**Introduction to Physics practise questions**

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|  | |  |  | | --- | --- | |  |  | | **1.** | The table below shows the measurements recorded by a student for a solid metal sphere. The absolute uncertainties in the mass of the sphere and in its radius are also shown.     |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | |  | |  |  | | --- | --- | | mass | 100 ± 6 g | | radius | 1.60 ± 0.08 cm | |  |   What is the percentage uncertainty in the density of the sphere?   1. 1% 2. 11% 3. 16% 4. 21%   Your answer       |  | | --- | | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **2.** | Which physical quantity has the same base units as energy?   1. moment 2. momentum 3. force 4. pressure   Your answer    **[1]** | |

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|  | |  |  | | --- | --- | |  |  | | **3.** | The initial temperature T1 of water in a beaker was 20.1 °C ± 0.2 °C. After the water had been heated for some time, the final temperature T2 was 27.3 °C ± 0.3 °C. The temperature increase ΔAT is given by ΔT = T2 − T1  What is the best estimate of the uncertainty in ΔT?   1. ± 0.05 °C 2. ± 0.1 °C 3. ± 0.25 °C 4. ± 0.5 °C   Your answer    **[1]** | |

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|  | |  |  | | --- | --- | |  |  | | **4.** | Which is the **best** estimate of the area of a rectangular field of length 98 ± 3 m and width 47 ± 2 m?     |  |  | | --- | --- | | **A** | 4600 ± 5 m2 | | **B** | 4600 ± 6 m2 | | **C** | 4600 ± 300 m2 | | **D** | 4606 ± 337 m2 |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **5.** | Which of the following units is **not** an S.I. base unit?     |  |  | | --- | --- | | **A** | ampere | | **B** | mole | | **C** | volt | | **D** | kilogram |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **6.** | Which of the following shows the correct base units for pressure?     |  |  | | --- | --- | | **A** | kg m−2 | | **B** | kg m−2 s−2 | | **C** | kg m−1 s−2 | | **D** | kg m2 s−3 |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **7(a).** | A student carries out an experiment to measure g, the acceleration due to gravity, by measuring the time t for a steel ball to fall a distance s. The method is shown in **Fig. 2.1**    The break-to-start and break-to-stop contacts are connected to an electronic timer. As the steel ball is released from the electromagnet, the electronic timer starts. The ball falls a distance s before it hits a hinged metal 'trap door'. The trap door opens, breaks the circuit and stops the timer.  The student records the following data for a range of distances s, averaging the time t at each distance over several drops. He intends to plot a graph of s against t2 so adds a third column to his table of results.     |  |  |  | | --- | --- | --- | | s/m | mean t/s | t2/s2 | | 0.40 | 0.31 | 0.10 | | 0.60 | 0.38 | 0.14 | | 0.80 | 0.42 | 0.18 | | 1.00 | 0.47 |  | | 1.20 | 0.51 |  | | 1.40 | 0.55 | 0.30 |  1. Complete the table. Add the final two points to the graph of **Fig. 2.2**. Draw a straight line of best fit on **Fig. 2.2**.   **[3]**     1. Determine the gradient of the line. Show clearly your working.   gradient = .......................................... m s−2  **[2]** | |

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|  | |  |  | | --- | --- | |  |  | | **(b).** | The student expected the line to go through the origin and have a gradient of g/2. The timing device he used measures to within 0.01 s and the distance s was measured to within 0.01 m.   1. The fact that the line of best fit does not pass through the origin is unlikely to have been caused by random errors in his measurements. Justify this statement.         **[2]**   1. Explain how a systematic error in each of the measured quantities could contribute to the line not passing through the origin and what effect, if any, each would have on the gradient of the line.             **[4]**   1. Suggest one source of possible systematic error in the experiment.       **[1]** | |

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|  | |  |  | | --- | --- | |  |  | | **8.** | The unit of potential difference is the volt.  Use the equation W = VQ to show that the volt may be written in base units as kg m2 A−1 s−3.  **[3]** | |

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|  | |  |  | | --- | --- | |  |  | | **9(a).** | A student is investigating the resistance of a conducting putty.  The student rolls the putty into a cylinder shape and connects the ends of the cylinder to metal plates as shown in Fig. 5.1. The ohm-meter is used to measure the resistance R of the conducting putty.    **Fig. 5.1**   1. Suggest why the student uses large metal plates at the ends of the conducting putty.       **[1]**   1. Describe how the student can check that the diameter of the conducting putty is constant.       **[2]** | |

