PHYSICS

Paper 9792/01
Part A Multiple Choice

Question Number	*Key*	*Question Number*	*Key*
1	**B**	21	**A**
2	**B**	22	**B**
3	**C**	23	**B**
4	**D**	24	**C**
5	**C**	25	**B**
6	**C**	26	**A**
7	**C**	27	**C**
8	**C**	28	**C**
9	**C**	29	**C**
10	**C**	30	**A**
11	**D**	31	**D**
12	**A**	32	**B**
13	**C**	33	**A**
14	**D**	34	**A**
15	**A**	35	**A**
16	**C**	36	**A**
17	**D**	37	**D**
18	**A**	38	**C**
19	**C**	39	**B**
20	**D**	40	**B**

General Comments

The paper proved to be appropriately set, with a good number of easily accessible questions and some more challenging questions. It is clear that candidates have a good understanding of **Section A** of the syllabus.

There was a good spread of marks with a mean of 30 and a median of 31 marks. A small number of candidates gained full marks. All of the questions showed a positive discrimination, and the less able candidates were able to access the easier questions. Generally, candidates appeared to have been well prepared. The questions on this paper do require careful reading and candidates are advised to reflect carefully before recording their response. Candidates should be encouraged to make use of the space provided for their working.

Questions 2, **7**, **8**, **9**, **11**, **13**, **21**, **23**, **36** and **38** appeared straightforward, allowing the great majority of candidates to demonstrate their knowledge and understanding. In general, these questions involved calculations and it was pleasing that in a number of cases candidates were able to work through multi-step processes to arrive at the correct answer.

Candidates appeared to find **Questions 4**, **5**, **12**, **16**, **18**, **20**, **28** and **39** more challenging.

Questions 4 and **5** were concerned with forces. In **Question** 4, a large number of candidates either thought that the force from the lift floor on the man and the weight of the man are equal and opposite or if the force from the lift floor on the man and the weight of the man are equal then the lift *must* be at rest. **Question 5** caused the greatest difficulties for candidates with a significant number of candidates choosing each of the responses. Weaker candidates thought that the unbalanced force acting on the car was the same as the unbalanced force acting on the trailer.

In **Question 12**, many weaker candidates either calculated work when no force was applied or just determined the area under the graph.

For **Question 16**, just more than half the candidates gave the correct answer. Candidates often find ratios difficult; the common distractors were either B (stronger candidates) or D (weaker candidates).

Questions 18 and **20** involved candidates analysing parallel circuits. In **Question 18**, the common error was not to realise that the voltmeter reading would decrease because of the increased potential difference across the internal resistance. In **Question 20**, a surprising number of candidates thought that the electrons flowed away from the positive terminal of the battery.

For **Question 28**, candidates were required to apply their knowledge of refraction to a beam of microwaves. A large number of candidates assumed that the direction of the microwaves would remain unchanged. It was pleasing to see that few candidates thought that the speed of the microwaves increased (response **A**) and even fewer thought it would be response **D**.

Question 39 tested candidates' understanding of thermonuclear fission. The common distractor in this question was response **A**, implying that a large number of candidates had not included the neutron that had been absorbed by the uranium-235 nucleus in the calculation.

PHYSICS

Paper 9792/02

Part A Written

General comments

The general standard that was reached by the candidates in this session was commendably high and there were many candidates who scored well on all the questions and who very clearly had a really insightful understanding of the subject at this level. There is inevitably a variation in standard from candidate to candidate, but every candidate was able to show an understanding of some topics and some techniques at a perfectly decent level.

The candidates who scored the highest marks in this paper were, of course, those who had the clearest grasp of the underlying physics and who were able to express concisely and directly the point that the question was aiming to elicit. Most candidates were highly competent when performing calculations and when tackling the aspects of the paper that required a mathematical approach. The calculations tended to be accurate and well set out and well explained. The errors that crept in the most frequently were rather unfortunate ones. There were candidates who did not change from minutes to seconds or who missed an SI unit prefix in information given in a question. These candidates were sometimes those who were scoring very highly elsewhere in the paper and who will be disappointed at having forfeited marks in this way.

