GCE

Physics A

Advanced Subsidiary GCE **AS H156**

OCR Report to Centres June 2016

Oxford Cambridge and RSA Examinations

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This report on the examination provides information on the performance of candidates which it is hoped will be useful to teachers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding of the specification content, of the operation of the scheme of assessment and of the application of assessment criteria.

Reports should be read in conjunction with the published question papers and mark schemes for the examination.

OCR will not enter into any discussion or correspondence in connection with this report.

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OCR REPORT TO CENTRES

H156/01 Breadth in physics

General comments

This new examination paper produced a good range of marks from 2 to 67. It was clear that most Centres had effectively delivered the content of the new H156 Physics A specification. However, a small number of Centres did not equip their students with appropriate techniques for answering multiple choice questions (MCQs). A significant number of candidates provided detailed working for each numerical multiple choice question, instead of qualitative analysis or using a calculator. Some candidates were not aware of the new learning outcomes on Archimedes' principle, Newtonian laws, momentum and refraction. Candidates answered questions on practical skills quite well. This demonstrated a decent coverage of practical work.

Most candidates made good use of the Data, Formulae and Relationships Booklet. Examiners were generally pleased with the well-structured answers provided by the candidates when solving mathematical problems. The comments on the individual questions give more details on the opportunities missed by some candidates. The following key areas for improvement were identified by the examiners when tackling calculations.

- Avoid early rounding of intermediate numbers in long calculations.
- Take care when taking readings from graphs and avoid omitting any prefixes.
- Provide complete reasoning, especially in 'show' calculations.
- Rearrange equations with care.

The quality of written work was variable. A significant number of candidates could have gained more marks by stating definitions correctly and carefully examining the questions. Some candidates lost vital marks because their answers had little to do with the questions asked. It is important for all candidates to understand key command terms such as state, describe, define, etc.

It is worth reminding candidates that their scripts are scanned and then electronically marked by examiners. It is therefore important that answers are not written outside the space provided for the answers. The legibility of some candidates' work remains a serious concern. In some cases examiners found it difficult to decipher letters written in the boxes for the multiple choice questions.

The omission rate for most questions was very low and the majority of the candidates finished the paper in the scheduled time.

There were some very good scripts with clearly laid out physics and well-presented calculations. The comments that follow tend to relate mainly to the opportunities that were missed by the candidates.

Comments on Individual Questions

1 to **20**
All of the questions showed a positive discrimination, and the less able candidates could access the easier questions. The questions in Section A do require careful reading and scrutiny. Candidates are advised to reflect carefully before recording their response in the box. Candidates must endeavour to use a variety of quick techniques when answering multiple choice questions.

Questions **3**, **4**, **7**, **12** and **13** proved to be particularly straightforward, allowing the majority of the candidates to demonstrate their knowledge and understanding of physics. Question **13** tested knowledge of how uncertainties compound when determining resistance of a filament lamp.

At the other end of the scale, Questions **10**, **14**, **15**, **18** and **20** were found to be more challenging.

- Question **10** was concerned with the collision of two trolleys. The correct key was **C**: *The total force acting on the two-trolley system during the collision is zero.* The most frequent distractor was **A**: *The momentum of each trolley* is *conserved*. The term '*each*' did not register with most candidates. It is the total momentum of the two trolleys that is conserved.

- Question **14** was about a velocity-time graph for a golf ball dropped onto a hard floor. The correct key was **C**. The most popular distractor was **B**. This represented a point when the ball was just leaving the hard floor. The maximum height after the first bounce had to be when the ball was still accelerating and had zero velocity.

- Question **15** was about the final speed of electrons emerging from an electron gun. The correct key was **C**. It was only the candidates in the upper quartile who managed to get the correct answer using the expression $Ve = \frac{1}{2}mv^2$ (learning outcome 4.2.2e). Halving the accelerating voltage *V* will decrease the speed of the electrons by a factor of $\sqrt{2}$.

- Question **18** proved to be difficult for almost all candidates. The correct key was **C** and the most popular distractor was **A**. The kinetic energy of the ball at the ground was *K*. At maximum height, the ball just has horizontal component of velocity. The kinetic energy of the ball is proportional to speed^2. At the maximum height the kinetic energy must therefore be $\cos^2 30° K = 0.75 K$.

- Question **20** was about the refraction of light at glass-air boundary. The correct key was **B**. Many candidates showed poor knowledge of this topic. The refractive index of glass is 1.5. The angle of refraction *r* is given by the expression $1.0 \times \sin r = 1.5 \sin 10°$. This gives 15° for the value of *r*. The most common distractor was **A**, which used the incorrect expression $1.0 \times \sin 10° = 1.5 \sin r$.

