PHYSICS

Paper 9792/01
Part A Multiple Choice

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

General Comments

The paper proved to be appropriately set with all the questions accessible. All the candidates managed to answer the paper in the time available. Candidates appeared to have prepared well for the paper and showed a good understanding of all parts of **Section A** of the syllabus.

There was again a good spread of marks with a mean of 32 marks and a median of 34 marks. This year, nine candidates scored the maximum 40 marks available. All of the questions showed a positive discrimination.

Almost all candidates answered correctly **Question 11** and **Question 27**, which tested basic physics knowledge. In **Question 7**, a number of candidates gave the answer D, indicating a misunderstanding of Newton’s third law. **Question 13** was answered well by many candidates, but some candidates did not convert 2 cm^2 correctly to m^2.

The questions on this paper do require careful reading and candidates are advised to reflect carefully before recording their response. For example, in **Question 8** a number of candidates did not read that the aeroplane was ascending at a steady rate of four metres per minute and so incorrectly chose option B. Similarly, some candidates confused gravitational potential and gravitational potential energy in **Question 14**.

Questions 20 and **22** were the lowest scoring questions. In **Question 20**, candidates were required to interpret voltage-current graphs and in particular realise the implication of the gradient. The common incorrect answer was B. In **Question 22**, a significant number of candidates did not appear to understand that a voltmeter has a very high resistance and as a consequence selected option C. Some candidates were confused by the second source of electromotive force in **Question 23** and so chose option D.

Candidates generally found the questions that needed multi-step mathematical reasoning more difficult. In **Question 4**, all four options were equally popular. **Questions 16** and **31** were, however, well answered by many candidates. Radioactive half-life, tested in **Question 37**, was clearly understood by the majority of candidates.

PHYSICS

Paper 9792/02
Part A Written

Key Messages

Candidates should be reminded that, in calculations, care should be taken to ensure that the final answer is checked and seems reasonable. Full credit cannot always be awarded when a digit from a calculator display is omitted when the number is transferred to paper. It is always important to show working out, as when this is done, some credit may still be obtained even when the final answer is, for some reason, incorrect. Candidates who write on top of a previous answer risk producing answers that cannot be interpreted and which cannot receive full or sometimes any credit. It usually is better not to write over a crossed out prior attempt when a second attempt is made, but there is almost always a blank section of the question paper where the new answer can be written. In these circumstances, however, reference to its new location of should be made in the original answer space. The front cover, however, is not a suitable place to write a new answer.

General Comments

It is inevitable that the standard achieved by candidates varied and many candidates revealed a thorough, accurate and insightful understanding of this subject at this level.

Comments on Specific Questions

Section A

Question 1

(a) (i) Many candidates completed these three sentences correctly and completely. A very small number of candidates wrote *changing* where *increasing* or *decreasing* would have resulted in a more precise description.

(ii) This was very frequently correct.

(b) This answer was very commonly correct. On rare occasions, the reading from the graph were not sufficiently exact or the calculation produced an incorrect answer.

(c) (i) Many candidates obtained an appropriate estimate using a correct approach. Some candidates made approximations, which although obtaining some credit, were too approximate for a question at this level.

(ii) Many candidates determined an appropriate value for the uncertainty.

Question 2

(a) Whilst some candidates were able to produce a correct answer for all parts, others gave fewer correct answers. Many candidates knew what is meant by an elastic material and a plastic material, but rather fewer were as familiar with touhness and brittleness. Here, candidates need to be precise and for **(a)(i)** the answer *a material that returns to its original length when a force is applied* lacks any reference to the removal of the force.

(b) There were many good answers here, although there were candidates who confused malleability with some other property, most commonly *ductility*. Many different materials can be considered to be malleable and these were all accepted as correct.

(c) This question asks for an answer in terms of the microstructure of the polymer and answers that merely interpreted the graph in terms of its physical behaviour received no credit. Only a few answers were completely correct, but many candidates were able to achieve some credit for accurate partial explanations.

