PHYSICS

Paper 5054/11
Multiple Choice 11

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

General Comments

The number of candidates sitting this examination in June 2010 was 672. The mean score was 19.3 out of 40 (48%) and the standard deviation was 15%.

A surprising number of candidates had problems with some parts of the Mechanics syllabus.

Comments on Individual Questions

Question 8

More than half of the candidates chose A. This was a straight conversion of the labelled force into a mass and did not involve any use of moments.

Question 10

The largest number opted for C. This suggests that they were not familiar with the shape of the graph for an inverse proportionality, although this is relevant to other parts of the syllabus as well.

Question 11

The most popular choice was C, the distance the level had risen rather than the distance between the levels.

Question 12

Only 4% chose the correct option. The statement "at constant speed" means that the kinetic energy must be constant, so A, B and C cannot be correct.

Question 13

A large number chose C, calculating the energy per hour rather than the energy per second (power).

Question 30

Many candidates still think that kWh is a unit of power, not energy.

Question 31

It is a worry that the largest number of candidates opted for A, ignoring the reason for the use of the fuse.

Question 32

More than half of the candidates chose C, including many of the better ones.

Question 33

Each option attracted roughly the same number of candidates, suggesting that there may have been some guesswork involved rather than understanding the function of the commutator.

Question 35

This item showed an old problem; most candidates realise that the frequency increases but only one third remember that the induced e.m.f. also increases.

PHYSICS

Paper 5054/12
Multiple Choice 12

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

General Comments

The number of candidates sitting this examination in June 2010 was 10100. The mean score was 28.3 out of 40 (70.8%) and the standard deviation was 18%.

The results showed that all sections of the syllabus had been well covered. The candidates found **Questions 4, 5, 19, 31** and **39** very easy, but **Question 13** caused great problems.

Comments on Individual Questions

Question 7

The lower-scoring candidates chose A. This just involved converting the marked force into a mass with no consideration of moments.

Question 11

One third of the candidates chose C. This suggests that they are not familiar with the shape of the graph for inverse proportionality, even though this also applies to other topics in the syllabus.

Question 13

Most of the candidates chose C. This is the ‘standard’ situation when a body is accelerating under gravity. This question refers to a body falling ‘at constant speed’. This means that the kinetic energy is constant, which eliminates options A, B and C.

Question 28

Many candidates still think that kWh is a unit of power, not energy.

PHYSICS

Paper 5054/21

Theory 21

General comments

The standard of the answers presented by the candidates for this paper varied very widely; some candidates scored very decent marks indeed whilst others produced very poor answers to most of the questions and a very few candidates wrote almost nothing at all and left the majority of the answer spaces completely blank. The highest-scoring candidates could normally be relied on, in the calculation parts of the paper, to produce numerical answers that were well set-out and accurate. Likewise, such candidates wrote answers to the more descriptive parts that were clearly presented, well-ordered and unambiguous and which addressed the points being asked for directly. By and large, their diagrams were neat, labelled and helpful. The high-scoring candidates were, of course, able to present answers in this way because they had a clear understanding of the underlying principles of physics and because they were quickly able to see which part of the syllabus was being tested in a particular part of a question.

Candidates should be encouraged to write simply and clearly and, where appropriate, to use bullet points rather than more convoluted descriptions which are frequently less clear and sometimes contradict statements that have already been made. Furthermore, candidates might well be reminded that there is no credit awarded for quoting information given in the question and candidates should avoid wasting time and answer space by doing so. For example, in **Question 3(a)**, it is quite unnecessary to start the answer: *The main energy conversion that causes the hands to become warm is......* There are, of course, many other examples of this that could be quoted.

Where a numerical answer is expected, it will almost invariably require a unit. A numerically correct answer which either omits the unit or gives the wrong one will lose the answer mark. A particular confusion is that between the unit of angle *the degree (°)* and the unit of temperature *the degree Celsius (°C)*. These units are not the same and *34 °* is not the correct answer to **Question 9(e)(ii)**. Refractive index is one of the few quantities in this syllabus that is dimensionless and does not, therefore, require a unit.

Judging by the candidates' scripts, there was no suggestion that there was a problem with finishing the paper in the time allowed. Those candidates who omitted parts of the final question had tended also to leave gaps elsewhere in the paper.

Comments on specific questions

Section A

Question 1

(a) It was encouraging to note that this part was frequently well answered and many candidates knew what was being tested. Given the wording of the question, however, it was surprising how many candidates made no reference to forces in the answer.

(b) (i) This answer was very commonly correct but some candidates did not realise that direct, factual knowledge was being tested and tried to deduce the answer from the graph. The most common erroneous answer was 7.5 m/s^2.

(ii) Many candidates correctly determined the answer here, but errors arose from those who tried to use the equation $v = x/t$.

(iii) This graph was more testing with few candidates drawing a straight line from the origin to the point (0.20, 2.0) and only the highest-scoring candidates went on to draw a line of gradually decreasing gradient after that point.

Question 2

(a) The majority of candidates stated what is meant by *the elastic limit* rather than what was asked for. Some of those who did seem to know what was being asked for referred to *Hooke's Law* without indicating what the law is.

(b) Many candidates calculated the correct answer here although a surprisingly large number produced the answer 7.0 cm.

(c) It was pleasing that many candidates produced good answers in this part and scored both marks available. Some candidates, however, omitted to describe how the extension could be obtained from the readings taken with the apparatus given, whilst others only mentioned taking one reading and would not have been able to plot the graph that was asked for.

Question 3

(a) Most candidates mentioned either *kinetic energy* or *chemical energy* and *thermal energy*. In some cases, the inclusion of potential energy spoiled an otherwise good answer.

(b) Many candidates answered this part correctly.

(c) (i) Many candidates responded encouragingly to this part and knew how to calculate the work done. Most then went on to do so and hence obtained the correct answer.

(ii) Although many candidates used the correct relationship and calculated the correct answer, a common error was to multiply the *work done* by the *time* to obtain the *power*.

Question 4

(a) A few candidates had no clear idea of what was expected and drew a variety of waves: some refracted through the barrier, others reflected at right angles and some candidates just drew arrows on the wavefronts given in the question. Candidates who were aware that the incoming wavefronts were reflected, however, frequently lost marks by careless drawing or by failing to position the reflected rays at an angle that was sufficiently close to the correct value.

(b) (i) Again in this part, many candidates lost marks by poor drawing that resulted in a failure to keep the wavelength constant or the wavefronts straight.

(ii) It was good to see that most candidates recognised that the wave speed was reduced and that the frequency was unchanged.

Question 5

(a) (i) The majority of candidates drew a ray that was worth both marks. It was encouraging to observe that so many candidates realised that dispersion takes place at both faces. Just a few candidates drew the blue ray above the red one.

(ii) Many candidates were able to name two correct colours although purple was by far the most common incorrect suggestion.

