CONTENTS

FOREWORD

This booklet contains reports written by Examiners on the work of candidates in certain papers. **Its contents are primarily for the information of the subject teachers concerned**.

UNIVERSITY *of* CAMBRIDGE
International Examinations

PHYSICS

GCE Advanced Level and GCE Advanced Subsidiary Level

Grade thresholds taken for Syllabus 9702 (Physics) in the November 2005 examination.

	maximum mark available	minimum mark required for grade:		
		A	B	E
Component 1	40	33	30	22
Component 2	60	41	36	22
Component 3	25	21	19	14
Component 4	60	42	35	19
Component 5	30	25	23	16
Component 6	40	29	26	15

The thresholds (minimum marks) for Grades C and D are normally set by dividing the mark range between the B and the E thresholds into three. For example, if the difference between the B and the E threshold is 24 marks, the C threshold is set 8 marks below the B threshold and the D threshold is set another 8 marks down. If dividing the interval by three results in a fraction of a mark, then the threshold is normally rounded down.

Grade Thresholds are published for all GCE A/AS and IGCSE subjects where a corresponding mark scheme is available.

Paper 9702/01

Multiple Choice

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

General comments

The statistics for this paper were very similar to those for the paper in November 2004. Candidates seemed to find the paper to be slightly harder but the discrimination was very good. Apart from a few deliberately easy questions at the start of a new topic, and a few difficult ones at the end of a topic, the facility of the vast majority of questions was in the range 45%–80%. As last year, there was very little evidence of guessing by the large majority of candidates. Their results indicate a workmanlike approach to the paper with considerable attention to detail. It is usually the case with a multiple choice paper that candidates tend to do too much working on a calculator or in their heads. Candidates should use the space on the examination paper for clear working and should always be on the look out for any clearly impossible detail. Jumping to conclusions too quickly is a recipe for careless thinking.

Comments on specific questions

Some questions caused particular difficulties. These were:

Question 3

Too many candidates were simply not careful enough.

Question 5

There are probably too many candidates who do not know how to approach this type of problem. Adding fractional uncertainties was expected here. Adding actual uncertainties to get 0.13 gm cm^{-3} was a common response but is totally meaningless.

Question 6

Too many candidates, 24%, ignored air resistance and another 23% muddled up velocity with acceleration and gave option **D**.

Question 7

A tricky question but which able candidates could sort out.

Question 11

Too many candidates showed that while they may know Newton's first law, they do not believe it and do want a forward force to keep the stone moving forward. These gave the options **C** and **D**.

Question 12

Too many candidates (47%) ignored the weight of the beam and gave the option **B**.

Question 21

Great care is required in answering questions of this type. Thinking out the answer in your head is, again, a recipe for disaster.

Question 24

The comment given for **Question 21** again applies, as it does also for **Question 28**.

Question 34

This question, which was the worst answered question on the paper, showed that most candidates have the common misconception that the gradient of an I-V graph is the reciprocal of the resistance. This is true for a straight line graph – Ohm's law applying. These candidates 31% gave the response **B**. Another 30% gave **D**. Resistance however is defined as the potential difference per unit current and therefore the liquid has the smallest resistance where the ratio I/V is largest. Or, put another way, a straight line from the origin to a point on the graph has to have maximum gradient. This will be a line which is a tangent to the graph at C. Only 22% gave this correct answer.

Question 37

Too many candidates, by this stage, were guessing.

<table>
<tr><td>Paper 9702/02
Structured Questions</td></tr>
</table>

General comments

The general level of attainment was greater in numerical rather than non-numerical questions. On this occasion, there were several parts of the paper that demonstrated to a more than usual degree a serious lack of understanding of basic principles. Nowhere was this more apparent than in **Question 2**, where a large proportion of the candidates were quite unable to give an explanation as to why the suspended lamina would come to rest with its centre of gravity below the pivot.

Algebraic arguments continue to be expressed badly. Many use the '=' sign as some form of punctuation, with a string of elements all connected by the '=' sign, where the first element is of an entirely different nature and/or order of magnitude to the last.

