# Topic Test: OxfordAQA International A level Physics

Practical and Analytical Skills

Name: ____________________

Class: ____________________

Date: ____________________

---

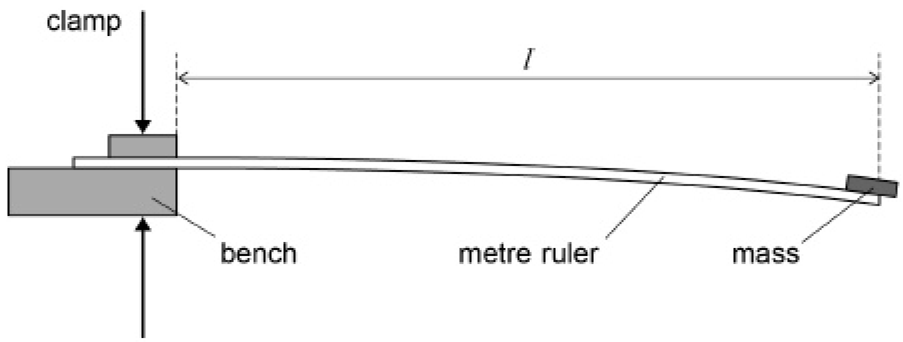
Time: **62 minutes**

Marks: **39 marks**

Comments:

---

**1** A metre ruler with a mass attached to the free end is clamped to the edge of a bench as shown in the diagram. The ruler oscillates when the mass is displaced vertically through a small distance and released.




Theory predicts that the period of oscillation $T$ of the system varies with length $l$ according to the equation

$$T^2 = kl^3$$

where $k$ is a constant.

Describe the procedure you would use to verify the equation. You may suggest the use of the apparatus in the diagram together with other standard laboratory equipment.

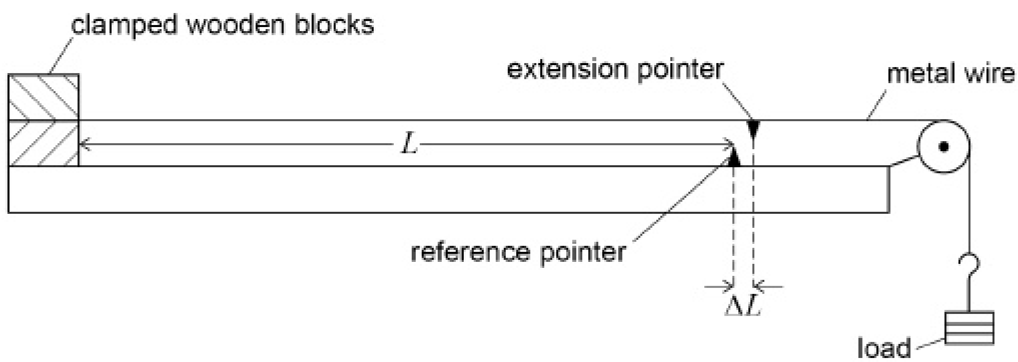
Your answer should include details of:

- the measurements to be made
- the measuring instruments that you would use
- how you would make the measurements accurately
- how you would analyse and interpret the results.

**(Total 5 marks)**

**2** **Figure 1** shows an apparatus used to measure the Young modulus of a metal.

**Figure 1**




The initial length $L$ of a wire made from the metal was measured using a metre ruler.
The mass of the load was increased in 50 g steps and the extension $\Delta L$ measured using vernier calipers.
The experiment was carried out three times.

(a) The table shows some of the results of this experiment.

