tera =

1 Which list puts the forces in order of increasing magnitude?

A 2 pN < 2 fN < 2 TN < 2 GN ○

B 2 pN < 2 fN < 2 GN < 2 TN ○

C 2 fN < 2 pN < 2 TN < 2 GN ○

D 2 fN < 2 pN < 2 GN < 2 TN ☑

tera $= 10^{12}$
giga $= 10^{9}$
pico $= 10^{-12}$
femto $= 10^{-15}$

(Total 1 mark)

2 A student carries out an experiment to determine the resistivity of a metal wire.
She determines the resistance from measurements of potential difference between the ends of the wire and the corresponding current. She measures the length of the wire with a ruler and the diameter of the wire using a micrometer. Each measurement is made with an uncertainty of 1%

Which measurement gives the largest uncertainty in the calculated value of the resistivity?

A current ○

[✓ **B** diameter] ○

C length ○

D potential difference ○

$$\rho = \frac{RA}{L}$$

radius is squared

(Total 1 mark)

3 A student has a diffraction grating that is marked 3.5 × 10^3 lines per m.

(a) Calculate the percentage uncertainty in the number of lines per metre suggested by this marking.

$3.5 \times 10^3 = 3500$

lowest is 0.1×10^3

So $\frac{100}{3500} \times 100$

percentage uncertainty = 2.9 %

(1)

(b) Determine the grating spacing.

$$\text{Space} = \frac{1}{3500}\ \text{m}$$

grating spacing = 0.29 mm

(2)

(c) State the absolute uncertainty in the value of the spacing.

$$0.29 \pm \frac{2.9}{100} = 0.008$$

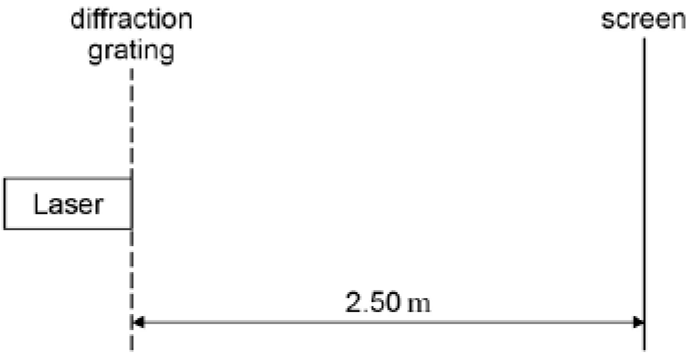
$$= 0.01$$

absolute uncertainty = ____________________ mm

(1)

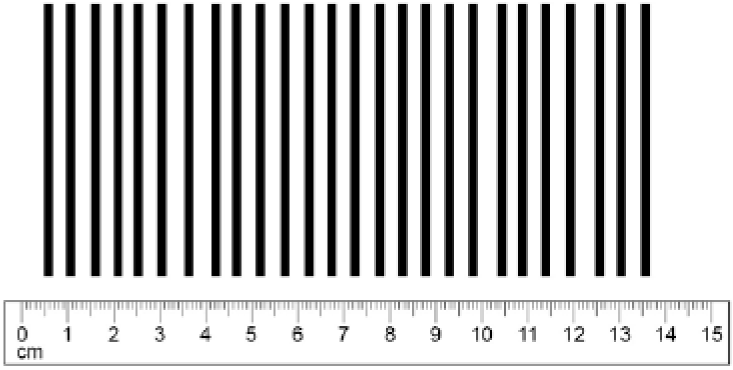
(d) The student sets up the apparatus shown in **Figure 1** in an experiment to confirm the value marked on the diffraction grating.

Figure 1



The laser has a wavelength of 628 nm. **Figure 2** shows part of the interference pattern that appears on the screen. A ruler gives the scale.

Figure 2



take at least 10 fringes

Use **Figure 2** to determine the spacing between two adjacent maxima in the interference pattern. Show all your working clearly.

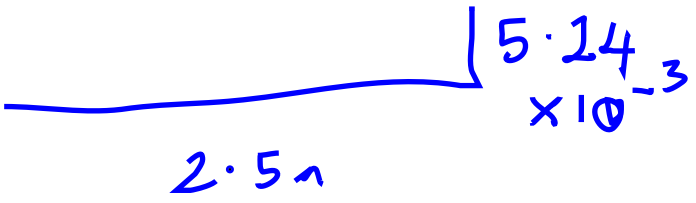
5.24

spacing = ____________________ mm

(1)

(e) Calculate the number of lines per metre on the grating.

