PHYSICS

Paper 9702/01

Paper 1

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

General comments

This paper had a few easy questions on it to introduce each section of work and generally the questions within a section increased in difficulty within that section of work. There were no questions that proved totally unsatisfactory for the paper. The mean mark out of 40 was 26.5 and the standard deviation was 6.7 The results showed that fewer than 6% of candidates scored less than 15/40 and that there were 29 of the candidates who scored 40/40. The implication of these figures is that the able candidates were able to show their ability and that the less able candidates still had something positive to do and, hopefully, were not disillusioned by the paper.

It is particularly important with multiple choice questions that candidates work to a routine in which they double check their work in order to avoid careless mistakes. Candidates should look critically at every answer to see that it makes sense. Too often powers of ten give rise to errors that a moment's thought would be able to correct. The worst way of working is fiddling on a calculator with the numbers given in the question, until one of the four answers appears. This is how we get the distractors!

Comments on individual questions

Answers that had high facility were 5, 6, 7, 8, 13, 20, 21, 23, 30 and 40.

Question 4 proved to be difficult for many candidates though the better candidates were able to see that option **D** is correct and that options **A** and **C** both have the graph cutting an axis, which would not be the case for an inverse square law graph.

The mechanics section, **Questions 1 – 15**, generally was well done, though rather too many candidates guessed, and guessed wrongly with **Question 12**. Questions on properties of matter also were done well but **Question 22** was the first question in which answer **A** had more responses than **B**, the correct answer. Three significant figures are possible here and the correct approach is to regard the required shape as a triangle, of area 2.50 J, and a trapezium of area 1.05 J.

The waves section was less well done. Too many candidates assumed that twice the intensity of a wave would be the result of twice the amplitude. This gave **Question 24** with more candidates choosing option **A** rather than the correct answer, option **B**. This question had one of the lowest facilities on the paper. **Question 27** surprisingly, also had an option, **C**, which was more popular than the correct answer, **B**.

Questions on electricity were generally done quite well although only 53% of candidates could answer **Question 31** and far too many candidates when answering **Question 34** worked out the total power from the source, as 36 W, rather than the power to the heater, 27 W. This was another question where a wrong answer was a more popular answer than the correct one.

In the final section **Question 37** had a facility of only 44% correct answers and **Question 38** was the only question on the paper where the facility was less than 25%. Clearly a great deal of guessing was done, yet candidates are meant to be able to estimate values and with a nucleus they should have the idea that, with atoms having dimensions about 10^{-10} m, nuclei have dimensions of the order of 10^{-14} m. Here, all four options were approximately equally popular, but at least there was some positive discrimination for able candidates. At the end, it was good to note that nearly everyone could answer **Question 40** correctly.

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Paper 9702/02
Paper 2

General comments

There were very few candidates who scored high marks throughout the whole Paper. The reasons for this have been given on several occasions in previous reports.

Learning formulae does not equate to understanding. In this Paper, there were opportunities to demonstrate some depth of understanding of the subject but the inability to do so by the majority of candidates was alarming. A good example is provided in **Question 7(e)**. Candidates were asked to comment on the difference between resistance values of a lamp measured with an ohm-meter (stated in the question to cause negligible current) and when operating normally. Rarely was there a comment related to resistance change resulting from a rise in temperature of the filament.

Candidates frequently fail to read questions carefully. For example, in **Question 2(c)**, far too many candidates lost three marks because they failed to provide equations. Instead, they merely wrote down resolved components of forces.

Comments on specific questions

Question 1

(a) Most candidates did give the SI base unit of force. Some weaker candidates quoted the derived unit *N*.

(b) Where the unit had been given as *N* in (a) then, mostly, a mixture of derived and base units was given here. However, most answers were correct.

(c) (i) This calculation presented very few problems. Candidates should be advised to use data as provided on page 2 of the Paper. The substitution of 10 m s^{-2} for g is not acceptable unless an answer to one significant figure is required.

(ii) The impression gained from most answers was that little or no thought went into what candidates were doing. Substitutions and calculations, without any words of explanation and leading to a totally unjustified conclusion were common.