There were, however, many good scripts to which these comments do not apply and which were a pleasure to read. Although most candidates attempted all questions, there were some scripts with blank pages towards the end of the paper and it is possible that some weaker candidates found themselves short of time.

Comments on specific questions

Question 1

(a) Most candidates gave adequate definitions of *pressure*, although some used expressions such as 'force on unit area' which fail to identify the ratio essential to the definition. The base units of pressure were given in most scripts, although there were some where the units were given as 'Pa' or 'Nm^{-2}'.

(b) Most candidates correctly identified the base units of density, acceleration and depth. These were combined appropriately to obtain the base units of pressure. However, many failed to draw a clear conclusion from their working.

Question 2

(a) The majority of answers identified the centre of gravity as the point where the weight of the body may be considered to act. Definitions involving the point where the mass of the body may be considered to be concentrated were accepted. There were also some candidates who attempted an 'explanation' which had little meaning, such as 'the point where the body is in equilibrium'.

(b) This part was poorly answered. Very many candidates showed that they were familiar with the use of a plumbline to determine the position of the centre of gravity. Comparatively few were able clearly to explain why there would be no turning effect about the pivot when the centre of gravity is vertically below the pivot.

Question 3

(a) Most candidates correctly defined *acceleration*, with few confusing velocity and speed.

(b) Although most candidates explained, with varying degrees of clarity, that the stone is accelerating because the direction is changing continuously and that velocity has magnitude and direction, there were many who decided that the stone is not accelerating because the speed is constant.

(c) There were some very clear correct solutions based on either scale drawings or vertical and horizontal resolution or the use of the cosine and sine rules. Many candidates ignored completely the components of forces in the vertical direction and offered no justification for the assumption that the resultant would be in the horizontal direction. A common error was to quote an angle on the answer line that could not be identified from any diagram e.g. 55°.

Question 4

(a)(i) Many answers for the initial acceleration were derived from the co-ordinates of a point on the curve within the first 0.1 s of the motion. Usually, such answers failed to explain that this is an approximation to the gradient at time $t = 0$. Very few candidates stated that what is required is the gradient of the tangent at the origin.

(ii) There were some good clear calculations based on the area below the curve. However, many did not make it clear how they were attempting to find the distance. Others used the equations for uniformly accelerated motion.

(b)(i) Almost all candidates were able to calculate the acceleration, based on their answer to **(a)(i)**. The most common error was a failure to convert the mass in g to kg.

(ii) There were some good descriptions where candidates correctly related the variation of the resultant force to the acceleration of the trolley, as evidenced by the gradient of the tangent. Unfortunately, some did not read the question and described the variation of the acceleration, not the force. A significant number, however, thought that the force would increase from time $t = 0$ to time $t = 0.3$ s and then would subsequently decrease.

Question 5

(a) Few candidates failed to identify appropriate similarities and differences.

(b) Most candidates stated that the waves are coherent because they have the same frequency, period or wavelength, without any comment on continuity. Comparatively few gave the reason as 'constant phase difference' and indeed, many thought that the waves would not be coherent because they are not in phase.

(c)(i) Although most answers included a reference to the relation between intensity and amplitude, the subsequent algebra frequently left much to be desired. Equations such as '$I = 4I$' were common. In such questions, candidates should be encouraged to use suffixes to indicate to which situation they are referring.

(ii) This part was completed successfully by only a small number of candidates. Most added or subtracted the intensities, rather than the amplitudes, of the individual waves.

(d) Most candidates did give zero resultant for the time $t = 3$ ms. For time $t = 4.0$ ms, it was pleasing to note that most did subtract the two displacements. However, many overlooked the factor of 10^{-4} in the final answer.

Question 6

(a) Disappointingly few candidates recognised that an upwards force on the particle is required to counterbalance its weight and that this force is provided if plate Y is positive. Instead, many ignored totally the gravitational force and stated that both plates must be positive so that equal but opposite forces act on the particle. Others suggested that plate X must be positive because 'the positive is always on the top'. A surprising number thought that, because the '+' sign is nearer plate X than plate Y, then plate X must be negative to attract the particle.

(b)(i) Almost all candidates could recall the relevant formula and very few failed to convert the plate separation to the appropriate unit.

