GCE A LEVEL EXAMINERS' REPORTS

PHYSICS
A LEVEL

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 component, 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	Eduqas 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.eduqas.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 Eduqas 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 component that contributes towards the overall grade. Grade boundaries are published on results day.	For unitised specifications click here: Results and Grade Boundaries (eduqas.co.uk)

Exam Results Analysis	WJEC Eduqas 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.eduqas.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 Eduqas subject page.
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Subject Officer's Executive Summary

Overall performance in the qualification is to be commended. Candidates performed well in all three components and to a similar standard as seen in previous series. Recall of knowledge in AO1 marks, such as the recall of definitions is still an area of development, with lack of clarity in responses seen. Quantitative responses usually are preferred by candidates compared to qualitative responses. There is room for improvement in questions based on experiment design with some confusion seen in the QER question in Component 3. Issues with error bars, gradient lines, significant figures were seen at times too. As ever, certain topic areas candidates perform in better than others, with misconceptions often the problem with the topics candidates perform not so well in. The Physics of Sports 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
Understanding of electromagnetic induction	**ELECTROMAGNETIC INDUCTION**	Knowledge organiser
Misconceptions in electrostatic and gravitational fields	**ELECTROSTATIC AND GRAVITATIONAL FIELDS**	Blended learning

PHYSICS

GCE A LEVEL

Summer 2023

COMPONENT 1 – NEWTONIAN PHYSICS

Overview of the Component

The general standard of performance of candidates is to be commended. The questions on basic physics, thermal physics and energy concepts were well done by most candidates. The questions on vibrations, circular motion and kinetic theory proved to be more challenging. In the kinetic theory data analysis question, candidates needed to find a way of calculating the data before analysing. This appears to be a skill that would benefit further practise. The vibrations and circular motion question included the QER. Referencing graphs drawn in QER responses is good practice and describing experiments is an area for development. Candidates generally showed good use of $y = mx + c$ in practical questions. It is worth noting that using the intercept instead of the gradient will help in some instances. It is pleasing to note that tangent drawing skills are well developed.

Comments on individual questions/sections

SECTION A

Q.1 After careful consideration of the diagram in (a), most candidates were able to suggest a way of ensuring the ruler was level. These included spirit levels, vertical height measurements and use of set squares or protractors. In (b) many candidates were able to define the centre of gravity. A small number confused mass with weight and were not awarded credit. Less candidates picked up the second mark as their attempts at labelling the centre of gravity on the ruler were not clear. Responses that didn't score both marks in (c)(i) failed to include 'sum of…' or 'total clockwise equals total anticlockwise…'. A small number incorrectly used 'an enclosed system' in place of 'a system in equilibrium'. There were many good responses to (c)(ii) that included the principle of moments and convincing algebra. Clearly dividing by 0.8 was enough, however, in many responses candidates showed clear algebraic steps in their workings. Some weaker responses appeared to reverse engineer a response which sometimes left an incorrect '0.5 W' in the starting equation. This year there was no credit for stating the point where moments were taken, although it was good to see candidates demonstrating this. In (d) many candidates did identify the first result as the anomaly. A good appreciation of $y = mx + c$ and use of the T intercept often followed. Some candidates used the gradient to calculate the value of W. Weaker responses included the thinking that the gradient of their graph was '$a + \frac{W}{2}$' and attempted to proceed with this. This was not credited. Many good evaluative responses were seen in the last part and responses depended on how candidates had tackled the previous question part. Good use of 'accuracy' was common.

Q.2 Most candidates were able to successfully navigate the synoptic 'show that' question in (a). There were the occasional slips where the diameter was used instead of the radius, however, some candidates seemed to have spotted this and re-showed their response correctly.

Part (b)(ii) proved to be somewhat of a discriminating question as candidates needed to appreciate that the copper container and the water received energy from the electrical heater to access the 2nd and 3rd marking points. Candidates found the last part of the question, challenging as well. Those who thought that it was bad practice as the heat would flow into the system from the surroundings, achieved some credit. A smaller number of candidates realised the energy absorbed below 16 °C would be countered by the energy emitted above 16 °C. This scored two marks if it was accompanied by a conclusion.

Q.3 Most candidates in (a) were able to link an increased velocity to an increased drag force. Less mentioned the greater collision rate. More were comfortable in explaining how the resultant force would eventually reach zero. This was done in several ways with many candidates referring to the 'drag force balancing mg'. In part (b) most were able to draw a suitable tangent and achieve a value within tolerance. Some candidates went on to use their value to calculate the resultant force but went no further. The appreciation of '$mg - ma$' was the important final step here. In the last part most candidates showed good responses regarding the ethical use of this money. Some responses gave a balanced argument, but most were loaded in favour of spending money on these parachutes. They were able to access full marks with a one-sided discussion.

Q.4 Most candidates were successful in part (a). There was the occasional omission of 'increase' or 'change' in internal energy by a minority of candidates. References to 'energy into a system' without mentioning heat were rarely seen and not credited. Part (b)(i) was very well answered either by using the ideal gas equation or Boyle's law. Most went down the route of calculating 289 K at A and B. In (ii) most candidates chose a correct method for obtaining the work done. The second mark was achieved for a close approximation. One single trapezium here would have fallen outside of this range. A significant number of candidates used a counting squares method. The responses to the last part of the question were encouraging. Candidates could obtain the correct answer of '+150 J and hence Joseph is correct' by several different methods – some looked at the process stage by stage whereas some calculated the area of the enclosed 'triangle'. A minority answered the question without referencing 150 J. They were still able to attain the first two making points.

