1 A student is doing an experiment to find the mass of a metre rule. He rests the rule on the pivot at the 40 cm mark.

He hangs a 100 g load at the 10 cm mark of the ruler. He hangs a balancing mass, *m* = 50 g, on the other side of the rule so that the rule balances, see Fig. 2.1. The balancing mass is *d* cm from the pivot.

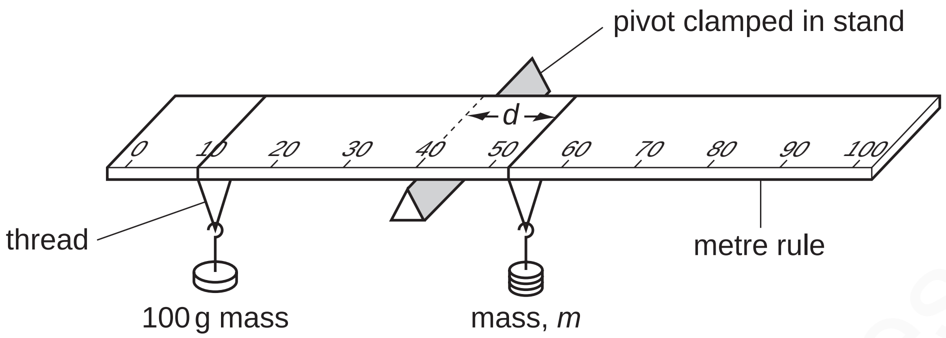



**Fig. 2.1**

- The student finds distance, *d*, and records it in Table 2.1.
- He adds 10 g to the balancing mass, *m*, and adjusts its position so that the rule balances.
- He finds the new distance, *d*, and records it in Table 2.1.
- He repeats this procedure using balancing masses, *m*, of 70, 80 and 90 g.

**Table 2.1**

| **mass, *m* / g** | **distance, *d* / cm** | $\frac{1}{m} / \frac{1}{g}$ |
|---|---|---|
| 50 | 34.6 | 0.020 |
| 60 | 28.8 | 0.017 |
| 70 | | |
| 80 | 21.9 | 0.013 |
| 90 | | |

**(a) (i)** Figs. 2.2 and 2.3 show the scale of the rule and the positions of the balancing masses when $m$ = 70 g and $m$ = 90 g.

Read and record below the scale of the rule for each mass.

scale reading for 70 g mass = ........................................ cm

scale reading for 90 g mass = ........................................ cm [2]

**(ii)** Use your answers to **(i)** to calculate the values of $d$ for each mass.

Record your values of $d$ in Table 2.1.

[1]