(ii) The majority of candidates were able to calculate the charge on the particle, including many who had ignored the gravitational force when answering **(a)**.

Question 7

(a)	Almost all candidates found an appropriate route in order to arrive at the given result. The large majority were familiar with the idea of the potential divider whilst the approach of others lacked clear explanation. Candidates should be reminded that, in questions where the answer is given, then clear explanation is vital.

(b)(i)	Many answers were limited to stating that since potential difference is proportional to resistance and resistance is proportional to the distance along the wire, then potential difference is proportional to distance. Relatively few made it clear what assumptions are made when quoting the proportionalities. Others made no distinction between statements such as 'A increases as B increases' and 'A is proportional to B'.

(ii)	Both parts were answered correctly by the majority of candidates. Some did, quite inexplicably, give the answer as 0 V or 4.5 V for the potential difference between M and Q but then went on to calculate a length of wire appropriate to a potential difference of 2.7 V.

(iii)	Candidates who knew that the resistance of the thermistor would decrease with temperature rise did, in general, arrive at the correct conclusion. Other answers referred to increases or decreases in resistance, potential difference or temperature without making clear which component was being considered.

Question 8

(a)	Almost all answers included a reference to '*force × distance*'. However, many did not make it clear that *distance* is the distance moved by the point of application of the force in the direction of the line of action of the force. Attempts to describe the concept of work without using a formula were often similarly imprecise and many implied that *work* is a *force*.

(b)(i)	Descriptions were frequently muddled and rarely developed the ideas of starting from rest with an acceleration that decreases to zero, resulting in a constant terminal speed until it hits the ground. Many answers dealt only with the terminal speed.

(ii)	The most common representation of the variation of gravitational potential energy was the inverse of the kinetic energy curve, showing the initial gravitational potential energy equal to the final kinetic energy. Where candidates did realise that the gravitational potential energy would decrease linearly, then most assumed the maximum potential energy would equal the maximum kinetic energy. Very few started their straight lines well above the point for maximum kinetic energy in order to reflect the energy expended in doing work to overcome the air resistance opposing the motion.

> **Paper 9702/03**
>
> **Practical 1**

General comments

The standard of the work done by the candidates was similar to last year. Candidates generally found the paper quite accessible, with the bulk of the marks ranging from about 12 to 23.

Few Centres reported difficulties with obtaining apparatus for the experiment, and very little help was given to candidates by Supervisors in setting up the equipment.

There were no problems with the rubric.

There was no evidence of candidates being short of time in this paper.

Comments on specific questions

Question 1

In this question the candidates were required to suspend a metre rule from two strings and measure the tension in one of the strings as the distance of a load from one of the strings was changed.

(a) Most candidates were able to set up the apparatus without difficulty.

(b)(i) Virtually all candidates were able to measure and record the distance d of the mass from the Newton metre and the reading on the Newton metre. A number of weaker candidates measured from the wrong end of the rule and obtained $(100 - d)$ instead of d.

(ii) Candidates were required to determine the percentage uncertainty in the value of d. Most candidates chose to use an absolute uncertainty of 1 mm, although some weaker candidates gave a value of 1 cm, which was not accepted. The ratio $\Delta d/d$ was usually given correctly to give a final answer of around 0.1% or 0.2%. A number of weaker candidates did not attempt the calculation.

(iii) Most candidates stated that they would measure the distance of the rule from the bench top at each end of the rule, and that the values would be the same if the rule was horizontal. This was accepted for one mark. The more able candidates went on to give further detail, usually involving the set square, to gain a second mark.

(c) The vast majority of candidates were able to use the apparatus to obtain six sets of readings for d and F. It was expected that the readings would be repeated and that the values of d would be reasonably spaced (i.e. more than five centimetres between each value of d). Most candidates did not repeat the readings, although many did use sensible intervals for d (usually 10 cm).

Candidates usually presented the results in tabular form with appropriate column headings. Raw values of d were sometimes given to the nearest centimetre instead of the nearest millimetre (it is expected that the values will be given to the nearest millimetre as a rule with a millimetre scale is being used to make the measurement).