Question 3

(a) This part was answered correctly by most candidates. A significant number of candidates, who produced the correct numerical answer, did not write down a correct unit.

(b) This was very commonly correct although a small minority of candidates divided by (5 × 60) instead of (5 × 3600).

(c) This was frequently correct, but some candidates were not awarded full credit because of some error involving the 15% metabolic efficiency; sometimes it was ignored and on other occasions, it was divided through on the wrong side of the calculation.

Question 4

(a) (i) The correct answer was very rarely supplied. Indeed, the whole of this question proved quite challenging for many candidates.

(a) (ii)(iii) These parts were answered correctly rather more frequently than was part **(a)(i)**, although some errors arose from an uncertainty in whether the series or parallel formula for resistance should be used and where the formula should be applied.

(b) This was commonly, although far from universally, correct either in absolute terms or as a result from a previous erroneous answer being used in a completely correct manner.

Question 5

(a) (i) This question was looking for the general conditions that lead to the formation of a stationary wave and many candidates gave answers in these terms, which were usually awarded full crediy. Some candidates, however, restricted their responses to the formation of a stationary wave by the reflection of a sound wave in a tube. It was still possible to be awarded full credit, but this was less common when this approach was taken.

(ii) Although there were some good answers, many candidates struggled in this part. In particular, few candidates made reference to the fact that on the opposite sides of a node, the particle oscillations are in antiphase. There were also candidates who stated that the pressure at a node is constant.

(b) (i) This calculation was very commonly completely correct. The two main sources of error were either to omit the square root stage or to misinterpret the SI prefix *G* to mean a factor of a million (10^6).

(ii) This was generally answered correctly either in absolute terms or in terms of a correctly used erroneous answer to **(b)(i)**. A very small number of candidates omitted the factor of two and calculated the time taken for the pulse to reach the top of the rod.

(iii) When a candidate did not obtain full credit in this part, it was usually because the description lacked detail. The use of light gates and using the rod and plate as a switch in a timing circuit were the commonest suggested methods. A few candidates suggested that an experimenter might start and stop the stopwatch manually at the appropriate times. Given the period for which the rod and plate were in contact, this method was not considered appropriate.

Question 6

(a) (i) This experiment was widely known and many diagrams obtained full credit here.

(ii) This part was well answered with the majority of candidates giving two observations and one deduction from each observation. It was unfortunate when both the observations and the deductions were correct themselves, but were either wrongly linked or linked in a way that was not sufficiently clear.

(iii) Most candidates gave an appropriate answer here.

(b) (i) Most candidates were awarded full credit on this part.

(ii) There were many correct answers that obtained full credit, but some candidates revealed rather elementary misunderstandings. The most common of these being a chain reaction caused by the repeated emission of α-particles. Some candidates implied that it is the turbine that generates the e.m.f. of the supply.

Question 7

(a) There were some good answers here but, few answers were awarded full credit. Common omissions included the use of an ammeter (or more sensitive instrument) to measure the current. Some other circuits did not included a source of e.m.f. and some candidates answered the question by explaining how the stopping voltage could be determined.

(b) (i) This graph was very widely known and was almost always correctly drawn by candidates.

(ii) A few answers made no reference to the kinetic energy of the photoelectrons, but most candidates answered this part correctly.

(c) Both calculations were very commonly correctly performed with only a very few candidates making errors in either part. Of these rare errors, the one that occurred a few times was to give the energy of the photon as the final answer and to omit any reference to the work function.

Section B

Question 8

(a) This was often correctly answered although some candidates wrote about the pressure difference between the top surface of the tube and its lower surface.

(b) (i) A significant proportion of the candidates confused radii and diameters when determining the volume of the concrete in the tunnel section. The outer diameter was commonly taken to be 7.92 m (7.30 + 0.62), but several other variations were seen.

