GCE

Physics A

Advanced GCE **H558**

Advanced Subsidiary GCE **H158**

OCR Report to Centres June 2016

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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

G481 Mechanics

General Comments:

The marks for this paper ranged from 6 to 60 and the mean mark was about 40. Most candidates used their time sensibly; there was little evidence of candidates running out of time. There were no significant omissions of specific questions.

The paper was taken in the final year of the teaching of this course. This resulted in many candidates being at the end of the two year course and this was reflected in the high standard of many of the candidates' responses.

Many Centres have continued to make good use of past papers, mark schemes and Examiners' reports. Most candidates showed good analytical skills and a decent command of technical language. Some descriptive responses lacked structure and knowledge of basic physics. Very few candidates took advantage of expressing their ideas in the form of bullet points. On some scripts, potentially good answers were marred by premature rounding of numbers and erroneous transfer of data between questions. Generally, candidates made good use of their calculators and often wrote the final answers in scientific notation. Few numerical answers were left as fractions or as surds. It is important that the final numerical answer conveys the significant figures used in the question and very few candidates made mistakes in their use of significant figures or made rounding errors.

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

Comments on Individual Questions:

Question No.

1(a) Candidates answered this opening question well with the vast majority writing a succinct and correct definition. A noticeable incorrect answer was 'the rate of change of velocity per unit time'; candidates need to be aware that in dynamics the term 'rate' includes per unit time.

1(b) This was another well answered question with almost all candidates scoring the mark. The commonest error was to write words to the effect that 'velocity is a vector and as acceleration contains velocity, it too, must be a vector'.

1(c)(i)1 Candidates had difficulty with this question. Many knew the motion of the object was not uniform acceleration and wrote 'non-uniform acceleration', which was insufficient for the mark. Many included the word rate in their answer in such a way that they negated a possibly correct answer. The correct way to have used rate to score the mark would be to write 'increasing rate of change of velocity', which a few candidates did.

1(c)(ii)2 Twice as many candidates answered this part of **Q1(c)** correctly. Again, incorrect inclusion of the word rate penalised some candidates.

1(c)(ii) It was well understood that the area beneath a velocity time graph gives distance. A small number of candidates tried to answer this question with reference to gradients or the length of the base line - but omitted to mention area. A few candidates used incompatible adjectives such as 'it has a shorter area'.

1(d) Many candidates achieved both marks on this question. Two common errors were to use time = distance divided by velocity as if the blood were not accelerating or to make a transcription error by using 0.20 instead of 0.02.

2(a) Over 85% of candidates wrote correct answers. A small number got Aristotle and Galileo's names interchanged. One common error was to write that Aristotle said acceleration depended on mass, without specifying that according to Aristotle heavier would mean faster.

2(b)(i) Many correct answers here also. One common error was to state that mass or weight would have an effect on aerodynamic drag.

2(b)(ii) Marks were lost here for writing 9.81 without the unit or using an incorrect unit. Candidates also incorrectly wrote that the drag was small or minimal rather than zero. Some wrote that 'the only force acting was gravity'; the mark was awarded for 'the only force acting is weight'. Many candidates wasted time writing about what happened to the acceleration as time passed - this was not asked for.

2(b)(iii) A majority of candidates scored both marks. Where marks were lost, it was for drawing a line showing increasing acceleration or drawing a straight line for the first 10 s. A tolerance of $\pm$ 1 s was allowed in the line becoming zero after 10 s.

2(b)(iv) Candidates found this to be a more straightforward question to answer and wrote full and correct answers. A small number calculated the net force as 240 N and stopped there.

3(a) All the candidates knew which formula to use but some used the incorrect height. Others arrived at the correct answer but wasted time calculating the change in gravitational potential energy (GPE) over 34.5 m, then subtracting the change in GPE over 9.5 m.

3(b) Almost universally correct answers.

3(c) A more testing question. Candidates attempted to use arguments about the motorcycle accelerating but failed to mention energy or work so didn't score the mark. Many candidates explained the difference in energy by discussing heat losses - which would have resulted in less kinetic energy rather than more. This question discriminated well between the upper, mid and lower quartiles.

3(d) Another excellent discriminating question. Many candidates wrongly applied equations of motion to the situation, using the length of the ramp as displacement in an attempt to determine the acceleration and hence the force, resulting in answers around 712 N.

3(e)(i) A significant number of candidates used 30 m s^{-1} as the initial velocity leading to an incorrect answer. Candidates who did not rearrange the formula to make *t* the subject of the equation did not score the second mark.

3(e)(ii) There were many good answers but a number of candidates who had failed to determine 1.39 s in the previous question omitted this question.

4(a) The most common mistake was to state that the resultant force was 900 N. This is the vertical reaction force. Candidates that considered horizontal and vertical forces separately usually described a zero horizontal resultant but a non-zero vertical resultant. Stating 'the velocity is constant' was insufficient for the second mark as this was given in the stem of the question.

4(b) Candidates were expected to include and to correctly spell the word perpendicular; most did score this mark. A common mistake was to fail to mention the pivot / point. A small number wrote the law of moments or the definition of work done by a force.

4(c) The most common error was to write a statement such as 'to be a couple forces must act in opposite directions', without saying that in this case the two forces acted in the same direction. Writing 'both forces act upwards' was insufficient, as it could be that two forces acting downwards would have constituted a couple.

4(d) The candidates demonstrated a good understanding of moments with almost 90% of candidates answering this question correctly. A small number did various calculations with the distances given on the diagram; this was unnecessary and lead to incorrect answers.

4(e) Whilst the majority of the candidates knew that the force at **X** decreased, many were unable to explain why clearly. Many wrote statements like 'because the distance to the pivot increases' without stating what distance or which pivot. Candidates needed to specify points using the labels given on the diagram.

5(a)(i) This mark scheme gave credit for a simple 'driver's head will bounce back / whiplash / suffocation'. Those candidates that wrote 'the driver would be severely injured' were expected to mention that the airbag would be rigid/hard and so the force would still be large - many did not write both required parts for this alternative approach.

5(a)(ii) This question appears often on physics examination papers as it tests both an understanding of the links between time, acceleration and force and also the candidates' ability to write a coherent argument. There was evidence that many candidates had experience of answering this question as there were many full and well written answers. Few candidates used bullet points to answer this question even though this question lends itself well to such an approach. Few attempted to answer this using a change of momentum method. A small number thought that the air bag reduced the impulse showing a poor understanding of impulse.

5(b)(i) Around half the candidates scored this mark. Common errors were to write that u is directly proportional to x, or that u is directly proportional to x^2 - the reverse of the correct answer.

5(b)(ii) Whilst the calculation of thinking distance was usually done correctly, the calculation of braking distance was a more complex calculation that produced excellent discrimination between the different quartiles. Interestingly many who had incorrectly written 'u is directly proportional to x^2 ' went on to calculate the correct value of braking distance in this question.

5(c)(i) There were three common incorrect responses given: that the circle represented the range of the signal from the satellite; that it represented the distance of the car from the satellite (which is the radius of the circle) and that it represented the signal wavefront. Examiners were generally surprised at this lack of understanding.

5(c)(ii) This element of the global positioning system is not well understood. Many candidates thought that a GPS unit a few centimetres across sent a signal to the satellite or that the satellite found the position of the car and relayed this information to the GPS unit. Many wrote about GPS units returning the signal to the satellite. Only a small proportion of the candidates wrote a clear statement about determining the time taken for the coded signal to travel from the satellite to the GPS unit.

