PHYSICS

Paper 9792/01
Part A Multiple Choice

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

All of the questions showed a positive discrimination, and the less able candidates could access the easier questions. 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.

Questions 2, 12, 13, 14, 15, 20 and **35** proved particularly straightforward, allowing the great majority of candidates to demonstrate their knowledge and understanding. Many of these questions involved one stage substitution of numbers into formulae. **Question 35** tested knowledge of the Rutherford alpha particle scattering experiment; this was answered well.

At the other end of the scale, **Questions 7, 18, 19, 26, 28** and **32** were found more challenging.

Question 7 was concerned with the force exerted on a wall being related to the rate of change of momentum. Weaker candidates often chose **A** omitting to square the velocity.

In **Question 18** many candidates determined the change in gravitational potential energy rather than gravitational potential.

Question 19 was found to have the lowest facility on the paper. The question required candidates to determine the increase in temperature of water in a tank when water at the top of the tank changes state. Weaker candidates tended to select each of the four responses, while a large number of the stronger candidates omitted to take into account that *half* of the latent heat given out by the ice goes to heating the water.

In **Question 26** candidates who correctly selected **D** realised that charge is conserved. The common distractor was **B**.

Question 28 required candidates to determine the ratio of power from a cell with resistors connected in parallel to the power from a cell with resistors connected in series. A large number of candidates determined the reciprocal ratio. A significant number of weaker candidates chose **A** or **C**.

In **Question 32** candidates had to do a multiple step calculation. It required candidates to think carefully about determining refractive indices as the speed of light decreased when travelling from water into glass before the speed of light increased when travelling from glass into air. The common distractor was **D**.

Weaker candidates often did not score well on **Questions 3, 11, 17** and **25**.

In **Question 3**, answer **A** was the common distractor; this was probably due to the use of inconsistent units in the calculation. **Questions 11, 17** and **25** required either a multiple stage calculation or ratio determination.

PHYSICS

Paper 9792/02

Part A Written

Key messages

When writing definitions, candidates are advised that if they choose to use an equation they need also to state the meaning of each of the individual terms in the equation.

In **Section B**, the best answers were given by candidates who used the question headings to structure their answer, and who made a number of different points rather than developing a single point in detail.

General comments

The standard of the candidates' work was very broadly in line with that of last year's examination; very many candidates scored extremely highly indeed and all candidates had at least some idea of what was expected and some understanding of the subject at this level. The highest scoring candidates ensured that every question was answered in the manner suggested by the wording and were frequently able to give answers of sufficient detail which adequately reflected the mark allocations. For example, such candidates gave exact definitions of the quantities requested where the question asked for a definition and ensured that a diagram was included in answers where one was demanded. Other candidates were less meticulous about such matters although there seemed to be very slightly fewer such candidates this year.

Comments on specific questions

Section A

Question 1

(a) The more able candidates wrote the correct definition either as a sentence or a phrase or as the standard equation with the symbols defined. On its own, $p = mv$ cannot be awarded credit.

(b) Many candidates were able to state Newton's second law and many chose to state it in equation form. Candidates who state the law in sentence form should be aware of the need to include the effect of the mass on the acceleration as well as the effect of the force.

Many candidates were able to deduce the proportionality required here and received credit for this. Some candidates expressed answers in terms of *Fdt* without making any reference to the relationship between this term and impulse.

(c)

(i) This question was best answered by candidates who realised that the change in velocity is the quantity that is added to the original velocity to obtain the final velocity. Other candidates tended to draw the 12 m s^{-1} vector on the right-hand side of the diagram and draw in the other diagonal of the rectangle; this leads to the sum of the original and final velocities, rather than the change in velocity.

(ii) The magnitude of the velocity was most commonly correct. Many candidates gained credit for the direction; others were not sufficiently clear about where the angle that they had calculated was being measured from.

(iii) The calculation was very frequently correct and the unit almost universally so.

Question 2

(a) All three parts of **(a)** were nearly always answered correctly; only occasionally was the graph misinterpreted.