Q.5 In (b)(i) most candidates were comfortable in calculating the gain of gravitational potential energy. There was a unit mark here and there were a few candidates who incorrectly stated the unit. The 0.92 is significant in (ii). The justification was missed by some candidates. Stronger responses included reference to 0.92 being 33% of (1.9 + 0.92) and so significant. This usually allowed for better access to the next question part. The input energy was correctly calculated by most in (iii). A significant number of candidates were not combining 1.9 and the 0.92 and hence incorrectly established an efficiency of either 24% or 12%.

Q.6 The ‘show that’ question in part (a) proved to be demanding. A significant number of candidates were unable to appreciate where the component of the bob’s weight was acting and diagrams indicating horizontal force directions were confused. The use of tension also halted progress here. The second and third marking points proved more accessible. Mainly very good candidate responses were seen in (b)(i).
There were some weaker attempts using $v = -A\omega\sin\omega t$ but these did not develop as the candidates were unable to determine the amplitude. For the GPE – time graph in (ii) we were looking for the correct period, phase, and shape. There was a good success rate. A triangular wave is not an acceptable alternative for a sinusoid. Candidates who used the negative portion of the graph were only able to access the period mark as this was a significant error. The transition from simple harmonic motion to circular motion in part (iii) proved demanding for some candidates. Some used $a = \omega^2 r$ and the periodic time of 1.4 s for the pendulum to be the time for one complete revolution. This is incorrect. Candidates who used $a = \frac{v^2}{r}$ were more successful. In the second part of the question, we were looking for candidates to show us that a centripetal force is a resultant force and at the bottom of the swing, this resultant force would be upwards. Some candidates were able to do this. We accepted ‘$T - mg = ma$’ for the first marking point. The direction needed to be clear for the second marking point. Some drew a diagram to support their responses and were often rewarded. The last part was the QER and it tested the candidate’s ability to describe how forced oscillations can be demonstrated and how the amplitude varies with frequency. It bridged AO1 and AO3 and this challenged candidates. The description of the experiment was often limited whereas the variation of amplitude and hence links to resonance were more readily seen.

A graph would often be seen, however, we wanted it to be referenced in their written response. The simple and effective way of obtaining the natural frequency of an oscillator (when the signal generator is off) was not regularly seen, however, it was encouraging to see additional practical detail regarding the amplitude measurement. There were a minority of confused responses involving damping.

Q.7 Apart from a handful of candidates who were more focused on kinetic energy than kinetic theory, candidate responses were generally very good to (a). Particles colliding with container or walls of container were credited. A small number led with collisions between particles which halted progress. Momentum change and force on wall was credited. It was pleasing to see many references to Newton’s first and second laws in candidate explanations. The final marking point was more readily missed by a smaller number of candidates. In part (b) there were a couple of number transfer errors and incorrect ‘regular’ mean calculations, but the majority of candidates were successful in calculating the rms speed. The last part was a demanding question where candidates needed to demonstrate advanced level analysis techniques.

Step 1 was to identify a way of calculating a rms speed at the stated temperatures. Those that did were usually able to pick up the first two marks. Ratios of speed of sound to rms speed then needed to be evaluated and a conclusion reached. Many good responses finished with a correct equation linking the two using a constant of proportionality of either 4.16 or 0.68. Some candidates who could not see how to calculate the rms speed set off by showing that the rms speed is proportional to the square root of temperature. If they did this and evaluated ratios of $\frac{v_s}{\sqrt{T}}$, they were awarded two marks.

SECTION B

Q.8 Most candidates were able to successfully identify the centripetal and gravitational forces in (a). Candidates were asked to use forces in their responses to part (b). In several cases this was not done. For the first mark candidates needed to reference the mass inside of the bulge. Some considered this as a point mass, but it was not a requirement. This mass causes a force towards the centre. As the star obits, the bulge outside will pull in different directions. This proved to be a tough marking point to achieve. Good algebra skills were on show in (c). The first marking point was sometimes missed in (d)(i) as candidates focused on using logs. Referencing the supermassive black hole or even the centre of the galaxy would have been enough. The mathematical demand in this question part made it difficult for some candidates. There were a good number who were successful and correctly identified -0.5 in their algebra and linked this to $y = mx + c$. In (ii) taking values from the graph was generally well done. Some candidates brought forward their log equations from (d)(i), leading to a relatively simple substitution and manipulation. Many candidates used 10^x to calculate a distance and a velocity and then used a rearranged version of the orbital velocity equation. A comment was needed to pick up the last marking point. In (e) many spotted the concise route using 2 million years and 4 million Suns. Others tried different paths and firstly calculated the number of kg ejected per year. One mark was awarded for this approach. There were a significant number who went no further even though the question clearly stated ‘in solar masses per year’. Candidates realised in (f) that ‘can’t be seen’ means ‘not visible’. We were looking for more than this. The jet is not visible because it is outside the visible range. Reference to doppler shift alone was not considered enough for the second mark. Good responses included reference to redshift. Most candidates picked up one of the marking points in the last part. A sensible comment about a burp not being enough mass was popular. Less candidates appeared to go on to describe some further observations.

