

Physics A

Advanced GCE **H558**

Advanced Subsidiary GCE **H158**

OCR Report to Centres

June 2013

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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Overview

The majority of the candidates were prepared well for the complexities and demands of the four theory papers. It was clear that many Centres and candidates continue to make good use of previous papers, marking schemes and Principal Examiners' reports.

There was a noticeable improvement in the presentation and execution of analytical problems. This was particularly true for the A2 candidates who demonstrated good algebraic skills and effortless use of trigonometry and logarithms. Examiners were very pleased with the meticulous manner in which they solved mathematical problems. The comments on the individual papers give more details on the opportunities missed by middle to low range candidates. The following key areas for improvement were identified by the examiners.

- Avoid premature rounding of intermediate numbers in long calculations.
- Avoid rounding and significant figure errors.
- Provide complete algebraic reasoning, especially in 'show' calculations.
- Take care when taking readings from graphs and avoid omitting any prefixes.

The quality of written work was variable. At AS-level, many candidates, across the ability spectrum, could have gained more marks by stating definitions correctly and carefully examining the questions. At A2-level, many candidates were inaptly using technical terms. All candidates would have also benefitted from planning their written answers and showing greater reasoning in the answers. Candidates are once again reminded that using bullet points, rather than continuous prose, can be an effective strategy when communicating complex physical ideas.

Most Centres submitted organised internally-moderated tasks for the practical skills. The application of the marking schemes was generally quite good. The annotations on the scripts helped in the moderation process. The standard of work is gradually improving. Centres are reminded not to discuss any of the practical tasks or mark schemes with their students. The detailed comments given by the Principal Moderators will help Centres in future sessions.

Experienced teams of assessors provided efficient marking of the theory papers and accurate moderation of the practical tasks. On-screen marking of the theory papers allowed analysis of the performance of the papers at a question-by-question level. The Principal Examiners' reports reflect this detailed analysis. These statistics are the basis of OCR's Active Results, which are available to all Centres via the Interchange.

GCSE and GCE/A level Science development, tell us your thoughts...

OCR is currently in the process of re-developing GCSE and GCE Science specifications for first teaching from September 2015. To assist with this work we would welcome your feedback regarding anything you would like to see changed or included as part of the new qualifications. If you have any comments/questions regarding GCSE or GCE Science developments please e-mail ScienceDevelopment@ocr.org.uk or join the OCR Community (www.social.ocr.org.uk) to be kept updated.

In summary,

GCSEs are being re-developed for first teaching from September 2015.

- The courses will be linear with separate Science (Biology, Chemistry and Physics) and a Double Award Science;
- There is no Single Award Science as part of the DfE Programme for Reformed GCSEs in Science.

For more details see <http://www.ocr.org.uk/ocr-for/teachers/newsletters/agenda/>, <http://www.education.gov.uk/schools/teachingandlearning/qualifications/gcse/a00221366/gcse-reform> and <http://ofqual.gov.uk/news/ofqual-launches-consultation-on-gcse-reform/>

GCE/A levels for Biology, Chemistry and Physics are also being revised for first teaching from September 2015. (Other Sciences will be developed in a later phase.)

- AS is to be a standalone qualification that does not count towards the A level, covering half the content of an A level and delivered over one or two years;
- The AS could be designed to be co-teachable;
- The standard of the AS is to remain broadly as it is now;
- A level is to be a fully linear, fully synoptic, two year course.

For more details see www.ofqual.gov.uk/news/ofqual-publishes-a-level-reform-correspondence/

Developers

During September, OCR will be advertising for Developers to assist with the drafting of new qualifications for Science. It is expected that adverts will be posted to the OCR website and TES and a notification will be posted on www.social.ocr.org.uk. Alternatively if you register your interest *via* e-mail to ScienceDevelopment@ocr.org.uk, we can send you more details when Developer roles are advertised.

G481 Mechanics

General Comments

The paper worked well to differentiate candidates. The marks for this paper ranged from 0 to 59 and the mean score was about 32. Most candidates made excellent use of their time when tackling the paper. Most demonstrated sensible examination techniques by underlining key information and carefully scrutinising questions before answering.

Candidates of all abilities fared better with their calculations than with their written explanations. The analytical skills were much improved. This was clearly demonstrated in the calculation for the time of fall in **4(a)**. The equation of motion appeared first, followed by careful substitution of data and this all culminated with a correct value for the time in seconds. Candidates are once again reminded that they must avoid premature rounding of numbers in long calculations. If possible, the best strategy would be to rearrange an equation first and then substitute the numbers. A small number of candidates were losing marks for truncating their final answers; for example, writing 2.7 instead of 2.78.

Most candidates did well with stating rudimentary definitions. Extended writing presented some candidates with a real challenge. It is easier to get across the physics by using bullet points. This was particularly relevant in **4(b)(iii)**, where verbose and continuous prose answers often lead to contradictions. Candidates must use technical terms with great care and precision. For example, acceleration can be 'smaller' or 'reduced', but little sense can be made of a statement such as 'acceleration is *slower* or *faster*'. At this advanced level of study, it is vital to have a decent grasp of scientific vocabulary.

Candidates continue to make good use of the Data, Formulae and Relationships Booklet. As mentioned in previous reports, the legibility of some candidates remains a cause for concern.

Comments on Individual Questions

Question 1

Most candidates made a good start in this opening question and scored three or more marks and demonstrated decent knowledge of units, prefixes and density.

- (a) Most candidates scored a mark for writing Pa and m s^{-2} . Expressing the pascal in base units was acceptable. The last question on the conversion factor, produced an array of incorrect answers. Instead of 1000, the most frequent incorrect responses were 3 and 100.
- (b) The equation for density was well known to almost all candidates. Many scored a mark for identifying the volume of the glass to be 7 cm^3 . Converting this volume into m^3 presented severe problems to most candidates. The frequent choice for the volume of the glass was $7 \times 10^{-2} \text{ m}^3$ instead of $7 \times 10^{-6} \text{ m}^3$. About a fifth of the candidates, mainly in the upper quartile, scored full marks. A small minority of candidates used either 75 cm^3 or 82 cm^3 for the volume and subsequently scored zero.

Question 2

This question on vectors produced a range of marks and discriminated well.

- (a) Nearly all candidates picked up a mark for their explanation of why a force was a vector quantity. The most common answer was '*force has both magnitude and direction*'. The spelling of the term 'direction' was an integral part of the definition.
- (b)(i) Almost half of the candidates scored full marks for correctly determining the components of the weight. The solutions were often well-presented. A significant number of candidates swapped their perpendicular and parallel components; they were awarded one mark. Surprisingly, about a quarter of the candidates could not correctly substitute values into the appropriate equations.
- (b)(ii) Most candidates managed to score one mark for stating the value of the force F . The explanations were generally poor. The component of the weight down the windscreen was too often referred to as the '*horizontal component of the weight*'. Many candidates did not appreciate that the resultant force along the windscreen was zero. A small number of candidates quoted the force F to be zero. The reasoning was that the '*water drop is in equilibrium, hence $F = 0$* '.