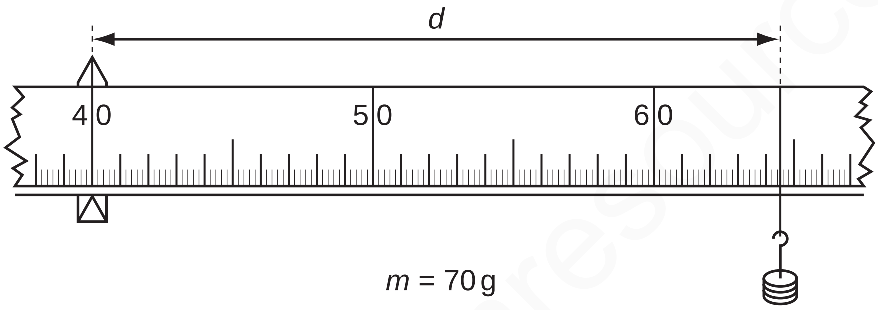



**Fig. 2.2**

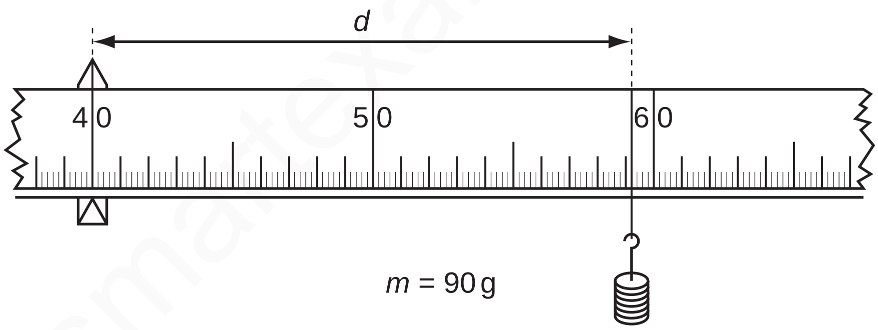



**Fig. 2.3**

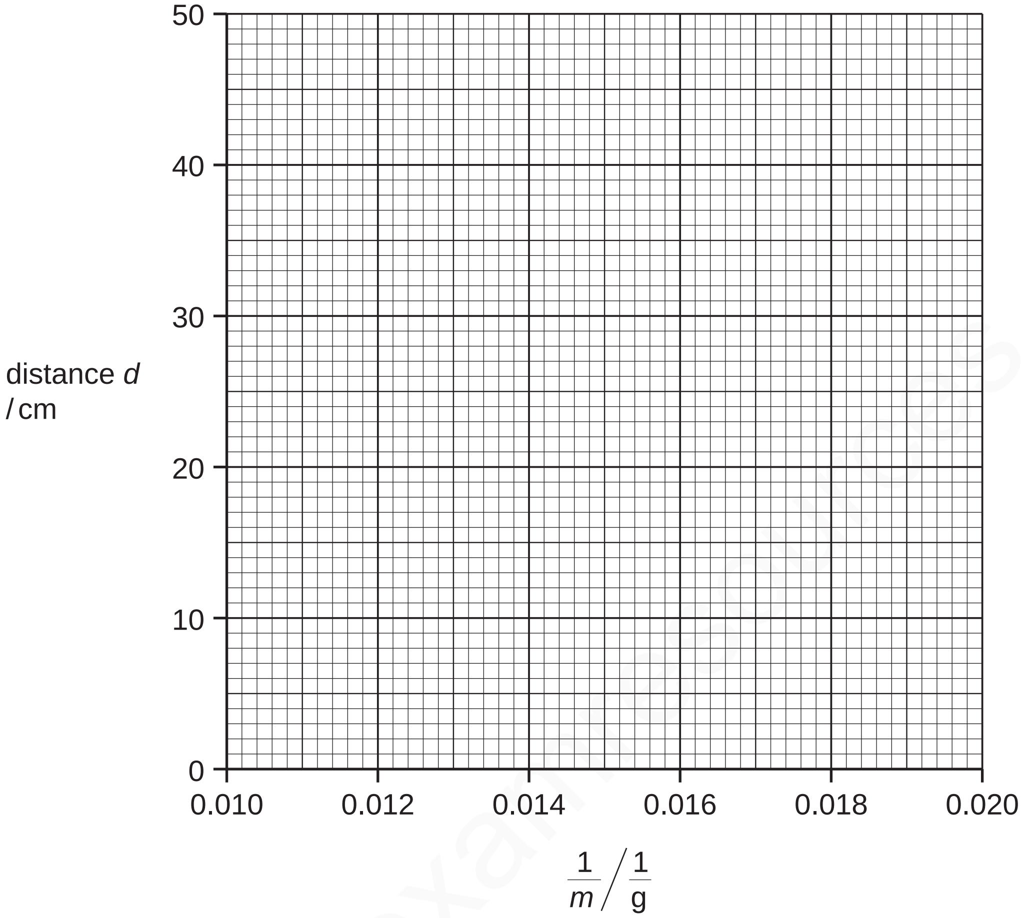
**(iii)** Calculate, to three decimal places, the values of $\frac{1}{m}$ for the masses 70 g and 90 g.

Record these values in Table 2.1.

