OCR
Oxford Cambridge and RSA

GCE

Physics A

Advanced GCE **H558**

Advanced Subsidiary GCE **H158**

OCR Report to Centres June 2014

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 0 to 60 and the mean mark was about 31. The majority of the candidates made good use of their time and completed the paper in the scheduled time of 1 hour. Most candidates made an attempt to answer all the questions and there were fewer omissions than previous session.

Centres have continued to make good use of past papers, mark schemes and examiners reports. Candidates did marginally better with stating definitions, using technical vocabulary and tackling multi-stage calculations. Most candidates showed a decent understanding of significant figures and rounding-up of numbers. All candidates are once again reminded that it is poor practice to round numbers up or down in the middle of long calculations. It is best to carry forward calculator values. Examiners were generous this session, but this poor technique will be penalised in the future. There were fewer transcription errors from the Data, Formulae and Relationships Booklet.

Some descriptive responses lacked structure and careful argument. Good answers were frequently spoilt by contradictory statements. If it helps, candidates can always communicate their ideas in the form of bullet points. There was a significant improvement in the comprehension of command words (e.g: state, define, describe, etc) used in the paper.

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:

Question	Comments
1(a)	Candidates answered this opening question extremely well, with most giving a perfect definition for velocity. Vague answers such as '*velocity is the speed in a certain direction*' and '*rate of change of displacement per unit time'* were not allowed. Candidates are reminded that a definition of a physical quantity must not contain any units. Therefore, velocity defined as '*change in displacement per second*' is simply incorrect.
1(b)(i)	A significant number of candidates struggled to convert the speed of 70 km h^{-1} into m s^{-1}. Quite often, 70 000 was substituted to give an enormous value of 3.2×10^{11} J for the kinetic energy of the ostrich. Candidates are once again reminded not to truncate or round numbers in mid-calculations and to be vigilant of powers of ten. A small number of candidates also failed to square the value of speed after correctly writing the equation for kinetic energy. The answer below, which was common with the low-scoring candidates, was awarded two marks. KE = ½ mv^2 = ½ × 130 × 19.4 = 1200 J.
1(b)(ii)	Many candidates answered this question well and secured one mark with answers such as the '*Mononykus has eighth the mass'* and '*the mass would be* $130/2^3$ = 16.25 kg'. The second mark was reserved for good reasoning in terms of the density equation and the assumption that the mean density of the ostrich and the Mononykus were similar. Only the top candidates secured this mark.

2(a) Candidates, across the ability spectrum, did well with this question. Candidates demonstrated an excellent knowledge of the principle of moments and the resolving a vector (the tension *T* in the string). The most common errors were using sin40° instead of cos40° and not converting the mass of 1.2 kg into the weight of the object when taking moments about the support.

2(b) Many candidates wrote a great deal. The important idea that the horizontal component of the tension meant that there had to be a horizontal force at the support eluded most candidates. Many answers either stated the principle of moments or mentioned the toppling of the object. Only a small fraction of the candidates at the top-end gave flawless answers.

3a(i) Candidates answered this question well; many scored full marks. The two main physical properties outlined by the candidates were *brittle* and *elastic*. One of the two marks was dependent on the correct spelling of the term 'brittle'. A few answers were spoilt with inappropriate references to either ductile or malleability. Examiners did not consider '*obeys Hooke's law*' as a characterising physical property of the wire.

3(a)(ii) Most candidates did well and secured two marks for drawing a steeper straight line through the origin and then a variety of allowable curved-sections illustrating plastic deformation.

3(b)(i) Most candidates answered this question extremely well and gained two marks for the answer of 9.0×10^{-5}. One significant figure answer was allowed because the digit after the decimal point was a zero. Any additional unit inserted after the numerical value was ignored by the examiners.

3(b)(ii) Most of the answers here showed good structure with excellent use of the equation stress = force/cross-sectional area. Substitution of numbers was clear and the answers were often quoted in standard form. A disproportionate number of candidates spoilt their answers by doing the following:

- Using either $2\pi r$ or $(\pi r)^2$ to determine the cross-sectional area.
- Multiplying or dividing the correct value of the tension by either 2 or cos12°.
- Using the value of the Young modulus instead of the stress value in the calculation.

3(b)(iii) The vast array of answers demonstrated excellent knowledge of resolving vectors and of triangle of forces. The majority of candidates opted for the route $2T\sin 12° = W$. Some drew correct triangle of forces and then successfully applied either the sine rule or the cosine rule to get the correct answer. Candidates who forgot that there were two cables and got an answer of about 7900 N, were awarded two marks.

4(a)(i) About a quarter of the candidates ignored the instruction that air resistance had negligible effect on the motion of the ball and gave incorrect answers in terms of drag. The vast majority of the candidates gave succinct answers such as '*the only force acting is the vertical weight*' and '*there is only vertical acceleration of g*'.

4(a)(ii) Most candidates sketched the correct path of the ball after hitting the vertical wall. Many candidates struggled to explain the time of fall for the rebounding ball. Candidates who were confident with projectile motion managed to pick up at least one mark for stating that the time was the same. The two most frequent incorrect answers were:

- The time is greater because the kinetic energy is reduced.
- The time is smaller because the distance travelled is less.

Too many candidates were using the term *gravity* to mean either *gravitational force* or *acceleration due to free fall.* It is best to avoid using the term gravity at this level.

4(b) The answers to this question were good. Most candidates opted for $s = ½\ at^2$ and gave clear description of how the distance and the time were measured. A significant number of candidates mentioned calculating the final velocity by dividing the distance of fall with the time; failing to realise that this would give the average velocity. A small number of candidates decided to plot distance against time^2 graph and got the acceleration of free fall by multiplying the gradient of the graph by two. This was a long but an acceptable method.

