# GCE Examiners' Report

Physics

AS / A Level

Summer 2024

## Introduction

Our Principal examiners' report provides valuable feedback on the recent assessment series. It has been written by our Principal Examiners and Principal Moderators after the completion of marking and moderation, and details how candidates have performed in each unit.

This report opens with a 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 then looks in detail at each unit, pinpointing aspects that proved challenging to some candidates and suggesting some reasons as to why that might be.[1]

The information found in this report provides valuable 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 |
|---|---|---|
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[1] ***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.***

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**Executive Summary**

The entry figures for both AS and A level Physics have seen an increase of nearly 10% when compared to 2019. The mean results for Units 2 and 5 were similar to previous series, Unit 3 increased and Units 1 and 4 saw a decrease.

Candidates answered quantitative responses far better than qualitative responses. Some excellent mathematical skills were seen across all units.

Qualitative responses lacked precision and the detail required to gain full marks. Answers often did not address the question being asked and suggested a lack of knowledge and conceptual understanding. A good example of this was the electromagnetic induction question in Unit 4 where a novel context was used.

**AO1** recall questions continue to cause problems for candidates, whereas **AO2** questions where the data is provided that test the ability of candidates to apply their knowledge tend to score highly. The QER questions were very dependent on the topic area, the AO1 recall on polarisation in Unit 2 was a step too far for many candidates, whilst the QER based on a radiation practical method in Unit 3 was well answered.

Candidates performed well in the practical examination. When practical questions are asked on the theory papers, they are answered far better on the A2 papers than on the AS papers, this is probably linked to the practical skills of the candidates being more developed by the end of Year 13. The performance in the option questions was comparable.

| **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 |
| **Electromagnetic induction** | **ELECTROMAGNETIC INDUCTION** | Blended learning |

## PHYSICS

## GCE

## Summer 2024

## UNIT 1 – MOTION, ENERGY AND MATTER

### Overview of the Unit

The unit provided opportunities for candidates to demonstrate their knowledge and understanding of key concepts related to momentum, moments and stability, particles, kinematics, energy concepts and stellar Physics. Newton's $2^{nd}$ law was the basis for testing candidates' knowledge and understanding of experimental skills, including the handing of uncertainties.

Whilst aspects of the paper scored well, it was evident once again that responses to many questions lacked the precision and detail required to gain full marks and consequently, as in recent sittings, the overall scoring was not as high as expected. Many questions or sub-sections of questions did not score as well as expected or were not attempted by a significant number of candidates.

AO1 style questions testing recall did not score well, such as the questions requiring knowledge of the principle of conservation of momentum, Q1(a) or the term 'hysteresis' in Q6(b). As in recent papers, 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 momentum conservation in collisions Q1(b), the application of moments Q2(b) and describing the motion of objects moving in circular paths. In all cases imprecise and vague responses were often seen which did not fully address the question being asked and suggested a lack of knowledge and conceptual understanding of the key principles associated with the Physics being tested. The question testing practical skills indicated that many candidates had a superficial understanding of uncertainties. Whilst some good attempts were made to describe the energy changes in a bungee jump, once again, many responses lacked the detail expected at AS level.

On the positive side, it was encouraging to see the responses to the question testing displacement-time and velocity-time graphs. In many cases candidates were able to use the data provided appropriately to determine the key information needed to successfully draw the required graphs correctly. Whilst the general standard of numeracy was good, examiners felt that the quality of written responses, especially in terms of succinctness and clarity continued to be weak. Once again, 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** **(a)** This AO1 style question asked candidates to state the conservation of momentum. In many cases, candidates omitted the term 'total' (momentum) nor did they refer to 'external forces' in their responses.

**(b)** Nearly all candidates were successful in determining the momentum before the collision, however only a minority understood the significance of the snowball rebounding on the overall momentum after the collision. Consequently, in many cases, only one mark was awarded for the correct initial momentum in part (i). In the next part ecf was applied from incorrect answers to (i). Many candidates correctly applied the concept of force as the rate of change of momentum and were awarded full marks. In a few cases, candidates first calculated the mean acceleration of the hat using the time given and then applied $F = ma$ to determine the mean force correctly.

**(c)** Few candidates understood that the momentum **change** of the snowball would be reduced if it had stuck to the hat, and that consequently the momentum increase of the hat would be less than in the previous scenario, thus leading to the increase in velocity being less than in (b)(i).

**Q.2** **(a)** Most candidates identified at least 2 of the 3 correct responses. Many incorrectly chose 'D'.

**(b)** Nearly all candidates were able to determine the distance required in **(b)(i).** Many chose to double the distance from the centre of the van, since the centre of gravity of the arm was at its mid-point. A few chose a trigonometric approach. Fewer candidates gained full marks in **(b)(ii).** The most common mark awarded was 1 out of 3 for determining the clockwise moment correctly. A significant number of candidates were unable to give a correct expression for the anti-clockwise moment. ecf was not applied within this question part.

**(iii)** many good responses were seen for this 'how science works' question, with ECF being applied from **(b)(ii)** if necessary. Candidates usually took one of two approaches, either:

- approximating the mass of two people to be 200 kg, converting and adding the weight of the platform and comparing with their answer to (b)(ii) or
- taking their answer to (b)(ii), subtracting the weight of the platform and converting the remainder to mass, comparing with the 200 kg given in the question and drawing a reasonable conclusion.

**Q.3** **(a)** Candidates showed a good understanding of how to determine both the absolute and percentage uncertainties from the data given.