(ii) It was possible here be awarded full credit here either in absolute terms or through the completely correct use of a wrong answer to **(b)(i)**. A frequently occurring error was to treat the tube as a flat plane and to work out the force from the pressure difference between the top and bottom surface.

(c) (i) Many candidates were able to suggest one reason here and a smaller number were able to suggest two correct reasons.

(ii) Some candidates were able to show that the value given was the approximate value required.

(d) (i) Only a small minority drew the correct vector diagram and used it to determine the tension. Many candidates produced a diagram similar to that in Fig. 8.5 of the question paper and then relied on a calculation to obtain the answer.

(ii) This was quite commonly correct although in many cases, this was because an incorrect answer from **(d)(i)** was used in a completely correct manner.

(iii) This was quite commonly correct although in many cases, this was because an incorrect answer from **(d)(ii)** was used in a completely correct manner.

(e) This was only answered correctly by a small number of candidates. Many candidates attempted to obtain an answer in terms of the difference in the water pressure between P and Q.

(f) Most candidates answered the question well and dealt with the issues associated with a submerged floating tunnel in an intelligent and practical fashion. Some candidates argued in a very coherent manner and made logical and relevant points that set out the factors that have, until now, prevented the construction of such a fixed link.

PHYSICS

Paper 9792/03
Part B Written

Key Messages

Most candidates appeared to be very well prepared for the paper. Candidates should, however, be reminded of the need to present their answers clearly and legibly and in a logical sequence.

General Comments

In questions requiring algebra, many candidates would benefit from the inclusion of explanations to make it clear the meaning of the symbols they are using.

Comments on Specific Questions

Section A

Question 1

This question was answered well by many candidates, but many did not attempt to draw a vector diagram. Some candidates drew an incorrect or in complete vector triangle and many candidates did not keep the directions of the two v arrows in the same direction as on the paper. This led to difficulties in trying to get the direction of δv. Many did not use AB = $v\delta t = r\delta\theta$. This frequently led candidates to arrive at the required equation by spurious methods. Parts **(b)** and **(c)(i)** were almost always totally correct, but correct answers to **(c)(ii)** were rare. This was because candidates did not include the potential energy of the Moon.

Question 2

This question was answered well by almost all candidates. One common mistake in part **(d)(iii)** was to give the energy in one cycle as 0.0113 J rather than the power output as 9.95 W.

Question 3

Candidates who were skilled at dealing with capacitor theory had no difficulties in getting full marks on this question. Other candidates could not understand how the answers to **(b)(i)2** and **(b)(i)3** could be different and these candidates usually could not deduce that the p.d. across all three capacitors are equal.

Question 4

Many candidates had difficulties with this question, mainly in sorting out directions for the three vectors involved. Some candidates used the electron direction rather than the direction of conventional current.

Question 5

Most candidates scored ten or more marks on this question.

Question 6

Most candidates answered this question well. In part **(a)(iii)** candidates were expected to appreciate that the fraction of carbon-14 nuclei to carbon-12 nuclei was low and with too few significant figures and that this is the cause of uncertainty in any estimates.

Question 7

This question was answered well. The vast majority of candidates could, with some trial and error, establish that the value of n was 3. They were then able to find the frequency of line Q. Unfortunately, quite a few candidates used line Q, instead of line R, in answering part **(b)**.

Section B

A majority of candidates answered **Questions 8**, **9** and **10**. Another large fraction of candidates answered two of the mathematical questions and one of the philosophical questions.

Question 8

Many candidates scored the full nine marks for part **(a)**. Fewer candidates scored all six marks for part **(b)**. Often this was because the distances and volumes used were inaccurate. A distance of 120 m was often used instead of 870 m. The volume of a sphere was not known by many candidates.
An interesting point from part **(c)** was that many candidates were reluctant to separate $\delta t/\delta g$ into the expression

$$\frac{\delta T}{T} = \frac{1}{2} \times \frac{\delta g}{g}.$$

Question 9

Candidates often find circular motion and the associated force diagrams difficult. The forces on the car in part **(a)**, when only vertical forces are being considered, are the contact force with the ground and the weight of the car. It was expected that candidates would realise that size and direction of the arrow to represent weight is the same for both locations of the car shown. Many candidates struggled to answer parts **(b)(i)** and **(b)(ii)2**, but part **(d)** was answered more successfully.