21(a) Candidates answered this opening question extremely well, with the majority gaining two marks. A variety of answers were accepted. Most candidates knew that the direction of velocities had to be considered when adding vectors. Candidates who identified mass as a scalar and velocity as a vector and then defined these two quantities were awarded full marks.

21(b)(i) Most of the candidates answered this question well with two clearly drawn arrows for the weight of the trolley and the tension in the string. The most frequent mistake was to draw the tension arrow parallel to the ramp.

21(b)(ii) Candidates answered this question extremely well. The correct equation was identified, values substituted correctly and the final answer written to two significant figures. Some low-scoring candidates attempted to use the equation $x = vt$ or struggled with rearranging the equation $s = ½ at^2$. A disappointing number of candidates lost a mark for writing the answer to one significant figure on the answer line after correctly calculating the time *t* to be 0.73 s.

22(a) This question on systematic errors favoured the top-end candidates; most of them appreciated that the gradient of the line would remain the same. The majority of the candidates were baffled and struggled to provide a creditable answer. Answers such as '*Systematic errors do not affect the experiment'* or '*Speed does not change when x changes'* demonstrated a poor understanding of the question and of systematic errors.

22(b) The majority of the candidates gained one mark for correctly calculating the gradient of the line using a large triangle. The reading of the coordinates was generally quite good. A pleasing number of candidates also realised that the gradient was equal to 2*a* and they then went on to correctly determine the braking force to be 7.4 kN. About a quarter of the candidates gained full marks. In spite of the equation $u^2 = 2ax$ and the hint of working out the gradient first, many candidates incorrectly assumed the gradient was equal to the deceleration of the car. A small number of candidates attempted to substitute values off the line into the equation $u^2 = 2ax$; they unfortunately missed the point of the whole question.

23(a) The majority of the candidates scored two or more marks for this practical based question. It is good to report that many candidates were familiar with instruments used to measure diameter and mass. Vernier calipers and micrometers were mentioned by some candidates for measuring the diameter of the metal cylinder. Instead of using the equation pressure = force/area, a small number of candidates successfully gained some marks by applying the equation $p = h\rho g$. A small number of candidates confused the terms *weight* and *mass*.
Only a very small number of candidates realised that precision was linked to reducing the percentage uncertainty in the final value of the pressure. Answers such as '*Use a micrometer measuring to* $\pm$ *0.01 mm instead of a ruler marked in mm*' or '*Use a digital balance giving mass to the nearest 0.01 g instead of 1 g*' were awarded the final mark. Most candidates however, confused accuracy with precision and went on to describe how the experiment could be made precise by taking multiple readings of diameter or mass. A significant number of candidates omitted answering the precision part of the question. It is worth reminding candidates that it is important to carefully examine the question before writing their answers.

23(b)(i) About one in every seven candidates omitted this question and only about a third of the candidates gave an acceptable statement of Archimedes' principle. It was clear from the answers that most candidates had not revised this topic. There were countless guesses, with many famous laws incorrectly linked to this principle.

23(b)(ii) This proved to be a discriminating question that favoured those candidates who could apply, rather than just rote learn, Archimedes' principle. About a third of the candidates scored nothing in this question but many candidates did score one mark for determining the upthrust of 1.2 N. Most candidates stopped at this point. The top-end candidates correctly determined the volume of the displaced water and then went on to successfully calculate the density of the metal.

24(a) A few candidates answered this question well demonstrating their knowledge of this fundamental law of physics. The most frequent incorrect answer was '*Force is equal to mass multiplied by acceleration'* rather than '*Force* is *proportional to the rate of change of momentum'*.

24(b)(i) Most candidates gained one mark for correctly stating two quantities from momentum, energy and mass. The most frequent incorrect answers were *kinetic energy* and *velocity.*

24(b)(ii) This question required knowledge and understanding of Newton's third law. Although many candidates were familiar with the law, they could not adequate describe or explain the force on the asteroid. There were vague answers such as '*The force goes up proportionally and then decreases exponentially'.* Some answers also focused unnecessarily on the transfer of momentum or kinetic energy but it was often the succinct answers such as '*The force on the asteroid is equal in magnitude but in opposite direction to the force F*; NIII law' that scored full marks.