**(b)** Far fewer candidates were able to determine the percentage uncertainty in the 60 g mass, with many assuming that the percentage uncertainty was 6 times the percentage uncertainty in the 10 g mass. In **(ii)** few candidates gained full marks for this question part. Candidates did, however, obtain marks for various marking points. In some cases, marks were obtained for correctly determining the mass of the trolley. In other cases, candidates gained marks for correct uncertainty analysis, even if their trolley mass was incorrect. ecf was applied extensively within this part. In many cases, candidates were not able to give their final answers to an appropriate number of significant figures. It should be noted that sig figs in the answer and uncertainty needed to be consistent and to a max of 2 sig figs for the uncertainty.

**(c)** Nearly 10% of candidates did not attempt this question. The mark scheme allowed for several responses, either based on experimental technique, such as ‘improving the release mechanism’ (no detail required), or on reducing the overall uncertainty in the data by repeating the experiment, taking more readings of acceleration.

**Q.4** **(a)** Nearly all candidates were able to give the correct number of protons and neutrons, and the majority of these correctly stated the number of leptons and baryons. Fewer candidates determined the number of up and down quarks correctly.

**(b)** Nearly all candidates were able to describe a meson in terms of quarks correctly in **(b)(i).** Fewer candidates gave an appropriate response to **(b)(ii),** with many not referencing the charges present on the quarks/antiquarks to explain the overall charge on the meson. Over 95% of candidates attempted part **(b)(iii)** with nearly all achieving full marks for correctly identifying the particles given in terms of their quark make-up. This was an impressive response. However, nearly 20% of candidates **did not** attempt part **(b)(iv).** Of those that did, many failed to read the question correctly and often gave responses which included both up and down quarks. In some cases, it was felt that candidates were not able to express their understanding succinctly and clearly, often confusing the quarks present initially with those produced during the reaction(s).

**(c)** Nearly all candidates referred to the time aspect of the decay, whilst many others were also able to give an additional reason for describing this as a ‘strong’ reaction. Those who failed to gain 2 marks usually only provided 1 reason rather than because they gave a second incorrect response.

**Q.5** **(a)** Most candidates provided an acceptable definition of 'mean velocity'. In this question the focus was on the term 'velocity' (emboldened on the question paper) and not on the term 'mean', and therefore responses referring to 'rate of change' of displacement were accepted on this occasion. It should be noted that this may not be the case in future and candidates should be taught the distinction between (instantaneous) velocity and mean velocity.

**(b)** Many candidates were able to determine the distance travelled by the train as it traversed the semicircle, and then proceeded to confirm the speed given. Unsuccessful candidates usually made a mistake in their determination of distance travelled. In **(b)(ii)**, the mean mark can be explained by the fact that nearly all candidates were able to determine the magnitude of the velocity correctly with only a very few also providing the direction, thus failing to gain the second mark. In **(iii)** few candidates understood the vector nature of acceleration and could not explain the changing acceleration in terms of directional change as the train traversed around the semicircle. Those that did gain some credit usually did so for providing a correct definition of acceleration.

**(c)** Many encouraging responses were seen. Most candidates correctly calculated the decelerating time and proceeded to sketch an appropriate velocity-time graph to show the motion of the train, including providing an appropriate velocity scale on their graph axis. Those that calculated the decelerating time incorrectly benefited from ecf being applied for the remainder of their response. Furthermore, many candidates proceeded to give an appropriate scale on the displacement axis and drew an appropriate displacement line for the first 2.0 seconds of the motion. However, only a few candidates sketched a correct displacement curve to describe the decelerating phase of the train.

**Q.6** **(a)** A variety of responses were seen for this QER question. Successful candidates were able to give coherent and logical responses based on the three energy types and the interaction between them during the motion of the bungee jumper. Higher band responses were able to describe the multiple energy transfers that occurred at key points in the motion. For example, successful candidates may have referred to energy being transferred from gravitational potential energy to **both** kinetic energy **and** elastic potential energy as the cord extended. Higher band responses also referred to energy losses through interaction with air particles and explained that the jumper would not return to the initial height due to these energy losses. Whilst the mark scheme does refer to 'subtle' ideas such as the kinetic energy continuing to increase during the initial stretching of the cord, it was not required that candidates provide this level of detail to access the upper marking band. Candidates who were less successful often omitted one or more of the energy types or considered only part of the motion, usually the 'dropping' part only, and usually failed to consider losses due to resistive forces. Lower band candidates usually limited their accounts to one or two energy forms and were unable to describe the energy transfers taking place.

**(b)** Only a minority of candidates correctly stated the feature of the graph which confirmed that the rubber was elastic. A common incorrect response was to state that the force and extension are initially proportional to each other. Likewise, only a minority correctly referred to 'untangling polymer chains' (or equivalent)

**(ii)** Reference to 'dislocation movement' was a common incorrect response.

**(iii)** Responses were disappointing. Few candidates understood that the area under the force-extension curves represented work. Of those that did, their attempts at determining the relevant area were often incorrect. Of the few correct responses seen, candidate approached the question in a variety of ways. Some chose to divide the area into a series of triangles and rectangles, others chose a trapezium-based approach. A small number attempted to count the squares. Each of these approaches is valid and credit was given for the attempt. It should be noted that the question was set up to enable candidates to easily divide the required area into rectangles / triangles and / or trapeziums.