Whilst significant figures and uncertainties are important in a subject such as this, candidates should be advised against rounding off intermediate answers at every stage of a calculation that contains several steps. This may lead to the final answers being rather different from what is expected.

The skill which candidates might be advised to concentrate on slightly more intensely is that of drawing and sketching. Occasionally, a diagram that is probably trying to reflect an accurate understanding of the topic, is so poorly drawn that it becomes ambiguous or even wrong and at that point, marks may be lost.

Comments on specific questions

Section A

Question 1

(a) (i) These calculations were performed well by the overwhelming majority of candidates. A very small number of candidates left the answers in terms of the trigonometric functions rather than actually calculating the numerical answer. Such candidates need to know that this is practice is not what is required in this subject and that final marks in calculations are almost always awarded for the final numerical answer.

(ii) This mark was again awarded for the final answer to what was a relatively simple calculation.

(iii) This calculation was somewhat more involved and was most easily tackled using the most appropriate kinematics equation. There were rather more errors made in this part with the most common being the use of a positive gravitational acceleration when upwards was taken as the positive direction.

(iv) It was very pleasing to see how many candidates were able to obtain the correct answer here. The main temptation is to attempt to calculate the angle from velocities rather than from distances and it was good that so few candidates did this.

(b) (i) The rough shape of an acceptable path is not very difficult to sketch and nearly all candidates produced this path. At this level, however, rather more was required and a significant minority of candidates drew a path which was below the path already shown even at the start implying that the ball is setting off at a reduced angle. A few candidates sketched paths that actually crossed over the original path.

(ii) Many candidates found this part of the question the most problematic to tackle with a few leaving it out altogether. This part was subdivided into distinct subsections which dealt with various aspects of the trajectory. Some candidates, however, tended to ignore this and gave general answers in the first two sections especially.

In **1.** many candidates who gave answers which applied more appropriately to the question in the second section. A relatively common misunderstanding was to state that during this part of the journey the ball had a velocity that was very nearly zero, but that the ball was accelerating.

In part **3.** Some candidates gave some very elaborate and carefully thought out explanations of the effect of air resistance on the horizontal and vertical components of the ball's velocity. This was very encouraging.

Question 2

(a) (i) This part of the question was very frequently answered accurately and so scored all three marks. An occasional candidate omitted to include the work done by the workman on the hammer as it fell. Such a candidate usually still scored the first two marks.

(ii) This part was also well answered with many candidates obtaining the correct answer fairly directly. There were some errors made in obtaining the square root and from time to time the half in the expression for kinetic energy was either ignored or multiplied by the value obtained in **(i)**.

(b) This calculation was very frequently correct and the overwhelming majority of candidates sored both marks here.

(c) There were some candidates who having scored full marks thus far in the question were less confident when explaining the reasons for what was done. Many candidates scored one mark here, but rather fewer gave a fuller explanation in terms of rate of change of momentum, constant impulse or the magnitude of the deceleration of the hammer.

Question 3

(a) (i) Many candidates, having calculated both of the thermal energy contributions, were able to obtain the correct answer. Where full marks were not scored, however, the most common omission was to leave out the energy needed to turn the water at 100 °C into steam at the same temperature.

(ii) This was very commonly answered correctly by all but the least highly scoring candidates on the paper as a whole.

(b) (i) The formula $P = Fv$ was widely known and very commonly applied here to obtain the correct answer. Even without this direct approach, the correct answer could still be obtained.

(ii) This was almost universally answered correctly either in absolute terms or by using previously penalised inaccurate answers correctly.

Question 4

(a) (i)(ii) Many candidates knew the definitions of *electromotive force* and *resistance* in terms of their defining equations or of equivalent word equations and explanations. These candidates, of course, scored the marks. A significant minority of candidates, however, attempted to explain in more general terms what the phrases suggest. These candidates should be aware that the command word *define*, as used in a question such as this, will always demand, in one way or another, the precise mathematical expression that produces a quantitative explanation of the term.