Question 3

All candidates attempted this question and marks scored covered the entire range.

- (a) This question was a good discriminator. Weak candidates attempted to define the force constant as the '*stiffness of the spring*' or the '*force that a spring can take before snapping*'. Middle and top-end candidates gave unambiguous answers that included '*force per unit extension*' and '*force divided by extension*'.
- (b)(i) Most of the arrows indicating the force exerted on the trolley by spring **A** were correctly pointing to the left. However, it was astounding to also see arrows pointing up and down the page.
- (b)(ii)1 It is good to report that many of the answers showed good structure and clear reasoning. A variety of approaches led to the correct answer of 3.5 m s^{-2} . The most common error was to add the tensions in the springs; this gave an incorrect acceleration of 14 m s^{-2} . A disappointing number of candidates used the tension in one of the springs to determine the acceleration of the trolley. This led to an acceleration of either 5.25 m s^{-2} or 8.75 m s^{-2} . A very small number of candidates confused the net force F with the force constant when using the equation $F = ma$.
- (b)(ii)2 This was another discriminating question with most candidates in the upper quartile picking up two marks. Many candidates calculated the elastic strain energy for each spring and then divided them. A pleasing number of candidates correctly showed that the ratio was simply $\left(\frac{0.50}{0.30}\right)^2 = 2.78$. Fractional answers, such as $25/9$ were allowed. Some candidates threw away a mark by writing the ratio as 2.7 instead of 2.78. A very small number of candidates attempted to use $E = mgh$ to determine the ratio.
- (b)(iii) Most candidates found this question challenging and there were very few correct answers. Many candidates attempted an answer in terms of the force or the extension produced by one or both springs. Some tried to bring in drag or frictional forces into their reasoning. Very few candidates realised that the '*net force*' on the trolley decreased and this led to a smaller acceleration.

- (b)(iv)** Most candidates scored a mark for stating that the acceleration of the trolley would decrease. The reasoning often lacked clarity and robustness. The equation $F = ma$ was quoted but only a small number of candidates realised that the net force acting on the trolley was the same and hence the acceleration was inversely proportional to the mass of the trolley. Candidates are reminded that '*acceleration slows down*' makes no physical sense and must be avoided in the future. A small number of candidates went Galilean by suggesting that '*the acceleration of the trolley was independent of its mass*'.

Question 4

The quality of the extended writing in **(b)(iii)** was variable. Most candidates managed to score seven or more marks.

- (a)** Most of the answers showed good understanding of the equations of motion. The solutions were often well structured and easy to follow. A small number of candidates quoted their final answer as 0.37 s instead of 0.378 s or 0.38 s. There were also a few strange attempts such as: $t = 0.70/9.81 = 0.71\text{s}$.
- (b)(i)** The majority of the candidates scored a mark for correctly identifying acceleration and distance respectively.
- (b)(ii)** In view of the fact that most of the answers to **(b)(i)** were correct, it was surprising that the majority of the candidates failed to draw a tangent to the graph at point **A**. This question gave opportunity for high-ability candidates to shine. Most candidates in the upper quartile gave perfect answers and got a magnitude for the deceleration in the range 13 m s^{-2} to 17 m s^{-2} . Most attempts at calculating the deceleration involved dividing the velocity of 1.85 m s^{-1} at point **A** by 0.05 s. This gave an erroneous answer of 37 m s^{-2} .
- (b)(iii)** This question discriminated well with a good spread of marks. There were some superb descriptions and reasoning of the motion of the ball at points **A** and **B**. However, a disappointing number of candidates thought that the ball was accelerating at point **A** and the reason given was '*weight > drag*'. Many candidates wrote about net forces rather than how this net force came about from the weight of the ball and the drag on the falling ball. The motion of the ball at point **B** was better understood. Most candidates demonstrated good understanding of terminal velocity. Those candidates who incorrectly assumed that the upward force was the '*upthrust*' lost a couple of marks. Candidates who mentioned both upthrust and drag as the two vertically upward forces often gave accurate account of the motion of the ball at points **A** and **B**. Some candidates in the lower quartile thought that the '*ball was stationary*' at point **B**. A few even mentioned '*kinetic energy = drag*' at point **B**.
- (b)(iv)** Many candidates correctly reasoned that the kinetic energy of the falling ball remained constant. In spite of this, they still described the conversion of energy from gravitational potential energy to kinetic energy.

Question 5

This was a well-answered question with candidates showing good understanding of equilibrium and the principle of moments. Most candidates scored five or more marks for this question.

- (a)** A large number of candidates gave perfect definition for centre of gravity. A significant number of answers stated that centre of gravity was '*a point where mass of the object appeared to act*'.

- (b) The answers here were generally good. A small number of candidates defined either a couple or gave a definition for torque of a couple. A few even quoted the principle of moments.
- (c)(i) The answers here were concise and most candidates picked up two valuable marks. Vague statements such as '*the moments of M and S are equal*' and '*the forces balance out*' did not get any credit. A small number of candidates thought '*no external forces acting on the rod*' was one of the conditions for equilibrium.
- (c)(ii) This was a real success with the majority of the candidates scoring two marks. The answers were generally structured well and it was great to see a variety of techniques leading to the correct answer of 0.37 m. A small number of candidates successfully used either iteration methods or knowledge of ratios to determine the value of the distance x . These different approaches demonstrated an intuitive knowledge of moments and equilibrium. Algebraic manipulation presented an obstacle for some candidates in the lower quartile. The moment of **S** about **A** was often written as ' $0.35 \times 0.50 - x$ ' rather ' $0.35(0.50 - x)$ '; this led to inevitable errors.
- (c)(iii) The omission rate here was unexpectedly high, but the majority of the candidates had no problems arriving at the correct answer of 0.47 N.

Question 6

This question on energy and power produced a range of marks and discriminated well.

- (a) A significant number of candidates spoilt their answers by defining the watt as '*1 joule per second and the rate of work done*'. Candidates are reminded not to mix quantity and unit when defining the watt. Answers such as '*1 joule per unit time*' and '*energy per second*' are simply incorrect.
- (b)(i) The majority of candidates used $E_p = mgh$ to correctly calculate the gravitational potential energy gained by the bricks.
- (b)(ii) Most candidates had no problems calculating the output power of the crane. Unfortunately, some of the answers were spoilt by multiplying the correct output power by 0.30.
- (b)(iii) This question discriminated well. A significant number of candidates in the lower quartile gave the answer as: $58400/45 = 1300 \text{ W}$.

