GCSE

Rewarding Learning

Chief Examiner's Report

Physics

Summer Series 2022

Foreword

This booklet outlines the performance of candidates in all aspects of this specification for the Summer 2022 series.

CCEA hopes that the Chief Examiner's and/or Principal Moderator's report(s) will be viewed as a helpful and constructive medium to further support teachers and the learning process.

This booklet forms part of the suite of support materials for the specification. Further materials are available from the specification's microsite on our website at www.ccea.org.uk.

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GCSE Physics

Chief Examiner's Report

Subject Overview

The pandemic has resulted in considerable disruption in schools, however teachers are to be congratulated on the preparation of their candidates resulting in paper means very similar to those of the first written examinations on this specification in 2019. Small numbers were entered for the optional omission (Unit 3), but those centres entering did excellent work in preparing the practical activities for those candidates who undertook Booklet A.

It has been our policy to advise candidates to show clearly how they get their answer, starting with the equation they plan to use. Examiners will always check that although a numerical answer is correct the appropriate physics equation is present. The rule is wrong physics, no marks. However, if the final numerical answer is wrong partial credit can be awarded for a correct and appropriate physics equation. As pointed out in a previous report there appears to be a growing trend that candidates present their own versions of physics equations rather than the ones stated in the specification. It was pleasing to note the absence of memory aids, such as triangles, since not even partial credit is given to such.

The plotting and drawing of a graph can result in candidates obtaining many marks. In this series of papers, we advised candidates to show plotted points using the notation shown, ◉ or ✕, unfortunately many candidates failed to follow the advice. I would encourage centres to persuade candidates to adopt this approach as well as labelling graphs using the solidus notation such as distance/m.

The poor quality of handwriting has been mentioned in the past and again this year by most of the assistant examiners. This seems to be an ongoing issue. If an examiner cannot read the response, they cannot award any credit. Perhaps less examination practice recently may also have contributed to this issue.

As already mentioned, the number of candidates entered for the optional Unit 3 was small, approximately 10% of those entered for the Higher Tier unit, GPY22. The disruption of lessons in the last two years possibly played a part in this. Candidates scored well in this part of the assessment which used two of the prescribed practicals listed in the specification. Candidates would clearly benefit from participation in these prescribed practicals, as such a practical task will appear as part of the final practical assessment.

Assessment Unit 1 Motion, Force, Density and Kinetic Theory, Energy, and Atomic and Nuclear Physics

Foundation Tier

Overview

The entry for this paper was 138 with a mean mark of 44.9, the maximum mark being 80.

The responses offered by the candidates were generally good, when the interruption they have experienced in school is considered. As has been the case in previous examined years there are candidates at the lower end of the mark spectrum who appear to find the conceptual nature of the subject an intellectual challenge.

Q1 **(a)** This question received a most positive response with the majority of candidates achieving full credit.

(b) **(i)** Knowledge of the distance travelled as the area under the graph or average speed x time was lacking in many instances with many candidates using the final speed of 9 m/s to calculate an answer.

(ii) Generally, well answered but a significant number did not have an appreciation of rate of change of speed (or acceleration) as the slope of the graph.

(c) **(i)** Most candidates achieved at least partial credit often failing to provide a full statement.

(ii) The majority of candidates managed to find the correct value of the weight W, even those who failed to gain any credit for Part (i).

(iii) Surprisingly, a large number of candidates failed to achieve credit for what was a simple understanding of the Principle of Moments.

(d) This question attracted an array of vague answers with candidates confusing the terms Force and Pressure and failing to make the link between small area and large pressure.

Q2 **(a)** Only a small number of candidates managed to achieve full credit – naming the upward Force of Reaction proved to be beyond many.

(b) Responses were in general deserving of credit but in Part (i) responses that described the motion as constant, as opposed to constant speed, were considered too vague and not worthy of credit.

(c) Many candidates used incorrect arrangements of the equation F = ma.

(d) On the whole this was well attempted with most candidates achieving at least partial credit.

(e) This QWC question on the Centre of Gravity and Stability proved to be rather demanding. Frequently, responses were vague and lacking the detail required to provide sensible connections.

