Oxford Cambridge and RSA

GCE

Physics B

Advanced GCE **H557**

OCR Report to Centres June 2017

About this Examiner Report to Centres

This report on the 2017 Summer assessments aims to highlight:

- areas where students were more successful
- main areas where students may need additional support and some reflection
- points of advice 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.

The report also includes:

- An invitation to get involved in Cambridge Assessment's research into **how current reforms are affecting schools and colleges**

- Links to important documents such as **grade boundaries**

- A reminder of our **post-results services** including Enquiries About Results

- **Further support that you can expect from OCR**, such as our Active Results service and CPD programme

- A link to our handy Teacher Guide on **Supporting the move to linear assessment** to support you with the ongoing transition

Understanding how current reforms are affecting schools and colleges
Researchers at Cambridge Assessment[1] are undertaking a research study to better understand how the current reforms to AS and A levels are affecting schools and colleges.
If you are a Head of Department (including deputy and acting Heads), then we would be very grateful if you would take part in this research by completing their survey. If you have already completed the survey this spring/summer then you do not need to complete it again.
The questionnaire will take approximately 15 minutes and all responses will be anonymous.
To take part, please click on this link: https://www.surveymonkey.co.uk/r/KP96LWB

Grade boundaries
Grade boundaries for this, and all other assessments, can be found on Interchange. For more information on the publication of grade boundaries please see the OCR website.

Enquiry About Results
If any of your students' results are not as expected, you may wish to consider one of our Enquiry About Results services. For full information about the options available visit the OCR website. If university places are reliant on the results you are making an enquiry about you may wish to consider the priority 2 service which has an earlier deadline to ensure your enquires are processed in time for university applications.

Supporting the move to linear assessment
This was the first year that students were assessed in a linear structure. To help you navigate the changes and to support you with areas of difficulty, download our helpful Teacher guide: http://www.ocr.org.uk/Images/345911-moving-from-modular-to-linear-science-qualifications-teachers-guide.pdf

Further support from OCR

activeresults

Active Results offers a unique perspective on results data and greater opportunities to understand students' performance.
It allows you to:

- Review reports on the **performance of individual candidates**, cohorts of students and whole centres
- **Analyse results** at question and/or topic level
- **Compare your centre** with OCR national averages or similar OCR centres.
- Identify areas of the curriculum where students excel or struggle and help **pinpoint strengths and weaknesses** of students and teaching departments.

http://www.ocr.org.uk/administration/support-and-tools/active-results/

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[1] Cambridge Assessment is a not-for-profit non-teaching department of the University of Cambridge, and the parent organisation of OCR, Cambridge International Examinations and Cambridge English Language Assessment.

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Advanced GCE Physics B (H557)

OCR REPORT TO CENTRES

H557A/01 Fundamentals of physics

General Comments:

This was the first ‘Fundamentals of Physics’ examination for this new specification and the nature and style of the paper were necessarily new to candidates. This component is worth 110 marks and assesses specification content from across all the teaching modules. However, almost all of the content and most of the assessment techniques were similar to those employed in the legacy Physics B AS and A2 papers. Unlike those papers, there are 30 multiple choice questions at the start of the paper, which is divided into three sections.

Section A consisted of thirty multiple choice questions, each worth one mark. A whole section of multiple choice questions is new to this specification. The candidates were required to write their response in a box; very few candidates did not understand this rubric, although some did circle the letter in the question. Many candidates did appropriate working in the spaces, showing how they reached their answer although this is not required. A significant number of candidates did not attempt one or more of the multiple choice, although there is no penalty for incorrect responses. When candidates changed their mind, many made this clear by fully crossing out the incorrect response and writing the new response next to it, often in a newly drawn box. This was a better tactic than writing their second attempt over their first, as it was not clear which of two overlapping letters they had finally chosen.

Section B has short answer question styles; typically each examines a single context: including estimates, structured questions, problem solving, calculations and practical based questions. This season, section B consisted of 5 questions, totalling 23 marks. There is little room for extended writing in section B.

Section C, consisted of six questions worth 57 marks consisting of some short answer styles and extended response question styles. There were two opportunities for extended writing worth 6 marks each. It also had a practical and data analysis based question regarding terminal velocity. Many of the techniques needed for this question had been covered in the previous specification. There was little evidence of lack of time for the vast majority of candidates. The additional answer space was used by few candidates, often replacing work which had been crossed out.

Comments on Individual Questions:

Section A (Questions 1 to 30) 30 marks

Q1
This question to select a pair of vector and scalar quantities was well answered by the vast majority of candidates.

Q2
Candidates had to select an equivalent unit for electrical resistance to the ohm Ω. Most successfully chose the unit S^{-1}. A common incorrect answer was D presumably because it involved the units for current and voltage, but in the incorrect inverse ratio.

