GCE EXAMINERS' REPORTS

PHYSICS
GCE
AS/Advanced

SUMMER 2023

Introduction

Our Principal examiners' reports offer valuable feedback on the recent assessment series. They are written by our Principal Examiners and Principal Moderators after the completion of marking and moderation, and detail how candidates have performed.

This report offers an overall summary of candidates' performance, including the assessment objectives/skills/topics/themes being tested, and highlights the characteristics of successful performance and where performance could be improved. It goes on to look in detail at each question/section of each unit, pinpointing aspects that proved challenging to some candidates and suggesting some reasons as to why that might be.[i]

The information found in this report can provide invaluable insight for practitioners to support their teaching and learning activity. We would also encourage practitioners to share this document – in its entirety or in part – with their learners to help with exam preparation, to understand how to avoid pitfalls and to add to their revision toolbox.

Further support

Document	Description	Link
Professional Learning / CPD	WJEC offers an extensive annual programme of online and face-to-face Professional Learning events. Access interactive feedback, review example candidate responses, gain practical ideas for the classroom and put questions to our dedicated team by registering for one of our events here.	https://www.wjec.co.uk/home/professional-learning/
Past papers	Access the bank of past papers for this qualification, including the most recent assessments. Please note that we do not make past papers available on the public website until 6 months after the examination.	www.wjecservices.co.uk or on the WJEC subject page
Grade boundary information	Grade boundaries are the minimum number of marks needed to achieve each grade. For unitised specifications grade boundaries are expressed on a Uniform Mark Scale (UMS). UMS grade boundaries remain the same every year as the range of UMS mark percentages allocated to a particular grade does not change. UMS grade boundaries are published at overall subject and unit level. For linear specifications, a single grade is awarded for the overall subject, rather than for each unit that contributes towards the overall grade. Grade boundaries are published on results day.	For unitised specifications click here: Results, Grade Boundaries and PRS (wjec.co.uk)

Exam Results Analysis	WJEC provides information to examination centres via the WJEC secure website. This is restricted to centre staff only. Access is granted to centre staff by the Examinations Officer at the centre.	www.wjecservices.co.uk
Classroom Resources	Access our extensive range of FREE classroom resources, including blended learning materials, exam walk-throughs and knowledge organisers to support teaching and learning.	https://resources.wjec.co.uk/
Bank of Professional Learning materials	Access our bank of Professional Learning materials from previous events from our secure website and additional pre-recorded materials available in the public domain.	www.wjecservices.co.uk or on the WJEC subject page.
Become an examiner with WJEC.	We are always looking to recruit new examiners or moderators. These opportunities can provide you with invaluable insight into the assessment process, enhance your skill set, increase your understanding of your subject and inform your teaching.	Become an Examiner | WJEC

Subject Officer's Executive Summary

Overall performance in the qualification is pleasing. Performance in all units, except Unit 1 is comparable to previous series. Advance information was provided for all units and it was apparent in some cases that it was likely to have been very useful to candidates, e.g. the comprehension in Unit 3. Recall of knowledge in AO1 marks, such as the recall of definitions is still a weak area, with lack of clarity in responses seen. Quantitative responses usually are preferred by candidates compared to qualitative responses. Performance in the QER questions is dependent on the topic the question is based on. Issues with units and the conversion of units was seen across all units. Performance in the practical examination unit was excellent, however this was not reflected in the theory units when practical skills were assessed. Candidates struggled with the application of $y = mx+c$ in a practical context, how to determine uncertainties and what number of significant figures to express their answers to. Alternating currents is still the most popular option, but there are healthy numbers for all four.

Areas for improvement	Classroom resources	Brief description of resource
AO1 marks requiring recall of knowledge	**TERMS, DEFINITIONS AND UNITS**	Document containing all definitions that need to be learnt by candidates
Practical skills e.g. uncertainties	**STUDENT PRACTICAL GUIDANCE**	Guidance on AS and A level practical skills
Units: providing appropriate units and converting units	**BASIC PHYSICS**	Knowledge organiser
Circular motion and nuclear decay	**CIRCULAR MOTION** **NUCLEAR DECAY**	Blended learning

PHYSICS

General Certificate of Education

Summer 2023

Advanced Subsidiary/Advanced

AS UNIT 1 – MOTION, ENERGY AND MATTER

Overview of the Unit

Candidate responses were not as encouraging as in previous years with aspects of the paper not scoring as well as expected. A few questions or sub-sections of questions did not score well or were not attempted by an unusually high number of candidates. For example, AO2 style questions which asked for explanations in a Physics context did not score as highly as anticipated, such as the questions exploring candidates' understanding of springs in combination Q1(c) and projectile motion Q3(a). In both cases imprecise and vague responses were often seen which did not address the question being asked and suggested a lack of conceptual understanding of the key principles associated with conservation of energy, resultant forces and spring combinations.

Contrary to this was the encouraging response to AO1 style questions testing recall and knowledge. Question 7, which tested particles and interactions scored well, as did the QER question testing candidates' knowledge of the stress-strain curve for a ductile material. Responses to the practical question were satisfactory, however many candidates failed again to convert units and also determine correctly the absolute uncertainty in the answer for density. Many candidates did not recognise the need to draw a tangent on the graph of momentum against time with the majority choosing to take data points. On the positive side, it was encouraging to see the improved response to the question confirming an inverse square relationship from a graph.