(b) (i) Many candidates realised that the angle of incidence exceeded the critical angle and that *total internal reflection* took place. Some candidates, however, wrote that the angle of incidence exceeded the angle of refraction or referred, unfortunately, to *total internal refraction*.

(ii) Very few candidates scored this mark. The point being assessed is that all the component colours of white light are reflected at the same angle and so no separation occurs.

Question 6

(a) Only the lowest-scoring candidates did not score this mark.

(b) A straight-line graph that passed through the origin was the most frequently given answer here – even from those who went on to get **(c)(i)** correct – and of those who drew a curve, most drew a curve of increasing gradient.

(c) (i) Many candidates knew the correct answer here but very few were able to use this knowledge in **(b)** or **(c)(ii)**.

(ii) Very few correct answers were produced here. Many simply stated that as both the current and the p.d. were increasing, so must be the resistance.

Question 7

(a) (i) Most candidates were able to give the correct answer here but there was a minority who rearranged the usual version of the formula incorrectly and obtained $I = R/V$.

(ii) This was less frequently correct with 6.0 V being a very common answer.

(b) There were a few candidates who answered neither part of **(b)** but who left gaps nowhere else in the paper.

EITHER This alternative part was poorly answered with only a small number of candidates referring even to the charging of the capacitor.

OR This alternative part was very poorly answered; very few candidates understood the operation of a transistor and many candidates took the transistor to be a semiconducting diode.

Question 8

(a) Very few candidates made any reference at all to *electromagnetic induction* here and the only mark that was commonly scored was scored by those who referred to the deflection of the ammeter. Some candidates referred – rather oddly – to the *induction* of a magnetic field in the iron ring whilst others stated that the current was actually transferred through the iron ring to the second coil.

(b) The answer that was very commonly supplied here wrongly stated that the electric current and ammeter deflection remained at the values reached in **(a)**.

(c) The almost universal answer was that the ammeter reading would return to zero because the switch had been opened.

Section B

Question 9

(a) (i) Pleasingly, most candidates produced the correct answer.

(ii) Many candidates produced a good answer here but some implied that simply putting the marked divisions closer together was all that was needed.

(b) (i) Some candidates answered this well but others gave answers suggesting that a more sensitive thermometer would either be more accurate or respond more speedily.

(ii) Some candidates gave a correct answer to this part, but those who thought that a more sensitive thermometer would respond more speedily often suggested using thinner glass for the bulb. Consequently, the answer *use a thinner thermometer* could not be credited. To score the mark here, it was necessary for the candidate to make it clear that it is the bore of the thermometer tube that is reduced in size.

(c) There were good points made here by the candidates but few made the three separate points that were needed for full marks. The purpose of the constriction was very poorly described.

(d) (i) Very few candidates were able to answer this part of the question at all. Some drew versions of liquid-in-glass thermometers whilst others made no attempt at all. Of those who had some idea of the structure of a thermocouple thermometer, very few mentioned the need for wires of different metals and in many cases two wires were connected to a galvanometer with the other ends of the wires immersed in separate liquids but without any connecting wire between these ends.

(ii) Many candidates – even those who had not been able to score any marks in **(d)(i)** – were able to score at least one mark here. Some scored both marks.

(e) (i) Many candidates produced the correct answer to this part but others made a variety of errors. Some candidates used the value 1.8 kg when attempting to calculate the energy supplied and there were those who did not convert the time elapsed into seconds when calculating the answer.

(ii) It was very encouraging indeed to notice how frequently this part of the question was well answered and, although a few arithmetical errors were made, many candidates used the correct approach and scored both marks.

Question 10

(a) Few candidates scored both of the marks available here. In general, answers were too vague and some even attempted to produce an explanation without using ideas such as *pressure* or *force*. In questions such as this, there is the temptation to forget that this is a Physics examination and to resort to excessively simplistic, descriptive answers using ill-defined terms and concepts.

(b) (i) A pleasingly large number of candidates obtained the correct answer to this part.

(ii) Although many candidates calculated the correct answer, there were some candidates who, despite the unambiguous wording of the question, still divided the correct answer by two.

(iii) Few candidates were able to explain clearly why the force on the master piston was larger than that applied by the foot on the pedal. Some candidates, however, did realise that the difference in the two distances was significant. Some candidates simply quoted *the principle of moments* without relating it to the specific circumstances of this question.

(c) (i) This is a straightforward description which was correctly answered by many candidates.

(ii) Only rarely did answers refer to the increased frequency of molecular collision with the walls; too many candidates merely stated that there would be more collisions and made no reference to any time period. The reduction in the volume of the gas was quite commonly referred to but many candidates spoiled otherwise good answers by stating that it was the area that was reduced. Some even applied the equation $P = F/A$ to explain the increased pressure.

(iii) This application of Boyle's Law was commonly but not invariably correctly answered. Those who did not realise what was expected attempted to apply many different formulae that involved *pressure*.

(d) Most candidates merely stated that the brakes would be less efficient or less effective but did not offer any real explanation of why this was so.

Question 11

(a) Most candidates were able to state correctly the electric charges of the two types of radiation but the description of their nature proved more troublesome to many candidates. Some candidates stated that these radiations contained no protons and no neutrons but did not state what their nature was. Very few candidates applied the word *electromagnetic* to gamma-radiation.

(b) (i) Many answers involved the time taken for something to halve but only a minority of these mentioned the halving of a quantity that is both measurable and appropriate. *Mass* is not an appropriate quantity in this definition.

(ii) In this part of the question, many candidates referred to the ionising and penetrating abilities of alpha-particles and gamma-rays but only a small fraction of these candidates were able to explain the relevance of these properties in the circumstances of this question. Many candidates referred to the radiation entering the body or treating the cancer.

(iii) Many candidates gave answers here that were not appropriately detailed. It was not sufficient merely to state that 6 minutes is not long enough, in order to score the mark.

(iv) This part was rather better answered than **(iii)** and many realised that by using an isotope with a half-life of 6 days, the patient's exposure to the radiation was increased unnecessarily and that this might prove harmful.

(c) (i) A very disappointingly small number of candidates explained that the variation in the count rate was due to the random nature of radioactive emission; many other explanations were offered.

(ii) This difficult calculation was rarely answered completely correctly but many candidates made some important points and scored some marks as a result.

(iii) It was surprising that only a minority of candidates were able to state one cause of background radiation.

PHYSICS

Paper 5054/22
Theory 22

General comments

On the whole, the examination produced encouraging answers, particularly in ***Section A,*** with a number of candidates showing the ability to handle unusual questions in ***Section B***. However the questions in ***Section B*** proved a challenge to most candidates. Descriptions of experiments in **Question 10** and particularly in **Question 11** were disappointing and often led to a lower performance in these questions than in **Question 9**.

