PHYSICS

Paper 9702/01
Multiple Choice

Question Number	*Key*	*Question Number*	*Key*
1	**D**	21	**D**
2	**B**	22	**B**
3	**A**	23	**C**
4	**D**	24	**B**
5	**A**	25	**C**
6	**D**	26	**D**
7	**C**	27	**C**
8	**D**	28	**A**
9	**C**	29	**B**
10	**B**	30	**C**
11	**D**	31	**A**
12	**B**	32	**D**
13	**B**	33	**A**
14	**B**	34	**A**
15	**C**	35	**D**
16	**D**	36	**B**
17	**A**	37	**B**
18	**C**	38	**C**
19	**C**	39	**D**
20	**B**	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 a few questions that proved to be very easy, however, with more than 90% of candidates getting the correct response. These were **Questions 19**, **35** and **39**. Partly as a result of this, the mean mark was 2 marks higher than on last June's paper at 28.6 out of 40. The standard deviation was 6.8. The results showed that only 11% of candidates scored less than half marks and that there were 176 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. Except for **Question 38** the number of correct responses to every question exceeded the number of responses to any of the distractors. All the questions in the paper showed good discrimination apart from the very easy questions mentioned already.

Too many candidates still do not check their work with sufficient care. Checking multiple choice questions must be done immediately and not after finishing the paper. Answers should be checked particularly for powers of ten and also for positively being able to reject the other three answers to a question. These can often introduce to the candidate another point that they had not previously considered and which might be important.

Comments on individual questions

Other questions that had high facility were 1, 2, 5, 7, 12, 13, 16, 23, 24, 29, 36, 37 and 40.

Question 10 showed that 30% of candidates believe that the acceleration and velocity of an object are necessarily in the same direction. Answers to **Question 18** showed that it was not the electrical data that caused the difficulty but compensation for the efficiency. Too many candidates either ignored this aspect and gave 160 A as their answer or worked the efficiency the wrong way round and gave 130 A. There was only one question on the paper which had a facility less than 40% (**Question 38**) but **Question 21** also proved to be difficult for many candidates. It is a quite straightforward question but no doubt the algebra caused the problems for some candidates. **Question 25** caused difficulty. The answer n = 1.5 was almost as common as the correct answer, n = 3, probably because it was nearest to 1.

The electrical **Questions 30 - 34** caused difficulty. In answering **Question 30** too many candidates did not appreciate that the field between a pair of plates is, for the most part, uniform. The novel situation in **Question 31** foxed many but it was surprising to find how many candidates chose options **B** and **C** in **Question 32**. There is a strongly held, but incorrect, opinion that the gradient of a graph of I against V is the reciprocal of the resistance. In **Question 33** a creditable 63% steered clear of this opinion to get the correct answer **(A).** 19% just used the gradient while 18% could not see that the resistance must stay constant during the first section. **(A)** seems so obviously the correct answer to **Question 34** that one wonders how 43% of candidates cannot see this. It is the old problem with potential division presumably. Now to what proved to be the most difficult question on the paper (**Question 38**). 57% of candidates thought that an alpha particle was a helium atom. It might be an ion of helium but an atom of helium has two electrons that will not be present on an alpha particle. The correct answer is **(C)**, 35% correct responses; alpha particles cause the tracks in a cloud chamber because of their ionising ability.

PHYSICS

Paper 9702/02

Structured Questions

General comments

Some Centres entered candidates who attained a uniformly good standard but there were very few outstandingly good scripts. There was a disappointingly large number of candidates who produced scripts of poor quality.

As is usually the case, numerical questions were answered far more successfully than those requiring discussion. The former would have been even more successful if candidates had taken the advice, so often given in these reports and on question papers, to include a few words of explanation and to ensure that any mathematical argument is expressed clearly and logically. Similarly, answers requiring discussion would have been more productive had candidates taken more care to read the questions carefully and then to discuss what was intended to be discussed – no more and no less.

There was no evidence to suggest that the great majority of candidates had been short of time.

Comments on specific questions

Question 1

(a)(i) A common omission was to give the definition as *force* × *distance* which could have applied equally to moment of a force. The majority of candidates did make reference to *distance moved* or *displacement* but frequently, the direction of movement or displacement was not made clear.