4(c)(i) Most candidates scored more than two marks for their descriptive answers. Most candidates did appreciate that the ball had a constant deceleration whilst moving up the slope. It was important to qualify the constant nature of the deceleration. Candidates were frequently switching between the terms acceleration and deceleration. Examiners were happy to condone this as long as there were no serious contradictions. There was a mark for realising that the ball stopped momentarily at time t = 1.5 s and another for appreciating that the ball came back down the ramp.

4(c)(ii) Most candidates scored full marks by determining the maximum distance travelled from the area under the graph from t = 0 to t = 1.5 s. A significant number of candidates also used an equation of motion to determine this distance. Success with this method depended on using the correct negative sign for the acceleration a in the equations $s = ut + ½\ at^2$ or $v^2 = u^2 + 2as$. A disappointing number of candidates misread the graph.

5(a)(i) Most candidates recognised that the acceleration of the golf ball immediately after release would be g or 9.81 m s^{-2}. Some candidates failed to scrutinise the question and ended up describing terminal velocity.

5(a)(ii) The vast majority of the candidates picked up a mark for '*weight* = *drag*'. The statement '*net force* = 0' was true but did not answer the question which required a response in terms of the two significant forces acting on the golf ball.

5(a)(iii) Most candidates identified the golf ball to have the greater terminal velocity. Many recognised that the final drag force on this ball had to greater because of its greater weight. Since drag $\propto$ speed^2, this lead to the correct conclusion that the golf ball was the one with the greater terminal velocity. Some low-scoring candidates were convinced that both balls would have the same terminal velocity because '*mass does not affect acceleration of free fall*'.

5(b)(i) The success in this question rested on determining the correct value of the net force acting on the lorry. Most candidates read off the value of the drag force correctly from Fig. 5.1 and then went on to calculate the correct value of the instantaneous acceleration. No marks were awarded for 3200 N being divided by the mass of the lorry. This was prevalent amongst the low-scoring candidates. This question discriminated well, with the majority of high-scoring candidates scoring full marks.

5(b)(ii) Examiners allowed a variety of responses here. The key idea was to recognise that the drag force at 40 m s^{-1} was greater than the forward force provided by the lorry. Most candidates gained a mark for their answers.

5(c) The majority of the candidates scored two or more marks. Most candidates expressed their ideas well in terms of either $F = ma$ or $Fs = \Delta KE$. The answers showed a good understanding of this topic. Generally, candidates made good use of technical terms.

6(a) The majority of the candidates gave a perfect definition for work done by a force and scored a mark.

6(b) There were many answers here such as '*work done increases*' and '*net force on the crate is zero*'. However, only a small number of candidates appreciated that the work done against the frictional forces generated thermal energy.

6(c) Most candidates gave either a brief (1 W = 1 J s^{-1}) or a verbose (watt is when 1 J of work is done per unit second) definition for the watt. On some scripts, it was difficult to untangle the answers – it was not clear if power or the watt was being defined.

6(d)(i) It was important for candidates to determine the vertical height gained by the digger before any marks could be gathered. A pleasing number of candidates successfully used 60 m to calculate the rate of work done of 3.4×10^4 J s^{-1}. No marks were awarded for the direct use of either 75 m or 45 m, instead of 60 m, when determining the gain in gravitational potential energy.

6(d)(ii) Efficiency was well understood. Most candidates effortlessly substituted the correct values to get an efficiency of 20%. Many candidates also benefitted from the error carried forward (ecf) rule applied to their values from 6(d)(i).

7(a) With the answer given, and this being a show question, most candidates managed to correctly apply the equation $F = kx$ to answer the question.

7(b)(i) This was a discriminating question that favoured the top-end candidates. The answers from such candidates were well-structured and showed good understanding of elastic potential energy. A significant number of candidates struggled with the equations and the information provided in the question. A disappointed number of candidates assumed that the force constant of the spring was the 'F' in the equation $E = ½ Fx$.

7(b)(ii) This proved to be a tough question for candidates, with many unable to determine the net force acting on the object. Some candidates either attempted to use equations of motion to solve the problem or divided the weight of the object by its mass to get 9.81 m s^{-2}. This question did favour the top-end candidates who had no problems arriving at the correct answer of 6.5 m s^{-2}.

G482 Electrons, Waves and Photons

General Comments:

Candidates scored across the range from zero to about 95%. There were some excellent papers but also many lacking basic GCSE knowledge. Most candidates appeared to have enough time to complete the paper but some weaker ones failed to do so either through lack of time or lack of knowledge of the particular topics in the last question. Candidates scored freely in questions where the exercise was mainly substituting into formulae but there were fewer opportunities to do this than in recent papers. Where explanations were required the answers proved to be more discriminating, especially in Q1 and Q6. Good candidates were able to demonstrate their knowledge on the wide range of topics covered. Weaker candidates appeared to find most of the paper accessible.

The quality of the setting out of work especially of calculations was often very poor making it difficult for the examiner to follow. However, there were fewer rounding or significant figure errors. Much of the handwriting is still very difficult to decipher, most frequently in cases where it is very small, especially when writing powers of 10. Candidates should be reminded that the examiner has to read their answers on a computer screen.

Many candidates fail to describe situations accurately by using incorrect terms, by using casual phrases or by omitting key words; for example in Q7 waves *bounce off the walls* rather than are reflected at the walls. It was not uncommon in Q1 or Q2 to read phrases like *voltage through* rather than potential difference across.

The explanations, relating to polarisation in Q6, often referred to the *waves travelling through* rather than to the direction or plane of oscillation of the waves.

Candidates should consider any section of a question as part of a whole, rather than approaching it as a separate question, instead of fitting it into a bigger picture. This was especially evident for example in Q1 where the data on the figure and the information in part (a) were all clues towards the description required in part (b).

Comments on Individual Questions:

Question No.