Many candidates went on the write 'the delay time and the speed of light can be used to find the distance between the car and the satellite' - which did not answer the question. A number of candidates wrote 'use $d = st$ to find the distance'; this is not a formula that is given in the Data, Formulae and Relationships Booklet. If a candidate wishes to use a non-standard formula they should define each of the terms fully; few who wrote $d = st$ explained their terms. Some used the correct formula but did not rearrange it to give distance as the subject. In questions of this type the candidate needs to demonstrate they know how to rearrange the formula to show how distance is determined from the data. If a candidate uses numerical data such as 3×10^8 they need to include the correct unit to score the mark.

6(a)(i) Most candidates scored this mark by writing the definition of force constant or writing the correct equation. Some only used symbols for their formula. When using a formula for a definition the terms should be written in full or defined separately. Mixing quantities and units is not accepted in definitions. Answers such as force per metre of extension do not score the mark.

6(a)(ii) Many candidates found it difficult to express their ideas clearly. Those that stated that the extension halved did not always make it clear that the force applied (to the system) was the same. Some answers were not specific e.g. 'the same force is shared out so the extension is less' is inadequate as it does not explain the doubling of the system force constant. Other candidates contradicted a well expressed answer by the addition of some incorrect algebra that concluded $F = 2kx$, which would imply a halving of the spring constant.

6(b) Very few candidates used the word thickness to describe the thickness of the foil. The closest many got was to use breadth, which, if used to explain that cross-sectional area could be calculated using width × breadth could score them a benefit of doubt (bod) mark. Many wrote about measuring the diameter of the foil and using the area of a circle formula to calculate cross- sectional area. Others measured the dimensions of the card rather than the foil. Many candidates confused breaking stress and the Young modulus and explained how they would load the foil, measure its extension and plot a graph of extension against load to find the breaking stress. Calculating the breaking load from the mass was generally done well by those candidates who described breaking the foil. Most candidates scored the final mark by selecting the correct formula for breaking stress.

6(c)(i) Most candidates were able to correctly identify elastic behaviour or to state that the wire was obeying Hooke's law. Some went on to waste time explaining what happened to the wire as the strain increased beyond 0.1%.

6(c)(ii) This question was well understood and many clear and concise answers were written.

6(c)(iii) Most candidates recognised that the Young modulus of the material did not apply at this point but did not give a correct explanation as to why. Clear reference to the linear section of the graph was required. The guidance in the mark scheme did allow a candidate to score the mark if they explained that the Young modulus only applies to elastic behaviour.

7(a) This multi-stage calculation required good algebraic skills and the handling of powers of ten. Most top quartile candidates scored all four marks. If they made an error it was to forget to account for the fact that there are four cables. Candidates in the lower quartile often scored two marks, for the calculation of the weight and stress. Marks were lost by making power of ten errors or by incorrect algebra in the later stages of the multi-stage calculation. Candidates that used multi-layer fractions frequently made errors in rearranging them.

7(b) Most candidates scored the first mark. Few candidates referred to the tension in the wire. About half of the candidates scored both marks for this question.

G482 Electrons, Waves and Photons

General Comments:

The marks for this paper ranged from below 5 to above 90 with a mean mark between 50 and 55. Most candidates made good use of their time as there were no significant omissions in any question. Candidates scored freely in questions where the exercise was mainly substituting into formulae. These questions were where weaker candidates gained the majority of their marks. Where explanations were required the answers proved to be more discriminating, especially in Q1, Q3 and Q4. Good candidates were able to demonstrate their knowledge on the wide range of topics covered.

Candidates often are not diligent in reading the question carefully, which is usually designed to lead the candidate. For example in Q1c a current value was given in the stem of the question but many used their own value from the previous part. In Q6b a particular scenario was given about justifying the particle model of light. Many answers just included a general description of the photoelectric effect rather than addressing the particular situation.

There were some very good scripts with clearly laid out physics and well presented calculations. However the most common fault was a lack of any explanation in questions containing calculations, for example Q2b(i). The reader was expected to fill in the logic between the lines of numbers.

The comments below relate mainly to the opportunities that were missed by the candidates.

Comments on Individual Questions:

Question No.

1a Almost all candidates were able to write the definition successfully.

1b Part (i) was done well. Some were unable to calculate the area correctly, most commonly using diameter for radius. Most gave the correct unit.
Part (ii) proved to be very challenging. Few appreciated that the circuit as arranged was just three 4 ohm resistors. It was common to see simplistic statements such as *twice the resistance, half the current*. The calculation revealed that the majority of candidates viewed the circuit as resistors of 8 Ω and 4 Ω in parallel. Less than one fifth of the candidates calculated the current correctly.

1c Most candidates completed this calculation correctly. A common fault was to use the current calculated in part b instead of 0.4 A given in the stem of the question. Some misunderstood the meaning of *n*, multiplying the given value by the volume of the graphite rod.

1d The common answer to part (i) was that *there are more free electrons or charges*. The examiners were looking for any comparison of *n* or the number per unit volume. About half of the candidates failed to score a mark for part (ii) considering the resistance to increase with temperature for both copper and graphite. Ions were often described as atoms or particles in the metal. A minority gave very good answers to this question.

2a All drew a straight line through the origin, but some missed the (2,30) point by more than half a grid square. In part (ii) in general the explanation was good but it was not uncommon to see reference to a constant gradient rather than a straight line therefore discussing a relationship between the change in the quantities rather than the quantities themselves.

2b In part (i) some candidates found it hard to express their analysis clearly. One common error was to assume that any potential difference in excess of 1.6 V would make the LED light normally. Another was to take the p.d. across the resistor to be 5 V.
Part (ii) was done well. In part (iii), very few realised that all 21 LEDs in the number display are in parallel and hence that the answer is just 21 times the current in one. Most tried to calculate an overall resistance, forgetting the series resistor.

2c Most candidates scored both marks here.

3a More than half of the candidates selected *energy*.

3b Many candidates gave a good definition of *potential difference* ignoring the initial word *terminal*. Candidates writing about the meaning of internal resistance often stated *energy is lost inside the supply* rather than *the cause of the loss of energy is considered as an internal resistance*.

3c It is disappointing that even when candidates are given a circuit, most are unable to describe an experiment with a graphical solution. Fixed known values of the variable resistance were often assumed and many suggested measuring the potential difference for known resistance values and then calculating current, not thinking just to take the reading from the ammeter. A majority assumed the value of the e.m.f. to be 6 V hence removing the need to take more than one set of readings.
Less than half of the candidates approached the exercise by suggesting taking a range of readings, plotting the appropriate graph and explaining that the internal resistance was the gradient of the graph.
When considering the effect of excluding the 3 Ω resistor it was rare to find candidates alert to the possibility of short circuit and the implications of the high currents possible. Many embarked on discussions involving potential dividers.

3d Over half of the candidates recognised that the two cells were in opposition and calculated the net e.m.f. as 2.1 V. but few appreciated that the total circuit resistance was 3 Ω.in the circuit.

4a Explanations of why light is produced only at certain angles by a diffraction grating were weak. Many candidates gave a well rehearsed answer in terms of Young's slits writing about the interference of two waves creating alternating light and dark fringes. The purpose and outcome of having many slits was completely missed.

