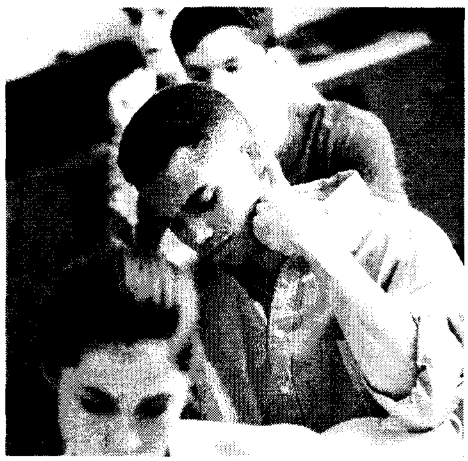
CAMBRIDGE
INTERNATIONAL EXAMINATIONS

**Physics**
**SR11 (IJ) 2001**



**Report on the June 2001 Examination**

UNIVERSITY *of* CAMBRIDGE
Local Examinations Syndicate

# PHYSICS

## GCE Advanced Level

**Paper 9243/01**
**Multiple Choice**

| *Question Number* | *Key* | *Question Number* | *Key* |
|---|---|---|---|
| 1 | **B** | 16 | **A** |
| 2 | **A** | 17 | **A** |
| 3 | **A** | 18 | **C** |
| 4 | **A** | 19 | **D** |
| 5 | **D** | 20 | **B** |
| 6 | **C** | 21 | **B** |
| 7 | **D** | 22 | **D** |
| 8 | **B** | 23 | **D** |
| 9 | **C** | 24 | **A** |
| 10 | **A** | 25 | **C** |
| 11 | **B** | 26 | **C** |
| 12 | **C** | 27 | **B** |
| 13 | **B** | 28 | **B** |
| 14 | **A** | 29 | **D** |
| 15 | **C** | 30 | **A** |

**General comments**

The mean score was 17.8 out of 30, slightly lower than last year; the standard deviation was 6.2. The number of candidates scoring full marks was 16, whilst over 9% scored 27 or more; at the lower end 10% had fewer than 10 correct. Although these figures are not quite as good as in previous years they still indicate a high standard by the majority of candidates.

**Comments on specific questions**

**Question 3**

The option **B** was the most common wrong answer, particularly amongst the weaker candidates. This is obtained by assuming that the stone falls from rest for 10m.

**Question 15**

This question had the largest number of correct answers (79%), although it was not one of the most straightforward to answer. The candidates had been well prepared to tackle circuit calculations.

**Question 16**

Only 32% of candidates obtained the correct answer **A**, but 39% chose **B.** This shows a lack of understanding of charging by induction, and also a failure to appreciate that lines of electric field begin on positive charges and end on negative ones. The question did not discriminate well between stronger and weaker candidates.

**Question 21**

The correct answer **B** was chosen by 42% of the candidates but the option **C** was selected by 44%. This shows confusion with the r.m.s/peak relationship. The first sentence of the question is in effect the definition of r.m.s. The question discriminated well.

**Paper 9243/02**

**Theory (Core)**

## General comments

The paper discriminated well but nevertheless most candidates could access the majority of the paper. There was a reasonable mix of mathematical and non-mathematical questions and these frequently enabled candidates to score high marks, even if the candidate was not particularly able mathematically. Candidates almost invariably do not score as well on descriptive questions and usually this is because they do not write well reasoned answers. There were a significant number of candidates who appear to have had little experience of practical work. These candidates often make unrealistic suggestions and are frequently unable to apply their knowledge of physics to unfamiliar situations. This year there was an increase in the number of candidates who did not complete the paper. This usually was because a candidate had apportioned his or her time badly. Some of the descriptive questions were answered much too lengthily and **Question 2** often appeared to take candidates a long time (Many candidates drew the scale diagram and then spent a great deal of time with the trigonometry of the figure to get a theoretical answer. It took even longer if their two answers did not agree with one another.) Since the final question on this paper carries 20 marks candidates would be well advised to answer it first and if necessary omit a question carrying fewer marks.

## Comments on specific questions

**Question 1**

Candidates generally scored well on this question, provided they had covered the work. The majority of marks were lost by not mentioning the temperature gradient necessary for thermal conduction and the change in density in part **(a)**. Many answers on conduction appeared to suggest that heat flow is associated with electron flow in such a way that one end of the conducting material must become electrically charged. Only better candidates recognised that radiation would increase for **(c)**. Any rise in the temperature of the filament will take place rapidly until a new equilibrium temperature is established. Many candidates' answers implied that the filament temperature rises ad infinitum.

**Question 2**

This question was again well done, although many stated that a body must be stationary in order to be in equilibrium and therefore did not give the resultant torque on the body as zero, and the vector diagram caused some problems. A disappointing number of candidates lost the mark for **(b)(i)** by not giving the appropriate unit for weight.