1 (a) Most candidates stated clearly that p.d. was not proportional to current or wrote a similar statement so few did not score the first mark. Again most were able to calculate the resistance near the origin as 10 ohm but few explained that they were approximating the initial section of the graph to a straight line.

Most realised that the change in resistance is related to a change in temperature but many did not associate the heating effect with current. A minority still related the change only to the change in gradient of the graph. There were also many unnecessary explanations in terms of electron-ion collision models, trying to justify the resistance increase.

(b) Discerning candidates successfully used a potential divider argument but initially ignored the fact that the lamp is in parallel with the LDR. This error hardly changes the analysis when the LDR resistance is very small but gives answers which would fuse the lamp filament when the LDR resistance is high. None appreciated that the lamp resistance effectively determined that the p.d. across it at night is 6 V. The majority of candidates based their answers incorrectly around the proportions of current in the two components in parallel, without considering the resistor in series and ignoring the p.d. across them.

2 **(a)** The majority scored both marks for relating quantities and units with only a very few not linking two of them correctly.

(b) The majority of candidates scored at least one mark for the definition of *potential difference* realising that it is the energy transfer from electrical into some other form. However, it is common to omit *per unit charge*. Some wrote *per coulomb of charge* which is unacceptable as definitions do not contain units. Most answers about *internal resistance* effectively just repeated the words in the question rather than justifying the need for the concept in the analysis of a live circuit.

All candidates could add resistors in series but some forget to add that the combinations were in parallel, justifying the same value of p.d. across them. The calculations of the p.d. and internal resistance proved to be good discriminators with about half of the candidates obtaining the correct answer for the p.d. and one third for the internal resistance. Candidates should be encouraged to add values for current and p.d. onto the circuit diagram which would reduce many of the errors that were made in the calculations.

3 **(a)** Resistance was correctly defined by almost all. However, there is still a minority who write *over* for *divided by* and write units for quantities in their definitions, e.g. amps instead of current.

(b) Most candidates were able to calculate the resistance of the conductor in the microchip correctly. The value for the area of cross-section created the most confusion for those who failed to reach an acceptable answer. The calculation of the number density of free electrons was often not attempted. Many then substituted the number of atoms rather than the number density into the correct equation to calculate the current in the conductor. Almost all candidates selected the correct expression to calculate the power dissipated in the chip but did not appreciate which quantity increased by a thousand million, multiplying the current by this figure rather than the power dissipated by one conductor.

(c) Many tried to read too great a significance into this question which only required a statement about the drift velocity of electrons in the wire compared to the signal speed of an e-m wave.

4 **(a)** Three quarters of the diagrams showed correctly connected ammeters and voltmeters. Only half of the candidates were able to work out that the terminal p.d. of the supply is 6 V. Methods ranged from the very simple to use of the potential divider equation. The latter method often led to an answer of 2 V showing that the problem had not been understood.

(b) Almost all managed to calculate the energy of a blue photon and then recognised that it was related to the onset of current in the LED.

(c) Less than half of the candidates realised how to calculate the number of electrons passing through the LED per second. Only a minority of these used this figure to calculate the power emitted by the light. The most popular and incorrect choice was to use the final point on the LED characteristic which led to confusion when calculating the efficiency of the LED. Many of the weaker candidates left this section blank.

(d) The majority scored both of these marks drawing a straight line between the two end points. A few tried to draw a freehand graph on the blank page beneath the question rather than adding to the printed graph.

5 (a) Almost half of the candidates are aware that coherence requires a constant phase difference. The differences in amplitude or phase between the two oscillations were given as incorrect justifications for a non coherent situation.

(b) Many answers mixed the words *amplitude* and *displacement* both here and in later sections. Most candidates did not appreciate that it was necessary to state that the oscillations are in *antiphase* and just wrote inadequate statements about *destructive interference not completely cancelling*.

(c) Many candidates gave a response in terms of wavelength. Candidates are still confusing phase difference and path difference. A unit, i.e. degrees or radians, had to be included to score both marks.

(d) There were many good answers. A small number could not read a period from the graph but a larger number did not realise that the scale is in milliseconds. However, almost all used the correct expression to calculate the distance of the line from the speakers. Few recognised that the distance required in the formula is to the first maximum and substituted the distance given to the first minimum.

(e) The definition of intensity is well known and also the relationship between intensity and amplitude. However, only the better candidates were able to calculate the maximum intensity, often showing little explanation possibly because the numbers involved were very simple.

6 (a) This was well answered with almost all knowing the properties of electromagnetic waves which distinguish them from other waves.

(b) Most candidates just repeated the question when explaining plane polarisation, failing to define clearly the plane or direction of oscillation. Candidates should be encouraged to think of a polarised wave as oscillating in a certain direction rather than in a single plane, and to think of the vector nature of the oscillation and answer in terms of components. Those who had some understanding of Malus' law scored good marks. Those without a mathematical approach who considered that a polarising filter only stopped completely oscillations perpendicular to the transmission axis also often gave good answers. The majority considered that once polarised only oscillations in the direction of the first polariser's transmission axis could exist and would be maintained through any subsequent polarisers. They therefore came to the wrong conclusions.

7 (a) The majority were able to describe successfully how a stationary microwave pattern is set up in the oven.

(b) About half of the candidates were able to state that the crosses were points of maximum amplitude or intensity. Some answers failed to score because a suitable scientific vocabulary was not used.

(c) About one third scored full marks. Many did not write down their initial measurement or else did not make it clear whether their figures referred to the scale diagram or real space. Sometimes this failure led to their own confusion and downfall by providing an answer half of the correct value.

8 (a) The definition of *work function* is known well. However the fact that work function refers to an electron energy and threshold frequency to a photon energy is not evident from the answers given. The formula in algebraic form relating the two quantities was widely known but candidates should be encouraged to define any symbols used when stating a formula as an answer to a question. The relationship written out in words was expected here.

