2.1 Measurements & Errors

Question Paper

Course	CIE A Level Physics (9702) 2019-2021
Section	2. Measurement Techniques
Topic	2.1 Measurements & Errors
Difficulty	Hard

Time allowed: **10**

Score: **/10**

Percentage: **/100**

Question 1

A mass is dropped from rest and falls through a distance of 2.0 m in a vacuum. An observer records the time taken for the mass to fall through this distance using a manually operated stopwatch and repeats the measurements a further two times. The average result of these measured times, displayed in the table below, was used to determine a value for the acceleration of free fall. This was calculated to be 9.8 ms^{-2}.

	first measurement	second measurement	third measurement	average
time/ s	0.6	0.73	0.59	0.64

Which statement best relates to the experiment?

A The measurements are precise and accurate with no evidence of random errors.

B The measurements are not accurate and not always recorded to the degree of precision of the measuring device but the calculated experimental result is accurate.

C The measurements are not always recorded to the degree of precision of the measuring device but are accurate. Systematic errors may be present.

D The range of results shows that there were random errors made but the calculated value is correct so the experiment was successful.

[1 mark]

Question 2

A steel wire is stretched in an experiment to determine the Young modulus for steel. The uncertainties in the measurements are given below.

measurement	uncertainty
load on wire	±2%
length of wire	±0.2%
diameter of wire	±1.5%
extension	±1%

What is the percentage uncertainty in the Young modulus?

A 1.3% **B** 1.8% **C** 4.7% **D** 6.2%

[1 mark]

Question 3

A student finds the density of a liquid by measuring its mass and volume. The following is a summary of his measurements.

mass of empty beaker = (20 ± 1) g
mass of beaker + liquid = (70 ± 1) g
volume of liquid = (10.0 ± 0.5) cm^3

He correctly calculates the density of the liquid as 5.0 g cm^{-3}.

What is the uncertainty in this value?

A 0.3 g cm^{-3} **B** 0.5 g cm^{-3} **C** 0.6 g cm^{-3} **D** 2.6 g cm^{-3}

[1 mark]

Question 4

A micrometer screw gauge is used to measure the diameter of a copper wire.

The reading with the wire in position is shown in diagram 1. The wire is removed and the jaws of the micrometer are closed. The new reading is shown in diagram 2.

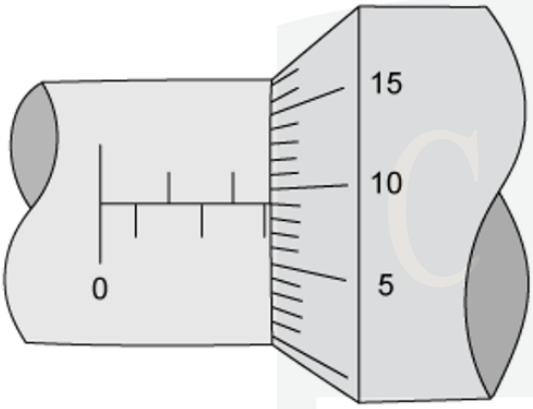


Diagram 1

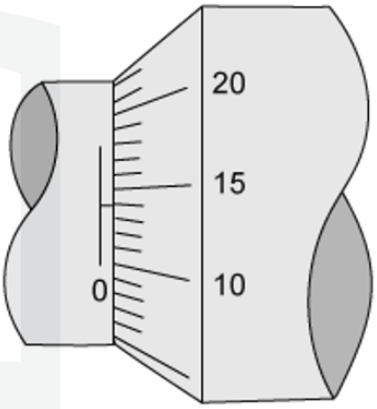


Diagram 2

What is the diameter of the wire?

A 1.90mm **B** 2.45mm **C** 2.59mm **D** 2.73mm

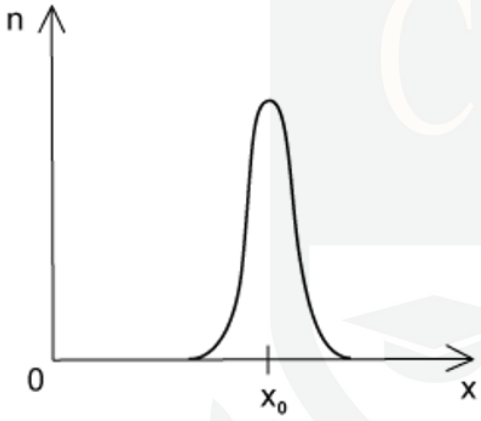
[1 mark]

Question 5

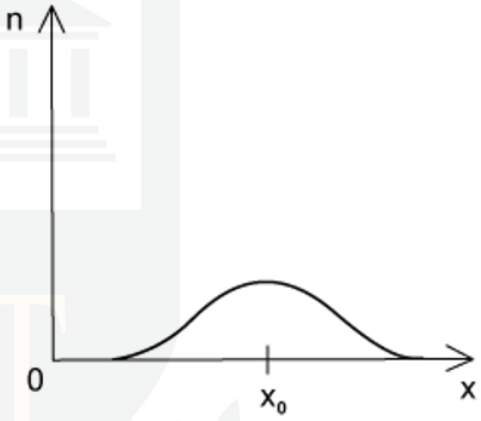
A fixed quantity x_0 is measured many times in an experiment that has experimental uncertainty. A graph is plotted to show the number n of times that a particular value x is obtained.

Which graph could be obtained if the measurement of x_0 has a large systematic error but a small random error?