PHYSICS

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Summer 2023

COMPONENT 2 – ELECTRICITY AND THE UNIVERSE

Overview of the Component

Candidates displayed a good appreciation of the physics tested in the paper with some areas scoring better than others. Responses to questions testing conduction in wires, stellar physics and materials were encouraging with candidates scoring particularly well in the numerical questions in these areas. The question on electric circuits was also well answered with many candidates showing a good understanding of potential divider concepts. Practical analysis skills using logs was carried out well, however many candidates lost some marks due to a lack of accuracy when drawing error bars or gradient lines. The question testing experimental technique was very well answered. The core skills of literacy and numeracy were displayed to a high standard, as would be expected at this level, with algebraic skills in particular demonstrated to a very high standard. On a pleasing note, and an improvement on previous years, few candidates lost marks for confusing surface area with cross-sectional area in the question testing stellar physics. Similarly, some improvements were seen in questions testing wavelength shift in spectra from distant galaxies and in the application of potential energy equations to determining the velocity of launch from the surface of a planet. However, some misconceptions remain which are described in more detail below. Responses to electric field strength and electric potential questions were not as strong as expected, with many candidates confusing the vector and scalar nature of the aspects being tested. Responses were reasonably well-presented and better in general than in the previous sitting of this paper. Written responses were usually well constructed and logically reasoned, though once again, definition-based questions often lacked precision. The QER question was attempted reasonably well with many candidates picking up some marks, however only a few candidates provided enough detail to be awarded marks from the higher marking band.

Comments on individual questions/sections

Q.1 Around half of the candidates in (a) provided a clear and accurate definition of the potential difference between two points in an electric field. Of those that were unsuccessful, many did not include the term ‘per coulomb (or unit charge)’ in their responses. In (b)(i) most candidates provided clear and logical responses to the double instruction of ‘state’ and ‘explain’ how the reading on the voltmeter changed in the circuit. Many chose to compare the pds across the relevant components in the circuit and discussed how these would be affected by the changing resistance across the LDR. Others chose to discuss the changing current (because of the reduced overall resistance) and the impact of this on the pd across the fixed resistor, and hence the reading on the voltmeter. Both approaches were equally valid. It was noted that responses were presented clearly and logically. In (ii) a few candidates lost marks for miscalculating the pd across the fixed resistor. In (iii), nearly all candidates sketched the variable resistor in series with the LDR, however a significant number were not awarded the mark as they gave an incorrect circuit symbol for the variable resistor, with many giving the symbol for a thermistor.

Encouraging responses were seen in (iii)(II), with many candidates showing clearly that the modification to the circuit would allow the water feature to be turned off in full sunlight. Many candidates chose to show that the minimum pd across the fixed resistor would fall to 1.8 V with the variable resistor set to its maximum value, commenting that this is below the activation pd.

Q.2 Nearly all candidates in (a) were able to explain resistance in terms of collisions between electrons and the lattice (or equivalent). Once again however, a small minority of candidates gave incorrect responses based on collisions between conducting electrons. A variety of valid responses were seen in (b)(ii) with credit given for responses involving at least two relevant substitutions involving $I = nAve$, $R = \frac{\rho l}{A}$ and $V = IR$. In many cases marks were awarded as Benefit of Doubt (BOD) as the algebra seen was not always clearly laid out. It would be useful for example for candidates to show how particular terms (e.g A) cancel out, rather than just 'disappearing'. In (iii), a small number of candidates did not gain the mark for not including a unit in their final answer or providing an incorrect unit. Whilst many candidates in (c) identified and explained why n and v were incorrect, fewer made any reference to the fact that ρ and A were correct, thus not fully answering the question. Good attempts were made at answering the issues-based question, with many candidates identifying reduced energy loss during transmission, reduced cooling costs (or easier to cool) and the possibility of a more widespread use of technology such as MRI scanners being amongst the more common responses seen.

Q.3 There were impressive responses to the experimental technique question in (a), with many candidates providing clear and logical steps to obtain the required data. A few candidates did not clearly explain that readings should be taken at intervals, implying instead that only one reading of V be taken, which was not credited. The majority in (b) were able to plot the required point along with error bars, though a small number drew error bars which were twice as large as required. In part (c) candidates who took care to draw accurate gradient lines usually scored full marks. Lack of accuracy unfortunately led to some candidates losing marks when determining the gradients. ECF (Error Carried Forward) was applied in (ii) for calculated gradients which were outside of tolerance. Regardless of the values used, it was encouraging to note that most candidates were able to determine the mean gradient and the percentage uncertainty in it correctly. In (d)(i) most candidates recognised the relationship: $\text{gradient} = \frac{1}{CR}$ and hence successfully determined the capacitance of the capacitor, in some cases as ecf from part (c). Two marks were awarded for calculating C. Two further marks were awarded for determining the total % uncertainty and the consequent absolute uncertainty in C, which many candidates managed successfully. Far fewer candidates provided the final answer to the correct number of significant figures. A useful rule of thumb would be to ensure that the number of significant figures in a calculated value and corresponding uncertainty are the same, with no more than two significant figures given for the uncertainty. In (ii), only a minority of candidates were successful in determining the pd of the power supply and the uncertainty in it. In many cases candidates determined an appropriate value for the mean intercept from their graphs and hence the value of V from their intercept. Far fewer were successful in determining the absolute uncertainty associated with their value for V, with many omitting to convert $\ln\Delta V$ into ΔV.