(ii) Most definitions included a reference to *work done* and *time taken* although the essential detail regarding the ratio was often omitted.

(b) Most candidates successfully developed the definitions given in **(a)** in order to derive the expression.

(c)(i) Most candidates did calculate the final kinetic energy and then divided this quantity be the elapsed time. However, a significant number assumed a constant acceleration and hence a constant accelerating force. Rather than multiply this force by the average speed, they calculated the power by multiplying by the final speed.

(ii) This was answered poorly. Many candidates did not seem to appreciate that this question still relates to the acceleration during the first 8.1 s of the motion. Instead, they discussed changing road surfaces and gradients, cornering etc. An alarming number stated that the acceleration could not be constant simply because the speed is increasing, without mentioning the constraint of constant power. There were very few clearly developed explanations, based on sound principles of physics.

Question 2

(a) Approximately one half of all candidates correctly attempted to find the acceleration by drawing a tangent to the curve at the specified time. These tangents were drawn with varying degrees of precision but most were within acceptable limits. Of the remaining candidates, some did find a gradient by using the co-ordinates of two points on the curve but a surprisingly large number merely found the ratio of speed and time at the specified time.

(b) (i) Most did relate acceleration to gradient but many found difficulty in expressing the idea that, as time increases, the gradient decreases. Many referred to the line as 'flattens out' or 'bends downwards' or 'becomes less steep'.

(ii) There were very few correct suggestions such as increasing air resistance or changing slope of the ramp. Many candidates stated that friction would cause the trolley to decelerate. Others thought that the trolley had run off the end of the slope.

(c) In a significant number of answers, there was a failure to observe the instructions. Rather than name the features of Fig. 2.2 that indicate the presence of the two types of error, there were lengthy explanations as to what is meant by these terms, with no reference to the graph. Many candidates did relate a systematic error with an intercept. The feature identifying random error was less positively identified in that the scatter of points was not related to their distribution about the curve.

Question 3

(a) The nature of an α-particle was frequently confused with its properties. Thus, there were answers describing the penetrating or ionising properties of the particles, rather than their identification. There were some who identified the α-particle with the helium atom, rather than the helium nucleus.

(b) Most candidates successfully showed that the speed is approximately 1.8×10^{7} ms^{-1}. Interestingly, there were many alterations to working that indicated, had the answer not been given, then the mass would not have been stated to be 4*u*.

(c)(i) Most candidates did associate constant momentum with the principle. However, many failed to emphasise that it is the total or sum in a closed system that is conserved. Some candidates even restricted their answers to a single object.

(ii) Many answers contained a symbolic equation where the masses and velocities were identified only by unexplained numerical subscripts. The equation was then followed by a substitution of numbers. This meant that, where a substitution was inappropriate, it was not possible to distinguish between a major error of principle or a simple error of substitution. In such circumstances, some words of explanation would have enabled credit to have been given.

(d) Very few candidates suggested the simultaneous emission of another particle or a γ-ray photon. Instead, many suggestions were based either on the electrostatic repulsion between the astatine nucleus and the α-particle or the influence, in some way, of the francium nucleus.

Question 4

(a)(i) Candidates were expected to state that interference occurs when two or more waves meet at a point and that this results in an overall change in displacement or intensity. In practice, most answers did not make any reference to change in displacement or intensity.

(ii) A significant number of candidates did not seem to realise that 'constant phase difference' implies that the frequencies of the two waves are the same. 'Zero phase difference' or 'in phase' were not accepted.

(b) (i) Some candidates attempted to use the double slit formula. Of those who did give an appropriate grating formula, approximately one half derived the correct result. The most common source of error was in calculating the grating element (in m) from the number of lines per millimetre. Others, having found a value of 2.8 for *n*, then proceeded to 'round up' their answer.

(ii) Many candidates gave, in effect, the same answer for both parts. Most did state that a greater angle of diffraction would give rise to a longer wavelength. However, few gave a convincing argument based on, or a mere mention of, the grating formula. Even fewer attempted to explain that, or even state that, the separation between any two wavelengths would also increase as the order of the diffracted light increased.

Question 5

Answers indicated that many candidates were not able to distinguish between structures (to be discussed in **(a)**) and properties (to be discussed in **(b)**).