**Question 3**

Several candidates said that there must be an acceleration due to there being a centripetal force, without making the connection with speed and velocity, and few candidates illustrated their answer with a vector diagram showing that the change in velocity is directed towards the centre. In part **(b)** candidates generally failed to recognise that if the maximum sideways force is 0.8W, then the radius ought to be the same for all vehicle masses. The key point is that a torque is applied to the vehicle and if it has a high centre of gravity then it could topple over. Candidates tended to say that because the lorry was heavier, then a smaller speed was necessary.

**Question 4**

Parts **(a)** and **(b)(i)** were answered well but **(b)(ii)** proved very difficult, and few candidates scored the two marks. Most identified damping as a cause, or simply that the concrete would change the resonant frequency. The mark scheme required that two marks could only be gained by the candidate who stated that the extra mass reduced the resonant frequency so that it was lower than the speed of rotation of the drum.

**Question 5**

This relatively straightforward question was very badly done by very many candidates. Those candidates who understand electrical circuits had no difficulty with the problem but many scored only 2 or 3 marks for the whole question and a significant minority scored zero.

**Question 6**

Part **(a)** was well done by all but the weakest candidates. Part **(b)** depended largely on the mathematical competence of the candidates. These candidates rarely noticed if their answer was ludicrously impossible, perhaps as a result of having a number in a numerator when it should have been in the denominator. A surprising number of candidates used the mass instead of the weight.

**Question 7**

Generally, a low scoring question. Part **(a)** scored well, although many candidates confused e.m.f. and current being induced. Candidates usually knew Lenz's law but could not explain how it was effectively a statement of the law of conservation of energy as applied to the production of an induced current. Part **(c)** scored very badly, and this really was a differential question between the more able and weaker physicist.

**Question 8**

The calculation was straightforward, and if candidates had covered the material and understood the calculations, they scored easily. A surprisingly large number of candidates talked about the energy levels of electrons in atoms being responsible for the difference in part **(b)**. Too few candidates were aware of the experimental determination of the kinetic energy for the last part of **(b)**. Candidates tended to score either all or none of these marks.

**Question 9**

One Examiner wrote in his report 'This question proved interesting because some candidates who had scored poor marks on other questions scored good marks on this one, while others scored poor marks on this question having scored high marks on the other questions'. Apart from the time factor mentioned above there were two other main problems which arose with this question. First, measurement of time in hours and minutes seemed to confuse many candidates. For example, it was not unusual to see 1046 – 0824 = 0122, which was then treated as 1.22 hours rather than 1 hr 22 min (1.37 h). Secondly, and this contributed to the time problem, there were far too many candidates who, instead of answering part **(c)** quickly as, say, 80 km in 82 s = 0.975 km min-1 found seven separate speeds and took an average of these speeds – just ignoring the stationary interval. Most candidates could answer parts **(a)**, **(b)**, **(d)** and **(e)**, but there were fewer who could proceed to **(f)** with confidence. Answers to part **(g)** were disappointing. Too many candidates confused speed with acceleration and many stated that the trains all had zero acceleration all the time. It was very rare to read that the graph showed that the trains had infinite acceleration when leaving a station. Those candidates who reached the end of the question could usually insert an additional train timetable – but some of them were travelling extremely fast and others were destined to crash every day.

**Paper 9243/03**
**Theory**
**(Core and Options)**

## General comments

The paper provided the opportunity to obtain a satisfactory mark by the recalling of basic definitions and principles and applying these to the solution of straightforward calculations. Additionally, there were more searching parts to questions, providing adequate discrimination between better candidates.

The choice of questions in ***Section A*** was fairly evenly distributed, although **Question 1** was the most popular, but not necessarily the highest scoring. In ***Section B***, **Questions 10** and **12** were the most popular. **Questions 8** and **13** attracted very few candidates.

There was an increase in the number of scripts where more questions were answered than was stated in the rubric. Examiners are instructed to mark all the work and give the highest mark consistent with the rubric. However, candidates should realise that they handicap themselves by not spending more time on the required number of questions.

Candidates appeared to have sufficient time to complete their answers. The overall level of presentation was about the same as in previous sessions.

## Comments on specific questions

### *Section A*

### Question 1

**(a)** With very few exceptions, linear momentum was defined satisfactorily.

**(b)** In part **(i)**, most candidates realised that the collision is inelastic. However, very few discussed the relative speeds of approach and separation. Many merely stated that the spheres stuck together. Some tried, unsuccessfully to base their argument on conservation of kinetic energy. In part **(ii)**, many candidates had difficulty in considering each sphere separately, and there were many sign errors. Those candidates who, in part **(iii)** ignored the instruction to use the answers from part **(ii)**, frequently wrote down a correct expression for momentum conservation. Those who used their answers from part **(ii)** often equated the changes in momentum rather than equated their sum to zero.

**(c)** In part **(i)**, almost all candidates knew that elastic collisions are assumed. However, the vast majority then said that the momentum of the atom would be conserved. A minority did say that the atom had changed direction, giving rise to a change in momentum. Very rarely was a mention made of the fact that the atom is not an isolated system. In part **(ii)**, most candidates did indicate that the speed would be reduced, although their reasoning was frequently flawed. However, when deciding that the temperature would fall, very few made a clear statement relating mean kinetic energy to thermodynamic temperature.