Many chose the wrong wavelength of the two given to calculate the work function. Some realised this when continuing to the next question and returned to amend their initial answer. The correct formula was used by all.

(b) Mathematically strong candidates were easily able to score full marks. A majority scored full marks for the de Broglie wavelength calculation.

(c) This question discriminated well between the better candidates; only the strongest scoring full marks. The two most common answers were to add or subtract the two given wavelengths despite the fact that the diagram referred to energies and candidates had written earlier that energy is inversely proportional to wavelength.

G483 Practical Skills in Physics 1

General Comments

Teachers and technicians in Centres are thanked 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.

One of the purposes of the moderation process is to confirm the marks awarded by a Centre. To assist this process 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. Centres are encouraged when marking B1.2 in the Qualitative Tasks and C4.1 and C4.2 in the Evaluative Tasks to include the numerical marking point as well, e.g. C4.1-2 for the second marking point for C4.1.

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.

Another purpose of the moderation process is to ensure consistency between Centres and thus it is essential that the mark schemes provided are followed. Centres are asked to use the marking boxes provided on the tasks so that the moderators are aware of which marks have been awarded. 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.

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

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 use of the cover sheet and the spreadsheet from 'Interchange' has helped reduce the number of arithmetic/transcriptions errors with marks. There are three different ways of these errors occurring:

1. Inaccurate completion of the MS1 or 'electronic' equivalent. It is good practice for Centres to ensure that there is a suitable procedure for checking the compilation of marks.
2. Adding up of the three tasks. A large number of Centres successfully used the spreadsheet which is available on 'Interchange' to assist the process. Centres are advised to use both the spreadsheet and the cover sheet.
3. Incorrectly filling in of the mark boxes (particularly A2.3, B2.3, and C1.3) which are only worth one mark and were often credited with two.

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 "lost" work of candidates. 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 Centres marked these tasks accurately.

Where candidates are asked to describe an experiment, the description should include how the variables are to be manipulated as indicated in the additional guidance of the mark scheme.

Likewise additional method marks (A1.2) must be detailed – vague answers should not be credited.

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.

B1.2 is still generously marked; candidates' answers must be detailed and explanations must be thorough – the guidance given in 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. It was noted that in some larger Centres, there was inconsistent marking of this part of the task by different teachers. Again Centres are always welcome to email OCR for further guidance.

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. It was noted that in some larger Centres, there was inconstancy in the marking of these tasks by different teachers.

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. Candidates still appeared to be confused 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.

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) errors 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. As the Practical Skills Handbook indicates, candidates do not need to use error bars. 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” is 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 detailed 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 both 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.

Reminders

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.

Centres are required to submit one type of each task for each candidate. Where Centres submitted more than one task of each type, moderators are required to return the whole sample to the Centre.

Candidates should complete the tasks in black (or blue) pen using pencil for graphs and the marking should be carried out in red pen.

Centres should ensure that the candidate number is the same on each piece of work that is submitted.

The Practical Skills Handbook (available from the OCR website) is a useful document for both the preparation of candidates and the marking of the tasks.

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 15^{th} 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 3 to 56 and the mean score was 32. Most candidates used their time efficiently and were able to attempt all sections of the paper.

It is clear that Centres have continued to make good use of past papers, marking schemes and examiner's reports. This was particularly evident in the calculations where marks were generally very good. There were far fewer errors in basic arithmetic this session although a minority still have problems transposing equations. Unfortunately there was not a corresponding improvement in answers involving extended writing. Many candidates lost marks as a result of failing to notice that a reason was specifically requested in the wording of the question. Other answers lacked clarity and sufficient detail.

This paper included a description of an experiment in which labelled diagrams were specifically required. Many of the diagrams given were very poor quality freehand sketches. Candidates should be aware that at A2 level, examiners do expect clear, simple 2d diagrams, drawn with a straight edge where appropriate. Circuit diagrams were rarely drawn with sufficient clarity and accuracy. Many candidates gave apparatus diagrams little larger than a postage stamp making it almost impossible to assess the arrangement.

On a more positive note there was little evidence that candidates were not working to sufficient accuracy and the application of a significant figure or rounding error was rare.

There were very few omissions this session and it is good to report that candidates were able to attempt to answer most questions on the paper. This suggests that there was adequate time to read questions and complete detailed answers. There were plenty of opportunities for good candidates to demonstrate their knowledge on the many topics covered on the paper. Weaker candidates were able to attempt most questions apart from the stretch and challenge question Q6d and were therefore able to score marks over the entire paper.

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

Comments on Individual Questions:

Question	Comments
Q1(a)	Most candidates were able to score one mark for completing the elastic collision column correctly. Unfortunately less than 50% were able to complete the inelastic collision column with the same accuracy.
Q1(b)(i)	Many realised that the force was constant but were unable to link this to constant acceleration. Of those that made the link a significant number did not answer the question by making a comment about the velocity change resulting from the acceleration. What was thought to be a straight forward question turned out to be a good discriminator.
Q1(b)(ii)	Most candidates, wisely, attempted this by calculation of area rather than counting squares. Most used the area of 2 triangles and a rectangle while only a minority used the trapezium rule. A minority counted squares to give a fairly good area but wasted a lot of time doing so. POT errors were not often made.

Q1(b)(iii) Answers to this question were generally accurate given the possible ECF from (ii)

Q2 This was a wide ranging question on one of the most important sections of the Specification, covering many elements tested in earlier question papers.

Q2(a) Most candidates gave correct directions for T and W, although there were a significant number with T towards the right. Only a minority realised that the aircraft was in equilibrium and as such F must act upwards and at an angle to the right of the horizontal.

Q2(b)(i) Well answered by all but a small number of candidates who, having determined the time correctly, proceeded to calculate the distance using the product of final velocity and time.