[2]

**(b)** **(i)** On the graph grid provided. plot distance, $d$, (vertical axis) against $\frac{1}{m}$.

Draw the best straight line.




[2]

**(ii)** Find the gradient of the straight line you have drawn. Show clearly on the graph how you obtain the values used to calculate the gradient.

gradient = .................................. [2]

**(c)** Calculate the mass of the rule using the formula

$$\text{mass of rule} = 300 - \frac{\text{gradient}}{10}.$$

mass of the ruler = .......................... g [1]

## MARKING SCHEME

**(a)** **(i)** 64.5 ;
59.2 ; [2]

**(ii)** (64.5 – 40 =) 24.5 ***and*** (59.2 – 40 =) 19.2 (both correct) ; [1]

**(iii)** 1/70 = 0.014 ;
1/90 = 0.011 ;
(penalise incorrect d.p. once only) [2]

**(b)** **(i)** correct plots of 4 or 5 points ;
straight line drawn ; [2]

**(ii)** *x*- and *y*- distances shown on graph ;
*y*/*x* correctly calculated (1600 to 1800) ; [2]

**(c)** 300 – gradient/10 correctly calculated from candidate's graph (around 120 to 140), do not allow impossible masses e.g. negative ; [1]

**[Total: 10]**

**2** A student is investigating forces acting at different angles. He is using the apparatus shown in Fig. 2.1.

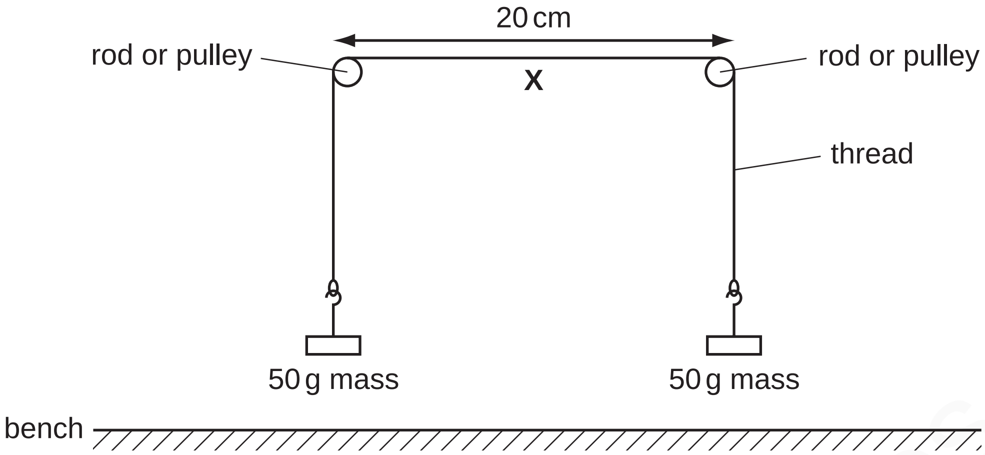



**Fig. 2.1**

- He hangs a 20 g mass, *m*, half way between the pulleys, at point **X**.
- He places a protractor behind point **X** so that angle $\theta$ can be measured, as in Fig. 2.2.
- He measures angle $\theta$ and records it in Table 2.1.
- He repeats the experiment using masses of 40, 60 and 80 g for mass, *m*.