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|  | |  |  | | --- | --- | |  |  | | **(b).** | The student measures the resistance R of the conducting putty for different length L. The volume of the conducting putty is kept constant.  The student's results are shown in Table 5.2.     |  |  |  | | --- | --- | --- | | **L / m** | **R / Ω** | **L2 / 10−3 m2** | | 0.049 | 14 | 2.4 | | 0.060 | 21 | 3.6 | | 0.069 | 28 | 4.8 | | 0.081 | 37 |  | | 0.090 | 46 | 8.1 | | 0.099 | 57 | 9.8 |   **Table 5.2**   1. Complete the table for the missing value of L2.   **[1]**   1. Each length is measured to the nearest millimetre using a ruler. Determine the percentage uncertainty in L2 for L = 0.049 m.   percentage uncertainty = ...........................................................% **[1]** | |

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|  | |  |  | | --- | --- | |  |  | | **(c).** | Fig. 5.3 shows the graph of R (y-axis) against L2 (x-axis).   1. Plot the missing data point and draw the straight line of best fit.   **[2]**   1. Determine the gradient of the line of best fit.   gradient = ........................................................... **[2]**    **Fig. 5.3** | |

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|  | |  |  | | --- | --- | |  |  | | **(d).** | The relationship between R and L is    where ρ is the resistivity of the conducting putty and V is the volume.  Use your answer to **(ii)** from the previous question and V = 1.9 × 10−5 m3 to determine a value for ρ. Include an appropriate unit.  ρ = ............................................ unit: ............................................ **[3]** | |

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|  | |  |  | | --- | --- | |  |  | | **10.** | Fig. 21 shows the drum of a washing machine.  **Fig. 21**  The clothes inside the drum are spun in a **vertical** circular motion in a clockwise direction.  The drum has diameter 0.50 m. The manufacturer of the washing machine claims that the drum spins at 1600 ± 100 revolutions per minute.  Calculate the speed of rotation of the drum and the absolute uncertainty in this value.     |  |  |  |  |  | | --- | --- | --- | --- | --- | | speed = |  | ± |  | ms−1 **[3]** | | |

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|  | |  |  | | --- | --- | |  |  | | **11.** | An approximate value of the Planck constant h can be determined in the laboratory using light-emitting diodes (LEDs). An LED suddenly starts to conduct and emit monochromatic light when the potential difference across an LED exceeds a minimum value V0. The potential difference V0 and the wavelength λ of the emitted light are related by the equation    where e is the elementary charge and c is the speed of light in a vacuum.  Fig. 20.1 shows some data points plotted by a student on a V0 against graph for five different LEDs.  **Fig. 20.1**  The potential difference across each LED was measured using a digital voltmeter with divisions ± 0.01 V. The values for the wavelengths are accurate and were provided by the manufacturer of the LEDs.  The value of V0 was determined by directly observing the state of the LED in the **brightly** lit laboratory.   1. Draw the straight line of best fit on Fig 20.1 and determine the gradient of the line.      |  |  |  | | --- | --- | --- | | gradient = |  | V m **[2]** |  1. Use your answer in **(i)** and the equation above to determine a value for h to 2 significant figures. Show your working.      |  |  |  | | --- | --- | --- | | h = |  | J s **[3]** |      1. Calculate the percentage difference between your value in **(ii)** and the accepted value of the Planck constant.      |  |  |  | | --- | --- | --- | | difference = |  | % **[1]** |  1. Identify the two types of errors shown by the data in Fig. 20.1 and suggest how you could have refined the experiment to reduce or eliminate these errors.                       **[4]** | |