Q3
Here candidates had to handle order of magnitude estimates for a wide variety of quantities. Most candidates correctly chose the weight of an apple at 10^0 N. Perhaps the candidates that chose other answers did not realise that $10^0 \text{ N} \equiv 1 \text{ N}$. A common incorrect answer was D.

Q4
This question about digitising a sampled signal was well answered by the vast majority of candidates, who picked out the correct statement A.

Q5 & Q6
This pair of questions was about a resistor network. The vast majority got the total resistance of the network correct (Q5), but under half went on (Q6) to correctly select the p.d. between two specified points in the network.

Q7 & Q8
This pair of questions was based on a Q – V graph for a capacitor. Both the capacitance (Q7) and the energy stored (Q8) were correctly selected by almost all candidates.

Q9
This question concerned selecting a correct statement about electron diffraction. A good majority of candidates were successful.

Q10
Candidates had to select a correct statement about the probability of arrival of a photon at a position. The vast majority were successful in selecting answer C:
proportional to (resultant phasor amplitude)^2.

Q11
This question involved the addition of three scaled vector forces. The vast majority of candidates were successful. The most common incorrect answer was B, a vector of correct magnitude but pointing in the opposite direction.

Q12
Candidates had to predict the braking distance of a car with quadrupled speed. Most chose correctly. The most common error B was to assume that the distance also quadrupled, instead of increasing sixteen-fold (distance $\propto$ speed ^{2}).

Q13
The vast majority of candidates correctly realised that the power $\propto v^3$ and correctly chose C. The most common error was B which assumed power $\propto$ force $\propto v^2$, as in the given equation for drag force.

Q14
This question about decay probability was well answered by a good majority of candidates who chose C. A common misconception was that the decay constant did not remain constant (other answers).

Q15 & Q16
This pair of questions was about the resistance and diameter of wires for two equally powered heating coils. The numerical ratios involved scaling reasoning and candidates found this challenging. A common error on Q15 was to get A, the inverse of the correct ratio. In Q16 many forgot that diameter $\propto$ √(cross-sectional area) and chose A again.

Q17 & Q18
This pair of questions concerned an elliptical planetary orbit. Q17 was about changing speeds and Q18 about the energy changes around the orbit. Both were well answered by a large majority of candidates.

Q19
This question was about two samples of ideal gas of equal mass. Many candidates thought that the r.m.s. speed of the molecules depended on pressure, volume and temperature of the samples answer A, rather than only on the temperature answer D.

Q20
It was pleasing that a significant majority got this difficult question on the Boltzmann factor correct.

Q21
Candidates found this question on a magnetic flux circuit hard. By far the most common incorrect answer was B. This showed that many candidates did not realise that halving the length of the magnetic circuit would double the flux (by halving the reluctance).

Q22
This question was about a jumping induction ring. It was well answered by a good majority, D. Incorrect answers were split between A and C, where candidates thought the demonstration would work equally well on a.c. or d.c. power, or that the only purpose of the steel rod was to support the jumping aluminium ring.

Q23 & Q24
This pair of questions on transformers was well answered by a good majority of candidates, Q24 to calculate the primary coil current being the slightly more discriminating.

Q25
Most candidates recognised the correct formulation for balancing a charged drop in the oil drop experiment. Many wrote down the forces balance and reorganised the equation.

Q26 & Q27
These were discriminating questions about a graph of average binding energy per nucleon against nucleon number. It was pleasing that nearly half the candidates managed to select the correct answer for each.

Q28
The vast majority of candidates knew that different isotopes of an element have the same proton number.

Q29
Most candidates could select the correct statement comparing the α-particle and the β-particle.

Q30
Most candidates correctly selected the correct isotope at the end of a 2 α, 4 β decay series.

Section B (Questions 31 to 35) 23 marks

Q31 (lightning bolt)
In part (a) most candidates realised that air needs mobile charge carriers in order to conduct electricity. In part (b) affectively all could calculate the charge carried by the bolt (7.5 C) given the current and its duration.

Q32 (refraction from glass to water)
In part (a) nearly all candidates could complete the algebraic reasoning for the refractive index from glass to water which was pleasing. Part (b) was much more discriminating, as candidates are more used to handling refraction from air to glass (or water). The majority used the inverse of the correct refractive index, despite their reasoning in (a), and got the incorrect refraction angle of 24°. Candidates should have been expecting: angle r > angle i

given that the light was entering a less optically dense medium. The ratio of refractive indices from air to medium, method or the *n* sin (θ) = constant method, were credited provided the candidates got the correct angle of refraction at (38°).

Q33 (operating an electrical water heater for a shower in summer and winter)

(ai) The vast majority of candidates calculated correctly the energy to heat 1 kg of water in summer (71 kJ). The most common error was POT (power of ten) in converting 7.1 x 10^4 J into kJ.