Question 7

This was a challenging question. (a)(ii) definitely suited top-end candidates and (b) tested the reasoning skills of all candidates. Most candidates managed to score three or more marks.

- (a)(i) Most candidates gave the correct expressions. Some candidates used labels other than those stated in the question. The marking was made a little generous. The use of the labels s and d were allowed instead of the distance x moved by the car. A small number of candidates wasted their time by writing word equations for work done and force. A very small number of candidates opted to write the work done equation as $\frac{1}{2}Fx$.
- (a)(ii) Many candidates managed to arrive at the pivotal expression $W = max$ using the earlier equations of $F = ma$ and $W = Fx$ from (a)(i). They then either gave up or tried to fiddle their work towards the equation for kinetic energy. Many candidates used $v = at$ and $x = vt$ and ended up with $KE = mv^2$. They then used some incorrect reasoning to introduce the factor of $\frac{1}{2}$ into this equation. A pleasing number of candidates

demonstrated great algebraic skills by using the equation of motion $v^2 = u^2 + 2ax$ with $u = 0$ to arrive at the correct equation $\frac{1}{2}mv^2$. Some candidates even used $s = \frac{1}{2}(u + v)t$ and $v = u + at$ to arrive at the correct equation.

- (b) The majority of the candidates realised that the braking distance of the car would increase. This answer was often intuitive and many candidates struggled to give clear reasoning to back this claim. There was rote learning of '*braking distance is proportional to the mass*'. Only the most able candidates showed good reasoning using $Fx = \frac{1}{2}mv^2$. A small number of candidates were led astray by incorrectly mentioning that the force acting on the car would increase because '*force \propto mass*'.

Question 8

Most candidates scored five or more marks. The extended writing question in (b) produced a range of marks. Brevity was often a sensible strategy because contradictions could be avoided. Candidates opting for bullet points often did well.

- (a)(i) The question favoured candidates who took care in scrutinising the labels on the axes of Fig. 8.1. Too many candidates omitted the giga prefix and failed to correctly convert the % strain. The most common answer was 1.9 Pa instead of 1.9×10^{11} Pa.
- (a)(ii)1 Elastic behaviour was the common answer for the property of the material in the linear region. Some candidates described fully what was meant by elastic behaviour by mentioning the material returning back to its original shape when unloaded. The other acceptable answers were '*Obeys Hooke's law*', '*stress \propto strain*' and '*force \propto extension*'.
- (a)(ii)2 Most candidates scored a mark for mentioning '*plastic behaviour*'.
- (a)(iii) This proved to be a challenging question, even for some candidates at the top-end. Full credit was given to candidates for identifying that the gradient of the line was unchanged because altering the length does not affect the Young modulus of the material. Too many candidates thought that the Young modulus, and hence the gradient, would change when the length was doubled. This was often incorrectly reasoned by writing the equation $E = \frac{FL}{Ax}$. This was followed by '*Young modulus E is directly proportional to the length L*' and hence the graph would be steeper.
- (b) Many candidates correctly identified the material as rubber, a polymer or a polymeric material and that it had elastic properties. Those who wrote '*polymetric*' lost the QWC mark. Some candidates spoilt their answers by stating that the material was also ductile. The term hysteresis was occasionally seen but the idea that the area under the loading graph was greater than that under the unloading graph or its significance in terms of the work done or the energy returned did not feature clearly in any of the answers. A very small number of candidates mentioned that the tyres prevented bounce or '*absorbed energy during landing*'. Most of the answers about the suitability of the material were related to the idea that the material was elastic and so the tyres would regain their shape and hence could be used again.

G482 Electrons, Waves and Photons

General Comments

Candidates scored across the range from zero to about 95%. There were some excellent papers but also some lacking basic GCSE knowledge. All candidates appeared to have enough time to complete the paper and there was no evidence of any misunderstandings in what was being asked. Candidates scored freely in questions where the exercise was mainly substituting into formulae and managing powers of ten. Where explanations were required the answers proved to be more discriminating, especially in Q1, Q5 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 appeared to have been poorer than of late; especially the setting out of calculations neatly and logically. This was particularly evident in questions where candidates had to 'show' something – numbers were often written on the page with no proper conclusion to the calculation. Some of the handwriting was very difficult to decipher, often in cases where it was very small. Candidates should be reminded that the examiner has to read their answers on a computer screen.

Many candidates do not learn their definitions precisely and consequently squander marks by use of casual phrases. For example in Q6 *photons hit, collide or knock out electrons* rather than being absorbed by electrons. There were more rounding and significant figure errors. For example in Q2(a) the expected answer for the charge was $2.88 \times 10^6 \text{ C}$ or $2.9 \times 10^6 \text{ C}$. However some candidates rounded down to 2.8 whilst others were tempted to give the answer to only one significant figure.

It was very evident in the mechanical wave question, Q4, that many candidates have little appreciation of the actual motions that are taking place, partly perhaps by the incorrect use of words. In this, as in all 'wave' questions candidates should be advised not to use such phrases as 'the wave oscillates' but to discuss in terms of 'particles oscillating' to improve their understanding. Descriptions usually refer to all of space at one time or one point in space over a period of time. The muddling of these two views, the path or phase difference description, leads to many poor or confused explanations.

Comments on Individual Questions

Question 1

- (a) About a third of the candidates described the effect of resistance rather than giving a definition. A few still give symbols without defining the quantities represented. Almost all could read the correct value from the graph and change milliamps into amps.
- (b) Most candidates recalled the resistivity formula but some could then not manipulate it or failed to work out the correct area of the slice.
- (c) A significant number of candidates still believe that resistance is related to the gradient of the characteristic. It was also common to relate temperature rise to the voltage rather than the current in the slice. There were also many microscopic explanations in terms of free electrons, not answering the question as set. The question proved to be a good discriminator with better candidates scoring full marks.

Question 2

- (a) The majority of candidates scored at least one mark for the definition of *e.m.f.* realising that it is the energy transfer into electrical from some other form. However it is common to omit *per unit charge*. The calculations of charge and energy were well done. See comment in general above.
- (b) Most candidates were able to draw a battery or cell symbol with the correct polarity and then to verify the value of the limiting resistor. The calculations of power and efficiency proved to be very straightforward for most but a number became confused and used power output rather than power input. Others mixed power and energy in their efficiency calculation.
- (c) There were many convoluted attempts to achieve a charging time of 7 hours with less than half being correct. Even fewer completed the cost calculation correctly. It proved to be too daunting a question for many of the weaker candidates, who did not attempt it.