Whilst the general standard of numeracy was good, examiners felt that the quality of written responses, especially in terms of succinctness and clarity had deteriorated in comparison to previous years. It was also felt that the overall standard of presentation was disappointing, with markers commenting on the difficulty of reading a significant number of poorly laid out responses.

Comments on individual questions/sections

Q.1 The majority of candidates in part (a) were able to define the spring constant k as 'force per unit extension'. A significant minority however were imprecise with their language with uncreditworthy responses such as *'force over length'* or *'how far it stretches when a weight is added'*, amongst other similar responses often seen.

In (b) the majority of candidates were successful in gaining two marks for determining the spring force. Far fewer went on to apply the principle of moments correctly to the system, with many miscalculating the distance from the mid-point of the ruler to the pivot. Nearly all candidates attempted to answer part (c), but with varying success. The majority failed to pick up the two marks due to imprecise use of language. Candidates should realise that if numerical data is provided then the expectation is that it should be referred to in their response. To gain the marks, candidates needed to state that the extension in the spring system would **double** for the **same** force, which would then lead to the **halving** of the spring constant (or equivalent). Responses such as *'the springs would extend more and so the spring constant would be less'* were not credited.

Q.2 The majority of candidates used the correct formula for the volume of a sphere in part (a)(i) and were able to substitute a valid figure for the radius of the sphere into the formula – the mark was awarded for substitution in either mm or cm. Of those who did substitute in mm, very few were able to give the final answer for volume in cm^3 as required. Good attempts were made to confirm the percentage uncertainty in the volume given, with many understanding the need to add percentage uncertainties in radius cubed. In (ii) nearly all candidates were able to determine a value for density with ecf (error carried forward) being applied for an incorrect volume (from part (i)) where relevant. Far fewer candidates successfully determined the % uncertainty in mass from the data provided. However, ecf was applied to determining the total % uncertainty, which many candidates successfully achieved. In many cases the final mark was not awarded as the answers for density and associated uncertainty were not given appropriately.

In (b) only a few candidates understood the need to (at least) show that the % uncertainty in Jerry's volume is greater than that of Tomos'. Knowing that the uncertainty in mass is the same for both approaches would then have allowed candidates to conclude that the uncertainty in Jerry's approach would be greater than Tomos' approach. A few candidates used the data to show numerically that Jerry's overall uncertainty was greater than that of Tomos, which is a perfectly valid approach and awarded full marks.

Ecf was extensively applied to responses in part (c) with many candidates giving a valid conclusion based on their incorrect answers to previous parts of the question. It was only required that candidates chose the metals which lie within their calculated uncertainties.

Q.3 It was felt that many candidates had a good understanding of both the horizontal and vertical motions, but once again, marks were lost due to imprecise or incomplete explanations. A mark was awarded in part (a)(i) for '*constant speed horizontally'* without the need for an explanation in terms of forces, and many candidates were successful in gaining this mark. Most candidates were also aware that the pellet would accelerate in the vertical plane but did not qualify this with an explanation in terms of the force of gravity acting downwards on the pellet. The mark was not awarded in this case. In (ii), nearly all candidates realised that the pellet would still strike the apple (1 mark), but at a lower point in the apple's descent (1 mark).

In (b) nearly every candidate calculated the horizontal component of velocity correctly. In (ii), a variety of approaches were seen with candidates showing good confidence when applying the equations of accelerated motion to the problem given. However, a significant minority of candidates lost one mark because of incorrect trigonometry when determining the initial vertical velocity of the stone. Part (iii) highlighted misconceptions regarding application of the principle of conservation of energy, which were also apparent in the previous sitting of this paper. In this question, a significant number of candidates did not understand that, at the highest point in its trajectory, the stone possessed both kinetic and potential energy. In many cases, candidates omitted one or the other in their calculations.

Many candidates in part (c) were able to show that the energy of the stone at point C = 0.54 J. However very few were then able to go on to show that this represented a 20% decrease in energy. In some cases, ecf was applied when a correct comparison with a previous answer led to different conclusion.

Q.4 Many candidates were able to identify and describe the key features of the stress-strain graph for a ductile metal very well. The higher scoring candidates provided nearly all of the key features and gave good accounts of both the elastic and plastic regions. Mid-scoring candidates were able to provide some of the key features and give either a partial description of each region or a good description of either. Weaker scoring candidates gained some credit for referencing any key feature or region. Higher scoring candidates often referred to the 'yield point' as being the point where a large increase in strain for very little increase in stress is seen. They also referred to the ultimate breaking stress and some even described the process of necking (though reference to necking was not a requirement to access the higher marking band). It was noted that many candidates, including those who scored highly, often gave the 'elastic limit' and the 'limit of proportionality' the wrong way around, with elastic limit often described (or shown on the graph) as being before the limit of proportionality.

Q.5 In (a) nearly every candidate was able to explain $\sum F$ as being the resultant (or similar e.g. total) force (AO1)). Fewer candidates were able to illustrate this through explanation or a sketch/diagram (AO2). Those that did, nearly always drew a simple sketch of an object acted upon by two linear forces and then showed the vector sum of these forces.