A frequently seen approach was to calculate a force using the equation $F = crv$ and the value of v calculated in (a). Most then said that the value of this force is small and can be ignored. Very few explained the significance of F (the air resistance that would be experienced at the speed calculated in (a)) and that this air resistance is much less than the weight mg of the ball and so can justifiably be ignored. Other candidates offered similarly unexplained and incomplete arguments based on the terminal speed of the ball.

Question 2

(a) (i) Most candidates did give an adequate explanation for centre of gravity.

(ii) As is often the case, a significant number of candidates considered only linear motion. Answers were marred by imprecise statements such as ‘equal and opposite forces’ when ‘the resultant force is zero’ would have been correct.

(b) It became obvious that very few candidates realised why the three forces must pass through a single point. Common suggestions were 'to complete the triangle of forces' and 'since *W* and *T* start at P, then *F* must start at P'. Very few answers included a mention of moments and that, since *W* and *T* pass through P and therefore have zero moment about P, then *F* must also have zero moment about P. Hence it must pass through P. All three forces passing through P does not imply translational equilibrium.

(c) The most common mistake in this section was a failure to give equations. In most scripts, components of forces were given. Where equations were given, then these were usually correct.

Question 3

(a) Potential and kinetic energy were mentioned in most answers. However, frequently it was not made clear that it is the sum total of the random kinetic and potential energies of the atoms or molecules of the substance that constitute its internal energy.

(b) (i) Most candidates referred to a reduction in kinetic energy of the molecules but 'reduced speed' was frequently given as the explanation, rather than a decrease in temperature. Potential energy was usually ignored.

(ii) In general, this was poorly answered partly because candidates were unable to accept that the evaporation takes place at constant temperature. They insisted that the mean kinetic energy of the water would decrease because 'faster molecules would escape'. The large majority of candidates either ignored potential energy or stated that it would remain constant, clearly ignoring the fact that the evaporated water is still part of the system. Those who did include potential energy frequently implied that the energy increases because the vapour rises.

Question 4

(a) Most candidates did define density correctly in terms of a ratio.

(b) (i) Many answers were unconvincing in that they gave the impression that the pressure would be the same on the same horizontal level in the water and in the oil. Clearly, a reference to the same horizontal level in the same liquid (mercury) was necessary.

(ii) Most candidates did arrive at a correct value for the density of the oil. However, many candidates ignored the instruction to explain their working and far too many answers amounted to a jumble of figures with '=' signs included where they were not appropriate.

Question 5

(a) Many candidates failed to make it clear that the evidence for an elastic change is that there is zero extension when the load is removed. The most common answer was 'the graph is a straight line'.

(b) There were some well-explained answers that showed every step clearly. However, it was not uncommon to find attempts that lacked logical argument. Symbols changed without explanation. For example, x became Δx or $(x_2 - x_1)$ and, even more frequently, $(x_2 - x_1)^2$ became $(x_2^2 - x_1^2)$. There were many answers that included appropriate algebra but lacked a clear indication of an understanding of the underlying physics.

(c) Very few candidates were able to calculate the total energy stored in the springs. Having been instructed to use the expression in (b), many did not realise that the trolley is controlled by two springs but the formula in (b) is for one spring only. Consequently, most solutions began by substitution into the expression in (b), with a variety of numbers used for x_2 and x_1. However, most candidates did calculate an energy and then equated this energy to the maximum kinetic energy of the trolley.

Question 6

(a) (i) Most sketches did indicate a node at the water surface. However, many failed to recognise that, since the two diagrams represent water levels for two successive loud sounds, then the separation of the two levels must correspond to one half wavelength. All too frequently, the sketches drawn indicated that the candidate had no real understanding of the concept.

(ii) Most candidates did identify the nodes on their diagrams.

(b) Almost all candidates could give a correct expression relating speed, wavelength and frequency. Despite inappropriate diagrams, many did realise that the distance specified would be one half wavelength.

(c) Most candidates merely stated that the antinode would be at, or slightly above, the top of the tube. There were some correct solutions but many who did attempt a quantitative answer assumed the wavelength to be a multiple of the quoted length of the air column, rather than the wavelength they had calculated in (b).

Question 7

(a) The majority of candidates did identify correctly the faulty lamp. However, all three lamps and, indeed, all three switches were variously nominated. Of those candidates who correctly identified the faulty lamp, the majority were unable to state the nature of the fault. The most common explanations were ‘the filament has broken’ or ‘the lamp has fused’.

