PHYSICS

Paper 9792/01
Part A Multiple Choice

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

General Comments

The paper proved to be appropriately set with a good number of easily accessible questions and a range of testing questions. Generally, candidates demonstrated a good understanding of **Section A** of the syllabus.

There was a good spread of marks with a mean 31 and a median of 33 marks. This year one candidate scored the maximum 40 marks available. All of the questions showed a positive discrimination, and the less able candidates were able to access the easier questions. The questions on this paper do require careful reading and candidates are advised to reflect carefully before recording their response. Generally, candidates appeared to have prepared well. Candidates should be encouraged to make use of the space provided for their working on the paper; this was particularly important for **Question 28** where candidates were required to work logically through refraction of light calculations as light travelled from one medium to another.

Several questions tested basic understanding of physics principles and it was pleasing to see that the vast majority of the candidates gained these marks. On the paper there are also a number of questions which required candidates to undertake a number of steps in order to gain an answer, for example, **Questions 31** and **40**. These were answered particularly well by the stronger candidates with weaker candidates answering these questions reasonably well, indicating that they were approaching the questions logically.

Candidates did find the questions that needed multi-step mathematical reasoning more difficult. One example was **Question 13** where candidates were required to determine the stress and extension in wire **Y** of the same material but twice the length and halve the diameter. In this case the common incorrect answer was **B** indicating that candidates had correctly determined the stress in the wire **Y** but had not allowed for this different stress in wire **Y**.

In **Question 25** some candidates found it difficult to combine the equations $R = \frac{\rho l}{A}$ and $P = \frac{V^2}{R}$.

Candidates also found **Question 39** difficult where it was necessary to apply the conservation of energy, realise that $E_k = \frac{1}{2}mv^2 = \frac{p^2}{2m}$ and then use the relationship $\lambda = \frac{h}{mv} = \frac{h}{p}$.
A common incorrect response resulted from candidates forgetting to calculate the square root in the final stage.

Candidates should be encouraged to work through their responses logically. The use of the space provided for working is essential for success in these types of questions.

Question 34 caused the greatest difficulty to candidates on the paper. This question required candidates to determine the type(s) of radiation emitted from a radioactive source. Almost all candidates correctly realised that alpha particles were not being emitted and that beta particles were emitted. The reasoning for this conclusion was that 1 mm of aluminium reduced the average number of decays detected in one minute, but 1 mm of aluminium would still allow some beta particles to pass. Hence, the lead reduces the beta particles further and the average number of decays detected in one minute decreases. Candidates needed to read the question carefully to realise that the background count rate was stated in Becquerel (Bq) and the count rate was given in the number of decays per minute.

Question 23 was answered well although a significant number of candidates gave **D** as their answer; possibly forgetting that current is inversely proportional to resistance for the same potential difference.

PHYSICS

Paper 9792/02
Part A Written

General comments

To score highly, candidates need to be very familiar with the topics included in the syllabus and demonstrate their understanding in a variety of ways. When answering the numerical questions, candidates need to be able to select or know the correct formula, and then use it accurately to produce the correct answer.

Candidates need to be meticulous and careful when using calculators, for example, adding instead of multiplying using the radian, rather than degree mode.

In other questions, the skill lies in describing what is needed in words, graphs or diagrams and here candidates also need to be familiar with the syllabus topics and the pre-released material and need to be able to demonstrate their understanding clearly. Whilst a slightly unusual or less logical order of presentation of ideas might well still obtain full credit, candidates should avoid contradicting in one sentence what has been stated in another.

It always helps when a candidate shows the logical progression which leads to a correct answer, even when a number of calculations have been carried out directly with a calculator. Candidates are advised to show the working out. An incorrect answer which appears without any previous working is unlikely to obtain any credit.

Occasionally, a sentence in a candidate's answer would make more sense and would be more consistent with the rest of the answer if certain key words had been included. Candidates should not write answers so speedily that important words are omitted or the sense becomes unclear.

Comments on specific questions

Section A

Question 1

(a) Candidates generally used the correct formula to obtain the distance 1.6 m and then the correct answer. Some candidates, who had not read the question as thoroughly as they might have done, gave 1.6 m as the final answer.

(b) The actual calculation here was relatively straightforward, but candidates needed to be clear as to which distance needed to be used in the formula. The diagram made this easier, but some candidates omitted to calculate the square root in their final answer.

(c) Where a candidate obtained the answer by using the difference between the initial and the final velocity and a value for *g*, the answer was usually correct and relatively easily obtained. Candidates who used more complicated calculations, with two or sometimes more stages, were less likely to arrive at the correct answer.