(b) This answer was very widely known and frequently correct.

(c) This answer was very widely known and frequently correct.

(d) Many candidates drew a straight line parallel to the line from the origin to **A**. In some cases, the line was straight but clearly not parallel to the original line. When a candidate drew the line without the use of a ruler, it was not always possible to award credit.

(e) The overwhelming majority of candidates realised what was expected here and were able to access at least partial credit. The candidates whose answers were sufficiently close to the expected value used the origin and the co-ordinates of a point on the proportional section of the line that was close to **A**. This ensured that the sides of their triangle were large and could be determined precisely.

Question 3

(a) Many candidates gave the definition clearly here. Other candidates need to be aware that an answer such as *the ability of a conductor to impede the flow of current* is not a definition of resistance. Likewise, $V = IR$ will only gain credit when the three terms themselves are defined.

(b) This calculation was most commonly performed correctly.

(c)

(i) Many candidates gave the correct value, 2.0 V; other candidates gave answers such as 12.0 V or 14.0 V.

(ii) The correct answer was commonly – though not always – given here, even by some of those candidates whose answer to **(c)(i)** was not correct.

(iii) Many candidates realised that this answer could easily be obtained from **(b)** and **(c)(ii)**.

(d)

(i) This part of the question proved very challenging for many candidates and some omitted it altogether. Many realised that 12/1.25 gave 9.6 (Ω) but rather fewer explained why this is important and relevant in this context.

(ii) Many candidates stated that the direction of current flow would be reversed but most of these did not then say that this would lead to the battery being recharged; some, in fact, stated that it would stop the battery being charged.

Question 4

(a) Many candidates gained full credit here. Many of the candidates who did not might well have benefited from including a diagram showing reflection rather than refraction, or should have made it clear which of the media in the diagram was the more dense.

(b) This deduction was very commonly performed correctly and many candidates received full credit. Others should have made it clear that at the critical angle, the angle in the rarer medium can be considered to be 90°.

(c)

(i) Most candidates gained credit here by making a relevant point; just occasionally a candidate referred to diffraction rather than refraction or simply referred to dispersion without any subsequent explanation.

(ii) The answer in the first part of this section was very frequently correctly calculated but occasionally it was only quoted to 2 sig. figs. In this question, at least 3 sig. figs. were required. Similarly, the second part was usually well answered. Candidates who calculated the critical angle using the speed of light in a vacuum did not obtain the correct value for the angle.

(iii) This answer was very commonly correct and even candidates who had not obtained the correct angle in **(ii)** might well have received full credit here by using their value correctly. An occasional cause of inaccuracy was to omit the final subtraction of 4.00 km (4000 m).

Question 5

(a)

(i) The formula $v = f\lambda$ was widely known, frequently quoted and accurately used; the question was almost invariably answered correctly. A very few candidates misinterpreted the prefix in the unit *nm* and obtained an answer which was too large or too small by various factors of 10.

(ii) The answers given here were very often within the correct range, with nearly all candidates obtaining their answer from the periodic time of the wave. A small number of candidates either gave this time as the final answer or took it as the time taken for one of the wave trains illustrated to pass and hence obtained an answer that was several times too small.

(iii) A number of candidates were able to correctly state that there is not a constant phase difference between light that is not coherent. Other candidates wrongly suggested that incoherent light is light that is simply not in phase.

(iv) Few candidates gained full credit here. Only very rarely indeed was it suggested that any interference pattern would be produced at all. Similarly few candidates explained that such a pattern would only last for an extremely brief period of time and that, as a result, it would not be visible. Rather more candidates stated incorrectly that, because the waves were always out of phase, there would be destructive interference everywhere at all times.

(b) Most candidates knew what was being asked for here and were awarded full credit.

Question 6

(a) Many candidates performed really well here; this experiment was widely known and its implications were well understood. A few other candidates were less familiar with the details but had a general idea of the experimental procedure involved. The candidates who did not gain full credit here would nearly always have accessed further credit by stating that the experiment was conducted in a vacuum. This experimental detail was very rarely mentioned.