Question 3

- (a) The two laws were well known. Some used the word point rather than junction in the first law whilst others omitted the word sum or total. It was very common to see the part requiring the statement of the conserved quantity omitted, even by good candidates. Conservation of current and voltage were popular incorrect answers here.
- (b) Most candidates were able to calculate the current and voltage correctly but more struggled with the values of the resistors, especially R_1 .
- (c) The LDR symbol was well known; a minority choosing the thermistor or diode symbol. Most appreciated the fact that the LDR resistance decreased with increasing light intensity but then went on to state that the current was unchanged. There were many answers that insisted that an increase in p.d. across the LDR implied that there would be a decrease in p.d. across the 750 ohm resistor. Those adopting a potential divider approach by including resistor R_1 usually scored, but these were very much in the minority. The majority correctly used a voltmeter or ammeter of an appropriate range although some had unusual choices for the value of full scale deflection.

Question 4

- (a) Most candidates were aware that progressive waves transfer energy but the role played by oscillations was often omitted. Few of the weaker candidates were able to give two sensible differences between a progressive and a stationary wave.
- (b) The sketch produced mainly sine curves and many of the shapes bordered on the triangular. An amplitude of 0.3 was very common. The graph proved to be an excellent discriminator with almost every possible combination of marks gained. W, X, Y and Z movements were not well interpreted with W considered at rest, X moving fastest and Y & Z being 90° out of phase. Many appreciated that points Y and Z moved vertically, though only a minority had Y upwards and Z downwards.
- (c) Many produced the correct answer but struggled to justify it. Many algebraic manipulations failed to cope with the \sqrt{T} .
- (d) The majority confused the wave speed with the speed of a particle oscillating in the transmitting medium.

Question 5

- (a) Many answers confused amplitude and displacement. Many restricted the principle to only certain categories of waves rather than being universal. The ability to be polarised was often stated as a distinguishing feature of electromagnetic waves. Most scored the last mark in this section.
- (b) There were good answers to part (i), but some candidates failed to note the request for explanation of the whole phenomenon and concentrated on the reduction of the signal to zero. Many could not differentiate between *path* and *phase* difference and some did not appreciate that a *difference* is only possible when comparing two quantities. Part (ii) was less well answered with polarisation being given as the result of rotation or only one wave being polarised. The majority discussed the interference between the two waves rather than focussing on the fact that the detector only receives the signal from one transmitter.

Question 6

- (a) In (i) few candidates gave a simple answer, i.e. *light shining on a metal surface causes the emission of electrons*. The sentence *photons hit, collide or knock out electrons from a material* gives a summary of many of the words used to produce a poor description. (ii) and (iii) proved to be good discriminators.
- (b) Again, *work function* was poorly defined but most candidates could do the calculations and scored the majority of the marks here.
- (c) Electron diffraction was understood by most though the subsequent interference producing the pattern on the screen was often neglected in the answer. Very few appreciated the polycrystalline nature of graphite. Many thought that the wavelength was of the same order of magnitude as the gap. It was frequently assumed that the electron needed to be travelling at the speed of light for it to exhibit proper wave behaviour.

Question 7

- (a) Many candidates did not fully comprehend what this question was asking. Few realised that it was talking about the coherence of the light and fewer still were able to relate this to the need for a single source. Many discussed the diffraction pattern formed.
- (b) 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 full marks.
- (c) A large number failed to extract the correct information from the diagram to determine the fringe width. A small minority worked backwards from the given answer of about 5×10^{-7} m to state the answer as 1.875 mm, giving themselves away. The calculation was done well.
- (d) The majority of candidates failed to realise that the path difference was twice the wavelength and many of those who did, failed to give the correct value in nanometres.
- (e) Part (i) was very well answered but in (ii) IR and UV were often reversed or outer regions of the electromagnetic spectrum were chosen.

G483/01 Practical Skills in Physics 1

General Comments

As has been discussed in previous reports the assessment of practical skills relies very much on the care and attention to detail that the individual Centres put into the process. Again the majority of Centres approached the organisation of the tasks well and candidates appear to have been suitably prepared. There were no major issues with the apparatus required to carry out the tasks. Centres are thanked again for the valuable contribution that they have made in making this unit of assessment successful.

One of the purposes of the moderation process is to confirm the marks awarded by a Centre. It is thus very helpful where a Centre has annotated the script 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.

It was clear that the majority of larger Centres had carried out appropriate internal moderation. Centres must ensure that the marks awarded are clearly indicated on the scripts. Furthermore, where marks have been changed as a result of the internal moderation process, the MS1 is completed with the agreed Centre mark. 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 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 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 Centre should contact OCR either by telephone or email. When 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. About two thirds of Centres included a sample set of results together with any details of any modification to the tasks. This is very helpful and it is hoped that all Centres will supply the sample results in future.

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. It is important that Centres review their procedures with regard to storing the work for next year.

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.

Qualitative Tasks

Generally Centres marked these tasks accurately.

For B1.2 Centres are able to award one mark for “other detailed correct statement that supports the observations”. Where Centres are unsure as to whether the mark should be awarded, clarification should be sought from OCR.

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 inconsistency in the 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 inconsistency 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. 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.

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. Often for C2.1, the first mark is given for equating the gradient or y -intercept correctly; the second mark determining a value for the quantity using their particular values for the gradient and/or y -intercept. At this stage candidates are not usually penalised for a power of ten error or indeed if a mistake has been made in determining the gradient or y -intercept. 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.

For example, a candidate determining the acceleration of free fall, g , and the mark scheme may say allow 9.00 ms^{-2} to 11.0 ms^{-2} . If this was the case a candidate who calculated g correctly for C2.1 for two marks having arrived at a numerical answer correctly using the equation given, would score one mark for C2.2 for an answer of 970 ms^{-2} or 971 ms^{-2} (since there is a power of ten error but the number of significant figures in both cases is appropriate). Candidates who do not use their gradient and/or y -intercept values cannot score C2.2 marks.

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 correctly 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 need 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.

Again in evaluative task 2 this year for C4.1, the additional guidance stated that “one limitation must be either 1 or 2”. The following table indicates how this statement should be applied:

Limitations included	Marks Awarded
1 only	1
2 only	1
1 and 2	2
1 or 2 and 3	2
1 or 2 and 4	2
3 or 4 only	1
3 and 4	1

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 that 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 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 2 to 60 and the mean score was almost 37. 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 significantly better than expected. There were far fewer errors in basic arithmetic and powers of ten this session; a welcome response to the comments in the last report. Unfortunately this was not matched by an improvement in answers involving extended writing. Many candidates lost marks as a result of giving insufficient detail in their answers.

This paper also included two questions where diagrams were specifically required and while many were carefully drawn there were a significant minority of poorly constructed freehand sketches. Candidates should be aware that at A2 level examiners do expect accurate diagrams, drawn with a straight edge where appropriate, and reasonably smooth curves on graphs with axes clearly labelled.

