PHYSICS

Paper 9792/01
Multiple Choice

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

General comments

This was the second paper that tested both ***Section A*** and ***Section B*** of the syllabus. The paper proved to be appropriately set and all the candidates appeared to answer the paper in the time available. Candidates appeared to have been prepared well and have a good understanding of all parts of the syllabus. Candidates appeared to find a similar number of questions difficult on both part A of the syllabus and part B of the syllabus.

There were a number of straightforward questions on both ***Part A*** and ***Part B*** of the syllabus.

On ***Part A*** of the syllabus, **Questions 1**, **4**, **5**, **6**, **13**, **14** and **19** appeared to be straightforward. These questions either tested simple recall or the application of physics concepts.
Questions 2, **11**, **12** and **16**, were found to be the most challenging.

On ***Part B*** of the syllabus, **Questions 21** and **25** were particularly well answered; both questions required candidates to manipulate data.
On ***Part B*** of the syllabus **Questions 22**, **32**, **34**, **35** and **37**, were found to be the most challenging:

Comments on specific questions

Question 2

This question required candidates to determine the perpendicular distance from the step to the forces; weaker candidates found this difficult with many opting for distractor **D**.

Question 11

Distractors **A**, **B** and **C** were all selected – candidates did not appear to understand that the change in resistance depends on length for a constant cross-sectional area of the wire.

Question 12

Most candidates realised that the current through the 20 Ω resistor was equal to 0.20 A (answer **C**). A significant number of candidates did not realise that the battery of emf 6 V had a current of 0.05 A so that the current in the battery of emf 4 V was 0.15 A.

Question 16

This appeared to be the most difficult question on the paper. Surprisingly the common error was to assume that total internal reflection could occur as light passed from air into glass. Good candidates realised that the light would follow the same path in both directions.

Question 22

Most candidates determined the weight correctly (answer **C**) but many did not allow for the centripetal force.

Question 32

In **Question 32**, many candidates chose option D ($\Delta U = W$). Candidates need to understand the meaning of the terms ΔQ and ΔU.

Question 34

Candidates knew how to determine the kinetic energy for one molecule but did not determine the total kinetic energy for 0.800 moles of the gas.

Question 35

This question was found more difficult by weaker candidates. Surprisingly some candidates thought that the density of the air would increase. Other candidates did not convert Celsius to Kelvin for the unit of temperature.

Question 37

This question tested the use of the absorption equation. The common error was to use 0.75 as opposed to 0.25 for the ratio.

PHYSICS

Paper 9792/02
Paper 2 Written Paper

Key messages

Section 1 of this paper examines part A of the syllabus, although Section 2 can range more widely. The questions are very likely to deal with many different topics and candidates need to be familiar with the all of the topics in part A. When answering the question in Section 2, the candidates also need to have studied and thought about the subject matter in the Insert which will have been received in advance of the examination.

Candidates should bear in mind that the expected answers should relate to conventional Physics and use precise terminology in an accurate manner. Vague explanations and descriptions that use a more informal and casual approach are unlikely to be awarded full credit. Diagrams and sketch graphs do not need to be drawn with an enormous accuracy and should not take an excessive amount of time, but they must be clear and must indicate precisely what is asked for. When numerical values are obtained using a calculator, it is terribly easy to press the wrong key and to end up with an answer that, in terms of the question, is very unlikely to be correct. When time allows, answers should be checked or at the very least looked at to see if the value is sensible.

The single most important points to be considered when writing an answer is to check that the question asked is the one that is being answered and that the answer is dealing with the Physics of the situation.

General comments

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In the more descriptive parts of the paper, there is no need to write elegant and grammatically unassailable sentences and short brief points expressed in bullet-point form can sometimes be clearer and better. Candidates need to be sure that the answer is unambiguous and correct.

Issues that very commonly lead to lost credit are many and various but include hastily drawn diagrams, carelessly performed calculations, poorly rearranged equations and written answers that do little more that re-state the question.

Comments on specific questions

Question 1

(a) Most candidates were credited for giving an appropriate definition here. The standard definition is the ratio of two quantities and so an expression such as *the gravitational force on unit mass* was not accepted.

(b) (i) This was generally well answered with the overwhelming majority of candidates drawing five vertical arrows that pointed downwards. An occasional candidate did not receive full credit because the arrows were positioned very unevenly.

(b) (ii) This was almost always correct.

(c) (i) Most candidates found this calculation to be fairly straightforward and the correct answer was supplied extremely commonly. Very occasionally, an error in the calculation led to an answer that was incorrect.

