1. Four students measured and calculated the electronic charge, e. The table shows the results obtained. Which student obtained a set of results that could be described as accurate but least precise?

Student	Electronic Charge, e (10^{-19} C)				
A	1.62	1.59	1.59	1.61	1.60
B	1.57	1.63	1.64	1.58	1.59
C	1.59	1.60	1.58	1.57	1.57
D	1.58	1.62	1.65	1.59	1.66

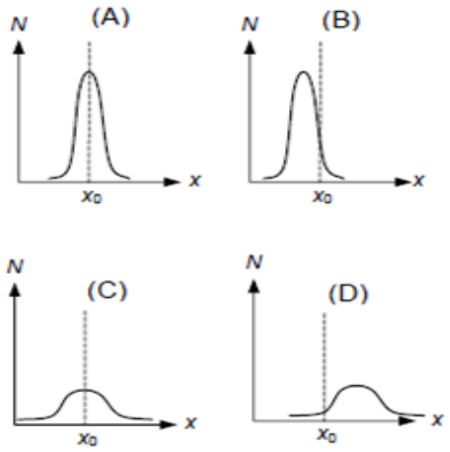
2. A cylindrical container has a diameter of (2.45 ± 0.05) m and a depth of (1.25 ± 0.05) m.

The maximum percentage uncertainty in the volume of the container is

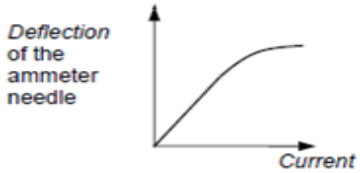
(A) 4% (B) 5%

(C) 6% (D) 8%

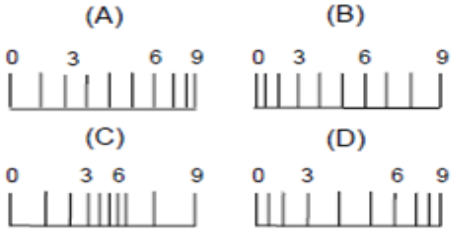
3. A quantity x is measured many times and the number N of measurements giving a value x is plotted against x. The true value of the quantity is x_o. Which graph best represents an accurate measurement with poor precision?



4. The deflection of the needle of an ammeter varies with the current passing through the ammeter as shown in the graph.



Which diagram could represent the appearance of the scale of this meter?



5. In an experiment to measure the density of steel, a steel sphere was used. The following measurements were obtained:

Mass of the sphere = 530 mg ± 1mg

Diameter of the sphere = 0.51 cm ± 0.01 cm

Estimate the percentage error in the calculated value of the density of steel.

(A) 0.4% (B) 2%

(C) 4% (D) 6%

6. A student determined the density of the material of a rectangular block by measuring the mass and linear dimensions of the block. His measurements were as follows:

Mass = (80.0 ± 0.2) g

Length = (5.00 ± 0.01) cm

Breadth = (2.00 ± 0.01) cm

Height = (1.00 ± 0.01) cm

How should he express the uncertainty in his result?

(A) 0.01 $g cm^{-3}$ (B) 0.02 $g cm^{-3}$

(C) 0.1 $g cm^{-3}$ (D) 0.2 $g cm^{-3}$

7. A steel rule can be read to the nearest millimeter. It is used to measure the length of a bar whose true length is 895 mm. Repeated measurements give the following readings.

Length/mm: 892, 891, 892, 891, 891, 892

Are the readings accurate and precise to within 1 mm?

	Results are accurate to within 1mm	Results are precise to within 1mm
(A)	No	No
(B)	No	Yes
(C)	Yes	No
(D)	Yes	Yes

8. An experimenter wishes to determine the resistivity of a metal X. He made some measurements of the length L and diameter D of a rod of metal X. After connecting the rod to a battery, he measured the potential difference V across the ends of the rod and the current I flowing through the rod. He obtained the following data.

Length, L = (400 ± 1) mm

Diameter, D = (3.0 ± 0.2) mm

Current, I = (0.220 ± 0.005) A

Potential Difference, V = (8.0 ± 0.2) V

The percentage uncertainty in the value of the resistivity, ρ calculated is

(A) 6 (B) 9

(C) 12 (D) 18

9. A student measures the diameter of a cylindrical wooden pencil with a ruler. How could he increase the precision of the measurement?

(A) Use a micrometer with zero error and take one value of the diameter.

(B) Take the average value of several measurements of the diameter along different parts of the pencil using the ruler.

(C) Take the average value of several measurements of the diameter along different parts of the pencil using vernier calipers without zero error.