24(c) This was a good discriminator with many of the top-end candidates scoring full marks. Most candidates opted to answer the question using the principle of conservation of momentum. A few candidates used ideas of conservation of kinetic energy for this perfectly elastic collision. It is good to report that most candidates coped well with powers of ten. The most common mistake was to use +420 m s^{-1} for the final velocity of the hydrogen atom, rather than – 420 m s^{-1}; this gave the incorrect answer of 6.8 m s^{-1}. A small number of candidates used relative velocities before and after to arrive at an alternative correct answer of 80 m s^{-1}.

25(a)(i) Most candidates knew that e.m.f. and p.d. were both measured in volts (V). A small number of candidates thought that '*volt'* was the same as '*voltage'*. This question benefitted those who taken time to revise thoroughly. The modal mark was one, but a significant number of candidates scored two marks for their flawless answers.

25(a)(ii) Almost all candidates were familiar with the equation $I = Anev$. However, only the top-end candidates realised that the number density of the charge carriers (electrons) had to be calculated from the number of electrons given and the volume of the resistor. The majority of candidates incorrectly assumed n to be 9.6×10^{16} m^{-3} when it should have been 1.3×10^{25} m^{-3}. Examiners awarded one mark for those candidates who arrived at the answer 1.6×10^{5} m s^{-1} using the incorrect value of *n.*

25(b) Candidates were familiar with this experiment and some gave answers using the bullet points as prompts. Although most candidates scored two or more marks, there were some missed opportunities. The most common error was the incorrect symbol for the variable resistor in the circuit. It was either a thermistor symbol or a hybrid. Some candidates also lost a mark for not clearly specifying the graph being plotted. Instead of '*Plot a graph of V against I and determine the gradient which is equal to the internal resistance*', examiners were faced with less robust statements such as '*Plot a graph and find the gradient'* or '*Use the data to draw a graph and use E = V +Ir to calculate r*'.

26(a)(i) The majority of the candidates gave a good answer. Most realised that the particles at **A** and **B** will be moving in opposite directions or have a phase difference of 180°.

26(a)(ii) This was a notable success for the candidates; many correctly determined the wave speed to be 60 m s^{-1}. The absolute uncertainty of 3.0 m s^{-1} was correctly calculated by most of the top-end candidates. The most frequent incorrect values for the uncertainty were 0.02 m s^{-1} and 0.04 m s^{-1}. A significant number of the low-scoring candidates took the wavelength to be 0.40 m. This gave an answer of (30 ± 1.5) m s^{-1}. Examiners awarded two marks for such an answer.

26(b)(i) Most candidates wrote down generic statements about stationary waves and did not address this specific question. About half of the candidates either scored one or two marks by mentioning that the transverse waves were reflected at the fixed ends and the superposition of these waves resulted in the observed stationary wave.

26(b)(ii) Most candidates gave the correct answer; the wavelength of the transverse wave was equal to twice the length of the rubber cord. A small number of candidates thought the inter-nodal separation was a quarter of a wavelength.

27(a) Most candidates scored two or more marks, but examiners felt that there were many missed opportunities here. The most common error was to quote the resistance of the LED as zero when it was not conducting. Sadly, this was often supported by the calculation $R = V/0 = 0$. A number of candidates attributed the decrease in the resistance beyond 2.6 V to the '*increase in the temperature of the LED*'. The straight line section of the graph for the last voltage range led many candidates to quote Ohm's law and the statement that '*the resistance of the LED is constant'*. A very small number of candidates opted to write about a bulb or a lamp. Top-end candidates effortlessly used $R = V/I$ to calculate the resistance at various p.ds and draw sensible conclusions from their calculations.

27(b) This question was not answered well whencandidates failed to use their earlier answer in **(a)** to explain why the circuit shown in Fig. 27.2 did not work. It was only a small number of candidates who realised that the LED was in reverse bias and the solution would have been to either swap the terminals of the LED or the cell. Most candidates did not appreciate that the p.d. had to be greater than 2.6 V for the LED to emit light. A very small number of candidates opted to use two 1.5 V cells in series. Some candidates thought that swapping the resistor and the LED would solve the problem because then the '*resistor will not prevent the current from reaching the LED*'.

27(c) The term 'photon' and the 480 nm wavelength should have prompted most candidates to calculate the energy of a single photon. The most common answer was to divide the 1.2 mW by 480 nm. Once again, it was the top-end candidates who correctly arrived at the answer of 2.9×10^{15} photons per second. About 1 in every five candidates omitted this question.

H156/02 Depth in physics

General comments

This new examination paper produced a good range of marks. It was clear that most Centres had effectively delivered the content of the new H156 Physics A specification. Candidates answered questions on practical skills quite well which demonstrates a decent coverage of practical work.