(aii) Given the current and voltage to the heater most candidates could calculate the time taken to heat the 1 kg of water by 17° (6.7 s).

Part (b) was more discriminating, most candidates realised that the flow rate in winter would have to be lower than in summer (1 mark), but few spotted that the temperature rise in winter was doubled, and so the flow rate would be halved (2^{nd} mark). Weaker candidates missed out all together, by only talking about the time to heat the water being longer, and not considering the flow rate as requested.

Q34 (iterative model of capacitor decay)

In part (a) nearly all candidates could predict the next iteration for ΔQ (0.45 C) and the new value of Q (4.05 C).

Part (bi) did not elicit the responses intended, few candidates could explain the physics behind the approximation that drives the model. Most discussed rather well, the analytical solution to the problem, i.e. exponential decay, but missed the point and the marks. A few candidates drew out that current $\approx \Delta Q / \Delta t$ depends on V / R (Ohm's Law) and that the p.d. V across the capacitor is given by $V = Q / C$ (definition of capacitance). Hence $\Delta Q / \Delta t \approx Q / RC$.

The majority were back on track in (bii) stating an assumption behind the model's approximation, e.g. charge on capacitor remains constant during the time interval Δt ; and that the model can become more precise by taking smaller time intervals and repeating more iterations. In (bii) a few candidates did not attempt an answer either because they did not feel confident in carrying on from (bi), or perhaps because they had already made the marking points in (bi), where sadly they could not score, as they were not an answer to that part of the question.

Q35 (velocity of approach of a distant asteroid)

Part (a) although a straightforward velocity = change in displacement / time calculation there was plenty of scope for error with the rather complex units, as displacements were given in light-minutes, separated by one whole day. These needed to be converted to metres by multiplying by *,* the speed of light, then subtracted to find the change in displacement and then divided by the number of seconds in one day. With all these pitfalls it was pleasing that the majority of candidates achieved both marks for the answer (50 km/s).

Part (b) was even harder and more discriminating to find the asteroid velocity component perpendicular to the line of sight. The neatest solution was to use $v = R\,\omega$ since the angular position shift of the asteroid in the day was given at 1.8 mrad. Where R is the range, either min. max or mean over the one day period makes negligible difference to the answer (17 km/s). Some candidates did a full analysis of the triangular geometry using the cosine rule and got the correct answer – well done, but must have taken more time. The most common error was to incorrectly treat the tiny angular shift 1.8 mrad as the angle of the asteroid's velocity to the line of sight and then solve using sin θ or tan θ or θ (small angle) which gave an answer far too small, of about (90 m/s). It was pleasing also that the vast majority of candidates were prepared to have a go at this novel question using small angles in radians.

Section C (Questions 36 to 41) 57 marks

Q36 (Moon accelerating towards Earth)

Part (a) had only a small proportion of candidates securing the 2 marks available. The question asked for an explanation of the Moon's acceleration towards Earth whilst in a circular orbit. Most candidates missed the clue to talk about circular geometry and the changing of the direction of the Moon's velocity vector towards the Earth, even if its speed remains constant. Notions of centripetal acceleration were credited one mark if correctly discussed, but those who relied solely on a gravitational force explanation were not rewarded, unless they drew out that acceleration depends on resultant force:

$a = F / m$ or $a \propto F$.

Part (bi) brought much richer rewards, using the equations of circular motion to show that the acceleration in a circular orbit $a = 4\pi^2 R / T^2$. Candidates were roughly evenly split between using $a = v^2 / R$ or $= R\,\omega^2$.

In part (bii) a negligible few could not get the acceleration of the Moon (2.7 mm/s).

Part (biii) was more discriminating candidates had to decrease Earth's surface gravitational acceleration (9.8 m / s^2) using the inverse square law, by a factor x 1 / 60^2, because the Moon is 60 Earth radii away. Many did this correctly, but then failed to compare the acceleration with (bi) for the 3rd mark (same value of acceleration to 2 S.F.)

Q37 (analysis of data from terminal velocity experiment)

A good majority of candidates could read the terminal velocity from the graph in part (a). About half went on to estimate the uncertainty in it given $\pm$ 3% uncertainty in velocity measurement. (0.65 $\pm$ 0.02 m/s).

The most common error was to quote the uncertainty as $\pm$ 0.0195 m/s which was penalised as a S.F. error, as it shows a lack of appreciation of significance.

In part (b) nearly all got the first mark for saying the ball-bearing was still accelerating, but only half went on to correctly account for this using a resultant force argument. (There was no need for them to consider the upthrust of the fluid to gain full credit here).

Part (ci) was well answered by most, who named and could explain a control variable for the experiment to see how terminal velocity depends on the diameter of ball-bearings. A suggestion that was not accepted was the height of drop of the ball-bearing above the surface.

