GCE

Physics A

Advanced GCE **H558**

Advanced Subsidiary GCE **H158**

Reports on the Units

January 2010

H158/H558/R/10J

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Advanced Subsidiary GCE Physics (H158)

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Chief Examiner's Report

There is no doubt that many Centres have used previous examiners reports to guide their students. There was a significant improvement in the quality of calculations, with fewer candidates making algebraic and numerical mistakes. It is also nice to report that candidates were making good use of the error carried forward rule in the analytical questions. The quality of written work is still cause for concern. Candidates were losing easily accessible marks simply because of their failure to scrutinise questions. It is important that candidates focus on the clues embedded in the questions. For example, in Q6 of the G484 paper, it clearly stated that the answers had to be in terms of the '*motion of the molecules*'; most candidates ignored this vital instruction. It is essential that candidates understand what the question requires before embarking on their written answers. In most cases, the structure lacked both clarity and scientific accuracy.

As always, experienced teams of examiners provided accurate and efficient marking. On screen marking of the three papers allowed analysis of the performance of the papers at a question-by-question level. The principal examiners reports reflect this detailed analysis.

The report for each unit of the January 2010 examination is given below.

G481 Mechanics

General comments

The marks for this paper ranged from 0 to 59 and the modal mark was 32. All examiners marking this paper commented that there was less omission of questions and there was no evidence that candidates were short of time to answer the paper.

It is good to report that most candidates were taking advantage of the error carried forward (e.c.f.) rule as they progressed through questions. As with previous papers, there was a small number of candidates who were simply daunted by the language and the rigour of this AS paper. Some candidates were not familiar with key command words such as *state*, *describe*, etc.

Candidates are reminded that in a '*show*' question, where the answer is given, it is important to write down all stages of the calculation. Sadly, the quality of written answers from candidates of all abilities was generally poor, often lacking in scientific and technical terms and poor spelling and grammar. This was very noticeable in Q7 where scientific ideas were poorly presented and answers often lacked coherence. Poor handwriting was a problem for a minority of candidates. The examination papers, including any additional sheets used by the candidates, are electronically scanned before being dispatched to the examiners. Most candidates were writing within the scanned zones. A small, but significant number of candidates, did not make good use of the Data, Formulae and Relationships booklet. Weaker candidates frequently misquoted equations. Manipulating equations remains an immense task for a significant number of candidates. As indicated in the last report, candidates can maximise their marks by substituting values into a correct equation before rearranging the equation. No marks will be awarded when values are substituted into a physically incorrect equation, such as $t^2 = \frac{s - ut}{2a}$ in question **2(b)(ii)**.

Comments on Individual Questions

Question One

Most candidates made a good start by scoring four marks in this opening question.

The majority of candidates demonstrated a good understanding of units by scoring full marks in **(a)**. Sadly, about a quarter of the candidates showed poor knowledge of units by linking the newton to N m and the joule to J s^{-1}. In **(b)(i)**, the vast majority of candidates correctly estimated the weight of a person by using $W = mg$. Inevitably, a small number of candidates quoted the mass of the person rather than his weight. The estimation of the cross-sectional area of the shoes in **(b)(ii)** produced some bizarre values. The largest value for the area reported by examiners was 120 m^2. Many candidates calculated the area in cm^2 and then went wrong by dividing their value by 10^2 rather than 10^4. About a third of the candidates had their values in the allowable range 0.01 m^2 to 0.08 m^2. Almost all candidates managed to secure the last mark in **(b)(iii)** for the pressure through the use of error carried forward rule.

Question two

This question produced a range of marks with many candidates scoring six or more marks.

