PHYSICS

Paper 9792/01
Part A Multiple Choice

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

*Question 39 was discounted.

General Comments

The questions on this paper do require careful reading and candidates are advised to reflect carefully before recording their response. It is hoped that candidates find the 'space for working' area on the examination paper useful. The paper proved to be appropriately set with a good number of easily accessible questions and some more testing questions.

Questions 2, **6**, **8**, **11** and **19** were particularly straightforward, allowing the majority of candidates to demonstrate their knowledge and understanding. **Question 2** was a basic knowledge question; otherwise these questions involved substitution of numbers into formulae.

Questions 7, **9**, **25**, **29** and **36** were found to be more challenging and many weaker candidates struggled with **Questions 18**, **23**, **24**, **28**, **33**, **35** and **37**.

Comments on specific questions

Question 7

This was concerned with a simple accelerometer. The most common incorrect response was **D**, where candidates did not realise that at position Y the car was travelling at constant velocity.

Question 9

Many candidates chose option **B**, not realising that the displacement in one complete revolution is zero.

Question 18

Many weaker candidates chose response **C**; candidates needed to realise that if the volume is constant, then the resistance is proportional to the square of the length.

Question 23

This was an application of a potential divider circuit. Many weaker candidates chose options **B** and **C** without realising that when it is dark the resistance of the LDR is $5\,\mathrm{M\Omega}$ and thus the potential difference across the LDR is $6\,\mathrm{V}$, and the p.d. across the $5\,\mathrm{k\Omega}$ resistor is zero. This type of question is useful for candidates to think how the circuit could be adjusted to obtain the other graphs.

Question 24

This question required candidates to determine the phase difference in radians. Weaker candidates probably chose **B** thinking that a quarter of a cycle is $\pi/4$ rather than $\pi/2$.

Question 25

Almost half the candidates chose the correct answer. The other three options were equally popular.

Question 28

Many of the weaker candidates selected **D**, presumably not fully understanding the term coherence.

Question 29

This question required candidates to carefully transfer the data shown on a displacement-distance graph to a displacement-time graph. Many weaker candidates selected **C**, whereas stronger candidates often selected option **D**. In both cases candidates did not realise that the displacement at point X would initially be negative. This concept requires candidates to practise the interchange of different graphs.

Question 32

A large majority of the candidates gave the correct answer. Option **B** was the most common incorrect response amongst the weaker candidates, with these candidates not recalling the relationship between amplitude and intensity.

Question 33

Many of the weaker candidates were confused about the effect of refraction, with all options being selected.

Question 35

This required candidates to do a multiple stage calculation. The common incorrect answer amongst the weaker candidates was **C**, these candidates having assumed that the work function was equal to *hf* rather than applying Einstein's equation in full.

Question 36

This was the question that candidates found the most challenging on the paper. The question was concerned with the photoelectric effect. It was clear from the responses that the vast majority of candidates correctly realised that when a yellow light source is replaced by a blue light source, the maximum kinetic energy increases. What was not understood was that for light of the *same* intensity, if the kinetic energy of the electrons is larger, the number of electrons emitted per second must decrease.

Question 37

Candidates had to apply knowledge to the α-particle scattering experiment. A number of weaker candidates selected option **A**, thinking that the heavier isotope would cause more scattering, rather than realising that the scattering depends on the charge, which does not change.

Question 39

This question was targeted at learning outcome 11 of *Section 8* of the syllabus, and was answered correctly by a large majority of the candidates. The question was discounted, however, since the distractors involved the structure of a nuclear reactor which is not a syllabus requirement.

PHYSICS

Paper 9792/02
Part A Written

Key Messages

The responses to non-numerical questions sometimes lack precision and logical flow of thought. Candidates are advised to read the question carefully and make sure that their answers fully address what is being asked. Credit is often lost due to incorrect use of terminology or answers which are too vague or ambiguous. Where symbols are used in definitions, it is imported that the meaning of these is made clear.