In part (ciii) there was an opportunity to run a data test on some values to test for $v \propto D^2$. Candidates should be advised to run a quick numerical test on **all the data offered** (not just 2 or 3 data points in case there is a trend upon which they could comment). Here looking for D^2 / v = constant or the inverse is quick and easy on a calculator. Some candidates go to the trouble of plotting a graph and looking for proportionality, but if graph paper is not offered this is probably not advisable due to inherent inaccuracy of judgement by eye. Some even sketched a log/log graph, but the time taken must be considerable. All these methods if correctly applied were fully credited. This was a 5 mark question so there is time to invest in getting a good quick test and reaching a sound conclusion. The first mark was for the proposed data test, the next for testing two data sets, and another for testing all data sets. Finally two marks for reaching a full conclusion. Here the three smallest ball-bearings did show a consistent constant ($D^2 / v \approx 144$) but the larger two bearings have higher values (204, 221). Then comment on the initial proposal so not proportional across the whole range, or on the repeatability of the constant value for the last two marks.

This part was well answered, the most common errors were to only test two datum points and to under-conclude and thus score only one of the two marks available in both cases.

Q38 (simple harmonic motion, displacement and velocity time graphs and simple pendulum)

This was a straightforward question on S.H.M. but was well answered by the majority and gave good discrimination.

In part (a) candidates could draw a tangent to the curve and find the gradient (maximum velocity when displacement is zero), or calculate using $v = A\,\omega$ with values read from the graph (A = 0.70 m, $\omega = 2\pi / 4$ rad/s). Both methods give the velocity at (1.1 m/s) and a tolerance $\pm$ 0.1 m/s was allowed for graph method, here sign was ignored and only magnitude inspected. The most common error for the graphical method was for candidates to take too small a triangle for the gradient and estimate outside the acceptable range, they should be encouraged to take the maximum triangle they can fit in when applying this method (either full Δy or Δx range) to minimise reading uncertainties.

In part (b) they were asked to plot the velocity time graph and to scale the *v*-axis appropriately (ECF error carried forward was allowed). There was a mark for the scaling (quite a few ignored this instruction), and a mark for the correct sine curve, here the sign counted, which also spread the marks. Candidates should be reminded to read the question, underline or identify key action words and attempt every aspect requested.
Part (c) was well answered by a good majority who could reorganise the simple pendulum equation as:
$L = T^2 g / 4\pi^2$ and show that the length of the simple pendulum that would give these graphs was less than 4.0 m. (3.97 m).

Q39 (analysing radioactive sources and accounting for counts against range in air graph)
Candidates were given a table of activities in part (a) for 3 sources with absorbers of 1 cm of air, 0.1 mm paper, 2 mm aluminium and 5 mm lead, and asked to identify the sources: pure β, mixed α β γ and mixed β γ. There was a mark for correctly identifying all sources, a further mark for two correct explanations and the final mark for the third correct explanation. Candidates who could not correctly identify all the sources scored zero on this scheme, which gave a good spread of marks from 0 to 3/3, with about a quartile on each mark. The most common error in explanation was to rely on some argument involving β radiation, but this did not work as it was present in each source.
In part (bi) candidates had to measure the gradient of the steep part of a log (activity) against log (range in air) graph of a source containing α β γ radiation. The gradient (-2.3) should again have been assessed from a large triangle. Most candidates got the value but many dropped the minus sign which cost them a mark here.
Part (bii) was much more discriminating, stating whether the log / log graph supports the activity $\propto 1 / R^2$ and explaining which radiation(s) might be responsible. There were 4 marks available here and candidates could well be advised to try to make four separate meaningful statements under such circumstances.

Many made only one or two comments and limited their score accordingly. Many good points were made by better candidates: log (activity) = constant - 2 log (range), so gradient quite close to - 2 agrees with inverse square law of dilution. For low range not a good fit (flat knee on graph) possibly due to short range in air for α radiation. Inverse square law applies to e-m radiation spreading from a point source and not interacting with medium so could be due to γ radiation. β rays travel fairly straight at start of tracks which are mostly straight so could also follow inverse square dilution.

Q40 (stress / strain graphs for pure metal and alloy, dislocation image and LOR answer)
Part (a) was a Young modulus estimate from the stress against strain graph, and a large majority estimated a value in the acceptable range (7.0 to 7.3) x 10^{10} Pa.
Part (b) drew many wrong answers, most candidates believing that pure aluminium is more suitable for crumple-zone construction than aluminium strong alloy, simply because it undergoes more strain. However the energy dissipating capability (area under the graph is proportional to energy per volume) is more important in dissipating crash energy outside the passenger compartment. Many asserted the area under the graph is greater for the pure metal, but measurement would have shown that the strong alloy is more than twice as capable of absorbing energy per unit volume! Candidates should be encouraged to be as quantitative as possible in answering questions.
In part (ci) most candidates attempted to divide a scaled distance by a counted number of atoms and got the method mark. Only the more careful made allowance for the angle of the atomic planes and got an acceptable value for the atomic diameter in the range (1.8 to 2.7) x 10^{-10} m.
In part (cii) most could identify the dislocation from the STEM image.
Part (d) was a LOR (Level of Response question) and worth 6 marks. Candidates had to use ideas about bonding and structure in metals and alloys to explain elastic and plastic behaviour. The most common error was for candidates to miss out on one or more of these elements and thus restrict the level they could achieve. However most candidates could write meaningfully and