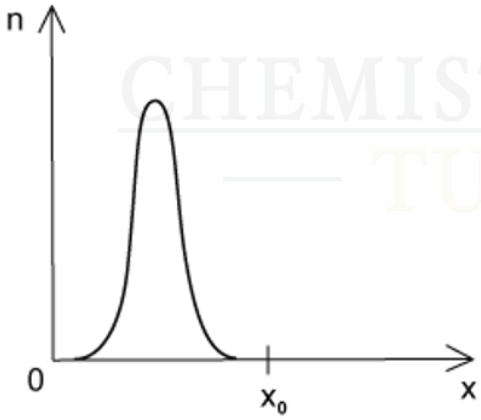
A



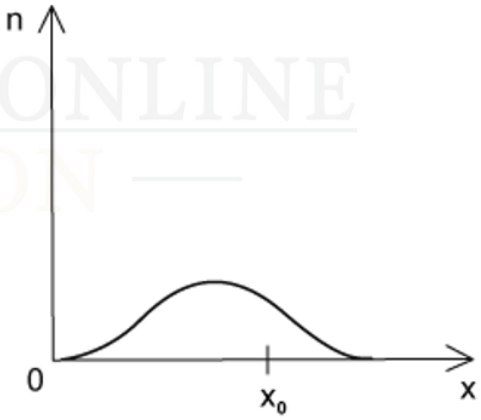
B



C



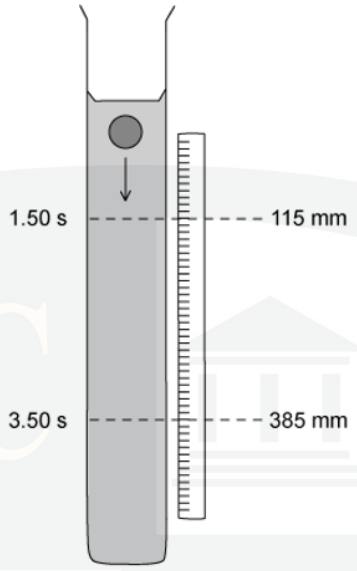
D



[1 mark]

Question 6

The diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.



There are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

The constant speed of the ball is calculated to be 135 mm s^{-1}

Which expression calculates the fractional uncertainty in the value of this speed?

A $\frac{2}{270} + \frac{0.04}{2.00}$

B $\frac{1}{270} + \frac{0.02}{2.00}$

C $\frac{1}{115} + \frac{0.02}{1.50}$

D $\frac{1}{385} + \frac{0.02}{3.50}$

[1 mark]

Question 7

In an experiment to determine the acceleration of free fall *g*, a ball bearing is held by an electromagnet. When the current to the electromagnet is switched off, a clock starts and the ball bearing falls. After falling a distance *h*, the ball bearing strikes a switch to stop the clock which measures the time *t* of the fall.

If systematic errors cause *t* and *h* to be measured incorrectly, which error **must** cause *g* to appear greater than $9.81 ms^{-2}$?

A *h* measured as being **smaller** than it actually is and *t* is measured correctly

B *h* measured as being **smaller** than it actually is and *t* measured as being **larger** than it actually is

C *h* measured as being **larger** than it actually is and *t* measured as being **larger** than it actually is

D *h* is measured correctly and *t* measured as being **smaller** than it actually is

[1 mark]

Question 8

The uncertainty in the value of the momentum of a trolley passing between two points X and Y varies with the choice of measuring devices.

Measurements for the same trolley made by different instruments were recorded.

1 distance between X and Y using a metre rule with cm divisions = 0.55m

2 distance between X and Y using a metre rule with mm divisions = 0.547m

3 timings using a wristwatch measuring to the nearest 0.5s at X = 0.0s and at Y = 4.5s

4 timings using light gates measuring to the nearest 0.1s at X = 0.0s and at Y = 4.3s

5 mass of trolley using a balance measuring to the nearest g = 6.4×10^{-2} kg

6 mass of trolley using a balance measuring to the nearest 10g = 6×10^{-2} kg

Which measurements, one for each quantity measured, leads to the least uncertainty in the value of the momentum of the trolley?

A 1, 3 and 6 **B** 1, 4 and 6 **C** 2, 3 and 6 **D** 2, 4 and 5

[1 mark]

Question 9

A student uses a digital ammeter to measure a current. The reading of the ammeter is found to fluctuate between 1.98A and 2.02A.

The manufacturer of the ammeter states that any reading has a systematic uncertainty of ±1%.

Which value of current should be quoted by the student?

A (2.00 ± 0.01) A

B (2.00 ± 0.02) A

C (2.00 ± 0.03) A

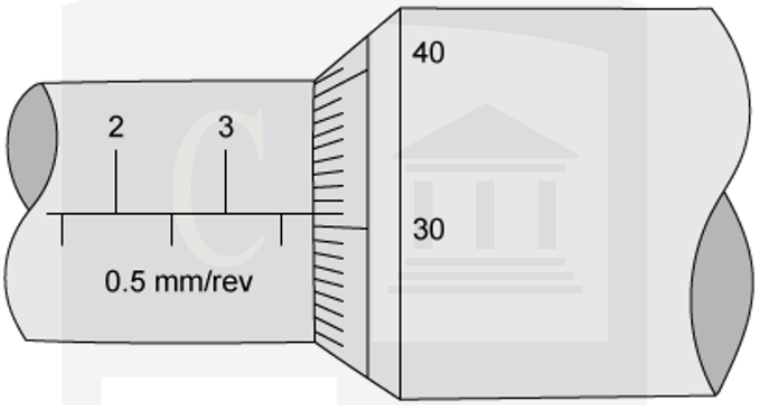
D (2.00 ± 0.04) A

[1 mark]

Question 10

The diameter of a cylindrical metal rod is measured using a micrometer screw gauge.

The diagram below shows an enlargement of the scale on the micrometer screw gauge when taking the measurement.



What is the cross-sectional area of the rod?

A $3.81mm^2$ **B** $11.4mm^2$ **C** $22.8mm^2$ **D** $45.6mm^2$

[1 mark]