$n\lambda = d\sin\theta$



$\theta = 0.12 \Rightarrow d = 3\times10^{-4}$

so $1/d = 3300$

number of lines = ______________________

(2)

(f) State and explain whether the value for the number of lines per m obtained in part (e) is in agreement with the value stated on the grating.

% diff $= \frac{3300}{3500} = \approx 4-5\%$

nope lies outside the 2.9%

(2)

(g) State **one** safety precaution that you would take if you were to carry out the experiment that was performed by the student.

Don't look into laser

(1)

(Total 10 marks)

4 1.0 kilowatt-hour (kW h) is equivalent to

$1000\,J \times 60^2 = 3.6\times10^6\,J$

$1eV = 1.6\times10^{-19}\,J$

so $\frac{3.6\times10^6}{1.6\times10^{-19}}$

A 6.3×10^{18} eV ○

B 6.3×10^{21} eV ○

C 2.3×10^{22} eV ○

[✓ **D**] 2.3×10^{25} eV ○

(Total 1 mark)

5 Measurements are made to determine the tension, length and mass per unit length of a string stretched between two supports. The percentage uncertainties in these measurements are shown below.

Quantity	**Percentage uncertainty**
Length	0.80%
Tension	4.0%
Mass per unit length	2.0%

A stationary wave is formed on the string.

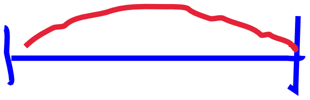
What is the percentage uncertainty in the calculated value of the frequency of the first harmonic?

A 1.8% ○

B 3.8% ○

C 6.8% ○

D 13% ○



$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

(Total 1 mark)

$$\frac{1}{0.8}\sqrt{\frac{4}{2}} = \frac{1}{0.8} \times \sqrt{6} = \frac{1}{0.8} \times 3$$