(d) Candidates were required to draw a graph of F against d. Weaker candidate still tended to make life difficult by choosing awkward scales (e.g. 3 units corresponding to ten small squares). This often led to plotting errors and misread scales when finding a gradient or an intercept. Candidates should be encouraged to use scales that are simple and easy to work with (e.g. 2:10 or 5:10). Some of the weaker candidates chose to use compressed scales (where the plotted points occupied less than half the graph grid in either the x or y directions, or both). The graph grid measures eight large squares (in the x-direction) by twelve large squares (in the y-direction) and therefore it is expected that the plotted points would occupy at least four large squares in the x-direction and six large squares in the y-direction. It is expected that all the observations will be plotted to half a small square on the graph grid. Plots in the margin area are not acceptable.
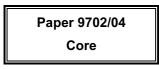
Most candidates were able to draw an acceptable line of best fit through the points.

Two marks were available for the 'quality of results'. This was judged on the scatter of points about the line of best fit. Candidates who had done the experiment carefully were able to score here if the scatter of points were small. If the experiment had been performed with reasonable care it was possible to obtain six points with little or no scatter about the line of best fit.

(e) Most of the better candidates were able to determine a value for the gradient of the line correctly. When the mark was not awarded it was usually because the triangle that had been used was too small or an error had been made in the read-offs. Sometimes the negative sign had been omitted.

The y-intercept was usually read correctly from the graph or found using the co-ordinates of a point on the line and the equation of a straight line. A number of weaker candidates incorrectly read the intercept from a line which was not the y-axis (i.e. a false origin had been used).

(f)   Candidates were given the equation relating *F* and *d* and asked to find values for *W* and *m* by using their values of gradient and *y*-intercept. Many weaker candidates attempted to substitute into the formula and did not use their answers from **(e)**. This resulted in pages of algebra and did not score any analysis marks. It was expected that −*W*/*L* would be equated with the gradient of the line and *mg*/2 + *W* equated with the *y*-intercept. Weaker candidates sometimes did not attempt this section. The final values of *W* and *m* were expected to agree reasonably well with the Supervisor's values. Candidates who gave unreasonable number of significant figures in their answers (usually four or more) were unable to score the significant figure mark.

| **Paper 9702/04** |
| **Core** |

General comments

The paper produced a very wide range of marks. There were some excellent scripts. On the other hand, some candidates scored very low marks.

Candidates found some questions more difficult than others but most were able to find some sections where they could score marks. As is usual, some topics were found difficult by most candidates, in particular, electromagnetic induction.

Fewer candidates are now leaving sections of questions unanswered. Candidates should always be encouraged to attempt questions. Marks are awarded for all stages of an answer and not just for the completion.

With some exceptions, candidates appeared to have had sufficient time to complete their answers.

Comments on specific questions

Question 1

(a)   Weaker candidates found difficulty in setting up a relevant equation. For those who did establish an equation, a common error was to substitute either the Earth's radius or the acceleration of free fall at the Earth's surface.

(b)   More able candidates scored full marks here. Common errors were either to determine the increase in gravitational potential, rather than the increase in the potential energy, or to calculate the gravitational potential energy at the Earth's surface or in orbit. Surprisingly, some attempted to use the expression $\Delta E_P = mg(R_0 - R_E)$.

(c)   It was unfortunate that many candidates misinterpreted the question and simply gave an advantage, or use, of geostationary satellites.

Question 2

(a)   Most candidates scored some credit by stating *pV=nRT* but very few went on to give the necessary conditions. Those who answered the question by reference to kinetic theory assumptions very rarely gave adequate answers. Few could give three independent relevant assumptions. It is becoming more common to find that it is assumed, quite wrongly, that the mass of the molecules is negligible.

(b)   Most candidates scored full marks for this calculation. It was pleasing to note that very few used Celsius, rather than Kelvin, temperature.

(c)   In the majority of calculations, the amount of gas at the new pressure was calculated correctly. However, a significant minority used the expression *pV/T = constant*, thus assuming no change in the amount of gas. Having determined the new amount of gas, many failed to calculate the change in the amount before finding the number of strokes.