As in previous sessions there is still evidence that candidates are not carrying sufficient number of significant figures in their working. Since the data in all questions were given to two significant figures examiners expected candidates to carry at least three significant figures in their working and intermediate answers in order to ensure that the final answer could be confidently rounded to two significant figures. It was not uncommon to see intermediate values being round to two significant figures resulting in an inaccurate final answer. This was particularly noticeable in Q5c(ii).

There were very few omissions this session and it is good to report that candidates were able to attempt to answer all questions on the paper. This suggests that there was adequate time to read questions carefully 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 and were able to maintain their confidence resulting in marks being scored over the entire 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 1

- (a)(i) Most candidates were able to get off to a good start on the paper. Only a small number lost the mark by basing their answer on $F = ma$.
- (a)(ii) It was essential to start this 'show' question with the equation $F = \Delta(mv)/\Delta t$. The examiners agreed to allow $(mv - mu)$ and Δp as equivalent to $\Delta(mv)$ provide p was defined as mv . Unfortunately many candidates omitted this step and consequently were not awarded any credit. It is important to realise that in any 'show' question all steps must be given in the answer.

- (b)(i)** Only a minority of candidates realised that the area under the given force graph was the impulse acting on the object. Unfortunately many used the maximum force and the time taken to reach this value (2.0s) in a formula amounting to $F=ma$ to obtain the change in velocity. Since the force, and consequently the acceleration, in this case is variable this is wrong physics and could not gain credit despite producing the same numerical value for change in velocity. Full credit was, of course, given if the mean force (10N) was applied for the full time (4.0s).
- (b)(ii)** Most candidates were able to score this mark given the application of ECF.
- (b)(iii)** Answers to this question were particularly disappointing with only a minority gaining full marks. Many assumed that the negative gradient of the graph in the second stage implied deceleration. Only a small minority made reference to the constant rate of change of acceleration in either stage.

Question 2

- (a)(i)** It was clear that the majority knew the correct diagram but it was disappointing to see a significant number of poorly drawn freehand sketches. All too often the lines were not radial nor did they cross in a common point near the centre of the Earth. Candidates should realise that a carefully drawn diagram using a straight edge is expected at this level. Only a small minority failed to indicate the correct direction of the field lines which was encouraging.
- (a)(ii)** This question discriminated well. It was pleasing to note that only a few lost a mark as a result of misspelling 'parallel'.
- (b)(i)** Well answered by all but a small number of candidates.
- (b)(ii)1** Apart from a small minority the appropriate equations were well known by candidates. The most common errors were the expected use of the mass of Rhea rather than Saturn and the use of the g value at the surface of Saturn rather than at the orbit of Rhea. A small number did not read the question carefully and added the two radii together. It is a pity that these candidates rushed into the formulae without giving the situation a little more thought.
- (b)(ii)2** Given the application of ECF this rarely caused candidates any difficulty.

Question 3

- (a)** Almost all candidates knew that acceleration was in the opposite direction to displacement but there was less success in identifying the final correct statement.
- (b)(i)** An easy mark for all but a handful.
- (b)(ii)** It was disappointing to see so many candidates misreading the scale from the graph; most commonly quoting 0.8 ms^{-1} .
- (b)(iii)** The majority correctly identified the required equation and given the use of ECF made a correct substitution and arrived at a consistent answer.
- (c)(i)** This question also discriminated well with most candidates able to score some marks. The graph shape was well known even if the smooth nature left a little to be desired in some cases. Unfortunately the axis labelling caused a significant number to lose the mark. A second mark was awarded for labelling the frequency at the peak of the graph as well as a clear statement in the written explanation, giving two marks for many candidates. The final mark for the 'maximum amplitude' was less commonly scored.

- (c)(ii)** In view of the limited number of marks available for this question it was decided to give credit for a range of examples and explanations in which it was relatively easy to identify the driver and driven system. Most answers were sufficiently clear to score at least one mark. Of the small minority quoting a musical instrument as their example, very few were able to identify the driver and driven system.

Question 4

- (a)** The majority scored well in this question.
- (b)(i)** Most were able to identify the correct energy to use in this calculation and arithmetical errors were rarely seen.
- (b)(ii)** A difficult calculation for many. Common errors that were encountered included not knowing which energy to use and the volume of the room used instead of the volume of the heating gas.
- (c)** Most answers were at GCSE level and talked about energy lost to the surroundings, or to the heater. At A2 examiners expect a more specific detailed response.

Question 5

- (a)** Most candidates realised that the key to the question was the vector nature of momentum. It was rare, however, to find answers where candidates clearly linked the elastic nature of the collision with conservation of kinetic energy and hence the speed of the molecules would be unchanged in the collision. All too often reference was made to conservation of momentum being the reason for the speed of the molecules remaining unchanged.
- (b)** Although there were many good answers to this basic kinetic theory question, a significant number of candidates failed to score the first marking point because they did not specifically link an increase in kinetic energy with the speed of the molecules. While many candidates mentioned an increase in the number of collisions taking place at higher temperatures few realised that it was the rate of these collisions that was the crucial factor. The third marking point was more commonly given accurately.
- (c)(i)** This straight forward gas law calculation was well answered by all but the weakest candidates who had not registered the need to convert the temperatures into Kelvin before substituting.
- (c)(ii)** It was particularly pleasing to see so many good responses to this slightly more tricky question. The most common misconception was that the change in area could be determined by dividing the weight by the change in pressure.

Question 6

- (a)(i)** While many candidates correctly identified the relationship between pressure and volume only the better ones realised that two quantities needed to be kept constant in order for the law to hold true.
- (a)(ii)** There were many good answers, as expected to this follow-up question.
- (b)(i)** It was encouraging to see many good clear answers to this two-part question although there is still a minority who are persisting in using Celsius temperatures in gas calculations.

- (b)(ii)** It was encouraging to see many good attempts at this stretch and challenge question. Most candidates followed the 'hint' given in **(i)** and found the number of moles added and hence the total number of moles in the cylinder after the addition. Only the most able candidates realised that the cylinder volume was unchanged and correctly determine the pressure for a volume of 0.05 m^3 .

G485 Fields, Particles and Frontiers of Physics

General Comments

The paper worked well to differentiate candidates of differing abilities. The marks for this paper ranged from 0 to 98 and the mean score was about 55. The majority of the candidates attempted all of the questions and there were no timing issues with completing the paper in the scheduled 2 hours. The additional space was occasionally used; indicating ample space for the answers on the question paper itself. Candidates who used the additional space on page 23 did so for rough numerical work and also for extra extending writing for question **11(b)**.

Candidates displayed an improved mathematical competence. There were fewer rudimentary slip ups with significant figures and rounding numbers. Analytical solutions were structured well and showed confidence with exponential functions and natural logarithms. As always, a small cohort of candidates lacked the algebraic skills necessary at this advanced level. Top-end candidates revelled in questions requiring synoptic knowledge. This was particularly noticeable in questions **2(c)(ii)** and **7(b)**.