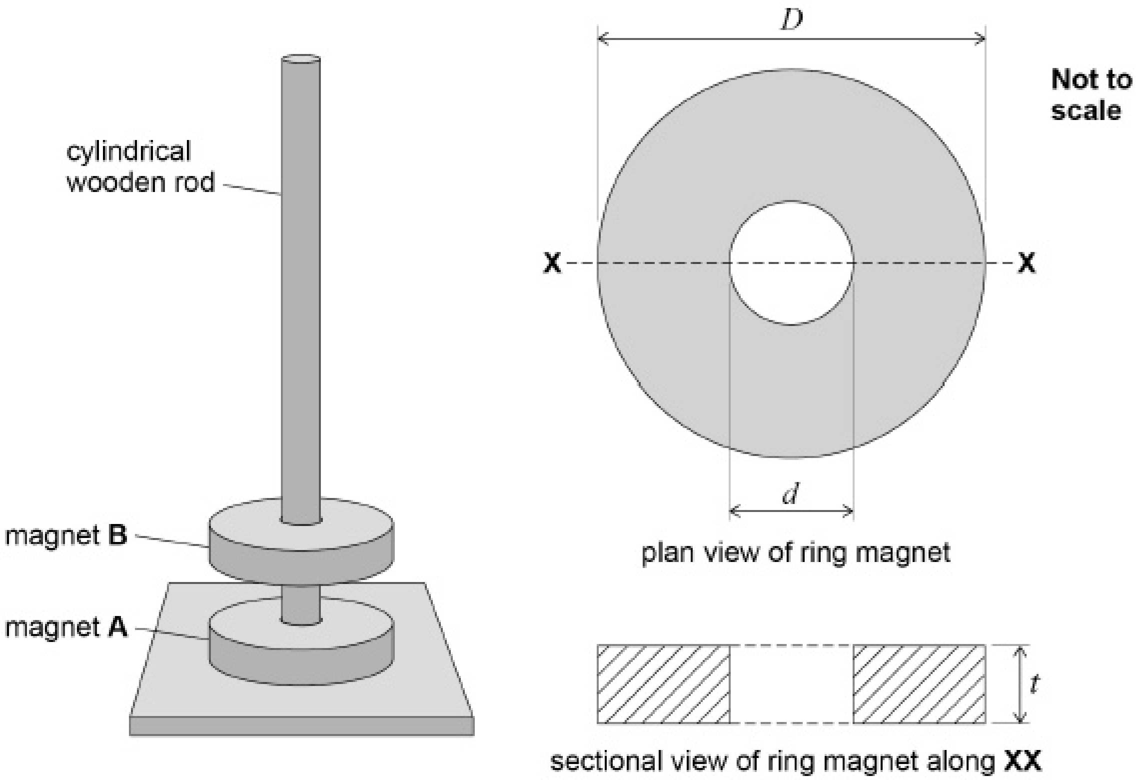
$$= 3.8$$

these figures are the % uncertainties

6 Identical ring magnets **A** and **B** are arranged on a cylindrical wooden rod. The magnets' magnetic poles are on their largest faces. When placed with like poles in opposition, the magnets repel one another as shown in **Figure 1**.

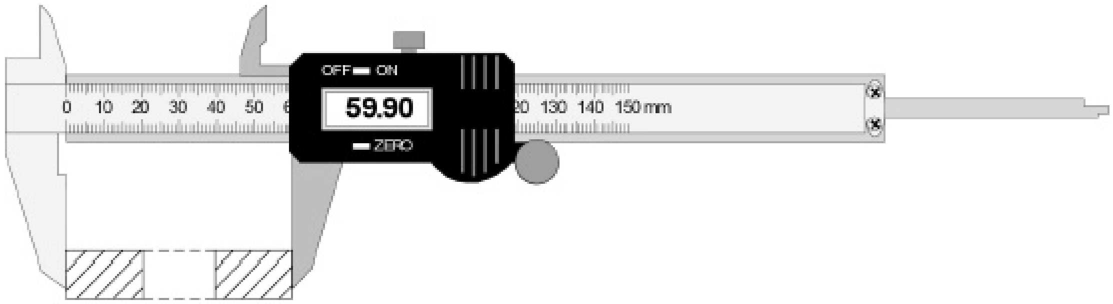
The plan and sectional views in **Figure 1** identify the dimensions of these magnets.
Each magnet has a circular cross-section and the central hole is circular.

Figure 1



(a) A student uses digital vernier calipers to find the external diameter D of magnet **B**, as shown in **Figure 2**.

Figure 2



State precautions the student should take to reduce the effect of systematic and random errors when making this measurement.

Precaution to reduce effect of systematic error:

tare the micrometer (set it to zero)before you start)

Precaution to reduce effect of random error:

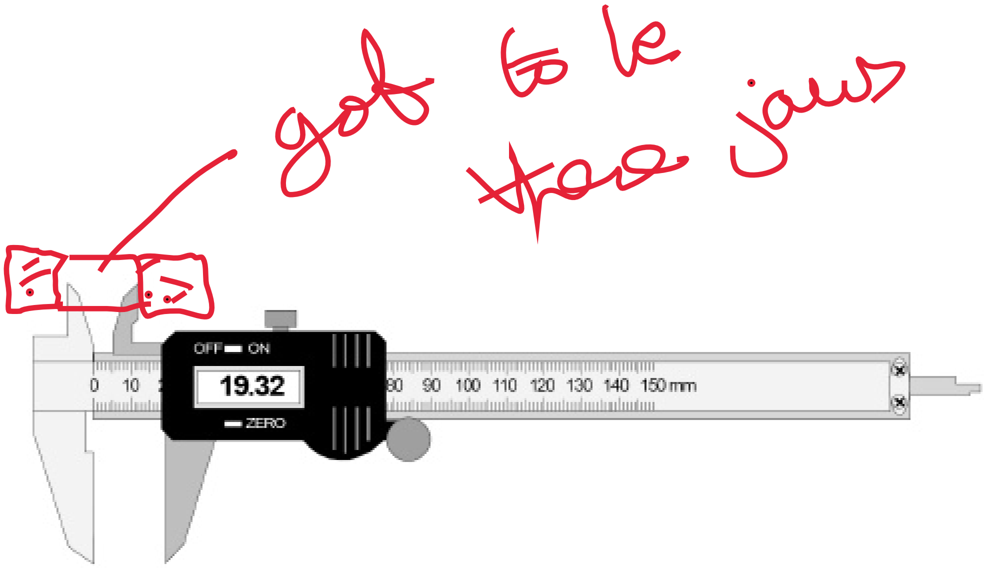
repeat the readings to identify anamolies

(2)

(b) **Figure 3** shows the reading on the calipers as the internal diameter d is measured.

Draw the sectional view of magnet **B** on **Figure 3** to indicate how d is measured.