(b) Candidates were very aware of the danger of being electrocuted and many warned of the damage which might be caused. Very few, however, recognised that the predicted damage might arise only if lamp A is shorted.

(c) With few exceptions, candidates arrived at the correct answer for the resistance.

(d) Not surprisingly, almost all candidates correctly applied Ohm’s law in (i). Only a small number failed to calculate the power in (ii).

(e) Very few candidates seemed to realise that, in normal operation, a lamp is bright because the filament is at high temperature. Consequently, very few accounted for the difference in resistance as being due to the rise in temperature of the filament. Statements such as ‘resistance increases as current increases’ were, regrettably, all too common.

Question 8

(a) Most candidates correctly related radioactive decay to the emission from the nucleus of an α-particle or β-particle and/or a γ-ray photon. Some did confuse radioactive decay with fission and others referred to ‘radioactive emissions from the nucleus’.

(b) Most candidates who were familiar with the term adequately explained that rate of decay is unaffected by environmental changes. They then gave examples of such changes. Some candidates had confused spontaneity with randomness but many others were unfamiliar with the term.

(c) Most candidates did convey the idea that ‘random’ means that something cannot be predicted. However, many thought that either the rate of decay or the type of emitted radiation is unpredictable. A minority did state that it is not possible to predict when an individual nucleus will decay but very few mentioned that all identical nuclei have an equal probability of decay in a given time interval.

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Paper 9702/03
Practical Test

General comments

The overall standard of the work produced by the candidates was generally good, although as in previous years the performance variation was mainly by Centre (i.e. some Centres prepare their candidates very well for this examination). There were few low scores (<12) and a good number of strong candidates scoring 20+.

Many candidates carried out the careful measurements necessary to produce a clear trend, but the descriptive sections proved more challenging.

Candidates generally followed instructions well, and there was no evidence of candidates being short of time.

Comments on specific questions

Section A

Question 1

In this question candidates were required to investigate the variation in toppling angle for a plastic bottle as the depth of water in it was varied.

(c) (i) Most candidates recorded a sensible initial toppling angle for the empty bottle.

(iv) The calculation of percentage uncertainty was generally carried out very well, with candidates showing their working clearly. It was expected that the calculation would be based on an absolute uncertainty of ± 1 or 2 mm (± 0.5 mm was considered to be unrealistic).

(v) Many candidates scored this mark, good responses often referred to 'parallax error' (due to corrugations on the side of the bottle) or 'zero error' (on the ruler attached to the bottle).

(vi) 'Parallax error' was again credited as long the source was explained (e.g. distance between ruler and scale). Many candidates referred to the large intervals on the angle scale, and this was credited if the terminology was correct (i.e. 'inaccurate scale' or 'large scale' was not accepted). Vague references to 'random error' or 'systematic error' were not accepted.

(d) This was generally done successfully, with nine sets of readings laid out clearly in a table. Surprisingly few candidates recorded repeated readings with an average for the toppling angle – important in this experiment (to reduce scatter on the graph).

Readings of angle were expected to the nearest degree, and of d to the nearest mm.

Quite a few candidates did not cover the full range for *d* and those with no readings above 10.0 cm were penalised.

(e) The quality of graphs varied – many were good, with axes labelled and sensible scales used, but although most candidates plotted all the points from their table they were sometimes not shown as clear crosses or circled dots. Another common error was that of not using at least half the graph paper in both directions.

Many candidates had trouble drawing the required smooth curve through often scattered points. A common error was to draw a plateau through points at the peak of the curve (this also lost a mark when determining the maximum value).

(f) Most candidates successfully read the value of *d* for maximum toppling angle from their curve. Examiners expected a value to the nearest mm.

(g) The second curve (labelled C) for a hypothetical, larger diameter, bottle usually scored a mark for having a similar shape to the experimental curve. However, many candidates lost the second mark because their curve C was below rather than above the experimental curve.

(h) Only a few candidates scored both the marks available for improvements, often because they did not express their ideas in enough detail and using correct terminology.