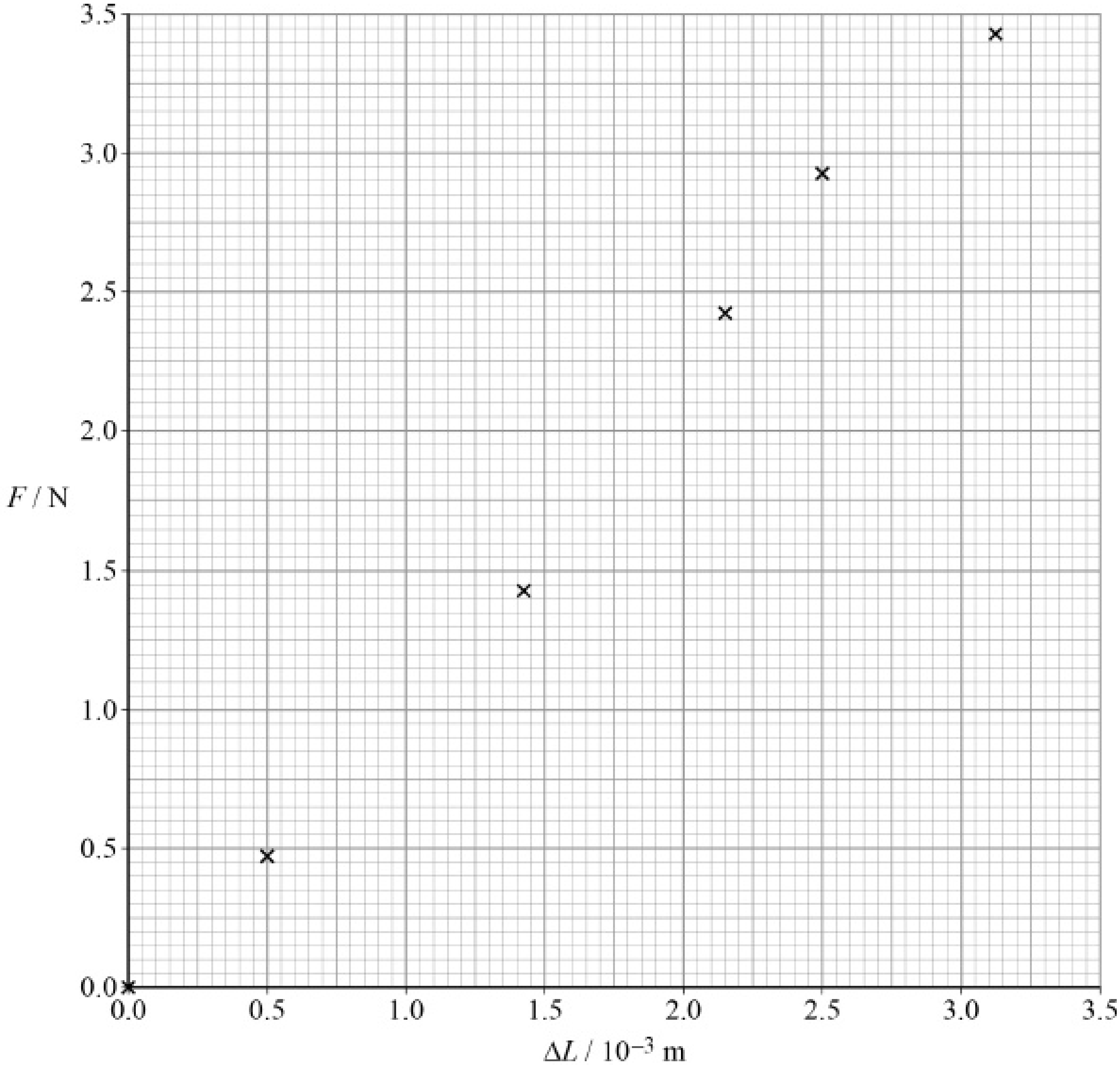
Complete the table.

| Tension $F$ in the wire / N | $\Delta L$ / $10^{-3}$ m | | | |
|---|---|---|---|---|
| | **First reading** | **Second reading** | **Third reading** | **Mean** |
| 0.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.49 | 0.5 | 0.5 | 0.5 | 0.5 |
| 0.98 | 0.8 | 0.7 | 0.9 | |
| 1.47 | 1.4 | 1.4 | 1.5 | 1.4 |
| 1.96 | 1.8 | 1.9 | 1.9 | |
| 2.45 | 2.2 | 2.1 | 2.3 | 2.2 |
| 2.94 | 2.5 | 2.5 | 2.5 | 2.5 |
| 3.43 | 3.1 | 3.1 | 3.2 | 3.1 |

**(1)**

(b) Plot on **Figure 2** the two missing points.
Draw a best fit line.

