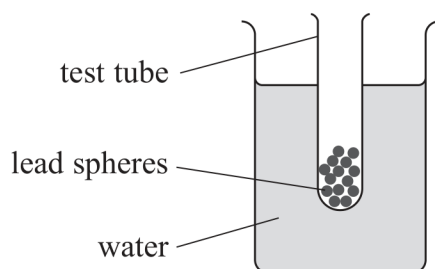


- 4 A student added small lead spheres to a test tube. The student placed the test tube in a small beaker of water. The test tube floated as shown.



The student gave the test tube a small vertical displacement. The test tube then oscillated vertically.

- (a) The student measured the time period  $T$  of the oscillations using a stopwatch. She repeated the measurement of  $T$  and calculated a mean.

- (i) Describe **two** other techniques she should use to determine  $T$ .

(2)

- (ii) She recorded the following measurements.

$5T / \text{s}$	3.43	3.36	3.28	3.49
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Calculate the mean value of  $T$  and its uncertainty in seconds.

(3)

Mean value of  $T = \dots \text{ s} \pm \dots \text{ s}$



- (b) The student estimated that the diameter of the test tube was approximately 2 cm.

Explain why vernier calipers are a suitable instrument to measure the diameter.

Your answer should include a calculation.

(2)

- (c) The student replaced the water with a different liquid and determined the new value of  $T$ .

$T$  is given by the formula

$$T = \sqrt{\frac{16\pi m}{D^2 \rho g}}$$

where

$D$  is the diameter of the test tube

$m$  is the mass of the test tube and lead spheres

$\rho$  is the density of the liquid.



(i) Show that  $\rho$  is about  $1200 \text{ kg m}^{-3}$ .

$$D = 2.38 \text{ cm} \pm 0.01 \text{ cm}$$

$$T = 0.61 \text{ s} \pm 0.01 \text{ s}$$

$$m = 48.95 \text{ g}$$

(2)

(ii) Show that the percentage uncertainty in  $\rho$  is about 4%.

(3)

(iii) The density of glycerol is  $1260 \text{ kg m}^{-3}$ .

Deduce whether the liquid could be glycerol.

(2)

(Total for Question 4 = 14 marks)