4b There were many good answers to these sections. Most achieved reasonable marks although the label for spectral line C was often confined to one side of the normal. When substituting in the formula $n\lambda = d\sin\Theta$, n was often taken as 5, and the value of λ assumed to be 365 nm by some. Descriptions of the similarities and differences of emission and absorption spectra tended to focus on their production rather than on their appearance on a screen. In part (iv) and (vi) some of the substitution was often omitted in weaker answers. When the answer is given full evidence of calculation is required.

5a The definitions lacked precision and detail. For example, w*ave* or *length of an oscillation* was used for *wavelength; oscillations passed a point* rather than *at a point* and *oscillation of a wave* rather than *oscillation at a point* or *of a particle.*
Derivations of the wave equation generally ended with the correct formula, but many used undefined symbols with no explanation which is a risky strategy in a question of this nature, especially for those who used t for T. The handwriting of some candidates was such that it was often very difficult to distinguish between f and t.

5b The sketches and labelling of the waveform in a closed tube were good. Calculations of the speed of sound in the tube were often compromised by using the wrong value for the wavelength. Just over half of the candidates reached the correct answer.
Sketches of the stationary waves in an open tube were not as good with many leaving the fundamental blank; others indicated nodal points at the ends. A majority assumed the fundamental frequency to be 512 Hz or doubled rather than halving the frequency. This led to problems in the rest of the question, especially explaining the concept of the second harmonic correctly.

6a The de Broglie equation was familiar to most although some did not relate the terms to particles.
For the evidence for the wave nature of electrons many knew of the diffraction experiment using graphite but failed to state that the electrons passed through a thin sheet. A minority gave a vague answer in terms of a double slit system, scoring no marks.
The calculations were done well with the majority of candidates scoring full marks. In the last part, although many gave the correct answer of 5 very few quoted an acceptable value for the wavelength of visible light, if at all.

6b Most realised that the question related to the photoelectric effect. Although many answers showed a clear recollection of an experiment, they often described what happened in great detail rather than answering the question and relating the observations to a photon model of electromagnetic radiation.

G483 Practical Skills in Physics 1

General Comments

Teachers and technicians in Centres are thanked for once again for their hard work in organising the practical skills assessment. The successful assessment of practical skills relies very much on the care and attention to detail that the individual Centres put into the process.

The purpose of the moderation process is to confirm the marks awarded by a Centre and to ensure consistency between Centres. It is essential that the mark schemes are followed and Centres must annotate candidates' scripts either to justify the award of a mark or to indicate why a mark has not been awarded. It was clear from the moderation process that the majority of Centres marked the tasks carefully and there were many helpful annotations. There were, however, still a significant number of Centres where the marking of B1.2 in the Qualitative Tasks and C4.1 and C4.2 in the Evaluative Tasks failed to include clearly the numerical marking point as well, e.g. C4.1-2 for the second marking point for C4.1. The questions at the end of the Qualitative Tasks and the Evaluative Tasks are 'high demand' questions and thus Centres should not credit trivial answers. Additional guidance is given in the mark schemes and Centres are welcome to contact OCR for further guidance. Centres do need to be careful about giving 'benefit of doubt' marks. If a Centre is to award a mark which is 'benefit of doubt' then the script must be annotated with reasoning. The same candidate should not then be awarded another benefit of doubt mark.

The majority of larger Centres had carried out appropriate internal moderation. Centres must ensure that the final agreed marks awarded are clearly indicated on the scripts. For large Centres it is important that marks agreed at internal moderation meetings are then applied consistently across all the candidates in the Centre.

Candidates should be reminded of the need to show all the steps clearly when carrying out calculations; this particularly applies to the end of the quantitative tasks and when determining uncertainties in gradients or *y*-intercepts in the evaluative tasks. In addition, candidates should be encouraged to include greater detail in their answers to descriptive type questions, giving reasons where necessary.

Centres are reminded that the only help to be given to candidates is clearly indicated in the 'instructions for teachers'. Any help given must be recorded on the front of the appropriate task. Under no circumstances should help be given in the construction of the table of results, the graph or the analysis parts of the quantitative tasks. Centres must ensure that the guidance within marks schemes remains confidential at all times.

Administration

Centres are advised to check that they are using the latest assessment material from 'Interchange'. Before marking a task, 'Interchange' should be checked. Centres are advised to sign-up to the email update process.

A small number of Centres did not include the candidate numbers (or used incorrect numbers) on the work that was submitted. The cover sheet is a useful sheet to include with each candidate's work which is sent to the moderator. The cover sheet is available from and the spreadsheet from 'interchange'. There is also a useful spreadsheet.

Centres should ensure that the marks are submitted to OCR and the moderator by 15th May. Small Centres should also submit all their candidates' work in line with the moderation instructions directly to the moderator and not wait to hear from the moderator. Larger Centres should wait for the automated email from OCR. If a Centre has not heard from OCR by the end of May then the OCR contact Centre should be either telephoned or emailed. Where work is submitted late, the candidates' marks may not be ready for the publication of results.

It was very helpful where Centres enclosed with their paperwork any correspondence with OCR including copies of emails and coursework consultancies.

The Centre Authentication Form must be completed and sent to the moderator. Moderators had to ask a small number of Centres to supply this form. Copies of this form are available from the OCR website.

Re-submitting Tasks

A number of Centres did not always follow the rule on resubmitting tasks correctly. As the 'Frequently Asked Questions' on 'Interchange' indicates, candidates wishing to improve their mark by re-sitting this unit can re-submit one or two Tasks (from any of the Qualitative, Quantitative or Evaluative Tasks) plus one (or two) of the new available Tasks **OR** complete three new Tasks (from the selection available for assessment on Interchange clearly marked with the current assessment year).

When a candidate re-sits this unit and uses up to two tasks from the previous session, the marks confirmed by the original Moderator in the previous session cannot be 'carried forward'; the re-submitted tasks should be reviewed in the light of the moderator comments and Teachers are advised to re-mark the Task in light of any comments made by the original Moderator (the Archive Mark Schemes are available on Interchange for this purpose) and it will be re-moderated when it is re-submitted. Thus the Centre must include one Qualitative, one Quantitative and one Evaluative Task for each candidate in the sample.

Where a candidate has not made any improvements to their marks on a 'new' task, they should not be entered (or if they have been entered, they must be withdrawn). Centres should ensure that the candidate number is the same on each piece of work that is submitted. The Cover sheet also allows for additional information to be given to the moderator, for example indicating that a task was previously submitted.

A number of Centres did not have available the work of candidates from the previous year. If a candidate is to resubmit work next year, then the candidate's work from this year must be kept securely. It is important that Centres review their procedures with regard to storing the work for next year.

Qualitative Tasks

Generally these tasks were marked to the published mark schemes. The marking criteria that were generously awarded were A1.2, B1.1 and B1.2.

For A1.2, candidates' responses must be detailed and the additional guidance given in the mark schemes should be followed. Annotation is helpful.

Where graphical work is requested in the Qualitative Tasks, candidates are not being assessed on the size of the graph or the labelling of the scales since this is assessed in the Quantitative Tasks. The graph may be used to judge the quality of an experiment. In addition, candidates may be assessed on their drawing of a straight line of best-fit or a smooth curve. This latter marking point was again generously awarded. There should be a balance of points about the line and 'hairy' lines should be penalised. Further guidance is given in the Practical Skills Handbook.