Q.4 Disappointingly in (a)(i), fewer than half of the candidates drew the pre-stressed bar towards the lower surface of the concrete beam as required, with many sketching the bar near the middle of the beam. The response in (ii) was more encouraging with many candidates recognising that the bar would put the concrete under compression which would inhibit crack propagation. Nearly all candidates in (b) correctly referred to the fact that the initial gradients of the three graphs were the same. Many candidates identified that high carbon steel is 'stronger' (or equivalent) than low carbon steel and explained this physical property in terms of additional carbon atoms inhibiting the flow of dislocations within the metal. This was understood better than in previous sittings of this paper. However, once again, a significant minority of candidates incorrectly described carbon atoms inhibiting the motion of whole planes of atoms rather than dislocation movement. Reference to whole plane of atoms was not credited. In (c)(i) many candidates were able to show that the extension in the cable approximated the value given in the question. Of those that failed, many incorrectly resolved the force given, often multiplying rather than dividing by cosine (20°). In (ii), most candidates used $W = ½ F\Delta l$ to determine the energy stored in the cable, with ecf being applied to F and Δl for those who failed to resolve correctly in (i). Some candidates chose to use $½ k\Delta l^2$ to determine W, which is perfectly acceptable, though a more time-consuming method. Most candidates in (iii) were able to refer to the large extension at a lower stress as a reason why it was not be a good idea to use low carbon steel to tow the ship.

Q.5 Part (a) was the QER question and in general, good attempts were made to explain the shapes of the potential vs distance curves. Higher scoring candidates (top band responses) were able to refer to the definition of potential and the expected relationship between potential and distance (i.e. $V_g \propto -\frac{1}{r}$). They explained the reason why the potential near the earth had a greater (negative) value than near the Moon and identified the relationship between the gradient of the curves and gravitational field strength. They described the scalar nature of potential and explained that the combined curve was due to the sum of the individual potentials. They also correctly described the significance of the gradient at X in terms of field strength and, in some cases, the work needed to escape the system. Middle band responses contained some of the above points, with lower band candidates only managing to describe one or two of these aspects. Many candidates in (b)(i) had an appreciation of the energy principles involved in determining the launch speed of the rocket, including the concept of initial E_p and E_k at the surface being equal to the E_p at the given height in orbit. However, a significant minority of candidates failed to gain full marks due to their incorrect use of signs when considering E_p. That is they failed to account for the negative values of E_p at both the surface and at the height of the orbit. Responses to (ii) were more successful with many applying the appropriate circular motion equation to confirm the orbital speed. In a few cases candidates used the orbital speed given in the question to determine the period of orbit, T, and then used the same equation again to re-confirm the orbital speed - a circular approach which was not credited.

Q.6 In (a) a significant number included negative signs in their answers which seemed to be related to the sign of the given charge. Whilst this was not penalised at the stage of calculating the individual field strengths, this lack of conceptual understanding was highlighted when calculating the overall horizontal and vertical components, which were often incorrect because of the 'sign' values in their calculations for the individual field strengths.

This in turn led to an incorrect overall vale for the intensity due to all the charges and its direction. Where candidates did calculate the magnitude of the overall intensity correctly, the direction associated with it was not always clearly shown. More often than not candidates were successful in (b) in calculating the combined potential due to the four charges at point P. Once again however, some candidates showed confusion with the use of signs. In this case, consideration of the negative or positive nature of the potential due to each charge is important. Those that ignored the scalar nature of the individual potentials were unsuccessful when calculating the overall potential. In light of the comment related to (b), ecf had to be applied frequently in (c) with many candidates successfully achieving full marks for a correct application of physics principles. Regardless of the figures used, many candidates displayed a good understanding of the concepts involved to achieve full marks here.

Q.7 Many candidates were successful in sketching an appropriate spectrum in (a) with nearly all gaining at least one mark for drawing the same pattern as the one given in the question. Most candidates showed a 'shift to the right' as required, however a few candidates showed a shift to the left, which was not credited. In (b)(i) nearly all candidates were successful in using Wien's law to calculate the required wavelength, with most stating that the wavelength lies in the visible or 'blue' part of the spectrum. Unlike previous sittings of this paper, it was encouraging to note that many candidates used Stefan's law correctly by including the formula for surface area of a sphere ($4\pi r^2$), rather than the cross-sectional area of a sphere. A few candidates did not gain the second mark for giving an incorrect unit for luminosity or for omitting it altogether. It was expected that only high achieving candidates might be able to access part (c) as it required a consideration of the impact of two changes to the properties of the star on its temperature in comparison to the star's initial conditions. Responses however were very encouraging, indicating that candidates from a broad range of abilities were able to confidently manipulate the data given to confirm the decrease in temperature required in the question. As with other AO3 style questions of this nature, many approaches are possible. Many candidates chose an algebraic approach, comparing initial and final conditions for the star, usually ending with a factor $\sqrt[4]{\frac{3}{4}}$ decrease in temperature. Others chose to take a numerical approach, showing that the decrease in stellar temperature amounted to about 440 K, a decrease of less than 10% as required.