(b) (i)1. This was almost always answered correctly.

(i)2. This was comparatively straightforward and the majority of candidates scored both marks.

(b) (ii)1. Most, but not all, candidates gave the correct expression here.

(ii)2. Although the points were usually plotted well and accurately, the quality of the drawn line varied. Some candidates would have found it much easier to draw an acceptable curve, had they rotated the question paper through 180° and drawn the line with their wrist on the inside of the curve. A very few lines were very poorly drawn indeed and some candidates stopped short of plotting the last two points.

(c) (i)(ii) Many candidates obtained the correct answer here by the correct method. It was good to see that many candidates who obtained the correct answer in **(i)** were able to see that the same principle applied in all cases; such candidates tended to write down the correct answer in **(ii)** without any further explanation.

(iii) This part was the most testing in the question and comparatively few candidates gave answers in terms of the increased power output that would be possible with the parallel network. The most frequently offered answer was to state that the circuit would still work even if one of the resistors failed. This answer could still obtain full marks if it was explained that the new circuit would have a resistance that was not too different from the original value.

Question 5

(a) This part was almost always answered correctly; only the least highly scoring candidates over all lost marks here.

(b) Although the diagrams varied in quality in this part, it was often possible to see what was intended and when this was correct, the mark was awarded. In order to obtain the second mark, it had to be clear that it was the oscillations (or something equivalent) that were confined to the plane of polarisation. This was not always clear.

(c) (i) The question used the word *calculate* and answers given in surd notation were not accepted.

(ii) This angle was very commonly correctly stated.

(iii) In this question, it was also the final section that proved to be the most challenging. There were many correct answers, but there were also candidates who became muddled when deciding where to use the square roots and when to square their various expressions. There were still, however, an encouraging number of candidates who obtained the correct final answers.

Question 6

(a) (i) This was almost universally measured accurately from the diagram.

(ii) A significant number of candidates omitted any unit from the answer here. Where units are not given on the answer line, candidates are always expected to supply them. Candidates who gave answers in degrees were much less likely to omit the unit than those giving an answer in radians.

(iii) Many candidates obtained an acceptable answer here, although there were some who did not go beyond the initial measurement that was required. There was a certain amount of variation in the measurements made, but allowance was made for this and a slight error in the measurement did not usually result in a mark being lost.

(iv) A significant number of candidates stated, in one way or another, that the approximate nature of the formula was due to a small angle approximation being made in its derivation, but few candidates were able to give a second, different, suggestion.

(b) A very few candidates were able to produce very clear explanations of the meaning of the term *amplitude modulation* and these, of course, scored all three marks. Many other candidates scored either one or two marks by making relevant references to the *signal* and the *carrier wave* or by drawing appropriate diagrams. A very large number of candidates stated or suggested that these two waves were superposed and some drew diagrams that made this suggestion quite explicit.

(c) This part of the question was found to be very challenging by many candidates. It tests, of course, a skill that is not easily taught and which relies on the physical understanding of what is happening. It was especially unfortunate when a candidate who might well have scored all three marks and who could see what had led to the production of a complex wave of this shape, did not take into account the fact that the horizontal scale was in milliseconds not seconds.

Question 7

(a) (i) Many candidates scored highly on this part of the question. The few inaccuracies that arose were mainly either due to arithmetic errors that resulted from division by a number in standard form with a negative power of ten, or due to the omission of the term *c* from the photon energy formula. Both $E = h\lambda$ and $E = h / \lambda$ were either specifically given or implied by the substitutions that were made.

(ii) Several candidates who had scored full marks thus far in the question did not go on and get this part correct. Very commonly, one of the answers in **(i)** was divided by *e* although equally the correct answer was also seen very regularly.

(b) Most answers scored at least one mark here, with the simple statement that these photons did not have enough energy to cause the photoelectric emission and many more scored the second mark for correctly referring to the work function, or for giving a similarly detailed explanation of what was needed.