Only a few candidates in (b)(i) were able to calculate the upward acceleration of the block. In most cases one mark only was awarded for candidates who correctly found the weight of the block. In most cases, these candidates incorrectly used this value to determine an acceleration, which did not consider the maximum safe lifting force given in the question. An alternative approach taken by a significant number of candidates was to consider accelerations, which also led to the majority gaining one mark, in this case for failing to consider the acceleration due to gravity in their solutions. In (ii), many candidates failed to pick upon the essential physics involved in the given situation, that the driver did not take account of any additional accelerating forces which, when added to the weight, may exceed the safe maximum lifting force.

Very few candidates in part (c) were able to show that the block was decelerating upwards. A significant minority were able to determine the tension in the cable through correct use of stress and strain equations and were awarded 2 marks. Very few successfully proceeded to apply this information to the scenario given, suggesting a lack of understanding of the link between the net force and its effect on the motion of the block.

Q.6 Candidates in (a) either scored very well or very poorly here, reflecting their understanding of the correct approach to answering the question. Those that knew to determine the gradient from an appropriately drawn tangent usually scored full marks. Around half of the candidates took data points directly from the graph at t = 1.0 s, which was not credited.

Candidates responded well to the double instruction of 'state' and 'explain' given in (b). Many candidates stated correctly that the slope of the graph became horizontal before impact and then proceeded to explain the significance of this in terms of the removal of external forces and hence the validity of applying the law of conservation of momentum to the collision.

In (c) many candidates showed good understanding of the momentum changes experienced by carriage B over the first 4 seconds and were able to draw appropriate lines on the graph to show this. Candidates should be encouraged to use a ruler when drawing straight lines on graphs. On many occasions, candidates lost marks for inaccurate free-hand line drawing. In (ii), many candidates successfully identified the gain in momentum of carriage B and used this to determine its speed.

Q.7 The majority of candidates in (a) were able to identify the particles or interactions in the table. The sentence 'antibaryons are a combination of three of these' was the most problematic with a significant number of candidates giving 'quarks' as an answer.

Part (b) was answered well with nearly all candidates responding well to the instruction 'show your working clearly', using antiquark charges appropriately to show that the overall charge on the antiparticle = 0. Slightly fewer candidates were able to identify the antiparticle as being an antineutron. 'Anti-neutrino' was a common incorrect answer.

Again, in (c), candidates showed good confidence and understanding of the laws of charge, baryon and lepton numbers when applied to the given interaction. Candidates should be encouraged to write down '0' when this applies to a given particle rather than leaving blanks.

Doing so assures examiners that candidates are aware of when 0 should be applied and credit be given. In (ii), many candidates identified that the reaction would still not occur due to baryon number not being conserved.

Q.8 In (a) many candidates were able to describe the appearance of an absorption spectrum in terms of dark lines superimposed on a continuous spectrum, though on a few occasions candidates used the term 'rainbow' (or similar) instead of continuous, which was not credited. Most candidates identified the atmosphere (or chromosphere) as the source of the spectrum, however a significant number incorrectly stated, 'the core'.

Candidates were usually successful in reading values from the graph in (b) and substituting them correctly into the equation for the inverse square law. Some candidates did not provide an appropriate unit in their final answer and lost one mark consequently.

In (c) nearly all candidates gained at least two marks for using Wien's law and information from the graph to determine the temperature of the star. Alternative approaches using Stefan's law and information from part (b) were adopted by many to confirm either P, A, σ or T, with most choosing to show that T is consistent.

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AS UNIT 2 – ELECTRICITY AND LIGHT

Overview of the Unit

Questions 1, 5, 7 and 8 provided mean marks of 50% or above. These questions covered the topics of resistance, refraction of light, photons and lasers. They also included two practically based questions. By contrast, Q4 had the lowest mean mark. This question covered wave properties. The QER involving the comparison of progressive and standing waves candidates found challenging. AO1 marks that involved recall of definitions and theory as ever caused problems for candidates.

Reinforcement of key maths and practical skills is an area of development. An understanding of $y = mx + c$ is fundamental to experiments where a straight line can be drawn. A more considered approach to units is advised. An area in cm^2 and a length in cm will not give a resistivity value in Ωm. Uncertainty calculations and how to approach them is an area also to look at.

Comments on individual questions/sections

Q.1 In (a)(i) the majority of candidates were able to use the graph to obtain a value for the resistance, however, identifying the connecting wires as the source of this resistance proved more challenging. Responses including the internal resistance of the cell were given no credit. In (ii) there were very mixed responses for this question type. Candidates were mentioning 'straight line' and 'positive gradient' regularly. We did accept 'as length increases, resistance increases' for the positive gradient mark. Some confused responses were seen where candidates stated that the graph showed the resistance is proportional to length as it was straight. Pleasingly, part (iii) was answered well by many candidates. They were able to name digital or even vernier callipers regularly. Responses were mixed to part (iv). Strong responses either used a gradient calculation or a point on the line with a consideration of the resistance of the connecting wires. There were some factor of 2 errors and a lack of consideration of units in a minority of responses. Part (b) was the least Well accessed question part in Q1. The 'avoids heating / small current' was seen regularly in strong responses. Reference to preventing fires and explosions were not awarded credit.