The detail of the answers needs to reflect both the wording of the question and the credit allocation given for each question part.

Full working should always be shown in calculations and, particularly where there are several steps, the method needs to be clear.

General comments

The standards achieved by this year's candidates were in general very similar to last year. A large number of candidates scored highly and answered the more challenging questions with accuracy and some elegance. There were slightly more candidates this year who scored very high credit indeed and many of these scripts were direct, accurate and clear. The overwhelming majority of candidates were able to produce many encouraging answers even to the more difficult parts of the paper, and all candidates had at least some idea of the physics underlying the various questions. All of the candidates were able to score well in at least some topic areas, although there were significant gaps in the knowledge of some.

The scripts that scored the highest were distinguished by answers that tackled the question directly and that indicated in this way that the parts of the syllabus being tested were well understood and very familiar. Formulae were quoted accurately and when symbols were used there was no confusion in their meaning. Diagrams and graphs were clear and straightforward and answered the exact points that the question required.

Whilst most candidates had good recall of the basic laws and principles, some struggled to apply these to unfamiliar situations.

Comments on specific questions

Section A

Question 1

(a) (i)(ii) This was answered extremely well, with almost all the candidates scoring some credit, and a very large majority scoring full credit. A few of the lower-scoring candidates confused vectors and scalars, transposing, for example, *speed* and *velocity*, *distance* and *displacement*, or both.

(b) (i) This question was also well answered with nearly all candidates realising that an exact scale diagram was not required here for full credit. A very small number of candidates drew very rough diagrams that were inaccurate. Those candidates who drew the correct diagram but then put a reversed arrow on D were still able to score some credit.

(ii) These two answers were almost always accurately calculated and many candidates gained full credit. However, despite the clear labelling on the diagram, there were some who confused the x

and *y* directions. As the term *calculate* appeared in the question, it was surprising that a small number of candidates gave the answers as $37\cos 25°$ and $37\sin 25°$.

Question 2

This question was based on Newton's third law of motion and its application in three progressively unfamiliar situations. Very few candidates were able, consistently and accurately, to apply this law in all three cases being tested.

(a) (i) This part was frequently answered well, with many candidates realising that the law applied to two equally sized forces acting in opposite directions on different bodies. Many candidates drew the Earth, and some even stated that the Earth lay in the gravitational field of the falling object. There were some candidates who stated that the law did not apply in these circumstances as only one force was acting.

(ii) Many candidates found this part more difficult to explain and went on to answer in terms of the two equal and opposite forces which act on the object and which are not a third law pair: the *weight* and the *contact force*. Some candidates, however, did realise what was expected and referred to the two contact forces that were acting, as well as the two gravitational forces. Some of these candidates referred to the contact force acting on the floor as the *weight* of the object and this prevented credit being awarded.

(b) (i) This graph was almost universally correct and the overwhelming majority of candidates gained full credit. The candidates who lost credit, usually did so as a result of a careless drawing, indicating that some aspect of the motion was misunderstood. For example, a few graphs finished with a section that had a clear negative gradient.

(ii) In this case, the most common misunderstanding was that the third law related to the opposition of the *air resistance* and the *weight* of the falling object, even though these two forces are not always equal and do not act on different bodies. It was encouraging to see the very highest scoring candidates answer this part of the paper with ease; the statement that 'the downwards force exerted by the falling object on the air increases' was all that was needed to obtain full credit.

Question 3

(a) Very many candidates started from the definition of work and deduced the relationship for power. The best answers gave all the essential intermediate steps, but even the shorter answers almost invariably gave enough detail to score full credit. It was good to see some answers that were given using the calculus notation.

(b) Both parts of this section were answered correctly by most candidates. The first answer was simply obtained using the formula from **(a)**, and the fact that the second answer was equal to the first was almost always recognised.

(c) Here the formula $F = ma$ was very commonly given in these terms, or implied by the use of the correct numbers from the question. This leads to a net force of 2125 N. There were inevitably candidates who gave this as the final answer, but a few candidates went on to subtract 150 N from this value rather than adding it on.