**(iv)** Only 86% of candidates attempted, of those that did, many were able to state the phenomenon in question, however not all were able to spell the term 'hysteresis' correctly. Whilst 'benefit of doubt' was applied to 'close' spellings (e.g. hystersis), credit could not be given to responses such as 'oystersis', 'hystis' and 'hyperenthesis'.

The concept of hysteresis was also not well understood. Whilst it was clear that many candidates had the vague idea that it was related to energy loss, few were able to give a precise and logical explanation in terms of the **difference** between energy stored in the rubber band when it is stretched and [useful] energy recovered from it when it is released.

**Q.7** **(a)** A complete response required candidates to refer to both the term ‘astronomy’ and ‘multiwavelength’. Many correctly referred to ‘looking at space/stars/galaxies’ when describing ‘astronomy. Most also referenced use of different wavelengths of the electromagnetic spectrum when explaining ‘multiwavelength’ which was credited. Candidates who were unsuccessful were often imprecise with their explanations e.g. describing ‘multiwavelength’ as ‘different wavelengths of light’.

**(b)** Few candidates were able to access this question. One mark was awarded for showing the base units of **one** of the watt, the joule or the newton. Only a very few candidates succeeded in gaining this mark. Fewer still proceeded to determine the base SI units of the Stefan constant.

**(c)** This was an encouraging response with nearly all candidates substituting into and re-arranging Wien’s law correctly to determine the temperature of the star and using the given wavelength to correctly state the colour of the star.

**(d)** As in previous papers, a persistent source of error continues to be the incorrect application of Stefan’s equation. All too often candidates mistakenly substitute cross-sectional area instead of surface area into their equation. This often leads to answers which are incorrect by a factor of ‘4’ (i.e. $\pi r^2$ instead of $4\pi r^2$). Ecf was applied to responses making this error. Notwithstanding this common mistake, responses to this part were general successful with candidates taking a multitude of possible paths to answering the question.

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**UNIT 2 - ELECTRICITY AND LIGHT**

## Overview of the Unit

Questions 1, 2, 4, 7 and 8 provided mean marks of 50% or above. These questions covered the topics of resistance, dc circuits, the nature of waves, refraction of light (including practical skills) and photons. The mean percentage marks on the electricity section (questions 1, 2 and 3); the waves and refraction section (questions 4, 5, 6 and 7); the photons and lasers section (questions 8 and 9) were all below 50%. The standalone QER practical question on polarisation had the lowest percentage mean mark. In this question only AO1 was assessed. The next weakest answer was for question 3, on emf and internal resistance.

As in previous Unit 2 papers examiners were encouraged by the mathematical skills shown by candidates, particularly when handling equations. Candidates also had opportunities to demonstrate their extended writing skills and they generally did so well, giving, in many cases, good, clear and concise explanations.

Candidates need to:

- continue to learn definitions, however, they must also use values within their definitions where necessary.
- further develop an understanding of how pd is distributed in series and parallel circuits that include a source with internal resistance.
- appreciate that for in-phase sources, a point of constructive interference is caused by a path difference of $n\lambda$. Furthermore, the central constructive interference zone (where $n$ = 0) has a path difference of zero. The 3$^{rd}$ constructive zone out from this central zone gives a path difference of $3\lambda$.
- describe what is meant by unpolarised light and develop practical techniques when investigating polarised and unpolarised light.
- clearly express the difference between stimulated and spontaneous emission.
- develop use of units within problem solving. Although ‘SI units’ is a Unit 1 requirement, the use of alternative units is a powerful tool throughout the AS course. It can allow candidates to ‘see’ what calculation is required without the need for an equation from the data booklet.

**Comments on individual questions/sections**

**Q.1 (a)** Candidates generally performed well in this AO2 question. There were some errors due to power of ten slips. We also saw candidates confusing diameter with radius. Individually these errors resulted in the candidate losing only one mark. The manipulation of the resistivity equation was good.

**(b)** There were many positive attempts at this AO3 question. The candidates were expected to use the resolution in the two instruments. They regularly did this as outlined in the mark scheme using a maximum $V$ with a minimum $I$, followed by a minimum $V$ and a maximum $I$. Some decided on a different path and instead of calculating $R$, they used 56 Ω to calculate $V$. This was accepted if they incorporated the uncertainty of the ammeter and voltmeter in their answer. The conclusion was not free standing and needed to be linked to good physics previously seen.

**Q.2 (a) (i & ii)** Many correct responses were seen in this question. Candidates did need to use the correct subscript values with $I$ and $V$. A small number of candidates made errors with this.

**(b) (i & ii)** Candidates generally responded well to this 'show that' question. It was pleasing to see the potential divider equation regularly being stated.

**(c)** There were a small number of good attempts at this particularly demanding AO3 question. Some of these candidates spotted that $R_A$ and $R_B$ each had 2.0 V across them and the 20 Ω resistor had 8 V across it.

**Q.3 (a) (i)** Although we saw that candidates had learnt definitions it is important to remember that if a value, i.e. 12 V, has been given in the question, the candidate should make reference to it. They also must consider alternative units for well-known quantities i.e. 12 V = 12 J C$^{-1}$.

**(ii)** Candidates showed us varied responses here. 'Battery gets hot' or 'current reduced' were basic responses that generously gained credit. Reference to 'pd drop' or 'lost volts' gained the mark as one would expect. 'Emf is split between internal and external circuit so less available to external' was seen and awarded credit.