Almost all candidates correctly calculated the weight of mass **B** in **(a)**. A significant number of candidates were baffled by **(b)(i)** and their responses made no reference to forces as required by the question. Some common misconceptions are illustrated by candidates' responses below:

- *Mass B has not reached terminal velocity yet.*
- *Mass B has to pull up mass A as well.*
- *Gravity takes time to act on mass B.*
- *The friction from the pulley and the air affects mass B.*

Almost half of the candidates scored full marks for **(b)(ii)**. The simplest approach adopted by these candidates was to use $s = \frac{1}{2}at^2$. Some candidates lost easy marks because they failed to scrutinise the question and ended up using a distance of 2.80 m or assumed the acceleration was 9.81 m s^{-2}. A disappointing number of candidates did not realise that the question was about equations of motion. Low-scoring candidates tried to determine the time of fall by dividing the distance of 1.40 m by the acceleration 1.09 m s^{-1}. The majority of candidates scored full marks in **(b)(iii)** for the velocity of the mass **B** after falling 1.40 m. About a tenth of the candidates omitted **(b)(iv)**, but the potential grade A/B candidates understood the vector nature of velocity and picked up two valuable marks. The most popular answer was 32.3 m s^{-2} with candidates using a change in velocity of 0.97 m s^{-1} instead of the correct value of 3.97 m s^{-1}.

Question three

This proved to be a very challenging question with a minority of the candidates scoring five or more marks. The analytical question **(b)(i)** provided opportunities for good physicists to show off their skills.

Almost all candidates understood what was required in **(a)** and generally gave concise answers. Some candidates divided the total mass of the cable by its length to get the mass per unit length of 3.0 kg m^{-1}; this was accepted.

There is no doubt that **(b)(i)** was demanding. A small number of candidates gave superb and well structured answers in terms of $T = m(a + g)$. However, the majority of candidates found this question a challenge in terms of both using the correct total mass and the relevance of the vertical acceleration of 1.8 m s^{-2} of the lift. The majority of the candidates were simply overwhelmed by the information given and ended up calculating the weight of the lift or the passengers. Inevitably, some candidates tried playing with all the numbers given in the question to come up with the correct value for the tension of 1.7 × 10^4 N. Examiners were not surprised to see the following wrong answer:

$$\textit{tension} = (500 + 560) \times 1.8 \times 9.81 = 1.87 \times 10^4 \text{ N} \sim 1.7 \times 10^4 \text{ N}$$

Sadly, many candidates failed to use the value of the tension given in **(b)(i)** to calculate the maximum stress in **(b)(ii)**. At times, examiners found it difficult to apply error carried forward rule because of multiple answers given for the tension in the previous question.

Question four

This question produced a range of marks with most candidates scoring five or more marks.

In **(a)**, the vast majority of the candidates did not realise that the question was to do with the relativistic mass change of the electron. Those who did realise this, sadly ended up giving incomplete answers. The responses below show the range of obscure answers given by the candidates:

- *The acceleration decreases because of drag forces acting on the electron.*
- *The acceleration drops because the electron reaches terminal velocity.*
- *The mass of the electron just <u>changes</u> when it moves.*

Few candidates appreciated that the mass of the electron increased as its speed approaches the speed of light.

A small number of candidates gave no response to **(b)(i)**. A significant number of candidates could complete the diagram to show the two components of the velocity on Figure 4.1. However, many candidates were careless in their approach, and did not give sufficiently accurate lengths of the two components or in some cases omitted the arrows on their vectors. Almost all candidates correctly determined the horizontal component of the velocity in **(b)(ii)**. A few candidates failed to change their calculator mode from radians to degrees and they ended up with the wrong answer of 7.32 m s^{-1}.

It is good to report that most candidates secured two or three marks for **(c)(i)**. Most candidates were able to calculate the resultant force correctly by either using Pythagoras' theorem or trigonometry but failed to secure the mark for the vector triangle. The vector triangles were generally very sloppy with arrows either missing or inconsistent. Many candidates knew that the drag force was equal to the net pulling force of the tug boats in **(c)(ii)** but could not explain why. A significant minority mentioned that the drag force '*had to be less than the total force otherwise the ship would not be able to move forward'.*

Question five

Many candidates scored six or more marks in this question.

The majority of candidates gave an adequate statement of the principle of conservation of energy in **(a)**. A surprising number of candidates, albeit a small minority, latched on to the word 'conservation' and wrote about the '*need to conserve fossil fuels*' or '*saving energy until it can be used later*'.

About half of the candidates mentioned springs and elastic bands in **(b)** but failed to gain a mark because examiners were looking for such items being strained.