Question 3

(a) In general, a correct statement was given. This may be, in part, as a result of each term being carefully defined in the stem of the question. However, a minority still insisted on thinking that ΔU is the internal energy. Candidates should appreciate that what can be measured is the change in internal energy.

(b)(i) There were few problems with this calculation.

(ii) Unfortunately, some candidates mistook the molar latent heat to be the specific latent heat and so multiplied the given value by a mass.

(iii) It was common to find that the answers to **(i)** and **(ii)** were added, rather than subtracted.

(c) Most candidates realised that the Avogadro constant had to be included. It was pleasing to note that very few ridiculous answers were given.

Question 4

(a) Most candidates were able to calculate correctly both the angular frequency and the acceleration. However, many failed to read the question and gave the answer to more than two significant figures.

(b) Most sketches showed a straight line through the origin with negative gradient. However, few added a quantitative aspect by labelling the end-points of the line. Indeed, many were so poorly drawn that the line was of unequal lengths in the two quadrants.

(c) Apart from power-of-ten errors, the calculation presented very few difficulties. However, candidates were equally divided between zero displacement and maximum displacement for the point at which the speed would be maximum.

Question 5

(a) Most candidates did arrive at the given answer. However, there was a minority that appeared to have no real understanding as to what was required of them.

(b)(i) Written descriptions were, with few exceptions, less than adequate. Most candidates scored their marks from well-labelled sketches. Common errors included thinking that the path within the magnetic field would be parabolic, rather than circular, and to show a kink in the path as the electron leaves the field.

(ii) The quality of answers was very variable. There were some good verbal discussions whilst others relied on an algebraic equation, with terms defined. Both approaches were acceptable. However, a significant number of answers either did not make the final step from the radius of the path to the final deflection or assumed reduced radius would give rise to smaller deflection.

Question 6

(a) There were very few answers that scored full marks. For those answers that were based on the correct expression, few considered the angle between the flux and the current-carrying conductor. Definitions based on the relation between flux and flux density were common.

(b) Frequently, the symbol Φ was used, without explanation, for both flux and flux linkage. It was disappointing that answers were often a mere statement without any intermediate steps being shown. Despite being mentioned in the question, few answers commenced by considering the flux through the coil.

(c)(i) Most candidates could give a satisfactory definition in terms of induced e.m.f.

(ii) There were very few completely correct responses. Most candidates failed at the first hurdle in that they did not realise that there would be two regions where the induced e.m.f. would be constant, corresponding to a constant rate of change of flux density. Of those who did indicate constant e.m.f's, most did show them to be in opposite directions although the relative magnitudes were rarely correct.

Question 7

(a)(i) Some candidates thought, quite incorrectly, that binding energy is 'the energy to hold the nucleus together'. Very few answers indicted that the nucleons must be separated to infinity.

(ii) Most candidates did show S to be near the peak of the curve.

(b)(i) The majority of answers were correct but the answer of 'three' was quite common.

(ii) The calculation of the energy released in the fission reaction was generally well done, with relatively few arithmetical errors. A significant minority did, however, merely consider binding energy per nucleon and neglected to include any of the proton numbers.

Attempts to calculate the equivalent mass were less successful. Many failed to convert successfully the energy in MeV to J.

Paper 9702/05

Practical 2

General comments

The general standard of work by the candidates was very similar to previous years. The wide range of marks scored reflected the wide range of abilities of the candidates. It was clear that some candidates had prepared well for this examination, especially in the practical **Question 1**. Generally, the marks for **Question 1** were better than the marks for **Question 2**. Supervisors gave very little help to candidates.

The vast majority of Centres did not have difficulty in obtaining the required apparatus for the experiment in **Question 1**, and generally the experiment was performed as intended.

Weaker candidates found the design question difficult, and candidates' answers to this question were generally disappointing. There was no evidence that candidates were short of time, although a number of very weak candidates did not attempt **Question 2**.

Comments on specific questions

Question 1

In this question, candidates were required to investigate how the period of oscillation of a mass suspended from a chain of springs, depended upon the number of chains in the spring.