(d) (i) Most candidates had a clear idea of what was expected here and answered the question in terms of proportions or by calculating a constant of proportionality for the relationship $F \propto v^2$. Errors arose when candidates simply calculated 36^2. Although this answer is close to the correct one, this is solely due to the value of the constant of proportionality.

(ii) Many candidates gained full credit here, either by obtaining the correct answer or by correctly using an erroneous and previously penalised answer from **(i)** and obtaining the appropriate answer in this part of the question.

(e) Many candidates were able to use their previous answer and the appropriate ratios to show that $n = 3$. It was harder for candidates who had made errors earlier to score full credit here as the answer obtained from these values is not *3*. Many such candidates did, however, score at least some credit here.

Question 4

(a) (i) Most candidates used the correct method to obtain the correct answer here.

(ii) Again, most candidates used the correct method to obtain the correct answer.

(b) (i) Although most candidates stated correctly that the three lamps A, B and C, would light, a few added or implied that the rate at which the water heater was supplying thermal energy would be reduced, which is not the case.

(ii) Many candidates had some idea that this was a two-way switch and were able to make clear some aspects of its operation. Those answers which did not obtain full credit tended to concentrate on only one aspect of the operation of this arrangement of switches. For example, some answers only referred to how the lamp could be switched on, whilst others only mentioned the effect of one of the switches. Answers given in terms of the switches having an *on* and an *off* position were sometimes difficult to interpret.

(iii) Most candidates were able to obtain the correct value for the resistance. A very small minority used a value of 80 V in the calculation, possibly because these candidates believed that the 240 V supply was in some way shared equally amongst the three major, parallel sections of the circuit.

(c) (i) A significant minority of candidates drew the current flowing from Q to P. Many candidates drew currents flowing in both halves of the inside circle but rather fewer drew currents in both halves of the outside circuit. Some candidates only considered the left hand side of the circuit.

(ii) Many candidates' answers concentrated on the advantages of the separate components being in parallel which, of course, they are in a ring main. Only minimal credit was awarded for this. To score full credit, the answer needed to include at least one specific advantage of the parallel arrangement being a ring main. Ring mains are not on the syllabus; candidates were expected to be able to apply their understanding of circuits to a novel context.

Question 5

(a) (i) This part of the question was high scoring and many candidates were able to give text-book definitions of the basic difference between the two types of wave. Candidates who only referred to displacement of the particles and not to their vibration, were able to score minimal credit.

(ii) This difference is surprisingly difficult to express succinctly and in writing. Diagrams often helped, and the majority of candidates gave clear and precise answers here. Many answers were not only correct, but were well set out and mostly easy to understand.

(iii) There were several ways of gaining credit here, but only a few candidates gave sufficient detail to obtain full credit.

(b) (i)(ii) These parts of the question were well answered and many candidates scored full credit. There were a few errors in calculations, and sometimes an incorrect power of ten was given in the answer.

(iii) Most candidates found this part challenging. Very few converted the angular difference of 0.04° to radians, and a significant number of candidates divided one of the calculated wavelengths, or difference between them, by one of the angles, or by the difference between the two angles. The correct answer was obtained only by the most able candidates.

Question 6

(a) (i) Very many candidates were able to calculate the correct values for P, Q and R.

(ii) There were many correct points made here, but not all candidates stated that the reaction produced more neutrons than were required to initiate it.

(b) (i) Most candidates wrote out the correct equation for the nuclear transformation. The more common errors included confusion caused by the subscript -1 on the beta-particle and the use of the alpha-particle values.

(ii) This calculation was performed correctly by almost all candidates. Those who did not spot that 112 years is, for this isotope, exactly four half-lives and used the equation $N(t) = N_0e^{-\lambda t}$ were not always successful. Of these, however, most were able to score some credit.