Suggestions involving changing the experiment (e.g. using a different bottle or liquid) were not credited. Good answers included ‘marking a scale on the bottle itself’, ‘colouring the water’ and ‘marking smaller divisions on the angle scale’ (but not ‘more accurate’ or ‘better calibrated’).

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Paper 9702/04

Paper 4

General comments

The Paper did produce a wide range of marks. However, the number of candidates scoring very high marks was disappointing. This can be attributed to the very poor performance of the vast majority of candidates in **Question 7** and the disappointing answers to **Question 8**.

Candidates appeared to have sufficient time to complete their answers. It was pleasing to note that most did attempt all parts to all questions.

The general standard of the explanation given for calculations and other work is improving. Candidates do need to be encouraged to give explanation, particularly where a question asks either '*state and explain*' or '*suggest*'.

Comments on specific questions

Question 1

(a) Comparatively few candidates justified the equating of the formula for centripetal force with Newton's equation for gravitational force. Many implied an equilibrium situation, rather than the gravitational force providing the centripetal force.

(b) (i) A pleasingly large number of candidates did arrive at a correct expression for the kinetic energy.

(ii) There were many answers where the potential energy was given as a positive quantity. Candidates do need to be warned that they should distinguish clearly between upper- and lower-case letters. In this instance, many failed to distinguish between M an m, thus giving a final answer of M^2 or m^2.

(iii) With very few exceptions, candidates realised that they had to find the sum of the energies in (i) and (ii). Only a minority arrived at the correct expression.

(c) (i) There were very few correct responses, even amongst those candidates who had arrived at the correct expression in (b)(iii). The majority of candidates did not appreciate that, if the total energy decreases then the expression $-GMm/2r$ becomes more negative and hence $GMm/2r$ becomes larger.

(ii) There were even fewer correct answers here. Candidates seemed to be reluctant to believe that a decrease in total energy could lead to an increase in speed.

Question 2

(a) This part could be answered by reference either to macroscopic or to microscopic properties of a gas. Many answers were given full credit. However, a common misconception is that 'the volume of the gas is negligible compared with the volume of the container'. Weak candidates frequently stated that either temperature or pressure or volume must be held constant.

(b) (i) Most calculations were correct. It was pleasing to note that many set out their work clearly and logically. The most common error was a failure to convert correctly the volume in cm^3 to m^3.

(ii) With few exceptions, candidates calculated correctly the amount of gas in a balloon and then divided the total amount of gas by this quantity. Very few made any allowance for the amount of gas that remains in the cylinder.

Question 3

(a) Answers were very disappointing. The vast majority merely made a statement to the effect that resistance decreases non-linearly with temperature rise. Candidates were expected to appreciate that sensitivity is concerned with the rate of change of resistance with temperature (i.e. the gradient of the graph) and that the gradient decreases with temperature rise.

(b) Surprisingly, only a minority of candidates determined the uncertainty in the resistance for the given uncertainty in the temperature. Most did quote an expression for the conversion of Celsius temperatures to kelvin, but generally, the numerical factor was given as 273, rather than either 273.15 or 273.2. Consequently, with the uncertainty in temperature being ± 0.2 °C, then the answer for the temperature was not given to one decimal place.

Question 4

(a) (i) Most candidates did realise that one oscillation would be required.

(ii) There were many correct answers. However, it was quite common to find that either the period or the angular frequency were calculated.

(b) (i) It was pleasing to note that many candidates could quote a correct expression for the speed. A common error was to fail to use the amplitude in metres or to make an incorrect conversion of mm to m. A disturbing number of weak candidates attempted to use the formula $v = f\lambda$, with λ being made equal to the amplitude.

(ii) As in (i), many could give a correct expression and, having made allowance for 'error-carried-forward', arrived at a satisfactory conclusion.

(c) It was unfortunate that many did not read the question carefully. Instead of marking positions of the pivot P on the wheel, they attempted to mark positions of the piston in the cylinder.

Question 5

(a) (i) It was pleasing to note that a greater proportion of candidates now define field strength in terms of the ratio of force and charge, rather than the 'force on unit charge'. Candidates should be advised that, in electrostatics, the sign of the charge is important.