Section B

Question 8

(a) (i) A significant number of candidates obtained the correct value here and scored both marks.

(ii) Many candidates realised what was expected in this part of the question and multiplied the original number by eight. Just a few divided by eight and some used the number of half-lives (three) directly.

(iii) Most of the candidates found this calculation to be fairly straightforward and scored the mark.

(iv) The majority of candidates stated that the current abundance ratio is too low for a chain reaction to occur, but this was not always accompanied by an appropriate explanation. Consequently, there were many candidates who scored only one mark in this part.

(b) (i) It was very pleasing to observe that nearly all the candidates were able to deduce the number and nature of the emissions required.

(ii) A large number of candidates stated that even as it decays, more uranium-234 is being produced. Rather fewer candidates were as explicit in observing that since uranium-234 is in radioactive equilibrium with uranium-238, the number of atoms of uranium-234 present decreases at a rate that has a half-life period equal to that of uranium-238.

(c) (i) These answers were generally correct with only a very few candidates not taking into account the fact that there were three neutrons emitted in this particular fission reaction.

(ii) A large number of candidates deduced and stated the correct answer in **1.** but not many of these continued to **2.** and gave the correct answer to this second part.

(d) (i) This was usually understood and well answered although some candidates gave answers that did not explain the behaviour of more than one isotope. This needed to be referred to in order to produce a thorough explanation.

(ii) It was not always clear from the answers, that the point that was being tested here was thoroughly understood. Some of the suggestions made, concentrated on what would allow a chain reaction to occur without giving a sufficiently explicit answer to the question asked.

(e) Many candidates performed very well indeed on this question and only a small number of candidates lost significantly more than two or three marks. Many candidates were able to suggest both advantages and disadvantages and then presented a well-balanced review of the major points relevant to the issue of nuclear power.

PHYSICS

Paper 9792/03

Part B Written

General comments

The standard of answers was very high for most candidates. There was no evidence that candidates were unable to complete the paper in the time available. As in previous series, the mathematical questions proved more popular than the philosophical ones in Section B, but the proportion of candidates staying entirely within these divisions was small.

Candidates generally need to put more explanation in words when answering mathematical questions. Too many answers are written with a string of numbers and letters without much of an explanation.

Significant figures continue to cause problems for some candidates. Unless a question specifically asks about significant figures, a tolerant approach is used by Examiners. For the candidate answering a multi-stage question it is preferable to keep all the figures in until the final answer is given. Too few significant figures in the final answer are often more of a problem than too many.

Comments on Specific Questions

Section A

Question 1

Part **(a)** of this question was answered very well by most candidates. Almost all candidates were able to suggest some situation where the only force acting on them was the force due to gravity, but many insisted that this only occurred at the top of a jump rather than at any time after losing contact with the ground. Maybe they were thinking that when moving, air resistance would be appreciable. There was a surprising number of candidates who thought that the gravitational force on the astronaut was very small compared with the force on the jumper, despite having worked out in part **(a)** that the acceleration of the astronaut was not very much less than the acceleration of the jumper. A few candidates did state, correctly, that a human being has no gravitational force detector, only able to detect contact forces, which are electrical in nature. Many candidates lost a mark because they did not compare the two situations, but simply wrote about the astronaut.

Question 2

Part **(a)** was answered well. Marks for part **(iii)** could be obtained either from simple harmonic motion analysis or by trigonometric methods. Answers to part **(b)** were generally poor. It was expected that candidates would describe a method whereby the time for a single oscillation could be obtained, rather than simply saying ‘time 10 oscillations and divide by 10’. One obvious method for doing this is to use an extra-long period by use of an extra-long pendulum, but very few candidates suggested this. Other methods using light gates or high speed filming were acceptable, but more detail of how the measurements were obtained was required than just stating ‘make a high speed film of an oscillation’.

Some candidates suggested using $T = 2\pi\sqrt{\frac{l}{g}}$ to check to see if their values were correct.

Another common suggestion was for one experimenter to release the bob and for another to start the stopwatch.