Extended writing was a challenge for many candidates. Those who wrote concisely did generally well. Technical terms were not used effectively in explanations. Many candidates need to improve their scientific vocabulary. The comments on the individual questions show where opportunities were missed by some of the candidates.

Candidates continue to make good use of the Data, Formulae and Relationships Booklet. There was misinterpretation by a small number of candidates regarding '*the second page*' of this booklet in question **6(c)(iii)**. This led some to focus on the atomic mass unit u rather than the masses of the proton and the neutron. The marking scheme was adjusted to accommodate this confusion. As mentioned in many previous reports, the legibility of some candidates remains a cause for concern.

Comments on Individual Questions

Question 1

Most candidates made a decent start in this opening question and scored four or more marks. The solutions were often well-structured and easy to decipher.

- (a)** Almost three quarters of the candidates scored full mark. The equations for total capacitance in series and in parallel had been well rehearsed by most of the candidates. A few candidates stopped after calculating the total capacitance of the 100 μF and 300 μF capacitors. About one in five candidates either added all the capacitances (900 μF) or assumed that the capacitors were all connected in a series combination (65 μF).
- (b)(i)** Most of the candidates did score full marks, however, a significant number also scored zero. Many candidates either used the exponential decay equation or the time constant idea to determine the resistance across the terminals. The reading of the graph was generally quite good. A significant number of candidates took the value of the time constant to be 42 s (half life) rather than 60 s. A small number of candidates used their total capacitance of 575 μF rather than 500 μF in their analysis. There was just a penalty of one mark for this error. The knowledge and competence of using logarithms was commendable.

- (b)(ii)** Most of the candidates had no problems arriving at the correct answer of 5.8 mJ. Some candidates only determined the energy stored at 6.0 V. A few attempted to use the expression $\Delta E = \frac{1}{2} \times 500 \times 10^{-6} \times (6.0 - 3.6)^2$ to calculate the energy lost by the capacitor. A small number of candidates misread the graph, whilst others attempted to use the equations $Q = It$, $V = IR$ and $Q = VC$ to solve this problem.

Question 2

This question on the electrical force between charged spheres and vectors produced a range of marks and discriminated well.

- (a)** The majority of the candidates found this question to be straight forward and had no problems picking up the one mark. A very small number of candidates divided the charge on the sphere by the mass of the electron.
- (b)** The Coulombic equation for the electrical force between the charged spheres was familiar to most of the candidates. Many used it effortlessly to arrive at the correct answer of 1.8×10^{-4} N. A few spoilt their answers by halving this correct value. The other most frequent errors were:
- forgetting to square the separation of 0.02 m between the spheres
 - using 0.01 m instead of 0.02 m for the separation between the spheres
 - using the elementary charge 1.6×10^{-19} C instead of 2.8×10^{-9} C
- (c)(i)** The modal mark for this question was zero. Candidates in the upper quartile were succinct with their answer by mentioning the '*tension and weight of the sphere*'. However, answers such as '*strong nuclear force*' and '*magnetic force*' were also seen.
- (c)(ii)** This was a good discriminating question; it required synoptic knowledge of vectors. It was a pleasure to see many well structured answers. The vector diagrams were labelled and this guided the candidates towards the correct answer for the angle of dangle. Not many candidates used a scale drawing. A small number of candidates used the mass of the sphere rather than its weight in their analysis. There were also some issues with using sine or cosine rather than tangent.

Question 3

All candidates attempted this question and marks scored covered the entire range. Most candidates were scoring five or more marks.

- (a)** Most of the arrows showing the direction of the electric field were pointing in the incorrect direction or simply omitted. Slightly less than half of the candidates had an arrow pointing to the left.
- (b)(i)** Determining the kinetic energy of an electron in electronvolts proved to be far more complicated than necessary. A significant number first calculated the kinetic energy of the electron as 2.4×10^{-16} J. They then divided this by the value of 1 eV in joules to arrive at the obvious answer of 1500 eV. Top-end candidates did no analysis and simply quoted this correct value on the answer line.
- (b)(ii)** Most of the answers showed excellent structure. There was error carried forward from the incorrect answer of 2.4×10^{-16} eV from **(b)(i)**. This gave an unusually small value for the speed of 9.2×10^{-3} m s⁻¹. A very small number of candidates used 1500 J as the kinetic energy of the electron; no credit was given for this fundamental error.

- (c)(i) Only a small number of candidates appreciated that an electron was un-deflected because the electrical force EQ was numerically equal to the magnetic force BQv . The forces were of course in opposite directions. In spite of this, most candidates managed to gain two marks by substituting either $Q = F/E$ into $F = BQv$ or $Q = F/Bv$ into $F = EQ$.
- (c)(ii) Most candidates did not give the correct description or explanation. Many candidates had the electrons moving 'upwards' and cited Fleming's left hand rule. The most frequent wrong answer followed the pattern below.
- $v = \frac{E}{B}$, hence the speed v decreases as B increases.
 - The slow-moving electrons would therefore drift downwards.

Question 4

Many candidates did particularly well with the calculations in (b). Most candidates managed to score five or more marks.

- (a) The definitions for magnetic flux were variable. A significant number of candidates were not accurate enough with the idea of the area being perpendicular to the magnetic field. A small number of candidates quoted $\phi = BA\cos\theta$ but then failed to adequately define the angle θ . Some candidates at the lower end defined the magnetic flux as '*magnetic flux density per unit area*'.
- (b)(i) This was a real success for candidates of all abilities. The resistivity equation was used correctly to get a resistance of 3.32Ω and hence the current in the copper wire. About a fifth of the candidates lost all three marks because of their inability to determine the cross-sectional area of the copper wire. The most common errors were:
- area = $2\pi r$
 - area = $\pi r^2 L$
 - resistance = $\rho = 1.7 \times 10^{-8} \Omega \text{ m}$
- (b)(ii) It is good to report that the majority of candidates gained full marks for correctly using Faraday's law of electromagnetic induction. Those who failed did so because of weak algebraic skills.

Question 5

There was a good spread of marks for this question on nuclear and particle physics. Examiners were particularly pleased with the clarity of ideas presented in (b).

- (a)(i) Very few candidates got this question right. There were many strange guesses that included 3 and '*many*'.
- (a)(ii)1 Most candidates effortlessly used the de Broglie equation $\lambda p = h$ to calculate the momentum of the electron. A very small number of candidates attempted to use $E = \frac{hc}{\lambda}$.
- (a)(ii)2 There were some superb answers that started with Einstein's mass-energy equation and then a clear explanation of how an increase in kinetic energy led to an increase in the mass of electron. There were some missed opportunities here too. No marks could be given for a statement such as '*mass changes because of speed*'.