Almost all candidates selected the correct equations for the gravitational potential energy and kinetic energy in **(c)(i)**. A large number of candidates went on to secure two marks in **(c)(ii)**. A small number of candidates went as far as '$mgh = \frac{1}{2}mv^2$' and then did not cancel the mass m. A disappointing number of candidates did not understand what was required and simply wrote the equation for kinetic energy E_k and rearranged it as '$v^2 = 2E_k / m$'.

Most candidates made a good start by correctly showing the mass of the water deposited in **(d)(i)**. The structure and clarity of the answers was quite good. The question **(d)(ii)** was challenging with only the high-scoring candidates picking two or three marks. There was the inevitable mistake of omitting the factor of 0.30. Surprisingly, some candidates thought that 30% of the gravitational potential energy of 1.77×10^{12} (J) was the average electrical power; the time of 900 s was nowhere to be seen. Answers such as the one below, could only be awarded two marks:

$$\textit{power} = 0.30 \times 2.4 \times 10^{8} \times 9.81 \times 2500 = 1.77 \times 10^{12} = 2 \text{ GW}$$

The majority of candidates gave a plausible reason in **(d)(iii)** for there being a problem with this energy production scheme.

Question six

In **(a)**, the majority of candidates knew why the graph did not pass through the origin and gave succinct answers. Answers such as '*the spring cannot have zero length'* and *'the spring has length of 2 <u>metres</u>'* were allowed.

Many candidates in **(b)** quoted Hooke's law and hence secured one mark. A few candidates spoilt their answers by making a contradictory statement such as '*force is proportional to the <u>length</u>'*.

The answers to **(c)** were disappointing because the candidates were given a clear hint in the question that the force constant of the spring was equal to the gradient of the line. The list below shows some typical errors made by candidates:

- Omitting the 10^{-2} factor from the length axis.
- Using the line to find an arbitrary value of the force and dividing it by the corresponding length of the spring.
- Determining the inverse of the gradient.

The vast majority of the candidates scored zero in **(d)** by writing down '$3.0 \times 0.06 = 0.18$ J'. Such candidates did not appreciate that the work done on the spring was the elastic potential energy or the area under the force against length graph.

High-grade candidates did well with **(e)** by realising that the maximum speed was equal to the '*maximum gradient*'. A disturbing number of candidates referred to the area under the graph or the use of distance divided by time to give an average speed.

Question seven

The majority of candidates scored six or more marks for this question. There was no evidence that the candidates were rushing to finish this last question on the paper.

The answers to **(a)(i)** were generally quite disappointing. There was little explanation of why the tape was likely to break at point **B**. Answers such as '*this is the narrowest section of the tape*' or *'the pressure here is greatest*' were not allowed. In order to secure a mark, candidates had to mention that the stress at this point was greatest; less than 20% of the candidates could manage this. Most candidates lost an easy mark in **(a)(ii)** by giving either incomplete or ambiguous answers.

The majority of candidates scored five or more marks in **(b)** but as a whole, the description of the experiment to determine Young modulus lacked robustness and scientific clarity. It was clear that many candidates had never carried out the experiment or seen a demonstration of the experiment. Two marks were reserved for the correct use and spelling of the words *diameter* and *micrometer*. Even some of the high-scoring scripts failed to mention the *diameter* of the wire had to be measured. Instead, candidates were writing about a '*special tool used to measure the cross-sectional area of the wire*'. The micrometer was frequently omitted or it was incorrectly referred to as a '*nanometer*' or '*millimeasurer'*. Some candidates gave up and resorted to sketching a diagram of the micrometer. Sadly, no matter how good the sketches were, no marks could be awarded for the drawing in this description question. Under the heading of equipment, too many candidates made unnecessary reference to the pulley, the wooden block and the G-clamp. A disappointing number of candidates referred to continuing the experiment until the wire snapped. The majority of candidates managed to secure two marks for writing the equations for stress, strain and Young modulus. Although rare, some candidates produced immaculate answers in terms of determining '*the gradient of the linear section of the stress against strain graph'*.