**(b) (i) I& II** In a previous question candidates were asked to write down an equation that linked $V_1$, $V_2$ and $V_3$. This was generally well answered, however, applying this principle to a circuit including a battery with internal resistance was not regularly well done. Understanding of how the 12 V is 'shared' is important and should be emphasised in the future. A number of candidates calculated '0.25 A' but could not determine the pd across the parallel arrangement. Often candidates used 12 V across the parallel arrangement leading to ecf in the subsequent question part. This would often be seen with a final answer of 5.9 Ω.

**(ii) I** Candidates were regularly seen using one of the three electrical power equations and we were holding out for correct $I$, $V$ or $R$ values here. Unfortunately, 12 V was again seen being incorrectly used, however, these candidates were able to access the second marking point if they multiplied by 2400.

**(b)** **(ii)** **II** Candidates gave mixed responses to this question. Many candidates showed an understanding of the correct energy transfer. Many also made reference to [free] electrons colliding. Less than half were able to correctly give both comments.

**(b)** **(iii)** This proved to be the most challenging question on the paper for candidates. It was AO3 by design. Some candidates stated the current through $R$ decreases and current through the $20\,\Omega$ resistor increases. Many got no further than this because they didn't consider the internal resistance. It was noticeable that a significant number of candidates incorrectly assumed that 0.6 A would continue to flow. Internal resistance, $r$, was mentioned by a few candidates. They stated $r$ would stay the same but then incorrectly stated current would also stay the same.

**Q.4** **(a)** **(i)&(ii)** There were a small number of power errors caused by the 100 ms, however, this was a well answered question.

**(iii)** We were mindful that there was no grid and candidates were forgiven for small variations in amplitude. We focused on phase. Some candidates 'moved' the graph line the 'wrong way' resulting in a cos function rather than a -cos function. As a result, however, the 2nd graph proved to gain more credit than the first.

**(b)** **(i)** There were many positive responses here. We did accept '2 waves travelling in opposite directions' as an alternative for 'wave is reflected'. The 'fixed point' was given in the question and in this case was not required in the candidate's response. We were pleased to see reference to 'both waves having the same speed, frequency or wavelength' although we did not give credit on this occasion.

**(ii)** Again, there were more correct versions of the 2nd graph. Further focus on the particular movement of adjacent 'loops' would benefit candidates in the future.

**Q.5** **(a)** **(i)** Some candidate responses showed an understanding that diffraction is the 'spreading' of waves after it passes through a gap. We wanted to see reference to this taking place at both slits ideally, but some candidates inferred this when discussing the waves interfering. However, this was not regularly the case as responses were often too vague.

**(ii)** This question was well answered by many candidates. Other than power slips, most candidates chose the correct equation and used it.

**(iii)** This question proved to be more of a discriminator. Path difference is considered to be a tricky concept by many candidates. A significant number knew that it would be a whole number of wavelengths. Some used triangles drawn over the diagram but did not realise the diagram wasn't drawn to scale. A few candidates had a go at the geometrical method that could have scored 1 mark (as no wavelength used) but often faltered with the mathematical demands.

**(b)** Some candidates gave information about how a grating is physically different to a double slit. We didn't award credit for this. When using a diffraction grating rather than a double slit, the bright fringes would be 'further apart' and 'sharper / brighter'. 'Less fringes' was not deemed enough for credit. This proved to be a challenging AO1 question. Some candidates who had learnt the necessary theory produced some excellent responses.

**Q.6** Candidates struggled to describe unpolarised light in this AO1 question. Good responses included reference to light vibrating in all directions. Few mentioned that the vibrations were at right angles to the wave direction. There were better responses regarding the method. There was clear evidence of a 'rotating polaroid' regularly seen but often there was a lack of detail. We were not expecting reference to a $\sin^2$ function but too many candidates did not describe the continuous change from bright to dark. In future, for this specified practical it would be advisable to use light intensity meters to monitor this. Two filter responses were often very confused. Unfortunately, we rarely saw a good description and a good method. In a small number of cases the standard of punctuation and grammar was not to the expected level.

**Q.7** **(a)** Most candidates found this difficult. We awarded the mark for 'light enters along the normal' or 'angle of incidence equals zero degrees' or even 'parallel to the normal'. It is hoped that these ideas are further developed through practical exploration.

**(b)** Nearly all candidates were able to correctly complete the table and plot the point. We accepted the point plotted as a circle in this instance, but we generally looking for crosses in the future.

**(c)** **(i)** A significant number of candidates did not draw a line of best fit even though they may have stated this in their response. They could still be awarded the 1st and 2nd marking points however, if they stated points were close to the best fit line when no line was drawn we did not award credit. The relationship was regularly stated to be linear. We also saw responses using 'positive gradient' but not linked to being linear. As such, this was deemed not enough for credit.

**(ii)** It was positive to see that many candidates used the gradient method here and they generally went on to gain both marks. As the best fit line was expected to go through 0.0, we accepted use of a single point, however, the point had to be on the best fit line. A number of candidates used a point that wasn't on the best fit line, and they were not awarded the 1st marking point. If the candidate did not draw a line, they also could not access this marking point. The 2nd marking point was free standing and many calculated a value within the range 1.57 to 1.65.

**(d)** In this question, quantitative back up was sometimes incomplete, however, it was well accessed. Candidates who did give quantitative back up did so in a number of different ways as outlined in the mark scheme. The most regularly seen answer involved a calculation of the critical angle.

**Q.8** **(a)** **(i)** **I** A minority of candidates stated what each letter of the equation, $hf$, represented and didn't gain credit.