Q.2 Candidates who spent time on their AO1 preparation did well on part (a). There were plenty of good responses. A small number of these omitted the 'per coulomb' element of the definition. In part (b)(ii) the different approaches on the mark scheme were all seen. There was some confusion between pd and resistance with a minority of candidates. A small number failed to divide by 4 after correctly arriving at 2 Ω. In (iii) the first making point was awarded for a 'correct' substitution – namely current, pd or resistance values that would allow a relevant power to be calculated. Stronger responses showed correct use of a power equation and arrived at 0.18 Ω for both marks. Part (b)(iv) had the lowest facility factor on the paper. Candidates who thought the current would stay the same after X was replaced were unable to gain credit. Candidates who thought the current would double also did not gain credit. This was the same for candidates who believed that the internal resistance would change. It is worth noting that halving the external resistance does not double the current in this case.

Q.3 In (a)(i) 'maximum displacement' was seen regularly. We would have liked to have seen 'from the equilibrium position' but we did not hold out for this. Weaker attempts showed a double headed arrow on the diagram above from peak to trough which was a little disappointing at AS. Part (ii) was accessed by nearly all. Use of $v = f\lambda$ was seen regularly and a good range of marks were evident. There was some confusion between wavelength and periodic time which held some candidates back. Part (iii) was well answered by a large majority of candidates. For the displacement-time graph we were looking for a sinusoidal wave with the correct period, amplitude and phase. There was a relatively good success rate. Some phase shifts went the wrong way and it should be noted that a triangular wave is not an acceptable alternative for a sinusoid. The QER question proved to be challenging for candidates. The more able responses seen were able to explain how a stationary wave is formed. The comparison between stationary and progressive waves proved to be more demanding, however, all parts of the indicative content were covered in responses.

Q.4 The first part was not answered well. Coherent sources have a constant phase difference was the answer that was required. 'In phase' was not accepted. In (b)(i) path difference is the difference in distance that the two waves travel [from their source to a point]. Candidates were often vague with their answer here. For the second mark, we wanted candidates to link the first maxima to a 1λ path difference. This was done well by a minority of candidates. A regularly seen response was that 'path difference is 1λ because the waves arrive in phase'. The waves at the 2nd maxima also arrive in phase so this was not deemed enough for credit.

In (b)(ii) a good number of candidates were able to arrive at 0.3 m and / or 0.9 m. Less stated both. Some candidates responded with '$\lambda/2$ and $3\lambda/2$' which was awarded 1 mark only. The question did ask for values. In (c)(i) basic, but not necessarily credit worthy responses, included reference to 'addition of amplitudes' or stating 'peak plus peak and trough plus trough'. Use of the terms and definitions document should benefit candidates in the future.

There were some very good responses for part (c)(ii). The general misconception was that the constructive and destructive zones would simply swap. This is not the case. Constructive interference would continue at A and B. The amplitude would be less. Annotated diagrams were used by some candidates. At C, it would continue to be destructive but not total destructive interference.

Q.5 The recall question in part (a) was answered very well by some. Candidates who used their data booklet also needed to define the letters $n = \frac{c}{v}$ in their answer. Most candidates did well in the 'show that' question. They were able to select the correct equation and substitute values. In part (b)(ii) most candidates were able to determine the distance travelled. Candidates who failed to calculate the speed of light in material A were able to score 2 marks. Candidates approached (c)(i) in a couple of different ways as outlined on the mark scheme. Many completed the three steps correctly. It is worth noting that stating '10° is less than the critical angle' isn't enough for the 3rd marking point. A significant number of candidates went down this path. A minority of candidates did the calculation at the incorrect boundary. In the last part one 'good' reflection would have been enough for candidates to get their mark. Many correct responses were seen. There were several 'dragon's teeth' diagrams which showed little awareness of the angle of incidence being equal to the angle of reflection.

Q.6 The [minimum] energy needed to liberate an electron – not electrons – was generally seen in part (a). Around half of the candidates in (b) opted for zinc and gave correct reasoning. We assumed candidates were referencing the ultraviolet light in their responses and we were looking for 'more energy' or a 'higher frequency' or 'lower wavelength'. In part (c)(i) candidates found the 1st mark more accessible than the second. The sudden disappearance of $E_{\mathrm{k\,max}}$ was not enough in this 'show that' question. Good responses noted that $E_{\mathrm{k\,max}}$ was zero at threshold and this was then usually accompanied by convincing algebra. Most students answered part (c)(ii) well. Both routes on the mark scheme were regularly followed.

The last part proved less accessible than the previous question part. The stronger responses stated an increased intensity means more photons. They then connected photons with hf and how the intensity of light would not affect this. In a minority of responses there was some confusion between photons and electrons.

Q.7 In (a)(i) nearly all candidates were able to successfully calculate the mean. A common mistake when calculating the absolute uncertainty in V_{min} was failing to divide the range by 2. This often led to a percentage uncertainty of 6.4% and scored 2 marks. There were no significant figure penalties in this question part. In the next part the simple algebra was generally well done. Many candidates were able to calculate the mean value correctly and the absolute uncertainty but did not necessarily state this to 1 or 2 significant figures. In part (b) 'use a light detector' was a common accepted response for this question part. We did not accept more repeat readings. Using an ammeter or even a microammeter was also seen and awarded credit.