from knowledge that they understood about metals and alloys and how their different mechanical properties arise, this was most encouraging. Labelled diagrams could have been used more often to advantage. The average response here was at mid Level 2 (3 or 4 marks out of 6), but a significant number of candidates achieved Level 3 (5 or 6 marks out of 6), which was pleasing.

Q41 (electric field and potential and LOR answer)
Most candidates could identify the N neutral point between like charges, rather fewer placed the zero potential point V midway between the opposite charges in part (a). Some thought that both points were coincident.
Candidates had to sketch 3 complete equipotentials on each pair of charges in part (b). Many drew fewer and lost credit, the attractive field and potentials were the best known, candidates had more trouble with the repelling field example, many seemed unfamiliar with the “figure of 8” shaped potentials in this case. Quite a few equipotentials were not strictly orthogonal to the given field lines, but this was generously interpreted as long as general shape was correct.
In part (c) to find the field at mid-point of the opposite charges a large minority did a correct field calculation, but about half forgot to double the field of a single charge and scored 1 / 2. Those that remembered got the total field to be 7.2 x 10^4 Vm^{-1} and scored both marks.
The final LOR question part (d) saw candidates given graphs of the field and potential near an isolated -1 C charge. They were asked to explain the relationship between electric field and electric potential by considering movement of a unit + 1 C charge from *R* = 100 m to 300 m. This was a deliberately testing question on a challenging aspect of A level physics, some candidates were running short on time, although very few made no attempt at all. The majority gained some credit, many made one or two isolated points reaching L1, (commonly recognising the appropriate shapes of the graphs as $1 / R^2$ and $1 / R$) and fewer reached L2 and L3. Again candidates limited the scope of the level reached by missing one or more of the strands that they should have covered: the work done, the area under the *E*(*R*) field graph and the gradient of the *V*(*R*) potential graph. Better candidates drew potential gradients, estimated values and showed equivalence to the field at a point, and / or numerically integrated (by counting about 15 squares under the field graph) between the suggested *R* values showing the change in potential to be 60 MV, which agreed with the change on the potential graph from going from -90 MV to -30 MV. Candidates should be encouraged that writing good technical physics with equations, quantitative estimates, diagrammatic reasoning and explanation will all be credited, some seem to think that only prose is acceptable for this type of question.

H557A/02 Scientific literacy in physics

General Comments:

This is the first paper in revised specification and is in a markedly different style from previous Advancing Physics papers. Not only is it completely synoptic, it also has no 'short answer' questions other than in Section C, the advance notice section. These two changes have increased the challenge of the paper considerably.
The marks on the paper ranged from 4 to 94 out of 100. The mean mark was 54. Very few candidates failed to complete the paper and nearly all candidates attempted all the questions. The standard of response to questions from the 'AS' section of the course was similar to that for the material covered in the second year of the course, suggesting that candidates revised the whole course in Centres and at home. The question on a new area of the course – charging a capacitor – proved challenging.
The paper included three 'level of response' questions. These will be considered in detail below. Candidates reached all three levels and the best answers were most impressive. Perhaps unexpectedly, the arithmetic parts of the questions were answered with the greatest confidence.

Comments on Individual Questions:

Section A

Question No.1
This question was about standing waves in air. This is an area that has been frequently examined in Advancing Physics in the past. Part (a) required candidates to explain the formation of standing waves in a tube. Although most were familiar with the concept and gained a mark for correct use of the term 'superposition', few gained all three available marks. This was, for the most part, due to lack of precision in language. For example, stating that the waves in the tube were 'reflecting' without giving an indication of where the reflection took place. It may be helpful to remind candidates to include any relevant information in their answers which is not in the stem of the question and to ensure that their explanations clearly move from one statement to the next. Part (b) asked candidates to draw the next possible standing wave. This was answered confidently by the majority. However, many candidates failed to get the second mark as they assumed that the velocity remaining constant was a given that did not need to be stated. This omission rendered their explanation incomplete. Part (c) asked candidates to rearrange some equations to reach a given relationship and was performed clearly by most. Part (d) was a little more challenging as candidates had to use the dependency on the square root of temperature revealed in (c) and needed greater mathematical competence. Weaker responses used incorrect equations or ignored the square root in the relationship.