(a) Most candidates were able to convey, with wildly varying degrees of lucidity, the idea of atoms in a metal having being arranged in some form of regular pattern. Some also mentioned long-range order. Similarly, a reasonable number made reference to long-chain molecules with the repetition of smaller units. However, a typical answer would be 'lots of monomers joined together'.

(b) Answers here were as unsatisfactory as in **(a)**. Expressions such as 'more elastic' or 'less elastic' were equally likely to occur in both sub-sections with rarely any indication of what is meant by 'elastic'. Contradictions were very common. Statements such as ' it will be stiffer and more ductile' and 'it will have a high elastic limit and will show ductile properties only' were seen frequently.

Question 6

(a)(i) Most formulae were correct.

(ii) In most answers, a satisfactory definition of strain was given. Candidates did then arrive at the correct conclusion but frequently, explanation was either totally lacking or inadequate. It was common to assume that resistance is proportional to length (or worse still, equal to length!), without giving any indication as to what has to be held constant.

(b) This was answered well by most candidates although a small number confused stress and strain. Most answers were given appropriately to three significant figures. Interestingly, a significant number did not recognise the connection with the relation they had just derived in **(a)**. Instead, they made laborious calculations to find the new resistance and hence the change in resistance.

Question 7

(a) Some answers were limited to stating that e.m.f. is the p.d. across the terminals of the cell when the cell is on open circuit. The most common approach was to associate e.m.f. and p.d. with the work done in transferring an unspecified amount of charge around either a complete or an external circuit respectively. More acceptable answers discussed the energy conversions in the two cases. Significantly, regardless of approach, candidates very frequently failed to emphasise that both e.m.f. and p.d. are measures of energy conversion or work done *per unit charge*.

(b) (i) Most candidates successfully applied Kirchhoff's first law.

(ii) The second law was not nearly as well understood and, indeed, many answers either did not even involve a complete equation or e.m.f. was equated to current. Where equations were established, signs were frequently incorrect. For example, E_1 and E_2 were given the same sign, despite clearly having the two cells in opposite directions in the stated loop.

PHYSICS

Paper 9702/03

Practical 1

General comments

The overall standard of the work produced by the candidates was generally good. (it was evident that some Centres had prepared their candidates very well for this examination). There were very few scores less than 9, and a good number of candidates scored 20 or more. There was no evidence of candidates being short of time.

Although the Confidential Instructions emphasised that bare copper wire was required, some Centres provided lacquered wire. Any necessary remedial action in the examination itself may have unsettled some candidates and put them at a disadvantage.

Comments on specific questions

Question 1

In this question candidates were required to set up a circuit to provide an alternating current through a length of tensioned wire positioned between the poles of a magnet. The resonant length for each value of tension was determined by adjusting a sliding contact.

Locating the nodes required care and patience but the weaker candidates tended to rush to take readings rather than spending some time reading the instructions carefully and getting used to the apparatus.

The paper included a note that some of the materials provided may not have been needed, but many candidates chose to use a crocodile clip as the moveable contact (rather than the plug, as instructed) and this would have increased the tension in the wire.

(b) (ii) Most candidates recorded a sensible initial length for *d*, but a significant number used the suspended mass in g rather than kg when calculating the tension in N.

(c) The method of calculating percentage uncertainty was usually correct, but many candidates lost a mark for the absolute uncertainty that they used (1 to 5mm was accepted).

(d) (i) Most candidates presented six results clearly in a table and calculated the value of $\sqrt{T}$ correctly.

A mark was available for quality of results, based on the scatter shown on the graph. Many candidates had carried out their measurements carefully enough to score this.

Few candidates recorded repeat readings for *d*. This was particularly important in this experiment to reduce scatter.

Very few candidates labelled the $\sqrt{T}$ column with the correct unit ($N^{½}$).

Most candidates recorded their *d* values with consistent precision (all to the nearest mm or the nearest cm).

(d) (ii) Many candidates attempted to justify the number of significant figures given for $\sqrt{T}$ but some lost one of the marks because they did not specify that the sf were based on the sf in *T* (or in the mass). Justifications in terms of 'ease of plotting the data' scored no marks.

(e)(i) Graphs were usually of a good standard, with accurate plotting of data and a well chosen best fit line. Choice of scales, however, often led to the points occupying less than half the grid in one direction (this was penalised). Plotting points as large 'blobs' rather than crosses was penalised.