**Figure 2**




**(2)**

(c) Determine the stiffness of the wire.

stiffness = ____________________ N $m^{-1}$

**(2)**

(d) The cross-sectional area of the wire was $1.8 \times 10^{-8}$ m$^2$.
$L$ was 1.800 m.

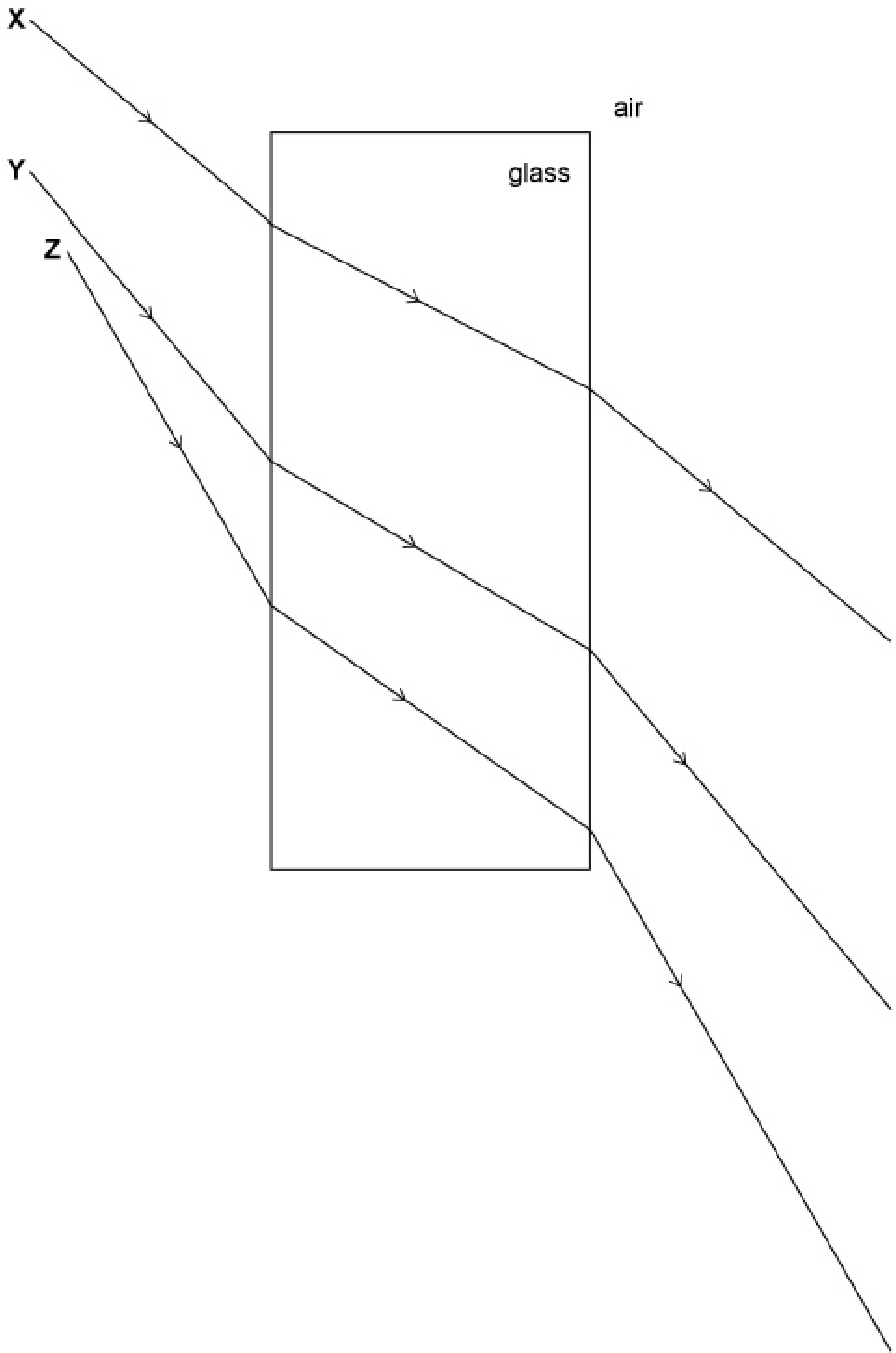
Calculate the Young modulus of the metal.