**(d)** The equations given in part **(i)** usually included appropriate symbols. However, candidates must be encouraged to explain clearly the direction in which each change is taking place. In most answers, it was stated that work is done by the gas on expanding, but few argued that there is no change in thermal energy. Most concluded, with or without justification, that the internal energy would decrease, resulting in a decrease in temperature.

### Question 2

**(a)** In general, both definitions were satisfactory, although many did not make reference to positive charge. Similarly, most candidates associated the gradient of the graph with field strength, but there was no reference to direction.

**(b)** Only a minority pointed out that the work done in moving a unit mass from infinity towards the surface of an attracting body is negative. Most merely stated that the potential is greatest at infinity, and since the value at infinity is zero, then all values must be negative. In part **(ii)**, most candidates did relate the gradient to gravitational field strength but then, disappointingly, did not relate field strength to the acceleration of free fall. In part **(iii)**, most candidates correctly identified the point of zero acceleration. However, although many answers indicated that the gradient of the graph was being used to find the acceleration on the surface of Charon, there were comparatively few correct answers, either through not reading the graph correctly or using the co-ordinates of a single point.

**(c)** In many scripts, no significant attempt was made at this section. Of those who did, many equated gravitational potential to kinetic energy or attempted to use the equations of uniformly accelerated motion. In part **(ii)**, very few candidates realised that the important point is difference in the change in potential between the surface and the peak for the two objects.

*Answers*: **(b)(iii)** $13.7 \times 10^6$ m, 0.052 m $s^{-2}$; **(c)(i)** 940 m $s^{-1}$.

**Question 3**

**(a)** In part **(i)**, imprecise expressions such as 'the particles move at right angles to the wave motion' were far more common than answers based on the oscillations of the particles being in a plane perpendiular to the direction of propagation of wave energy. The standard of the drawing of sketch graphs has improved. However, marks were lost through poor labelling of axes. In particular, an *x*-axis labelled 'time' cannot be used to illustrate what is meant by wavelength. The derivations in part **(iii)** were disappointing in that the vast majority were no more than a collection of formulae without explanation. The most convincing answers consist of a definition of each of the quantities involved, from which the formula then follows logically.

**(b)** Usually, there was a reference to waves 'meeting' but then, many answers involved resultant amplitude, rather than resultant displacement.

**(c)** Part **(i)** presented very few problems. In part **(ii)**, a variety of calculations were used, many leading correctly to the required result, but others floundering in a muddle of symbols and numbers. Very few candidates failed to decide that, when crest meets trough, the resultant amplitude is zero. Although most realised that there would be a variation in loudness, many failed to make it clear that the change would be continuous, not intermittent.

**(d)** As is usual, few candidates referred to a constant phase difference. Most discussed 'same frequencies' or 'in phase'. Very few candidates explained that two continuous waves of slightly different frequencies would result in identifiable slow changes in phase angle.

**Question 4**

**(a)** In general, capacitance and resistance were adequately defined, the most common error being a failure to make it clear that ratios are involved.

**(b)** Part **(i)** was answered poorly. Most stated that current would flow until the capacitor is fully charged. It was not made clear that charge moves from one plate of the capacitor to the other through the resistor and that moving charge constitutes a current. Part **(ii)1** presented few problems. However, in **(ii)2**, although many stated that the p.d. across the capacitor would rise, comparatively few then discussed the change in p.d. across the resistor with consequent decrease in current.

**(c)** The straightforward calculations posed no significant problems to the large majority of candidates who remembered the relevant formulae.

**(d)** A very common error was to assume that the charge calculated in **(c)(iii)** would be the charge on the new capacitor. Very few mentioned that they were assuming that the charge on the isolated capacitor remains constant during the reduction in capacitance. In part **(ii)**, few answers involved the principle of conservation of energy to explain that the increase in energy of the capacitor resulted from work done to decrease the capacitance of the capacitor.

*Answers*: **(c)(i)** 3.6 V, **(c)(ii)** 2.4 V, **(c)(iii)** $3.4 \times 10^{-5}$ C, **(c)(iv)** $4.0 \times 10^{-5}$ J; **(d)(i)**17 V, $7.1 \times 10^{-4}$ J.

**Question 5**

**(a)** The relationships were known by most candidates.

**(b)** In part **(i)**, most candidates confirmed the value given for the extension, but explanation was sometimes less than adequate. The calculations in part **(ii)** presented few difficulties although there was some confusion with units and the use of mass, rather than weight, when calculating the stress.

**(c)** Most sketches showed a straight line graph passing through the origin. In the derivation, it was common to find that it was not made clear what area represented the strain energy. The calculation was completed successfully, apart from some confusion with units and weight/mass.

**(d)** A significant number of candidates did not attempt this section, but of those who did, most arrived at a satisfactory answer. The most common error was confusion between the mass of the wire and the mass of the weight. In part **(ii)**, relatively few discussed the small compression of the hammer head at each impact and the cumulative effect of the transfer of the resulting strain energy to thermal energy. Many gave very superficial answers such as 'the kinetic energy of the hammer is converted into heat'.