Q2(b)(ii) Most candidates mentioned air resistance and friction but only the minority of very good candidates continued the discussion to give a mathematical reason for the increase in distance. A clear example of the need to read the question carefully.

Q2(c)(i) Most candidates handled the calculation well and showed their working clearly.

Q2(c)(ii) Candidates used a range of approaches to the trigonometry required in this more searching calculation, and although most were successful, a disappointing proportion used the raw value of L from (i) rather than the horizontal component.

Q2(d)(i) The vast majority of candidates showed their understanding of this aspect of motion in a vertical circle by scoring the first mark for the position of A. Many went on to score the mark for the vertical contact force, although there were a variety of incorrect answers from weaker candidates, the most common of which was the weight.

Q2(d)(ii) Only the best candidates were able to give clear, correct answers to this stretch and challenge question. There were some excellent answers including diagrams to illustrate the situation. One worrying aspect evident in many incorrect answers was the number of candidates who thought that there was no resultant force acting on the aircraft at the point B. The somewhat ambiguous phrase ‘balancing forces’ was frequently seen where ‘zero resultant force’ was more appropriate.

Q3(a) Almost all candidates were able to score full marks in this question. Only a minority making errors in reading the scales given on the graph.

Q3(b)(ii) This was another question requiring a reason from candidates and all too often this was not given at all or was only partially stated by the observation that the periodic time had not changed.

Q3(c)(i) This question also discriminated well, largely as a result of candidates not reading the question carefully. The vast majority knew the conditions for SHM and stated them accurately but failed to relate them in any way to the features of the graph. Full credit was only given if both requirements were clearly linked to the separate features of the graph. A significant number of candidates were under the impression that any straight line graph indicated direct proportionality and made no mention of the fact that the graph passed through the origin.

Q3(c)(ii) Most candidates scored full marks in this calculation. The most commonly seen error was the omission of the millimetre to metre conversion in the determining the gradient. Only a small minority made errors in handling the square root which was encouraging.

Q4(a) The majority scored the mark in this question but unfortunately a significant minority did not make any reference to the direction of rotation in relation to the Earth and so could not be given the mark.

Q4(b)(i) Many candidates found difficulty in expressing their thoughts in this question and as a consequence marks were generally lower than expected.

Q4(b)(ii) Well answered, on the whole; although a significant number unfortunately forgot to square the period before taking the cube root.

Q5 The vast majority of answers to this question were disappointing, to say the least. There are only two experiments specifically mentioned in the Specification and good answers were expected as a result. The question specifically asked for a labelled diagram and it was expected that this should be clear and carefully drawn with a suitable circuit using accepted symbols. Unfortunately most diagrams were too small, poorly drawn attempts at a 3d picture with incorrectly placed components. This immediately reduced the mark of all but the best candidates. Bunsen burners were also seen in several diagrams despite the wording of the question.

The majority were able to score marks for the measurements and calculation although the logical sequence was often unclear. Those using bullet points generally scored better marks.

At A2 level, heat loses to the surroundings should automatically be minimised by the use of insulation and lids for liquids. As a result no credit was allowed in the uncertainties for this response. It was realised that few were showing insulation in their diagrams or labelling and allowance was made in allocating the apparatus mark.

Q6(a) Although there were many good answers to this basic question on Brownian motion a significant number of candidates failed to score the second marking point in (i).

Q6(b) Kinetic theory of gases is the major application of Newton's laws to the microscopic world of molecules that is considered in the Specification. This question, although similar to the question set in January 2012, focused the candidate's attention towards Newton's laws. The mark scheme was slightly tightened from the one used in 2012 by the addition of specific references to the walls and molecules.

Q6(b)(i) Given that the random motion of the molecules had been established in (a) it was decided not to include this in the list of critical assumptions detailed in the mark scheme. The mark scheme required specific references to the 'only collisions' considered at this level and comparisons in the references to volumes and times. Candidates were not penalised for giving extra details or additional assumptions. As a result the question discriminated well with the more able candidates scoring at least 2 marks while most were able to score 1 mark.

Q6(b)(ii) There is a clear logical sequence to the application of Newton's laws to the explanation of the existence of gas pressure. Unfortunately this was rarely conveyed by candidates in their answers. Many jumped straight from change in momentum of the molecules, to the force on wall with no reference to the laws involved. It was rare to see an answer in which the candidate had realised that the observed pressure was in fact the sum of a large number of individual forces acting on the area of the wall. Far too many expected to score the mark with the simplistic P = F/A formula.
On the whole this was a disappointingly, poorly answered question where only the most able were capable of demonstrating a reasonable understanding of the theory.

Q6(c) This difficult question allowed the more able candidates to display their logical presentation in a show question designed to give a hint to candidates for Q6d. Many were able to score the first mark but were unable to score the subsequent marks. Many candidates did not draw a clear distinction between the symbols and n was often set to 1 for no reason other than to remove it from the equation. Those who showed a clear distinction between m and M fared much better. A few candidates introduced their own notation to aid themselves and this was, of course, accepted by the examiners.

Q6(d)(i) This stretch and challenge question clear gave many candidates some difficulty. Many used the gas laws in PV/T form correctly and eventually arrived at the correct answer. Only a small number realised that they could use the expression given in (c) to formulate an equation relating P to ρT saving a considerable amount of time and effort.

Q6(d)(ii) Given the difficulty shown in arriving at the correct answer to (i) it was pleasantly surprising to see the quite large number of candidates scoring marks in (ii) using the ratio of densities even though a few inverted the ratio and failed to spot the illogicality of their answer.

G485 Fields, Particles and Frontiers of Physics

General Comments:

The marks for this paper ranged from 0 to 98 and the mean score was around 53. Most of the candidates were able to complete the paper in the scheduled time of 2 hours. The majority of the candidates also attempted every question on the paper; there were no significant omissions of questions.