Most candidates were able to set up the apparatus as intended and measure and record times from which the period could be determined. A number of weaker candidates did not record the number of oscillations and hence the period could not be checked. A surprising number of candidates did not repeat readings of time.

In **(b)(ii)**, candidates were required to determine the number of oscillations required to produce a percentage uncertainty of 1% in T. Many candidates found this section challenging. Invalid approaches using $\Delta T/T$ were common. A number of weaker candidates stated the uncertainty in the raw time to be the same as the precision of the stopwatch (0.01 s) which is clearly not achievable. A sensible estimate of 0.1 s to 0.4 s is expected.

In **(c)**, most candidates were able to repeat the procedure with a different number of springs in series to give six sets of readings for T and n. A number of weaker candidates forgot to divide the raw times by the number of oscillations and calculated log t instead of log T.

Most candidates presented the results in a table with correct column headings. A solidus notation is preferred (i.e. t/s rather than t (s)). Some of the weaker candidates omitted the units in the column headings. Values of t in the table were usually given consistently to an appropriate number of decimal places.

Candidates were required to plot a graph of log (T/s) against log n. Most candidates were able to do this quite well, although the weaker candidates tended to use awkward scales (e.g. three units corresponding to ten small squares) or compressed scales (where the plotted points occupied less than half the graph grid in either the x or the y direction). There were a number of reversed scales (i.e. the log T axis increasing negatively in the upward direction).

Data values were usually plotted correctly (allowing a tolerance of half a small square) and lines of best-fit drawn quite well. It may be helpful to candidates if they can be encouraged to use clear plastic rules when drawing the line. This is because all the points can be seen when the line is drawn, and therefore it is easier to judge the balance of points. The line of best-fit mark was sometimes not awarded because points that were not on the line were all to one side of the line (either above or below) instead of being reasonably scattered about the line.

One mark was available for the 'quality of results'. This was judged on the scatter of points about the line of best-fit. The candidates who had done the experiment carefully were able to score this mark if the scatter of points about the line of best-fit was small. It is expected that there will be at least five trend plots for this mark to be awarded.

Candidates were required to find the gradient of the line. It is expected that candidates will use well-spaced co-ordinates on the line when determining the gradient. Candidates should use triangles where the length of the hypotenuse is at least half the length of the line that has been drawn. Small triangles were penalised. Candidates using values from the table where the points did not lie on the line of best-fit were not given credit here. A number of weaker candidates used $\Delta x/\Delta y$ instead of $\Delta y/\Delta x$.

Most candidates read the y-intercept correctly from the y-axis.

In the analysis section, the more able candidates identified the gradient with q and the y-intercept with p. A number of candidates attempted to calculate values for p and q by substitution into the logarithmic form of the given equation. This was not accepted as the question required the candidates to use their answers from **(d)(iii)** to determine values for p and q (i.e. the gradient and y-intercept values should be used). A number of candidates who inadvertently mixed up the values of p and q were not penalised for this small error.

In part **(f)**, candidates were required to determine a value for the spring constant k. Weaker candidates usually did not attempt this section. Where an answer had been given it was expected that it would be in the range $20 - 35$ N m^{-1}, be given to two or three significant figures and that a valid unit would be included. The more able candidates did this section well, and had no difficulty with the algebra.

Question 2

In this question, candidates were required to design an experiment to investigate how the total energy lost per second from a hot wire depends on air pressure. A well-drawn, labelled diagram could score many marks, even if the accompanying explanation was weak.

There were many answers containing basic errors of principle or where the procedure described was unworkable. Circuit diagrams produced by the weaker candidates were usually incorrect (either the voltmeter was placed in series with the wire, or the voltmeter had been placed in parallel with a variable resistor, thus giving an invalid potential difference). Some candidates suggested heating the wire with a separate electrical heater (or even a Bunsen burner or candle flame). There was widespread confusion between energy and power and the majority of attempts involved switching on a circuit for a measured amount of time and use of the expression ItV. Graphs of energy versus pressure were common. Disappointingly few attempts appreciated that the power supplied was a variable along with pressure. Very few candidates discussed changing the current in the wire to maintain constant temperature – in fact many wanted to keep the current constant, or tried to use current as the independent variable. This mark was scored by only a handful of candidates.