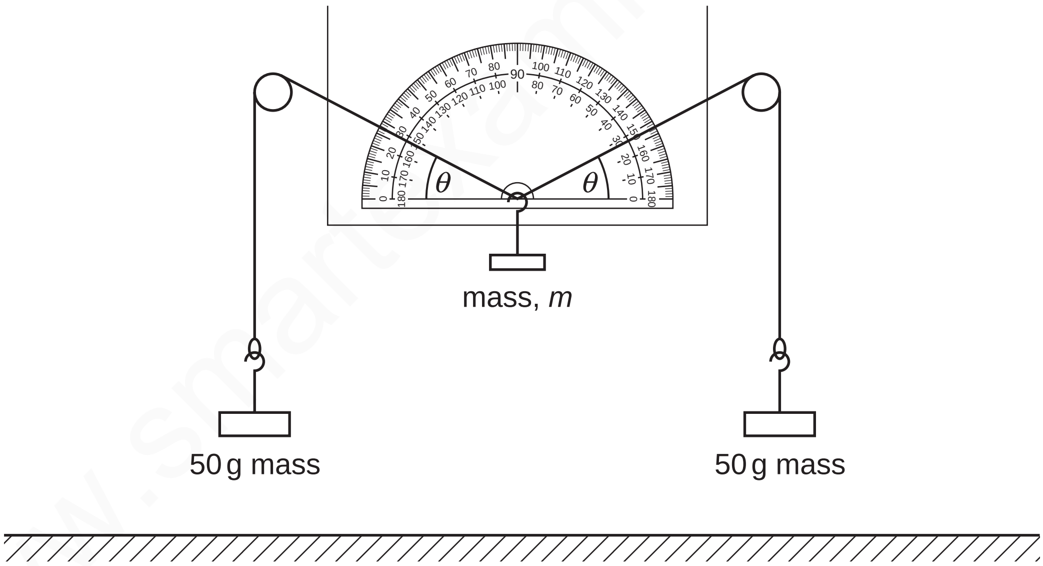



**Fig. 2.2**

**Table 2.1**

| mass, $m$/g | angle $\theta$/° | sine $\theta$ |
|---|---|---|
| 0 | 0 | 0.00 |
| 20 | 11 | 0.19 |
| 40 | 22 | 0.37 |
| 60 | | |
| 80 | | |

**(a) (i)** Fig. 2.3 and 2.4 show the angles at point **X** for the masses $m$ = 60 g and $m$ = 80 g.

For each diagram, read angle $\theta$ and record it in Table 2.1. [2]