*Answers*: **(b)(ii)** $1.1 \times 10^8$ Pa, $8.6 \times 10^{-4}$, $1.3 \times 10^{11}$ Pa; **(c)(iii)** 0.054 J; **(d)(i)** 0.021 K.

**Question 6**

**(a)** Many candidates scored full marks in this section. There was little confusion when discussing neutrons, protons and nuclear notation.

**(b)** In part **(i)**, many candidates repeated what is in the question i.e. 'decay by $\beta$-emission'. The idea that a free neutron is not stable appeared to cause confusion. As is usual, explanations of half-life mostly referred to the halving of some appropriate characteristic, but only a few made a reference to one particular isotope, thus eliminating any effect produced by a daughter product. In part **(ii)**, it was common to find that the nuclear equation did not 'balance'. However, in part **(iii)**, candidates indicated that they were practiced at such calculations and the only errors were arithmetic.

**(c)** With few exceptions, the sketch graphs were the correct shape, but little regard had been given to the position of the peak or the relative slopes on each side of this peak. Explanations were poor. There was confusion between fission and fusion. Of those who did discuss fusion, there was insufficient detail given as regards the relative masses of the nuclei involved. Furthermore, there appeared to be very little understanding of the relative changes, or values, of binding energy per nucleon and total binding energy.

**(d)** Most candidates gave the correct equation, but a significant minority ignored, or wrongly identified, the emitted neutron. Some did suggest that the instability of the superheavy nucleus is due to an inappropriate ratio of neutrons to protons or, more commonly, low binding energy per nucleon. Of those who did attempt the final part of the question, many gave the nuclear notation of the resulting nucleus, rather than the number of protons and of neutrons.

*Answer*: **(b)(iii)** $1.3 \times 10^{-13}$ J.

***Section B***

**Question 7**

**(a)** Most answers were inappropriate and revealed some serious flaws in candidates' understanding e.g. the distance across the Universe being smaller than the distance to the nearest galaxy.

**(b)** This lack of understanding was also seen in part **(i)**. Most candidates gave a series of unrelated events, some not even relevant to the specified period. In part **(ii)**, candidates were expected to discuss the difficulty of reproducing the conditions, such as temperature, that existed at that time.

**(c)** This section was where candidates scored most of their marks in this question. Sensible suggestions were made by most candidates in parts **(ii)** and **(iii)**.

**Question 8**

**(a)** In part **(i)**, most candidates drew a diagram for a hexagonal close-packed lattice. The understanding of what is meant by a Bravais lattice was highly suspect and sketches frequently lacked detail as to angles and lengths.

**(b)** With few exceptions, the outlines were adequate. However, there is general confusion between the terms 'dead hard', 'strong', 'tough', 'hard' 'brittle' and 'ductile'.

**(c)** Some candidates gave very good descriptions of creep, but a significant number confused creep with fatigue.

**Question 9**

**(a)** This section was answered well by nearly all of the candidates who attempted the question.

**(b)** In part **(i)**, the impression gained was that there was guesswork on the part of some candidates. In part **(ii)**, most gave the correct value for the e.m.f., but explanation was frequently inadequate. Apart from the minority who confused this amplifier with the non-inverting amplifier, there were very few problems encountered with the calculation.

**(c)** Most candidates scored full marks in parts **(i)** and **(ii)**. However, in part **(iii)**, some forgot that output A would also be at logic 1.

*Answers*: **(a)(i)** 3.0 V, **(a)(ii)** 3.27 V, **(b)(iii)** 140 kΩ.

**Question 10**

**(a)** Streamline diagrams were generally very poor. Little attention had been paid to the relative spacing of the lines, symmetry or continuity where appropriate, and direction.

**(b)** This was well answered by many candidates. Weaker candidates confused upthrust and apparent weight and thus equated drag force with upthrust in part **(iii)**. The most common errors were in the formula for the volume of a sphere and confusion over mass and weight.

**(c)** Almost all candidates were aware of the Bernoulli relationship though their reasons for applying this concept to the spinning ball were sometimes obscure. Frequently, candidates made reference to regions of 'high' and 'low' pressure, without specifying where on the ball these would be located.

*Answers*: **(b)(ii)** $4.3 \times 10^{-4}$ N, **(b)(iii)** 1.5 kg $m^{-1}$ $s^{-1}$.

**Question 11**

**(a)** In part **(i)**, the effects of ionising radiation were generally vaguely expressed and often went little beyond stating 'causes cancer' or 'kills cells'. The use of the filter to remove low-energy photons and thus reduce exposure was rarely understood.

**(b)** In part **(i)**, the intensity calculation caused very few problems. However, in part **(ii)**, very few candidates had any understanding of the situation and many of the claims made for the use of the short focal length lens were the reverse of the truth.

**(c)** There were wide differences in the suggested frequencies, but most were of the correct order of magnitude. In part **(ii)**, intensity level was defined correctly, though opinions were divided as to the effect of its use on the *y*-axis. Very rarely was there any mention that the scale on the axis for intensity would be logarithmic.