Q3 **(a)** The density calculation often attracted full credit or at least partial credit. The topic appeared to have been well understood.

(b) **(i)** Kinetic theory descriptors for phases of matter were well known.

(ii) The electron was well known to be responsible for conduction of heat but not so a description of the mechanism with candidates referring to the conduction of charge.

Q4 **(a)** The main pitfall here was between the choice of Strain and Power.

(b) This question often achieved at least partial credit but the equation offered to support the choice of diagram was often not acceptable with formats such as J = Nm or E = mxh in evidence.

(c) **(i)** Most were able to state the Conservation of Energy.

(ii) Naming energy types presented little difficulties for the candidates.

(iii) Candidates either knew how to perform the calculation on efficiency or not but happily the former were in the majority.

(d) **(i) & (ii)** A significant number of candidates were unable to provide the correct equations to calculate Potential and Kinetic Energy.

(e) While 'Can A' was usually identified as that which cooled fastest the explanation on offer often incorrectly referred to it as a better conductor or better absorber of heat. Only a relatively small number of candidates correctly identified the matt black can as a better emitter/radiator of heat.

Q5 **(a)** Knowledge of atomic structure was generally well known with the majority of candidates achieving at least partial credit and a significant number full credit.

(b) **(i) & (ii)** Naming of Background Count appeared to be demanding for a not insignificant number of candidates as was identification of its origin. This was a disappointing outcome to what would have been considered as a simple question.

(iii) A disappointing number of candidates offered range values well beyond that offered on the distance axis of the graph.

(c) Precautions were sometimes too vague and, in some instances, not realistic/ practical or repetitive. However, most candidates did manage to achieve partial credit.

(d) Knowledge of Fission and Fusion and their use as named sources of energy was either well or poorly known.

Higher Tier

Overview

The entry for this paper was 3967. The mean score was 70.4 out of 100 marks, this compares with the mean score in 2019 of 74.9. The larger than normal entry comprises Year 11 pupils and those Year 12 pupils who missed out on the opportunity to sit the examination in 2021.

Candidates did very well in this paper. The paper whilst, allowing candidates of differing abilities to demonstrate their knowledge and skills, worked well to differentiate candidates. Generally, responses were well attempted with candidates showing their working out and paying attention to units.

Q1 **(a)** **(i) & (ii)** Almost all read the graph correctly and achieved both marks.

(iii) Weaker candidates picked a pair of values from a single point on the line. They usually obtained only the mark for the equation and the distance substitution.

(b) **(i)** Although the expectation was that most candidates would use the area under the graph method, many successfully answered this question using the equations of motion. Those who began with the distance = speed x time usually lost all marks since they failed to appreciate that the speed was changing.

(ii) Although this was a simple application of the definition of acceleration, weaker candidates lost a mark because of u,v confusion.

(c) **(i)** This was correctly answered by most candidates.

(ii) A significant number of candidates pointed to the fact that the car was now back where it started. This was not enough. Examiners required the student to realise that the displacement was zero.

(d) **(i)** Once again, those who began with the distance = speed x time usually lost all marks since they failed to appreciate that the speed was changing. The easy way to approach the question was to use the average speed, although other methods were also given full credit.

(ii) There were numerous ways to do this question. Most used an appropriate equation of motion, but some used energy conservation ideas. All were given credit. The expected response was to use the average velocity together with the calculated time.

Q2 **(a)** **(i)** The expectation was that candidates would rule a straight line from the origin and a smooth curve thereafter. A few candidates joined the points together, while others drew a single straight line. The limit of proportionality was well done.

(ii) Most could do the Hooke's Law calculation, although some gave themselves needless extra work by converting from centimetres to metres or millimetres.

(iii) Those who appreciated that the line would have a smaller gradient generally obtained full marks.

(b) This question was quite well done with most picking up at least 4 of the 6 marks. However, only the better candidates realised that standing on the upper deck of the bus raised the centre of gravity and reduced stability. Many candidates used inappropriate physics terminology and referred to the "CoG being outside the base".