(e)(ii) Gradients were usually calculated correctly, the only common error being the choice of too small a triangle.

(f) Good candidates recognised that the gradient was equal to $1/(2f\sqrt{m})$ and then equated this to their gradient value (as instructed) to determine *m*. Many substituted the coordinates of a point into the equation to find *m*. This was not credited.

Surprisingly few gained the mark available for a correct unit for *m* (kg/m or g/m).

(g) Many candidates successfully described a difficulty, most related to the measurement of *d* (parallax problems, holding the rule still, seeing the thin wire, and so on).

Good suggestions for improvement were slightly less common. Significant changes to the apparatus or experimental procedure (such as using a sonometer arrangement) were not accepted, and neither were procedures that should have been carried out anyway (such as repeated readings, or adjusting eye level to the position of the contact). Simple, useful additions were credited (such as mounting the rule in a stand, or putting a white screen behind the wire).

PHYSICS

Paper 9702/04

Core

General comments

The general opinion of examiners is that the Paper was of comparable difficulty to that of November 2005. Some Centres did enter candidates where the overall standard of answers was good. However, there were very few outstanding scripts.

Candidates scored higher marks in numerical questions rather than in those where they were expected to 'explain' or 'discuss'. As has been reported previously, there is a marked failure in calculations to provide explanation. Candidates should realise that explanation enables an examiner to understand the intentions of a candidate, even when the final answer is incorrect.

There was no evidence to suggest that the great majority of candidates suffered from a shortage of time to complete their answers.

Comments on specific questions

Question 1

(a) There were many adequate comparisons. However, in low-scoring scripts, insufficient detail was common. For example, 'both involve work done' was considered by the examiners to be inadequate. It was expected that candidates would comment on what is being moved, and from where.

(b) The majority of candidates did make a reference to attraction/repulsion between the masses or charges. However, they were usually vague when attempting to explain how the direction of the force leads to the sign for the potential. Frequently, a reference was made to 'work in moving from infinity' but it was not made clear whether work was done on, or by, the mass/charge.

Question 2

(a)(i) This was a relatively straightforward question that caused a surprisingly large number of difficulties. Some candidates launched into a substitution without any words of explanation. Others did explain what was gaining and what was losing thermal energy, thus enabling the examiner to follow what was being done. The number of correct solutions was disappointingly low. The main contributing factor was a failure to include the final temperature on both sides of the equation.

(ii) There were many instances where the change in temperature was not calculated. Rather, the ratio of the final to the initial temperatures was found. Candidates should be advised that, where a ratio is required, it should be expressed as a simple fraction (e.g. $1/x$) or as a decimal.

(b) Most candidates suggested a thermocouple, rather than a thermistor. The thermocouple is unlikely to have sufficient sensitivity. Very few went on to give an adequate explanation for their choice. That is, the thermal capacity is much smaller.

(c) Some candidates did appreciate that the boiling point would be at a constant temperature. However, very few made any further comment. There were very many ingenious, but totally fallacious, answers based on the properties of mercury which indicated that the candidates had no real appreciation of the use of a liquid-in-glass thermometer.

Question 3

(a) In general, this was done well, with many scoring full marks. The most common error was in the conversion of units where, even with incorrect substitutions, the expressions miraculously led to the correct answer!

(b) (i) The majority recognised the phenomenon as being resonance. The most common incorrect response was 'damping'. However, in order to illustrate damping, a 'family' of curves would be necessary.

(ii) With few exceptions, the frequency was stated to be 8 Hz, although a small minority gave the answer as 4 Hz.

(c) Nearly all candidates recognised the need to increase the amount of damping. Suggestions to increase damping were frequently feasible although many failed to appreciate that the resonant frequency must not be changed. There were some who suggested either immersion in liquid or changing the springs or changing the mass.

Question 4

(a) (i) The majority of candidates appeared to know which formula to use but their mathematics failed them. For example, there is a widespread belief that $1/y + 1/x$ is equal to $1/(y + x)$

(ii) A similar problem as regards mathematical ability arose here. Many candidates gave an incorrect answer as a result of a failure to use basic mathematics. For example, $v_1^2 - v_2^2$ was assumed to be equal to $(v_1 - v_2)^2$.