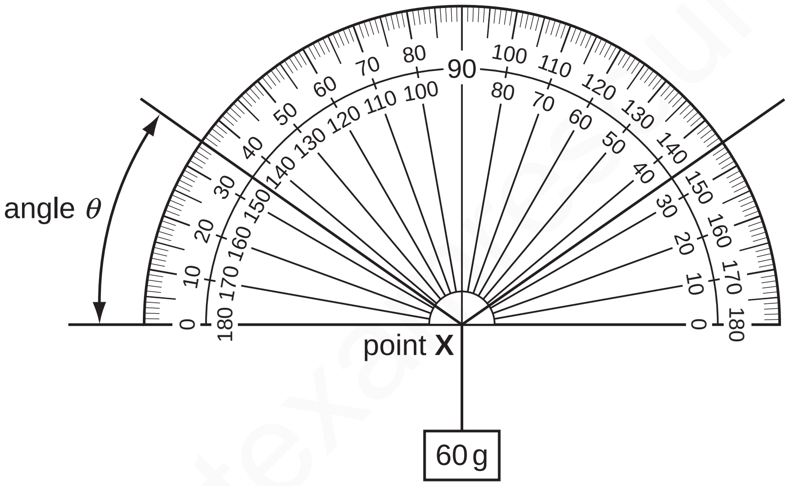



**Fig. 2.3**

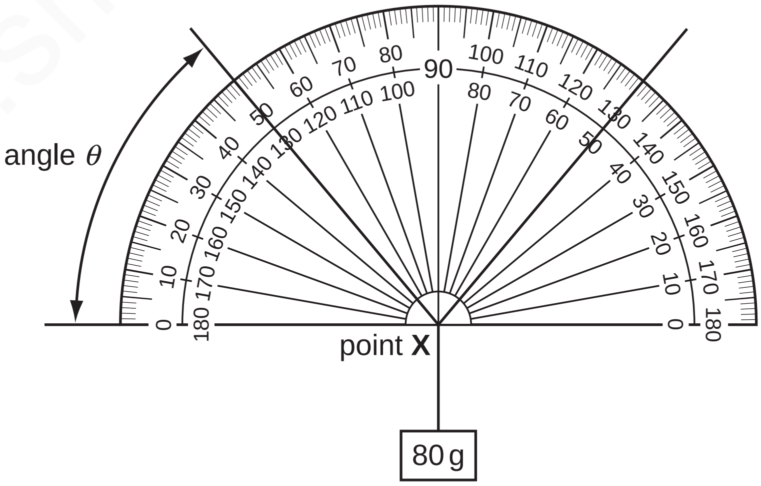



**Fig. 2.4**

**(ii)** Use Table 2.2 to find the sines of the angles you have recorded in column 2 of Table 2.1.

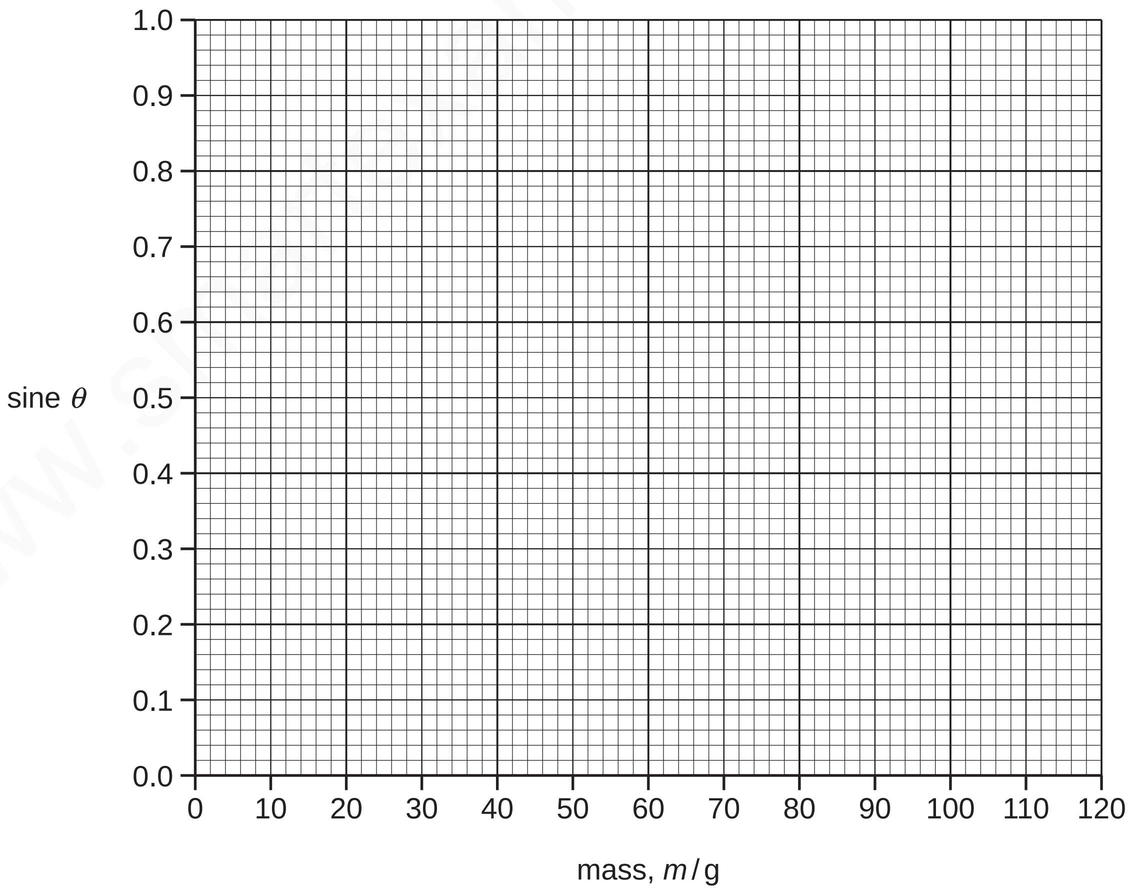
Record them in column 3 Table 2.1. [2]