Q.8 Candidates, overall, applied the principle of conservation of energy and equations for density and the Hubble's Law appropriately to derive the equation for the critical density of the Universe in (a)(i). Candidates should however be encouraged to provide some context to their work, with many going straight into 'algebra mode' without setting the scene in terms of the rationale behind the proof being given. A simple comment such as: "*consider matter within a spherical shell of radius R*" (or equivalent) would at least give some context to the argument. Where this was seen full marks were awarded. One mark was deducted where no context was given. In (ii) nearly all candidates were successful in confirming the relationship between the Hubble constant and the number of atoms of hydrogen per m^3 in the universe. Once again, many approaches are possible with some candidates choosing to use the value for the Hubble constant given in the data booklet and the critical density equation to determine the number of hydrogen atoms per m^3, while others chose the converse approach of starting with the number of atoms to determine the corresponding Hubble constant.

Both approaches are equally valid. Nearly all candidates successfully confirmed the receding velocity of the galaxy in kms^{-1} as required in (b)(i). In (ii) many candidates, though by no means all, were successful in using $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ to determine $\Delta\lambda$. Of those candidates who successfully determined the change in wavelength a significant minority **subtracted** this from the original wavelength given rather than adding the two figures together. As in previous years it seems that candidates continue to have misconceptions regarding this part of the specification. In the last part it was expected that candidates would identify from part (b) that the galaxy emits radiation across a wide range of the electromagnetic spectrum, beyond that of visible light. A few candidates identified that the hydrogen line described in (b) was in the infra-red part of the spectrum for example. Using this knowledge, candidates were expected to comment on the usefulness of using the Hubble telescope to detect wavelengths beyond the visible spectrum in comparison to telescopes sensitive only to visible light. Fewer candidates than expected were able to recognise this relationship.

PHYSICS

GCE A LEVEL

Summer 2023

COMPONENT 3 – LIGHT, NUCLEI AND OPTIONS

Overview of the Component

The general standard of performance of candidates is outstanding. This was a slightly more demanding paper than last year. The statistics indicate that the paper was of an appropriate level of difficulty and provided good differentiation for the cohort of applicants.
Topics: the weakest topics this year were electromagnetic induction (Q9), basic wave properties (Q1) and Medical Physics (Q11).
Language: answers to the QER question were of a high standard this year and most candidates found no language difficulties when expressing difficult explanations. There was some evidence of candidates, whose first language is not English, using incorrect words from time to time but this tends to lose no marks unless fundamental terms are misused.
Mathematics: no particular mathematical weaknesses were apparent this year.

Comments on individual questions/sections

SECTION A

Q.1 The first part was slightly disappointing. The best definition is "the distance between adjacent points on the wave moving in phase". Sometimes candidates referred to "peaks" and some weaker candidates were talking about more than one wave. Part (b)(i) was well answered in general. Many candidates only scored half marks by starting from $v = f\lambda$ i.e. $v = f\lambda$ and $f = \frac{1}{T}$ hence $v = \frac{f}{T}$ Part (b)(iv) was quite poorly answered. There were two approaches to explain the factor of two difference in the results. First, the stroboscope could be flashing at half the correct frequency – the loudspeaker would still appear stationary. Second, the student could have timed half oscillations instead of full oscillations – resulting in a frequency 2× too large.

Q.2 Most candidates in (a) realised that the gap was less than a wavelength and drew full semi-circles. Keeping the wavelength constant was the main problem. Part (b) was generally answered poorly. Candidates were stuck if they didn't talk about the slits (or lines). Many tried to talk about interference and diffraction but without mentioning the slits themselves.

It was surprising in (c)(i) how many candidates used the double slit equation instead of the diffraction grating equation. Perhaps this was because calculating the correct angle using tan was more difficult than finding the mean separation of the fringes. A maximum of three marks was available for those who did this approximation. Part (c)(ii) was quite poorly answered. The essential point missed by many candidates was that the **percentage** uncertainty decreases. On average, in the last part, only one mark was gained by the candidates. However, two of the points were obvious and standard – the fringes are brighter and the fringes are sharper.

Q.3 Candidates found (a)(ii) challenging. They were expected to comment on the graphs already drawn but they often suggested other graphs or additional lines of fit. Once again, standard but important lines of conclusion would have sufficed – straight line through origin, line of best fit passes through all error bars, the gradient decreases etc. The last part was well answered in general but justifying the best method for obtaining the refractive index proved difficult – “the gradient incorporates all points” would have sufficed.

Q.4 In part (a) the UV wavelength was better known than the microwave. Occasionally the word “minimum” was missing in (b)(i). Part (b)(iii) was extremely well answered especially considering that the speed of the electron was required.

Q.5 Slightly disappointing responses in general were seen for the QER. Many candidates confused this experiment with the stopping potential in the photoeletric effect. Fortunately, for those candidates that made this mistake, they were not penalised heavily. They could still talk about plotting the correct graph and how to obtain the Planck constant from the gradient.

Q.6 Part (b) was very well answered. However, very few candidates were able to state that the rate of pumping was equal to the rate of dropping at equilibrium. In part (c), one mark was rarely awarded. After the previous calculation, one would expect some candidates to state that the population of the metastable state was proportional to its half-life. Unfortunately, the best candidates were just falling short and stating that the population increased with the half-life.