Question 3

A full range of marks was awarded for this question. Many candidates did not understand the principles behind charging a capacitor and the fact that the total charge on the central pair of plates and their connecting wire could not be altered. Many candidates thought that the p.d. across the 4 μF capacitor would be 6 V. Most candidates could then work their way along the top two lines of the table, getting marks by error carried forward in many cases. Hoverer, many candidates had a charge of 9 μC on X because that was the charge on the capacitor it was in parallel with. Part **(b)** was answered by more than 50% of candidates by adding the third and fourth columns.

Question 4

Parts **(a)** and **(b)(i)** were answered well by those candidates who knew the basic facts about electromagnetic induction. Many candidates did not appreciate the fact that in part **(b)(ii),** the secondary coil is not connected to anything so no current will be in that coil. In an open circuit there will be an emf across the coil, but no power supplied to it. Current in the primary coil will be small and any power supplied to it will be wasted as heat energy in it or in the core. Candidates needed to know some use of this arrangement, as in a transformer, together with some example of its use.

Question 5

Parts **(a)** and **(c)** of this question were answered well by a great majority of candidates. Some candidates seemed reluctant to use the word 'molecule' in their answers with the result that it was not clear that they were considering some particles of molecular size travelling quickly and colliding with relatively massive particles, of smoke , having a random motion that is just visible under a microscope.

Part **(d)** was not answered well by many candidates. Many candidates answered part **(i)** in terms of heat supplied and work done which does not define internal energy. It is defined as the sum of the (random) internal kinetic and potential energies of the molecules. It is essential that this relates to the random movement of the molecules, but answers were accepted provided candidates referred to molecules in their answer. Parts **1** and **2** make no difference to the random kinetic or potential energies and therefore no change to the internal energy. Part **3** does require the answer internal energy decreases because the average speed of the molecules is reduced.

Question 6

This question was answered well. The calculations were usually accurate and candidates were aware of the high speed of the electron in relation to the proton. Many sketch diagrams made it look as though the electron speed was only two or three times larger than that of the proton. A scale drawing of this is not possible, but at least the electron speed ought to look significantly larger than that of the proton. A few sketches of the effect of a third particle could have answered part **(d)** as long as the equation, with subscripts and superscripts had been included with the correct symbol for an antineutrino.

Question 7

This question was generally well answered. Answers to **(a)(i)** needed to make it clear that luminosity is the total power radiated from a star and for **(a)(ii)** candidates needed to state that luminous intensity is the intensity of radiation at a distance from the star. Part **(b)(i)** required the (surface) temperature of the star as an answer and **(b)(ii)** to have both the elements present and the star's speed of recession. Part **(c)** was usually answered correctly. The only incorrect answer seen with any frequency was to use 545×10^{-9} m for wavelength rather than 516.7×10^{-9} m.

Section B

Mathematical questions

Question 8

This was a very popular question. Many candidates made errors in answering part **(b)**, largely as a result of not distinguishing between force and acceleration. A force diagram for this question will show the weight of the child, 200 N, acting downwards and the force the rope exerts on the child as *T* upwards. The resultant force upwards can then be calculated as equal to 361 N. Answers, such as 200 N, 161 N and 39 N were common and show a basic lack of understanding of Newton's second and third laws.

Answers to part **(c)(i)** often failed to give a clear explanation of how to find the moment of inertia of a disc. Many candidates did not show a ring of radius *r* with another ring of radius $r + \delta r$. In many cases *r* was used, but not defined. This was further confused by many candidates using a double integration of $\theta\delta\theta$ and $r\delta r$.

A common incorrect approach was to use the law of conservation of kinetic energy in answering **(c)(iv)**. The correct approach was to use the law of conservation of angular momentum.

Question 9

Parts **(a)**, **(b)** and **(c)** of this question were answered well by a majority of candidates, although many of them lost a mark in part **(a)** by not stating that the force must be the *resultant* force. Candidates had two difficulties in answering part **(d)**. The first was with the minus sign for gravitational potential energy at a point. This is defined as the work done in moving the object from (its zero value at) infinity, to the point. The effect of this is that the gravitational potential energy will always have a negative value. The second difficulty was in coping with all the numbers and the corresponding arithmetic. The candidates that knew the numerical relationship between the values of kinetic energy (x), potential energy ($-2x$) and total energy ($-x$), had a much easier task.