(c) This was well done. Weaker candidates either gave their answer as the resultant force (400 N) or added the resultant force to the engine force instead of subtracting it.

(d) This was poorly answered. The expectation was that candidates would begin with a mathematical statement of the Principle of Moments and then begin to make substitutions, However the ACM = CM statement was often omitted and many failed to see that the CM was the product of the weight of the ruler and 20 cm.

(e) This straightforward question on the application of P = F/A was generally well done.

Q3 **(a)** **(i)** This question on the need to read to the bottom of the meniscus at eye level was well done.

(ii) Most could do the straightforward addition calculation.

(iii) The density question was generally well done, although a number of candidates used the volume calculated in Part (ii) instead of the 28 cm^3.

(iv) Some failed to notice that the volume and mass should be on the y-axis and x-axis respectively. A few labelled one of the axes density and were not awarded any marks.

(b) (i) & (ii) These questions were well done.

Q4 (a) (i) The table was completed well by most candidates.

(ii) Most recognised the major pollutant from coal was carbon dioxide.

(b) (i) Those who recognised that the useful output energy was 80 J generally scored well in the question. A minority of candidates misquoted the efficiency equation and scored zero marks.

(c) (i) Most could do the straightforward calculation to find kinetic energy.

(ii) Very many recognised that the kinetic energy lost by the car was equal to the work done by the brakes.

(iii) It was expected that most would start this question using the equation linking work done and applied force. Those who started this way generally went on to obtain most of the marks. Some used equations of motion and others applied energy conservation ideas. While all methods capable of obtaining the correct numerical answer were rewarded, centres might consider advising candidates to apply the most obvious and straightforward method of solution.

(iv) This was well done.

(d) (i) Marks were awarded here for showing that the GPE was 1.68 x 1012 J.

Many candidates failed to convert the 400 km to metres and lost one mark.

(ii) This required candidates to add two numbers in index form.

Unfortunately, some were unable to do so on their calculator and, if their work was clearly set out, they lost one mark.

(e) This was well done.

Q5 (a) (i) The equation was completed well by those candidates who recognised that beta decay was occurring.

(ii) Many candidates showed a lack of understanding by repeatedly halving the half-life or believing that the decay was occurring over four half lives.

(b) (i) This was well done.

(ii) Some quoted background activity here, rather than its source. A minority wrote CMBR.

(iii) Most candidates gave an acceptable range for alpha particles.

(c) While most knew that nuclear radiation can disrupt DNA and cause cancer, few appreciated that this occurs because it causes ionization.

(d) (i) Some candidates may not have covered this material. They sometimes quoted isotopes used in nuclear fission.

(ii) Weaker candidates did not read the words “on earth” in the question and gave answers such as “in the Sun” or “stars”.

(iii) Most candidates gave “helium” as their answer.

Assessment Unit 2 Waves, Light, Electricity, Magnetism, Electromagnetism and Space Physics

Foundation Tier

Overview

The entry for this paper was 96 with a mean mark of 41.9 from 80 marks.

In comparison to Unit 1 candidates did not provide the same level of response. This may be a reflection on the demand for more written responses in this unit and perhaps also that they may have had less time in the classroom, to hone this aspect of an examination paper.

As was the case in Unit 1 there are candidates at the lower end of the mark spectrum who appear to find the conceptual nature of the subject an intellectual challenge.

Q1 In general, this question was well attempted.

(a) The majority of candidates achieved at least partial credit but many appeared to think that sound travels in a vacuum.

(b) The regions of the electromagnetic spectrum were well known but too often the correct order in terms of wavelength was not.

(c) Only a small number of candidates gained full credit.

(d) **(i)** This was reasonably well attempted with most candidates obtaining at least partial credit.

(ii) Surprisingly the equation $v = f\lambda$ was not well known or attempts to rearrange it were erroneous. Many candidates attempted to use the equation $s = d/t$.

(e) Calculation of the time saw most candidates making a good attempt but many failed to recognise the need to double the distance and so gained three of the available four marks.