**END OF QUESTION PAPER**

# Mark scheme

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| **Question** | | | **Answer/Indicative content** | **Marks** | **Guidance** |
| 1 |  |  | D | 1 |  |
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| 2 |  |  | A | 1 |  |
|  |  |  | **Total** | **1** |  |
| 3 |  |  | D | 1 |  |
|  |  |  | **Total** | **1** |  |
| 4 |  |  | **C** | 1 | **Examiner’s Comments** In this question, candidates generally forgot that the practical skills guide recommends that uncertainties are usually given to one significant figure, ruling out option D. Furthermore, the length and width are both given to two significant figures, which means that the area should also be to two significant figures. The correct procedure is to add the percentage uncertainties in the length and width, which gives the percentage uncertainty in the area and hence the absolute uncertainty of 300 m. This question provided opportunities for middle-grade candidates. |
|  |  |  | **Total** | **1** |  |
| 5 |  |  | **C** | **1** | **Examiner’s Comments**  About three quarters of all candidates recognised that the volt is not an S.I. base unit. |
|  |  |  | **Total** | **1** |  |
| 6 |  |  | C | 1 | **Examiner’s Comments**  Since P = F/A, we need the units of force and area in base units. F = ma, so force has the base units of kg m s-2 . Area’s unit in base units is m2. Hence pressure has the base units kg m s-1/m2 = kg m-1 s-2, which is answer C. |
|  |  |  | **Total** | **1** |  |
| 7 | a | i | 0.22 and 0.26 | B1 |  |
|  |  | i | correct plotting of points on Fig. 2.2 | B1 | tolerance on each point ± 0.5 small scale division |
|  |  | i | sensible line not through origin | B1 | expect x-intercept at about 0.02 |
|  |  | ii | triangle with base at least half width of graph | B1 | must have appropriate triangle on Fig. 2.2 or two sets of data lying on the line clearly shown |
|  |  | ii | expected gradient close to 5 | B1 | ecf line; typical values (1.4 – 0)/(0.30 – 0.02) |
|  | b | i | All points lie below the theoretical line | B1 | accept quantitative answers e.g. error in s is half a square |
|  |  | i | the error bars on each reading are not long enough to allow a worst line through the origin / AW | B1 | and in t2 is 3 to 4% as several readings averaged 2 marks for two valid points |
|  |  | ii | s is too small | B1 | Or s should be larger |
|  |  | ii | same shift in all values so no change to gradient | B1 |  |
|  |  | ii | t is too big | B1 |  |
|  |  | ii | constant error in t leads to increasing error in t2 so gradient is changed / steeper | B1 |  |
|  |  | iii | sensible reason for t being too large or s too small | B1 | e.g. electromagnet does not release instantaneously,trapdoor is stiff, faulty contacts,etc e.g. scale on ruler does not start at the end / AW |
|  |  |  | **Total** | **12** |  |
| 8 |  |  | (1 C =) (1) A s | C1 | **Allow** alternative methods |
|  |  |  | (1 J = ) (1) kg m s−2 × m or (1) N = (1) kg m s−2 | C1 |  |
|  |  |  |  | M1  A0 | **Note** this mark is for clear substitution and working   **Examiner's Comments**  Some candidates were not clear on what was meant by base units. Most realised that the quantity of electric charge is measured in As. Weaker candidates had difficulty deriving work done. |
|  |  |  | **Total** | **3** |  |
| 9 | a | i | To ensure whole cross-sectional area or end of the conducting putty is in contact with the metal plate (AW) | B1 | **Not** good electrical contact / reduces contact resistance / surface area   **Examiner's Comments**  Conversely, candidates struggled with an explanation as to why large metal plates were used. Many candidates discussed the electrical properties of the metal plates rather than understanding the need of the experiment. |
|  |  | ii | Use a (Vernier) caliper / micrometer (screw gauge) | B1 | **Allow** ruler |
|  |  | ii | Repeat measurements along the conducting putty | B1 | **Examiner's Comments**  Most candidates discussed measuring the diameter with a named instrument at different points along the putty. |
|  | b | i | 6.6 | B1 | **Allow** 6.56 **Ignore** 10−3 factor  **Examiner's Comments**  This part was answered well with the majority of the candidates recording the correct value to two significant figures. Some candidates made rounding errors or recorded spurious values. |
|  |  | ii |  | B1 | **Ignore** significant figures **Allow** 4 %  **Examiner's Comments**  Most candidates were able to determine a percentage uncertainty although many did not multiply by 100. Some candidates thought that the nearest millimetre meant 0.01m instead of 0.001m. Some candidates did not realise that the percentage uncertainty in d needed to be multiplied by two. |
|  | c | i | Plots the missing point to less than a half small square | B1 | **Allow** ECF from **(i)** Penalise blob of half a small square or larger |
|  |  | i | Draws straight line of best fit | B1 | **Allow** ECF Expect to be balance of points about line of best-fit. Judge straightness by eye. **Not** a top point to bottom point line / not a top point to (2.0, 10) line   **Examiner's Comments**  The plotting of the missing point was accurately positioned by the majority of the candidates. There were major difficulties on drawing a suitable straight line of best fit; it is expected that there should be a balance of points about the line. Many lines could have been rotated. Lines that were drawn from the bottom plot to the top plot invariably had too many points below the line and were penalised. Some candidates did not draw straight lines. |
|  |  | ii |  | M1 | **Not** one R/L2 value using the line or a data point **Ignore** POT for M1 |