Most candidates expressed themselves in good English, but legibility was sometimes poor. In particular, candidates should be encouraged to plan their answers and attempt to keep them in the spaces provided.

A number of candidates wrote lengthy answers which exceeded the space allotted.

Numerical questions were almost invariably correctly calculated and the results expressed to an appropriate number of significant figures. Data in the questions was given to two significant figures and the answers below are also given to the same number of significant figures. Candidates were allowed to give more figures in their answers but were expected not to make an error when rounding their answers. Working was usually included, but perhaps less so than in previous years, meaning that a number of candidates missed some marks which, in all probability, would have been awarded had working been seen. Units were generally well known and included.

Candidates appeared to make good use of the time and there was no evidence of there being too little or too much time available for the examination. The vast majority of candidates attempted the questions fully and a few even attempted all three ***Section B*** questions.

Comments on specific questions

Section A

Question 1

(a) Only a few candidates gained full credit for this section. Most candidates did not give a numerical value for the direction of the resultant displacement but merely stated, for example, NE. It was not intended that candidates use a particular method of expressing a direction, such as 022°, N22°E or 22°East of North; rather credit was given for any angle quoted as an answer and shown clearly on the diagram. Weaker candidates drew a resultant in the wrong direction but were still able to gain credit for the size of it.

(b) This question proved to be a challenge to even the most able candidates, but did seem to show those who had a real grasp of the meaning of a vector quantity. Many candidates wrongly suggested that displacement is a scalar or stated that the journey was only in one direction. Acceptable answers included that the journey ended at the starting point or that two equal stages were in opposite directions. Some candidates referred to forces instead of distances.

Question 2

(a) Most candidates stated that power is energy/time. However, fewer gave the definition of the watt as the transformation of one joule of energy in one second. Weaker candidates merely stated that the watt is a unit of power or referred to the product of volts and amps, which did not receive any credit.

(b) (i) This was answered correctly, in general, only by those candidates who appeared to know that tension was a force. The value of the acceleration due to gravity was not provided in the question but the syllabus does require candidates to know the value as approximately 10 m/s^2. Candidates merely had to find the weight of the lift and man. However many candidates attempted to find an acceleration and use the formula *F=ma*, whereas the acceleration is zero.

(ii) There were many correct calculations and the formula for potential energy was well known. Some candidates omitted the unit for energy or made complicated subtractions from the final answer which lost them credit.

(iii) There were a large number of correct answers, even from those candidates who had made a mistake in **(b)(ii)**. Where the wrong answer was obtained, candidates were still able to gain credit for stating the formula for efficiency or by showing a correct calculation of power or input energy. It was disappointing that many candidates did not set their working out in enough detail. A statement that efficiency = output/input was not accepted; candidates were required to state either power output/power input or the equivalent expression using energy.

Question 3

High marks were generally obtained on this question.

(a) Most candidates knew that radiation was involved and that conduction and convection require a medium. Nevertheless there were some answers that suggested that only radiation could travel through the atmosphere.

(b) Full marks were awarded for the realisation that conduction was involved and that particles pass energy from one to another. The majority of candidates earned at least one mark, but a few omitted any description of the process of conduction.

(c) The majority of candidates produced the correct calculation using specific heat capacity. However, some gave the correct formula but confused thermal energy (heat) and specific heat capacity.

Question 4

(a) This section, unsurprisingly, produced the highest marks on the paper. Some candidates suggested that more humidity increased evaporation. Weak answers did not suggest a change in the atmospheric conditions at all but merely stated “temperature” or “humidity”.

(b) The accounts of evaporation were very encouraging. Often candidates gave a very full textbook account of the process. Weak answers earned only partial credit for statements such as “the water gains energy and molecules escape”. Fuller accounts suggested that it was the faster, more energetic molecules that escape.

Question 5

This question was very well answered by able candidates but it was encouraging to find weaker candidates displaying some knowledge of refraction.

(a) Many candidates gave correct definitions of the critical angle but a few answers were spoilt by wrong references to the density of the material, such as the ray passes from the less to the more dense medium. Weaker candidates had difficulty in stating that the critical angle was an angle of incidence but merely stated that it was “the angle when the refracted ray was along the surface”

There were a significant number of answers where the definition of the angle of incidence was correct but where the angle drawn on the diagram was wrong. In **(iii)**, a ray along the surface and/or a ray reflected at M was accepted.

(b) A correctly refracted ray was required in the air outside the glass block. A reflected ray may also have been drawn, but such a ray alone was not accepted.

(c) The formula for refractive index was well known. Weaker candidates found difficulty in the calculation, particularly when taking the inverse of a sine to find the angle of refraction.

Question 6

(a) The majority of candidates recognised that electrons were lost from the aeroplane. However there were a surprising number of candidates who mentioned 'beta particles', which was not accepted. While most answers suggested that charge on the aeroplane was neutralised when the aeroplane lands, the explanation in terms of electrons flowing from earth was only given by more able candidates.

(b) Most candidates were able to discuss the danger of a fire or explosion as an aeroplane is refuelled, but found it harder to discuss why earthing is required. There was some confusion with live current and the avoidance of 'shocks' in some answers. A few candidates expressed their ideas in terms of the reverse argument and were usually successful in gaining the marks available.

Question 7

(a) A great variety of arrow directions were produced in this section. Some arrows were carelessly drawn and missed going through the base of the bar magnet. A significant number of candidates drew arrows that seemed to suggest a circular magnetic field existed around the South pole, or drew a vertical field only extending from the North to the South pole and failed to indicate the direction of the compass arrows in a horizontal plane. A large number of candidates failed to label the N-pole of the compasses.

(b) This section was well answered with clear statements about the magnetic field created in the coil and the attraction of the other piece of soft iron. However, some candidates suggested that closing the switch stops the current or that the pivoted iron is repelled. A few candidates also wrongly suggested that current flows through the core of the electromagnet rather than in the coil.

(c) The decrease in resistance of the LDR was well known in **(i)**. The answers to **(ii)** were not so encouraging. The best answers included a battery or even used the original battery on the question paper in a simple circuit with the lamp and the contacts. Partial credit was given where the lamp was connected to the contacts without a battery. However many answers connected the lamp, the contacts and the LDR in arrangements that would not work or even short out the battery.

Question 8

(a) The Geiger-Muller tube was the most popular accepted answer in **(i),** with the cloud chamber as an occasional alternative. A surprising answer, given by some candidates, was the cathode-ray oscilloscope. In **(ii),** there were several possibilities for a safety precaution, the most popular being the use of tongs, gloves, lead-lined suits or some form of lead shielding. Weaker candidates were confused about the actual rock and the radiation emitted and suggested that the teacher should not touch the radiation or even that dark glasses should be worn.