(b) Candidates were awarded credit here if the formulae quoted in **(a)** were dimensionally sound. This was an occasion where explained work, despite being numerically incorrect, could be given credit.

Question 5

(a) (i) It was pleasing to note that most candidates could give a satisfactory statement and were able to explain why an e.m.f. would be induced.

(ii) Very few candidates scored any marks here. Most answers were vague and gave the impression that they were unaware as to why eddy currents would be formed. It was sufficient for candidates to realise that the rate of change of flux would not be the same over the whole of the disc, thus the e.m.f. would have different magnitudes in different parts of the disc.

(b) Some candidates did not read the question carefully and consequently attempted an answer in terms of forces, rather than energy. Of those who did discuss energy, most realised that the eddy currents would dissipate thermal energy in the disc. However, the links between this energy conversion and the disc coming to rest were rarely expressed convincingly.

Question 6

(a) (i) With few exceptions, candidates realised that a factor of $\sqrt{2}$ was involved. However, a significant number arrived at the answer of 4.2 V – a maximum value less than the r.m.s. value!

(ii) There were very few correct statements, and even fewer with some explanation. In most scripts, the answer given was the same as that in **(i)**, rather than zero.

(b) (i) Disappointingly, many drew a sinusoidal wave. Full-wave rectification was also common. Usually, the period was correct.

(c) (i) In approximately 50% of scripts, the capacitor was shown in an appropriate position.

(ii) Generally, this calculation caused few problems although a significant minority substituted the r.m.s. voltage, rather than the peak.

(iii) Very few candidates realised that the fraction could be calculated using 0.43^2. Most laboriously calculated the energy remaining and then found the ratio. There were numerous errors here. Many took the voltage to be 0.43 V, rather than 0.43 V_0. Others assumed that the charge in **(ii)** and **(iii)** would be the same.

Question 7

(a)(i) This was answered well by many. Some failed to mention that a photon is associated with electromagnetic radiation.

(ii) Very few candidates appeared to appreciate that the maximum kinetic energy is associated with an electron emitted from the surface and that, where an electron is below the surface, then energy is expended in bringing the electron to the surface, thus reducing its kinetic energy.

(b) Many argued that, with increased photon energy, each photon would be able to emit more electrons. The fact that the intensity is constant was ignored by most. Candidates are expected to realise that, when the frequency of the radiation is increased at constant intensity, then each photon will have more energy but the number of photons incident per unit time on unit area will be smaller.

Question 8

(a)(i) There were many correct answers here although a minority failed to include either N_A or 234 in the calculation.

(ii) Generally, this calculation was completed successfully, with candidates using their answer from **(i)**.

(iii) Despite being instructed to give the half-life in years (and the unit on the answer line being years), many left their answers in seconds.

(b) Most candidates did realise that the count-rate would appear to be constant because the half-life is long.

(c) Unfortunately, those who gave good answers in **(b)** seemed not to appreciate the consequence of having a short half-life. Very few candidates realised that the mass and/or the count-rate would change significantly while measurements were being made.

PHYSICS

Paper 9702/05

Practical 2

General comments

The general standard of the work done by the candidates was similar to last year, with a reasonable spread of marks. **Question one** was relatively straightforward, although some of the weaker candidates found the analysis section challenging. Candidates attempted **Question two** but found it difficult to obtain many marks. It would be helpful to candidates generally if attention could be drawn to the published mark schemes.

LDR's used by some Centres did not meet the specification. A few Centres used pins, which were not approximately 0.65 mm diameter. 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 one**. Supervisors are reminded that under **no circumstances** should help be given with the recording of results, graphical work or analysis.

Candidates seemed not to be short of time. Both questions were attempted, although most candidates poorly answered **Question two**. (A minority of candidates scored above 5/10 for this question.)

There were no common misinterpretations of the rubric.

Comments on specific questions

Question 1

In this question candidates were required to investigate how the resistance of an LDR depends on the number of holes made in the Aluminium foil placed above the LDR.

(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) Many candidates found difficulty in reading a 0-2 mA scale ammeter, resulting in a power of ten error in the resistance. These errors were then transferred to the table and consequently to the calculation in part **(g)**. Either candidates missed 10^{-3} for mA or used 10^{-6}. The R values resulting from these errors ranged from 10^{-2} to $10^{9}\,\Omega$.

