MEASUREMENT

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

1 You are provided with 2 types of resistors, one type of value **300 Ω** with a percentage uncertainty of 10% and another type of value 330 Ω with a percentage uncertainty of **5%**.

(a) If two of the **300 Ω** resistors are placed in series, work out the value of their total resistance with its associated uncertainty.

Total resistance =…… ± ……..……Ω **[2]**

(b) If two of the **330 Ω** resistors are now connected in parallel, work out both the *maximum* and *minimum* resistance of this combination.

Maximum value = ……..Ω

Minimum value = ……..Ω **[3]**

Ans

(a) R = 300 ±10% = 300 ± 30 Ω **M1**
Total resistance = 300 + 300 = 600 Ω
Δ(R+R) = 30 + 30= 60 Ω

Total resistance = 600 ± 60 Ω **A1**

(b) R = 330 Ω hence ΔR = 5% of 330 Ω = 16.5 Ω **M2**
Hence maximum value for a single resistor is (330 + 16.5) Ω = 346.5 Ω
Hence minimum value for a single resistor is (330 - 16.5) Ω = 313.5 Ω

Since combined resistance, $R_c = R/2$
Maximum value for $R_c = 346.5/2 = 173.25\Omega$
Minimum value for $R_c = 313.5/2 = 156.75\Omega$

Rounding off to the nearest ohm, **A1**
Maximum value = 173 Ω
Minimum value = 157 Ω

2 **(a)** The travelling microscope may be read to ± **0.1 mm**. Discuss whether it would be possible to use this apparatus to detect a variation of **1%** in the diameter of the tube between two points, **25 mm** apart.

[2]

(b) To reduce random error, we can take the average of several readings of a quantity. Explain why taking average of a few readings can reduce random error.

[2]

(c) 'Velocity is a vector quantity, and kinetic energy of a body is equal to half its mass times the square of its velocity. Hence, kinetic energy must also be a vector.' Comment on the correctness of this statement.

Ans **a** 0.01x25 = 0.25mm = 0.3 mm
Hence, not possible as the instrument cannot read up to the 2nd dp.

b Taking average of a few readings could reduce the scatter of the readings from one another. Hence, random error is reduced since random error is a measure of the scatter of the data points.

c The statement is incorrect. The kinetic energy of a body is equal to half its mass times the square of the **value of** its velocity. Since the calculation consists of the multiplication of scalar values, the result is a scalar value and not a vector.

3 50 copper rods are arranged side by side closely without any gaps between them as shown in Fig 1.1. A metre rule is used to measure *L*, the total length as shown, and recorded as **(60.5 ± 0.1)cm**.

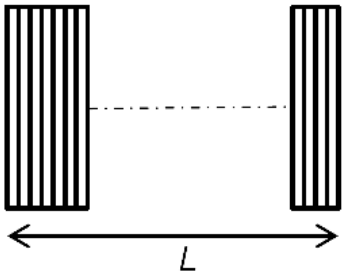

Fig 1.1

(a) Calculate the diameter of a single rod, together with its uncertainty.

diameter = …….. cm [2]

(b) Given that the resistivity of copper is **1.7 x 10^{-8} Ω m** and the average length of each rod is measured by the same metre rule to be **14.2 cm**, calculate the percentage uncertainty of the resistance of a single copper rod.

percentage uncertainty = …….. % [3]

(c) Explain what is meant by random errors, and identify a source of random error which can occur in the measurement of the diameter of a single copper rod.

……

……

……

…… [2]

Ans (a) Diameter of one rod = L/50 = 1.210 cm **C1**

Uncertainty in diameter, $\Delta d = \Delta L / 60 = 0.0017$ cm = 0.002 cm (1 SF)

Hence, d = 1.210 ± 0.002 cm **A1**

(b) **(b)** $R = \frac{\rho L}{A} = \frac{\rho L}{\left(\frac{\pi d^2}{4}\right)} = \frac{4\rho L}{\pi d^2}$ **C1**

$$\frac{\Delta R}{R} = \frac{\Delta L}{L} + 2\left(\frac{\Delta d}{d}\right)$$

Percentage uncertainty $\frac{\Delta R}{R} x100 = \left[\frac{\Delta L}{L} + 2\left(\frac{\Delta d}{d}\right)\right]100$ **C1**

$= [\frac{0.1}{14.2} + 2(\frac{0.002}{1.210})]100 = 1.03\%$ **A1**

(c) Random errors are errors with different magnitudes and signs in repeated measurements, occurring without any fixed pattern. **B1**

Non-uniformity in diameter of the rod along its length **B1**