Question 2

(a) This question uses the command word *define*. This always means that the exact quantitative meaning of the term is needed rather than an explanation of what the term describes or suggests. Strictly speaking, the phrase "the force on a unit mass" is incorrect as it has the dimensions of force. The phrase "force per unit mass" is the correct way of stating what is being asked for here, and was included in the better definitions.

(b) Many candidates realised that the problem here depended on the fact that g is not a force and these candidates were given full credit. Other explanations suggested that the problem lay with the fact that g is a variable or suggested other difficulties.

(c) Although the mathematics here is straightforward, and the majority of candidates scored much of the available credit here, many candidates did not include the weight of the astronaut when calculating the pressure. The answer 37 600 Pa occurred very frequently.

Question 3

(a) (i) This was generally well answered with the large majority of candidates giving the correct numerical answer. A few candidates did not include the factor of one half in the calculation.

(ii) This part was well answered with almost all candidates carrying out the correct calculation by substituting the numbers correctly into the right formula.

(iii) There were many good answers here with many candidates showing that the energy transformation that they had suggested in part **(a)(ii)** also produced the correct value of elastic energy. Some candidates did not support the answer with a relevant calculation and consequently did not obtain full credit.

(b) It is interesting that when this climber falls, the maximum stress and the maximum strain in the rope is not affected by its length, provided that the climber does not hit the ground. Whilst some candidates suggested an explanation of this sort, only some candidates gave explanations in terms of the fundamental physics. Rather more candidates gave answers of a general nature.

Question 4

(a) Many candidates obtained full credit here by giving both a correct numerical answer and the correct unit on all four occasions. A few candidates were uncertain about the correct approach to **(a)(iv)** and did not obtain full credit here; others used the correct approach but suggested rather generous values for the time lag between the two waves. This led to a calculated phase difference that lay outside the allowed limits.

(b) Most candidates stated the correct answer. It is possible that those candidates who did not do so might well have believed that the graph in **Fig. 4.1**, already gave the wavelength of the wave and that some other information was required. There was little consistency amongst the incorrect answers.

(c) (i) Generally, candidates thought carefully about this question and drew a line which was accurate and clear. Some candidates drew the line extremely carefully for most of its length, but started the line at the position (0, 0) rather than at (0, –2). A few candidates drew the curve with an amplitude that was much too large or much too small and did not obtain full credit.

(ii) Although many candidates gave the correct answer, there were some candidates who simply doubled the amplitude of the original waves, or whose answer did not seem to be related to anything that had preceded this part. This was perhaps unexpected given that the curve in part **(b)** had been drawn correctly.

Question 5

(a) (i) Many candidates obtained full credit for correctly obtaining all five numerical answers. This was a question where an incorrect calculator setting caused some candidates to give very unexpected answers.

(ii) It was encouraging that a large majority of the candidates were able to describe the pattern that the answers given in **(a)(i)** suggested.

(b) When answering this part of the question, many candidates did not take into account the fact that the spacing for the double slit was identical to the line spacing of the diffraction grating in part **(a)**. The consequence of this was that the pattern of a double slit with a much wider separation was compared with the diffraction grating pattern. Few candidates obtained full credit here.

Question 6

(a) The majority of candidates gave the correct answer. Some candidates did not calculate a value for the power of the heater and simply used the number 230; a number of candidates used a temperature difference of 356. This error probably arose because the unit of the quantity specific heat capacity was expressed in kelvin.

(b) The correct answer was very commonly given here and many candidates obtained full credit.

(c) The majority of candidates obtained credit here for one correct reason although rather fewer candidates offered two distinct reasons for the time difference.

Question 7

(a) Many candidates gave the correct answer. Several candidates gave a value that was one quarter of the correct value as a consequence of using the diameter instead of the radius in the formula for area. Some candidates were uncertain of the formula that relates resistivity to resistance and obtained numerical answers that were extremely small.

(b) This question was almost always correctly answered.

(c) This calculation was generally carried out correctly and a very significant number of candidates obtained full credit for the correct final answer or for an answer where a previous error had been carried forward and used completely correctly.

(d) In this part, only a minority of candidates obtained full credit. Many candidates calculated the power wasted in the cables, but compared this answer with the answer obtained in **(c)** which is the power supplied not the power wasted. Similarly, those candidates who offered a more descriptive explanation here only occasionally gave an answer which was sufficiently detailed.

Question 8

(a) (i) Many answers here were correct, but there were candidates who gave an answer which attempted to explain what this term means in a more general sense, rather than giving the precise meaning that it has in radioactivity.

(ii) This was very commonly correctly answered although a few candidates used the term *random* in their explanations. If this was the only explanation offered, then it was impossible to obtain any credit.

(b) (i) It was very encouraging to notice that the overwhelming majority of candidates obtained full credit here for a completely correct equation.