Q.7 In (a)(i) the atomic number was more difficult to obtain than the mass number. Part (a)(ii) was a difficult part question, usually involving taking logs but it was extremely well answered.

The next part was quite well answered considering that this was a very difficult calculation. Those candidates who scored poorly usually tried to solve the problem by considering only one of the two radioactive nuclei. In order to score well, equations for both nuclei had to be set up and these equations had to be divided at some point. The last part of the question was not well answered. Part of the problem was that an increase from 0.4% to 0.5% is a **small** increase of 0.1%. However, it could be argued that an increase from 0.4% to 0.5% is a **large** increase of 25%. Hence, the increase of lung cancer incidence had to be marked strictly.

Q.8 This question was extremely well answered. Some candidates thought that the particle was a photon. Some candidates were a factor of 2 out in the final mass.

Q.9 The direction was frequently wrong in (a) and the mass or the charge was sometimes wrong in (b). Part (c) was quite well answered. Few candidates realised that the frequency of the ac supply was 2× the frequency of performing circles (the pd needs to change sign 4× per cycle but the pd changes twice per cycle for a given frequency). The last part was quite poorly answered. Although the $8 \times n \times V$ was difficult to explain (4 kicks per cycle and a charge of $2e$), converting $1.6 \times 10^7\ \mathrm{m\,s^{-1}}$ to 5.3 MeV should have been straightforward. Perhaps candidates had forgotten that the speed was at the start of the question.

Q.10 Both parts of (a) were poorly answered in general, most candidates couldn’t quite find a form of words to answer (i). Probably the easiest way to answer the question is “the horizontal lines are not cut”.

In (ii) some answers to the direction of flow were impossible to understand e.g. the current flows left to right or the current flows upwards (without stating where). Many had the wrong direction for the current. Some of the rules stated were insufficient e.g. using Fleming's left hand rule. By itself, FLHR is not enough to explain the current direction. However, FLHR applied to the electrons in the slider is valid as is FLHR along with Lenz's Law. If candidates knew the relationship $V = Blv$ then (iii) was answered well. The last part was quite well answered but the explanation was often inadequate. Some candidates incorrectly thought that the current increases. Many explanations involved the area decreasing when the area was actually increasing. If an explanation was attempted with area, it needed to say that the area was increasing at a decreasing rate.

SECTION B

Option A – Alternating Currents

Q.11 In (a)(i) most candidates noted that $X_L = X_C$ at resonance and went on to derive the resonance frequency equation in clear steps. Most candidates realised that the maximum resonance frequency corresponded with the lowest value of the variable capacitor and hence calculated the maximum resonance frequency correctly in (ii). There were some factor-of-ten errors seen, especially when candidates decided to write their answers with a prefix. In (iii) most candidates noted that $Z = R$ at resonance and went on to calculate the rms current correctly. In (b)(i) a minority of candidates showed X_C leading R by 90° and therefore lost one mark. Many candidates got the correct answers in (iii) but few showed the comparison between the equation given and the straight line equation, $y = mx + c$. Some candidates omitted the $\times 10^{-11}$, resulting in a much larger capacitance; candidates didn't seem to pick up on this. In the last part there were lots of well written responses with candidates approaching this question in different ways. Having identified the effect of increasing the frequency on X_C, some candidates went on to discuss the effect on the current and hence V_R. Others used a potential divider argument. The majority of candidates constructed a clear step-by-step explanation based on their chosen method.

Option B – Medical Physics

Q.12 The few candidates who didn't attain the mark in (a)(i) made factor of 10 errors. In (ii) line and emission spectra were often not labelled and so one mark was lost, the minimum wavelength however was generally well done. The vast majority of candidates in (iv) realised that infinite energy / voltage would be needed to give a minimum wavelength of 0, however a number did not justify why and lost the second mark. In (b) a number of candidates talked about the cost of each treatment, these comments were classed as neutral and ignored. The majority of candidates didn't realise that moving images were needed to see the valve functioning in real time. Part (c) was very well answered by the vast majority of candidates. Most used $\frac{\Delta\lambda}{\lambda} = \frac{2v\cos\theta}{c}$, however on a few occasions they were unable to rearrange it correctly to determine v. In the last part a number of candidates incorrectly stated that a radioactive tracer was injected into the body to produce a PET scan. The majority however stated that positron–electron annihilation occurred producing two gamma rays in opposite directions. Not as many stated that a gamma camera was used or that there was a time delay in receiving the gamma rays.

Option C – The Physics of Sports

Q.13 Part (a) was answered well by all candidates. Frequent slips seen were that candidates did not use the correct component or the perpendicular distance was not determined correctly or used when applying the principle of moments. Part (b) was not answered well by candidates with many noting that the r represented the radius in the definition rather than correctly defining this as the distance from the axis of rotation. Error carried forward from the previous part for the moment of inertia was often applied in (c)(ii). The projectile part of (d)(i) was answered well but a surprising number of candidates commented that the final answer of 11.8 m could be approximated to 11 m and therefore commented that this was achieved by the bowler. In (d)(iii) the direction of the lift force was frequently incorrectly given as an answer to this part. This should point downwards and perpendicular to the direction of motion. In the last part the effects of the forces could be explained to a certain extent by nearly all the candidates. Error carried forward was applied for an incorrect lift force from the previous part.