**(a)** **(i)** **II** A small number of candidates wrote down 'it's the work function' but the question asked for a response 'in terms of energy'. 'Energy needed to release an electron' alone was not deemed enough.

**(a)** **(ii)** Einstein's photelectric equation was used well by the majority of candidates. When using the equation candidates needed to explain that a 'negative $E_{k\,max}$' suggested electrons would not be liberated. The stopping potential (using $eV_s$) was not so regularly calculated. A few candidates used the threshold frequency method and this proved quite successful.

**(b)** There were many reasonable attempts seen in this well accessed 'issues' question. 'Cost', 'variable cloud cover' and 'reduced $CO_2$' emissions were popular answers and gained credit. Some responses were, however, too vague. 'It's renewable' and 'it's sustainable' were not given credit. We saw a small number of answers about compulsion not being ethical and did award credit for this.

**Q.9** **(a)** **(i)** This AO1 question proved to be difficult for candidates. For both marks we were looking for a link between the incoming photon and the 'dropping' of an electron. Some confused responses involved links to absorption before emission indicating spontaneous rather than stimulated emission. No marks were awarded in these cases.

**(a)** **(ii)** Another AO1 question that was not particularly well answered. We were looking for an understanding that stimulated emission is more likely than absorption. In correct responses, this was often expressed as 'more frequent' or 'more probable'. Again, there was sometimes confusion between stimulated and spontaneous emission.

**(b)** Generally candidates showed good use of $\lambda = \frac{hc}{\Delta E}$ . The correct energy (1.79 eV) was used by most candidates who attempted the question and a wavelength of 694 nm was readily seen. Ecf was available to those who subtracted 1.79 eV from 2.25 eV even though it was stated in the question that stimulated emission involved levels U and G.

**(c)** **(i)** The mean mark for this question was 0.5. Knowing 'W' and '$J\,s^{-1}$' are equivalent helped candidates. Furthermore, '$J\,s^{-1}$ J' will give '$s^{-1}$' which allowed candidates to show $2.1 \times 10^{18}$ photons $s^{-1}$.

**(ii)** There appeared to be improvement in the use of $p = \frac{h}{\lambda}$. The unit mark was an issue for some candidates. $kg\,m\,s^{-1}$ was regularly seen, however, it was nice to see variation in units too. $J\,s\,m^{-1}$ can be quickly extracted from the equation used.

**(iii)** This question was challenging. We allowed credit for use of a multiplication of 2 where candidates realised that the change in momentum was twice that of the initial momentum. There were a number of blank spaces in last question parts, however, this may be because of the demand of the question rather than a timing issue. Some very good responses showed both 'use of the factor of 2' and realisation that '$kg\,m\,s^{-1}\,s^{-1}$' was indeed the unit of force.

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## UNIT 3 - OSCILLATIONS AND NUCLEI

### Overview of the Unit

The general standard of performance of candidates is to be commended. This was not an easy paper, but the mean mark was slightly higher than last year. The statistics indicate that the paper, although slightly easy, provided good differentiation for the cohort of applicants. There was little evidence of candidates struggling with time restrictions this year.
No individual topic provided cause for concern this year but there were certain aspects within topics and certain skills missing. These will be discussed later.

### Comments on individual questions/sections

**Q.1** The only aspect of this question that was below expected performance was no surprise. In part **(b)**, calculating the number of nuclei was achieved by only around half the cohort.

**Q.2** This question was extremely well answered except for the rather open-ended last part. The ability of candidates to express themselves clearly in **(b)(iii)II** caused issues for many. Why is it that, when travelling at about 1000 mph on the Earth's equator, you cannot feel this speed? The best responses were able to state that we cannot "feel" velocities / speeds and that the acceleration was small because the velocity was changing slowly. This was more than enough for the 2 marks.

**Q.3** The QER question obtained a mean mark of over 55% which is good. The part that scored a very low mean mark was the issues question – **(b)(ii).** The main problem here was that candidates insisted upon using Geiger counters to check the output of mobile phones. In some respects, this is commendable – cancer is caused by ionising radiation. However, the output of mobile phones is well known and checking the output of a mobile phone for gamma rays (which is what the candidates wanted to do) would be pointless.

**Q.4** This question was well answered. **(a)**Most candidates were unable to draw a good curve of best fit and were stuck on half marks. The curve needed to be accurate with maximum and minimum at the correct places. **(f)**This was a tough question. The trap here is to forget about the equilibrium extension. Unfortunately, the vast majority fell into that trap.

**Q.5** With a mean mark of 70%, this question was well answered. **(b)** This is a particularly difficult question but the mean mark was almost 70%. The skills required for unit 5 means that WJEC candidates are particularly adept at these types of questions.

**Q.6** With a mean mark of above 70%, this question was particularly well answered. Again, logarithmic skills acquired from unit 5 help the candidates here.

**Q.7** **(a)** The mean mark for the kinetic theory assumptions was too low but the candidates just need to learn these – they are basic AO1 marks.

**(b)** **(ii)** This is similar to part 1(b) but here, it is the correct mass that is difficult to calculate.

**(c)** These were not difficult AO3 marks (although most AO3 marks tend to be slightly tough). Setting an argument out clearly was a problem and also backing it up with the correct equations caused some candidates issues.

**Q.8** The mean mark for the comprehension was relatively good. The only general comments worth making are:

- Candidates are good at using unusual new equations.
- Candidates do not like to explain Einstein's photoelectric equation in terms of conservation of energy (a forgotten part of unit 2?).
- Converting room temperature KE to 0.038 eV which would affect the "turning on pd" of a diode by 0.038 V was a difficult concept to grasp.