As has been stated in previous reports, for B1.2 candidates' answers must be detailed and explanations must be thorough – the guidance given the mark scheme should be followed. It is very helpful to indicate where the mark is awarded with an indication to the corresponding point in the additional guidance. Again Centres are welcome to email OCR for additional guidance or confirmation of marks awarded.

Quantitative Tasks

The mark schemes for the quantitative tasks are generic in nature and very much reflect good practical skills which candidates should develop throughout the course. To accurately mark these tasks, markers must check carefully the table of results, the graph and the various calculations towards the end of the task.

Centres are able to help candidates in setting up the apparatus (as indicated in the mark schemes); any help given must be recorded in the box on the front of the Task. Under no circumstances may Centres assist candidates in the construction of graphs or in the analysis section. Most candidates were able to set up the apparatus in the tasks without help. Centres that did provide help clearly indicated it; this was very helpful to the moderation process.

Results tables were generally well presented. The majority of candidates labelled the columns with both a quantity and the appropriate unit although weaker candidates often did not score this mark with the more complicated units. It is expected that there should be a distinguishing mark between the quantity and the unit. Index notation should be encouraged, e.g. $1/t^2$ / s^{-2} or t^{-2} / s^{-2} are encouraged.

All raw data should be included in a table of results and given consistently. Common errors in this part were to have inconsistent readings e.g. distances not measured to the nearest millimetre when using a metre rule or not to use a suitable full range. Often candidates recorded distances to the nearest centimetre although a small number added zeros so as to indicate that they had measured distances to the nearest 0.1 mm. When significant figures are assessed in the table, the guidance in the mark schemes must be followed. There still appears to be some confusion by candidates regarding the difference between decimal places and significant figures.

Graphical work was generally done well. When a candidate asks for another sheet of graph paper, a similar sheet should be issued. Weaker candidates often used less than half of the graph grid for their points. On the graph paper provided, it is expected that the points should occupy four large squares horizontally and six large squares vertically when the graph paper is portrait. When the graph paper is landscape the points should occupy four large squares vertically and six large squares horizontally. Centres should ensure that the graph paper is clear before giving the task to candidates. If it is not appropriate, then another similar sheet should be used, perhaps downloaded from the task individually.

Points were usually plotted accurately to within half a square. Often mis-plotted points were very obviously wrong; candidates should be encouraged to check points like this as they finish plotting graphs. The mark schemes very clearly state that "two suspect plots" should be checked and that these plots must be circled. The majority of candidates drew their line of best-fit with a fair balance of points. For the award of this mark there must be at least five trend plots. Centres were sometimes generous in awarding this mark.

Candidates will normally need to determine the gradient and/or the *y*-intercept of their line of best fit. It is expected that the gradient should be calculated from points on their best-fit line which are at least half the length of their line apart. Weaker candidates often lost marks either by using triangles that were too small or by working out $\Delta x/\Delta y$. Good candidates indicate clearly the points that they have used and show their calculation. Where candidates have used data from their table that does not lie on the line of best-fit, then this mark should be penalised. Centres should check the calculation. The plots selected must be accurate within half a small square and the calculation must be checked. Where candidates are not able to read off the y-intercept directly, it is expected that they should substitute a point on their line into the equation $y = mx + c$. Guidance is clearly given in the Practical Skills Handbook. Gradient/y-intercept values do not need units. Centres are asked to ignore both incorrect units and significant figures at this stage – candidates will invariably be penalised in C2.2.

Candidates are then required to use either their gradient or their y-intercept to determine another quantity. It is essential that candidates show their working. Candidates who do not use their gradient and/or y-intercept values cannot score C2.2 marks. The C2.2 marks are awarded for candidates who have used the gradient/y-intercept and given their answer to an appropriate number of significant figures and the second mark is awarded for the quantity being within a specified range with a consistent unit having used the gradient/y-intercept. It is at this stage that a power of ten (POT) error would be penalised.

The final mark for the quantitative task (C2.3) is awarded for justifying the number of significant figures. The phrase "raw data" is not explicit enough; candidates must explicitly quote the quantities that have actually been used. Thus, where a candidate states "I quoted my answer to 2 significant figures because that was the least number of significant figures in my data", the mark should not be awarded.

Evaluative Tasks

Again the Evaluative Tasks were where weak candidates had greatest difficulty. There are a large number of high demand marks in these tasks and Centres should not give credit for weak or vague answers. It is important that the additional guidance in the mark schemes is carefully followed.

The initial part of the task requires candidates to determine percentage uncertainties. When marking this part, significant figures should not be penalised. Centres were sometimes generously awarding the uncertainty in a measurement; it is important that the mark scheme is applied consistently.

Where candidates are asked to determine a percentage uncertainty in a quantity requiring the use of the gradient and/or y-intercept then the worst acceptable line should be drawn. In many cases, the worst acceptable line was generously credited for lines which often did not follow the original trend. It is expected that candidates will determine the gradient and y-intercept correctly for the award of this mark; small triangles, incorrect read-offs and incorrect calculations should be penalised.

In C3.2, there continues to be confusion between the terms *accuracy* and *reliability*. A number of centres were generous in awarding marks for a single sentence with ambiguous phrasing. It is suggested that candidates be encouraged to approach each term independently and allotting each a separate sentence. When candidates are discussing reliability they are expected to make a relevant point regarding the scatter of points about the straight line of best-fit. For the award of the accuracy comments such as "it is close to the accepted value" are not good enough for a mark – the answer needs to be more detailed with reference to the percentage uncertainty determined earlier.

For C4.1 and C4.2, the mark schemes allow for "one other <u>detailed</u> correctly identified limitation" and a corresponding improvement to this limitation. Again it was most helpful where Centres annotated the work with the actual marking point awarded e.g. C4.1 – 3 for the third limitation point. Weak candidates are still often describing the procedure they followed. Some candidates wrote very little of substance. Good candidates scored well by describing relevant problems and suggesting specific ways to overcome them. Vague suggestions without explanation did not gain credit. Centres should ensure that they credit detailed answers at this stage – candidates should clearly explain the limitations and not just list points. For example, a common answer from candidates is ‘parallax’ without indicating how the ‘parallax’ occurs. Other examples include ‘light gates’ or ‘motion sensors’ without explanation; credit must not be given. Centres should ensure that they follow the mark schemes carefully. Centres should not be awarding ‘benefit of doubt marks’. If a Centre wishes to gain further clarification then advice should be sought either by email or by using the coursework consultancy service.

The last part of each Evaluative Task (C4.3) requires candidates to identify one source of uncertainty and indicate the likely effect that this uncertainty would have on the quantity determined. Candidates should use a step-by-step approach and include the effect on the gradient and/or *y*-intercept. The reasoning by candidates must be consistent and correct for the award of this mark. Vague answers should not be credited.

Finally

Centres should receive an individual report from the moderator. This will be available from interchange – the Centre’s Examination Officer should be able to access the report.

Centres are always welcome to email OCR for clarification. There is also a coursework consultancy service available – further information is available from ‘Interchange’. It would be helpful if Centres could submit coursework consultancies as they mark the tasks and preferably by the end of the Spring term so that feedback can be given in good time before the 15th May deadline.