(c) (ii) This calculation caused a few more problems, with some candidates omitting the factor of two and some others omitting the final stage of taking the square root.

Question 2

(a) (i) Most candidates gave answers that revealed that an elastic deformation is not permanent but there were some who did not indicate that it was when the deforming force is removed that the deformation disappears. A reference to this was needed for credit to be gained.

(a) (ii) Most answers gave two or three appropriate materials although fewer candidates gained credit in **(a)(ii)(3)** than in the other parts. The question asked for the name of three materials and adjectives such as *brittle*, *tough* and *ductile* did not answer the question.

(b) (i) This calculation was usually carried out correctly but errors were made because the cross-sectional area of the wire was given in cm^2. This led to answers that were incorrect by either a factor or 10^2 or a factor of 10^4. There were some candidates who although they had written down an equation such as $\frac{F}{A} = \frac{Ex}{l}$ rearranged it incorrectly when attempting to make x the subject.

(b) (ii) Many candidates obtained the correct answer and were awarded full credit. Occasionally, the factor of $\frac{1}{2}$ was omitted or an erroneous expression such a $\frac{1}{2}Fx^2$ was used.

Question 3

(a) (i) A correct definition was very commonly supplied either in words or by using symbols whose meaning was then indicated.

(a) (ii) This was quite often correct but the error which occurred most frequently was to state that impulse is *the rate of change of momentum*.

(b) (i) Many candidates stated two appropriate reasons for the acceleration not being constant and were awarded full credit. A few candidates misinterpreted the emphasis of the question and supplied answers such as *for the comfort of the passengers*.

(b) (ii) It was commonly realised that the momentum of the aeroplane corresponded to the area under the graph. Whilst many candidates then went on to determine the correct answer, some candidates did not do so. A common reason was a simple error in calculation but there were also candidates who made unsuitable approximations; a common approximation was $0.97 \times 10^5 \times 55$.

(b) (iii) This part was almost always awarded the credit. Most answers were correct in absolute terms whilst others were credited through the error carried forward procedure.

(b) (iv) Many decent attempts were made here and some very reasonable graphs sketched. There were those who misinterpreted what was required and who supplied either a graph identical to **Fig. 3.1** in shape or a graph where the decreasing force between 25.0 s and 55.0 s produced a deceleration. Occasionally, the candidate's line was so thick or so carelessly sketched that the intention of the candidate was far from clear.

(b) (v) There were many sensible estimates here.

Question 4

(a) (i) This was very commonly correct. At this level, an answer such as *current in* = *current out* is too vague to be credited. Even for a statement such as this, it is not always necessary to write perfectly grammatical sentences, or even to use the conventional terminology, but the meaning must be clear, unambiguous and relevant.

(a) (ii) The overwhelming majority of answers were correct.

(b) (i) There were many correct statements given here but answers that were expressed entirely in terms of potential difference or electromotive force were not accepted. Similarly, answers that clearly only applied to simple series circuits were not sufficiently general to be credited.

(b) (ii) These calculations were quite often correct but not invariably so. Various combinations of the values from the question were also seen from time to time.

(b) (iii) The wrong direction (A to B) was given more commonly that the correct direction. In a paper such as this, conversational explanations such as *the current take the path of least resistance* or *the current takes the shortest route home* are unlikely to be awarded credit.

(c) Candidates who knew the conservation laws that were asked for here, were simply able to write down the correct answers. Those who did not know suggested a large variety of differing quantities. Answers such as *current* and *voltage* occurred quite commonly.

Question 5

(a) This part was often correct although candidates who rounded off numerical values at different stages in the calculation produced slightly different final answers. An appropriate diagram was not always used and those answers which did not reach as far as the correct final answer were credited according to how much progress had been made.

(b) Many answers were awarded full credit. The only real error was to show a ray with a larger angle of refraction. Some of the emergent rays, were drawn rather carelessly and it was not then possible to deduce whether the new emergent ray was intended to be parallel to the one already shown or not.

Question 6

(a) This was very commonly awarded full credit. The most complete answers included two sinusoidal waves in antiphase and several intermediate positions.

(b) This was generally well answered with just a few candidates drawing a second wave that was $\frac{\pi}{4}$ radians out of phase with the wave shown.

(c) Only occasionally was full credit obtained in this part. Although the gap in the barrier was smaller than the wavelength, the diffracted waves drawn quite infrequently showed diffraction to sufficiently large angles. There were also candidates who did not draw a wave with a consistent wavelength that was smaller than the gap. Many candidates should consider spending just a few more seconds on this sort of question in order to produce diagrams that more clearly illustrate what has been asked for.