(ii) Generally, the formula was quoted correcting and ε_0 was identified. Some candidates elected to use the expression kQ/r^2. The use of this expression may not be advisable because many of these candidates either stated that k is the permittivity or, in the subsequent calculation, substituted the value of the Boltzmann constant.

(b) (i) Apart from arithmetical errors, there were very few problems with this calculation.

(ii) There is a common misconception that the expression $E = V/d$ may be used in such calculations, with $d = r$. The expression for a constant field strength in terms of potential gradient may not be used for the non-uniform field at the surface of the sphere. If the expression $E = Vr$ is used, then careful explanation is required.

(c) There were some good explanations. However, many could do little more than mention 'ionisation'. Where a reference was made to oppositely directed forces on the nucleus and the electrons, the impression gained in many cases was that all the electrons would be stripped off the atom.

Question 6

(a) Very few diagrams indicated the correct direction for the magnetic field. There were many more correct directions for the force. Presumably, candidates had memorised the 'pinch effect' without understanding its origins.

(b) (i) A disturbing number of candidates merely stated 'action and reaction are equal and opposite', without making any reference to an interaction or the forces on different bodies.

(ii) Examiners allowed 'error-carried-forward' and thus, most candidates gained credit here.

(c) A number of candidates did make reasonable estimates and then went on to show that the force between the wires would be much less than the weight of one of the wires. However, most candidates scored very few marks. Most did not follow the instruction to 'make reasonable estimates' and consequently, they could not expect to be awarded much credit. Common misconceptions were that either the wires would vibrate too quickly for the vibrations to be seen or that the force would always be attractive and so the wires could not vibrate.

Question 7

It became obvious that very few candidates realised that a diffraction pattern consisting of concentric rings would be produced.

(a) Very few answers indicated that a bright spot would be produced. Some answers hinted at an α-particle scattering experiment.

(b) Candidates who realised that a diffraction pattern would be seen were in a small minority. Even then, most of these candidates thought that a series of straight lines would be formed.

(c) The most common answer was based on the electrons having higher energy and thus producing a brighter light on the screen. Very few realised the connection with the de Broglie equation.

Question 8

(a) The majority of candidates did indicate the correct direction for the electric field. There were, however, some responses that indicated a total lack of appreciation of the situation.

(b) (i) There were some very good answers, based on a quote of the formulae for the force due to each field. However, the majority failed to appreciate that both fields exert a force. A common answer was to state that 'the α-particle will deflect, but because it is four times more massive than a proton, the deflection will be small'.

(ii) Once again, well-described correct answers were rare. Generally, it was thought that the forces due to both fields would be in the same direction.

PHYSICS

Paper 9702/05

Practical Test

General comments

The general standard of the work done by the candidates was similar to last year, with quite a wide spread of marks. **Question 1** was relatively straightforward, although some of the weaker candidates found the analysis section challenging. More candidates attempted **Question 2** than last year but found it difficult to gain half marks. As in previous years, there was a significant variation in performance between Centres. It would be helpful to candidates generally if attention could be drawn to the published mark schemes.

Constantan wire or an equivalent resistance wire is something which Centres are expected to have available (it is included in the syllabus in the list of items regularly used in practical examinations). Centres should check with CIE if they want to use items that are close to the specifications in the Instructions but which do not exactly match them, and contact details are provided on the Confidential Instructions for this purpose. Some help was given to candidates from Supervisors in setting up the apparatus in **Question 1**. Supervisors are reminded that under **no circumstances** should help be given with the recording of results, graphical work or analysis.

Some candidates appeared to be short of time. Answers to **Question 2** were sometimes finished in mid-sentence.

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question candidates were required to investigate how the current through a resistance wire varied with the length.

(a) Most of the candidates were able to set up the equipment without help from the Supervisor. Weaker candidates needing help only lost 2 marks.

(b)(ii) Few candidates suggested the use of a sharper or thinner edge to take the reading or to take the reading with the wire on top of the *scale* (not ruler) or the eye at right angles to the *scale*. It was expected that the candidates address the precision of the one reading of x they had taken. Repeating the reading to improve precision did not gain credit.

(c) Virtually all candidates were able to record six measurements of x and I with correct column headings. Most candidates calculated lg x and lg I correctly. Some candidates recorded their values of d to the nearest centimetre. It is expected that d will be recorded to the nearest millimetre. A rule with a millimetre scale had been supplied to make the measurement.