Question No.2
This question was about discharging and charging capacitors. The first two parts of the question were answered correctly by the majority of the candidates. Part (c) asked candidates to draw two lines showing the p.d. across each of the two series resistors during the charging of the capacitor. A sizeable minority showed the p.d. across the resistors increasing over time, showing a lack of understanding of the situation. Others drew curves of negative gradient beginning at the correct p.d.s but failed to gain full marks either through lack of labelling or inaccurate drawing. Candidates losing marks through insufficient care with diagrams is not a new problem. Part (d) was one of the most challenging questions on the paper. Many candidates used the discharge equation to reach an incorrect answer whilst some who used the correct equation inserted the incorrect values. There was an unsurprising but still noteworthy correlation between poor answers to parts (c) and (d).

Question No.3
This question was about air pressure and dynamics. It focused largely on topics covered in the first year of the course. Part (a) asked for a particulate explanation of air pressure. Whilst many candidates gained one or two marks for this part, relatively few gained all three marks. Once again, this was often due to leaping over steps in an argument. For example, writing 'air particles collide with the sail and exert a force' is correct, but does not explain the situation in sufficient depth as it misses the discussion of momentum changes (i.e. 'how' the particles exert a force). Weaker answers ignored the requirement to give a particle explanation and described the situation in terms of bulk forces. Part (b) proved challenging to many. The most common error was in correctly calculating the mass striking the sail each second but equating this value with the force on the sail. Some candidates gave assumptions that were contradicted by the stem of the question; for example, some wrote that 'the wind may not have been at 90 degrees to the sail' whilst the stem stated that this is the case, furthermore, the assumption given does not address the stated assumption of the wind velocity dropping to zero.
Part (c) was accurately and clearly answered by the majority of the candidates.

Section B

Question No.4
This question was about imaging Pluto. Parts (a) and (b)(i) were standard calculations involving distance measurement and resolution of digital images. Both parts were answered confidently by the majority of the candidates. Part b(ii) proved much more challenging. In part this was due to an apparent lack of familiarity with radian measure, in part the difficulty lay in candidates using a circular argument through using data calculated from part (b)(i) rather than calculating the radian angle subtended by Pluto. It was also evident that many candidates were not confident in using radian measure, preferring to calculate the sine or tangent of the angle in degrees. It would be useful to give future candidates practice in the use of radians and give groups of questions where calculators have to be changed from degree to radian mode and vice versa as this was not the only question where problems handling radians cost candidates marks.
Part (c) was a level of response question about ways of powering a spacecraft near the Earth and near Pluto. The Advance Notice article includes a discussion of the inverse-square relationship of light intensity and distance so it was surprising that only about half the candidates gave some creditworthy explanation of the low intensity of light at Pluto. Ignoring this part of the question closed off the possibility of gaining level 3 (5 or 6 marks) for many. Candidates were more confident in describing and calculating the activity and power available from the RTG at Earth and Pluto and many correctly calculated the power output – a long and unscaffolded calculation involving careful thought. The very best candidates compared the two power sources through the percentage drop in output power at Earth and Pluto. Such answers were impressive but rare.

Question No.5
This question, focusing on the Boltzmann factor, was well answered in parts but, once again, explanatory answers were weaker than calculations. Part (a) asked candidates to use a graph of three lines A, B and C to explain why the activation energy for process C is greater than that of A and B. The best responses followed the additional guidance given in the mark-scheme and were algebraic in nature. Some candidates gave a complete explanation in words. The most common error was to focus on the gradients of the lines without giving sufficient explanation of what the gradients showed. These weaker responses did not make it clear that for any given temperature, the Boltzmann factor is lower for process C than for processes A or B.
Part (b) was a standard calculation to find an activation energy and was correctly answered by most. Part (c) required a statement of energy gain in successive collisions leading to a particle energy greater than the activation energy. Many candidates gained the mark for energy exchanges in collisions but far fewer were clear about the need for successive gains in energy (of 'getting lucky' consecutively).
Part (c) was a level of response question which asked the candidates to explain why alcohol feels cooler on the skin than water. Nearly all the candidates correctly calculated the Boltzmann

factor for the evaporation of alcohol at body temperature. Many used their answer to explain the faster rate of evaporation for alcohol leading to a quicker cooling of the remaining liquid and a greater rate of energy transfer from the skin to the liquid. The best answers were extremely impressive.
Weaker candidates assumed that the alcohol felt colder because it took more energy to evaporate, even though their calculation suggested otherwise.