Young modulus = ____________________ Pa

**(2)**

**(Total 7 marks)**

**3** The diagram shows the paths of three light rays **X**, **Y** and **Z** as they pass through a rectangular glass block.



(a) Determine the refractive index of the glass for ray **X**.

Use a protractor to take suitable measurements from the diagram.

refractive index = ____________________

**(3)**

(b) Assume that the percentage uncertainty in the sine of an angle is equal to the percentage uncertainty in the measurement of that angle.

Take the absolute uncertainty of measurement of all angles in this question to be ±1°

Calculate the absolute uncertainty in your answer to question (a).

absolute uncertainty = ± ____________________

**(3)**

(c) State and explain which of the three rays is most likely to provide a value for refractive index with the smallest **percentage** uncertainty.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

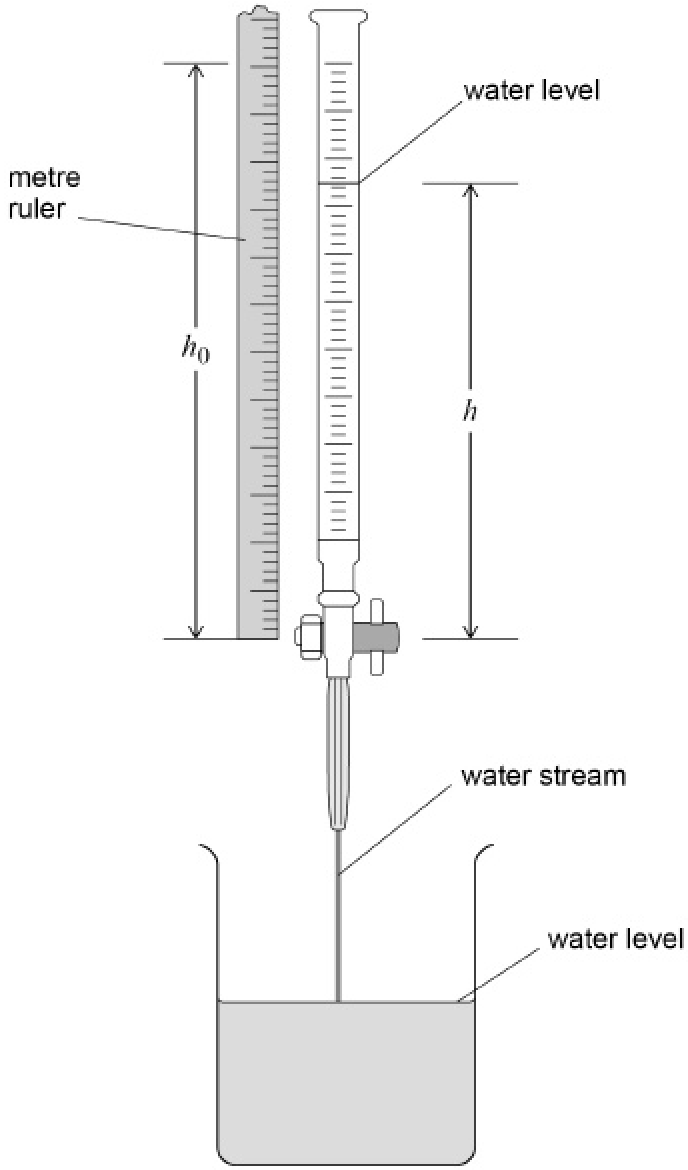
**(2)**

**(Total 8 marks)**

**4** A burette is used to measure the volume of liquids.
A student investigated how the height $h$ of water flowing out of a burette varied with time $t$.

**Figure 1** shows the apparatus the student used.

**Figure 1**



The height of the water level above the burette tap at time $t$ = 0 is $h_0$.

The student recorded $h$ at 10 s intervals as the water drained into the beaker.

The student repeated the procedure.

The table shows the mean value of $h$ for each value of $t$.