*Answer*: **(b)(i)** $1.3 \times 10^{9}$ W $m^{-2}$.

**Question 12**

(a) In part **(i)**, many candidates merely stated that a fuel would provide thermal energy when burned. In part **(ii)**, most answers contained something of merit, but it was often hidden in verbose padding.

(b) With few exceptions, the derivations were little more than a series of unexplained lines of formulae, some totally irrelevant. Diagrams were omitted or very poorly drawn and there was much dubious algebra to arrive at the expected relation. Substitution in the formula for part **(ii)** was more successful and most candidates gave at least one sensible suggestion in part **(iii)**.

(c) Although most candidates could recall the expression for the efficiency, the vast majority substituted temperatures in degrees Celsius rather than kelvin. Most candidates made a sensible suggestion as to how to improve the efficiency.

*Answers*: **(b)(ii)** 59 kW, **(c)(i)** 52 %.

**Question 13**

(a) Modulation was generally well understood although it was rarely made clear what remains constant in AM and FM. Advantages and disadvantages were, in general, quite well known.

(b) Although candidates knew that optic fibres are subject to less attenuation and less noise than metal cables, relatively few were able to quantify the comparison or discuss the effects.

(c) Answers generally had some substance but equally, many revealed misconceptions about communication both by ionospheric reflection and satellites, indicating a lack of understanding of the subject.

**Paper 9243/04**

**Practical Test A**

## General comments

The paper produced a wide range of marks (most in the range from ten to the mid-forties). It was very pleasing to see a number of candidates scoring full marks. As in previous years it was quite clear that some Centres had prepared their candidates extremely well for this paper.

Candidates appeared to have sufficient time to complete all the questions on the paper.

The weaker candidates continue to find the design questions, **Question 3** and **Question** 4 difficult. It may be helpful in the future if candidates were able to have the opportunity to try out some simple investigations in the laboratory.

## Comments on specific questions

**Question 1**

In this question candidates were required to construct an equilateral triangular wire framework and measure the natural frequency of oscillation of the framework as the length of side of the framework changes. Nearly all candidates were able to do this experiment without help from supervisors.

Most candidates were able to take six sets of readings of $t$ and $L$ for a specified number of oscillations of the framework and present their results in tabular form. Most candidates repeated the readings. Sometimes units were not included with the headings in the table, or the units were incorrect. This was usually at the head of the column of values for $f^2$(Hz was given instead of $Hz^2$ or $s^{-2}$). Some of the weaker candidates are still including the unit with the value in the body of the table, which is not considered to be good practice. A number of candidates became muddled between frequency and period and tabulated values of $T^2$ instead of

$f^2$. Some of the weaker candidates attempted to count the number of oscillations in a specified time. This was considered to be poor procedure and was not condoned.

Candidates are expected to record their results consistently. This means that all of the values of $L$ should be given to the nearest millimetre (since a rule with a millimetre scale is being used to make the measurement), and values of $t$ should be given to the nearest 0.1 s or 0.01 s. The most common error was to give the values of $L$ to the nearest centimetre instead of the nearest millimetre.

Candidates were asked to justify the number of significant figures that they had given for $1/L$. There continues to be much confusion in this area. Some candidates gave answers in terms of decimal places and not significant figures, whilst others stated that they were going to plot a graph and so only needed three significant figures. $1/L$ is a calculated value, and as such is dependent on the precision of the raw data from which it has been calculated. Candidates are not expected to state anything more than this. All that was wanted was a simple statement to this effect (e.g. 'since $L$ is measured to three significant figures it follows that $1/L$ should be quoted to three significant figures'). Some of the more able candidates illustrated their answers by showing that a change in the third significant figure in the value of $L$ produced a change the third significant figure in the value of $1/L$.

Candidates were required to plot a graph of $f^2$ against $1/L$. Most candidates chose sensible scales where the plotted plots occupied at least half the graph grid in both the $x$ and $y$ directions. A number of weaker candidates used compressed scales, or chose intervals that were difficult to work with (e.g. three units corresponding to ten small squares). Awkward scales makes the plotting of points difficult and candidates who had used scales of this type often made plotting errors. It is expected that candidates will plot points to an accuracy of half a small square. Most candidates were able to draw a reasonable line of best fit and determine the gradient of the line. Occasionally errors were seen in the calculation (usually $\Delta x/\Delta y$ instead of $\Delta y/\Delta x$) although the most common problem was in reading the co-ordinates of the vertices of the triangle from the scales. A number of candidates used very small triangles. This was not acceptable as the uncertainty in $\Delta y$ and $\Delta x$ was considered to be too large. It is expected that the triangle used will be such that the length of the hypotenuse is greater than half of the length of the line which has been drawn.

The Examiners judged the quality of the candidates' results by the scatter of points on the graph. Candidates who had done the experiment carefully (i.e. little scatter of points on the graph) were rewarded here.

