

- 4 A student measured a metal nut of the type shown below.



- (a) The student measured the diameter d of the hole in the centre of the metal nut.
- (i) She made one measurement in cm using Vernier calipers and one measurement in mm using digital calipers. The photographs show the measurements.



Explain why the digital calipers would be a better choice of instrument for this measurement.

You should include calculations in your answer.

(4)

- (ii) The student determined a more accurate value for d .

Explain one technique she could have used.

(2)

(iii) The student recorded the following measurements.

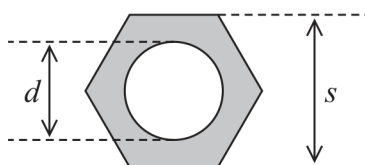
d / mm	6.57	6.58	6.54	6.52
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Determine the mean value of d and its uncertainty in mm.

(3)

Mean value of $d = \dots \text{mm} \pm \dots \text{mm}$

(b) The student was given a different size metal nut. She measured the distances shown.



She calculated the shaded area A of the metal using the formula

$$A = \frac{\sqrt{3}}{2} s^2 - \frac{\pi}{4} d^2$$

$$s = 16.83 \text{ mm} \pm 0.02 \text{ mm}$$

$$d = 8.55 \text{ mm} \pm 0.04 \text{ mm}$$

$$A = 1.88 \text{ cm}^2$$

Show that the uncertainty in A is about 0.01 cm^2 .

(4)



(c) The student measured the mass m and the thickness x of the metal nut.

$$m = 10.3 \text{ g} \pm 0.1 \text{ g}$$

$$x = 7.92 \text{ mm} \pm 0.03 \text{ mm}$$

$$A = 1.88 \text{ cm}^2 \pm 0.01 \text{ cm}^2$$

(i) Determine the density ρ of the metal from which the nut is made.

(2)

$$\rho = \dots\dots\dots$$

(ii) The density of steel ranges from 7.85 g cm^{-3} to 8.03 g cm^{-3} .

Deduce whether the metal nut could be made from steel.

(3)

(Total for Question 4 = 18 marks)