|  |  | ii | gradient = 5700 (5550 − 5850) | A1 | **Allow** ± 150 for the value of gradient **Ignore** units   **Examiner's Comments**  This question tested the practical skills of candidates to determine the gradient from their results. To score these marks candidates had to show their method. A large number of candidates failed to realise that the x-axis had a factor of 10−3. Other common errors were to assume that the graph commenced at (0, 0). Good candidates clearly demonstrated their method by indicating the points taken, made sure that the length of their gradient was at least half the length of their line and correctly substituted into Δy / Δx. |
|  | d |  | ρ = 5700 × 1.9 × 10−5 | C1 | **Note**: ECF from **(ii)** **Allow** any subject for equation **Not** use of data points from table |
|  |  |  | ρ = 0.108 given to 2 or 3 sf | A1 |  |
|  |  |  | Ω m | B1 |  |
|  |  |  |  |  | **Examiner's Comments**  Candidates were expected to use the gradient that they had calculated in (ii) of the previous question part to determine a value for the resistivity; candidates who substituted a data point from the table did not score the first two marks. The final answer needed to be given to two or three significant figures. There was also a mark available for the correct unit; a good number of candidates scored this mark although a number of candidates did write the unit for density. |
|  |  |  | **Total** | **12** |  |
| 10 |  |  | T = 60/1600 or T = 3.75 × 10−2 (s)  (v = π × 0.50/3.75 × 10−2)  speed = 42 (m s−1)   uncertainty = 3 (m s−1) | **C1     A1   A1** | **Allow:** f = 26.7 or (Hz) or ω = 168 (s−1)    **Note:** v must be to 2 or more SF   **Note:** uncertainty must be to 1 SF **Allow:** ecf on candidate’s value for speed i.e. uncertainty = candidate’s value / 16 (to 1 SF)  **Allow for 2 marks max: 84 ± 5 (m s−1)**   **Examiner’s Comments**  About half of the candidates got this item right or provided clear working to show where they were going. There was much confusion about which quantity was which. 1600 revolutions per minute refers to the frequency of the rotation, not the angular speed, angular frequency or the speed itself.  The percentage error of the frequency was 6.25%, prior to rounding. Some candidates multiplied this by their value for the speed to get the correct absolute uncertainty, although good practice is to round uncertainties to 1 SF. |
|  |  |  | **Total** | **3** |  |
| 11 |  | i | A straight line with non-zero V0 intercept      gradient = 1.3 × 10−6 | **B1      B1** | **Ignore** spread of data points on either side of the line  **Allow** Intercept > 0 and < 1.0 V   **Allow** (1.10 to 1.60) × 10−6; no need to check calculation  **Examiner’s Comments**  Most candidates scored either 1 or 2 marks. The straight lines of best fit were generally well drawn. A significant number of the candidates forced their lines to go through the origin. The tolerance for the value of the gradient was deliberately made large. The ultimate penalty was the power of ten. Very few made two errors here – straight line through the origin and missing 10−6 factor. |
|  |  | ii | |  |  | | --- | --- | |  | (Any subject) |        |  |  | | --- | --- | |  | (Any subject) |   h = 6.9 × 10−34 (J s) | **C1     C1    A1** | Possible ECF from **(i)**   **Note** the answer must be given **2 SF** only  **Examiner’s Comments**  This was not an easy question, but a good number of candidates did exceptionally well on this practical-style question. The first mark was for correctly identifying ‘gradient = hc/e’, and subsequent marks were for correct substitution and writing the final to 2 significant figures (SF). A significant number of candidates quoted their correct h value to more than the required SF. Many candidates were scoring full marks through the error carried forward rule.    **Exemplar 9**    This exemplar illustrates how full marks can always be scored from error carried forward (ECF) rule.  The gradient of 1.08 × 10−5 was well outside the range allowed. This had already been penalised in the earlier part **20(b)(i)**. This erroneous value has been used correctly in this section. The answer is nowhere close to the Planck constant, but this is irrelevant – the physics has been applied correctly here, the answer is correctly written with 2 SF, so well deserved 3 marks for this E-grade candidate. |
|  |  | iii | difference = 4.1 % | **B1** | Possible ECF from **(ii)**  **Ignore** sign **Not** division by value from **(ii)**  **Allow** 1 SF answer |
|  |  | iv | Random (error) / data points are spread about line  Systematic (error) / line does not pass through origin  Take (many) repeat readings (of V0) **and** average   Conduct the experiment in a darkroom / use (black) tube over the LED to view when it is lit / use a (digital) voltmeter with no zero error | **B1    B1   B1     B1** | **Allow** other sensible suggestion **Not** faulty voltmeter     **Examiner’s Comments**  The two errors in this experiment were systematic and random errors (see learning outcome 2.2.1a in the H556 specification). Many candidates did not name these two errors, instead focussing on nebulous terms such as human error, equipment error, etc. Appropriate descriptions of these two errors were allowed. Only a small number of candidates appreciated that taking multiple readings of V0 and averaging will lead to reduction in the random error. A pleasing number of candidates realised that the main reason for the non-zero intercept (systematic error) was the ambient light and switching off the lights would improve matters. Sorting out the zero-error on the voltmeter was an acceptable alternative.  Descriptions about using ‘precise instruments’ for measuring potential difference or light intensity often led to no credit. |
|  |  |  | **Total** | **10** |  |