Q2 **(a)** This QWC question did not see many candidates achieve the full 6 mark credit and this was both surprising and disappointing. A good number of candidates failed to name the seven colours of the visible spectrum, often replacing indigo and violet with purple. Explanation of the appearance of the colour order in terms of speed or refraction was all too often missing.

(b) Completion of the reflected rays was well attempted.

(c) **(i) & (ii)** Labelling of the angles of incidence and refraction was poorly done while naming a controlled variable frequently attracted an answer of 'The width of the glass block'.

(iii) & (iv) Marks were often lost by transposition of the axes or by not including units on the labeling of the axes. However, the skill of drawing a best fit line on the graph was in evidence. A good proportion of the candidates did calculate the value of the constant k correctly.

Q3 **(a)** Circuit symbol for a fuse was not well known and many confused that of the battery with a cell.

(b) Candidates often failed to distinguish correctly between electron flow and conventional current flow, but many appeared to know that of the latter to gain partial credit.

(c) Explanation of electrical conductors and insulators using the free electron model was surprisingly lacking in the vast number of scripts.

(d) **(i)** Total resistance of the series circuit was well done but this was not the case with the parallel circuit with variations of the correct equation being replaced by numerous others such as RT = 1/R1 +1/R2 appearing on scripts. It had been anticipated that candidates would have used the simpler approach of RT = R/2.

(ii) & (iii) These on the whole were correctly answered with perhaps that of the current less so than the voltage.

(e) **(i) & (ii)** In the main these were well answered with the majority of candidates correctly reading the meters, but a number then proceeded to employ an incorrect version of the Ohm's law equation or failed to rearrange it correctly.

(iv) & (v) The main cause of a mark loss was the failure to include units in the labelling the axes of the proposed graph, whilst the explanation for the graph shape sometimes failed to include the term proportionality or direct proportion. Many offered explanations such as 'positive correlation' which was not acceptable.

Q4 **(a)** Only a small number of candidates managed to achieve full credit, suggesting the explanation of Electromagnetic Induction, in terms of the ammeter reading, was not well known.

(b) The majority of candidates did gain at least partial credit in this section. However, a sizeable number failed to draw the secondary coil with more turns than the primary coil or indeed make any attempt at all. Most did know that the output voltage showed an increase on the input voltage. Naming the voltage supply as Alternating or a.c. was not well known as indeed was the explanation of using a high voltage for transmission of electricity in terms of current reduction to reduce heat loss in the cables.

Q5 **(a)** Names of the planets were well known but classification into Rocky and Gaseous planets not so in Part (ii).

(b) Overall, responses here were good but the spelling of Fusion was frequently replaced by 'Fussion' which was not accepted.

(c) A frequent downfall here was for candidates to be too generous with their ticks which resulted in a loss of marks.

Higher Tier

Overview

The entry for this paper was 2598 with a mean of 72.7, the maximum mark being 100.

The overall standard of answering was good, when the disruption to schools is considered.

It was evident from those questions testing knowledge of practical activities, that candiates had suffered from lack of involvement in such tasks. Many candidates did not present mathematical solutions in any logical order or did not seem to know how to. Starting a solution with an appropriate equation and following the advice to show your working out is crucial to obtaining some partial credit should an error occur later in the attempt. As mentioned earlier in this report the quality of handwriting was in some cases very poor, a little more care might result in more marks.

Q1 **(a)** Most successfully recalled how the wavelength frequency and speed behaved when wave move from deep water to shallow water.

(b) **(i)** The majority of candidates were able to identify the amplitude and wavelength from the graphs of displacement – time and displacement – distance.

(ii) Frequency and its unit were generally well done. A small number of candidates quoted frequency = 1/period but were unable to take this any further.

(iii) The calculation of wave speed was again well done, with many gaining credit when an error carried from Part (ii) was applied. The use of speed = distance/time was allowed provided the distance was indicated as the wavelength and the time as the period.

(c) **(i)** Very well done, with most candidates knowing to double the distance or the time to obtain the correct answer.

(ii) The reason for not using sonar to detect aircraft was poorly answered. A minority of candidates did provide the correct response of sound waves being too slow.