# PHYSICS

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## UNIT 4 – FIELDS AND OPTIONS

**Overview of the Unit**

The general standard of performance of candidates dropped considerably this year compared with last year. This was a difficult paper, but no more so than last year. The statistics indicate that the paper, despite its low mean mark, provided good differentiation for the cohort of applicants. There was little evidence of candidates struggling with time restrictions again this year.
Capacitance was the only topic that seemed to have been understood well this year while all other topics seem to be a cause for concern (especially electromagnetic induction).

**Comments on individual questions/sections**

**SECTION A**

**Q.1** The whole of this question was well answered with the exception of part (c). In this part, the main problem was that candidates did not read the question properly and simply stated that capacitances are added in parallel. Two marks were available simply for stating that both capacitors had the same pd and charge. The third mark was trickier and required candidates to realise that the combination stored twice the amount of charge (for the same pd).

**Q.2** This was quite a straight-forward 6 mark QER, but the responses were of a generally poor standard. So many candidates were unable to draw remotely sensible circuits. Far too many candidates had ammeters in parallel and voltmeters in series. Many, many candidates had charging circuits only but insisted that these circuits would discharge when the switch was opened – leaving no circuit at all and a fully charged capacitor! The details of how to collate data were quite good and the analysis usually reasonable.

**Q.3** This was not a novel question – the exoplanet data has been given in a similar manner previously. The question was also broken down in a generous manner with many "show that" parts to ease the route through the question. Part **(a)** proved quite difficult and it was rare to encounter a candidate who could calculate both the mean recessional speed and the orbital speed. Part **(d)(i)** was unusually low scoring and many candidates failed to select the correct equation from the data booklet. A similar problem was encountered for part **(d)(ii).**

**Q.4** This was a tough question but the mean mark was considerably lower than expected.

**(a)** **(i)** is the simplest of definitions but the mean mark was low – less than half of the cohort knew that the electric field was the force per unit charge. In a normal year, one would expect a far higher percentage to know this.

**(ii)** On the other hand, this was more difficult and very well answered!

**(iii)** This part question is challenging but the mean mark was lower than usual.

**(b)** **(i)** A completely standard definition but more difficult than part **(a)(i)**. Were this question awarded 2 marks then most candidates would have scored 1/2 for a part definition but the vast majority was unable to provide a complete definition.

**(ii)** A standard potential question made easier by being a “show that” but the mean mark was only 30%

**(iii)** This was not a standard question and was deliberately testing some difficult AO3 marks. Nonetheless, the mean mark was very low even after making the mark scheme far more lenient than the original.

**(iv)** This part question was a completely standard final part to calculate a final speed. The mean mark was again low but when you look at the mark scheme a semi-competent attempt would gain 3/5 marks.

**Q.5** This was quite a tough experimental question based on a log-log graph. Some aspects were very well done but some were poor.

**(a)** Surprisingly few candidates knew that the “background” field was the Earth’s magnetic field.

**(b)&(c)** Unit 5 skills had been transferred and these were generally superbly done.

**(d)** Not an easy log proof but the mean was close to 50%.

**(e)** These were completely standard points but the mean mark was below half marks.

**(f)** Quite a tough calculation for both the current and the uncertainty. Not a standard calculation and so the low mean mark was understandable.

**(g)** This was a final unexpected question and few candidates realised that the first graph had equally spaced points whereas the 2$^{nd}$ graph had data points bunched towards the origin. Perhaps most candidates did not realise that both graphs contained exactly the same data points and uncertainties.

**Q.6** This was a novel electromagnetic induction question and low marks were to be expected. To assist candidates, an attempt was made to help guide them through the question by a generous breakdown of the difficult theory.

**(a)** This standard definition had a very low mean mark. Most candidates could not even start from Faraday's Law without being prompted to do so.

**(b)** **(i)** Conceptually difficult so the result was given and an explanation sought. Unfortunately, candidates were unable to explain the net emf around the loop (by talking of the emf on the LHS & RHS). Nor could they explain via a rate of flux in minus a rate of flux out for the loop.

**(ii)** Most candidates obtained the correct answer here by juggling the numbers rather than understanding what was going on – they multiplied the 3 numbers then realised that if they multiplied again by 0.038 the answer arrived by magic.

**(iii)** Synoptic so inherently tough. The low mean mark was to be expected.

**Option A – Alternating Currents**

**Q.7** **(a)** **(i)** Some candidates confused the inductor for a capacitor.

**(ii)** Mixed responses were seen.

**(iii)** A high number of candidates failed to calculate the correct pd here, with many giving an answer of 1.25 V (half of the $V_{rms}$) and failing to make the link with the impedance of the circuit.

**(b)** **(i)** Most candidates could state Faraday's law, and many were able to explain in terms of rate of flux linkage. Some candidates used a mathematical method to demonstrate proportionality while others explained in terms of cutting flux lines.

**(ii)** This was not answered well - those who identified the correct position didn't always explain how this resulted in the peak emf, while others identified the incorrect position. Lots of answers referred to an unspecified angle leading to ambiguous answers.

**(c)** **(i)** A straightforward calculation with many correct answers, although some went on to divide their correct answer with $\sqrt{2}$ , resulting in an incorrect answer.