Most candidates made good use of the Data, Formulae and Relationships Booklet. Examiners were generally pleased with the well-structured answers provided by the candidates when solving mathematical problems. The comments on the individual questions give more details on the opportunities missed by some candidates. The following key areas for improvement were identified by the examiners when tackling calculations.

- Avoid early rounding of intermediate numbers in long calculations.
- Take care when taking readings from graphs and avoid omitting any prefixes.
- Provide complete reasoning, especially in 'show' calculations.
- Rearrange equations with care.

The quality of written work was variable. A significant number of candidates could have gained more marks by stating definitions correctly and carefully answering the questions set. It is important for all candidates to understand key command terms such as state, describe, define, etc.

It is worth reminding candidates that their scripts are scanned and then electronically marked by examiners. It is therefore important that answers are not written outside the space provided for the answers. The legibility of some candidates' work remains a concern.

The majority of the candidates finished the paper in the scheduled time. A significant number of candidates omitted 8 (a) and 8 (b) but then attempted 8 (c).

There were two levels of response (LoR) questions which gave candidates the opportunity of demonstrating their knowledge and understanding of Physics. It is important that candidates answer the question set in a logical way with clear explanations.

There were also a number of "show" questions on the paper. These type of questions prevent candidates who struggle one part being penalised on the next part – for example, candidates who could not do question 8 (a) could still gain full marks in question 8 (b). They also help signpost candidates to an appropriate answer, e.g. 4 (a) indicating what was meant by base units. These "show" questions do require candidates to clearly indicate their method. The unknown should be the subject of any equation – credit is not given for using the "show" value.

There were some very good scripts with clearly laid out physics and well-presented calculations. The comments that follow tend to relate mainly to the opportunities that were missed by the candidates.

Comments on Individual Questions

1 (a) The opening question was supposed to be accessible to all the candidates. A significant number of candidates did not gain credit because of vague terminology, with 'move' or 'travel' often used to mean two things at once or not giving sensible discrimination between the directions of oscillation and wave/energy travel.

1 (b)(i) This was well answered. A few candidates gave an answer of 80 mV.

1 (b)(ii) This was also well answered although some candidates did not allow for the milliseconds.

1 (b)(iii) Most candidates correctly rearranged the formula and used their answer to (b)(ii). Some candidates truncated their answer to one significant figure which was not penalised this year.

1 (c) Most candidates understood that the new amplitude would be less than the original. Many thought it would be 1/16th of the original. The second mark was only gained by stronger candidates who explained why it would be 20 mV.

2 (a)(i) This was poorly answered. Candidates gave confused answers, often referring to constructive and destructive interference. Most candidates had the idea that the waves needed to be added in some way. Common incorrect answers referred to the addition of the amplitudes. It was expected that candidates would state that the resultant displacement was equal to the sum of the displacements of the individual waves.

2 (a)(ii) A good proportion of candidates scored this mark. A common error was just stating frequency and wavelength were the same.

2 (b) This was well answered with few responses referring to degrees. Some candidates gave generalised answers in terms of n. Other candidates thought it was the third minima.

2 (c) Candidates needed to explain that the fringe spacing was inversely proportional to the slit spacing – this was often missing. Candidates should be encouraged to identify the constants in any expression when answering this type of question.

3 (a)(i) There were some convoluted answers. A number of candidates gained credit but wasted time by solving a quadratic equation. Some candidates assumed that the vertical velocity was an average and determined the time and then just multiplied by two without explanation – this did not gain credit. Clear explanations of the method are used to answer these types of "show" questions.

3 (a)(ii) This part was answered better although some candidates tried using an equation with acceleration.

3 (a)(iii) A pleasing number of candidates determined the magnitude of the velocity correctly, Some correctly used trigonometry methods.

3 (b)(i) This was generally well answered.

3 (b)(ii) Most candidates correctly calculated the gravitational potential energy although some weaker candidates used the answer from 3(b)(i).

3 (b)(iii) Candidates either used the kinetic energy equation of subtracted the change in gravitational potential energy form their answer in (b)(i). Common errors were either to state that the kinetic energy was zero or equal to the change in potential energy calculated in (b)(ii).

3 (c) Most candidates realised that the path was lower but few realised that it would reach a maximum height before the goal.

4 (a) Some candidates were not clear on what was meant by base units. Most realised that the quantity of electric charge is measured in As. Weaker candidates had difficulty deriving work done.