(d) Candidates were required to plot a graph of lg x against lg I, where the values of lg x and lg I were negative. The negative scales on both axes caused many problems. It is expected that candidates are able to use the third quadrant of a graph, although other variants were not penalised. The most common error was probably the use of awkward scales which consequently resulted in the misplotting of points. Candidates often used compressed scales, in order that the intercept could be read off from the y-axis. This resulted in the plotted points occupying only a small part of the graph grid, which lost credit. It is expected that plots occupy more than half the graph grid and the intercept is then found by substituting a point on the line. A few candidates used scales that resulted in points beyond the grid. In these cases the plotting marks were not awarded. It is expected that all the observations will be plotted on the grid.

Most candidates were able to draw an acceptable line of best fit. The correct method was usually used in the determination of the gradient, although weaker candidates tended to use too small triangles or calculate dx/dy instead of dy/dx. It is expected that the length of the hypotenuse of the triangle used will be greater than half the length of the drawn line. Some candidates misread the co-ordinates for the gradient or intercept calculations. It is expected that candidates can plot and read plots to the nearest half a small square.

The y-intercept was usually read correctly or $y = mx + c$ used correctly with a point on the line and the gradient value. The most common error was in reading the y-intercept from a line where $x \neq 0$. Weaker candidates chose points not on the line (e.g. straight from the table) or read (y,x) instead of (x,y).

(e) In the analysis section candidates were able to state the logarithmic form of the given equation. This was much better answered than last year. Most were able to equate the gradient with n and lg k with the y-intercept.

(i) More candidates than the previous year were able to use a micrometer screw gauge to measure the diameter of the wire. However, many candidates did not repeat their readings.

(ii) The majority of candidates substituted the diameter to find the area correctly.

(iii) Most candidates attempted to calculate the percentage uncertainty in A. Common errors included a value for Δr or ΔA or omitting the factor 2 in the calculation. It was expected that the percentage error in the area is (± 0.01mm/diameter reading) x 2 x 100% as the measured quantity here was the diameter.

(g) Many weaker candidates found this section difficult. There was much confusion of units resulting in power of ten errors.

(h) Many candidates worked out that if the diameter doubles, the k would increase by a factor of four.

Question 2

In this question candidates were required to design a laboratory experiment to investigate how to determine the spacing between wires of a fine mesh using light of a single wavelength.

It was expected that candidates would show a labelled diagram of the setup showing a light source, a wire mesh and a screen. It was expected that candidates would be able to identify a source giving monochromatic light from a point source (e.g. laser, Sodium lamp plus slit to name a few possibilities).

Weak candidates used ultra-violet, infra-red, gamma, alpha, microwaves or 'white monochromatic light'. Some candidates used a light bulb which when combined with a filter and a slit was credited. Many candidates responded with a double slit setup or used a diffraction grating instead of the wire mesh which was not credited. The best candidates realised that the pattern produced on the screen would be a rectangular array of bright dots (candidates were not required to work this out). Answers that referred to crossed patterns of lines or to circular fringes were allowed. Weak candidates showed no pattern at all or made no reference to a pattern within the written text.

It was expected that candidates would state the quantities they would measure in order to find θ. Many candidates used a protractor without credit (indicating candidates did not appreciate the size of angles involved). Good candidates said they would measure D, the mesh to screen distance, and x, the dot separation. Good candidates took these measurements and used $tan\theta = x/D$ to find θ and subsequently used $n\lambda = d\sin\theta$ (where $n = 1$) to find d. Weaker candidates confused the symbols and their meaning, for example 'd', instead of being the 'spacing between the wires', became 'the distance between the mesh and the screen'. Also many candidates thought d = 1/spacing. It was expected that n would be given a value (e.g. $n = 1$) in order to use the equation $n\lambda = d\sin\theta$. Vague comments about the 'order of a fringe' did not gain credit. Some strong candidates labelled a spectrometer and gained marks for taking the angle from the table and saying how they did this in detail. Some good candidates suggested plotting $n\lambda$ against $\sin\theta$ to get d from the gradient.

A good, well-annotated diagram could gain up to half marks for this question, whereas a poor one often received little or no credit.