Question 7

(a) Many candidates scored highly on this part of the question. The photoelectric effect was well understood and the three explanations of the terms were very commonly accurate. Where credit was lost, it was often because the requirement for a minimum frequency or energy of illumination was not related to the photon or, in some cases, was not referred to at all. A few candidates' answers confused photons with electrons or, (more understandably), with photoelectrons. Such answers tended to be unclear and low scoring.

(b) This part of the question was not very commonly well answered. Some candidates described in full the determination of the Planck constant by measuring the stopping voltage at a variety of frequencies of illumination, but did not answer the question asked. Some answers included circuit diagrams which did not include ammeters or any means of varying the voltage. A few candidates gave a correct circuit and described how to obtain a value for the stopping voltage, but then did not go on to describe how to obtain a value for v_{max}.

(c) (i) This question asked directly for an observation. Many candidates gave one, but others explained that electromagnetic waves show particle behaviour but omitted to give any specific observation that suggests that this is so.

(ii) Many candidates found some difficulty with this part. Some did not use the same observation that had been given in **(i)**, while others gave answers that were too general. Only the most able candidates did well in this question.

(iii) This part was rather better answered and many candidates were able to make a relevant point.

Section B

Question 8

(a) (i) Many candidates obtained a value for the acceleration that lay within the acceptable limits. Almost all candidates used a value for the velocity at the time t = 150 s to calculate the acceleration. Those who approximated this velocity to 100 m s^{-1} did not obtain an acceptable value and only scored minimal credit.

(ii) This answer was very frequently correct or at least scored full credit as a consequence of the correct use of an incorrect value from **(i)**.

(iii) Many candidates realised that the appropriate numerical value here was equal to their answer to **(ii)**.

(b) Most candidates gave good answers here, although not all stated or implied that the resultant force remained constant.

(c) Some candidates, including some of the higher-scoring ones, did not obtain answers that were sufficiently close to the correct value to be given full credit. Candidates used a variety of ways to obtain an approximate value of the distance covered, but a significant number were rather too approximate. At this level, care needs to be taken in this sort of question and a sufficiently accurate answer may take longer to calculate.

(d) (i) This answer had to be read straight from the graph and many candidates were able to do this. A misinterpretation of the vertical scale by some, however, led to answers such as 138 m s^{-1} or 128 m s^{-1}.

(ii) This was well answered and most candidates obtained the correct value here. Just a few forgot to multiply the mass of a single section of the train by 5, although they had done so previously.

(iii) The majority of candidates obtained the correct answer here and scored full credit. Some did so directly whilst others used a previously penalised incorrect answer correctly, and were consequently awarded full credit.

(e) (i) In order to score credit here, it was necessary for the candidate to state, in some way, that the resistance of a superconductor is zero, or very close to zero. A phrase such as 'the resistance reaches a low value' was not considered an adequate explanation. It should be noted by some candidates that superconductors are not only found in the coils in an electromagnet.

(ii) Candidates who gave an advantage or disadvantage of maglevs in general, rather than the use of a semiconductor, were unlikely to score credit.

(f) This part of the question allowed candidates a certain freedom to choose points raised in any of the extracts, or even to discuss other points which are definitely applicable to the operation of maglev transport systems. Since the question asked candidates to explain the advantages and the disadvantages, candidates were expected to explain examples of both and, in order to gain full credit, there had to be at least two examples of each. The candidates who scored highly in this section were those who raised many points and discussed them sensibly and comprehensibly. Candidates who explained just one or two points, albeit in great detail, did not generally score as highly.

In questions of this nature, there is a tendency when discussing the economic effects to be insufficiently precise. For example, a candidate who merely stated that a maglev system is expensive, should have gone on to explain whether the system is expensive to install or, once installed, expensive to operate. It was noticeable that a few candidates who had performed less well on the rest of the paper were able to improve their relative performance by answering this part thoughtfully and thoroughly.

PHYSICS

Paper 9792/03

Part B Written

Key Messages

It is important for candidates to take care when selecting questions from ***Section B***. In some cases candidates started a question but then omitted some of the later parts; candidates would be advised to look through the full question to check they have the knowledge needed for all parts before making a start.