Question 7

(a) The correct equation was very commonly supplied and full credit obtained by many candidates. Occasionally, the incident neutron was omitted from the equation and only two neutrons were included on the right-hand side. A significant number of candidates balanced the otherwise correct equation using the symbol ${}^{3}_{0}\text{n}$ rather than by using $3\,{}^{1}_{0}\text{n}$.

(b) (i) Most candidates stated that nuclear fission reactions produce more than one neutron and that these could lead to further fission reactions being initiated. Many candidates suggested that all fission reactions produce exactly three neutrons or even that subsequent fission reactions would be identical to the reaction in **(a)**.

(b) (ii) A rather large number of candidates did little more here than restate the question by suggesting that a control mechanism is needed to control the reaction. Answers such as this gained no credit.

(c) Many candidates were able to supply the correct numerical answer to this calculation and a significant number of those who did not do so, the only error was to ignore the factor of 10^6 represented by the M in MeV. A small number of candidates either ignored the factor of 1.6×10^{-19} that is used when converting electron volts to joules or used it incorrectly.

(d) This was commonly answered correctly even by candidates who chose to express time in seconds. Perhaps such candidates were unsure whether the equations would still produce the correct answer when non SI units were used.

Question 8

(a) (i) In this part there was a considerable scope for uncertainty as to what was expected. Some candidates simply described how the quantum theory explains photoelectric emission rather than describing observed features of the effect. An observation that was commonly quoted was the fact that the rate at which electrons are emitted depends on the intensity of the incident radiation; this can, of course be explained in terms of the classical wave theory.

(a) (ii) In this part, many answers simply stated learned feature of quantum theory which did not always explain the corresponding observed feature. Similarly, the fact that the maximum kinetic energy of the photoelectrons does not depend on the intensity of the incident radiation, is not explained by stating that it does depend on the frequency. This was a part where many candidates did not give an answer to the question asked.

(b) (i) Only a minority of candidates recognised that the variable resistor was acting as a potential divider and a significant number of candidates did not explain how the apparatus shown was used. Many answers were too general and did not get as far as explaining how the stopping voltage was determined.

(b) (ii) Some candidates recognised how to conduct the experiment and explained how to obtain a value for the Planck constant. If a graph of V_s against f is plotted then the gradient is related to the value of $\frac{h}{e}$; many candidates, however, omitted the *e*. There were many candidates, who tried to obtain a value for the Planck constant from a single stopping voltage. These answers were rarely awarded any credit.

Question 9

(a) This part was almost invariably correct.

(b) (i) The candidates who referred to Extract 3 and who described the voltage characteristic, very commonly did so accurately. There were many answers, however, that made no reference to *voltage* at all; most of these discussed the efficiency of the charging process.

(b) (ii) This part was often well answered and full credit was frequently obtained.

(c) (i) Although many candidates determined the correct value of the current in the circuit, there was some uncertainty concerning the magnitude of electromotive force to be used in the equation. Most candidates used a multiple of 1.24 V but all of 1.24 V, 3.72 V, 4.96 V and 6.20 V occurred quite commonly. The resistance of the buzzer was ignored by many candidates.

(c) (ii) Many candidates drew an arrow that indicated the correct direction but some did not. There were some candidates who drew several arrows which were not always consistent with each other.

(c) (iii) Many candidates struggled here and few candidates were awarded full credit. As in part **(c)(i)**, several different values were chosen for the forward electromotive force and several different resistance values were used when calculating the potential difference that was established with the battery.

(d) (i) There were many carefully explained answers here which obtained full credit and most answers revealed some understanding of what was happening. Most of the answers that were not awarded full credit were too general or not applied to the arrangement of diodes in **Fig. 9.3**. This is illustrated by answers such as *Diodes only conduct current in one direction and so the current in the cell is always in the same direction*.

(d) (ii)(1) This was rarely well answered and very few candidates made reference to the electromotive force of the cell opposing the electromotive force of the supply. Slightly more often, candidates wrote about the diodes. A common suggestion was that there was no electromotive force from the supply as it was reversing direction. This is a situation excluded by the way in which the question is worded.

(d) (ii)(2) Although many candidates attempted to obtain a value from the area under the graph, the values obtained varied widely and only occasionally were they within an acceptable range of values.

(d) (iii) Many candidates supplied either the correct answer or more commonly, an answer that used a previous inaccurate answer correctly.