There were very few good, clear answers to **(iii)**, as candidates often failed to understand that the experiment was to demonstrate that radioactive emission is random in time. Many candidates incorrectly described a penetration experiment, with count or count rates from the GM tube linked to the presence of paper or aluminium barriers, and were aiming to verify only that the radiation is gamma. Even these candidates were able to earn some credit for obtaining a count in a period of time or reading a count rate. A small minority chose to explain how a GM tube works or used several GM tubes to demonstrate randomness in direction rather than in time.

(b) Most candidates were able to indicate that gamma-rays are electromagnetic waves, often specifying high frequency or low wavelength, although some failed to answer the question by describing the properties of gamma-rays and writing in detail about penetration power, ionisation or speed.

Section B

Question 9

This was answered by nearly all candidates who found it the most accessible of the optional questions. The quality of answer could vary considerably but many able candidates scored full, or very nearly full, marks. In general, where candidates had a good grasp of stopping distances and were able to express themselves clearly, high marks were obtained.

(a) Both answers were often correct, although in **(i)** some candidates found difficulty in expressing a clear answer and some suggested that thinking distance is the distance that a driver estimates he will travel while stopping. In both **(i)** and **(ii)** some candidates referred to time rather than to distance.

(b) In **(i)**, the most popular acceptable answer was the condition of the tyres, although the speed of the car or the condition of the brakes were other answers. Some candidates gave general responses which were not accepted, such as "the car must be the same". In **(ii)** there were many good answers that mentioned an increase in inertia or a decrease in deceleration, but weaker answers merely stated that the mass was larger. There were some misguided attempts to relate a greater braking distance to friction.

(c) Weaker candidates found this section surprisingly difficult. This was largely due to friction not being mentioned, an incorrect statement that greater friction increases braking distance or explanations that involved stopping time rather than distance. Stronger candidates had no difficulty in understanding the sense of the question and choosing a suitable road condition as the basis of their argument such as a wet or icy road.

(d) Answers to this section were usually correct and gave the reason for the decrease in pressure as an increase in the area. Some candidates wrongly referred to a decrease in the force acting on the tyres.

(e) Although the equation for acceleration in **(i)** was generally known, there were surprisingly few full marks because many answers used the wrong time in the calculation. A significant number of candidates gave the unit of acceleration as m/s rather than m/s^2. Any error in **(i)** still allowed full marks to be awarded in **(ii)**. A significant number of candidates used $F = mg$ with g as 10. The speed-time graph in **(iii)** was well answered, although some candidates failed to label the axes, started the deceleration from $t = 0$ or even showed an initial acceleration. Candidates did not need to find the distance covered in **(iv)** but merely to state how the distance is calculated. In general, only weaker candidates failed to score this mark.

Question 10

(a) Most attempts at describing the measurement of sound had some merit, with the simple flash-bang experiment being the most popular. Echo methods were slightly harder to describe, as the distance must be doubled and candidates found it more difficult to describe the measurement of the time involved. In all methods, candidates needed to make clear exactly what time was being measured and to have a distance that was actually measured. In many answers, observers were just placed a distance apart but that distance was never measured.

(b) Definitions of ultrasound were encouraging with the majority of candidates stating that such sound was above 20 kHz and inaudible to humans. Few candidates achieved full marks in **(ii)**, although those who explained that they were using 1/time in their calculation usually scored one mark. Most candidates did not recognise that one pulse takes 6×10^{-6} s. The answers to **(iii)** were disappointing, as they were usually too vague. Acceptable answers included absorption of energy by the metal, sound passing out of the back of the metal or being scattered in all directions. In **(iv)** most candidates drew reflected pulses that were smaller in amplitude and earned one mark, but these were often placed in the wrong position. The answers to **(v)** involved a simple and well known equation and only weaker candidates found difficulty in remembering the equation or in dealing with negative powers of ten.

Question 11

This was a slightly more popular choice of question than **Question 10**, but the detailed argument, knowledge required and mistakes made in the calculation meant that most candidates found some difficulty.

(a) The majority of candidates attempted to show that resistance increases with temperature but provided no details whatsoever as to how this could be verified experimentally. A suitable circuit diagram and an indication of how resistance can be calculated were often the only mark scoring possibilities. Even then voltmeters were often in series or placed across the wrong component. Very few answers indicated clearly how temperature could be changed, by providing a water bath or an independent electric heater for example – some thought that the presence of a thermistor in the circuit was a means of varying the temperature and most answers omitted any form of thermometer. A fair number of answers mistakenly showed a thermistor in the circuit diagram as the resistance wire under investigation; both a lamp and a wire were accepted but not a thermistor. A significant proportion of candidates failed even to state the equation that enables resistance to be calculated.

(b) In **(i)** a mark was generally gained for the statement that 'as temperature increases the resistance increases'. Some strong candidates suggested, for full marks, that the increase in resistance is proportional to the temperature rise, or nearly so. The graphs drawn in **(ii)** were disappointing as the majority were straight lines which showed a constant resistance, whereas candidates are expected to know the sketch graph of current against voltage for a filament lamp.

(c) Most candidates recognised that the current increases in **(i)** and linked this to the reduced resistance of the thermistor at the higher temperature. Those who merely referred to a reduced resistance did not supply sufficient explanation. The description of what happens to the voltmeter reading was less well answered. Many candidates suggested that the voltmeter reading decreases or stays constant and few were able to explain or attempt to use the idea of a potential divider. The calculation in **(ii)** earned good marks for strong candidates. However, a common wrong approach was to calculate the current by assuming that there is a p.d. of 6 V across the fixed 2000 Ω resistor. Lack of understanding of the concept of the potential divider meant that 2.2 V across the thermistor was not evident in many calculations.

PHYSICS

Paper 5054/31

Practical Test 31

General comments

Question 4 was particularly challenging. Discharging of a capacitor through a resistor had not been set before, so the situation was new to the candidates. Also the discharge led to a curved graph of potential difference against time and candidates had to find the gradient of this graph and take data from the graph. However the question worked very successfully and produced good discrimination between candidates. More able candidates coped well with the question and less able candidates were able to use their graph plotting skills to obtain some marks.

Comments on specific questions

Section A

Question 1

(a) Most candidates gained credit for the value of *L*. Virtually all candidates obtained a value in the correct range. The common mistakes made were the omission of the unit or not quoting the value to the nearest mm.

(b) Good answers used the 2 set squares like the jaws of vernier callipers with one edge of the set square against the edge of the rule. Diagrams that did not score the mark included;

- those where the set square was standing vertically on the rule so that it was not clear that the face of the set square was perpendicular to the line of spheres,
- those where the hypotenuse of the set square was used at the end of the line of spheres because it was not clear that the edge of the set square was perpendicular to the line of spheres.

(c)(i) Most candidates correctly determined the value *d* from their value of *L*.

