InkPhysics

QUESTION WORKBOOK

Uncertainty and error

Measurements · Year 12

AQA 3.1.2 · CIE 1.3.1, 1.3.2, 1.3.3
OCR A 1.1.3(c), 1.1.4(d), 1.1.4(e), 2.2.1(a), 2.2.1(b), 2.2.1(c), 2.2.1(d)

19 questions · 60 marks

NAVY SCREEN EDITION

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SECTION A · Warm-up

A1 Distinguish between random errors and systematic errors. [2]

A2 A length is measured as 2.50 ± 0.05 m. Calculate the percentage uncertainty. [2]

A3 Distinguish between the precision and the accuracy of a set of measurements. [2]

A4 State what is meant by the resolution of an instrument, and give the resolution of a digital stopwatch that displays times to 0.01 s. [2]

A5 A student's repeated measurements of a resistance agree closely with each other. A second student, using a different meter, obtains values that agree closely with the first student's. State the term that describes each of these two observations. [2]

SECTION B · Standard

B1 Two lengths, 3.0 ± 0.1 m and 5.0 ± 0.2 m, are added. State the total length and its absolute uncertainty. [2]

B2 A rectangle has length 10.0 ± 0.2 cm and width 5.0 ± 0.1 cm. Calculate its area and the absolute uncertainty in the area. [4]

B3 A length of 45 mm is measured with a ruler of 1 mm resolution, giving a reading uncertainty of ±0.5 mm. Calculate the percentage uncertainty. [3]

B4 Four repeated readings of a length are 20.1, 20.3, 20.2 and 20.4 mm. Calculate the mean and estimate its uncertainty from the range. [3]

B5 With its jaws fully closed, a micrometer reads −0.03 mm. With a wire between the jaws it reads 0.36 mm. (a) Name the type of error the closed-jaw reading reveals. (b) Determine the diameter of the wire. (c) Explain why taking repeat readings would not remove this error. [3]

B6 To find the extension of a rubber cord, a student measures its stretched length as 482 ± 1 mm and its unstretched length as 476 ± 1 mm. (a) State the extension and its absolute uncertainty. (b) Calculate the percentage uncertainty in the extension. (c) Suggest one change to the experiment that would reduce this percentage uncertainty. [4]

B7 A student determines g from $g = 4\pi^2 l/T^2$ using a simple pendulum, with $l = 0.650 \pm 0.002$ m and $T = 1.62 \pm 0.02$ s. Calculate the percentage uncertainty in the value of g. [3]

SECTION C · Stretch

C1 The radius of a circle is 4.0 ± 0.1 cm. Calculate the area and its absolute uncertainty (area = πr^2). [4]

C2 A density is found from $\rho = m/V$, with $m = 0.500 \pm 0.005$ kg and $V = 2.0 \times 10^{-4} \pm 0.1 \times 10^{-4}$ m^3. Calculate the density and its absolute uncertainty. [4]

C3 State how you would reduce (a) a random error and (b) a systematic error in an experiment. [3]

C4 A student investigating a falling ball plots a graph with error bars on every point. The best-fit line has gradient 0.204 $s^2\ m^{-1}$. The steepest and shallowest lines that still pass through all the error bars have gradients 0.212 $s^2\ m^{-1}$ and 0.196 $s^2\ m^{-1}$. Determine the absolute and percentage uncertainty in the gradient, and quote the gradient with its uncertainty. [4]

C5 A supplier claims that a batch of ball bearings has diameter 5.00 mm with a tolerance of ±1%. A student measures one bearing four times with a micrometer, reading 5.11, 5.09, 5.07 and 5.09 mm. Deduce whether the bearing meets the supplier's claim. [4]

C6 A student measures g by timing a ball falling a height h and using $g = 2h/t^2$, with $h = 1.250 \pm 0.005$ m and $t = 0.505 \pm 0.005$ s. Determine the percentage uncertainty each measurement contributes to g, and state which single measurement most needs improving. [3]

C7 A student varies the length l of a simple pendulum, measures the period T for each length, and plots T^2 on the y-axis against l on the x-axis, with error bars on the T^2 values. The period is given by $T^2 = 4\pi^2 l/g$. Describe fully how the student should use the graph to determine a value for g and its percentage uncertainty. [6]