Option D – Energy and the Environment

Q.14 In (a)(i) the majority of candidates were able to access the data given in the diagram. The more readily used approach involved a calculation of the intensity absorbed by the Earth. They then used this to calculate the fraction to be 0.71. An alternative route saw candidates calculate the fraction reflected. A further subtraction allowed the 2nd mark to be obtained.

Part (a)(ii) proved to be more demanding than expected. Weaker responses included reference to reflected radiation being absorbed. Stronger responses included the Earth emitting longer wavelength radiation that then gets absorbed. This is then re-radiated causing the planet to warm. In (a)(iii) candidates were very aware of the human activities that were contributing to this effect. Many were able to link this to increased carbon dioxide or methane or simply greenhouses gases. Less candidates achieved the last marking point where they needed to state that ‘more infra-red radiation is absorbed’ or ‘less infra-red radiation is escaping’. In the second part candidate responses were mixed. Weaker responses sometimes included reference to ozone which was not credited. The majority realised that this was a positive feedback question and strong responses made reference to albedo changes after snow or ice melt. This was the most popular correct response however all options on the mark scheme were regularly seen. Part (b) gave a good range of marks. Stronger responses included good use of the intensity and efficiency equations and an appreciation of sin 62 or cos 28 at some point in their response.

A minority of candidates confused sin with cos, however, they were able to attain three marks with ecf. A small number of candidates failed to address the angle but were able to use both equations and achieve two marks. In (c)(i) there were some limited responses that involved the apparent heating of the wall. The U-value is not the power needed to heat up 1 m^2 by 1 K. There were also some confused responses that involved reference to a temperature gradient. Stronger responses made clear reference to a ‘temperature difference of 1 K’. In the first part of (c)(ii) the majority of candidates used the gradient method outlined in the mark scheme.

A minority of candidates missed 4 °C and hence, the temperature difference. Some of these candidates then realised their answer was incorrect and often attempted this again correctly. There were many different approaches used in the last part. Many candidates produced excellent responses. Some noticeable errors involved the use of $\frac{1}{U_T} = \frac{1}{U_W} + \frac{1}{U_P}$. Some weaker responses got as far as calculating the area of the wall but then paired this with the U-value for the patio doors. It is worth noting that candidates were trying to determine if the U-value of the insulated wall was *less than 0.2* $W\,m^{-2}\,K^{-1}$. This was not the same as the usual checking if the value was close to 0.2 $\mathrm{W\,m^{-2}\,K^{-1}}$.

PHYSICS

GCE A LEVEL

Summer 2023

COMPONENT 4 – PRACTICAL ENDORSEMENT

Overview of the Component

From September 2022 we returned to face-to-face monitoring after a period when we carried out remote monitoring due to restrictions imposed by the pandemic. This year also saw a return to the requirement that all aspects of the Practical Endorsement should be met. We only observed a relatively small number of centres in this academic year, the majority of centres having been monitored in the previous year of the cycle.

It is perhaps worth reminding centres of good practice that we have seen in the delivery of Practical Endorsement:

- Clear planning of practical work. A good plan identifies not only when specified practicals will be conducted but also states the specific CPAC that will be assessed. The plan may be part of the Scheme of Work or a separate document. The planning should show the CPAC assessed.
- Planning allows for the development of skills within Practical Endorsement.
- The maintenance of accurate and up-to-date Teacher and Candidate Records.
- Candidates know which CPACs are assessed in a particular practical and understand what they need to do in order to succeed.
- Practical books are used in 'real time' at the bench by candidates when collecting experimental data. We do not expect to see practical books which are in immaculate condition! Candidates should **not** write on scraps of paper and later copy the work up neatly into practical books.
- Simple annotation of the candidate work shows where the candidate achieves or fails to achieve a CPAC, (e.g. with *CPAC 3(a)✓* or *CPAC5(b)✗).* If a candidate does not succeed feedback is given so they have a better chance of getting it next time. (Feedback on how to improve may be given verbally or in writing).
  Important note: Many centres now record the CPAC element assessed in a practical which helps ensure all aspects of CPAC are covered. However, if teacher records do not show this level of detail (i.e. the element assessed) then teachers should annotate the candidate work showing the element achieved (e.g. *CPAC 3(a)✓* or CPAC 3(a&b)*✓).* Monitors will always check to ensure all elements of each CPAC are covered and will ask teachers how they ensure all aspects of the skills are achieved by each candidate.
- Marking which shows a progression in candidate skills. We do **not** expect to see every candidate getting every criterion each time they are assessed! Indeed, when this happens there will be legitimate concerns about whether the work has been appropriately assessed. There should be a progression. The key question is, 'Is the candidate competent at the end of the course?' In short we expect to see that there are places where candidate work is marked 'not achieved'.

- There is evidence of standardisation across all teachers delivering Physics when Practical Endorsement is delivered by a team.
  Important note: This is a requirement of Practical Endorsement that is recorded in the monitor's report of the centre and must be implemented for a centre to pass the monitoring visit. Please expect questions on how you do this if visited by a monitor.

Make sure that candidates are informed whether or not they have achieved Practical Endorsement before the final outcomes are submitted to Eduqas in accordance with JCQ requirements. Eduqas will not change centre gradings if a centre has passed the monitoring visit.