**(ii)** Some candidates realised that they had to calculate the resonance frequency (or $\omega$), double it and use this value to calculate the impedance of the circuit. Some candidates calculated an incorrect value for $f$ or $Z$ but went on to use this value correctly in subsequent calculations, therefore gaining some credit.

**(d)** A common mistake was identifying 240 mV as the maximum pd rather than the rms pd. Another mistake was reading the volts/div as 0.5 mV and therefore concluding that the amplitude of the trace would be too large to be plotted. Most candidates calculated the time period correctly. The best answers were where candidates calculated the number of divisions, both horizontally and vertically, required to plot the trace and commented on the suitability of both scales.

**Option B - Medical Physics**

**Q.8** **(a)** Good spread of marks 0 to 4, $\lambda_{\text{min}}$ was often not labelled / calculated. Sometimes the two intensity graphs overlapped and the line spectra appeared in different places so losing marks.

**(b)** **(i)** Generally well done, a few had problems rearranging the equation but ecf was applied and they only lost one of the marks.

**(ii)** Many thought ultrasound was a form of treatment rather than it being a diagnostic method. Also, incorrectly some thought it was being used to monitor blood pressure.

**(c)** **(i)** Some candidates confused MRI with CT, a gamma camera and / or radioactive tracers. A number of candidates lost the third mark by not stating radio waves needed to be detected.

**(ii)** Most candidates correctly calculated the frequency but then, unfortunately, didn't continue to find the wavelength. Generally, though very well done.

**(d)** **(ii)** Very well done by the vast majority who noted that it was very expensive. A small number confused it with radioactive tracers.

**(e)** Some omitted to comment on all of the methods available and so lost marks, others confused some of the methods. Generally, however, very well done.

**Option C – The Physics of Sports**

**Q.9** **(a)** The majority of candidates were able to use an equation for the moment of inertia to determine the correct bat to be used. Candidates lost marks in dividing the length by 2 in a similar manner to converting diameter to radius. Also, candidates lost marks in not comparing all the bats and using the information given in the question.

**(b)** **(i)** Many candidates were not able to convert the number of revolutions per minute into a value for the angular velocity to determine the angular acceleration. Also there were frequent mathematical mistakes in substituting values into the moment of inertia equation and omitting the square factor for the radius of the baseball.

**(ii)** Similarly to part **(b)(i)**, the squaring of the angular velocity was frequently omitted even though the correct equation was correctly identified. Many candidates did score full marks for this part as an error carried forward for incorrect values of the moment of inertia and angular velocity.

**(iii)** The explanation for the reason that a glove is worn in baseball was poorly answered. Some candidates based their answers on how this enables better catching skills which did not gain any marks. A similar approach was based on the fact that the glove provides an increased surface area. Many candidates were able to gain the mark for the fact that the glove reduced the force or the effects of friction on the hand. Only a minority of candidates were able to base their answers on either an energy or using the appropriate equation for force.

**(c)** **(i)** Nearly all the candidates that gained full marks decided to determine the horizontal component of velocity for this part and were able to gain full marks with a valid conclusion. However, a significant number simply stated that the velocity had decreased and consequently were not able to gain any marks.

**(ii)** There existed different possibilities of evaluating whether the acceleration due to gravity acted on the ball. These possibilities were all based on determining the components of velocity correctly and then using an appropriate method based on equations of motion to draw a conclusion. The most popular method was to determine the acceleration in the vertical direction directly. However, some candidates chose to determine the height using acceleration due to gravity to determine the vertical component of velocity expected at a height of 0.85 m with the acceleration due to gravity. As noted previously, a surprising number of candidates were not able to use the correct numerical skills to determine the acceleration even if the appropriate method had been chosen.

**(iii)** The majority of candidates were able to identify that a lift force is acting on the ball but were not able to state that this lift is a consequence of a difference in speeds or pressure. Candidates stated the Magnus effect but were expected to explain this effect. A number of responses were based on energy and air resistance which did not gain any credit.

**Option D – Energy and the Environment**

**Q.10** **(a)** **(i)** Most candidates identified the weak force interaction correctly.

**(ii)** Most candidates attempted the calculation successfully, but some made mathematical errors or slips leading to an incorrect final answer.

**(b)** **(i)** Candidates were generally familiar with the term ‘solar constant’ but lots of incomplete definitions were stated, often missing one or more key elements.

**(ii)** Some candidates made reference to varying solar power but very few references to the Earth’s elliptical orbit were seen.

**(iii)** Common mistakes included: not stating the name of the law used, confusing which radius to use in the calculations and omitting the factor of 4. Credit was given for a correctly calculated intensity arising from an incorrect power.

**(c)** Although there was evidence of some understanding of the greenhouse effect, few candidates used the numerical data from the graph to explain this in terms of the wavelengths absorbed. It was evident from some answers that candidates believed that the carbon dioxide and the water were being absorbed. Reference to waves being re-emitted in all directions was not seen often, with candidates making vague references to 'heat becoming trapped' instead.

**(d)** **(i)** Some candidates mistakenly stated that U-238 is fissile and U-235 is not.

**(ii)** A significant number of candidates used the diameter instead of the radius in their calculation.

**(iii)** Some candidates got the correct answer by calculating the increase at each step, but the method $1.15^n$ was not seen often. Lots of candidates failed to answer this question correctly.

**PHYSICS**

**GCE**

**Summer 2024**

**UNIT 5 – PRACTICAL EXAMINATION**

**Overview of the Unit**

Candidates showed a good understanding of the concepts for this unit.