(ii) The question asked the candidates to determine the average mass *m* of a sphere. It was expected that the candidates would measure the total mass of all 20 spheres that they had available and then divide by 20 to obtain the average mass of a sphere. In the event quite a number of candidates just measured the mass of 1 sphere. Two other common mistakes in this section were to:

- give the mass *m* as the total mass of the 20 spheres,
- not subtract the mass of the container from the total mass that had been measured on the top-pan balance.

(iii) At most Centres the spheres used must have been very uniform, because even those candidates who only measured the mass of one sphere obtained a good value for the density of the material of the sphere.

Question 2

(a) It was good to see that the majority of candidates had followed the instructions and had the start position of the mass hanger just below the pulley. Most candidates had a value for *y* that was in excess of 60 cm, with only a few candidates having low values such as 20 cm or 30 cm. The normal requirement for measurements to the nearest mm was relaxed here, so that Examiners could credit those candidates who used a large height through which the mass would fall but omitted to quote the measurement to the nearest mm.

(b) The best diagrams showed the set square between the vertical metre rule and the horizontal floor. Other diagrams only showed the metre rule and the set square without the floor; such diagrams did not score the mark.

(c) (i) The question asked the candidates to record the total mass of the mass hanger and the slotted masses. However it was clear that some candidates had also included the mass of the wooden block or the additional mass that was on top of it. Using the apparatus specified in the instructions, it should have been impossible to obtain a mass greater than 100 g.

(ii) The question asked candidates to determine the average time for the mass hanger to fall to the floor. Candidates were therefore expected to take at least 2 measurements and find the average. Quite a number of candidates took only 1 measurement. It was pleasing to see that fewer candidates than usual had systematic errors (e.g. 0.0250 s) or measured the time to the nearest second.

(d) The most common errors in the calculation of the acceleration were;

- carrying out the calculation in cm and putting the unit as m/s^2,
- using a unit of m/s or cm/s.

Question 3

(a) As in the previous two questions, the use of the word ‘average’ in a question should imply that more than one measurement is to be made. However in this question, not many candidates realised that more than one measurement of the diameter of the cross-wire object was required.

(b) (i) It was expected that Centres would use a 15 cm focal length lens in this experiment. With an object distance of 20 cm, such a lens should give an image distance of 60 cm, which was the expected value for *v*. A number of candidates reported that they were unable to obtain an image and had increased the object distance (*u*) without consulting the Supervisor. In other cases the Supervisor reported that there were insufficient 15 cm focal length lenses and that 20 cm focal length lenses had been used. In either event the candidate was given credit for a reasonable answer. The allowed range for *v* was from 45 cm to 80 cm, which allowed both 15 cm and 20 cm focal length lenses to be used, correspondingly the allowed range for *D* was from 4.0 cm to 9.0 cm.

(ii) Despite the large range of values allowed for *D*, a large number of candidates did not gain credit because only 1 measurement was taken.

(c) Virtually all candidates gained credit for the correct calculation of *m* and *f*, partly because the units given for *m* were ignored. *m* should, of course, have had no units, but many candidates gave the unit as cm. Where it was clear that a 15 cm focal length lens had been used the range for the focal length was from 13.0 cm to 17.0 cm as in the published mark scheme. However if it was clear that a 20 cm focal length lens had been used, then a range of 18.0 cm to 22.0 cm was used.

Section B

Question 4

(a) Many candidates were given credit for the circuit diagram without any problem. Essentially the resistor, capacitor and power supply should have been connected in parallel. The omission of a switch was ignored because it was felt that at some Centres disconnecting two of the connecting leads would have been used as a switch. However if a switch was included in the circuit it was important that it was between the power supply and the capacitor rather than the resistor and the capacitor. In the latter case no credit was given for the circuit because it would not have worked i.e. the capacitor would have remained connected to the power supply and would not have discharged. Apart from switch positioning errors, the only other error that candidates made on the circuit diagram was connecting the power supply, resistor and capacitor in series rather than in parallel.

(b) Most candidates obtained a correct value for V_0, the most common errors were:

- not quoting the potential difference to 0.1 V or better, e.g. 3 V,
- omitting the unit from the quantity.

(c) Most candidates obtained a correct value for V_R which was less than or equal to the value of V_0. The errors were as stated in **(b)** but were not penalised if they had already been penalised in **(b)**.

(d) Some Supervisors complained that candidates had insufficient time for this experiment. This could only be the case if readings were not done continuously, i.e. the capacitor was discharged for 10 seconds and the final voltage was recorded, the capacitor was recharged and then discharged for 20 seconds, etc. It was anticipated that candidates would take readings continuously as they would do if they were, for example, plotting a cooling curve. In this experiment the switch should have been opened and the stopwatch started, readings on the voltmeter should then have been taken at 10 s, 20 s, etc. Candidates did not receive credit if they:

- omitted units from the headings of the table,
- did not start the stopwatch and open the switch at the same time; this led to an apparent large drop in voltage in the first few seconds. This was penalised as a systematic error,
- only did readings every 20 seconds resulting in only 5 points for the graph.

(e) Graph plotting skills seemed to have improved with many candidates getting full marks for the graph. Examiners were slightly more lenient with the suitable scale mark than in previous years. First of all the graph was allowed to start at the origin. With the total time being 80 seconds a horizontal scale of 1 cm = 5 s, was most appropriate, but 1 cm = 10 s was allowed as this just filled half the page. Equally, with a maximum voltage in the region of 3.0 V, a vertical scale of 1 cm = 0.2 V would have been appropriate, but a vertical scale of 1 cm = 0.25 V was allowed as again this just filled half the page.

(f) Only the most able candidates gained credit in **(f)** and **(g)**. Firstly many candidates interpreted $V_R = 0.5\ V_0$ as V_R = 0.5 V, and hence measured the gradient at 0.5 V. Some candidates did not draw a tangent but used two points on the curve, either side of the point at which the gradient was required. This is not an acceptable method. Others drew a tangent in the correct place but only used a very small triangle to determine the gradient, this lost the large triangle mark. Finally the gradient was often quoted to 2 decimal places rather than 2 significant figures, e.g. 0.04 (V/s), hence the correct calculation to 2/3 significant figures mark was lost.

(g) As in **(f)** $V_R = 0.37\ V_0$ was often interpreted as V_R = 0.37 V, so candidates obtained much higher values for the time than expected.

PHYSICS

Paper 5054/32

Practical Test 32

General comments

Question 4 was particularly challenging. Discharging of a capacitor through a resistor had not been set before, so the situation was new to the candidates. Also the discharge led to a curved graph of potential difference against time and candidates had to find the gradient of this graph and take data from the graph. However the question worked very successfully and produced good discrimination between candidates. More able candidates coped well with the question and less able candidates were able to use their graph plotting skills to obtain some marks.

Comments on specific questions

Section A

Question 1

(a) Most candidates gained credit for the value of *L*. Virtually all candidates obtained a value in the correct range. The common mistakes made were the omission of the unit or not quoting the value to the nearest mm.