Question No.6
This question was about muon decay and relativistic time dilation. Part (a) required candidates to show that charge and lepton number are conserved in the decay of a muon into an electron, neutrino and anti-neutrino. This was not performed as well as expected as many candidates did not give sufficient detail, for example, by omitting to state that neutrinos are neutral when considering charge conservation. More interestingly, some candidates assumed that a muon has a lepton number of -1, or that it is not a lepton, even though the stem makes a clear statement to the contrary. It was also assumed, by many, that neutrinos are not leptons. In contrast, the calculations in parts (b) and (c) were confidently answered by the majority of the candidates. Part (d)(i), required a clear explanation of the greater than previously suggested number of muons reaching the ground level. Weaker candidates struggled with this and wrote rather vague statements about 'less (or even more) time for the muons' whereas the better responses clearly explained that the observer records the muon time as dilated. Not all responses linked the relativistic effect to the muons travelling at a high percentage or proportion of the speed of light.

Section C
This section was based on the Advance Notice article. It was clear that many candidates had been studied this in detail and the best answers were very impressive.

Question No. 7
This short question about logarithmic scales was answered well by the majority. However, some responses suggested that the increments rose by intervals of 10^3 rather than factors of 10^3. The disadvantages of using the scale were not always clearly stated, making the second mark less accessible than the first.

Question No. 8
This question was about estimating the size of an atom. The majority of the candidates scored at least 3 marks out of 4, gaining the marks for the calculation but not always being sufficiently clear about the assumption made. A significant minority of the candidates failed to give an assumption.

Question No. 9
This question was about the resolution of the eye. Part (a)(i) required candidates to give the spread of a group of data. A sizeable minority of responses confused spread with range. Part (a)(ii) involved comparing uncertainties. To gain marks in this question the candidates had to give at least one percentage uncertainty. Many did not do this and gave rather descriptive responses that did not have sufficient merit to be awarded a mark. Part (a) (iii) proved to be challenging. Many candidates did not use radian angles directly but calculated an angle in degrees before converting it to radians. This could still gain a mark if the answer was correct but it is, at best, an inelegant method. The better responses described how the percentage uncertainty was used to find the absolute uncertainty or how the range of angles was found from the spread of the data. Lastly, many candidates failed to gain the third mark through giving the uncertainty with excessive significant figures.
Part (b) was also challenging. Once again, the calculation was straightforward and the candidates performed it with ease. Linking the results to the experimental data was rarely clearly described, with most responses merely pointing out the difference rather than considering the reason.

Question No. 10
This question asked candidates to calculate a distance in light years when given the parallax angle. Some candidates clearly knew the number of parsecs in a light year. Others calculated the distance by a number of different, acceptable methods. A common error was to calculate a sine (or tangent) of an angle when the calculator was set on radians. This gave a distance to the star of 0.15 light years. Although such responses gained 2 out of 3 marks it was surprising that the candidates believed such answers when the distance to the nearest star is given (albeit in metres) in the article.

Question No. 11
This question asked candidates to explain why turbulence in the atmosphere limits resolution. Although this was answered correctly by about half the candidates many responses confused refraction and diffraction effects.

Question No. 12
The last question on the paper was a level of response question focusing on measuring distances to stars using real and apparent magnitudes. The majority of the candidates correctly calculated the distance to ‘star X’ in parsecs and many made a clear link between absorption spectra and atomic energy levels. The best responses clearly linked all three aspects of the explanation together – that is, the role of energy levels in producing an absorption spectrum, the value of identifying the spectral class of a star and the calculation of distance. Some candidates, however, wrote a great deal but essentially closely paraphrased or quoted the article.

H557A/03 Practical skills in physics

General Comments:

This was the first 'Practical skills in Physics' examination for this new specification and the nature and style of the paper were necessarily new to candidates. All three exam papers in this new specification also covered the whole specification whereas the previous specification had been modular, but there has been little change to the content of the specification. Question style was similar to that used in the previous specification, but this paper was more focussed on the assessment of both theory and practical skills within practical contexts.

The paper consisted of two sections. Section A had 3 questions and a total of 40 marks, each based on a different practical activity involving skills, apparatus and techniques which should have been familiar as part of the course studied. Section A contained two Level of Response questions. Section B was one question totalling 20 marks and incorporated data analysis. There were a number of easily accessible parts to questions together with longer parts where candidates needed to apply their knowledge.

There was little evidence of lack of time for most of candidates. The additional answer space was used by several candidates, mostly for the two Level of Response questions or for replacing work which has been crossed out.

Comments on Individual Questions:

Question 1 [temperature sensor]
Part (a) was a two mark response on the basic requirements for varying and measuring the temperature of a thermistor for the first mark, with some extra details needed to gain the second mark. Common errors included omitting the use of a thermometer and heating the thermistor by passing current through it. The second mark was often awarded for providing an explanation of how to obtain a temperature of 0 °C such as adding ice.
Part (b) was fairly straightforward and many candidates realised that measuring V across the fixed resistor would give a rising output with a rising temperature. Common incorrect responses included keeping the voltmeter away from the heat source or water.
The first part of (c)(i) was well answered, the majority of candidates correctly adding the error bars and drawing a straight line of best fit within the error bars. The most common error was to have both vertical and horizontal error bars of the same length. For the third marking point of this part required the candidate to say that a straight line could be drawn within the error bars. Many candidates omitted the word 'straight' or used 'linear' instead, but this was included in the question stem and linear does not necessarily imply straight.
Many candidates missed the point of (c)(ii) and described the method given in the earlier parts of this question rather than explain how the temperature could be read off the voltmeter directly. Very few candidates explained that the scale should be re-drawn as a temperature scale, but some candidates gained a mark for stating a conversion factor.
Part (d) was a complicated level of response question requiring both calculations and qualitative comments. Candidates could gain low level marks for correct qualitative statements or for reading data from the graphs, but the higher levels required several calculations. Many candidates used the data from both graphs to find an approximate value for the initial resistance of Q. Candidates then went on to work out the range of voltage outputs for both a higher value and a lower value of Q. If candidates chose values which were too close to the initial value of Q, the range of voltage may not have changed much, giving an incorrect trend in sensitivity. Some candidates only worked out a voltage output for one temperature, and some candidates discussed uncertainties in readings rather than sensitivity.

Question 2 [mass on spring oscillations]

In part (a) most candidates calculated and compared suitable ratios, but not all of them used sufficient data. Stronger candidates included reference to mass being proportional to force, although those who used F=ma were penalised as the masses were not accelerating at 9.8 ms^{-2}, but experiencing a field strength of 9.8 Nkg^{-1}. Usually candidates recognised that the ratios calculated were approximately equal, or referred to experimental uncertainty. There were a few power of ten errors in the calculation of the spring constant in part (ii).

In part (b) nearly all candidates recognised where speed was at a maximum on the displacement-time trace. Also the majority of candidates were able to correctly calculate the time period and hence the frequency of oscillation. However many candidates only used the time for one complete cycle, rather than the whole trace. Part (b)(iii) was generally well done, although those candidates who had a power of ten error in their value for spring constant managed to fudge their answer to fit 500g. Some candidates did not realise that they should use the value of frequency calculated to find mass, but instead attempted (unsuccessfully) to use mg = kx using the maximum displacement shown in the graph as extension.

Part (c) was accessible to most candidates even if they were unable to describe the correct experiment as they could pick up a mark for some valid procedure. Most candidates gave level 1 or level 2 responses. Candidates who sketched the graph tended to do better than those who tried to describe the shape in words. However few candidates gained level 3 where more details about practical techniques or explanations for the shape of the curve away from resonant frequency were required.

Question 3 [current balance]

Part (a)(i) was well answered, with nearly all candidates showing the correct direction of the magnetic field. Some lines were badly drawn (without a ruler) or were not equidistant. There tended to be a larger gap between the lines near the position of the wire. A few candidates attempted to draw the field lines when the wire carried a current. In part (ii) reference to F=BIl was insufficient to gain the mark, as they needed to refer to the interaction of the two magnetic fields. Few candidates included any explanation of the action/reaction pair of forces.

In part (b)(i) most candidates successfully completed the table, with only a few candidates making rounding errors. In part (b)(ii) there was some confusion between absolute and percentage uncertainties, as well as some weaker candidates using the whole range of readings for all values of I, instead of the range across individual rows of the table. Candidates could plot the points on the graph well in part (iii), but drawing the best fit line was not so good. Some candidates forced the line through the origin so it was too far from the top plot. In part (iv) most candidates were able to calculate a value for B to the correct power of ten. However many of them used a point on the graph rather than the gradient of the line.

Question 4 [converging lens]

In part (a)(i) many candidates discussed percentage uncertainties rather than the practical consideration of finding the image position. Part (a)(ii) was nearly always correct, but in part (iii) most candidates were able to calculate the mean value correctly many did not realise the importance of using the same number of significant figures as the raw data and consequently quoted their answer as 0.40 or 0.400. The mean value was usually correctly indicated on the grid with either a spot or a line. In part (a)(iv) some candidates used incorrect values for 2x spread – usually either 0.015 or 0.060. Some candidates calculated different values of range which included the potential outliers instead of the value calculated in part (ii).

The calculations of magnification in part (b)(i) were usually carried out correctly, but some candidates gave the two values to different numbers of significant figures. Only a few omitted the negative sign. The points were invariably plotted correctly. Many candidates demonstrated correct algebra in part (iii), although some followed a rather circuitous route eventually leading to the correct expression. Most candidates calculated the focal length of the lens by substituting data into the expression rather than using the reciprocal of the gradient.

Candidates found part (c) more accessible as most were able to give the correct power of the lens in part (i). Most candidates drew acceptable steeper and shallower worst-fit lines through the error bars on the graph and provided they knew to use the intercept were able to gain all four marks in part (ii). If they used some other method to find the power, they were usually able to pick up the final mark for percentage uncertainty using errors carried forward. A few candidates did not draw worst fit lines on the graph.

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