- (b)(i) Most candidates correctly identified that the isotopes had different number of neutrons. Only a very small number thought that '*the proton number changed*'.
- (b)(ii) Examiners were delighted to see '*uud*' as the most common answer.
- (b)(iii) The most concise answer was $u \rightarrow d + e^+ + \nu$; this was worth two marks. Most candidates either used words or the correct symbols for the particles to get their physics across. Some candidates even went further by mentioning the weak interaction and the *W*-boson. There was only one mark awarded for $p \rightarrow n + e^+ + \nu$ because there was no mention of the up or down quarks.
- (b)(iv) Almost all candidates gained a mark for stating two quantities that were conserved in a beta plus decay.
- (b)(v) Most candidates correctly interpreted the information given in the table and gave clear and detailed answers.

Question 6

This question discriminated well. High-ability candidates had the chance to display their excellent understanding and reasoning powers in (b) and (c)(iii).

- (a) Most candidates struggled to give clear answers. Many answers, such as '*it cannot be predicted*' and '*you can never tell when it is going to happen*', lacked clarity and made no reference to the decaying **nuclei**. The most frequent answer from the upper quartile candidates was that '*it is not possible to predict when or which nucleus was going to decay next*'. Reference to either the nucleus or nuclei was essential. Many answers were spoiled by referring to decaying *particles, atoms* and even *elements*.
- (b) Well done to the majority of the candidates, across the ability range, for their well-structured and reasoned answers. Most candidates made an excellent use of the exponential decay equation $N = N_0 e^{-\lambda t}$. Many even had the confidence to calculate the decay constant in year^{-1} rather than in second^{-1} . It was great to see a variety of techniques used to get to the correct answer of 4.6×10^9 y. Some candidates attempted to estimate the age of the Earth by consistently halving the half life. No credit was given for such an approach.
- (c)(i) Almost all candidates managed to quote the value of the nucleon number in the range 50 to 70 and therefore scored a mark. A significant number of candidates knew that the maximum peak occurred for iron-56.
- (c)(ii) This was a low-scoring question with many candidates not making any reference to the graph shown in Fig. 6.1. The most frequent incorrect answers were:
- fusion cannot occur after iron-56
 - only fission can produce energy
 - the binding energy of the product will be higher

Only a small number realised that the resulting nucleus would have a lower binding energy per nucleon and hence no energy would be released in the reaction.

- (c)(iii) The concepts of binding energy and binding per nucleon are tough and require excellent conceptual and mathematical skills. This question was targeted towards the high-ability candidates. As such, examiners were not disappointed by the well-reasoned and elegantly laid out solutions. Some of these candidates stopped after

calculating the binding energy of 9.2×10^{-12} J. As mentioned in the introduction, there was some misunderstanding about the ‘second page’ of the booklet and consequently the marking scheme was made a little flexible to accommodate solutions in terms of the unified mass unit. Low-ability candidates struggled with the complexities of this question. The most common answers from such candidates were:

- $BE = 1.329 \times 10^{-26} \times (3.0 \times 10^8)^2 = 1.2 \times 10^{-9}$ J
- $BE \text{ per nucleon} = 1.661 \times 10^{-27} \times (3.0 \times 10^8)^2/8 = 1.9 \times 10^{-11}$ J

Some answers were marred by premature rounding of numbers at intermediate stages. This must be avoided in the future.

Question 7

This question on X-rays produced a range of marks and discriminated well.

(a) The answers to this question about photons focussed more on the properties of electromagnetic waves. The most frequent correct answers were:

- X-ray photons travelled at a speed of 3×10^8 m s⁻¹ in a vacuum
- X-rays photons are highly ionising.
- X-rays photons have no charge

(b) This was a perfect question for the high-ability candidates. There were two routes to the correct answer of 1.2×10^{-12} m for the maximum wavelength of the X-rays.

- Calculating the total mass of the electron and the positron, then using Einstein’s mass-energy equation and then finally using $\frac{hc}{\lambda}$ to determine λ .
- Using Einstein’s mass-energy equation and $\frac{hc}{\lambda}$ to derive the expression for the wavelength of the X-rays. Then substituting the data into the expression

$$\lambda = \frac{h}{2mc}$$

There was the inevitable error with omitting the factor of two. Some candidates managed to recall that the minimum energy of an X-ray photon to produce an electron-positron pair was 1.02 MeV. There was no penalty for this as long as the correct conversions led to the correct value of the wavelength.

Many low-ability candidates either used $\frac{hc}{\lambda}$ or the de Broglie equation to determine the wavelength.

(c) Most candidates managed to score two marks. Ideas were communicated with confidence. There were good explanations of either using barium or iodine as the contrast materials in X-ray imaging. Most candidates recognised that the atoms of a contrast material have large atomic number Z or the material has large attenuation coefficient.

Question 8

This was a low-scoring question. The extended writing question in **(c)** produced a range of marks. Candidates who opted to present their ideas in concise bullet points did marginally better than those who decided to write in continuous prose.

- (a) The definitions for the activity were often incomplete or lacking in precision. Many candidates were referring to the decay of *atoms*, *particles* and even *elements*. Only a small number of candidates in the upper quartile gave correct definitions that took nuclei into account; for example, ‘*activity is equal to the rate of decay of nuclei*’. Candidates are reminded that the word equation ‘*activity = decay constant × number of nuclei left*’ is not a definition for activity.
- (b) Many candidates struggled to use the information given to calculate the initial rate of energy emission. This meant that many did not appreciate what was meant by the term activity or that a becquerel was equivalent to one gamma ray photon emitted per second from the source. A significant number of candidates multiplied the activity by the energy of a single photon to arrive at the correct answer of $1.1 \times 10^{-5} \text{ J s}^{-1}$.
- (c) Very few candidates omitted this extended writing question on the components of a gamma camera. There was a lot of variation in the quality and the precision of the written work. Most candidates could name the components of the gamma camera: lead collimator, scintillator, photomultiplier tubes and computer. The lead collimator and the computer functions were often well-described. The section below shows what some candidates were writing and what examiners were expecting for the scintillator and the photomultiplier tubes.

Component	Candidate response	Typical expected response
Scintillator	A scintillator changes <ul style="list-style-type: none"> • gamma into electrons • gamma radiation into specs of light • a gamma photon into <u>a</u> light photon. 	A single gamma ray photon incident on the scintillator produced many photons of light.
Photomultiplier	A photomultiplier changes <ul style="list-style-type: none"> • specs of light into electricity • gamma rays into electrons • light into an image 	A single photon of light entering the photomultiplier tube produces a pulse of electrons.

Question 9

Almost all candidates attempted this question. The quality of the written work was variable with most candidates scoring half of the available marks.