In the analysis section candidates were expected to equate the gradient of the line with $\frac{g\sqrt{3}}{2\pi^2}$ and rearrange the expression to give a value for $g$ with an appropriate unit. A value for $g$ in the range from 9.2 m s$^{-2}$ to 10.4m s$^{-2}$ was expected. It was pleasing to see many able candidates scoring here, although weak candidates often did not attempt the analysis at all. A number of candidates substituted values from the table into the equation to find a value for $g$. This was not considered to be good practice and was not allowed. Part **(e)(iii)** directs candidates to 'use your answer from **(ii)** to calculate a value for $g$'.

In the last section candidates were expected to use the thicker wire to investigate the effect of mass per unit length of the wire on the natural frequency of oscillation. Most candidates took a further measurement using the thicker wire, but a number of the weaker candidates did not realise what was wanted. The more able candidates compared the value for the frequency with that for the same length of thinner wire (realising that the frequencies were very similar thus the model may be successful in predicting the frequency of oscillation of the heavy framework).

**Question 2**

In this question candidates were required to discharge a capacitor through a resistor and measure the time taken for the discharge current to halve as the resistance of the resistor was changed.

Most candidates were able to set up the circuit correctly and obtain seven sets of readings for the discharge time. A number of weaker candidates were not able to find all the possible combinations of resistors (31.3kΩ usually omitted). This resulted in one of the three measurement marks not being awarded. A number of weaker candidates found the calculation involving fractions difficult, and these candidates only gave three values for the resistance (47 kΩ, 94 kΩ, and 141 kΩ).

Candidates were expected to repeat the readings for the discharge time, and this was usually done. Candidates who performed the experiment with reasonable care were rewarded with a 'quality of results mark', (as judged by the scatter of points on the graph).

Most candidates presented the results in tabular form with correct column headings.

Candidates were required to plot a graph of discharge time against resistance. Generally this was done better than in question one, although similar comments to those made in question one apply. Many weaker candidates made life difficult by choosing to use very awkward scales. The *y*-intercept was not easy to find (since it was such a small value), but most candidates were successful in reading the value from the graph to half a small square.

Most candidates were able to equate $C \ln 2$ with the gradient and $k$ with the *y*-intercept. The value of $C$ was sometimes not within the required range (800 μF to 1200 μF). This was usually because candidates had used values for resistance in Ω instead of kΩ. Most candidates were able to give correct units for $C$ and $k$ (F or s $\Omega^{-1}$ for $C$ and s for $k$).

**Question 3**

In this question candidates were given a 'scene setting' situation involving a golf ball, and then asked to design an experiment to investigate how the force acting on a stationary golf ball due to the air flowing past it depends on the speed of the air. Candidates were given a list of apparatus from which they were expected to make an appropriate selection. As in the past, some 'extraneous' pieces of equipment had been included.

The more able candidates suggested suspending the ball from the Newton meter in stationary air and then in moving air (using a vertically mounted pipe with a fan at one end). The two readings from the Newton meter were subtracted to obtain the drag force. It was usually suggested that this would be repeated for a variety of different airspeeds. Answers of this kind from the more able candidates were common, and many scored full marks.

Other workable arrangements includea suspending the ball from a string and blowing a horizontal stream of air at the ball from the blower. The angle would be measured and a 'triangle of forces' idea applied to calculate the drag force.

Weaker candidates were unable to give workable arrangements of the chosen apparatus. Usually the tube was employed horizontally to blow air onto a ball resting on a horizontal surface. The distance moved by the ball was measured and light gates were employed to find the time. The equations of uniformly accelerated motion were then used to find the acceleration. $F = ma$ was then applied to the ball. This method was not acceptable.

Other candidates suggested dropping the ball into the pipe and measuring the acceleration in a similar way. This method was also not allowed either as the relative velocity of the ball with respect to the air changes (the question instructs candidates to design an experiment on a *stationary* golf ball).

Other suggestions including mounting a spring vertically with the ball *above* the spring, and the spring somehow 'attached' to the fan. This was considered to be unworkable. Sometimes the pipe had been used to blow the air horizontally at a horizontal Newton meter with a ball attached by string. No mention was made of the weight of the ball, and this method was also deemed unworkable.

The very weak candidates had little idea of how to design an experiment at all. A number of scripts were seen where the golf club had been connected to the power supply or the experiment had been done underwater. Some candidates thought that the radar gun should be used to fire the ball. Other candidates suggested performing the experiment in a vacuum to reduce the air resistance (?).

Two marks were available for 'good further detail'. Some examples of creditworthy points made by candidates are as follows:

- Use the airspeed meter and the ball separately, so that one does not affect the other.
- Take readings from the airspeed meter at different times to ensure that the windspeed remains unchanged.
- Position the airspeed meter at the same point in the pipe as the ball.
- Allow the system to come to equilibrium before readings are taken.

**Question 4**

In this question candidates were given a situation involving a photocell and asked to design an experiment to investigate how the useful power output of the photocell varies with angle which the incident rays make with the surface of the cell.

Many candidates gave a circuit diagram showing a voltmeter and ammeter connected to the photocell, but no load resistance was shown.

Descriptions of how the angle would be measured accurately were rare. Often candidates omitted this part completely, or simply suggested 'use a protractor to measure the angle' with little further detail. Some candidates suggested the use of a spectrometer, but again, gave little or no further detail.