Figure 3

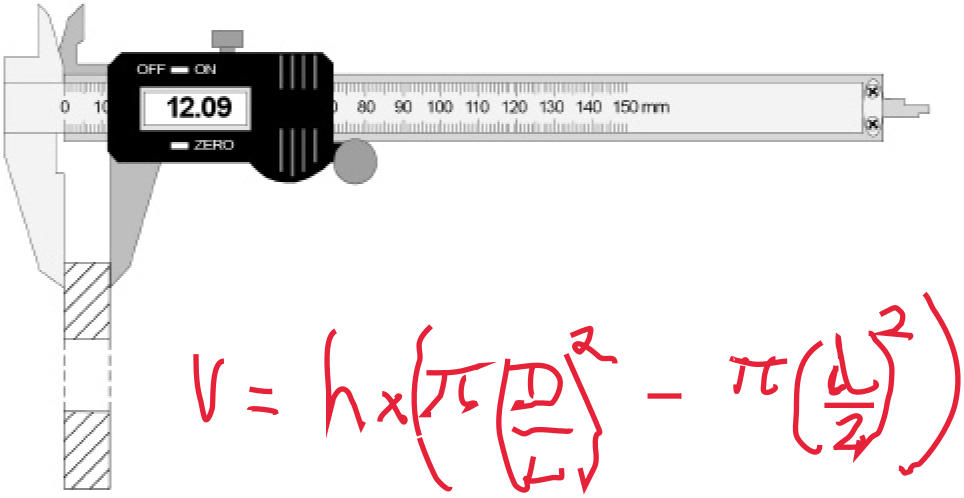


got to be these jaws

(1)

(c) **Figure 4** shows the reading on the calipers when the thickness *t* of magnet **B** is measured.

Figure 4



$V = h \times \left(\pi\left(\frac{D}{2}\right)^2 - \pi\left(\frac{d}{2}\right)^2\right)$

The readings that correspond to the dimensions of magnet **B** are shown in **Figures 2**, **3** and **4**.

Calculate the volume of magnet **B**.

inner = 19.32mm
height= 12.09 mm
outer = 59.90

so its vol of outer cylinder - vol of inner cylinder

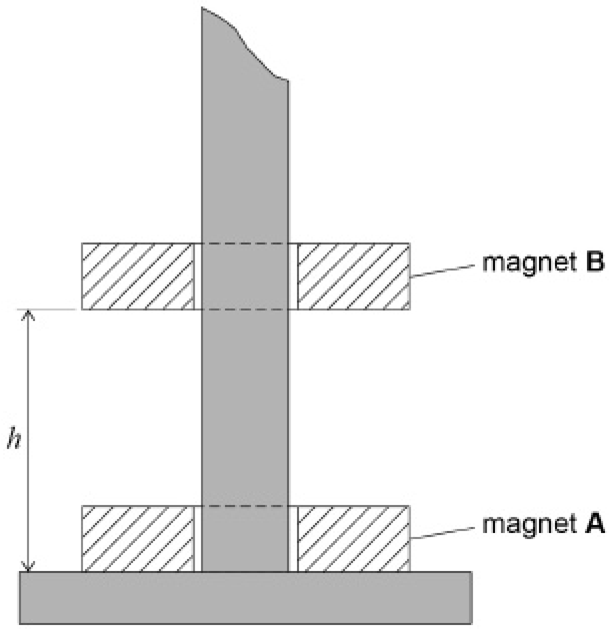
2.817×10^{-3}

volume = ____________________ m^3

(3)

(d) The student measures the mass m_B of magnet **B** and then positions the magnet so it is in equilibrium above magnet **A** as shown in **Figure 5**.
The student measures the distance h.

Figure 5



The student adds modelling clay to magnet **B** to reduce h by 50%
She measures the mass m_C of this clay.

She concludes that the force F exerted on magnet **B** by magnet **A** is given by $F = \frac{k}{h^3}$

where k is a constant.

Describe an experiment to test the student's conclusion that $F = \frac{k}{h^3}$

Your answer should include:

- the procedure that could be used
- how the data produced could be analysed by a graphical method
- how the value of the constant k could be determined.