Finally this year’s and the previous years’ tasks, instructions and mark schemes continue to remain confidential. Furthermore candidates’ work from this year (and previous years) also continues to remain confidential. If there is a possibility of a candidate re-submitting the work, then the Centre must keep the work securely, otherwise the work should be destroyed securely in line with OCR’s policy for controlled assessment.

G484 The Newtonian World

General Comments:

The marks for this paper ranged from 0 to 59 and the mean mark was about 35. The majority of the candidates made good use of their time and completed the paper in the scheduled time of 1 hour and 15 minutes. Most candidates made an attempt to answer all questions.

Centres have continued to make good use of past papers, mark schemes and Examiners reports. Most candidates showed a good understanding of significant figures and rounding of numbers. However, candidates are reminded that it is poor practice to round numbers in the middle of calculations. It is always advisable to carry forward values to at least four significant figures.

Candidates scored freely in questions involving substituting into formulae but experienced more difficulty in questions where some manipulation of the formulae was necessary. Questions involving explanations were, as usual, more discriminating. In such questions many candidates lost marks by making unsupported statements.

There were some very good scripts with clearly laid out physics and well-presented calculations. A significant minority of the scripts were unfortunately poorly set out and this was particularly noticeable in the calculation parts of questions 1, 4 and 5. Poor presentation makes it very difficult for Examiners to follow the logical steps and can result in candidates losing compensatory marks. A minority of scripts suffered, once again, from poorly formed digits particularly in indices. Examiners also reported a slight increase in candidates amending working by overwriting.

Examiners reported an increase in the number of candidates quoting correct formulae involving squares or cubes which were then 'lost' in subsequent working.

The comments that follow tend to relate mainly to the opportunities that were missed by the candidates.

Comments on Individual Questions:

1(a)(i) This question was generally answered fairly well although a significant minority could not be awarded the mark as they did not specifically link the gradient to acceleration of the ball.

1(a)(ii) Although the underlying physics was fairly well known, this became a discriminating question because a large proportion of candidates did not specifically refer to the change in kinetic energy on impact.

1(b)(i) This synoptic question caused little difficulty to the majority of candidates.

1(b)(ii) While most candidates linked this question to impulse and were able to score the first mark, it was only a minority that appreciated the vector nature of the problem and were thus able to complete the calculation correctly.
Only a small minority attempted to solve the problem by using ratios from the graph or by determining the mean acceleration of the ball during impact.

1(b)(iii) A number of candidates gave answers which were larger than the initial height of release. Largely these were a result of errors in previous answers. It is always advisable to reflect on the value of answers which are dependent on earlier working.

2(a) Many candidates could not be awarded this mark because their answer did not emphasise the need for a resultant force to be acting.

2(b)(i)(ii) It was clear that candidates had been well prepared for this Newton's third law question. As a result many were able to score highly in both parts. The most common error made was concerning the location of the forces.

2(c)(i) Well answered by almost all candidates.

2(c)(ii) Most candidates realised that the weight of the fireman was required in order to calculate the force exerted by the ground. However, only a minority were aware that the vertical component of the water force would create an additional component. It was rare to see a diagram used to support the answer. The most commonly seen error was the attempt to include a resolved component of the weight of water ejected.

3(a)(i) Most candidates secured the first mark by identifying correctly the two points at the amplitude position.

3 (a)(ii) It was disappointing to see that only a small minority were able to distinguish the lagging point from the leading point. As a result this became a very discriminating question.

3 (b)(i) Most candidates gave a correctly shaped curved graph but only a minority were able to correctly locate the maximum point at 50 mJ.

3(b)(ii) Given the application of 'error carried forward' the majority were able to score full marks here. The most common error seen was the failure to correctly interpret the milli prefix in the energy units.

3(b)(iii) Many recognised the need to use $v_{max} = 2\pi f A$ to obtain the frequency and subsequently the period. On the whole the calculation was carefully done and the answer correctly rounded to at least two significant figures. It was pleasing to note that few candidates attempted to answer this question using 'suvat' equations.

4(a)(i) Most candidates did well and secured both marks although a significant minority did not convert the given radius to metre. This was one of the questions where the square was omitted from the radius resulting in an unrealistically low mass for Mars.

4(a)(ii.) Candidates were well prepared in this area and answered this question well using consistent, if not SI, units. Most found it easier to use $g = \frac{GM}{(R+h)^2}$ together with their answer from (i) rather than a ratio method.

4(b)(i) Although Kepler's law was well known, many lost the mark by failing to identify carefully the terms used in the law.

4(b)(ii) Apart from a few cases where either the square or cube was omitted, candidates coped very well with this question. This clearly reflects a thorough preparation in Centres for this important topic. A small number of candidates lost marks through inconsistent units. An even smaller number approached the problem by the ratio method which would have eliminated much of the arithmetical work.

4(c) This discriminating question caused many candidates difficulties and even those who realised that the speed would increase were unable to convince Examiners with their reasoning. The expected energy method was rarely seen, unfortunately, as it is by far the easiest method to explain.

5(a)(i) Question 5 was specifically aimed at the high level candidates whilst giving some hints to enable others to score a proportion of the marks. Many were able to use the diagram to correctly identify the separation of the stars and so score the mark for the gravitational force.

5(a)(ii) Most candidates were aware that $F=mv^2/r$ was to be used with appropriate modification of the terms. Unfortunately many omitted the square when substituting for v and almost as many failed to square the period as well as the $2\pi R_1$ when undertaking the required simplification.

5(b) This question was deliberately written in 'show' format to enable all candidates to attempt part (c) on an equal footing. The proof depends on the fact that the forces on the stars are of equal magnitude and although many used this idea it was rarely stated explicitly nor linked to Newton's third law. The mark scheme was designed to enable these candidates to score marks as well as those forced to start from an incorrect formula derived in a(ii).

5(c) This part of the demanding question gave little trouble to the majority. The number of candidates giving 'reversed' answers was very small which was pleasing.

5(d) Most candidates were able to score one if not two marks particularly given the application of error carried forward.

5(e) As expected only the very able candidates were able to apply the hints given in the earlier parts of the question and so obtain the correct mass for the second star. Many attempted to apply the simplified form of Kepler's law to the problem despite the similarity in the masses of the two Stars. The Examiners decided to award a compensatory mark to those using this approach, who obtained an answer consistent with the given data. Almost as many equated the centripetal force to the force obtained from Newton's law but unfortunately did not use the correct separation of the stars despite the hint in a(i). They too were awarded a compensatory mark if they obtained a consistent answer.

6(a) Many of the answers here lacked precision and it was common for marks to be lost by implying thermal energy was created as the pellets were falling rather than on impact at the end of the tube.

6(b) Despite the poor start in (a) the vast majority scored highly in this part, indicating that candidates were well aware of the underlying physics in this experiment. Only a small number converted the rise in temperature into 277.5K which was a pleasing improvement on previous years.

6(c) The rather vague 'heat lost to surroundings' response was commonly seen.

6(d) The explanation of the physics involved in this experiment caused much difficulty even to able candidates. A significant number thought that the temperature rise was proportional to the gravitational potential energy and lost both marks.

7(a) The majority of candidates did not appreciate that this question was limited to ideal gases and consequently consideration of changes in potential energy of the molecules was inappropriate. This resulted in the loss of the first mark. The second mark was also rarely scored because candidates did not specify clearly that the temperature of the gas must be measured on the kelvin scale. This important distinction in the temperature scales appeared to have been unwisely assumed by the majority of candidates since most were aware that it was necessary to convert to kelvin scale in the calculations that followed.