(e) (i) Only rarely was this part answered in a way that related in a quantitative way to the voltages in the circuit and the way they affected the current. Answers in terms of the charge on one plate repelling the further addition of charge of the same sign, were sometimes sufficiently well worded to be given some credit but more commonly, the question was answered in a rather conversational manner with little regard to more conventional Physics. Phrases such as '*The change on the negative plate cancels out the force on the electrons*' is not one that is acceptable at this level. Some candidates gave answers in terms of the current caused by the cell cancelling the current caused by the charged capacitor. Such answers tended to be difficult to interpret.

(e) (ii) In this part, the answers tended to be rather poorly set out with different calculations leading to numbers whose significance was unexplained and unclear.

PHYSICS

Paper 9792/03
Paper 3 Written Paper

General comments

Some candidates answered all of the mathematical questions but very few answered all of the philosophical questions.

There was an improvement this year in the legibility of the candidates' writing.

Comments on specific questions

Section A

Question 1

Most candidates answered this question well, but candidates often read the distances from the graph inaccurately. The estimate of the gravitational potential difference in part **(c)** was often calculated and sometimes deduced from the shape of the curve.

Question 2

This question was answered well by most candidates. Some candidates used incorrect signs in the first law of thermodynamics.

Question 3

Some candidates were unable to draw an accurate diagram of the electric field in part **(b)**. Some candidates did not mark the neutral point and others drew field lines that crossed one another.

Question 4

Part **(a)** of this question was usually answered well, but many candidates found part **(b)** challenging.

Question 5

This question was answered well, though the weaker candidates struggled with the mathematics required for part **(b)(iv)**.

Question 6

Part **(b)** of this question was answered well by the most able candidates.

Question 7

Many candidates found this question challenging.

Section B

Question 8

This was the most popular question of the optional questions and it was usually answered well, with many of the able candidates being able to score full marks.

Question 9

This was a popular question and many candidates scored well. Parts **(a)** and **(b)** were answered well but a fairly high percentage of candidates had difficulty with part **(c)(iii)**.

Question 10

Many candidates found part **(d)(iii)** very challenging.

Question 11

This question was answered well by most candidates who attempted it.

Question 12

Candidates who attempted this question generally scored well.

Question 13

This question was the least popular question in this section and candidates found it challenging.

PHYSICS

Paper 9792/04
Personal Investigation

General comments

Again there was a good range of interesting topics. Good candidates clearly enjoy the experience and benefit greatly from the Personal Investigation. Candidates appear to have been suitably prepared. The majority of Centres take a large amount of care with regard to the marking, checking the marking and internally moderating the marking. This is very helpful to the moderation process.

Centres also take great care in the administration of the moderation process. For the future, when submitting the sample, Centres are asked to ensure that the candidate's number is also included on each investigation.

Centres are reminded that 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(s) should be highlighted so that the moderator is aware that the Centre has allowed for the errors in the marking.

When moderating the samples of work, 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 the highest 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 several Centres produced a rationale for the awarding of the marks. These processes very much assist 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 out an appropriate 'internal standardisation' process.

This year fewer candidates included photographs of their investigation. Candidates should also not be concerned about producing computer generated diagrams – labelled hand-drawn diagrams are acceptable and often give better detail. Candidates should also avoid just producing excel graphs without thought to the scales and axes; some of the graphs produced using 'Excel' were very difficult to interpret and often lacked explanation from the candidate. Where large quantities of data are collected, good candidates record the data in clearly labelled appendixes.

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

As has already been mentioned, Centres still tend to be too generous in the award of marks for the quality of Physics. 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 – it should not be copied sections of reference material or text book. In some cases there were investigations which were quite straightforward but were generously awarded high marks for this criterion. For the award of four marks, principles of physics should be used to interpret results.

Where a Centre find errors in the Physics, it is helpful for the Centre to highlight this so that the moderator is aware that the error has been allowed for in the marking. Large quantities of copied Physics from a text book cannot score the top marks unless there is a clear explanation of how the Physics is used in the investigation There should also be evidence of how Physics principles are used to explain a candidate's results, again using the candidates own words.

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 still generously awarded. 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 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.

These higher level marks must be rigorously applied.

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. For the highest marks, the report should clearly show development and feedback between experiment and analysis. References used should enhance the report. It should be noted that for the award of four marks, sources identified should include page numbers. References should clearly indicate how the material has been used to enhance the investigation.

Finally

Centres have approached the Personal Investigations professionally and as a consequence the overall quality of the investigations has been very good. The success of the Personal Investigation is also due to the care and attention to detail of Centres both supervising the investigation and assessing the candidates' work.