In the Experimental Task, generally, the candidates showed very good mathematical skills with tables, graphs and gradients being very well completed.

The aspect that proved to be most challenging in the Practical Analysis Task was in

**Q.1** **(a)** **(ii)** where candidates were asked to determine whether, $S$, the deflection of the beam is proportional to the length of overhang cubed i.e. $S = kL^3$. Many candidates were not able to use the data given in the table appropriately to determine a value for the constant $k$ and hence prove the relationship.

**Q.2** the majority of candidates were able to plot the graph correctly using an appropriate scale, plot the error bars correctly and also draw lines of maximum and minimum gradients appropriately with the data. Nearly all the candidates indicated clearly the data that they used to determine the gradient by triangles drawn on the graph. However, a significant number of candidates used data from the table to determine $\lambda$ rather than use the gradient. In the final answer for the wavelength, the number of significant figures was not consistently used.

**Comments on individual questions/sections**

**Experimental Task**

**(a)** **(i)** The log conversion was well done by the vast majority of candidates and the correct graph was chosen. Some candidates provided a minimum of 2 sets of trial readings however a number just stated 'I will take trial results' without providing any and so lost one mark. The sample size was good in almost all cases, but most ignored the zero error in the resistance of the leads and ohmmeter. Only a few candidates failed to take repeat readings as the experiment was relatively quick to carry out.

**(ii)** Most candidates stated that there was no significant risk. We didn't accept the wire getting too hot or crocodile clips pinching candidate fingers.

**(b)** Tables were well done, only a few put units in with the $\ln$ values however if brackets were used e.g. $\ln(R/\Omega)$ this was obviously acceptable. A few candidates forgot to include the resolutions of the instruments used or only included one so they lost the last mark.

**(c)** **(i)** The graph was very well drawn with almost all getting correct axis and no units but ecf was applied if units were given in the table. Scales, plotting of points and lines of best fit were very well done, candidates had obviously been very well taught in this aspect of the exam.

**(ii)** Triangles / points were chosen by the vast majority and the gradient calculated correctly as 1.0 ± 0.5. The intercept proved to be more discriminating but some chose a point on the graph and correctly applied the values in $y = mx + c$.

**(d)** **(i)** The diameter was measured correctly in most cases but it is worth pointing out that if centres use different apparatus to that specified in the instructions document, a note must be included with the exam papers to clarify the changes. The area was generally calculated correctly.

**(ii)** The resistivity was generally calculated correctly but in a few cases units were incorrect.

**(e)** This was a difficult part. Candidates needed to state that the intercept would change but the gradient would stay the same. Most thought both the gradient and intercept would change so they lost the mark.

**Practical Analysis Task**

**Q.1** **(a)** **(i)** The majority of candidates were able to determine the mean deflection correctly and use appropriate significant figures with the raw data.

**(ii)** As noted previously, this part was generally not answered well by candidates. The most common approach was to determine the constant $k$ in the equation $S = kL^3$ and most candidates used all the data values given in the table to form a conclusion. An alternative but similar approach was based on using ratios to determine the increase and compare different values. It was required that all the data be used to gain the mark for using all values. Unfortunately, a number of candidates were not able to use a correct approach to answering this question and subsequently lost all the marks.

**(iii)** For this part, several valid points were accepted to gain the mark e.g. comparing with someone else's results. Some responses were based on using a laser which did not gain any credit.

**Q.2** **(a)** The data was correctly determined by nearly all the candidates in the table. The frequent mistake that meant that candidates lost a mark was not to use significant figures that ensured the data was consistent with the raw data, though values to one decimal place were accepted for the larger values of $D$, the distance from the slits to the screen.

**(b)** The graph was drawn well by all the candidates with the data plotted correctly on an appropriately scaled graph. The error bars were also correctly plotted, and many referred to the error bar for $D$ being too small to be plotted. Some candidates lost a mark for the lines drawn through the error bars if they used an approach based on drawing from the maximum length error bar of the first to the last data point. Candidates need to ensure that the lines pass through all the error bars rather than basing their lines on the extremities of the first and final data points' error bars.

**(c)** **(i)** Nearly all the candidates were able to gain marks for this part. Candidates frequently did not refer to the lines passing through all the error bars though error carried forward was applied for the lines that they had drawn. Also, candidates did not gain the mark for stating that the lines straddle the origin.

**(ii)** As noted previously, the data used to determine the gradient was indicated clearly by nearly all the candidates with triangles or data points clearly shown on the graph. For this part, the use of appropriate significant figures was not applied as well as units. The common mistake on this part was simply not using the correct data points from their lines.

**(iii)** Nearly all the candidates gained full marks for this part and were also able to gain marks on error carried forward from their maximum and minimum gradient values.

**(d)** **(i)** Many candidates were not able to gain marks as they used an approach based on using a data point from the table of results rather than the mean gradient. Subsequently they were unable to access the uncertainty mark and were not able to determine the absolute uncertainty. Also a number of candidates did not give their final results to the appropriate significant figures and use this consistently in their answer with a unit for wavelength.

**(ii)** This part proved to be challenging for many candidates and they were not able to determine how to proceed if the distance of six fringes was used and how to determine the wavelength correctly. However, some candidates were able to explain clearly the steps needed correctly.

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WJEC
245 Western Avenue
Cardiff  CF5 2YX
Tel No 029 2026 5000
Fax 029 2057 5994
E-mail: exams@wjec.co.uk
website: www.wjec.co.uk