**Table 2.2**

| **angle $\theta$ / °** | **sine $\theta$** | **angle $\theta$ / °** | **sine $\theta$** | **angle $\theta$ / °** | **sine $\theta$** |
|---|---|---|---|---|---|
| 0 | 0.00 | 35 | 0.57 | 70 | 0.94 |
| 5 | 0.09 | 40 | 0.64 | 75 | 0.97 |
| 10 | 0.17 | 45 | 0.71 | 80 | 0.98 |
| 15 | 0.26 | 50 | 0.77 | 85 | 1.00 |
| 20 | 0.34 | 55 | 0.82 | 90 | 1.00 |
| 25 | 0.42 | 60 | 0.87 | | |
| 30 | 0.50 | 65 | 0.91 | | |

**(b) (i)** Plot a graph of sine $\theta$ (vertical axis) against mass, $m$ on the grid below.

Draw the best straight line. Extend it to the value of sine $\theta$ = 1.0.




[3]

**(ii)** Read and record the value of mass, $m$, when sine $\theta$ = 1.0.

When sine $\theta$ = 1.0, mass $m$ = .......................... g [1]

**(iii)** In theory, $m$, from **(b)(ii)** should equal the sum of the two masses on the ends of the thread (= 100 g). In practice it is rarely equal to the sum of the two masses.

Suggest another force, acting in the apparatus, which could cause the difference.

..........................................................................................................................................

.......................................................................................................................................... [1]

**(c)** Suggest how the results of this experiment will compare if the experiment is carried out on the surface of the Moon, where the acceleration due to gravity is much smaller than on Earth.

Explain your answer.

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

.......................................................................................................................................... [1]

## MARKING SCHEME

**(a)** **(i)** 35 degrees ; 50 degrees ; [2]

**(ii)** 0.57 ;
0.77 ; [2]

**(b)** **(i)** points correctly plotted ± half square (allow 1 error);
straight line drawn (line crosses at 100 max 2);
extending to sine $\theta$ = 1.00 ; [3]

**(ii)** mass = 104 g (or as candidate's graph) ; [1]

**(iii)** friction ; [1]

**(c)** (the results should be the same) because gravity acts equally (on all three masses) ; [1]

**[Total: 10]**

**3** A student carried out an experiment to investigate the extension of a piece of artery. She set up the apparatus shown in Fig. 4.1.

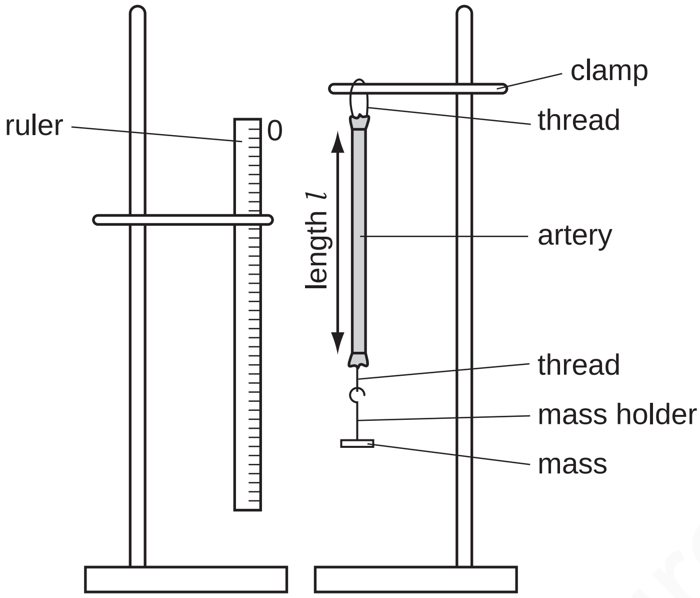



**Fig. 4.1**

- The student cut a length of artery and tied it firmly at each end.
- She suspended one end of the artery from a clamp.
- She measured the length $l$ as shown in Fig. 4.1.
- The student then added masses 20 g at a time to the mass holder and measured the value of $l$ after each addition.