The standard of work from the candidates was much better. Candidates were much more thoughtful and meticulous when presenting analytical answers. Most candidates coped extremely well with algebra and logarithms. The solutions were often well presented and the steps of the calculations were easy to follow. Answers were frequently expressed to the correct number of significant figures. All candidates are once again reminded that it is poor practice to round numbers up or down in the middle of long calculations. It is best to carry forward calculator values. Examiners were generous this session, but this poor technique will be penalised in the future.

The quality of written answers was very much Centre-dependent. Many candidates had rote learnt technical terms such as *mass defect* and *half life* without having deeper understanding. Consequently, some descriptive answers were convoluted and rife with misconceptions. Some candidates would have benefited by writing their answers in the form of bullet points rather than in continuous prose.

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:

Question	Comments
1(a)	Most candidates managed to secure one mark for the correct direction of the electric field between the plate and the sphere. Generally, the quality of the electric field patterns was poor, with field lines frequently not being normal at the surfaces of the sphere and the plate. A small number of candidates either drew straight field lines between the sphere and the plate or had field lines within the sphere itself. Candidates at the top-end drew perfect field patterns with most picking up the two marks.
1(b)(i)	Generally, candidates answered this question well. Many correctly identified the particle **B** as having the greater charge and then gave creditable reasoning for their choice. Many candidates, across the ability spectrum, gave excellent justification in terms of the electric field strength being inversely proportional to distance^2.

1(b)(ii) There were far too many variants of the *E* against *d* graphs; sadly most of them were incorrect. A pleasing number of candidates picked up one mark for a curve passing crossing the *d*-axis at the position of **X**. The remaining two marks were only secured by the very top candidates who drew a curve showing *E* to be positive between **A** and **X** and negative between **X** and **B** (or vice versa). This proved to a tough question, with most candidates having an attempt at sketching something.

1(c) This was a good discriminator with many candidates giving excellent answers in terms of the inverse square law with distance for both electric and gravitational field strengths. Some candidates even went as far as to derive an expression for the ratio and showed how the r^2 terms cancel out. A small number of candidates gave incorrect reasoning for why there was no dependence on the distance, this is shown below.
$g = F/m$ and $E = F/Q$. Therefore $g/E = Q/m$ which has no distance.

2(a)(i) Candidates answered this question well, with many making reference to either a force at right angles to the velocity of the helium nucleus or a force that was directed towards the centre of the circle.

2(a)(ii) There were some excellent answers in terms of no work done by the force acting on the helium nucleus, but equally, there were some simplistic answers such as the '*speed at **A** and **B** is the same, hence the kinetic energy remains constant'*. The modal mark for this question was unexpectedly zero.

2(b) Most candidates successfully secured full marks. The analytical answers were well-structured and easy to follow. Most candidates used first principles to show that the momentum was given by the equation $mv = BQr$. A small number of candidates determined the speed v of the helium nucleus first and then used mv to calculate the momentum. This method was a bit longer, but the final answer was still the same. A very small number of candidates were using Coulomb's law instead of $F = BQv$. Candidates are reminded that no marks will be awarded for substitution into incorrect equations.

2(c) Candidates answered this question well, with a significant number using the equation $E_k = p^2/2m$ and their value for momentum from (b) to determine the kinetic energy of the helium nucleus. The answers were once again well-structured and easy to decipher.

2(d) This proved to be a very testing question even for the top-end candidates. Many candidates failed to realise that the electric field would cause the helium nucleus to move towards the right. The path of the particle in the fields would be a combination of this translational motion to the right and a clockwise circular motion due to the effect of the magnetic field. The most popular incorrect answers were '*oval shaped path'* and '*helium particle spiralling out of the plane of the paper'*. It was good to see the odd correct path sketched with the correct supportive text. Examiners gave full credit for a clockwise looped path.

3(a)(i) Most candidates mentioned isotopes to have identical nuclear charge and substances having identical chemical properties.

3(a)(ii) This was a low-scoring question that favoured the top-end candidates. Many of them realised that mass of the nucleus had to be less than the total mass of the nucleons because external energy had to be supplied to the nucleus to free the nucleons inside. The vast majority of the candidates quoted the Einstein's mass-energy equation but then failed to explain how it was related to this question. Terms such as *mass defect* and *binding energy* were frequently used out of context.

3(b)(i) Most candidates successfully completed the nuclear decay equation by correctly identifying the missing particles as the proton and the antineutrino. Conventional symbols for these two particles were allowed. About one in five candidates could only identify one of these particles.

3(b)(ii) The majority of the candidates struggled to give a clear definition of half life. Definitions were often general and not specific to neutrons. The two most popular incorrect answers were: '*it is the time taken for a neutron to half its mass*' and '*the time taken for a neutron to half its radioactivity*'.

3(c)(i) Generally, candidates answered the question well and got the correct answer of 2.3 N. The equation for Coulomb's law was familiar to most candidates and the substitution of numbers was clear with fewer calculator errors. A small number of candidates used charges of 2*e* and *3e* and consequently scored no marks.

3(c)(ii) The majority of the candidates scored three marks for this synoptic question requiring knowledge of electronvolts and mean kinetic energy $\frac{3}{2}kT$. The answers were, once again, well-structured and logically presented. A small number of candidates either used 70000 or 18 MeV as the mean kinetic energy; no marks were awarded for such elementary errors.

3(c)(iii) This was a good discriminator, with top-end candidates giving perfect answers. Some even mentioned the Maxwell-Boltzmann distribution and how some of the nuclei would have kinetic energies greater than the mean kinetic energy. Descriptions were often far more complex than warranted by this one mark question. Examiners also allowed '*high pressure'* as a plausible answer.

3(c)(iv) This was another high-scoring question. Most candidates used the Einstein mass-energy equation and the energy of 18 MeV converted to joules to get the correct answer. Examiners gave no marks if 70 keV was used as the energy. Once again, candidates demonstrated good analytical skills.