(b) The meaning of the term *spontaneous* was less well known than that of *random*. The meaning of the former was commonly stated to be *immediate* or *without any delay*. Some candidates were tempted to use the word *randomly*, *randomness* or even *random* in the explanation of the word itself; more than this is expected.

(c) Most candidates had some idea of what was required here but rather fewer achieved full credit. Some candidates tended not to give much explanation in words of what was happening, and those who answered in purely mathematical terms rarely related the decay constant λ to the constant decay probability referred to in the question.

(d)

(i) This part of the question was very frequently answered correctly by all candidates including those who struggled with the remainder of the paper. Despite this, a few candidates tried to calculate the answer using the half-life of the source and ln 2. This was both cumbersome and unnecessary.

(ii) This part was very well answered indeed and there were very few candidates who received less than full credit here.

Question 7

(a) This result was very widely known and its implications were generally well explained. A few candidates incorrectly suggested that the particle model of the nature of light superseded the wave model.

(b) This part of the question was very well answered by all, and most candidates were awarded full credit.

Section B

Question 8

(a)

(i) Although part **1.** was almost invariably correct, a significant number of candidates gave *350 V* rather than *350 000 V* as the answer to part **2.**

(ii) The two subsections in this part of the question were marked together and most candidates obtained the correct answers by the correct method. It was noticeable and surprising that almost all the candidates who had given *350 V* as the answer in **(i)2.** used the value *350 000 (V)* here, but without going back to correct the previous value.

(iii) Many candidates gained full credit in this part but some candidates sketched a sin graph rather than the correct $\sin^2$ graph and a few others sketched graphs with double the periodic time.

(iv) This line was almost invariably correct.

(v) Some candidates produced good answers here, but a significant minority, despite the question, made no reference in the explanation to the graph drawn.

(b)

(i) Almost all candidates obtained the correct answer here but a few used *50* in the calculation and not $\sqrt{50}$. An answer given to 2 sig. figs. was considered acceptable but it must be correctly rounded: 0.011 (m). Neither 0.010 (m) nor 0.01 (m) were allowed.

(ii) The calculation in this part of the question required the use of an extremely familiar formula in slightly unusual circumstances. Only a minority of candidates ultimately obtained the correct answer. Some of the other candidates ought to have calculated the radius rather than just using the diameter given in the question. Others should have subtracted the full skin depth value from the radius rather than half of it. A third source of inaccuracy was the use of $\pi(r_1 - r_2)^2$ rather than $\pi(r_1^2 - r_2^2)$.

(iii) The appropriate formula was very commonly quoted here and many candidates were awarded full credit when it was applied correctly. A few candidates used an area here other than the one obtained in **(ii)**.

(iv) The correct formula was correctly used by many candidates who obtained full credit here. A few candidates did not take into account the word *maximum* in the question and used $P = ½ I^2R$ to obtain their value.

(c) This part of the paper gives the candidate a very obvious and direct opportunity to show that the pre-release material has been read and understood. The mark scheme lists many of the very large number of different ways of accessing the credit available. The majority of candidates used the information from the material wisely and made many valid suggestions in their answers.

The candidates who produced the highest scoring answers used information from several of the sources and used the headings in the question as a guide and a framework for their own answers. Such answers were characterised by the inclusion of a wide variety of different suggestions from the material which were both carefully explained and well described and which only infrequently wandered from the main point being addressed in the question. Suggestions that were not based on the pre-release material were rare but were usually relevant and valid.

Candidates who made less thorough use of the pre-release material or whose answers tended to concentrate on just a few points, tended not to score as highly. Sometimes such answers were either rather brief or repetitive or on occasion gave extravagantly detailed explanations of what amounted to just one suggestion.

A very few candidates produced answers which made little use at all of the pre-release material and made suggestions that were only very occasionally relevant to the point being addressed or valid. These answers tended to obtain little credit and such candidates would have been disadvantaged by this approach.