Sensible safety ideas only were given credit (e.g. 'do not look at the source directly' or 'use goggles to prevent damage to eyes'). 'Do not point laser at skin as it will burn' was not credited.

Marks were available for good further detail. Many candidates were able to access these marks. No credit was given for a darkened room as coherent light will produce visible fringes in a classroom. However, few candidates appreciated the need for a coherent source.

PHYSICS

Paper 9702/06

Paper 6

General comments

As is usually the case, Options F and P were by far the most popular. In Centres where a decision had been made that all candidates would study the same two Options, the marks were higher, on average, than Centres where it appeared that candidates had been given a free choice of Options.

In common with previous sessions, there were too many candidates who scored very low marks. Lack of appropriate preparation for the examination would appear to be the problem in that candidates did not know basic principles. Without a knowledge of basic principles, then the ability to apply physics to unfamiliar situations is severely handicapped.

Candidates appeared to have sufficient time to complete their answers to the questions. It was pleasing to note that, with very few exceptions, candidates did attempt all of the questions from two Options.

Comments on specific questions

Option A: Astrophysics and Cosmology

This Option was attempted by very few candidates.

Question 1

Many of the answers involved planets orbiting stars and comets orbiting planets. Some candidates did discuss the almost circular orbits of planet as opposed to the highly elliptical orbits of comets. Inclination to the ecliptic was seldom mentioned.

Question 2

(a) Frequently, the factor was given as ‘the density of the Universe’, without any reference to a mean density or the density of matter in the Universe.

(b)(i) The line drawn usually coincided with the given line from the origin to the ‘present time’. Candidates should realise that, regardless as to whether the Universe is ‘open’, ‘closed’ or ‘flat’, the lines will touch at the ‘present time’ but each will have a different time corresponding to the Big Bang.

(ii) Most answers made reference to the uncertainty as to the amount of matter in the Universe. Some mentioned dark matter. There were fewer references to the extent of the Universe. Candidates should be advised that, when answering questions such as this, the reasons must be distinct from each other. A mention of the uncertainty as to the extent of the Universe and the fact that light has not yet reached us from the most-distant galaxies are not separate points.

Question 3

There were some clear correct solutions. However, the majority of candidates should be encouraged to set out their work neatly, with explanation. A key issue in this calculation is the conversion of units. The identification of simple arithmetical errors is difficult when work consists of a jumble of numbers. Consequently, candidates may lose marks unnecessarily.

Question 4

Most answers did involve the vast expense and the limitations imposed by the atmosphere on Earth-bound observations. There were few comments as to either the benefits of the knowledge gained or the technological spin-off or alternative uses for the money involved.

Option F: The Physics of Fluids

This was the most popular Option.

Question 5

(a) The most common answer, by far, was 'conservation of mass'. The correct answer – conservation of volume – was given by very few candidates.

(b) This was usually correct although weaker candidates frequently attempted to quote the Bernoulli equation.

Question 6

(a) There were very few explanations that were satisfactory. Most candidates did realise that the water emerging from the nozzle would be at high speed. However, the majority then merely stated that 'high speed gives low pressure and hence there is a pressure difference'. Very few mentioned that air would be dragged along by the water and that this high-speed air would be at low pressure when compared with the stationary air outside the pump.

(b) (i) Many made a reference to reduced pressure as a result of higher-speed water but did not then relate this to the pressure difference.

(ii) Many candidates quoted, in some form, the expression $\Delta p = ½\rho(v_2^2 - v_1^2)$. They then stated that an increase in ρ would give rise to an increase in Δp. Their statements were not then related back to the given situation.

Question 7

(a) There were many correct explanations, usually based on increased drag force. Weaker candidates sometimes had difficulty with linking increased drag force to increased energy consumption. In such cases, it was common to find that it was thought that the car would slow down and that additional fuel would be required to speed it up once more.

(b) (i) The expression $P = Fv$ was quoted in most answers. Candidates were expected to make a definite comment as regards the quantities that are assumed to be constant, rather than merely replacing them in the equation by k.

(ii) There were many correct answers here. The usual arithmetical errors (failing to convert kW to W and taking the square root, rather than the cube root) lead to ridiculous answers. Candidates should always be encouraged to consider whether their answers are reasonable.