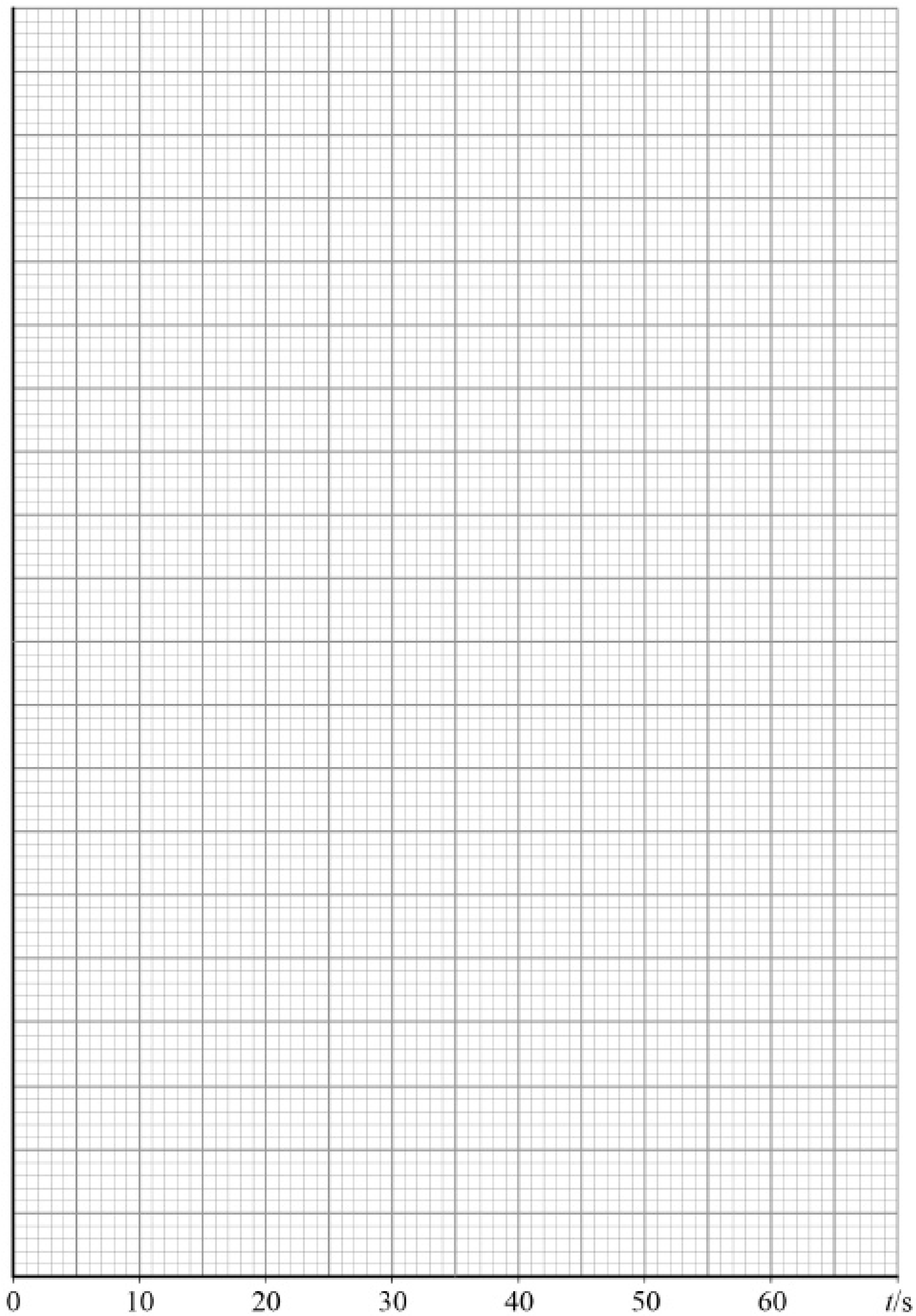
| **$t$/s** | **mean height $h$/mm** | **ln($h$/mm)** |
|---|---|---|
| 0 | 665 | |
| 10 | 572 | |
| 20 | 513 | |
| 30 | 428 | |
| 40 | 381 | |
| 50 | 336 | |

(a) Complete the table.

**(1)**

(b) Plot on **Figure 2** a graph of $\ln(h/\text{mm})$ against $t/\text{s}$.