(d) **(i)** Very many were able to place the various electromagnetic waves in the correct wavelength group.

(ii) The unique property of electromagnetic waves as the ability to travel through a vacuum was correctly given by approximately half the candidates.

Q2 **(a)** Describing the process and explanation of dispersion was well done by very many candidates. When listing the equipment, the ray box was often not mentioned. A complete listing of the colours of the spectrum was given by most candidates and they also place them in correct order of increasing wavelength. The explanation of the spectrum in terms of change of speed related to the amount of refraction was correctly given by many candidates.

(b) **(i)** Very many wrongly offered the critical angle to explain why the ray of light was not refracted as it entered the prism along the normal.

(ii) The diagram to show the path of the light through the periscope was correctly completed by nearly all candidates, care was also taken to ensure a 90^{o} reflection at each prism.

(iii) Most recalled total internal reflection as the effect that explains the path of the light through the periscope.

(c) **(i)** The straightforward task of marking the angles of incidence and refraction was poorly done by too many candidates. The angle of refraction was often incorrectly placed between the refracted ray and the dotted line showing the original path of the incident ray.

(ii) The need to keep the angle of incidence constant produced a disappointing level of success. Many candidates were unable to express their answer in a clear and unambiguous fashion.

(iii) The graph of displacement versus width of the glass block was very well done. Few marked the points in the manner suggested, an approach that helps those marking the papers identify the points on the grid, especially with online marking.

(iv) Most candidates were able to correctly calculate the value of the constant k.

(d) Completion of the ray diagram was generally well answered. The placing arrows on the rays was too often omitted. Indicating the image by an inverted arrow ↓ was essential to gain credit.

(e) **(i)** Nearly all candidates knew that a convex or converging lens in spectacles was need to correct longsight.

(ii) The most common error in the drawing of the ray diagram was not to show some refraction of the rays as they entered the eye.

Q3 **(a)** **(i)** Nearly all gave the correct formula for power either in words or the correct symbols i.e. P = IV.

(ii) Adding the ammeter and voltmeter in the correct positions in the circuit was correctly answered by nearly all candidates.

(iii) Completion of the table was very answered.

(iv) Identification of the correct graph to show the relationship between power and length of wire was again generally well done as was the associated explanation.

(b) Considering this was a relatively simple question, a disappointing number failed to correctly show the direction of both the electron flow and conventional current.

(c) **(i) & (ii)** The calculation of the resistance of the resistors in parallel and that of the resistor marked X were very well answered. Errors made in Part (i) could still gain credit in Part (ii) when an error carried forward was applied.

(d) **(i)** Most were able to state the two factors needed to be kept constant during the investigation of resistance and area of cross section.

(ii) The calculation of the constant k was correctly dealt with by most candidates.

(iii) Very few were able to correctly deduce the units of k.

Q4 **(a)** **(i)** Most correctly gave the correct direction for the magnetic field.

(ii) Use of Fleming's left hand rule allowed many to correctly show the current direction in the coil.

(iii) Fleming's left hand rule was correctly stated with most shortening it to the left hand rule.

(b) **(i)** Precise descriptions of a.c. and d.c were often lacking.

(ii) The correct identification of the two traces in Part (ii) was more frequent.

(c) **(i)** The completion of the diagram to show the number of coils on the step-up transformer was very poor, with many simply drawing the same number or less than those on the primary coil.

(ii) Most knew that a step-up transformer produced a greater output voltage than that applied to the primary coil.

(iii) The calculation of the ratio of the number of turns on the secondary coil to the number on the primary coil was not well done. Many did not fully understand what was required and calculated the inverse ratio.

(d) **(i)** Calculating the cost of using the electric fire was very well answered.

(ii) The conversion of 1 kWh to Joules was poorly answered.

Q5 **(a)** The classification of planets as rock or gaseous was known to nearly all the candidates.

(b) **(i)** The balancing of gravity and thermal expansion or radiation pressure was known to most candidates. Pressure alone without the addition of radiation to the answer did not gain credit.