(iii) A common error was to calculate the power for a speed of 9 m s^{-1} and to divide this by the power output in still air. Others added the power outputs for 9 m s^{-1} and 63 m s^{-1}, rather than calculating the value for 72 m s^{-1}.

Option M: Medical Physics

The most popular of the 'minority' Options.

Question 8

(a) Generally well-answered. It was pleasing that many mentioned resonance, but very few then made a reference to the dimensions of the crystal. Candidates should refer to an alternating potential difference, rather than an alternating current.

(b) There were very few correct answers. Most usually stated that a higher frequency would give greater penetration! Some did make a vague statement about ‘the image being clearer’. Very few stated that the wavelength would be shorter and hence greater detail would be possible.

Question 9

Most answers involved its use as a scalpel with mentions of vaporisation and minimal bleeding. Retinal repair and corneal re-shaping were less popular. Very rarely was any reference made to the type of laser. It was quite common for diagnostic uses to be described (in particular, the endoscope) and some confused the laser with ionising radiation for radiotherapy.

Question 10

(a) A significant number thought that the threshold of hearing is concerned with a minimum frequency, rather than a minimum intensity. Very few answers included the frequency at which the minimum intensity is quoted.

(b) (i) Most answers were correct although a minority made power-of-ten errors that lead to ridiculous answers.

(ii) Candidates who gave ridiculous answers in (i) seldom made an appropriate comment. However, many who were successful in (i) were able to make a sensible comment related either to the perceived loudness or to its effects on hearing.

Option P: Environmental Physics

A very popular Option.

Question 11

(a) Usually well answered. A minority gave the impression that the electrical energy generated is used to pump the water back up to the higher reservoir. Others described a water conservation system whereby water in the upper reservoir is used in times of drought.

(b) Nearly all candidates appreciated what was required for this calculation. However, many lost marks as a result of omitting, or using wrongly, the efficiency. Some substituted $g = 10\ \text{m s}^{-2}$ and then gave their answer to five or six significant figures. Candidates do need to consider the number of significant figures in an answer.

Question 12

(a) Few candidates did little more than give a quote of the second law. Even so, many were imprecise and gave the impression that the energy transferred to the lower temperature sink is energy lost through friction! Others gave an expression for the efficiency and then stated that the sink could not be at 0 K.

(b) Surprisingly, many candidates could not give the expression. It was common to find that different quantities were being added or subtracted. Candidates should realise that terms such as (T_H - Q_H) have no meaning.

(c) Surprisingly, a significant number of candidates who failed to give the expression in (b) were then able to complete this calculation successfully. It was pleasing to note that only a minority failed to convert the temperatures to Kelvin.

Question 13

(a) Generally answered well. However, some candidates do need to guard against giving the same reason twice. Furthermore, weaker candidates do tend to give statements, rather than explanations.

(b) Again, this was well answered although in (i), many did fail to realise that the change at 8 p.m. would be sudden.

Option T: Telecommunications

Question 14

(a) With few exceptions, candidates realised that the carrier frequency would vary. It was not always clear that the variation is determined by the displacement of the information signal.

(b) There were very few scripts where all four parts were correct. Generally, part **(i)** was correct. Common errors in **(ii)** and **(iii)** were to give the frequencies as 605 kHz and 595 kHz.

Question 15

(a) Block X was usually identified correctly.

(b) There were some correct responses here but many thought that the purpose of the clock is to time an interval.

(c) In general, those candidates who answered (b) correctly also gave a correct suggestion.

Question 16

(a) The majority of answers made a vague reference to shielding. However, the nature of the shielding was rarely made clear. Some even mentioned thermal shielding. Only a minority seemed to realise that the braid is earthed.

(b) Most answers made a reference to an increased capacity to carry information. Increased rate was seldom mentioned explicitly. However, candidates appreciated that more calls could be made simultaneously along one line, thus reducing the number of lines required.

Question 17

(a) Answers tended to be vague and few candidates made two clear distinct references.

(b) (i) Most candidates were able to give a correct formula for attenuation. The usual error was one of substitution into this formula.

(ii) As for **(i)**, most candidates were familiar with the procedures required. However, there were numerous problems with substitution of numbers into the formula for attenuation.