Comments on individual questions/sections

CPAC statements

Centres are reminded that in order to award a pass for Practical Endorsement, a candidate needs to 'consistently and routinely meet the criteria'. This does **not** mean a candidate gets a CPAC every time it is assessed. It does means that a candidate evidences a pass for each CPAC statement on a number of occasions. It is important that suitable opportunities have been built into the assessment plan which allow candidates to generate this evidence. It should be noted that candidates can work in groups when assessed. However, each candidate must generate suitable evidence that he or she **independently** meets the criteria. Therefore, centres must give careful consideration to how group work is conducted so that individual candidates can be assessed on their own performance.

CPAC 1

The assessment of this CPAC requires the candidate to correctly follow written instructions to carry out an experimental technique or procedure. If a teacher feels it is necessary to intervene and correct a candidate's technique etc. then the candidate should not be awarded the CPAC. In the vast majority of cases the monitor accepted the teacher's judgement unless there was strong evidence to suggest the CPAC was incorrectly awarded.

CPAC 2

Although this is the most difficult CPAC for candidates, it is relatively easy for centres to generate opportunities to assess this skill. Just make sure that you know where and when you are going to assess **each element** of this CPAC. It is also important that sufficient time is given to candidates to develop the necessary skills before assessment occurs. Generally, we do not expect to see this CPAC assessed in the first two terms of an A level course. However, we do expect to see evidence of some assessment of this criterion by the end of the first year of the A level course. It is **not** necessary to assess every element of CPAC2 each time this CPAC is assessed. However, it is a requirement that each element of CPAC 2 is met during the course. If you are monitored, the monitor will look at the coverage of each element.

CPAC 3

There is no need to assess this skill every time a practical is completed; choose practicals where there are some more significant hazards (e.g. experiments involving heating / lasers or the use of radioactive sources etc.).

(a) requires candidates to identify hazards and assess the risks associated with the hazards. A simple written risk assessment is the easiest and best way of evidencing this aspect of the skill.

(b) should be assessed by observation of candidates conduct during a practical session.

CPAC 4

There is no shortage of opportunities which centres can use to develop and assess this skill in physics.

(a) is about making accurate observations. Make sure candidates know what is expected of them before you assess this skill. The following points must be borne in mind when assessing this CPAC:

- Observations should be made directly into candidate practical books. They should not be written on to scraps of paper and copied up later.
- **Avoid** using templates for tables that direct candidates how to record data when assessing this skill. Templates may be useful to teach candidates a good approach to recording data early in the course but when it comes to assessment candidates **must** devise their own tables. If you give the candidate a table, then CPAC4 can**not** be awarded. Where necessary, remove table templates to allow candidates to construct their own.
- The tables which candidates construct **must** have appropriate headings and units, where relevant.
- The units must be written in the table column head and not in the body of the table. If units are missing, do **not** award criterion.

(b) obtaining accurate, precise and sufficient data .... Please carefully check candidates' data.

- Is it recorded to appropriate precision? Some centres are still too lenient on this. If data readings are not always consistently recorded by candidates, then do **not** award the criteria. Make sure that recordings are to the correct number of decimal places.
- Is there sufficient data? Is the data what you expect? Please set suitable standards at the beginning of the course and make sure candidates are aware of them. Remember, It does not matter if a candidate did not always achieve the criterion. It is best to draw high standards early in the course. Candidates will quickly realise what is required of them.

CPAC 5

This important higher-level skill should be assessed from early on in the course. There is no shortage of suitable assessment opportunities. CPAC 5 has two elements:

(a) Uses appropriate software and/or tools to process data, carry out research and report findings.

(b) Sources of information are cited demonstrating that research has taken place, supporting planning and conclusions.

(a) There should be evidence of candidates processing data using graphs and calculations. Centres should require candidates to use software (e.g. Excel) to draw graphs on a number of occasions. This aspect is generally well assessed in physics.

- Make sure graphs are constructed correctly, i.e. there is a title, each axis is correctly labelled, points plotted correctly, an appropriate scale used, suitable trend lines and error bars added as appropriate etc
- Processing data also involves carrying out calculations. This will often involve transformation of data using mathematical equations. Please watch that significant figures are used appropriately.

CPAC5(a) also includes ‘carry out research and report findings’. The report may simply be the conclusion they draw from their data. This may include determining the values of constants, considering whether experimental data supports a given hypothesis, and making predictions etc.

(b) Candidates must show evidence of referencing sources of information. This aspect of CPAC is still not getting enough attention from many centres and is generally still poorly evidenced in candidate work. Just a few centres are to be commended for having candidates demonstrating referencing on multiple occasions; a few of these even using the Harvard System (which exceeds our requirements for this CPAC).

Opportunities for assessing referencing **must** be built in from early in the course. The information referenced may be, for data or a quote; the information may come from a textbook, journal, website EDUQAS data booklet. For example, if the candidate quotes a value such as g or h, where did they get the value? The source must be cited even if it is the EDUQAS data booklet

Supporting you

Useful contacts and links

Our friendly subject team are on hand to support you between 8.30am and 5.30pm, Monday to Friday.

Tel: 029 2240 4252

Email: science@eduqas.co.uk

Qualification webpage: AS/A level Physics

See other useful contacts here: Useful Contacts | Eduqas

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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.***