(ii) Nuclear fusion as the production for elements in stars was know by most candidates.

(iii) The stages in the life cycle of massive stars were correctly identified by well over half the candidates.

(c) **(i)** The time of the Big Bang was correctly given by most but a few confused billion with million.

(ii) The red shift as evidence for the recession of galaxies was very well known as was cosmic microwave radiation for evidence of the Big Bang.

(d) The better candidates presented their calculation in a logical manner making it easier to follow. Many did gain full marks despite their presentation lacking a logical layout.

Assessment Unit 3 Practical Skills

This unit comprises Booklet A GPY33 worth 30 marks combined with Booklet B GPY34 worth 70 marks. The entry was 294 candidates achieving a mean mark of 76.7 out of 100 marks.

Foundation Tier

No entries were made for Foundation Tier.

Higher Tier

Booklet A

Overview

Candidates generally performed very well in this paper., achieving a mean score of 28. The paper allowed candidates of differing abilities to demonstrate their knowledge and skills. Generally, responses were well attempted and there was significant evidence that the candidates were familiar with these prescribed practicals and were able to competently follow the instructions. Marks were generally lost through a lack of detail in the responses rather than lack of skill or knowledge.

Question 1

Step 1 All candidates were able to measure and record the mass of the empty beaker using the electronic balance. The number of decimal places in the measurement was not considered in the award of the mark and the number of decimal places varied between candidates, not necessarily centres. Also, the mass of the beaker varied between centres.

Step 2 Many candidates failed to label the column with the correct quantity. Many labelled the column 'Mass of beaker' and failed to achieve the mark, others used 'Mass' and were awarded the mark. Most candidates included the correct unit with the correct symbol. Candidates were penalised if they used and upper case g for grammes Although candidates were not penalised for the presentation of the quantity and unit, many did not use the recommended solidus notation.

Step 3 All candidates were able to obtain five values of mass of water and beaker, and all candidates' data showed increasing values. The values varied between centres.

Step 4 Some candidates incorrectly transferred the values from Column 2 on page 3 to Column 2 on page 4 which limited their access to further marks. Many candidates added the correct column heading and others were awarded this mark for just 'mass/g'. Most candidates calculated accurate values of the mass of the water. Decimal places were not penalised on this step.

Step 5 Most candidates labelled the heading of Column 3 as 'density' and many candidates added the correct unit, although this was a fairly common source of error. Most candidates used the equation correctly to find the density of water. Some candidates failed to accurately record the density to one decimal place.

Interpretation 1 Most candidates labelled the axes of the graph correctly with appropriate units. Some candidates transposed the axes. Most candidates plotted the points on the graph accurately, although many failed to follow the instruction and did not use a cross or a dot with a circle to do so. Most candidates applied an appropriate best fit straight line through the origin, although there was significant evidence of the lack of use of a ruler.

Interpretation 2 Only the better candidates were able to name the correct mathematical relationship shown by the graph. Many vaguely suggested a positive correlation and did not gain credit

Interpretation 3 The gradient of the graph was well determined by many candidates although some made mathematical errors or obtained the reciprocal of the gradient. The unit was often incorrectly stated.

Question 2

Step 1 On the scripts of most candidates there was an indication that no help was given in completing the circuit, allowing all the candidates to gain two marks for this skill.

Step 2 Most candidates were able to record an increasing number of paper clips for both trials and the numbers were invariably integers.

Step 3 Most candidates correctly averaged the number of paper clips from the two trials. However, not all the candidates quoted their averages to the nearest whole number and were penalised.

Interpretation 1 The vast majority of candidates plotted accurate graphs with appropriate best fit straight lines, although many obtained data that occupied a small portion of the grid.

Interpretation 2 Most candidates identified the correct statement describing the relationship between the current and number of paper clips. A small number of candidates suggested that there was no relationship.

Interpretation 3 Many candidates correctly identified the independent variable, although some candidates confused this with the dependent variable.

Interpretation 4 Many candidates correctly identified the dependent variable, although some candidates confused this with the independent variable.