Q.8 Most candidates were able to access the first two marking points in part (a). Some stopped at 1.18 eV and scored 2. They did not go on to calculate the difference between 1.43 and 1.18. Dividing by e was a standalone marking point. The question produced a good range of marks. In part (c) 'cheaper' appeared to be the most popular response with 'more efficient' running a close second. 'Not as dangerous' was a common response that did not gain credit.

The last part on the paper had a high attempt % which suggests timing was not an issue for the paper. There were some very good responses from candidates. Stronger responses showed good awareness of the problems that this electronic waste poses as well as the opportunities it could bring to society.

PHYSICS

General Certificate of Education

Summer 2023

Advanced Subsidiary/Advanced

A2 UNIT 3 – OSCILLATIONS AND NUCLEI

Overview of the Unit

The general standard of performance of candidates is to be commended. The statistics indicate that the paper provided good differentiation for the cohort of candidates.

Topics: the weakest topic this year, as in most years, was the comprehension. However, the mean mark showed a considerable improvement over previous years. It is likely that the advance information proved useful. Applying conservation of energy to vertical circular motion was also problematic as was converting the mass of uranium to a number of fission reactions.

Language: answers to the QER were quite good this year and no general weaknesses were observed.

Mathematics: question 6(e) provided some difficulty with many candidates not able to obtain an expression for the gradient. Other than this, few problems with algebra and mathematical skills were encountered again this year and candidates now seem to provide a little more when the question states "Show that". For some candidates, they should set out their algebra / working out more neatly e.g. 4(b)(ii), 7(a) and 7(b)(iii).

Practical skills: uncertainties provided some difficulties again this year. These difficulties can be summarised as:

- Ensuring that lines of best fit pass through all error bars.
- Realising that the uncertainty in the length of a pendulum is 1 mm (or maybe 2 mm).
- Obtaining the final uncertainty in g after the gradient is squared.

Comments on individual questions/sections

SECTION A

Q.1

In part (a) the terms are well known but candidates sometimes lose marks for statements such as:

- Internal energy (instead of change / increase of internal energy)
- "Heat energy" or "heat energy flowing out of the system" or "heat energy flowing in or out of the gas". All three of these would not have gained the mark.
- "Work done" or "work done on the gas" or "work done on or by the gas". None of these statements would have gained the mark.

In part (b) sometimes incorrect units would appear e.g. ^{o}C or ^{o}K. Part (c)(ii) was not very well answered with many candidates not calculating the final temperature. Those who knew that $\frac{3}{2}nRT = \frac{3}{2}pV$ and used $\frac{3}{2}pV$ to calculate the change in internal energy did so with ease. Many candidates made use of error carried forward in the last part. Some candidates did not understand the First Law and subtracted the two energies instead of adding them.

Q.2 Part (a) was well answered although some candidates thought that the centripetal force was outwards away from the centre of the circular motion. In part (c) many candidates struggled. Only around half the cohort realised that the centripetal force was the resultant of the tension and the weight. Part (d)(i) proved to be the most challenging question on the whole paper. Those who could apply conservation of energy correctly inevitably strode towards full marks. Unfortunately, most applied conservation of energy incorrectly or tried completely invalid methods using forces. The last part on projectile motion was quite well answered but there were many common mistakes e.g. using the wrong initial vertical velocity (it should have been zero).

Q.3 Part (a) was quite well answered but there were often omissions. The most common omission was forgetting to state that alpha emission is expelled from the nucleus.

A common omission in (b) involved completing an excellent calculation to find that 95.3% of the nuclei remain undecayed without then stating that 4.7% of the nuclei are decayed.

In part (c) there was a tendency just to talk about alpha particles in general rather than referring to the context itself (although it was possible to obtain full marks by referring to the salient alpha particle properties). More candidates should have stated that the alpha particles would not penetrate the detector casing. The QER was quite well answered. The most common way of losing marks was to answer only half the question i.e. they described how to differentiate using absorbers or by using an electric field but not both.

Q.4 This question was well answered on the whole. In (b)(i) $Ivt = Pt = mc\Delta\theta$ should be familiar to the candidates. In (b)(ii) nearly all candidates were able to attempt conservation of energy but setting up a completely correct equation was the main hurdle.

Q.5 Part (a) was quite well answered but the main problems were in defining fission and fusion. Too many candidates were referring to atoms, molecules and elements rather than nuclei.

The definition in (b)(i) changed in 2019 but the old definition was accepted, and it was well answered with many candidates providing an adequate explanation of the Avogadro constant. In the last part calculating the energy released in the fission reaction was very well answered. The step that proved most difficult (as is often the case) was calculating the number of fission reactions with 1 gramme of U-235.

Q.6 Part (a) was not well answered considering that a bob on a piece of string was all that was required.

Part (b) is a standard definition so the mean mark should really be higher than it actually was.

Candidates found part (c) challenging. Few realised that the oscillation angle for A was rather large. Even fewer candidates could explain why the percentage uncertainty for B might be lower.