(b) (iv) Most candidates were able to relate the significant figures in resistance to the significant figures in voltage and current (not just saying 'raw data'). Some candidates mentioned just one and these candidates were given credit if a valid reason was given (e.g.….because the current was recorded to the least number of significant figures.) Often the value of significant figures stated did not match up to the value recorded in **(b)(iii),** although this was not penalised.

(c) Virtually all candidates were able to tabulate six measurements of *N* and *R* with correct column headings. A few candidates had the wrong trend in I or *R* suggesting an incorrect circuit setup. Most candidates calculated *lg N* and *lg R* correctly. A minority of candidates calculated *lnN* and *lnR* and a few did not work out any log values. Some candidates failed to record their values of I and V in order to work out *R* (leading to a loss of two marks for consistency of raw data and column headings). Some worked out *R* to only 1 significant figure possibly in order to plot the graph more easily, resulting in a large scatter around the line of best fit. Appropriate unit in all columns headings (except *N* and *lgN*) and an appropriate number of decimal places in the raw data (*V* and I) was used by the majority of candidates.

Candidates were required to plot a graph of *lg R* against *lg N*. Most candidates used suitable scales, with the plots extending over half of the graph grid available. Compressed scales were penalised. A few candidates used scales that resulted in points lying beyond the grid area. Any plots off the grid are discounted. Very few candidates used awkward scales this time – these often result in mis-plotted points. Even with correct axes, it was surprising how many candidates mis-plotted points or who mis-read plots for the gradient. It is expected that candidates can plot and read values to the nearest half a small square.

(d) Most candidates were able to draw an acceptable line of best fit. The results provided more scatter around the line of best fit than previous years, so this mark was difficult to obtain. The key was making the pinholes close to the centre of the foil (as stated in the question). The amount of scatter about the line of best fit was centre specific. A minority of candidates who used analogue voltmeters with lower resistances often obtained plots describing a gentle curve, and if they made a reasonable attempt at a best fit straight line they were credited.

Some candidates used triangles to determine the gradient with hypotenuse lengths less than half the length of the line drawn. The majority of candidates read off points for the gradient correctly to the nearest half a small square.

Most candidates used substitution into y=mx+c in the determination of the y-intercept. This approach was not penalised but the y-intercept in the majority of cases could easily be taken from the graph. Many candidates when using the substitution route incorrectly, did not check the graph to see if their intercept value was reasonable.

(e) In the analysis section candidates were able to state the logarithmic form of the given equation. Most were able to equate the gradient with *b* and the *y*-intercept with log a. A few candidates had trouble then getting 'a' out using $10^{\text{y-intercept}}$ = a. Some candidates incorrectly used $e^{\text{y-intercept}}$ = a. Credit was given to a few candidates who got a and b interchanged on the answer lines but who showed full working in the space provided.

(f) (i) The majority of candidates failed to read the micrometer screw gauge correctly when measuring the diameter of the pin (errors being 0.5 mm too much to give 1.15 mm or incorrect addition (0.5 + 0.015 rather than 0.5 + 0.15 mm)). The mistakes lead to diameters significantly different from the Supervisor's value. Many candidates rightly repeated this measurement. However, in this experiment, the most unreliable reading was the tube diameter.

(f) (ii) The majority of candidates substituted the diameter to find the area correctly. A few candidates used πd^2 or $2\pi d$ to find the area incorrectly.

(f) (iii) The majority of candidates failed to repeat their measurement of the tube diameter. It was very difficult not to distort the tube when handling it, so at least two readings of the diameter were expected. A surprising number of candidates could not convert the value in mm to cm and vice versa.

(g) Few candidates gained credit for the value of R. There was much confusion of units resulting in power of ten errors, ranging from 10^{-14} to 10^{+15} Ω. Many candidates quoted the resistance to the correct number of significant figures (2 or 3).

Question 2

In this question candidates were required to design a laboratory experiment to investigate how the force of attraction between the capacitor plates depends on the potential difference across the plates.

It was expected that candidates would give a labelled diagram of the setup showing capacitor plates, a D.C. power supply and a voltmeter connected across the capacitor plates. An arrangement to measure the force (spring and scale, newtonmeter or top pan balance) was expected on the diagram. A good, well-annotated diagram could gain up to half marks for this question. Even a poor one received some credit, with the majority of candidates gaining credit for the DC supply and voltmeter placed in parallel with the plates. However some candidates put a voltmeter in series and an ammeter in parallel with the capacitor plates. Other candidates specified an alternating power supply.