A number of candidates suggested performing the experiment at various altitudes thus saving the need for a vacuum pump. Quite a few answers were seen where candidates suggested the use of a fan to change the pressure. This was not accepted. Other methods were based on changing the pressure of air in the entire laboratory. A number of candidates did not show convincing diagrams of a sealed chamber with a method of evacuation. Just a box with a pressure gauge was relatively common.

Few candidates appreciated the safety aspects of changing the pressure in a container. All that was required was a simple statement suggesting the use of safety screens and safety goggles in case the container imploded/exploded.

As in previous questions of this type, marks were available for any 'good further design features' that were felt to be creditworthy. Some of these are as follows:

- appropriate thermometer shown attached to the wire to monitor temperature

- thermometer attached to wire at several different places to monitor temperature

- light spot galvanometer connected to thermocouple/millivoltmeter

- use of a needle valve to control pressure

- use of vacuum grease to seal the container

- allow time between readings for experiment to stabilise

- do not allow the wire to become too hot or the thermocouple may melt.

Paper 9702/06

Options

General comments

The most popular options were, as usual, options **F** and **P**. However, good answers were seen in all the options and there was no evidence that choice of option disadvantaged any candidates.

Overall, the paper appeared to be of a similar standard to previous examination sessions. Despite the fact that some candidates did very well, there are many who appear to be poorly prepared and had little knowledge or understanding of the work.

There was no evidence that candidates were unable to complete their answers in the available time.

Comments on specific questions

Option A: Astrophysics and Cosmology

Question 1

(a) Although the AU was defined adequately by most, there was much confusion surrounding the definition of the pc. Some gave vague mentions of an angle and in others, it was not apparent that the pc is a distance.

(b) There were some very clear concise answers but equally, a significant minority had no clear idea as to how to involve an angle and did not commence by stating the equation $arc = r\theta$.

Question 2

(a) Not all information quoted was experimental. Most candidates could state either 3 K microwave background radiation or redshift of light from distant galaxies. However, few could give two distinctly different pieces of evidence.

(b) There were some very clear statements. It was, however, quite usual to find that the assumption on which the paradox is based was not included.

(c) References to the mean density of matter in the Universe were usually inadequate. Candidates were expected to discuss the consequences of a mean density being less and then being greater than the critical density. Usually, only one aspect was considered.

Question 3

(a) Answers were frequently vague, with references to 'light pollution' and 'cloud cover'. It was expected that answers would be specific to infra-red radiation including, for example, absorption (by water vapour) in the atmosphere and stray infra-red radiation from Earth-bound sources.

(b) It appeared as if there was considerable guessing here, with objects such as planets being suggested. Examples of cool objects and light from very distant galaxies would be adequate suggestions.

Option F: The Physics of Fluids

Question 4

(a) Usually well answered but a minority quoted laminar flow and streamline flow as two distinctly different conditions.

(b) Generally, the correct expressions were quoted. However, there were many errors when calculating $(85^2 - 75^2)$. Frequently, this was thought to be $(85 - 75)^2$.

Question 5

(a)(i) This relatively simple definition did cause some confusion. Many referred to 'the point where the mass of displaced fluid acts', rather than the point through which the upthrust appears to act.

   (ii) The majority of sketches indicated B within the sand.

   (iii) Some candidates gave full answers, making reference to the forces involved, to where they appear to act and to the restoring couple produced. However, most answers were vague. Many stated that 'points B and C would provide a restoring couple'.

(b) Approximately one half of all answers were correct.

(c) Most candidates did say that B would be below C, regardless of their answers in **(a)**. Some then did go on to mention a toppling moment. Few described the situation where B and C would coincide, with no resultant couple.

Question 6

(a) Reference was made frequently, and quite incorrectly, to streamlines crossing. Others did mention eddy currents or non-steady, haphazard flow.

(b) Answers here were very disappointing. Very few followed the lead given in the question and discussed the increased kinetic energy of the air in the eddies behind the car. Most made reference to drag force being proportional to the square of the speed and, in some way, the car speeded up. A significant minority attempted an explanation in terms of Bernoulli, in spite of having stated in **4 (a)** that the principle applies only to streamline flow.