**Figure 2**




**(4)**

(c) Determine the gradient of your line.

gradient = ____________________

**(2)**

(d) Theory predicts that the relationship between $h$ and t is

$$h = h_0 e^{-\lambda t}$$

where $h_0$ is the height of the water level at $t = 0$

State a value for $\lambda$.

Give an appropriate unit for $\lambda$.

$\lambda$ = ____________________

unit for $\lambda$ = ____________________

**(2)**

(e) Suggest a possible source of systematic error in the student's experiment.

___________________________________________________________________

**(1)**

(f) Explain whether the systematic error mentioned in your answer to question (e) would have affected the value you determined for $\lambda$.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

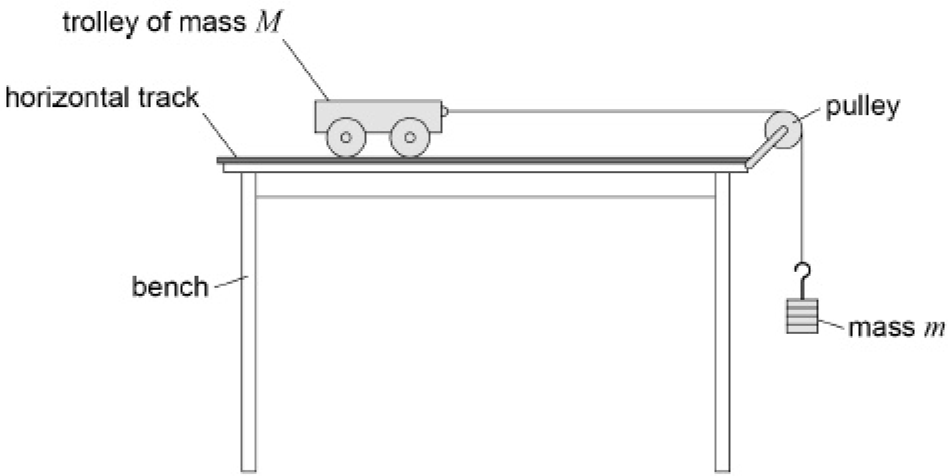
___________________________________________________________________

**(1)**

**(Total 11 marks)**

**5** The diagram shows the apparatus used in an experiment to illustrate Newton's second law of motion.

A trolley of mass $M$ is accelerated by the weight of mass $m$.




The trolley and mass $m$ are released from rest and travel a measured distance $s$ = 0.750 m. The uncertainty in the measured distance $\Delta s$ = ±0.002 m.

(a) The time $t$ taken for the trolley to travel distance $s$ is measured five times. The table shows the results.

| | | | | | |
|---|---|---|---|---|---|
| $t$ / s | 0.81 | 0.77 | 0.80 | 0.79 | 0.78 |

Calculate the mean time $t_{mean}$ and the uncertainty $\Delta t_{mean}$ in these data.

$t_{mean}$ = ____________________

$\Delta t_{mean}$ = ____________________

**(2)**

(b) The acceleration $a$ of the trolley is given by

$$a = \frac{2s}{t^2}$$

Calculate $a$ and its percentage uncertainty.

$a$ = ____________________ $\text{m s}^{-2}$

percentage uncertainty in $a$ = ± ____________________

**(4)**

(c) Newton's second law of motion when applied to the trolley and mass $m$ gives

$$mg = (M + m)\,a$$

The mass of the connecting string is negligible.

Using this formula, $a$ is predicted to be 2.56 $\text{m s}^{-2}$.

Explain how friction acting on the trolley can account for the difference between the predicted and the measured value of $a$.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

**(1)**

(d) Suggest **one** improvement to the apparatus that could compensate for the friction acting on the trolley.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

**(1)**

**(Total 8 marks)**

## Mark schemes

**1**

- Take measurements of $T$ for six (or more) different values of $l$ ✓

    *Award any four of the first four marking points plus last marking point*

- Use the metre ruler to measure $l$ ✓
- Time ten (or more) oscillations and repeat and average this measurement ✓
- Calculate the mean value of $T$ ✓
- Plot a graph of $T^2$ against $l^2$ ✓