7(b)(i) This calculation was generally well answered with a clear layout. Only rarely were errors seen in the determination of the number of moles of helium or in the appropriate temperature of the gas.

7(b)(ii) The number of moles remaining in the balloon was determined accurately by almost all candidates. Some, however, unfortunately overlooked the fact that the question asked for the number escaping and left their answer as 8700 mols.

G485 Fields, Particles and Frontiers of Physics

General Comments:

The marks on this paper ranged from 0 to 98. The mean mark of about 63 was higher than in previous years and showed the accessibility of the paper. The omission rate for most questions was very low and the majority of the candidates finished the paper in the scheduled time.

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 for some candidates.

- 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 carefully examining the requirements of some questions. It is important that technical terms are used carefully, especially in questions assessing the quality of written communication. The best scripts once again showed clarity of thought, careful preparation and a good understanding of the physics being tested.

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 a small number of candidates' work remains a serious concern. In some cases examiners found it difficult to decipher words and numbers.

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) Most candidates correctly used either $F = BIL$ or $F = BQv$ to determine the tesla in terms of kg, C and s. The answers were well-structured with majority of the candidates scoring two marks. The most common error from the low-scoring candidates was to quote the unit for force as kg instead of kg m s^{-2}.

1(b)(i) The majority of the candidates did extremely well in this question. The physics was clear and the manipulation of the equations was easy to follow. The majority of the candidates scored two or more marks. Many candidates had the confidence to derive an equation for the magnetic flux density B and then substitute the values. The most frequent error was to use the diameter of 5.0 cm as the radius of the circular path of the electrons.

1(b)(ii) In order to calculate the period, candidates had to divide the circumference of the path by the speed. This was effortlessly done by most candidates. There was error carried forward rule applied for candidates who used 5.0 cm as the radius in **(b)(i)**.

1(b)(iii) The answers were varied. Top-end candidates often opted for a mathematical approach. A significant number of candidates gained no marks. The most common answers from such candidates was '*distance travelled increases, so period must be the same*'. A few candidates thought that the period had something to do with the relativistic increase in the mass of the electron.

2(a) Almost all candidates picked up two marks for correctly identifying two errors with the field pattern shown in Fig. 2.1. The three most popular responses were:

- *The direction of the field should be from positive to negative.*
- *The field lines should be perpendicular to both plates.*
- *The separation between field lines cannot be the same; it's a non-uniform field.*

2(b)(i) This was a discriminating question, with many top-end candidates gaining full marks. The answers showed careful reasoning and good graphical skills. The charge Q on the nucleus was given by the equation Q = gradient $\times 4\pi\varepsilon_0$. The success in this question relied on the correct determination of the gradient.
Many of the low-scoring candidates either failed to recognise how Q was related to the gradient or found determining the gradient challenging. For example, instead of the gradient being $\dfrac{1.0\times10^{21}}{8.0\times10^{27}}$, it either became $\dfrac{1.0\times10^{21}}{\mathbf{8.0^2}\times10^{27}}$ or $\dfrac{1.0\times10^{21}}{\mathbf{\frac{1}{8}}\times10^{27}}$. Examiners awarded one mark for the gradient, where power of tens was ignored and the final mark was for the value for *Q.*

2(b)(ii) Most candidates scored two marks for recognising that the charge on the daughter nucleus was less and this meant that the gradient of the line would decrease. A significant number of candidates mentioned the gradient decreasing but gave the reason as '*the alpha particle has a smaller charge than the nucleus*'. A small number of candidates considered the effect on $1/r^2$ caused the loss of two protons and did not score any marks.

2(c)(i) The modal mark for this tough question was three. Most candidates correctly calculated the mass or the weight of the droplet and the electric field strength between the parallel plates. These quantities were correctly used to calculate the magnitude of the charge on the droplet. Some top-end candidates demonstrated excellent algebraic skills by deriving an equation for the charge and then substituting values to get an answer of 1.12×10^{-18} C. The most common error was to calculate the electric field strength using $E = \dfrac{V}{d}$ and then to spoil the answer by using $E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$ to determine the charge *Q.*

2(c)(ii) Most candidates quoted the number of electrons responsible for the charge to be 7. Examiners were expecting the answer to be integer, so an answer such as 6.9 was not allowed.

3(a)(i) About half of the candidates gave a decent definition for magnetic flux linkage. The other half showed poor recall of *magnetic* ***flux*** by confusing it with *magnetic* ***flux density***. This was a missed opportunity for picking up an easy mark. Lack of knowledge here also led to poor answers in **(a)(ii)**.

3(a)(ii) The success here depended on knowing the term *magnetic flux linkage* and not confusing it with *magnetic flux.* The question discriminated well with many top-end candidates effortlessly picking up two marks. A significant number of candidates did not use the hint on 'circumference' in the question and attempted to determine the number of turns N using πr^2 rather than $2\pi r$. It is worth reminding all candidates that in a 'show' question, it is vital to clearly set out all the steps of the calculation. Some intermediate explanation is also advisable.

3(b)(i) Most candidates gave a perfect definition of the Faraday's law of electromagnetic induction. Only a small number of candidates gave vague answers or omitted the question.

3(b)(ii) Having just given a statement for Faraday's law of electromagnetic induction, many candidates drew a correct graph for induced e.m.f. *E* against time *t.* The graph was a cosine graph intersecting the time axis at 1.0 ms, 3.0 ms and 5.0 ms. Inversion of this graph was ignored by the examiners. Many of the sketched graphs were neither smooth nor regular, but enough correct physics was demonstrated for two marks. A range of incorrect answers were seen, including sine, triangular and square graphs.

3(c) Candidates always find questions on electromagnetism rather challenging and this was no exception. About a third of the candidates gave flawless answers to explain how an e.m.f. was induced in the secondary coil of the transformer. Some candidates lost a mark for not mentioning that the iron core transferred the alternating magnetic flux from the primary coil to the secondary coil. A small number of candidates thought that iron core transferred the '*alternating current between the transformer coils'*.

4(a) The success in this question relied on knowing that each capacitor in a series circuit stored the same charge. Failure to mention this important idea led to no marks. This question favoured the top-end candidates, who once again gave brief answers such as '*the charge is the same on each capacitor and the p.d. is twice because* $V \propto 1/C$'. Some candidates attempted to answer the question in terms of sharing p.d., but without mentioning the charge being the same for each capacitor.
Weaker candidates often spoilt their answers by referring to the current being the same in a series capacitor, no doubt confusing the circuit with resistors in series.

4(b) The answers to this question were generally well-structured and easy to follow. Most candidates were familiar with the equations to determine the total resistance, total capacitance and time constant. Only a small number of candidates struggled with the prefixes kilo k and micro μ. The two most commons mistakes in the calculations were:

- total capacitance = 400 μF
- total resistance = $18 + (18^{-1} + 18^{-1}) = 18.1$ kΩ

4(c)(i) This question proved to be both challenging and discriminating. The majority of the upper quartile candidates scored two marks for calculating the initial charge stored by the capacitor. Many of these candidates derived and used the equation 'initial charge = I_0RC' or 'initial charge = $I_0 \times$ time constant'. A significant number of candidates got nowhere by using the exponential decay equation or determining the area under the curve.