Many candidates were able to suggest that the power could be obtained by multiplying the voltmeter reading by the ammeter reading (or $I^2R$ if a known resistor had been employed).

Candidates are expected to give some thought to control of variables in this experiment. Explicit statements are required. Candidates needed to state that the intensity of the light should remain constant throughout the experiment and that the distance from the source to the photocell should also remain constant.

As in the previous question, two marks were available for what was considered to be 'good further detail'. Many candidates were able to gain at least one of these marks by stating that the experiment should be done in a darkroom so that background light would not affect the results. Examples of other points, which were given credit, are as follows:

- Use a milliammeter or microammeter to measure the current if the initial reading of current is small.
- Avoid reflections from other surfaces/allow for non-zero readings when the source is switched off.
- Power output may vary with the load resistance.
- Take the readings remotely from the meters (avoiding unwanted light falling on the photocell).

**Paper 9243/05**

**Practical Test B**

## General comments

The performance of the candidates was similar to last year. Very little help was given to candidates by Supervisors. If help was given it was usually with the circuit in **Question 2**.

Most candidates seemed to have sufficient time to answer all parts of the paper, although (as in previous years) the weaker candidates tended to leave out the analysis sections of **Questions 1** and **2**, and **Questions 3** and **4** were not done well. Centres are reminded that help with the analysis section in **Questions 1** and **2** is not permitted.

It was pleasing to see many of the stronger candidates achieving marks which were close to the paper maximum.

## Comments on specific questions

**Question 1**

In this question candidates were required to suspend an equilateral triangular lamina from a pin and measure the natural frequency of oscillation of the framework as the length of side of the lamina is reduced.

Most candidates were able to take six sets of readings of $t$ and $L$ for a specified number of oscillations of the framework and present their results in tabular form. The majority of candidates repeated the readings and calculated an average time. Weaker candidates did not include units with the headings in the table, or gave incorrect units (this was usually at the head of the column of values for $f^2$; Hz was often seen instead of

$Hz^2$ or $s^{-2}$). A number of candidates became muddled between frequency and period and tabulated values of $T^2$ instead of $f^2$. Some of the weaker candidates attempted to count the number of oscillations in a specified time. This was considered to be poor procedure and was not condoned.

Candidates are expected to record their results consistently. This means that all of the values of *L* should be given to the nearest millimetre (since a rule with a millimetre scale is being used to make the measurement), and values of *t* should be given to the nearest 0.1 s or 0.01 s. The most common error was to give the values of *L* to the nearest centimetre instead of the nearest millimetre.

Candidates were asked to justify the number of significant figures that they had given for 1/*L*. There continues to be much confusion in this area. Some candidates gave answers in terms of decimal places and not significant figures, whilst others stated that they were going to plot a graph and so only needed three significant figures. 1/*L* is a calculated value, and as such is dependent on the precision of the raw data from which it has been calculated. A simple statement (e.g. 'since *L* is measured to three significant figures it follows that 1/*L* should be quoted to three significant figures') would have been sufficient. Some of the more able candidates illustrated their answers by showing that a change in the third significant figure in the value of *L* produced a change the third significant figure in the value of 1/*L*.

Candidates were required to plot a graph of $f^2$ against 1/*L*. Most candidates chose sensible scales where the plotted plots occupied at least half the graph grid in both the *x* and *y* directions. A number of weaker candidates used compressed scales, or chose intervals that were difficult to work with (e.g. three units corresponding to ten small squares). Awkward scales makes the plotting of points difficult, and candidates who had used scales of this type often made plotting errors. It is expected that candidates will plot points to an accuracy of half a small square. Most candidates were able to draw a reasonable line of best fit. Some candidates may find it easier to use a clear plastic rule when doing this so that plots below the line as well as above the line can be easily seen.

Candidates were required to determine the gradient of the best fit line. Occasionally errors were seen in the calculation (usually $\Delta x/\Delta y$ instead of $\Delta y/\Delta x$) although the most common problem was in reading the vertices of the triangle used from the scales. A number of candidates used very small triangles. This was not accepted as the uncertainty in $\Delta y$ and $\Delta x$ was considered to be too large. It is expected that the triangle used will be such that the length of the hypotenuse is greater than half of the length of the line which has been drawn.

In the analysis section candidates were expected to equate the gradient of the line with $\frac{g\sqrt{3}}{5\pi^2}$ and rearrange the expression to give a value for *g* with an appropriate unit. It was pleasing to see that many of the able candidates were able to do this without difficulty. A number of the weaker candidates substituted values from the table into the equation to find a value for *g*. This was not considered to be good practice and was not allowed. Part **(d)** **(iii)** directs candidates to 'use your answer from **(ii)** to calculate a value for *g*'.

In the last section candidates were expected to use the results of their experiment to determine the period of oscillation of a lamina of length 2 m. The more able candidates calculated the natural frequency for the larger lamina (using their value of *g* or 9.8 m $s^{-2}$) and went on to determine the period. Weaker candidates tended to omit this section. Only the best candidates were able to complete the last section, where a variety of different responses were allowed (e.g. the model may not hold for a lamina of large side length; air resistance effects may be appreciable since the area is large; friction between the pin and the support may be large).