It was expected that candidates would use a newtonmeter or top pan balance to measure the force between the plates. Only a minority of candidates gained credit here. Many candidates used charged particles (oil drop, electron or alpha particle) fired in between the plates when in fact they were finding the force on the charged particle as opposed to that between the plates. (These candidates incorrectly used E = V/d and F = Eq to find the force between the plates). Some candidates incorrectly based their calculation on measuring force by using the charging current where F = (V/d) x I x t. Some candidates incorrectly used a Hall probe to measure the force. In these cases, no marks were credited for the measurement of the force. Candidates were still able to access the procedural marks.

Some candidates were awarded a mark for changing the voltage by changing the power supply, however the majority of candidates used a variable resistor to change the voltage, which changes the rate of charging the capacitor plates to the same voltage. Candidates also suggested changing the distance between the plates as a way of changing the voltage. This did not gain credit. Credit was given for a correctly connected potentiometer.

Many candidates gained credit for the procedure: measure a voltage, find a force, change the voltage and repeat the experiment tabulating the results and drawing a graph. This mark should be accessible to all candidates as it is awarded even if the method is unworkable. Many candidates gained credit for suggesting that the distance between the plates should be kept as small as possible or that high voltages should be used to give a measurable force. Some candidates incorrectly referred to charging/discharging capacitors.

The mark for safety was rarely awarded as a precaution was needed together with a reason e.g. use rubber gloves to avoid electric shock. Candidates often discussed the plates getting too hot implying a current was flowing or just said ‘do not touch’.

Marks for good further detail were available and were rarely gained, the most common creditworthy points were to keep the distance between the plates constant and to fix the top of the newtonmeter and the lower plate.

PHYSICS

Paper 9702/06

Options

General comments

There was a small number of very good scripts. However, the general performance was very much as in previous sessions.

There were some candidates who scored very low marks. These candidates had attempted to answer the questions but it was clear that they had very little understanding of basic concepts. There were other candidates who produced creditable performances.

As in previous sessions, Options F and P were the most popular. There was no evidence that the vast majority of candidates had insufficient time to complete their answers.

Comments on specific questions

Option A

Question 1

(a) Generally well answered with two distinct points being made. Some candidates had, quite clearly, read recent literature relating to the definition of planets.

(b) Nearly all candidates defined what is meant by the AU. However, many then failed to come to a satisfactory conclusion. Rather, they repeated what was written in the question.

Question 2

(a) It the majority of answers, it was realised that the source would be moving away from the observer for the effect to be observed. It was common for candidates to state that ‘the light would be shifted to the red end of the spectrum’. This is, of course, untrue. The wavelength of the emitted radiation has a longer wavelength than when the source is stationary with respect to the observer. Very few scored the third mark for the comparison with the stationary source.

(b) It was pleasing to note that many candidates realised that the extent of any redshift is dependent on the ratio v/c. However, rather than state that v must be significant when compared with c, the usual answer was that ‘v must be fast/large’.

Question 3

(a) Many candidates gave answers that implied a geocentric Universe, and thus lost marks.

(b) The calculation was completed competently in most scripts. However, some candidates did make errors when converting Mpc to metres that gave rise to ridiculous answers. Such answers did not seem to alarm these candidates.

Question 4

(a) Most candidates either gave the answer that dark matter does not reflect/emit light or they did not appear to understand the question.

(b) Many candidates did not read the question carefully and continued to attempt to discuss dark matter. Others did make reference to the unreliability of estimates for the mass and the extent of the Universe. However, although suggestions were made, very few answers included any form of explanation.

Option F

Question 5

(a) As always with such questions, the streamlines were drawn carelessly. Candidates drew streamlines that touched each other and had sudden changes of direction. Also, it has to be assumed that in many diagrams, it was thought that the object represented an aerofoil because streamlines were drawn to provide lift.

(b) In many answers, a reference was made to the separation, or corresponding length, of the streamlines. However, it was clear that candidates did not relate this fact to their diagrams in **(a)**.