Question 10

Of the three mathematical questions, this was the least popular.

Part **(a)** of this question was answered well by most candidates. Part **(b)** was answered well by the majority of candidates, but a significant number of responses were based on an erroneous method. Candidates who simply used the numerical value of Q at t = 30 ms scored zero for this part of the question as the method used (by drawing a tangent at t = 30 ms) was deemed to be crucial. Generally, the integration in part **(c)** was done well, but candidates should be advised to write down each step in their analysis rather than combine several steps into one line.

Philosophical questions

Question 11

This was the most popular of the philosophical questions, but the number answering the question was small compared with the number answering the mathematical questions. Part **(a)** was straightforward and many candidates scored the three marks. Part **(b)** caused two problems. One was a calculation problem with candidates unable to see how they could get the 16^{th} significant figure from their calculator. The second was that many candidates, having found the time dilation factor, did not go on to find the time difference. This had implications for part **(c)(i)** as these candidates gave the answer 10480 s instead of 9542 s. The adjustment required is therefore 458 s. The shape of the graph required for part **(d)** is an almost horizontal line at value $\gamma = 1$ for a large fraction of the values on the speed axis. Then, near a velocity = c, the graph becomes asymptotic.

Question 12

This question was answered well by the small percentage of candidates who answered it. Parts **(a)** and **(b)** caused no problems, but there was some difficulty in finding the mass of a meson as $\frac{h}{2\pi c^2 \Delta t}$.

Values of this being about equal to the mass of 0.2 of a proton and of 400 electrons were expected. Also expected was the statement that this implies a new kind of subatomic particle. Explanations in terms of exchange particles were expected in answers to part **(d)**.

Question 13

The few answers seen for this question tended to be rather brief. Parts **(a)** and **(b)** were usually answered correctly, but answers to **(c)** and **(d)** often showed a lack of understanding of entropy. In particular, it was frequently implied in **(c)(ii)** that continual stirring would not unscramble the egg because the probability is too low. When candidates did include entropy in their answer they did not mention that the disorder would not go on increasing, but instead would reach a (macroscopic) equilibrium. In part **(e)** candidates did not include the fact that there can be no distinction between past and present in part **(i)** nor did they consider a starting position, with the molecules in some ordered state in part **(ii)**. This would give rise to an arrow of time existing while entropy is increasing, but no arrow of time existing once the molecules are evenly spread. There is a small (but non-zero) probability that the molecules might move back into a small region causing the entropy to decrease and there being a reversal of the arrow of time. This would be such a low probability as to be effectively zero where a large number of particles are involved.

PHYSICS

Paper 9792/04

Personal Investigation

General comments

The Personal Investigation relies very much on the care and attention to detail of individual Centres both supervising the investigation and the assessment of the candidates' work. It was clear that Centres approached the Personal Investigations professionally and candidates appear to have been suitably prepared. Centres are thanked again for the valuable contribution that they have made in making this assessment successful.

It was pleasing to see high marks awarded as well as Centres applying the criteria sensibly to weaker candidates. A 'best-fit' approach should be used when applying the criteria to an individual candidate's plan and report. It was pleasing to see that the '0' mark was being awarded appropriately in some cases. Centres need to be wary of giving a higher mark by giving the benefit of the doubt. Throughout the criteria, if a Centre believes that a candidate should deserve a higher of the mark, on balance, then the script must be annotated and if a similar situation arises later then the higher mark should not be awarded. Annotation of candidates' work is essential.

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 it was pleasing to see many helpful annotations. A number of Centres enclosed annotated copies of the marking criteria whilst one Centre produced a small comment on each of the criteria areas justifying the mark. It is obviously helpful that both good physics and wrong physics in the reports are highlighted so as to judge the award of the appropriate mark. It was clear that the majority of larger Centres had carried an appropriate 'internal-standardisation' process.