3(v) Most candidates wrote a great deal but the key physics was often omitted. Only a small number of high-scoring candidates realised that the helium nucleus had greater charge. This meant a greater repulsive electrostatic force between the helium nuclei and deuterium nuclei and hence a smaller chance of fusion between helium-deuterium nuclei. The most common misconception was that '*the greater mass of helium nuclei means that they are travelling slower and hence less chance of fusion*'.

4(a) There were missed opportunities with the definition of time constant of a capacitor-resistor discharge circuit. The majority of candidates were aware of the 37% or e^{-1} ideas, but these were not integrated into their definitions. Answers such as '*it is the time taken for the capacitor to discharge to 37%*' without any reference to current, charge or p.d, were quite common. Some even had the '*capacitance decreases to 37% of its initial value'*. Examiners did not allow time constant = capacitance × resistance as a definition for time constant.

4(b) All candidates had to do was to provide suitable values for the resistance and capacitance with appropriate units; this they did with great skill. Only a small number of candidates omitted either one or both units and lost this accessible mark.

4(c)(i) Most candidates picked up two or more marks in this synoptic question. Most candidates correctly used the resistivity equation to first determine the resistance of the bundle of wire and then the time constant of 2.2 s for the circuit. A very small number of candidates used $\rho = 8900$ for the resistivity of the metal instead of $\rho = 4.9 \times 10^{-7}\ \Omega$ m. This was taken as a monumental error of physics and prevented the candidates from picking up any marks in this question.

4(c)(ii) There was a good spread of marks, with many candidates scoring two or more marks. Most candidates did explain the charging of the two plates in terms of the flow of electrons in the circuit. Most candidates realised that the electrons would gather at plate **Y** giving it a negative charge. However, many could not adequately explain why the plates acquired equal but opposite charges. A significant number of candidates, mainly at the top-end, had no problems and gave superb answers in terms of equal number of electrons deposited and removed from the two plates.

4(c)(iii) The majority of candidates scored full marks. Answers were well-structured and showed excellent synoptic knowledge of specific heat capacity. A significant number of candidates struggled when calculating the volume and hence the mass of the bundle of wire. Some candidates used $V = \frac{4}{3}\pi r^3$ to determine the volume of the wire. Such elementary errors are unjustifiable at this level.

4(c)(iv) This question discriminated well with the majority of the candidates realising that the increase in the temperature would be four times greater. The explanations were often correct and elegantly presented in terms of energy $\propto$ p.d^2 for the energy stored in the capacitor. A small cohort of candidates gave qualitative answers and took no account of the potential difference doubling.

5(a) The majority of the candidates gave perfect definitions for Faraday's law. Some made reference to '*cutting of field line'* or '*cutting of flux*', but such answers often lacked clarity.

5(b) The modal mark for this question was zero. Many candidates stated Lenz's law and failed to answer the question. Only the high-scoring candidates appreciated that the face of the coil nearer to the magnet had to be a north pole in order for there to be work done against the repulsive force between the coil and the magnet. This proved to be a tough, but a discriminating question.

5(c)(i) The correct use of technical terms was important in answering this question. No credit was given for an answer such as '*the number of field lines remain the same*'. Most candidates realised that that there was no induced e.m.f. because there was no change in the flux linkage for the coil.

5(c)(ii) This was a tough question with most sketch graphs demonstrating a poor understanding of electromagnetic induction. The modal mark was zero. Incorrect graphs ranged from mirror image sketch of the graph in Fig.5.3 to sinusoidal curves. Most high-scoring candidates secured two or more marks for a graph showing $E = 0$ between 0 to 3cm, 5 to 8 cm and 10 to 12 cm and two 'pulses' between 3-5 cm and 8-10 cm. Examiners were not too worried with the actual shapes of pulses, as long as they appeared in the correct positions on the x-axis.

6(a)(i) Almost all candidates correctly identified the anti-proton as particle **C** from Fig.6.1.

6(a)(ii) Most candidates gave the charge of particle **B** to be zero; many even went as far to show how this came about from the charges of the up and anti-up quarks.

6(b)(i) The proton was correctly identified as particle **X**. However, about a third of the candidates thought it could have been any of these particles too – anti-proton, positron, electron and neutron.

6(b)(ii) Almost half of the candidates scored full marks for this challenging question. Most answers showed excellent structure and good understanding of radioactive decay and molar mass. A disturbing number of candidates were rounding numbers to 2 significant figures within their calculations. This is a poor practice. It would have been sensible to carry forward the calculator values between stages of this complicated calculation. Examiners were lenient this session, but this poor technique will be penalised in the future.

6(c) The answers for induced nuclear fission lacked clarity and preciseness. Most candidates scored nothing for their elaborate answers. One mark was being awarded for the idea that a thermal neutron caused the uranium-235 nucleus to split into two smaller nuclei and the other mark was for the emission of one or more fast-moving neutrons. Too many candidates gave unnecessary attention to chain reaction.

6(d) The descriptive answers demonstrated good understanding of the function of the moderator and the control rods. The QWC mark was reserved for explaining how the neutrons transferred their kinetic energy to the atoms of the moderator material; this was successfully communicated by the top-end candidates. A large number of candidates also realised that slow-moving neutrons had a greater chance of causing fission reactions. The answers to this question were very much Centre-dependent.

7(a)(i) Most candidates, across the ability spectrum, struggled to give an acceptable definition of an energy level. Energy levels were seen as '*shells'* or '*orbits'* rather than the quantised energy of electrons within the atom.

7(a)(ii) Most candidates correctly determined the energy of the X-ray photon. The value of the energy level labelled **B** had to be a negative value. The most common answer was 4.4×10^{-16} J, which scored two marks.