4(c)(ii) Although the modal mark for this question was one, the discharge curves were often poorly drawn. Most candidates did figure out that the time constant of the circuit was halved, but very few realised that the initial discharge current was 3.0×10^{-4} A. Just as in **3(b)(ii)**, candidates do need to improve their graph sketching skills.

5(a)(i) More than half of the candidates got the right answer $2\,{}^{1}_{0}\mathrm{n}$. The most frequent errors were ${}^{2}_{0}\mathrm{n}$ and using capital N for the neutron symbol.

5(a)(ii) The majority of the candidates correctly identified the electron ${}^{0}_{-1}\mathrm{e}$ and the antineutrino $\bar{\nu}$ in the decay equation.

5(b)(i) This was a good discriminating question with most candidates calculating the decay constant in s^{-1} and the activity of the source. Calculation of the mass of plutonium required knowledge of $A = \lambda N$ and molar mass and this is where the top-end candidates showed excellent analytical skills. A small number of candidates used 120 W instead of 200 W and got an answer of 0.21 kg; such an approach was awarded three marks.

5(b)(ii) The modal mark for this straight-forward question on kW h was zero. Most candidates overcomplicated the question by converting time into seconds and some even tried to link efficiency of the RTG in their answers. Only about 1 in every three candidates got the correct answer of 2.9 kW h.

6(a) Candidates answered this question well. The two most popular answers were '*Hadrons contain quarks'* and '*Hadrons feel the strong (nuclear) force'*. Only a small number of candidates gave weak answers such as '*Hadrons are heavy particles*' and *'Hadrons are not fundamental particles*'.

6(b) Almost all candidates correctly quoted the charges on the up and the down quarks. A small number of candidates omitted the minus sign for the charge on the down quark.

6(c) This was a very high scoring question with almost all scripts having the answer uud.

6(d) This was an unfamiliar question and required careful scrutiny of the question. Most candidates arrived at the correct quark combination for the pion. A range of methods were used, including the conservation of charge. Some answers were brief, almost intuitive.

6(e)(i) The Einstein's mass-energy equation was quoted well by most candidates. A small number of candidates spoilt their answers by using *mass defect* to mean 'change in mass Δm' and *binding energy* to mean 'change in energy ΔE'.

6(e)(ii) This was another well-answered question with clear conversion of energy from electronvolts to joules and correct application of the mass-energy equation. A very small number of candidates ignored the energy 1.4×10^8 eV and determined the difference in the mass of the neutron and mass of the proton using the Data, Formulae and Relationship Booklet. This gave the incorrect answer of 2.0×10^{-30} kg.

7(a) A range of responses were accepted by the examiners. This meant that the majority of the candidates scored one or two marks for describing the difference between fission and fusion reactions.

7(b) This question produced a range of marks. Most candidates knew about the repulsion between the nuclei (protons). Many also mentioned the high kinetic energy of the nuclei required for fusion but it was difficult to establish whether this was due to the temperature or the pressure. Answers such as '*High temperatures **and** pressures make the protons move faster'* were quite common. A significant number of candidates realised that high pressures helped to increases the chance of fusion reactions because of the closeness, or high concentration, of the nuclei.

7(c)(i) Top-end candidates were familiar with thermal neutrons splitting the uranium nucleus into two smaller nuclei. Some candidates lost a mark for not mentioning the thermal neutrons. A small number of candidates thought that this reaction was triggered by high-speed electrons.

7(c)(ii) The answers to this question were generally well-structured and easy to follow. Most candidates were familiar with the expression $\frac{3}{2}kT = \frac{1}{2}mv^2$. Very few candidates used 300 °C instead of 573 K in their calculations.

8(a) There were many missed opportunities when answering this question on the three attenuation mechanisms: photoelectric effect, Compton effect and pair production. The description of how X-rays interact with matter was variable, with some very general answers about absorption coefficients to detailed and accurate descriptions of all three mechanisms. It was important to mention a **photon** in all three methods and the idea of a one-to-one interaction of the photon. A significant number of candidates scored no marks because of vague answers such as '*In the P.E effect, an X-ray ejects electrons'*. Very few candidates scored the QWC mark. Examiners were happy to award a mark for a statement such as '*there are fewer photons (per unit time) detected'*.

8(b)(i) Most candidates picked up two marks for calculating the energy of a photon of wavelength 1.4×10^{-11} m. There were very few errors and the omission rate was less than 5 %.

8(b)(ii) This was a perfect question for the upper quartile candidates. The answers from these candidates showed excellent understanding of the exponential decay equation and natural logs. The absorption coefficient μ was equal to the - gradient of the straight line on the ln (I) against *x* graph. Middle and low scoring candidates struggled to determine the gradient because of misunderstanding of the ln (I) values. This is illustrated with the following incorrect answers:

- $\mu = \dfrac{\ln 2.15 - \ln 1.95}{1.0} = 0.098\ \text{cm}^{-1}$
- $\mu = \dfrac{e^{2.15} - e^{1.95}}{1.0} = 1.56\ \text{cm}^{-1}$

The correct analysis was much simpler; $\mu = \dfrac{2.15 - 1.95}{1.0} = 0.20\ \text{cm}^{-1}$

9(a) The modal mark for this question was three. The answers once again showed good structure and understanding of the key concept, which was angular frequency in the case. A small number of candidates confused angular frequency in rad s^{-1} with frequency in Hz. Although this is a serious mistake, examiners awarded one mark for the answer of 0.75 m.
Candidates are once again reminded not to leave the final answer in terms of π. Answers must be calculated to the correct number of significant figures in the final answer. The only exception to this rule would be phase differences in radians.

9(b) Relaxation time is not easy to define at this level. So examiners were very pleased to see answers such as '*It's the time taken for the protons to jump from high energy level to the low energy level by emitting a photon*'. The majority of the candidates scored one mark for a plausible definition for relaxation time.

10(a) Most candidates knew about the piezoelectric effect but some lost the mark for describing the effect as '*application of a voltage produces vibration'*. It's an **alternating** p.d. that would produce vibrations in the material.

10(b)(i) Acoustic impedance was correctly defined by almost all candidates. The most frequent slip was to confuse the speed of ultrasound *c* with the speed of light *c*.

10(b)(ii) It was the brief answers that often scored a mark. No credit was given for incorrect physics such as:

- *The speed of ultrasound is greater in air.*
- *The frequency of ultrasound is different in the body.*

10(c) The modal mark for this question was three, with most candidates answering the question with confidence and familiarity. The most common mistake was to leave the answer as 1.02 %. Surprisingly, a small number of candidates made an error when subtracting 1.02 from 100; the answer was given as 98.

11(a) Examiners concluded that it was the lack of understanding of the term ‘subtended’ in the question that caused confusion. Only a third of the candidates used simple trigonometry to arrive at the correct answer of 0.31°. Some of the answers were very large, e.g. 89°. Such an angle did not register as being unrealistic.

11(b) This was another confidently tackled question. The Doppler equation was used well, with most answers for the change in wavelength given in nm. A very small number of candidates struggled to convert their answer of 5.5×10^{-10} m into nm.

11(c) The modal mark for this question was four and about a third of the candidates scored nothing for their work. A range of methods were used to arrive at the correct answer of 3.0×10^{10} stars in the Andromeda galaxy. The most popular route was starting off with the expression $\frac{GMm}{r^2} = \frac{mv^2}{r}$. A significant number of candidates also successfully used the equation for Kepler’s third law. On the whole, candidates demonstrated admirable analytical and calculator skills.