(D) Take the average value of several measurements of the diameter along different parts of the pencil using vernier calipers with zero error.

10. In the determination of the electro-chemical equivalent, z, of copper by electrolysis, the following equation is employed: $z = \dfrac{m_1 - m_2}{It}$, where

$m_1 = (47.66 \pm 0.01) \times 10^{-3}$ kg

$m_2 = (43.67 \pm 0.01) \times 10^{-3}$ kg

$I = (2.00 \pm 0.05)$ A

$t = (6000 \pm 1)$ s

The value of z calculated from these readings will have an error of at most about

(A) 2.5% (B) 2.8%

(C) 3.0% (D) 3.3%

11. Shown below are four target boards from a shooting competition. Which one of them indicates a small random error but large systematic error?

(A)

(B)

(C)

(D)

12. In a simple electrical circuit, the current in a resistor is measured as (20.0 ± 0.4) mA. The resistor is marked as having a value of $(4.8\,\text{k}\Omega \pm 2\%)$. If these values were used to calculate the power dissipated in the resistor, what would be the percentage uncertainty in the value obtained?

(A) 2% (B) 4%

(C) 6% (D) 8%

13. The radius of a solid sphere is measured to be (7.50 ± 0.03) cm and its mass is measured to be (1.65 ± 0.02) kg. Determine the density of the sphere in kgm^{-3} and the uncertainty in the density.

(A) 0.00093, 0.00002

(B) 933.71, 0.02

(C) 934, 2

(D) 930, 20

14. A student wishes to determine the density ρ of a cylinder of mass M, height h and diameter of cross section d, using the formula $M = \dfrac{\pi d^2}{4} h\rho$. If the percentage uncertainties of his measurements of M, d and h are ±4%, ±1% and ±0.5% respectively, what will be the percentage uncertainty of ρ?

(A) 1.5% (B) 2.5%

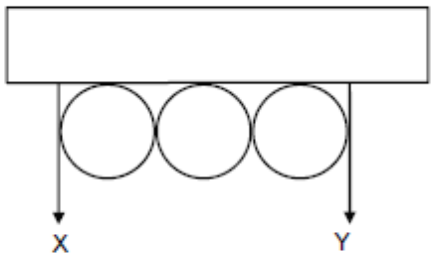
(C) 5.5% (D) 6.5%

15. In an experiment, the length and breadth of a rectangular card was found to be (64 ± 2) mm and (47 ± 1) mm respectively. The uncertainty in the area cannot be more than

(A) $90\,\text{mm}^2$ (B) $120\,\text{mm}^2$

(C) $150\,\text{mm}^2$ (D) $180\,\text{mm}^2$

16. A student attempts to measure the radius of a steel ball by using a ruler to measure three identical balls in a row.



The student estimates the positions on the scale to be as follows.

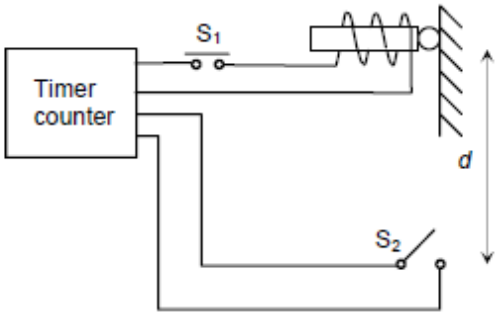
X: (2.0 ± 0.3) cm

Y: (7.0 ± 0.3) cm

What is the radius of the steel ball together with its associated uncertainty?

In a simple electrical circuit, the current in a resistor is measured as (2.3 ± 0.1) A. The resistor is marked as having a value of $47\,\text{k}\Omega \pm 4\%$. What is the power dissipated in the resistor together with its associated uncertainty?

17. The figure below shows the apparatus used by a student to measure the acceleration of free fall, g. Pressing switch S_1 simultaneously starts the time counter and releases the ball by withdrawing the peg P. The counter is stopped when the ball closes the lightly sprung switch S_2. The acceleration of free fall is calculated from the expression $d = 0.5\,gt^2$ where d is the distance the ball falls and t is the time it takes.



A student conducted the experiment and measured the distance d with a metre rule.

(a) How might this introduce into the measurement

(i) a random error

(ii) a systematic error

(b) He recorded the distance as $d = (90.4 \pm 0.1)$ cm and the time as $t = (0.43 \pm 0.01)$ s. Calculate the absolute uncertainty in the determination of g.

(c) He then repeated the experiment for different values of d and measured the corresponding values of time t. How would he use a graph to find a value for the acceleration of free fall?

(d) Give one reason for calculating the results with the aid of a graph.