(b) Good answers used the 2 set squares like the jaws of vernier callipers with one edge of the set square against the edge of the rule. Diagrams that did not score the mark included;

- those where the set square was standing vertically on the rule so that it was not clear that the face of the set square was perpendicular to the line of spheres,
- those where the hypotenuse of the set square was used at the end of the line of spheres because it was not clear that the edge of the set square was perpendicular to the line of spheres.

(c) (i) Most candidates correctly determined the value *d* from their value of *L*.

(ii) The question asked the candidates to determine the average mass *m* of a sphere. It was expected that the candidates would measure the total mass of all 20 spheres that they had available and then divide by 20 to obtain the average mass of a sphere. In the event quite a number of candidates just measured the mass of 1 sphere. Two other common mistakes in this section were to:

- give the mass *m* as the total mass of the 20 spheres,
- not subtract the mass of the container from the total mass that had been measured on the top-pan balance.

(iii) At most Centres the spheres used must have been very uniform, because even those candidates who only measured the mass of one sphere obtained a good value for the density of the material of the sphere.

Question 2

(a) It was good to see that the majority of candidates had followed the instructions and had the start position of the mass hanger just below the pulley. Most candidates had a value for *y* that was in excess of 60 cm, with only a few candidates having low values such as 20 cm or 30 cm. The normal requirement for measurements to the nearest mm was relaxed here, so that Examiners could credit those candidates who used a large height through which the mass would fall but omitted to quote the measurement to the nearest mm.

(b) The best diagrams showed the set square between the vertical metre rule and the horizontal floor. Other diagrams only showed the metre rule and the set square without the floor; such diagrams did not score the mark.

(c) (i) The question asked the candidates to record the total mass of the mass hanger and the slotted masses. However it was clear that some candidates had also included the mass of the wooden block or the additional mass that was on top of it. Using the apparatus specified in the instructions, it should have been impossible to obtain a mass greater than 100 g.

(ii) The question asked candidates to determine the average time for the mass hanger to fall to the floor. Candidates were therefore expected to take at least 2 measurements and find the average. Quite a number of candidates took only 1 measurement. It was pleasing to see that fewer candidates than usual had systematic errors (e.g. 0.0250 s) or measured the time to the nearest second.

(d) The most common errors in the calculation of the acceleration were;

- carrying out the calculation in cm and putting the unit as m/s^2,
- using a unit of m/s or cm/s.

Question 3

(a) As in the previous two questions, the use of the word ‘average’ in a question should imply that more than one measurement is to be made. However in this question, not many candidates realised that more than one measurement of the diameter of the cross-wire object was required.

(b) (i) It was expected that Centres would use a 15 cm focal length lens in this experiment. With an object distance of 20 cm, such a lens should give an image distance of 60 cm, which was the expected value for *v*. A number of candidates reported that they were unable to obtain an image and had increased the object distance (*u*) without consulting the Supervisor. In other cases the Supervisor reported that there were insufficient 15 cm focal length lenses and that 20 cm focal length lenses had been used. In either event the candidate was given credit for a reasonable answer. The allowed range for *v* was from 45 cm to 80 cm, which allowed both 15 cm and 20 cm focal length lenses to be used, correspondingly the allowed range for *D* was from 4.0 cm to 9.0 cm.

(ii) Despite the large range of values allowed for *D*, a large number of candidates did not gain credit because only 1 measurement was taken.

(c) Virtually all candidates gained credit for the correct calculation of *m* and *f*, partly because the units given for *m* were ignored. *m* should, of course, have had no units, but many candidates gave the unit as cm. Where it was clear that a 15 cm focal length lens had been used the range for the focal length was from 13.0 cm to 17.0 cm as in the published mark scheme. However if it was clear that a 20 cm focal length lens had been used, then a range of 18.0 cm to 22.0 cm was used.

Section B

Question 4

(a) Many candidates were given credit for the circuit diagram without any problem. Essentially the resistor, capacitor and power supply should have been connected in parallel. The omission of a switch was ignored because it was felt that at some Centres disconnecting two of the connecting leads would have been used as a switch. However if a switch was included in the circuit it was important that it was between the power supply and the capacitor rather than the resistor and the capacitor. In the latter case no credit was given for the circuit because it would not have worked i.e. the capacitor would have remained connected to the power supply and would not have discharged. Apart from switch positioning errors, the only other error that candidates made on the circuit diagram was connecting the power supply, resistor and capacitor in series rather than in parallel.

(b) Most candidates obtained a correct value for V_0, the most common errors were:

- not quoting the potential difference to 0.1 V or better, e.g. 3 V,
- omitting the unit from the quantity.

(c) Most candidates obtained a correct value for V_R which was less than or equal to the value of V_0. The errors were as stated in **(b)** but were not penalised if they had already been penalised in **(b)**.

(d) Some Supervisors complained that candidates had insufficient time for this experiment. This could only be the case if readings were not done continuously, i.e. the capacitor was discharged for 10 seconds and the final voltage was recorded, the capacitor was recharged and then discharged for 20 seconds, etc. It was anticipated that candidates would take readings continuously as they would do if they were, for example, plotting a cooling curve. In this experiment the switch should have been opened and the stopwatch started, readings on the voltmeter should then have been taken at 10 s, 20 s, etc. Candidates did not receive credit if they:

- omitted units from the headings of the table,
- did not start the stopwatch and open the switch at the same time; this led to an apparent large drop in voltage in the first few seconds. This was penalised as a systematic error,
- only did readings every 20 seconds resulting in only 5 points for the graph.

(e) Graph plotting skills seemed to have improved with many candidates getting full marks for the graph. Examiners were slightly more lenient with the suitable scale mark than in previous years. First of all the graph was allowed to start at the origin. With the total time being 80 seconds a horizontal scale of 1 cm = 5 s, was most appropriate, but 1 cm = 10 s was allowed as this just filled half the page. Equally, with a maximum voltage in the region of 3.0 V, a vertical scale of 1 cm = 0.2 V would have been appropriate, but a vertical scale of 1 cm = 0.25 V was allowed as again this just filled half the page.

(f) Only the most able candidates gained credit in **(f)** and **(g)**. Firstly many candidates interpreted $V_R = 0.5\ V_0$ as $V_R = 0.5$ V, and hence measured the gradient at 0.5 V. Some candidates did not draw a tangent but used two points on the curve, either side of the point at which the gradient was required. This is not an acceptable method. Others drew a tangent in the correct place but only used a very small triangle to determine the gradient, this lost the large triangle mark. Finally the gradient was often quoted to 2 decimal places rather than 2 significant figures, e.g. 0.04 (V/s), hence the correct calculation to 2/3 significant figures mark was lost.

(g) As in **(f)** $V_R = 0.37\ V_0$ was often interpreted as $V_R = 0.37$ V, so candidates obtained much higher values for the time than expected.