(ii) Many candidates had a clear idea of the mechanism of what was happening, but only a minority of these stated that in a nuclear reactor the chain reaction is controlled and that, on average, only one of the emitted neutrons produces a subsequent reaction. Many of the chain reactions described, suggested an exponentially increasing rate of reaction.

(iii) Many candidates suggested the use of control rods, but only some of these answers explained that these rods need to be inserted further or partially removed in order to vary the rate of reaction and hence the power output. There was some uncertainty as to whether control rods or a graphite moderator should be used. Many candidates suggested that the moderator slowed down the neutrons and therefore made a reaction less likely.

Question 9

(a) These two numerical answers were very commonly correct and many candidates obtained full credit for part **(a)**. Some candidates were unfamiliar with the formula to be used and others found some difficulty when manipulating numbers where the exponent had a large negative index.

(b) (i)(ii) These numerical answers were also very commonly correctly answered. Full credit for these two parts was frequently obtained.

(iii) Many candidates had some idea of what was required here, but many of the answers given were not, in fact, explanations of what was happening.

(c) Many answers confused photons with electrons and sometimes candidates used the two terms almost interchangeably. These candidates rarely obtained any credit for their answers. Similarly, there were candidates who confused the wavelength of an electron (treating it as a wave) passing through the photomultiplier tube with the colour effect of the wavelength of the original incident light.

Question 10

(a) (i) Many candidates tried to obtain an answer by using the difference between the two wave speeds. This was not the best approach and few candidates who used this method obtained any credit.

(ii) By contrast, this question was very commonly correctly answered, either in absolute terms or as a result of a previous error being carried forward and processed correctly.

(b) (i) Although many candidates distinguished between a longitudinal and a transverse wave, more was required here and only a few candidates obtained full credit. Some answers suggested that in a transverse wave it is the wave itself that moves at right angles to the wave direction. The meaning of this is not clear and rarely was any credit obtained by answers that include such suggestions.

(ii) Many candidates obtained full credit though some did not restrict their answers to S-waves and made no reference to the liquid phase of the outer core.

(c) (i) Many candidates obtained full credit with carefully explained answers.

(ii) This was generally well answered with most candidates realising that more was required than simply stating that the path would be curved.

(d) (i)(ii) This was usually well answered although many candidates drew the ray in **(i)** at an angle that was far too large. Not all the answers in **(ii)** were based on the law of refraction (Snell's law) expressed in terms of the ratio of the velocities. Consequently, full credit was not always obtained.

(iii) This part was, in general, poorly answered and few candidates obtained full credit here. A common approach was to copy a detailed diagram from the pre-released material and to give a rather too vague explanation of what was happening to P-waves.

(e) The answers given here varied in detail, but many candidates made several pertinent observations which were well thought out and recorded clearly and accurately.

PHYSICS

Paper 9792/03
Part B Written

General comments

There was no evidence that candidates were unable to complete the paper in the time available. The paper was answered very well indeed by a large number of able candidates, many of whom were able to score over 120 out of the 140 marks available. Very few candidates answered all the mathematical questions or all the philosophical questions in ***Section B***.

Candidates would benefit from additional detail to support their answers to mathematical questions, where a little more explanation would be helpful, especially in questions involving the manipulation of algebraic expressions. Candidates should also be encouraged to give greater thought to the layout of their answers to questions involving algebra. Many candidates do not always state the meaning of the mathematical symbols they use and often it can be difficult to follow their route to the final answer.

Comments on specific questions

Section A

Question 1

Most candidates answered this question well. Part **(a)** was usually all correct, although a considerable number of candidates in part **(a)(iv)** found the rotational speed, which is positive, rather than the rotational acceleration, which is zero. A good proportion of candidates demonstrated a good understanding of Newton's third law of motion, but a significant number did not. These candidates usually gave the 'equal and opposite forces' as different types of force. Most candidates answered part **(c)(ii)** correctly. It was pleasing to see that many candidates understand that the centripetal force is a resultant of all the forces acting on the passenger.

Question 2

This question was answered well. Candidates lost a mark in part**(a)** if they did not state that, in their final expression, the terms $4\pi^2/gM$ are all constant. Parts **(b)** and **(c)** were answered well, although some candidates thought that in **(c)** all that was necessary was to reverse the argument and treat the Sun as rotating around the Earth. Most candidates could think of some non-Solar System where the laws of physics apply, but answers in terms of the Doppler effect were not sufficient.

Question 3

Candidates found some parts of this question challenging. In part **(a)** many candidates did not mention the need for the charge to be positive. Part **(b)** was done well, but some candidates found adding arrows to the diagram in part **(c)**problematic. Often, the candidates did not make the forces on the central ion clear, with many drawing arrows on the surrounding ions. Candidates were expected to consider the relative magnitude of the forces on the central ion. Part **(c)(iv)** was not answered well. The question required candidates to appreciate that an equilibrium position is required and that the position is determined by the whole network having minimum (electrical) potential energy.