Question 6

(a) There were many attempts to answer the question by reference to the metacentre. Some candidates did mark the position of the centre of buoyancy. However, very few attempted to discuss why the tube would stay upright by reference to the restoring torque provided by the weight and the upthrust. Some candidates wrote as if the centre of gravity and the centre of buoyancy were, in fact, forces.

(b) With few exceptions, the derivation was given no credit. In many instances, there was no explanation and the proof amounted to a series of incomplete algebraic expressions. It was common to find that the relation *density* = *mass/volume* was quoted and then the mass of the tube and the density of the liquid were substituted without any further comment.

(c) In general, candidates were able to manipulate the relevant expression. However, many left the answer as the new submerged length, rather than the change in length.

Question 7

(a) There were some very good answers, scoring maximum credit. Some candidates confused upthrust and drag and others who found difficulty in understanding that, as the speed increases, the acceleration decreases.

(b) There were many answers that related to a cricket ball with terms such as 'swing' and 'lift'. In a significant number of answers it was not stated that the liquid is dragged along at the surface of the sphere. Others identified areas where there would be turbulence and then invoked the Bernoulli principle to explain why the turbulence would give rise to pressure changes!

Option M

Question 8

(a) As is usually the case, some confused the use of ultrasound with its generation. There were some good accounts but frequently, credit was lost because no mention was made as to how the reflected ultrasound pulse is detected.

(b) Many thought that ultrasound probes with multiple crystals are used so that either a range of frequencies is available or a greater intensity of ultrasound is produced. The possibility of building up a 2D image was appreciated by very few.

Question 9

(a) In many scripts, all of the relevant points were given but rarely under the correct sub-section. Examiners gave credit, regardless as to whether the point was written in **(i)** or **(ii)**.

(b) There was much confusion between the terms *iris*, *pupil* and *aperture*. Most candidates realised that the diameter of something would vary with change in light intensity. However, very few could give any further relevant comment.

Question 10

(a) In most scripts, the calculation was completed successfully and the limits of the frequency range were identified correctly.

(b) Two changes were required. In some scripts, three were given. A significant number sketched an appropriate line on Fig. 10.1 for which they received full credit.

Option P

Question 11

(a) The majority of candidates answered all three sub-sections very satisfactorily. In **(iii)**, some made reference either to containment or to shielding but not both.

(b) This was answered poorly. In most scripts there was, at best, a reference to the coolant carrying away thermal energy. In many accounts, the impression gained was that the coolant remains static within the reactor vessel. Very few candidates made any mention of the kinetic energy of the fission fragments/neutrons.

(c) Many candidates were under the false impression that nuclear fuel provides a renewable source of energy, that nuclear reactors are more efficient and that they do not cause any pollution. In general, the only mark scored here was for a reference to carbon dioxide or greenhouse gases.

Question 12

(a) This calculation presented very few problems, apart from the conversion of cm^2 to m^2.

(b)(i) Candidates were divided between the correct answer (large surface area) and 'expense'.

(ii) There were numerous answers where the orientation of the solar cells was discussed. A very common misconception was that connecting cells in series would increase both the e.m.f. and the current.

Question 13

(a) Many failed to realise that 30% of the power, not 27%, would be delivered to the motor. Otherwise, the calculation presented very few problems.

(b) There was a widespread misconception that desalination is a form of electrical energy generation. Most candidates did realise that thermal energy is required but the use of the production losses, rather than distribution losses, was frequently not made clear.

Option T

Question 14

(a) In general, explanations were good.

(b) The relevant formula was quoted in most scripts. However, a significant number of candidates failed to include a (–)ve sign and thus obtained an answer of approximately 10^{20} W!

(c) 'Frequency change' triggered a response based on FM in some scripts. Many did refer to swamping and attenuation. However, it was common to find that it was not made clear what was being swamped. Some used the term 'swapped' and answered in terms of the signals being mixed.

Question 15

(a) The majority of answers were satisfactory. However, it was disturbing to note that a significant minority had no real understanding of what is meant by modulation.

(b)(i) The vast majority gave the answer as 4470 Hz, rather than 9 kHz.

(ii) In a significant number of answers, the wavelength range in metres was divided by the bandwidth in hertz.

(c) The majority of diagrams that were recognisable showed a power spectrum for a single signal frequency.

Question 16

This was, in general answered well with most candidates scoring all three marks.