Whilst the number of printed lines on the question paper ought to allow enough room for many candidates to answer the question in appropriate detail, it is inevitable that some candidates will write in complete sentences whilst other use bullet points and phrases. Likewise, the size of handwriting varies. Candidates should not feel obliged to fill every line just for its own sake as this may well lead candidates to contradict a valid point already made. Similarly, answers that continue beyond the allocated space will be looked at and marked. Candidates who answer on the blank pages at the end of the question paper should be advised to make a simple reference to this in the original answer space. A simple *P.T.O.* would suffice in **8(c)**.

PHYSICS

Paper 9792/03
Part B Written

Key messages

Most candidates attempting this paper showed excellent mathematical skills. The same degree of rigour needs to be demonstrated when giving descriptive answers, where candidates occasionally display poor use of logic or make statements that are contradictory or do not address the question. A series of short statements is sometimes clearer than using unnecessarily long sentences.

General comments

This paper was found to be accessible to the full range of candidates. It is intended to be a challenging paper and the vast majority of candidates adjusted well to the demands of the paper and utilised their time well. Only the very weakest of candidates failed to answer all of the questions required and these candidates appeared to leave blank spaces because of deficiencies in their knowledge rather than lack of time. The overall standard achieved by the candidates was remarkable with a good number of candidates scoring over 120 out of 140. The top mark was an incredible 137/140.

From ***Section B*** of the paper, **Questions 9, 10** and **12** were the most popular choice and **Question 14** was selected by the smallest number of candidates. Very few candidates answered all of the mathematical questions or all of the philosophical questions.

Comments on specific questions

Section A

Question 1

Whilst the calculation part of the question was usually answered correctly, and candidates were clearly familiar with the relevant mathematical formulae for circular motion, the other parts of the question showed a number of weaknesses, and overall the question was not answered well. The proof of the equation for the acceleration of an object rotating in a circle was answered by many candidates by simply writing down a collection of facts in more or less random order. Some candidates did not use a vector diagram, as the question indicated, and simply started with $F = mv^2/r$ and $F=ma$ to deduce that $a = v^2/r$. For parts **(b)(i)** and **(ii)**, the answers were mostly correct. Part **(b)(iii)**, however, showed many candidates struggling to apply the concepts of circular motion and forces in a practical situation. Weight was frequently shown acting upwards and contact forces between the drum and the object were often shown as forces on the drum and not on the object. The resultant force was frequently not given as a constant force towards the centre of the circle. Candidates were able to gain credit for the resultant either by using appropriately sized arrows on their diagrams, or by description in mathematical terms or words. Many candidates demonstrated common misconceptions by using the term centrifugal force, or by referring to centripetal force as a type of force rather than another name for the resultant.

Question 2

Most candidates could answer parts **(a)(i)** and **(ii)** of the question correctly, but had more difficulty in using the information there to answer part **(iii)**. Part **(b)** was usually answered well, although a number of candidates suggested that, with + 5.2 nC on one plate and – 5.2 nC on the other plate, the charge on the capacitor was 10.4 nC. Part **(c)** proved challenging. Many candidates did get credit for showing a uniform field between the plates, except at the edges, but they did not know what to do with the field lines coming from the top of the top plate. At a large distance from the plates the field will be as it would be from a point positive charge, so answers required the field to spread out from the top plate and to start to spread around the whole.

Question 3

This question was exceedingly well answered, with many candidates scoring full marks. The only problem arose for those candidates who found the potential energy of the Moon to be – 7.63×10^{28} J in **(a)(iii)** but then transferred it to the table without the minus sign. The minus sign in the box above the one they were using should have hinted that the sign would be needed.

Question 4

Answers were mixed for this question. A few candidates spent too much time describing a mass spectrometer rather than concentrating on the velocity selector and the use of the fields. Part **(b)** was not answered well. The best answers concerning magnetic flux density were based on the equation $F = BIl$, but a lot of the candidates just went round in circles in their definitions. Part **(c)** was answered correctly by most candidates, but many of the answers to **(d)(i)** did not address the question which related to the current in the coil but instead focused on the size of the coil. Credit was given for answers to **(d)(ii)** which made suggestions such as using thicker wires in the coil, but many answers concentrated on making a coil as long as a person, which did not address the question.