Candidates must make sure they answer the question that is being asked. Credit is only given for answers that address the question, not for a general discourse about the topic or irrelevant additional details. There is a tendency for candidates to think less rigorously and logically in non-numerical questions, such as those with a more philosophical flavour, and credit is often lost due to the response being too vague, or using incorrect terminology.

General Comments

The paper was sat by candidates across the full ability range. Many candidates achieved excellent results, but there were a few who struggled with this paper.

When answering numerical questions, candidates should be careful that they use sufficient words in their answers. Often candidates use symbols and numbers almost exclusively, which results in unnecessary mistakes because, for example, an x on one line of a calculation might not be the same as the x on the next line. Statements such as 'distance car travels = ...' need to be written in words. It takes very little time to be precise and it can make for far greater accuracy. Working should always be carefully laid out and explained, particularly where an answer involves several steps.

It is better to start all answers at the far left hand side of the page rather than in the middle. This gives much more space for the answers and also gives additional space if a mistake is discovered.

The answer space provided on the question paper should always be adequate for a good answer, unless the candidate has particularly large handwriting, or chooses to write an unnecessarily lengthy response. Candidates are advised to read through their written responses to check the meaning is what they intended and not ambiguous.

Comments on Specific Questions

Section A

Question 1

Most candidates scored well on this question.

In part **(a)**, a few candidates incorrectly showed the change in velocity as the sum of the two vectors, and some showed the change in velocity in the wrong direction.

Part **(b)(i)** was answered well, although some candidates did not subtract the 40 000 J lost on the way down. Some candidates were confused by the idea that the path of the carriage from point B was circular, possibly because at point B the surface was horizontal.

The main reason why many candidates lost credit in part **(b)(ii)** was because of the use of the term 'centripetal force' as if it was a separate type of force. These candidates should know that, outside of the nucleus, forces are always either gravitational or electromagnetic. Contact forces between objects are electromagnetic because atoms have electrical charge. In the absence of air resistance and buoyancy the only vertical forces on the trolley are the gravitational force downwards on it, its weight, and the upward contact force provided by the track. The resultant of these two forces causes the centripetal acceleration v^2/r. This resultant is what some people describe as 'centripetal force', but it is important for candidates to recognise that this force does not exist as a separate type of force, but is simply the resultant of the other forces acting on the body. An extended equation therefore can be written:

$$\text{resultant force} = \text{mass} \times \text{acceleration} = (\text{upward contact force} - \text{weight}) = m \times \frac{v^2}{r}$$

Candidates were required to evaluate the upward contact force, not the resultant of the two forces.

Question 2

This question was answered well, although there was some careless reading of values from the graph.

Question 3

This question caused some problems for those candidates who did not recall that field lines are always at right angles to equipotential lines. Almost all candidates realised that the two diagrams could be identical. The calculations in the question were done well.

Question 4

Part **(a)** of this question was done well, although a number of candidates did not realise that the work done by the gas during stage D → A was zero.

Some candidates struggled with parts **(b)** and **(c)**. These parts showed the weakness in the candidates' understanding of some basic thermodynamic facts; similar misconceptions were also evident in several parts of **Question 13**.

Many candidates showed confusion over the signs to be used for the different terms. It helps to go back to the fundamental definitions: *internal energy,* which is the total kinetic and potential energy of all the molecules in a system; *heat,* which is the energy supplied **to** a system as a result of a temperature difference between the system and its surroundings; and *work* which is energy supplied **to** a system as a result of doing work on the system, e.g. by squashing it. It is sensible to write the equation for the First law of Thermodynamics in the following way:
the **increase** in the internal energy of a system (*U*)
= the work done **on** the system (*W*) + the heat supplied **to** the system (*Q*).

Candidates who use this statement <u>only</u> can avoid a great deal of confusion. Obviously *U*, *W* and *Q* themselves can be positive or negative but if just one equation is used it is clear when a negative sign is required.