Interpretation 5 Most candidates were able to state a suitable controlled variable, although some suggestions were too vague for credit.

Booklet B

Overview

The mean score for this paper was 48.7. The paper did provide a range marks indicating that while some coped admirably with the demands of the paper others did find it a challenge. The standard of answering was at times disappointing. There was no evidence that candidates had insufficient time to complete the paper.

The quality of handwriting was, at times, of a poor standard which made it difficult for examiners to decipher and decide what marks to award. It was clear that a lack practical work in school due to the disruption caused by covid had an impact of candidates' understanding of many activities.

Q1 **(a)** **(i)** Many candidates correctly calculated the average but failed to quote their answer to one decimal place as requested.

(ii) This was poorly answered with very few candidates referring to the increasing distance in equal time intervals.

(iii) A significant number of candidates failed to explicitly say the total distance and time.

(iv) Candidates often failed to adequately show how they arrived at the target speed and showed no indication of the unit conversion. This proved to be a challenge for many. Responses of 100/0.45 = 2.22 m/s or 100/45 were not infrequent.

(v) The majority of candidates answered this question adequately.

(vi) This proved a discriminating question, with only a small number of candidates achieving all the marks. Many candidates were awarded partial credit if they offered a correct initial equation, but this was not always the case.

(vii) This was poorly attempted by most candidates with many candidates failing to show an understanding of acceleration.

(b) This was generally adequately attempted with most candidates achieving at least four marks. Many candidates failed to state explicitly that the dependent variable was average speed rather than just speed, although many alternatively offered time as a response. Most candidates identified the height of the ramp as the independent variable and most candidates offered a suitable control. The two pieces of apparatus were a source of credit for the vast majority of candidates. Most candidates were able to suggest an appropriate graph to be drawn. Fewer candidates recalled that proportionality was indicated by a straight line through the origin.

Q2 **(a)** **(i)** Most of the candidates were awarded some of the five marks available for this circuit diagram. The symbol for the variable resistor proved the most challenging part.

(ii) This proved discriminating with a minority of the candidates able to describe how manipulation of the variable resistor would allow for the measurements to be obtained.

(iii) This was a generally well plotted graph. Scales were appropriate and points accurately plotted. A small number of candidates added an incorrect unit to the current axis.

(iv) Most candidates recognised the lack of proportionality and attributed it to the curve or lack of straight line.

(b) **(i)** This was a well answered question with most candidates able to carry out the calculation accurately and add an appropriate unit.

(ii) This was a more challenging question with only the better candidates able to offer two appropriate calculations that showed lack of proportionality. Many incorrectly tried to use a voltage current ratio.

Q3 **(a)** A significant number of candidates failed to calculate the weight of the mass. Sadly the candidates failed to recall the simple relationship between mass and weight.

(b) **(i)** Most candidates were able to identify the anomalous result and many were able to give an adequate reason.

(ii) Most candidates suggested an appropriate strategy for dealing with the anomaly.

(iii) This was well answered by many candidates, some utilising the previous incorrect answer for weight. Of the candidates failing to score marks, most offered an initial incorrect equation.

(c) **(i)** The graph was appropriately used by the vast majority of candidates to obtain the correct value.

(ii) This proved challenging for many candidates. The manipulation of the expression to obtain the input power or the substitutions were the main sources of error.

(iii) Most candidates recognised that energy was lost and some quoted the source of the loss.

(d) Very few candidates suggested clamping the motor to the bench.

Q4 **(a)** **(i)** Whilst candidates clearly recognised the rays, their labels lacked accuracy and so many failed to gain all the marks available.

(ii) The angle of incidence was identified by many candidates.

(iii) The angle of refraction was identified by many candidates.

(iv) Many candidates correctly attributed the refraction to the decrease in speed and so gained both marks.

(b) **(i)** The vast majority of candidates calculated the correct ratio and quoted the value to one decimal place.

(ii) Candidates found this question challenging and many failed to describe how the values supported lack of proportionality.

(iii) The graph was well plotted, with appropriate scales. A small number of candidates transposed the axes or failed to include degrees as the unit on the axes labels.

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