G482 Electrons, Waves & Photons

General Comments

More than three quarters of the 2600 or so candidature was made up of those retaking the examination. A few candidates gave up after an attempt at the earlier questions but most seemed to have sufficient time to complete the paper and weaker candidates managed to attempt to answer most sections in every question. Candidates scored freely in the first question proving it to be a good introduction easing them into the paper. This continued through question 2 until the last two sections which successfully differentiated between the different abilities. Questions 3 and 4 proved to be more exacting with precise descriptions being required. The definitions in question 5 were poor but then most candidates scored well on the remainder of the question. The waves question about interference was a good discriminator where many were able to show their knowledge and understanding and score highly. In questions 7 and 8 there were confusions between electrons and photons and wave and particle properties of both quantities. There were fewer problems with transposition and powers of ten in calculations than in the previous paper. Candidates seemed more comfortable with the numerical questions. However many descriptive responses still lacked structure and careful argument, often containing contradictions. There were parts, e.g. 2(b)(i), 4(a)(i), 6(b)(iii) where a purely qualitative answer was usually given although sufficient data was present for the expected more quantitative answer.

Comments on Individual Questions

Q1(a) Many candidates failed to use the formula, energy = power x time. Some confused current and charge but more gained the marks for this part than (i). Most were able to divide the answer to (ii) by the electronic charge to gain the marks in (iii).

Q1(b) Most answers paraphrased the question rather than giving any idea of knowledge of the rapid random thermal motion between ionic collisions resulting in a slow progression along the wire when a p.d. is applied. However most were able to substitute the correct quantities into the correct equation to gain the marks for the last part.

Q2(a) As a formula appears in the booklet accompanying the paper, candidates were expected to rearrange it making resistivity the subject and also to state the name of each symbol to gain both marks. Most achieved this successfully.

Q2(b) Most managed to score at least one of the two marks here. Those who failed to do so wrote answers that were too vague and failed to mention that there were 38 strands. The quantity 2.0 ohm per km caused some confusion with candidates who substituted 2000 into their equation resulting in very thin strands.

Q2(c) Most candidates were able to handle the powers of ten to calculate the input power but many then failed to realise that the number of cables had to be a whole number and failed to round up their answer. Many tried unsuccessfully to use the input voltage and resistance to find the power loss. A significant number realised that the current approach was best and achieved the correct answer of 10 kW. The answers to the last part were much improved over the similar question in the last paper with many candidates gaining at least one mark.

Q3(a) The majority of candidates were able to show convincingly that the p.d. across XY was 7.2 V.

Q3(b) Few were able to argue convincingly why the battery current increased and the p.d. across XY decreased because most wrote vaguely about resistance decreasing without stating to which resistor or combination of resistors they were referring.

Q4(a) Many descriptions were too vague, for example, not including data from the graph to indicate the regions where different features applied. Some stated that the resistance of the LED from 0 to 1.5 V was very high and then calculated it to be zero. Some thought that the gradient gave the resistance; others that the reciprocal of the gradient gave the resistance. Some thought that current and voltage were proportional; others that the component obeyed Ohm's law above 1.8 V. Few actually stated that the LED emitted light above 1.5 V and that the intensity increased with current or voltage. Some confused an LED with an LDR considering light to be incident on the component; whilst others wrote an answer for the behaviour of a thermistor.

Q4(b) Few gained all three marks for the circuit diagram. The most common error was an incomplete drawing of the circuit symbol for an LED, followed by connecting the voltmeter across more components than the LED alone.

Q4(c) Many knew that the resistor was included as a safety device but more than half tried to describe the action in terms of voltage rather than limiting current.
Q4(d) Most candidates wrote about the advantage of the circuit in terms of sensitivity of control rather than the range of values available. This question proved to be too sophisticated for all but the most able.

Q5(a) The terms were described very poorly, usually being too vague to be awarded a mark. It is suggested that students are encouraged to learn precise definitions using words like 'per unit time' instead of 'in one second'. For example, the speed of a progressive wave is the distance travelled by the wave energy per unit time. Most tried to derive the wave equation using symbols alone, rather than writing word equations. Most derivations were just a rearrangement of the three symbols, sometimes also including T.