The formula would be verified if

- The best-fit line is straight through the origin ✓

**[5]**

**2**

(a) 0.8 and 1.9 ✓ cao

*1 dp for both answers*

1

(b) Both points accurately plotted ✓

*Points must be plotted within ½ small square of true position.*

Well-drawn line of best fit ✓

*The line of best fit should follow the trend of the points with an even scatter of points on either side of the line.*

*Do not allow thick line or plots.*

2

(c) Points taken from large gradient triangle ✓

*Triangle hypotenuse must be greater than ½ length of candidate line.*

$k$ calculated to be in the range $(1.08 - 1.17) \times 10^3$ ✓

*Gradient readings must be notated on the graph in some way for MP1.*

*Accept 2 or 3 sf only*

2

(d) Use of $E = k\,L/A$

**OR**

$E = \frac{FL}{A\Delta L}$ ✓

*ecf and no sf penalty*

Young modulus = (1.08 − 1.17) × $10^{11}$ (Pa) ✓

2

**[7]**

**3** (a) angle of incidence = 40° ± 1° and angle of refraction = 27° ± 1° seen in calculation or on diagram for ray **X** ✓

*Accept 2 or 3 sf only*

Use of $\frac{\sin i}{\sin r}$ ✓

Refractive index from $i$ = 40° and either $r$ = 27° or 28° ✓

*Expect answers in the range 1.37 to 1.42*

max 3

(b) One value of percentage uncertainty calculated correctly ✓

*Allow fractional instead of percentage uncertainties*

Percentage uncertainties for sin $i$ and sin $r$ added ✓

Absolute uncertainty in the range 0.07 to 0.09 ✓

*No sf penalty*

*Allow ECF from (a)*

3

(c) Ray **Z** because it has the largest angle of incidence / refraction ✓

Percentage uncertainty = $\frac{\text{absolute uncertainty}}{\text{angle of incidence}}$ × 100 ✓

*Accept "percentage uncertainty is inversely proportional to angle" or a comparison of absolute uncertainty (±1) to angle.*

2

**[8]**

**4** (a)

| | |
|---|---|
| 665 | 6.500 |
| 572 | 6.349 |
| 513 | 6.240 |
| 428 | 6.059 |
| 381 | 5.943 |
| 336 | 5.817 |

*All 6 correct to either 3 or 4 sf in the In column.*

1

(b) Sensible scale (with appropriate label/unit) marked on the y-axis ✓

*The line of best fit should follow the trend of the points with an even scatter of points on either side of the line*

five points accurately plotted ✓

*Must have acceptable scales to get the plotting marks*

Six points accurately plotted ✓

Well drawn straight line of best fit ✓

*Can get the final mark even with a poor scale*

**4**

(c) Gradient value quoted with a minus sign ✓

*2 or 3 sf only*

Value in the range 0.0136 to 0.0140 (with or without minus sign) ✓

*Ignore any unit given*

**2**

(d) Candidate's answer to (c) **without a minus sign** ✓

Unit = $s^{-1}$ ✓

**2**

(e) There could be a systematic error in the measurement of $h$ ✓

*Accept other plausible answers*

**1**

(f) Since $h$ is numerically large this would be unlikely to affect the gradient and hence $\lambda$ ✓

*Sensible comment about significance of the error*

**1**

**[11]**

**5** (a) $t_{mean} = 0.79$ ✓

*Exact answers only*

$\Delta t_{mean} = (\pm)\ 0.02$ ✓

**2**

(b) $a = 2.40 \text{ m s}^{-2}$ ✓

*Accept 2 or 3 sf. ecf on $t_{mean}$ from (a)*

Either Δ$s$% or Δ$t$% correctly calculated ✓

*Look for 0.26% and 2.5% respectively (any sf)*

Use of Δ$a$% = Δ$s$% + 2Δ$t$% ✓

Δ$a$% = (±) 5.3 ✓

*Accept 1 or 2 sf only for final answer*

**4**

(c) Resultant force on trolley is reduced ✓

*Accept algebraic statement* $mg - F = (M + m)a$

**1**

(d) Tilt the trolley track (slightly) downwards ✓

*Accept add (small) additional mass to m (to compensate for friction)*

*Accept use a linear air track*

**1**

**[8]**