The table shows that heat is lost in stage 4. This is a fundamental point about heat engines; they can never be 100% efficient as they always lose energy to their surroundings. The efficiency of this engine is given by:

net work done by the system / heat supplied to the system = (63 + 333 – 235) / 246 = 0.65 = 65%.

Questions 5 and **6** posed few problems for candidates and there were a lot of good answers.

Question 7 was tackled well by a large majority of candidates. The most common error was to calculate the surface area of a sphere incorrectly, or not to use the 4π at all and just use r^2 by itself.

Section B

Question 8

Many candidates were able to score well on this question, but good answers all depended on realising that the parallel resistance formula needed to be used to answer **(c)(i)**. Whilst many candidates succeeded in performing the calculation using Faraday's law in **(d)**, not all of these could express it clearly in words, or explain the damping using Lenz's law.

Question 9

This was a very popular question and was done well. A number of candidates gave incorrect phase differences in part **(d)**; π and 2π were very common. Degree values were accepted. Many of the answers to part **(i)** were too vague, many of the better answers used mathematical ideas rather than pure description. Most candidates approached part **(f)(ii)** by considering the transfer of gravitational potential energy to rotational and translational kinetic energy, but credit was also gained by some candidates who knew or could work out the equation $I = ½mr^2$ for the moment of inertia of a rolling cylinder.

Question 10

This was another very popular question and was answered well by the majority of those candidates who chose it. Parts **(a)**, **(b)** and **(c)** usually caused no problem and it was good to see part **(c)** being tackled well. The unit m^{-1} was often not correctly given in **(d)**. In **(e)** many candidates struggled because they did not know the value of *r*. The problem was in not realising that angular momentum is the moment of the momentum, i.e. *mvr*. This means that no *r* occurs on the right hand side of the equation, which is $nh/2\pi$. Another problem arose with part **(e)(iii)**. It was possible to get numbers larger than 10^{99}, and so, to avoid calculator problems, the calculation needed to be broken into parts.

Question 11

This was the most popular of the philosophical questions on the paper and many good answers were seen. In **(e)** candidates had to think carefully about how to represent the time dilation factor and evaluate the time difference, with some stating that the number wouldn't fit on their calculator. The discussion of the uncertainty in the Hafele and Keating experiment was found quite challenging; the best candidates used the data to justify their conclusion rather than making vague generalisations.

Question 12

This was the least popular of all the questions on the paper and many answers were incomplete or vague. Answers were frequently in the wrong place because candidates were unable to relate their own knowledge to the particular item being examined. Candidates need to ensure they are making a number of clear, distinct points that fully address all parts of the question, rather than repeating the same vague comment in a number of different ways. In **(d)(iii)** many candidates gave a general description of the Many-worlds interpretation but did not go on to explain how this avoided the Measurement Problem.

Question 13

Many candidates were insecure in their understanding of the first law of thermodynamics, and some did not refer to it at all in their answer to part **(a)**. Explanations often showed confusion between internal energy and heat. In part **(c)** many could not see that heat flows from the warm food in the refrigerator to the heat exchanger, which is at a lower temperature. In parts **(d)** and **(e)** many candidates did not make use of the idea of 'ways in which the energy may be distributed' amongst the particles of the object. A number of candidates struggled in **(i)** to relate the second law of thermodynamics to the refrigerator, referring instead to conservation of energy. In parts **(i)** and **(j)**, a common answer was to say that the kitchen's temperature was unchanged when the door was left open because the heat extracted from the food was put into the kitchen. These candidates ignored the fact that disorder was increasing as a result. The entropy of the food is reduced by extracting heat from it, but the entropy of the kitchen increases by more than that because of the work done by the motor. This results in the temperature of the kitchen rising.

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 in supervising the investigation and in 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 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 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 out 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.

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

Centres' 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.

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 needed to be given 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 'Excel' graphs 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. 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. References used should enhance the report. It should be noted that for the award of four marks, sources identified should usually 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.