(5)

(Total 11 marks)

Mark schemes

1 **D**

[1]

2 **B**

[1]

3 (a) 2.9% ✓

Allow 3%

1

(b) $\frac{1}{3.5\times10^{3}}$ seen ✓

1

0.29 mm or 2.9 x 10^{-4} m✓ must see 2 sf **only**

1

(c) ± 0.01 mm ✓

1

(d) Clear indication that at least 10 spaces have been measured to give a spacing = 5.24 mm✓

spacing from at least 10 spaces
Allow answer within range ±0.05

1

(e) Substitution in $d\ sin\theta = n\lambda$✓

The 25 spaces could appear here as n with sin θ as 0.135 / 2.5

1

d = 0.300 x 10^{-3} m so
number of lines = 3.34 x10^{3}✓

Condone error in powers of 10 in substitution

Allow ecf from 1-4 value of spacing

1

(f) Calculates % difference (4.6%) ✓

1

and makes judgement concerning agreement ✓

Allow ecf from 1-5 value

1

(g) care not to look directly into the laser beam✓
OR
care to avoid possibility of reflected laser beam ✓
OR
warning signs that laser is in use outside the laboratory✓
ANY ONE

1

[10]

4 **D**

[1]

5 **B**

[1]

6 (a) to reduce the impact of systematic error: tare [zero] the callipers before use

OR

take reading with callipers fully closed (at some stage) and subtract from readings $_1$✓

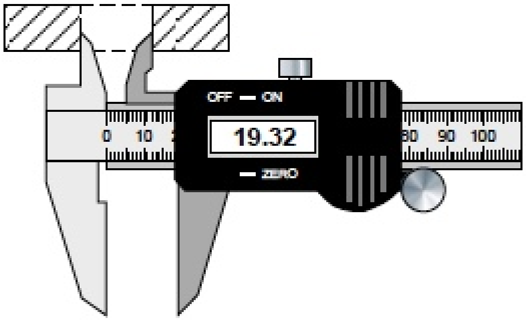
to reduce the impact of random error: take measurement several times for different diameters/directions and calculate mean

OR

take measurement several times for different diameters to check for anomalies $_2$✓

2

(b) use of inside jaws on callipers required: must have a clear drawing with inside jaws in <u>contact</u> internal diameter$_1$✓



*A **sectional** view of the magnet must be given*

Jaws must be inside cavity (as here)

1

(c) Determines a cross-sectional area: (larger A=) 2.82

$\times 10^{-3}$ or (smaller area =) 2.932×10^{-4}

OR

states that the cross sectional area from Δ

$$A = \left(\frac{\pi D^2}{4} - \frac{\pi d^2}{4} \right)$$

OR

Calculates one volume correctly $_1$✓

Allow POT error $_1$✓ *and* $_2$✓

Where r is used must have an additional statement on how r relates to D (in the case where there is no correct substitution and no correct answer) substitution of D = 59.90, d = 19.32 and t = 12.09 into

$$V = \left(\frac{\pi D^2}{4} - \frac{\pi d^2}{4}\right) \times t$$

OR

V = their ΔA × 12.09

OR

Correctly finds difference in ***their*** volumes $_2$✓

Or equivalent

Correct substitution into

$$V = \left(\frac{\pi D^2}{4} - \frac{\pi d^2}{4}\right) \times t$$

receives the first two marks (allow POT)

Expect values:

$V_D = 3.41 \times 10^{-5}$ *(m^3)*

$V_d = 3.54 \times 10^{-6}$ *(m^3)*

3.1×10^{-5} / 3.05×10^{-5} / 3.053×10^{-5} (m^3) $_3$✓

no limit on maximum sf

Correct answer scores 3

Allow 3rd sf round error where

answer rounds to 3.1×10^{-5}

when correct method seen

3

(d) ***Procedure:***

MAX 2

Take more measurement(s) of *h* for additional / different masses (of clay) ✓

More than one added mass, allow varies amount of clay

Convert (total) mass into weight (and equal to the repulsive force of magnet **A** on magnet **B**) ✓

Describe method to measure *h* using ruler or set square ✓

(in this case determination of k must be consistent with graph)

Analysis:

Plot a graph of F against $1/h^3$✓

Condone $1/h^3$ *against F or equivalent*

Should be a straight line of best fit ✓

This mark can be awarded if seen by drawing of straight line with positive gradient on sketch of graph

***Determination of k*:**

MAX 1

Measure gradient and set equal to *k* ✓

Allow one mark for plot of F against h^3 *and statement that area under graph is k. Mark* ***Procedure*** *as scheme*

Substitute (total) weight into formula and rearrange to find *k* ✓

Must be consistent with graph

5

[11]