_{rms} values (1) **Conclusion:** ratio is constant or proportional or equations seen (1) Award a maximum of 3 marks if only **two** temperatures considered. Award a maximum of 2 marks for use of $c_{\text{rms}} \propto \sqrt{T}$ and ratios of $\frac{v_s}{\sqrt{T}}$ calculated for all **three** temperatures			4	4	4	
			Question 7 total	**3**	**2**	**4**	**9**	**6**	**0**

SECTION B

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
8	(a)		LHS centripetal force (1) RHS gravitational force (1)	2			2		
	(b)		Bulge inside can be considered as [point mass] at centre so force is always towards centre (1) Bulge outside pulls in all directions [and hence cancels] (1)		2		2		
	(c)		Substitution for mass i.e. $\frac{mv^2}{r} = \frac{G\frac{4}{3}\pi r^3 \rho m}{r^2}$ (1) Algebra seen i.e. m cancelling and r collated (1) Final expression correct i.e. $v = r \times \sqrt{G\frac{4}{3}\pi\rho}$ or similar (1)	1	1 1		3	3	
	(d)	(i)	Left side is dominated by SMBH **OR** left side is centre of galaxy (1) Taking logs **correctly** e.g. $\log v = -0.5 \log r + k$ (1) Explanation of gradient and agreement e.g. -0.5 is circled and statement of "as expected" (1)		3		3	2	
		(ii)	Data point correct i.e. 16.55 ± 0.04, 5.08 ± 0.01 (1) Convert to m **OR** m s^{-1} i.e. 3.55×10^{16} m **OR** 120 000 m s^{-1} (1) Rearrangement of equation i.e. $M = \frac{rv^2}{G}$ (1) Final substitution (or answer) seen **AND** comment of agreement e.g. $\frac{3.55\times10^{16}\times120\,000^2}{6.67\times10^{-11}}$ (7.66×10^{36}) (1)			4	4	4	

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(e)		Correct data chosen i.e. 2 million year and 4 million Suns (1) Final answer = 2 [solar masses per year] (1) Award 1 mark only for answer of 4×10^{30}		2		2		
	(f)		Outside visible spectrum **OR** another part of em spectrum (1) Due to redshift **OR** wavelength increase (not just Doppler shift) (1)		2		2		
	(g)		Sensible comment about theory e.g. not enough mass **OR** mass might be too far away **OR** mass might be too close **OR** total mass of 100 000 burps plausible **OR** velocity shape would not agree (1) Need to look for the extra mass (if exists) **OR** need to show that the extra mass does not exist (1) Accept further research / observations			2	2		
			Question 8 total	**3**	**11**	**6**	**20**	**9**	**0**

A LEVEL COMPONENT 1: NEWTONIAN PHYSICS

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	4	5	3	12	5	9
2	4	5	2	11	6	7
3	1	6	2	9	3	0
4	3	4	3	10	5	0
5	4	2	2	8	4	0
6	8	10	3	21	8	6
7	3	2	4	9	6	0
8	3	11	6	20	9	0
TOTALS	**30**	**45**	**25**	**100**	**46**	**22**