12(a) The enthusiasm and knowledge of the evolution of the Universe jumped out from most scripts. The majority of the candidates scored three or more marks. A significant number of candidates used additional answer space to describe the evolution of the Universe after the formation of the atoms. This was not required by the question, but candidates were keen to describe the entire evolution, culminating with the current temperature of 2.7 K.

12(b) Most candidates gave a clear definition of Hubble’s law. A small number of answers were spoilt by omitting ‘*galaxy’* or using an inappropriate object (*star* and *planet*) in the definition.

12(c)(i) This was an impressively answered question. The critical density equation was manipulated correctly to calculate the Hubble constant in s^{-1}. Once again, the algebraic and calculator skills were superb. A very small number of candidates used the critical density of 8 (kg m^{-3}) and this gave an incorrect answer of 6.7×10^{-5} s^{-1}.

12(c)(ii) The omission rate for this question was very low indeed and it was a good to see that most candidates gained two marks for calculating the correct age of the Universe. A small number of candidates also scored full marks for 4.7×10^{-4} y thanks to error carried forward from the previous incorrect answer of $H_0 = 6.7 \times 10^{-5}$ s^{-1}.

G486/02: Practical Skills in Physics 2

General Comments:

Centres continue with confidence in the interpretation of the standards required for this assessment.

The annotating of candidate work continues to improve and is found to be very helpful by moderators in determining how candidate responses have been interpreted.

The lack of information on the cover sheets of a significant number of candidates hampered the administration procedure.

A small minority of the work sampled still showed random ticks, some for statements that were incorrect.

Most centres adhered strictly to the mark schemes. Many centres made contact with OCR over the past year and were able to clarify their queries making the moderation of these centres straightforward.

Qualitative Tasks

Generally Centres marked these tasks accurately and consistently.

A1.2 continues to be a place where generous marking is applied for phrases such as 'I measured from eye level'. In order for candidates to be given credit here, it is necessary for a degree of explanation to include *what is being measured*, *where the scale is in relation to the object* and why *moving the head to a position normal to both object and scale* is desirable.

Where graphical work is requested in the Qualitative Tasks, candidates are not being assessed on the size of the graph or the labelling of the scales since this is assessed in the Quantitative Tasks. The graph may be used to identify a trend. In addition, candidates may be assessed on their drawing of a straight line of best-fit or a smooth curve. It was common to see this mark credited for lines drawn with a thick pencil. This latter marking point was again on occasion generously awarded. It was quite common to find lines of length 25 cm drawn using a 15 cm ruler, producing two slightly differing gradients along the length. Further guidance is given in the Practical Skills Handbook.

Candidates were able to offer some A2 physics in their explanations in B1.2. It is expected for the award of these higher level marks that detail is incorporated in a response before credit is given. It is important when marking the physics in B1.2, that credit is not given for unrelated physics. Explanations must be thorough and linked to the practical observations made.

In the specific heat capacity qualitative task, it was common to see the response 'the mass might not be in thermal equilibrium' with no detail as to where or when in the procedure this occurred. Many centres credited this unrelated phrase as it appeared word for word in the mark scheme.

Quantitative Tasks

It is expected that most candidates should be able to follow instructions, record measurements taken in an appropriate table of results and plot a suitable graph. It is essential that candidates are taught to include **all raw data measured** in their **table** of results.

Results tables were generally well presented. The majority of candidates labelled the columns with both a quantity and the appropriate unit.

A number of candidates did not relate the number of significant figures in raw data with the number of decimal places quoted in the lg value and confusion continues to exist. A small number of centres are still misinterpreting the application of this mark scheme point.

The C1.2 mark for the line of best fit was still found to be awarded generously by a few centres. While most teachers are following the mark scheme guidance and ringing two suspect plots, there are still centres who fail to put any annotation on the graph and just use the mark boxes.

In the graphical skills a few centres were still penalising candidates whose plots fulfilled the 4 (across) x 6(up) large square grid criteria in portrait mode, but whose plots did not look like they covered more than half of the graph. (See the Practical Skills Handbook.)

Candidates will normally need to determine the gradient and/or the *y*-intercept of their line of best fit. It is expected that the gradient should be calculated from points on their best-fit line which are **at least half the length of their line** apart. Weaker candidates sometimes lost marks either by using triangles that were too small or by working out $\Delta x/\Delta y$. Candidates should be encouraged to indicate clearly the points that they have used and to show their calculation. The plots selected must be accurately read to within half a small square and the calculation must be checked. Where candidates are not able to read off the *y*-intercept directly, it is expected that they should substitute a point on their line into the equation $y = mx + c$. Guidance is clearly given in the Practical Skills Handbook. Gradient/*y*-intercept values do not need units. Centres are asked to ignore both incorrect units and significant figures at this stage – where mistakes are made in the units, candidates will invariably be penalised for this in C2.2.

Candidates were generally very good at showing their workings in the calculation of the gradient. There were again fewer small triangles used on the graph. The C1.3 mark should not be awarded if the points used came from the table of results rather than from the line of best fit (unless the two points chosen were both situated on the line).

The justification of the number of significant figures quoted in the final answer C2.3 still proves a stumbling block, both for candidates and some teachers who are crediting responses such as 'I quoted my answer to 2 significant figures because that was the least number of significant figures in my data.' Candidates must make reference individually to each quantity that contributes to the final answer.

Evaluative Tasks

The Evaluative Tasks continue to be challenging for weaker candidates. There are a large number of higher demand marks in these tasks and Centres should not give credit for weak or vague answers.

The pattern of candidate response is unchanged from last year with the calculation of 'uncertainty' in measurements and the percentage difference calculation generally being well done.

For C4.1 most candidates were able to gain credit for stating two limitations. Vague statements were again given credit by some centres and where the mark scheme was not followed, it was not unusual for those candidates to lose 2 or 3 marks, almost certainly bringing the centre out of tolerance.

For C4.1 and C4.2, the mark schemes allow for two "**detailed** correctly identified limitations" and corresponding **detailed** improvements to these limitations. Most candidates were able to gain credit for stating two limitations. Vague statements were again given credit by some centres and where the mark scheme was not followed it was not unusual for the moderator to differ in the award of marks to candidates sometimes by as many as 3 marks in this section alone. This usually resulted in the centre falling outside of the tolerance. The C4.2 improvement must be linked to an identified limitation.

The Future

The Tasks for the final resit opportunity in 2016/17 were published in June 2016. One Qualitative, one Quantitative and its associated Evaluative Task have been replaced. The tasks that have been replaced **must remain confidential**. Where a task has not been replaced, it is essential that centres use the current versions (identified at the bottom of each page by *'For assessment use between 1 June 2016 and 14 May 2017')* as in some cases, subtle changes have been made to reduce ambiguity. Consequently mark schemes may also have been adjusted. These changes have been made to assist candidates in their answers.

Centres are always welcome to email OCR for clarification. There is also a coursework consultancy service available. It would be helpful if Centres could submit coursework consultancies as they mark the tasks. Last year a number of consultancies were requested very close to the 15th May deadline which left little time for centres to implement necessary changes following feedback.

Finally, all of last year's tasks, instructions and mark schemes continue to remain confidential.

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