4 (b)(i) There were a number of correct methods using various arrangements of the potential divider equation. Candidates were able to arrange a complicated equation in a number of cases. Other candidates correctly determined the potential difference across the fixed resistor and then the current.

4 (b)(ii) Most candidates were able to calculate the current delivered by the battery. Candidates who did not score this mark often incorrectly assumed that the potential difference across the fixed resistor was 6 V.

4 (c) This part expected candidates to explain how the ammeter and voltmeter readings would change. Answers were sometimes convoluted and not clear; for example, it was not always clear as to whether candidates were referring to the resistance of the LDR, fixed resistor or the circuit. Candidates should be encouraged to structure their answers in a logical manner. Few candidates could explain clearly why potential difference across the LDR decreased.

5 (a) This mark was scored by most candidates. A power of ten error was usually the cause of losing this mark.

5 (b)(i) Conversely, candidates struggled with an explanation as to why large metal plates were used. Many candidates discussed the electrical properties of the metal plates rather than understanding the need of the experiment.

5 (b)(ii) Most candidates discussed measuring the diameter with a named instrument at different points along the putty.

5 (c)(i) This part was answered well with the majority of the candidates recording the correct value to two significant figures. Some candidates made rounding errors or recorded spurious values.

5 (c)(ii) Most candidates were able to determine a percentage uncertainty although many did not multiply by 100. Some candidates thought that the nearest millimetre meant 0.01m instead of 0.001m. Some candidates did not realise that the percentage uncertainty in *d* needed to be multiplied by two.

5 (d)(i) The plotting of the missing point was accurately positioned by the majority of the candidates. There were major difficulties on drawing a suitable straight line of best fit; it is expected that there should be a balance of points about the line. Many lines could have been rotated. Lines that were drawn from the bottom plot to the top plot invariably had too many points below the line and were penalised. Some candidates did not draw straight lines.

5 (d)(ii) This question tested the practical skills of candidates to determine the gradient from their results. To score these marks candidates had to show their method. A large number of candidates failed to realise that the *x*-axis had a factor of 10^{-3}. Other common errors were to assume that the graph commenced at (0, 0). Good candidates clearly demonstrated their method by indicating the points taken, made sure that the length of their gradient was at least half the length of their line and correctly substituted into $\Delta y/\Delta x$.

5 (e) Candidates were expected to use the gradient that they had calculated in 5 (d)(ii) to determine a value for the resistivity; candidates who substituted a data point from the table did not score the first two marks. The final answer needed to be given to two or three significant figures. There was also a mark available for the correct unit; a good number of candidates scored this mark although a number of candidates did write the unit for density.

6 (a) This question was designed to test candidates' practical planning skills. It is expected that candidates should be able to apply the laboratory techniques that they have encountered to novel situations.

This was the first LoR question. Candidates should explain their methods clearly and include any appropriate equations. Their account should be logical and the information given should be relevant to the experiment.

In this particular question a number of candidates explained a Young modulus experiment and suggested that the breaking stress could be determined from a stress-strain graph.

Good candidates clearly explained the procedure to be followed with a labelled diagram, the measurements to be taken (diameter, mass) and how the measurements would be used to determine the breaking stress.

6 (b) Candidates needed to indicate the loading and unloading directions on the rubber curve. For the rubber curve, a number of candidates indicated that the rubber was increasing its strain when the load was being removed. Where a straight line is intended, a ruler should be used.

7 (a) This was the second LoR question. It gave candidates the opportunity to discuss the photoelectric effect. Good answers were structured well and explained the observations with relevant theory. A surprising number of candidates did not appreciate that the white light did not release photoelectrons. Good answers clearly explained the differences between the white light and the ultra violet light, the effect of increasing the intensity was related to the rate at which photons were absorbed by the plate and gave appropriate equations.

7 (b) This part was generally well answered. Some weaker candidates were not able to rearrange Einstein's equation. Other candidates were unable to change electron volt to joule.

8 (a) Good candidates clearly showed the steps to determine the velocity. Weaker candidates found this question difficult. Clear substitution of numbers is required for these marks to be awarded.

8 (b) This part was generally well answered although some candidates confused terms in the equation or could not deal with the powers of ten. Some candidates were confused and used $E=hc/\lambda$.

8 (c) This was another question where candidates were expected to explain their answers. In this case a step by step approach was helpful. Some candidates stated that the energy and the wavelength would increase. Others thought that the pattern would become larger because of the increase in energy. Candidates should be encouraged to write clear, logical explanations.

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