Question 4

This question was answered well with many candidates gaining the maximum 15 marks. Candidates lost a mark if their answer to part**(d)** was obtained from too small a time interval on the graph. This resulted in a wide range of acceptable answers for part**(e)**since the answer to **(d)** becomes the power to which the 'half-life' has to be raised. Many candidates did not find the charge, stopping after having found the voltage.

Question 5

This question was generally answered well. Some candidates gave the mean square speed and not the root mean squared in part **(b)** and a few candidates squared the mean square speed. To gain 2 marks in part **(d)** candidates needed to show a higher speed for the maximum and the area beneath both graphs approximately equal.

Question 6

Part **(a)** was answered well by most candidates, but some candidates did not show a complete understanding of the standard model for classifying matter in part **(b)**.

Question 7

This question was answered correctly by a very large percentage of candidates.

Section B

Question 8

This question was answered by almost all candidates. Few had any difficulties with parts **(a)** and **(b)**, but some candidates failed to appreciate the length of the half-life of the rubidium-87 isotope in comparison with the age of the Moon rocks in part **(c)**. The required graph needed to start with a positive value and show a small, constant, positive gradient for most of its length and a slight upward curve towards its end.

Answers to part **(c)(iii)** often implied that the value of the ratio was actually measured some 4 x 10^9 years ago. Another frequent suggestion was to measure how much the ratio changed over a few years. In fact, the ratio could be found from samples on the Earth, but candidates were not expected to go into too much detail here. Instead, candidates simply needed to state that the initial ratio would be required.

The main reason for inaccuracy in part **(c)(iv)** is extremely long half-life, but other reasons, such as contamination, being hit by meteorites, etc. were accepted. Part **(d)** was answered well, but not many candidates saw the ratio method of 0.680 × (87/86) = 0.688, to give $\Delta E = 7.9 \times 10^{-7}$.

Question 9

Many answers to part **(b)** did not start with anything about flux linkage or back electromotive force, but stated simply that an induced current opposes the motion. In part **(c)** it was perhaps surprising that many candidates who correctly explained the difference in the electromotive force, made no comment about it changing from a positive to a negative value. Part **(d)** was generally well answered, although some candidates forgot one term in answering part **(iii)**. In part **(v)** candidates found it difficult to express correctly, all the relevant points concerning flux cutting and the electromotive force generated when the coil is in the two positions.

Question 10

In contrast to **Question 9**, this question was very popular, but many candidates found part **(a)** challenging. Candidates were expected to use of $\delta\theta = v\delta t/r$ from Fig.10.1 and $\delta\theta = \delta v/v$ from Fig 10.2. Many candidates did not use Fig.10.1, but tried to recall a proof of the relationship, including mass. This was rarely supported with additional words and often resulted in the required relationship being stated without any explanation.
Candidates should be encouraged to support the manipulation of algebraic expressions with some words of explanation. Part **(b)** was done well by the majority of candidates.

Question 11

This was the least popular of all the ***Section B*** questions. Those who did answer the question coped well with part **(a)**, but less well with part **(b)**. Many candidates used the space provided to draw the familiar energy level diagram when a diagram of standing wave patterns was expected. Most candidates coped well with parts **(c)** and **(d)** except parts **(c)(iv)** and **(c)(v)**. Few candidates demonstrated an understanding of the effect of the uncertainty in the momentum of the electron on the uncertainty in the kinetic energy and hence the resulting instability of the atom.

Question 12

Few candidates realised that a freely falling pendulum is ‘apparently’ weightless and so will not oscillate. Parts **(b)** and **(c)** were answered well as was part **(d)**. Many candidates realised that they were required to give their answers in terms of entropy for part **(d)(ii)**. Part **(e)** generated a range of answers, where almost all candidates correctly described the outcomes, but many did not mention wavefunctionsor wavefunction collapse.

Question 13

This was the most popular of the non-mathematical questions and was done well by many candidates. Entropy as ‘disorder’ was allowed one mark, but ‘number of ways of distributing energy among available states’ was required for the second mark. This needed to be included in an answer to part**(a)(iii)** for the second mark. A quantitative answer in terms of *Q/T* was not credited. Part **(b)** was answered well by most candidates. Part **(c)** was less well answered. Many answers to part**(c)(i)**did not mention entropy and in part **(c)(ii)** the importance of the environment was rarely included, leaving a situation where the entropy (of the universe) decreases.

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. It is clear that the candidates gain greatly from undertaking their personal investigations. 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 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.

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 checklists. 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.

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

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 are used to 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 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 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 must be clearly explained. In general candidates should be encouraged to explain how they are determining an uncertainty.

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.