Parts (d)(i) and(ii) were well answered but a common mistake was to miss the top of the fifth error bar. In (iii) more candidates should have stated the obvious – that the error bars are too small to plot. Also, more candidates should have realised that the length of the bob was measured to the nearest millimetre (or similar). In (iv) there was an added difficulty here because the time for 20 oscillations was plotted. Most candidates were able to measure their gradients, obtain a mean and uncertainty in the gradient. However, calculating a correct value of g was quite rare. Calculating the correct uncertainty in g was rarer with the vast majority not multiplying the uncertainty in the gradient by 2.

Part (e) was poorly answered. Most candidates were unable to adjust the equation: $T = 2\pi\sqrt{\frac{l}{g}}$ to obtain the factor by which the gradient would change.

SECTION B

Q.7 Part (a) was a demanding question but quite well answered. Calculating the small angle using the definition of the radian was the most difficult step here. In (b)(i) one would expect more correct answers but as a one-step substitution, this is about the most difficult equation that could have been chosen. Also, there were many conversions required to obtain the correct answer. Candidates seemed comfortable with the centre of mass equation in (ii).

Part (iii) was not well answered. Substitution of the correct values into Stefan's law was the problem here – it was difficult to match the correct luminosities and temperatures.

Part (c)(i) required not a particularly difficult explanation but candidates were not stating the obvious and simple things e.g. one dip is caused by one star going in front of the other and the other dip is when they are the other way round. These were the obvious two marks. Most candidates were able to obtain one mark in (ii) for realising that the hotter star has the greater luminosity or intensity. It was extremely rare to find a candidate that realised that the area being blocked is always the same – the area of the smaller star. In part (d) most realised that the important point was that the black hole is not visible. About half the cohort realised that black bodies are not meant to reflect in the last part.

PHYSICS

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Summer 2023

Advanced Subsidiary/Advanced

A2 UNIT 4 – FIELDS AND OPTIONS

Overview of the Unit

The general standard of performance of candidates is to be commended. The statistics indicate that the paper was of an appropriate level of difficulty and provided good differentiation for the cohort of candidates.

<u>Topics:</u> the weakest topics this year were electromagnetic induction, the Hall probe and the electric field due to two charges.

<u>Language:</u> answers to the QER were not of a high standard this year but this was more of a knowledge problem than a writing skills problem. Explanation answers, in general, suffered more from omissions and knowledge this year. There was little evidence of poor writing costing marks on this paper.

<u>Mathematics:</u> there was some evidence of bad algebra in rearranging the velocity equation to obtain mass in 2(c) but no other significant mathematical difficulties were encountered.

Comments on individual questions/sections

SECTION A

Q.1 Part (a) was very well answered generally. A small minority of candidates mixed up the equations for series and parallel combinations. Another small minority forgot to invert the answer for $\frac{1}{C}$. Another small minority left their answers as fractions. In (b) a very small minority thought that a separation of 0.6 μm was reasonable. Even if these perfectly engineered plates could be separated by this distance, sparks would fly with a 2 V p.d.

Q.2 Part (a) was well answered on the whole although a significant number could not derive this standard equation. In Part (b) weaker candidates were reticent to use the correct terms i.e. speed or velocity and mass. Other candidates did not refer to the equation that they had just derived. The equation in part (c) proved to be the most difficult to rearrange algebraically on the paper. The most common mistake in (d) was to read the wrong speed from the graph. Too many candidates chose the estimated speed rather than the measured speed. Surprisingly in part (e), there were many wrong values of the Hubble constant used. It is given in the data booklet.

Q.3 Part (a)(ii) was quite poorly answered. Many candidates did not realise that each planet experienced two forces (one from each of the other planets). Others could not obtain the $\cos 30°$ factor. The most common lost mark was explaining the direction of the force.

In (b)(i) those who did not start from the definition of cosine struggled. Part (c)(i) was well answered but often the potential due to the planets was not considered or even stated to be negligible. Part (c)(ii) was a demanding question but generally well answered. Some candidates compared PE with KE as was expected. Others converted the KE into its equivalent potential (increase) if transferred to the planet. Others calculated the escape velocity of the planet and the speed the planet would have with that KE. The last part candidates found challenging, the main problem was that candidates forgot the theory of exoplanets. The wobble is seen in the star not in the unobservable planets. Hence, a majority of the cohort referred to the motion of the planets rather than the star, leading to zero marks.

Q.4 The first part was not well answered by the majority. Candidates were jumping straight into Fleming's Left Hand Rule rather than discussing the positive reading on the balance and Newton's 3rd Law. In (a)(ii) the correct pole was not correct much more frequently than about half of the time. Part (a)(iii) was not answered well at all. The bottoms of these wires are in the field and are at 90^{o} to the B-field – this meant that 90% of answers were wrong (most answers stated "because they are not in the field" or "because they are parallel to the field"). Candidates had to say that the forces were horizontal or equal and opposite. Sometimes candidates forgot to draw the points on the graph in (b)(i). The next part was not well answered in general. The important point here was that, above a length of 5 cm, the wire did not remain in the uniform B-field. The most common mistakes in the last part were failing to convert from cm to m or from mN to N. Some candidates failed to quote 2 or 3 significant figures and a small minority did not quote the correct unit (T).