- (a) There were many missed opportunities here. Some candidates thought that ultrasound was ‘*an EM wave that can travel through vacuum*’. Many wrote answers that were not precise enough to gain marks. For example, writing ‘*ultrasound is greater than 20 kHz*’ instead of ‘*ultrasound has frequency greater than 20 kHz*’.
- (b) Most candidates understood how the piezoelectric transducer worked. However, a significant number failed to mention that an alternating e.m.f. was required. Many candidates did not plan their answers properly and only left the last answer line (or the additional page) to discuss the reverse process.
- (c) This was a well-answered question. Most candidates showed excellent understanding of acoustic or impedance matching. A few candidates made reference to attenuation coefficient μ instead of acoustic impedance Z . This was a real success for most candidates.

- (d) The answers here were extremely variable. Top-end candidates were scoring at least three marks. At the other extreme, candidates were familiar with the Doppler shifting in the wavelength of the ultrasound but many did not appreciate that this was caused by the reflection of the waves at the blood cells. A few thought that the change in the wavelength was the result of reflection at the artery. Far too many candidates incorrectly used the Doppler equation $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$ from the topic of cosmology to explain how the speed of the blood was determined. A few candidates correctly recalled the equation $\frac{\Delta f}{f} = \frac{2v\cos\theta}{c}$, which is not a specific requirement of the specification.

Question 10

All candidates have traditionally done well in cosmology questions, and this was no exception. The calculations in (c)(i) and (c)(ii) were commendable. Most candidates gained seven or more marks for this question.

- (a) The value of 1 light-year, 9.5×10^{15} m, is given in the Data, Formulae and Relationships Booklet, so candidates were expected to clearly show the steps leading to this value. Most candidates picked up a mark.
- (b) Most candidates correctly labelled Fig. 10.1 with 1 pc, 1 AU and 1".
- (c)(i) This was a real success, with clearly structured and reasoned answers. A small number of candidates used the conversion factor of 1 pc = 3.26 ly; this approach was acceptable.
- (c)(ii) This was a high-scoring question for candidates across the ability spectrum. Very few candidates made errors with powers of ten. A variety of different approaches were correctly used to get to the correct answer of 7.9×10^9 y.
- (d) The properties of a black hole were well known and enthusiastically outlined by the candidates. Many candidates effortlessly acquired two marks.

Question 11

This question produced a good spread of marks. All the calculations were attempted by the candidates, with many doing extremely well in (a)(i). The extending writing in (b) showed an extraordinary passion for the big bang.

- (a)(i) Well done to the majority of the candidates who gained at least two marks. Most candidates calculated the Hubble constant in s^{-1} with great ease. The conversion from s^{-1} to $\text{km s}^{-1} \text{Mpc}^{-1}$ was successfully tackled by the top-end candidates. A few candidates struggled with the various conversions and ended up with a value recalled from their teaching, which was often $75 \text{ km s}^{-1} \text{Mpc}^{-1}$.
- (a)(ii) This was a perfect question for the high-ability candidates. Many of whom coped extremely well with all the conversion factors and the manipulation of the Doppler equation $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$. Only a small number of candidates in this cohort subtracted the change in wavelength of 7.8 nm from 656 nm. Middle ability candidates managed to get as far as the recessional speed of the galaxy in either m s^{-1} or in km s^{-1} . Slightly more than one in ten candidates omitted this question.

- (b) All the answer lines, and sometimes more, were used in answering this question. The candidates filled the page with facts and managed to pick up at least three marks. Most candidates knew what was meant by the *big bang*. Many candidates gave lots of information about the evolution of elementary particles and the fundamental forces. The physics of the background microwaves radiation appeared almost as a footnote. A little planning and reflection would have helped some candidates to gain further marks in this question. Many candidates knew about the temperature of 2.7 K. Very few appreciated that the almost uniform **intensity** of the microwaves was the supportive evidence for the cosmological principle.
- (c) Most candidates were aware that further expansion of the universe would make the wavelength of the microwaves longer. An answer such as '*expansion would change microwaves into radio waves*' was acceptable. Many also appreciated that further expansion of the universe will lead to more cooling.
- (d) Most candidates drew a graph corresponding to an open universe. This was acceptable, as were graphs that portrayed an accelerating universe.

G486 Practical Skills in Physics 2

General Comments

The third moderation session of the A2 physics practical skills went smoothly with most centres taking on board the comments made from last year.

Many more teachers were annotating the written prose in the evaluative tasks indicating which of the marking scheme points were being credited. This was found to be very helpful by moderators, in determining how the candidate's work had been interpreted.

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

For consistency across centres it is also 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 the qualification manager over the past year and were able to clarify their queries.

Qualitative Tasks

Generally Centres marked these tasks accurately and consistently.

Where a relationship is to be tested, the first B1.1 mark is for a valid numerical test. A second calculation or equivalent reasoning together with a conclusion must be seen in order to award the second B1.1 mark.

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. 'Hairy' lines must be penalised. Further guidance is given in the Practical Skills Handbook.

In Task 1, it was not uncommon for candidates to state the period T without showing the measured $10t$ value. Some centres allowed full credit for this even though the mark scheme detailed the requirement that at least $10t$ is shown.

In B1.2 it is necessary for candidates to make reference to the magnetic properties of iron / steel in the clamp stands. Many candidates were given credit for saying that 'a metal stands attracts the magnet' (These should not have been given credit.)

B1.2 was marked generously by a few centres; candidates' answers must be **detailed** and explanations must be thorough – the guidance given in the mark scheme should be followed. A few centres credited a correct phrase which was buried in a sentence that was essentially incorrect. Again Centres are always welcome to email OCR for further guidance.

Task 3 was performed more smoothly this year. There were no reports of magnets getting stuck in the copper pipe and the results were much more consistent. Candidates were able to offer some A2 physics in their explanations in B1.2. Again 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 marks are not given for unexplained statements. For example, a number of centres were giving credit for 'It is due to Lenz's Law', with no further explanation.

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. It was less common this year to find the omission of raw t in Quantitative Task 3, (with only the period T shown in the 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. $1/t^2 / \text{s}^{-2}$ 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 mark for the line of best fit mark in C1.2 was found to be awarded generously by a number of 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 fill in 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.

The use of more than half of the graph paper was marked well. A few centres were still penalising candidates whose points fulfilled the 4 x 6 large square grid criteria, 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 fewer small triangles used on the graph. This 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 still 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.

In C3.2, there continues to be confusion between the terms *accuracy* and *reliability*. It is suggested that candidates be encouraged to approach each term independently and allotting each a separate sentence.

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 bring 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. This usually resulted in the centre falling outside of the tolerance. C4.2 improvement must be linked to an identified limitation.

The Future

The Tasks for 2013/14 were published in June 2013. 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 2013 and 14 May 2014*’) 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.

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