Option M: Medical Physics

Question 7

(a)   There were some good accounts that included both the continuous and the line spectrum of the X-rays. Common errors were to think that the X-rays are emitted as the electrons move towards the target or that the electrons are reflected off the anode target, out of the window and through the patient.

(b)   Sharpness and contrast were understood by most, with very few confusing the two.

Question 8

(a)   With few exceptions, the defect was identified correctly.

(b)   Generally, a diverging lens was drawn. With very few exceptions, the rays were made to converge on to the retina. However, the rays between the eye and the lens drawn at AB were shown in a significant number of scripts as being convergent.

Question 9

(a)(i)   Very few candidates gave a clear statement as regards intensity. Some did confuse intensity and intensity level. A greater proportion of candidates could make a satisfactory comment as regards loudness.

(ii)   There were some good precise statements made here. However, a significant number of candidates were confused and defined sensitivity in terms of a change in frequency.

(b)   Despite being given the ratio in the question paper, some calculated the ratio of the intensities at 89 dB and 92 dB. Many found the intensity corresponding to 3 dB above the threshold of hearing. It was pleasing to note that a few candidates realised that 3 dB would be a doubling of intensity and thus reduced the calculation to some clear explanation as to how the value of 1.0 is derived.

Option P: Environmental Physics

Question 10

(a)   Drawings were, in general, disappointing. Many forgot to show the coils in some form of enclosure with a transparent top. Frequently, there was no circulating liquid.

(b)   Many answers were expressed either in unscientific terms ('to get as much sunlight as possible') or considered only the situation at noon. The fact that this orientation would give maximum overall exposure was not appreciated by most.

(c)   The majority used a power per unit area of either 900 W m^{-2} or 850 W m^{-2}, rather than 800 W m^{-2}. There was much uncertainty as to how to involve the efficiency (frequently omitted). About one half of all answers gave the total mass of water heated in six hours, rather than the rate of flow.

Question 11

(a)(i)   Few made reference to a change in pressure and volume. It was not uncommon to find that any reference to thermal energy was omitted. Instead, no energy would enter or leave the system.

(ii)   Only a small minority realised that the compression would take place rapidly. Most attempted an explanation in terms of the valves being closed.

(b)   With very few exceptions, the direction of the changes was marked correctly. Although the majority did identify the correct section, a significant number were either incorrect or marked ambiguously.

Question 12

(a)   A common answer was that unleaded fuel is used because it is cheaper or that it produces no pollution. Some candidates did refer to lead compounds in the exhaust fumes. It was recognised by most that 'lead is dangerous', without being specific.

(b)   Generally answered with little difficulty, although some did ignore the question and answered by reference to air pollution.

(c)(i) Many referred to 'recycling energy' or 'using it over and over again'. Others thought that '*renewable*' meant that the energy source is infinite.

(ii)   There were some good answers where candidates did make two clear statements. However, many did not read the question and, instead, discussed respects in which wind turbines are not pollution-free.

Option T: Telecommunications

Question 13

(a)   Few mentioned a *glass* fibre or discussed the role of total internal reflection.

(b)   There were some very clear, concise answers. However, many gave valid points, but in the wrong section or repeated the same point in both sections.

Question 14

(a)   It was pleasing to note that most could identify correctly the main cause of power loss and could than go on to complete the calculation successfully. Conversion of metres to kilometres did, as usual, cause some confusion.

(b)   Although most could explain what is meant by *noise*, there was some confusion with acoustic noise when suggesting sources of noise in cables.

Question 15

In this question, as in other telecommunications questions, there was a wide belief that information is passed faster in fibre optic cables. Clearly, there is confusion between the speed at which an individual bit is transmitted and the speed of transmission of a complete set of data.

A significant number discussed the advantages of fibre optics, rather than digital. Others discussed scientific and engineering aspects, rather than the effects on society. Consequently, the average mark was rather disappointing. However, there were some accounts that were a credit to the candidates and showed that they had thought clearly about the situation.