PHYSICS

Paper 5054/41
Alternative to Practical 41

General comments

The aim of the examination is to enable candidates to display their knowledge and understanding of practical physics techniques. These include:

- graph plotting,
- tabulation of readings,
- manipulation of data to obtain results,
- drawing conclusions,
- dealing with possible sources of error,
- control of variables.

The general level of competence shown by the candidates was sound, although some candidates continue to approach this paper as they would a theory paper, and not from a practical perspective. Very few candidates failed to attempt all sections of each of the questions and there was no evidence of candidates suffering from lack of time. Many candidates dealt well with the range of practical skills being tested. The better candidates were able to follow instructions, record observations clearly and perform calculations accurately and correctly. Units were well known and usually included, writing was legible and ideas were expressed logically.

Comments on specific questions

Question 1

(a) The loss in mass of the water was generally calculated correctly, but occasionally answers were spoiled by careless subtraction.

(b) The graph was well drawn, with most candidates choosing scales which made best use of the available space. The expected scales were y-axis: 2 cm ≡ 50 g, and x-axis: 2 cm ≡ 50s, but a majority of candidates chose to use 2 cm ≡ 60s on the x-axis. The choice of scales using factors of 3, 7 etc. should be discouraged, as it often leads to errors in point plotting.

(c) The relationship between m and t was poorly described. Vague answers such as linear / as m increases t increases / proportional, were not accepted. Candidates should realise that if the graph is a straight line and also passes through the origin, then the quantities are <u>directly</u> proportional.

(d) Although the method of calculating the gradient of a straight line was well known, arithmetical errors abounded, and many candidates ignored the instruction to show their working.

(e) The majority of candidates were able to use the given formula and their own value for the gradient determined in **(d)** to calculate a value for the specific latent heat of vaporisation of the water.

(f) This more demanding part required candidates to realise that the mass of water boiled away required the subtraction of the mass of the kettle from the total initial mass. Only a minority of candidates did this and proceeded to obtain a correct answer for the time taken.

(g) Most candidates were able to give one sensible suggestion why the candidate should not touch the kettle – the obvious one that the candidate would get burnt because the kettle was hot. Far fewer realised that touching the kettle might affect the reading on the balance.

(h) Many answers to this more searching part, consisted of guesses, often not backed up with any justifying reason. Only the best candidates were able to explain, unambiguously, that the value for latent heat obtained would increase because, owing to condensation, there would be more water to be boiled away.

Question 2

(a) The skill of estimating a sensible value for a physical quantity is an important skill for a physicist to possess. The ability to make a sensible estimate for the time taken to cycle 100 m should be within the compass and everyday experience of candidates. A generous range for the time taken was allowed – answers between 5 s and 30 s were accepted. The range of answers suggested by candidates ranged from 1 s to 20 minutes!

(b) The measuring instruments needed to measure the length of the track and the time taken were well known, with the majority of candidates supplying correct answers. A common incorrect response for the distance measurement was to use a metre rule. The description of how the candidates could take readings to plot a distance-time graph for the cyclist proved to be a very good discriminator. It was rare to award full marks for this part of the question. Most answers lacked structure, and although many candidates realised that both distances and times needed to be measured, they were unable to explain logically how they would measure them. A significant number of candidates realised that distances would need to be marked around the track, but the idea of needing the cumulative times for each of the distances travelled defeated most candidates. Most candidates were content to measure the times to go from one distance mark to the next and then plot these. A number of candidates misread the question and described how to calculate the velocity of the cyclist as she travelled around the track.

(c) This demanding final part of the question proved to be beyond the scope of all but the very best candidates. The initial curve to represent the accelerating bicycle was invariably curving in the wrong direction, although some credit could then be scored for realising that when the speed became constant, the line became straight. Totally correct responses for the second curve were hardly ever seen. The fact that both journeys took the same time, indicating that curves A and B would cross at 100 m was only appreciated by a very small number of candidates. Credit was given for the realisation of this, even if the graph drawn was incorrect.

Question 3

(a) The resistor colour code was examined for the first time during this Summer session, and it seemed to take most candidates by surprise. The method of application of the code to determine the value of a given resistor was known only by a handful of candidates. Most answers consisted of guesswork, and were invariably incorrect.

(b) It was surprising to find that the standard method of measuring the resistance of a resistor using an ammeter and a voltmeter was so poorly known and understood. The better candidates scored full marks effortlessly, by connecting the ammeter in series with the resistor and a power supply and connecting a voltmeter in parallel with the resistor. It was common to see voltmeters connected in series in the circuit, and occasionally ammeters were seen in parallel with the resistor. There was some confusion created by the fact that the resistance of five resistors had to be checked. A significant number of candidates drew circuits with five resistors connected in series or parallel – for which full credit could be obtained, if the ammeters and/or voltmeters were correctly connected, so that the resistance of an individual resistor could be correctly measured. In the last section of this part of the question, the idea of tolerances for resistance being given to offset slight differences in manufacture when a component is mass produced, was beyond all but the very best candidates. Many candidates suggested that current/voltage would be ‘used up’ by the ammeter and voltmeter, as being the reason behind discrepant values.

Question 4

(a) Only a small minority of candidates could deduce that to obtain the maximum repulsive force between the two charged rods, the charged ends had to be alongside each other, with maximum area of overlap. When describing the direction in which rod A would move, many candidates merely quoted that the rods would repel without specifying a direction, or an implication that the rod would move. Often candidates answered this by drawing an arrow on the diagram – this obtained credit if the direction was correct, but often the direction of the arrow contradicted what had been written in the answer space.

(b) Most candidates realised that the rods needed like charges to show the force of repulsion. Occasionally, candidates confused electric fields with magnetic fields and talked about like poles repelling – for which no credit was earned.

(c) Although explanations were sometimes confused, most candidates realised that the charges on the rods would eventually leak away into the surrounding air or into the bench.

PHYSICS

Paper 5054/42
Alternative to Practical 42

General comments

Candidates entering this paper scored the full range of marks from 0 to 30. There were many excellent scripts and it was pleasing to see more candidates tackling the questions from a practical viewpoint and answering the questions rather than simply using standard responses. This was noted in **Question 2(b)(ii)** and **(iii)** and in **Question 3(c)**.

The graphical work was good with few candidates drawing a straight line through an obvious curve or simply joining the points with straight lines. However, drawing a best fit smooth curve is still a challenge for many. One surprising problem was in labelling the temperature axis correctly. The symbol θ and unit °C were often incorrect.

The numerical calculation was generally well done, although quoting answers to a suitable number of significant figures caused difficulty for some.

In practical work it is important to give units on all readings as otherwise the values are meaningless. This is reflected in the practical paper and candidates should be encouraged to check all their answers have units. There were several places on this paper where candidates were penalised for the omission of units.