**Question 2**

In this question candidates were required to measure the resistance of a set of constantan wires and investigate how the resistance depends on the diameter of the wire.

Most candidates were able to set up the circuit correctly and obtain six sets of readings for *V* and *I*. Most candidates chose a suitable length of wire (i.e. greater than 75 cm). It was pleasing to see that the majority of candidates were able to use a micrometer screw gauge correctly to measure the diameter of the wire Z, although many candidates did not repeat the measurement and calculate an average diameter. It was expected that the diameter of the wire would be measured in several different places along the wire.

Most candidates tabulated the results and recorded values of $V$ and $I$ consistently. The column headings were usually correct. If an error was made it was often in the heading of $1/d^2$ (the unit was usually omitted). The values of the resistance of each wire was usually given to a sensible number of significant figures.

Candidates were required to plot a graph of the resistance of the wire against $1/d^2$. Generally the graphical work was done better in this question than in question one, although similar comments apply here as were made in **Question 1**.

Most candidates were able to equate $\frac{4\rho l}{\pi}$ with the gradient and determine a value for ρ. If an error was made it was usually a power of ten error in the conversion of centimetres or millimetres into metres. It was expected that the value of ρ would lie in the range $4.5 \times 10^{-7}$ to $6.5 \times 10^{-7}\,\Omega$ m. Weaker candidates tended to omit this section. Even some of the more able candidates did not give a correct unit with their value.

**Question 3**

In this question candidates were asked to design an experiment to investigate how the ratio of the reflected intensity to the incident intensity of ultrasonic waves on an interface depends on the angle which the incident waves make with the normal to the interface.

Most of the better candidates drew an arrangement of apparatus showing one transducer connected to an a.c. supply and the other connected to an oscilloscope with both transducers on the same side of the interface. Measurement of the angle was not straightforward as ultrasound waves are not visible. The more able candidates realised that this would need to be considered and suggested using a laser mounted parallel to the transducer producing the incident waves in order to give a visible beam so that the angle of incidence and the angle of reflection could be measured.

Candidates were instructed to state how the output from the receiving transducer would be measured. It was pleasing to see that most of the more able candidates suggested measuring the peak height of the wave produced on the oscilloscope connected to the receiving transducer. However, many less able candidates gave vague responses such as 'the oscilloscope would be used to measure the output of the transducer' without stating how this would be done.

In order to compare the intensities, the incident intensity needed to be known. Few candidates stated how the incident intensity would be found. Many of the weaker candidates stated that the oscilloscope would be joined to the output of the a.c. power supply and the 'reading from the oscilloscope' would represent the incident intensity.

Most candidates had the right idea about how to perform the investigation (i.e. move the transducers to different positions and measure the intensity of the reflected waves at different angles) although few candidates stated explicitly that the distance between the transmitter and receiver should remain constant.

As with other questions of this type two marks were reserved for good further detail. Examples of some creditworthy points made by candidates are as follows:

- Use an amplifier as the output from the receiver may be small.
- Reason for T→R distance being constant (intensity decreases with distance).
- Detail of how angles are measured (more than 'use protractor' is expected).
- Example of material used as medium 2.
- Discussion of $y$-plate sensitivity on CRO to give output voltage.
- Some method of preventing waves from travelling directly from T to R.
- Any safety point relating to the use of lasers.

**Question 4**

In this question candidates were given a situation involving a yacht with a hydrofoil and asked to design an experiment to investigate how the upward force on the hydrofoil varies with the speed of the water flowing past it.

Candidates were instructed to explain how they would prevent the hydrofoil from being swept away. Some ingenious ideas were seen involving tubes and rods or slots and pegs. However, many of the weaker candidates simply clamped the hydrofoil so that it could not move (and so the force on it could not be measured).

Two marks were reserved for a method of measuring the force on the hydrofoil. The most common approach was to use a spring (which would be compressed), Newton meter or a lever balance. Some methods were unworkable (as they involved the measurements to be made underwater). Again some ingenious solutions were seen (e.g. systems of pulleys or several rods and pivots). Well-described and workable methods scored 2/2 marks, whilst dubious methods were only rewarded with 1/2 marks.

It was expected that some method of producing a constant flow of water would be given. A circulating water supply with pump was common. Some candidates used a constant head device, whilst others suggested the use of a very large tank of water so that the pressure would not change appreciably during the course of the experiment.

Candidates were asked to state how the speed of the water would be measured. The most common response was to suggest floating a small object in the water and timing it over a measured distance. Some candidates suggested the use of flow meters, but vague responses such as 'use a sensor' or 'use a computer' were not accepted.

Two marks were reserved for any good further detail. Examples of some creditworthy points are as follows:

- Allow flow rate to stabilise before measurements are taken.
- Calibration of the spring used in compression (if employed).
- Problems with friction between rod and tube.
- Use water speed meter and hydrofoil independently (so one does not interfere with the other).
- Use a water speed meter at same depth as the hydrofoil.