Question 5

This was another well answered question. Parts **(a)** and **(b)** caused no undue problems. In part **(c)** it was common for candidates to miss mentioning the speed distribution of molecules in a gas. It is only the fastest 10% of molecules that are important here.

Question 6

This was a straightforward question and caused no problem for most candidates.

Question 7

This question was set well before the recent Japanese earthquake, but it was clear that many candidates had seen the film of a skyscraper in Japan undergoing wobbling oscillations of period about 10 s on its rubber foundation. This may have helped their answers.

Question 8

Most candidates could answer this question fully, although a number did not know that this wavelength, right in the middle of the visible spectrum, is green.

Section B

Mathematical questions

Question 9

This was a very popular question. Diagrams and explanations for longitudinal waves were not clear in many cases. In cases where the candidate chose to use a graph to illustrate their answer, the labelling of the axes is crucial for these waves and it must be made clear that the direction of movement of the particles is in the direction in which energy is being transmitted. Parts **(c)** and **(d)** were particularly well answered. In answering part **(e)**, many candidates did not draw tangents to the graph to find dI/dx, but instead these candidates just used small part of the graph itself. Where tangents were drawn they were often too short for accuracy.

Question 10

Most parts of this question were answered well. Some mistakes occurred quite frequently, however: for **(b)(ii)** reading the intercept as 8.2, or as $e^{8.4} = 4447$, for **(d)(i)** making this a long complicated integral, and for **(d)(ii)** using ω as 4 or 8π. There was considerable need to award marks under error carried forward in this question. A simple mistake early in the calculation did not prevent the awarding of later marks.

Question 11

Comparatively fewer candidates chose to answer this question. Many candidate responses were reasonable for the numerical parts of the question but often lacked sufficient detail in the descriptive parts.

Philosophical questions

Question 12

Candidates found this question straightforward. The main problem involved sorting out who was having the time dilation. In particular, a problem arose for the example of ‘time travel’. Some candidates gave contradictory answers in parts **(e)(iv)** and **(v)** by making the suggestion that one of the groups of organisms had ‘gone into the future’ when their previous answer seemed to have made it go into the past.

Question 13

The weakest responses to this question were in parts **(d)(ii)** and particularly **(e)(ii)**; also the estimates in part **(e)(iii)** were often wildly wrong with temperature values much lower than expected. Nevertheless, many candidates did score well overall with the question.

Question 14

This question proved to be the least popular choice by candidates. Parts **(a)(b)** and **(c)** posed no problem to most candidates. A firm understanding of the uncertainty principle was required for answering parts **(d)** and **(e)**.

PHYSICS

Paper 9792/04

Coursework

Key messages

The use of clear annotations indicating where and why marks have been awarded is very helpful for the moderation process.

Candidates are advised to structure their reports carefully, and to make sure that the investigation shows a clear progression with interim conclusions stated where appropriate.

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 again for the valuable contribution that they have made in making this assessment successful.

It was pleasing to see Centres applying the criteria sensibly to all 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. Again annotation should be included.

One of the purposes of the moderation process is to confirm the marks awarded by a Centre. It is thus very helpful where a Centre has annotated the script either to justify the award of a mark or to indicate why a mark has not been awarded. It was clear from the moderation process that the majority of Centres marked the tasks carefully and it was pleasing to see many helpful annotations. A number of Centres enclosed annotated copies of the marking criteria whilst one Centre produced a small comment on each of the criteria areas justifying the mark. It is obviously helpful that both good physics and wrong physics in the reports are highlighted so as to judge the award of the appropriate mark. It was clear that the majority of larger Centres had carried an appropriate 'internal-moderation' process.

The majority of Centres met the relevant deadlines although one or two Centres were very late. 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.

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 were often a little generous on awarding the higher marks for this criterion. 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 last year, when data logging equipment is used, there should be some explanation in the report as to how the equipment is being used. 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. 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. All 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. 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.

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 usually include page numbers.