Centres met the relevant deadlines. It is essential that Centres include appropriate paperwork with their sample. In particular, there must be a copy of the MS1 (or equivalent) and the Coursework Assessment Summary Form (or equivalent Centre generated form) as shown in the syllabus.

A number of candidates included photographs of their investigation – this was both interesting and helpful. Candidates should also not be concerned about producing computer generated diagrams – labelled hand-drawn diagrams are acceptable and often give better detail. Similarly, hand drawn graphs are often better than graphs generated by Excel.

It is clear that Centres do take care over the marking of the work. In general, differences occur most often in the award of marks for the quality of physics, data processing and communication. Work that lacks the necessary detail should not be given six marks for these criteria.

Comments on applying the criteria

Initial planning

It was useful when candidates clearly indicated where the plan ended and the report and their investigation started. Four marks should be awarded for appropriately detailed work. For the award of two marks candidates must include a summary of how the investigation might develop. For the award of four marks, candidates should use the pilot experiment to explain clearly how the investigation may develop.

Organisation during the two weeks of practical work

Centre's comments were very helpful in justifying the award of the marks. Some Centres included candidates' laboratory books which indicated candidates' progression in their investigation. Candidates should be encouraged to date their records. For the award of two marks, Centres should be satisfied that candidates are analysing and interpreting each experiment as it is completed.

Quality of physics

Centres still tend to be generous in the award of marks for the quality of Physics. A number of weaker candidates tended to copy sections of the reference material. Good candidates explained how the Physics used was related to their investigation. For the highest possible marks, candidates should be explaining Physics which goes beyond the taught course and their explanations should be both clear and without error. There should also be evidence of how physics principles explain a candidate's results. It is helpful where Centres clearly indicate that the physics principles have been checked.

Use of measuring instruments

If a candidate has help in the setting up or manipulation of apparatus then the mark for this criterion is zero. For the award of two or three marks, two experiments must have been undertaken and some further attention is needed to the measuring instruments used. As mentioned in previous years, when data logging equipment is used, there should be some explanation in the report as to how the equipment is being used. This applies in particular to the use of light gates and motion sensors. For the award of three marks, the apparatus is either sophisticated or uses a creative or ingenious technique.

Practical techniques

For the award of the higher marks, it would be helpful if candidates could include an explanation in their reports of how they are considering precision and sensitivity. This will also assist candidates in the data processing section when determining error bars. Candidates should be analysing their results as the investigation proceeds and as a result it may be necessary to repeat readings or take additional measurements near any turning points. Candidates should be encouraged to explain their reasoning.

Data processing

This area was a little generously awarded. Some candidates produced many graphs using Excel without much thought to scales, plots, lines of best-fit and the analysis of the data – this cannot score highly. For the data processing to be successful there must be clear explanation of how the experiments are being analysed. It was pleasing to see that a large number of candidates added error bars to their data points, however, it was not always clear as to their reasoning and thus the treatment of uncertainties was in some cases generously allowed. Candidates should be encouraged to explain their reasoning when determining uncertainties. A good number of the more able candidates successfully plotted log-log graphs to test for power laws. Often their work was supported by detailed reasoning. For the award of the higher marks there does need to be some sophistication in the work and clear reasoning. Where error bars have been added, some explanation should be given to the size of the error bars. For four or more marks, there must be some treatment of uncertainties which should be clearly explained.

Communication

The marks for this section were a little generous in places. It was pleasing to see a number of stronger candidates include glossaries which were detailed. Candidates should be encouraged to include detailed references which include page numbers. Some of the reports were excessively long and thus were not well organised and did not have a clear structure; verbose reports should not be given six marks. It is also expected that candidates who are achieving the highest marks in this area include aims and conclusions for each practical and for any mathematical analysis. This particularly applies to the treatment of uncertainties. References used should enhance the report. It should be noted that for the award of four marks, sources identified should include page numbers.