Q5(b) The two most common errors were to forget to say that i.r. is electromagnetic radiation or to give a unit with the range of wavelength values. The calculations were correct and the graphs on average were drawn well.

Q6(a) The key statement looked for in this part was: where the waves meet their displacements are added. Many gained one mark but far fewer the second. In (ii) most tried to relate coherence to phase difference.

Q6(b) Some candidates confused phase with path difference giving a hybrid answer. Some thought that out of phase meant 90 degrees not 180 degrees. Others wrote that destructive interference occurred for path differences of n rather than (2n +1)/2 half wavelengths. Many gained full marks for part (i) and many more for (ii). In (iii) a significant number understood what was required of them and wrote very good answers; others just concentrated on either position or intensity. In 3 a significant number appreciated that maxima and minima changed places on the screen.

Q7(a) The first two parts were done well with only a few candidates not showing clearly that they had completed the calculations fully. In (iii) few could explain clearly what energy levels are. However the majority were able to discuss the absorption and emission of energy as an electron moved between levels. Common errors were to confuse electron with photon or to write purely in terms of atoms. A few tried to relate their answers to the photoelectric effect. In (iv) there was much confusion and contradiction comparing either frequencies or wavelengths and relating these to the effect on photon energy.

Q7(b) The decision on the direction of motion of the electron at X was split approximately equally between up and down. Many candidates did not realise that all that was required in (ii) was to calculate 0.2ne. The last part was done well by the most able and was a good discriminator.

Q8(a) Most candidates could explain diffraction adequately. However many then failed to relate this to electron diffraction failing to refer to the wavelength of the electrons. Others continued to refer to gaps rather than be more specific, e.g. interatomic spacing.

Q8(b) Almost all candidates chose the correct formula and were able to manipulate it successfully to calculate the speed of an electron.

Q8(c) This last section was a good discriminator with the better candidates correctly equating the electrical potential energy to the final kinetic energy of the electron. A common misconception was to use the de Broglie wavelength and the energy expression for a photon instead. In (ii) the sign of the electronic charge and the repulsion or attraction of the plates were required to gain the mark.

G484

General comments

The paper tested all areas of the specification and candidates had ample opportunity to demonstrate their knowledge and understanding of the content of this unit. There was a pleasing spread of marks from 0 to 59. The calculations were generally tackled more successfully than the questions requiring a written explanation. Some candidates were careless in reading the questions and consequently lost marks by failing to respond to the exact wording. This was particularly noticeable in Q5 where an <u>electrical</u> method for measuring the specific heat capacity was required and in Q6 where an explanation in terms of <u>the motion of the molecules</u> was needed.

Comments on individual questions

Q1

(a)(i) All candidates were able to spell the word momentum correctly but some lost the mark by failing to refer to the <u>rate</u> of change of momentum.

(a)(ii) Statements for Newton's third law were generally good but some candidates lost the mark by simply offering a vague "every action has an equal and opposite reaction".

(b)(i) Many candidates failed to score any marks. The most common errors were to treat the area under the curve as two triangles and to miss the milliseconds on the time axis. Candidates making both errors offered an answer of 1680 Ns. This was seen quite often but scored 0. A wide tolerance was allowed for the area under the graph – from 20 to 24 squares and it was disappointing that only a minority of candidates could determine the area to this degree of accuracy.

(b)(ii) The vast majority correctly identified and spelled Impulse.

(b)(iii) Full error carried forward was allowed for candidate's answer to (bi) even though their final answer was not close to 50 m s^{-1} . There was some evidence of candidates working backwards from the velocity of 50 m s^{-1} in order to determine the area under the graph in (bi) and this was allowed.

(b)(iv) This was a 'stretch and challenge' question and provided good differentiation. The normal 'structure' provided for this type of question on AS papers was absent and candidates had to determine for themselves the best method to solve the problem. Many realised that the initial velocity had to be resolved into vertical and horizontal components but only a minority were able to correctly determine the horizontal distance travelled. Most candidates picked up an easy mark by stating a valid assumption - most common was 'no air resistance'.