Q.5 Part (a) was very poorly answered for such a straightforward application of Faraday's Law. In the past, a statement of Faraday's Law has been requested before the induction question. Without this clue, the majority of the cohort gave answers that were complete and utter nonsense. Those who knew that this related to Faraday's Law answered the question successfully. The mean mark of the QER was a little disappointing. Many of the diagrams were incomplete or inadequate and many candidates were unable to explain the Hall theory. This was more due to a lack of knowledge rather than poor communication.

Q.6 Part (a)(i) was generally well answered but one would expect good responses to this straightforward "show that" question. The next part was a challenging question and the low mean mark is a reflection of this. Candidates obtaining all three marks were very rare. Were this a question about the potential between two planets, the responses would have been far better. However, the potential between a positive and negative charge is not seen as often and is a difficult concept to conquer at first sight. In (b) perhaps the point that caught candidates out was that the wording of this question was "Explain why…" Candidates were required to show (or state) that the field due to the farther charge was negligible. Explanations of the direction of the field were also poor with many candidates just mentioning the attractive forces experienced by these two charges.

SECTION B

Option A – Alternating Currents

Q.7 In the first part not all candidates used the correct equation. Some omitted ω and others included an incorrect angle. In (ii) most candidates chose the correct equation, but a significant number completed the calculation without setting the calculator to radian mode, despite being told to do so in the question. In (iii) responses varied with common errors including using the wrong equation and omitting the $\times 10^{-3}$ in the calculation. Many candidates calculated the period of 20 ms correctly in (iv) and noted that 5 ms was a quarter of a cycle. Fewer candidates were able to comment on the calculated values from parts (ii) and (iii) being consistent with the expected values. In (b)(iii) many candidates calculated Z correctly and went on to use this value to calculate the current. Those who incorrectly calculated Z were able to gain two marks using their incorrect value. A mixed response was seen in (iv). Many candidates realised that a small increase in the frequency resulted in a large drop in current and hence deduced that the curve would be sharp, consistent with a high Q factor. Some candidates tried to calculate the Q factor, but made no reference to the values in parts (b)(i), (ii) and (iii) of the question. Varied responses were given for the last part. Many candidates did not appreciate that an increase in the value of C would decrease the value of ω_0 and therefore omitted to consider this in their answer. Candidates were still able to gain one mark by correctly linking a decrease in Q with an increase in C with the use of a valid equation. Candidates who used $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ did not need to comment on ω_0.

Option B – Medical Physics

Q.8 In part (a)(i) some candidates thought the heater created the X-rays, and many thought the vacuum was to prevent X-rays being absorbed and stopped from getting to the target. A few times in (ii) mA was used as 100×10^{-6} and so one mark was lost. In part (iii) some candidates tried to apply $I = nAve$ to obtain v hence they attained no marks. In part (iv) a few candidates used any equation in the data book including Doppler shift to try and find λ and so lost the marks. Generally the majority of candidates gained at least one mark in (b)(i) with many scoring full marks. Some stated correctly that an alternating p.d. / current was applied but didn't state this caused the crystal (piezoelectric) to vibrate / oscillate and so lost one mark. For the final mark just 'doppler shift' on its own was not enough they also needed to state that the ultrasound was reflected by the blood (cells). In (ii) almost all candidates correctly chose the correct equation, however many had difficulties with the units given in the question such as MHz and kHz and so the final answer was incorrect. In the last part the vast majority realised that X-rays would not be useful. A few candidates thought the thyroid gland was moving, and so ultrasound was the best method to use. A number of candidates commented on the cost of the various treatments. This was seen as a neutral remark.

Option C – The Physics of Sports

Q.9 In the first part a significant number of candidates used an approach based on equating upward forces with downward forces rather than using the principle of moments. In addition, the correct component or perpendicular distance was not determined correctly or used when applying the principle of moments. Part (b) was well answered with nearly all candidates using $Ft = mv - mu$. However, the direction and the sign for the velocity was frequently omitted by many candidates. Part (c)(i) was not answered well. Most candidates were able to refer to the surface area affecting the drag force but did not refer to the equation and did not discuss other factors that affect the drag force. In (c)(ii) some candidates were able to state directly that the rotational kinetic energy would quadruple which scored both marks.

A significant number of candidates simply used the data and compared bounce heights in (iii) without using the coefficient of restitution equation as expected. In (iv) it is pleasing to note that some candidates used the fact that torque is the rate of change of angular momentum and were able to obtain the correct value for torque and gained all marks. The last part was answered well by all candidates with many obtaining full marks. The frequent skills where candidates lost marks were based on not using the 2 m height to draw a correct conclusion and not being able to determine the height correctly using the appropriate equation.

Option D – Energy and the Environment

Q.10 In (a)(ii) responses were mixed with many candidates giving vague answers referring to 'heat being trapped' and others discussing the ozone layer. Few candidates obtained all three marks and answers generally lacked detail. Many candidates did not appreciate the effect of the gases absorbing and re-emitting the longer wave radiation in all directions and many referred to heat being reflected. Although most candidates were able to use the density equation correctly in (b)(i) to calculate the volume of water released per year, many candidates failed to include the two decades and therefore omitted $\times 20$ in their calculation.

In (ii) many candidates failed to appreciate the importance of the discolouration stated in the question and were therefore unable to access the marks.