7(a)(iii) Many candidates, made good use of the clues provided in the question, to give well reasoned explanations. The equations $E = hc/\lambda$ or $eV = hc/\lambda$ were often used to support the answers. A small number of candidates gave qualitative answers such as '*the energy increases and therefore the wavelength is shorter*' and scored no marks.

7(b)(i) The majority of the candidates scored two or more marks for calculating the fraction of the X-ray intensity absorbed by the muscle. Answers written as fractions or as percentages were allowed. The most common error was the conversion of the attenuation coefficient into m^{-1}, written as 0.96×10^{-2} m^{-1} rather than 96 m^{-1}. Many candidates just used the thickness in cm and the attenuation coefficient in cm^{-1} given in the question to calculate the fraction of the intensity absorbed by the muscle.

7(b)(ii) About half of the candidates mentioned the bone-muscle image to give the better contrast. A disappointing number of candidates simply wrote '*bone'* and totally ignored the question.

8(a) Generally, candidates answered this question about the principles of a B-scan extremely well. Some candidates gave unnecessary details of ultrasound transducers and acoustic matching with a gel. A pleasing number of candidates picked up the QWC mark for explaining how the **intensity** of the reflected ultrasound at the boundary between materials depended on the acoustic impedances. A very small number of candidates used the term *attenuation coefficient* rather than *acoustic impedance* in their descriptions.

8(b) The majority of the candidates gave decent explanations of the basic principles of PET scanning and scored two or more marks. The quality of the answers was good, with many candidates showing excellent understanding of the annihilation of positron-electron, the production of two gamma photons and the detection of these photons to form an image. The question discriminated well.

9(a) The vast majority of the candidates correctly calculated the density of Sirius B to be 2.2×10^{18} kg m^{-3}. A very small number of candidates incorrectly calculated the volume of the star using the equation $V = 4\pi r^2$.

9(b) Candidates answered this question well. A variety of methods were used to get this correct answer. Some candidates calculated the surface field strengths for the Sun and Sirius B and then divided these to calculate the ratio. Candidates at the top-end opted for a simpler route. Since $g \propto 1/r^2$, the ratio was

$$\left(\frac{0.7\times10^9}{6\times10^3}\right)^2 = 1.4\times10^{10}$$

.

9(c) This was a tough question, but many candidates did exceptionally well to calculate the distance of 2.64 pc for Sirius B. A pleasing number of candidates then went on to use either trigonometry or the equation $p = 1/d$ to calculate the parallax angle in arc seconds.

9(d) Most candidates demonstrated good understanding of the Doppler equation and correctly calculated the percentage change in the wavelength of the spectral line. A very small number of candidates left the final answer as a ratio rather than a percentage.

9(e) The majority of the candidates stated Hubble's law but failed to answer the question. A disturbing number of candidates were convinced that this law could be applied to a star within our galaxy. Some decent answers were spoilt with comments such as '*the statement is incorrect because Hubble's law is for receding galaxies but Sirius is moving* ***towards*** *us*'. The omission rate for this question was high at about 10%.

10(a) The answers were brief with a mention of *homogeneous* and *isotropic*, so most candidates scored two marks. Many candidates even defined these terms and showed a good understanding the cosmological principle. Some candidates were convinced that the question was asking about Olbers' paradox.

10(b) The majority of the candidates were aware that the microwaves represented the universe to be at a temperature of 2.7 K. The descriptions were generally good with many candidates recognising the expansion of the universe led to cooling and hence we now observe microwaves rather than the short wavelength gamma radiation. The use of technical terms was generally good and it was easy to follow the text.

10(c) Candidates, across the ability range, enjoyed tackling this demanding question. Most scored full marks. The answers were logically presented and showed an excellent knowledge of critical density and age of the universe. There were fewer algebraic errors. This was a good finish for most candidates.

G486 Practical Skills in Physics 2

General Comments:

Centres are now becoming used to the format and the standards required for this assessment. With the change in tolerance for this unit, it is increasingly more important for Centres to mark accurately and carefully. Having a good understanding of the mark scheme is essential.
The annotating of candidate work continues to be on the increase and is found to be very helpful by moderators in determining how candidate responses have been interpreted.

There was a noticeable rise in administration errors. These ranged from clerical errors in transferring the marks to the front cover and onto the MS1, to incorrect addition of the marks in the boxes.

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

For consistency across Centres it is essential that the mark scheme be adhered to as strictly as possible. Where a teacher has doubt, the use of the free consultancy service is strongly recommended. Many centres did make contact with OCR over the past year and were able to clarify their queries

Qualitative Tasks

General:

Generally Centres marked these tasks accurately and consistently.

However, an increasing minority of candidates are being credited in A1.2 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 a relationship is to be tested, the first B1.1 mark is for a valid numerical test. The second B1.1 mark is awarded for a second calculation or equivalent reasoning together with a conclusion, and this must be seen in order to award credit.

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. 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 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. Again Centres are always welcome to email OCR for further guidance.

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 reminded that **all raw data measured must be recorded in a table** of results.

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

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 some confusion still exists.

The C1.2 mark for the line of best fit was found to be awarded generously by fewer Centres this year. 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. It is expected that teachers check the two plotted points that lie furthest from the candidate's line of best fit. These should be circled and if correct, ticked. Moderators have been instructed to confirm the position of the two plots circled only. However, in the event that ticks are placed by two plots near the line, moderators will check the two plots furthest from the line. This may lead to a difference between the moderator and teacher mark and increase the chance of putting the centre out of tolerance.

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 which did not look like it 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 often 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.

Many more candidates showed their workings in the calculation of the gradient this year. 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 that say '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. The C4.2 improvement must be linked to an identified limitation.

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 2014/15 were published in June 2014. One Qualitative, one Quantitative and its associated Evaluative Task have been replaced. The tasks that have been replaced may well be used again in future years and so **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 2014 and 14 May 2015')* 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 and 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.

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553

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