Q2

(a)(i) A large majority correctly found the time taken for a complete rotation

(a)(ii) Virtually all were aware that the centripetal force was given by mv^2/r but about 15% of candidates carelessly forgot to square the velocity or wrongly introduced 32 into the calculation.

(b)(i) The majority scored this mark but about 15% lost it by not clearly showing that the arrows were pointing directly towards the centre of the circle. It was surprising that only a minority of candidates used a ruler.

(b)(ii) The majority of candidates identified C as the point of maximum contact force, but the second mark was much tougher to score (another stretch and challenge question). Many answers suggested that the centripetal force was an extra force acting on the sock instead of explaining how the required force towards the centre was provided.

(b)(iii) Again a majority knew it was A but few got the mark with just as much confusion in the explanation.

Q3

(a) The best answers involved the use of a ruler, but most managed to score full marks by showing lines directed to towards the centre of the planet.

(b)(i) A large number of candidates scored full marks by correctly substituting values into the equation $M=gr^2/G$ and being able to carry out the calculation. A few simply wrote down 2×10^{27} and this was given no credit.

(b)(ii) A surprising number of candidates could not recall the volume of a sphere, even though it is given on the data booklet.

Q4

(a) This was answered well by most candidates with reference to a zero resultant force and correct identification of the forces provided by the spring (tension) and the weight

(b)(i) A large number of candidates defined SHM correctly and showed good awareness of the acceleration always acting towards the equilibrium position.

(b)(ii) About a third of the candidates failed to realise that $2\pi f = 7.85$ and consequently failed to score the marks.

(b)(iii) Just over half the candidates scored both marks but almost 40% failed to change the 12mm into 0.012m and lost 1 mark.

(c) Almost all got the first mark for the correct period (0.8s) but the phase was more difficult to get and quite a few struggled to match their (b)(iii) answer to a suitable scale, so 2 was a much more common mark than 3

Q5

(a)(i) Most candidates scored 2 marks but some lost a mark by calculating the inverse of the ratio.

(a)(ii) This was not answered well by candidates. They found it difficult to explain a valid situation and explanation. Only a few really emphasised the main effect - that the temperature of the water would not change much unless a large amount of heat energy was added or subtracted from the water. There was a bit of confusion over latent heat in some answers.

(b) A significant number of candidates failed to read the question carefully and missed the reference to an electrical method. Again, the lack of rulers was evident and the majority of diagrams were weak. The electrical circuit components were often poor with many just having a simple single wire to a power supply and the ammeter and/voltmeter being attached to the circuit again with a single wire. Most candidates identified all three measurements and most showed the rearranged equation used to calculate the s.h.c. The last 2 marks were often missed or badly described with 'human error' often being cited as a common source of uncertainty.

Q6

(a) Many candidates scored both marks but some simply quoted T as temperature instead of absolute temperature (or in Kelvin).

(b)(i) This was another question where many candidates did not read the question carefully and offered answers that did not refer to the motion of the molecules. The majority picked up the increased speed/KE mark, though there were some who just said the energy of the molecule increased. Many stated 'more collisions' but did not refer to the increased rate of collisions (or the number of collisions per second). Few could carry their explanation through to explaining what was needed if the pressure was to remain constant so only the best candidates were scoring full marks (good differentiation).

(b)(ii) Most scored full marks but many failed to convert the temperature into Kelvin.

(b)(iii) Full marks for were scored by candidates for correctly equating the average KE to 3/2kT. Some lost a mark by failing to find the square root.

Grade Thresholds

Advanced GCE Physics H158 H558
January 2010 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
G481	Raw	60	44	38	33	28	23	0
	UMS	90	72	63	54	45	36	0
G482	Raw	100	56	49	42	36	30	0
	UMS	150	120	105	90	75	60	0
G484	Raw	60	45	41	37	34	31	0
	UMS	90	72	63	54	45	36	0

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
H158	300	240	210	180	150	120	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
H158	15.7	36.4	61.9	83.5	95.8	100	661

661 candidates aggregated this series

For a description of how UMS marks are calculated see:
http://www.ocr.org.uk/learners/ums/index.html

Statistics are correct at the time of publication.

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