Most candidates in (c)(i) realised that the contribution of solar photovoltaic increased whilst the contribution from hydro remained fairly constant. Lots of candidates linked this to advances in efficiency of PV cells and many discussed the availability of domestic solar panels. Candidates realised that it is difficult to find new hydroelectric sites that are commercially viable and many discussed cost implications. Part (c)(ii) required candidates to use the graph to calculate the maximum power and hence calculate the efficiency of the solar panel. Many candidates were unable to calculate the maximum power correctly from the graph. It was common to see candidates substituting an incorrect maximum power into the efficiency equation but calculating the corresponding efficiency correctly and gaining two marks. Many candidates found the last part challenging and only a minority completed it successfully, gaining all three marks. The most common errors seen were using $\Delta\theta$ as 14 °C for each layer instead of the total decrease in temperature over all three layers, and adding the K values.

PHYSICS

General Certificate of Education

Summer 2023

Advanced Subsidiary/Advanced

A2 UNIT 5 – PRACTICAL EXAMINATION

Overview of the Unit

EXPERIMENTAL TASK

The task involved setting up an electrical circuit and taking measurements. In addition, candidates were expected to calculate the uncertainty values and include error bars on the graph. Maximum and minimum lines of best fit were expected to be drawn on the graph. These skills had not been assessed in an Experimental Task before as they were included in the Practical Analysis Task. The candidates were then expected to analyse the data from the intercept of the graph and the gradient of the graph. In general, the candidates performed well and were able to provide answers for all sections of the paper.

PRACTICAL ANALYSIS TASK

Graphs were very well done and the gradient calculated correctly. Candidates appeared to have been well prepared for the task. A number of marks, however, were lost for incorrect units. The mathematical skills of most candidates were on the whole very good, as was their appreciation of significant figures. This was evidenced in the table, Q2(a) where the vast majority used consistent s.f. throughout each column.

Comments on individual questions/sections

EXPERIMENTAL TASK

Part (a) was assessed by teachers in the centres and nearly all the candidates were able to connect the circuit correctly. The gradient and the intercept were identified correctly by nearly all the candidates in part (b). In (c) the method for using different resistance combinations was explained well but several candidates did not include how the pd was measured. There was no risk involved in this task and this was stated correctly and assessed correctly by teachers. However, a significant number did state that the wires or resistors would get hot and identified this as a hazard. This was not accepted for the mark unless the risk assessment stated clearly that the resistor can burn, and the risk identified if the resistor was touched. The first mark in the mark scheme for the table states that units needed to be included for all columns. The majority of candidates did not include the unit for the absolute uncertainty in the value of $\frac{1}{R}$. Also the units for $\frac{1}{V}$ and $\frac{1}{R}$ were also frequently omitted. Nearly all the candidates used a minimum value of five values for the resistance and used appropriate significant figures in the values given in the table. Graphs were well drawn with suitable scales being used by the vast majority of candidates. Points and error bars were plotted correctly as well. The mark for the maximum and minimum gradients was lost by a significant number of candidates as the lines tended to be from the limits of the error bars from the first and last data point.

This resulted in lines not going through all the error bars. Some candidates indicated points that were anomalous points which was accepted. In (f)(i) the maximum and minimum gradients were determined correctly by the majority of candidates and was answered very well. In part (b) of the paper; the candidates were asked to provide an expression for the intercept as $\frac{1}{E}$ which subsequently should have led them to determine the mean intercept from the graph to determine E. A significant number decided to use a data point from one of their lines or a value in the table for this part. In addition, many candidates did not use appropriate significant figures for their values of the percentage uncertainty in E. The last part was answered well by all candidates with the value of R determined correctly and error carried forward was applied for incorrect values of E from part (g).

PRACTICAL ANALYSIS TASK

Q.1 The first part discriminated well with marks ranging from one through to five. Unsurprisingly almost all candidates gained the first mark for calculating the corrected count rate. In part (b) many candidates only used two sets of values (usually the first and last set) to check the relationship and so only attained one of the marks. Part (c) was generally answered well with the majority of candidates using all the data provided to calculate the mean, and then used $\frac{(\text{max - min})}{2}$ to determine the uncertainty. A minority unfortunately, gave the value to more than 1 or 2 significant figures so they lost a mark.

Q.2 The table was generally well done, however a significant number of candidates gave incorrect units for l^3 and T^2. The calculations were generally of a high standard. The graph was very well done by the vast majority of candidates with only a few choosing incorrect scales. Almost all candidates plotted the points correctly and the lines of best fit were generally very well done. In (c)(i) a number of candidates stated it was a straight line and went on to state, 'it went through the origin'. A smaller number stated that 'all points were close to the line of best fit' and fewer again that it had 'a positive gradient'. Almost all candidates calculated the gradient correctly and the majority identified the gradient as k. It is worth noting that the units of a gradient are not needed and any given were ignored as were significant figures. Many candidates in (d)(i) forgot to include units for E or if they did, often they were incorrect. As expected, this part of the question discriminated well with candidates obtaining the full range of marks. In the last part many candidates stated Vernier callipers or micrometer but did not go on to give its resolution of 0.01 mm with units, and so, lost the mark.

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[i] ***Please note that where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.***