Question 10

Candidates found parts of this question difficult. In part **(b)(i)**, many candidates did not state that the force on both particles is the same. In part **(c)**, almost no candidates showed two equal field arrows at C, which would have helped them to deduce that the resultant field is $\sqrt{2}$ times the value of one of these fields. The performance of candidates on part **(d)(i)** was mixed. Some candidates did not include the integration limits and those that did, often integrated from zero to r. Parts **(d)(ii)** and **(d)(iii)** were done well by most candidates.

Question 11

Parts **(a)**, **(b)** and **(c)** were answered well. In part **(d)** candidates did not need to state sophisticated methods, but they did need to show an understanding that the straight line distance through the earth would be needed. Mention of a GPS system was credited when backed up with some detail of how this is used. The time measurement needs to the nearest nanosecond and the need to synchronise clocks at CERN and Gran Sasso was expected together with use of atomic clocks. Parts **(e)** and **(f)** were answered well.

Question 12

This was the least popular question on the paper. It seemed as though candidates did not see how to answer part **(a)** as the few candidates who attempted the question omitted part **(a)** altogether.

Question 13

This was the most popular of the philosophical questions. The diagrams used in answers to part **(a)** always showed the long strains, but in a high percentage of answers, the crucial cross links and bonds were missing. Parts **(b)** and **(c)** were answered correctly by almost all candidates although there were quite a few candidates who had **(c)(i)** correct, but then sketched a graph showing high entropy to be associated with maximum extension. Candidates needed to show a finite value of entropy for zero extension. Even those candidates who had part **(c)** completely correct usually answered part **(d)** with the reverse relationship between entropy and the extension of the rubber band in the heat engine.

PHYSICS

Paper 9792/04
Personal Investigation

General Comments

It is clear that candidates benefit greatly from the Personal Investigation and there was a good range of interesting topics investigated. Candidates appear to have been suitably prepared and the majority of Centres have taken great care with regard to the marking, checking the marking and internally moderating the marking.

As has been stated in previous years, 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.

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 and the '0' mark was being awarded appropriately in some cases. Centres need to be cautious of giving a higher mark by allowing 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 and in particular candidate errors should be highlighted so that the Moderator is aware that the Centre has allowed for the errors in the marking.

In general, differences occur most often in the awarding 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. There was a tendency to give benefit of doubt marks to higher scoring candidates particularly with regard to these criteria.

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. Other Centres included their own check lists. Some markers also wrote a rationale as to why the marks were awarded – this again very much assists the moderation process. 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 larger Centres had carried an appropriate 'internal-standardisation' process.

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.

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. To be awarded two marks, candidates must include a summary of how the investigation might develop. To be awarded 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. To be awarded 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 awarding 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. Where errors are found, it is necessary for the marker to highlight this so that the Moderator is aware that the error has been allowed for in the marking. There should also be evidence of how Physics principles are used to explain a candidate's results.

Use of Measuring Instruments

If a candidate has help in the setting up or manipulating apparatus, then the mark for this criterion is zero. To be awarded 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. To be awarded three marks, the apparatus is either sophisticated or uses a creative or ingenious technique.

Practical Techniques

To be able to award 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

Centres were a little generous in places in this section. As has been stated in previous reports, 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 a 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 large number of the more able candidates successfully plotted log-log graphs to test for power laws and often, their work was supported by detailed reasoning. To be awarded 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 must be clearly explained. In general candidates should be encouraged to explain how they are determining an uncertainty. These higher level marks must be rigorously applied.

Communication

Centres were a little generous in places in this section. 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 that to be awarded four marks the sources identified should include page numbers.