Comments on specific questions

Question 1

This question required the candidates to appreciate the practical difficulties in heating a liquid uniformly and timing an event. Graph plotting and extrapolating a graph line to take a reading were also tested.

(a) The majority of candidates were able to identify the need for a uniform temperature throughout the oil.

(b) In the context of this question, the need for small temperature rises was not recognised by many candidates. Weaker candidates here often gave the standard response of 'more accurate'. This needs to be qualified and on its own is an insufficient response. Answers referring to spitting or the flammability of the oil were not credited.

(c) (i) The graph was generally well executed with many candidates gaining all four marks.

Although a few candidates failed to label the axes at all, a surprising number lost this mark by incorrectly labelling the temperature axis. Common errors were: 0 instead of θ, omitting the °, giving C° or writing the ° above the C.

Very few candidates lost the mark for the scales. Errors seen were: non-linear scales where candidates missed out a value (e.g. going 20, 22, 26, 28), and ignoring the values given to start the scales. A few candidates still draw their own axes inside the graph grid. This often means their values do not fit easily into the grid and they fail to use the values given.

A few candidates still write the point values near each plotted point. This is discouraged as it can make it more difficult to draw a smooth curve and take readings from a graph.

(ii) A surprising number of candidates attempted to obtain a value for the time when the temperature was 80°C without extrapolating the graph line. All working lines should be clearly shown on graphs. The unit was required on this answer. Some candidates gave the incorrect unit °C or t/s.

(iii) Although the majority of candidates gained this mark, there were some unusual responses such as 17°C, 42°C and even answers to two decimal places.

(d) The response required here was that the temperature of the oil had changed or decreased. Answers referring only to heat loss were insufficient.

Many candidates thought the temperature would rise and the oil was still being heated. Some candidates thought the temperature needed to fall to 0°C before it could be used again.

(e) Very few candidates gained both marks here. Most thought incorrectly that accuracy was improved by using a more sensitive thermometer or by using a larger range of readings.

Most candidates ticked two boxes as required. Some ticked only one and others more than two. Candidates should read the instructions carefully.

Question 2

Most candidates had clearly performed simple timing experiments of oscillating systems and were able to apply this to the compound pendulum in the question. It was pleasing to see many excellent answers to **(b)(iii)** showing the candidates had understood the context and used this in answering the questions.

(a) Although many candidates gained full marks here showing a good appreciation of the practical requirements of measuring the period of an oscillating system, some did not give sufficient detail in their responses.

Repeat and average was the most common correct scoring answer, but just repeat was insufficient.

Some thought that timing *N* oscillations was a separate point to then dividing by *N*.

Some timed *N* oscillations then gave no detail of how *T* was then obtained.

There were several options for the third marking point. The most common response was to time from the centre of the swing or to use a (fiducial) marker. Some candidates had difficulty in expressing answers concerning viewing perpendicular to the swing, with perpendicular to the ruler or scale seen.

Responses which were not accepted included standard answers such as 'avoid parallax error' or the use of two candidates to take the readings.

(b) (i) Almost all candidates gained one mark here for identifying the change in *T* with *d*, but did not realise it both decreased and increased. Those who gained both marks generally gave clear responses. Many quoted values from the table, giving when the change occurred.

A few able candidates stated there is a minimum value for *T*.

Some candidates attempted to use proportionality here which was invariably incorrect and not required. These comments were ignored.

(ii) Most candidates who scored this mark gave the answer 1.61 s.

Incorrect responses were often to double 1.61 or were far outside the range given in the mark scheme.

(iii) It was pleasing to see so many candidates aware of the practical situation and explain that the rule would balance, rotate or not swing. That the ruler was suspended from its centre of gravity or centre of mass was an acceptable response, but not simply that it was the centre of the rule.

Some candidates thought that it was because sufficient readings had already been taken. This was not a creditworthy response.

Question 3

This question required the candidates to compute an average, complete a calculation and consider the number of significant figures in an answer.

(a) (i) This question was poorly answered by most candidates. Many reverted to standard answers here and did not answer the question fully.

Insufficient answers often seen included human error, reaction time error, parallax error and starting or stopping the stopwatch at the wrong time.

The question required a possible explanation of why the result was too large. Some excellent answers were seen, such as ‘starting the stopwatch early’ or ‘stopping the stopwatch late’.

Some candidates simply explained that it was discarded because it was larger than the others and did not give any possible cause.

(ii) It is disappointing that so many candidates cannot round values correctly. Many examples were seen of candidates incorrectly rounding 4.488 to 4.48 or 4.50.

Values of 4.49 or 4.5 were acceptable responses. (4.5 because of the range of ±0.2 in the data given.)

Some candidates lost the marks by averaging all six values. Many candidates did not show any working here and this often lost them a mark.

(b) This simple calculation required the candidates to substitute in the given equation. For most this was a simple task and they gained the mark. The unit % was required.

Errors here included simple arithmetic mistakes and candidates not understanding the % sign. Some multiplied their answer by 100. Credit was given for those dividing by 100 and giving the answer as a decimal with no unit.

(c) There were many acceptable responses here. Most candidates gained this mark.

Common acceptable responses included avoidance of parallax error, keeping the rule vertical and placing the rule close to the string. Credit was not given for ‘use a metre rule to measure the height’.

A surprising number of candidates used a tape measure rather than a metre rule.

Question 4

This question tested the candidates’ ability to draw rays accurately, construct a normal, measure angles and explain how pins are used in ray tracing. Many candidates found it difficult to explain tasks that they have familiarity with from practical sessions on light.

(a) Some candidates were able to explain clearly that the block may move and need to be replaced or to enable the rays to be drawn through the block. However a large number did not gain the mark for responses such as ‘to show its outline’.

(b) This answer required two practical details. Firstly looking through the block at the pins P_1 and P_2 and then secondly placing the pins P_3 and P_4 in a line with P_1 and P_2. Many mentioned one of these but few mentioned both.

A common error was to use a ray box to produce a beam of light then put the pins in the ray. Others attempted to calculate the angle using Snell’s law.

(c) (i) Most candidates were able to complete the path of the ray accurately through the block.

A surprising error was to continue the ray in a straight line into the block then change direction when level with the centre.

All candidates (bar one) used a ruler to draw the ray and the lines were neatly drawn.

(ii) Only a small number of candidates were able to draw the normal accurately. Most drew a tangent instead.

(iii) Candidates could only gain this mark if they had a correct normal in **(b)(ii)**.

Those with a correct normal were generally able to measure the angle accurately.

(d) Most candidates gained this mark by stating that the ray passed through the centre of the block.

Good responses seen were that the ray passed along the normal or that the angle of incidence was zero.

A few candidates gave a correct answer but then lost the mark by stating that the angle of incidence was 90°.

(e) The majority of candidates gained the mark here for ray 3 matching their ray 1.

Some candidates, however, lost the mark due to lack of accuracy.