At the end of the experiment the student removed the masses and the artery recoiled (sprang back) to its original length.

The results are shown in Table 4.1.

**Table 4.1**

| mass / g | length $l$ / cm |
|---|---|
| 0 | 10.0 |
| 20 | 10.9 |
| 40 | |
| 60 | 12.5 |
| 80 | 13.0 |
| 100 | 13.5 |
| 120 | 13.7 |
| 140 | |
| 160 | 14.1 |
| 180 | 14.1 |
| 200 | 14.1 |

(a) (i) Read the scales of the rulers shown in Fig. 4.2. Enter the values for $l$ in Table 4.1. [2]

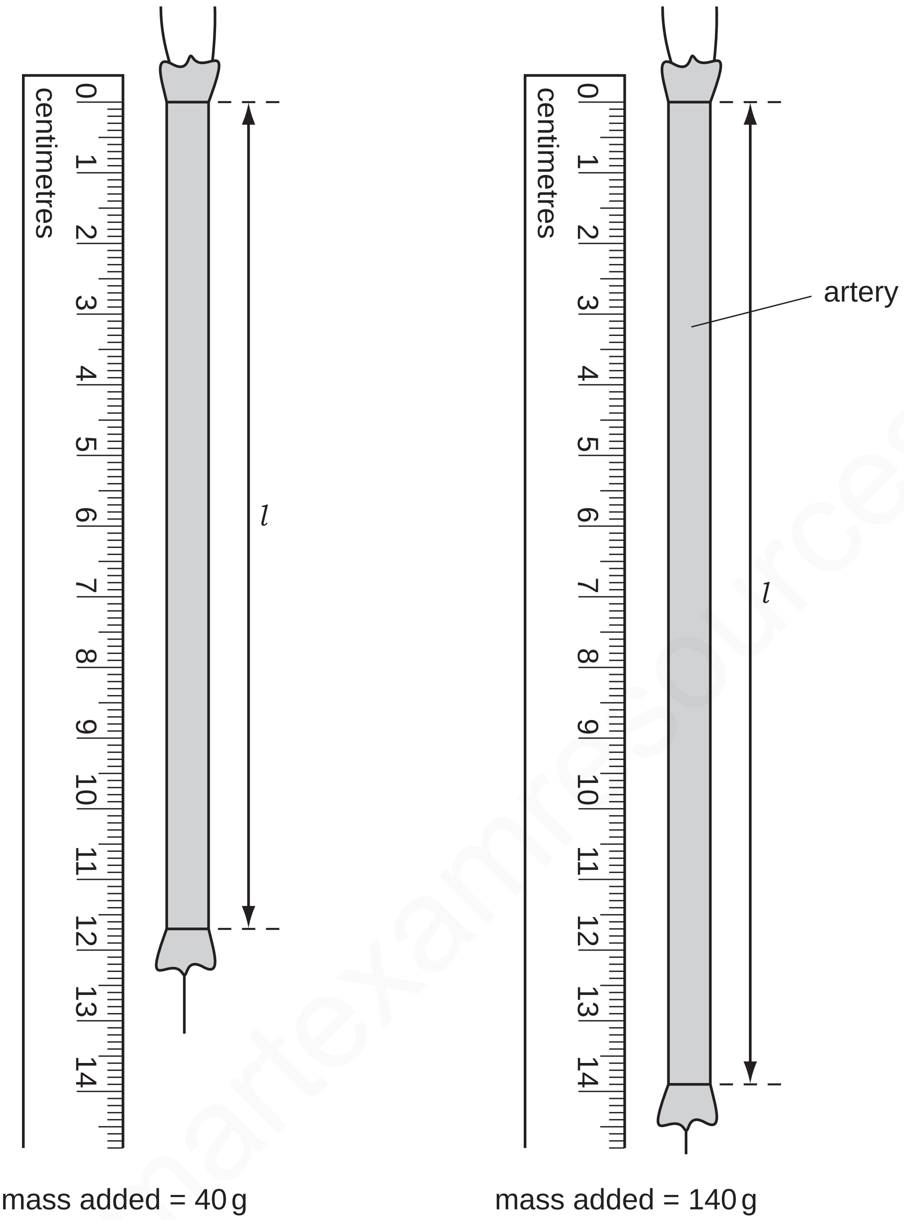
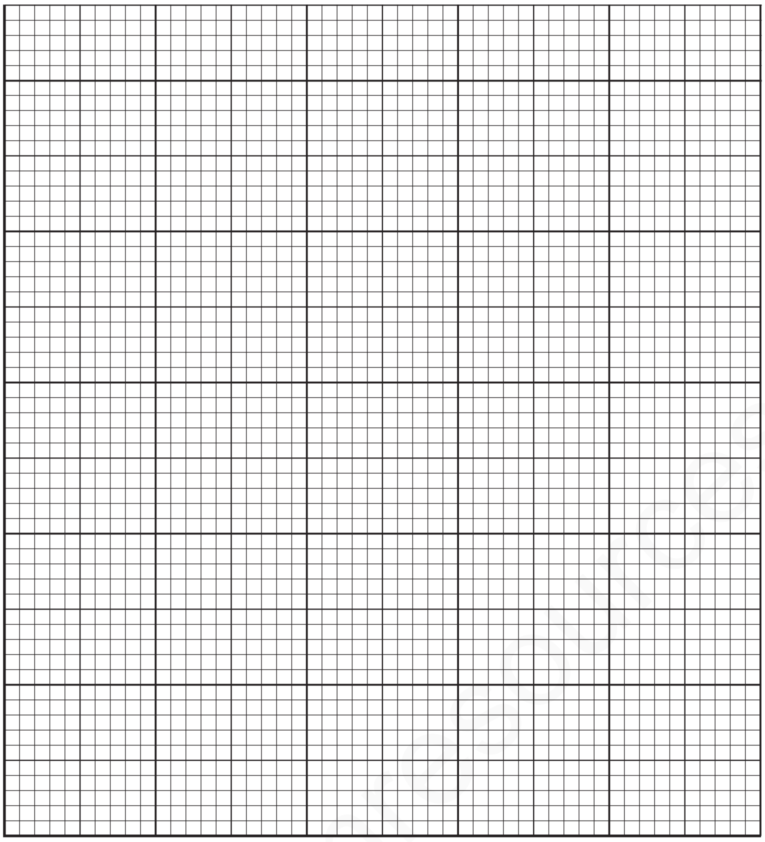



**Fig. 4.2**

**(ii)** Plot a graph of length $l$ against mass. Draw a smooth curve. [3]

length
$l$ / cm



**(iii)** Calculate the average extension of the artery per gram of mass added from 0 to 60 g,

average extension = ................................ cm / g

from 100 to 160 g.

average extension = ................................ cm / g

[2]

**(b)** **(i)** The experiment was carried out on a piece of aorta. This is the artery that comes straight from the heart.

Suggest an advantage to the animal of the ability of the walls of the aorta to stretch and recoil.

..........................................................................................................................

.......................................................................................................................... [1]

**(ii)** Explain why it is important for the artery to be able to cope with large forces as shown in Table 4.1.

..........................................................................................................................

.......................................................................................................................... [1]

**(c)** The student carried out a similar investigation on a piece of vein of the same length.

State **one** other factor she should keep the same to make it a fair test.

.................................................................................................................................. [1]

## MARKING SCHEME

**(a)** **(i)** 11.7 cm (no tolerance) ;
13.9 cm (no tolerance) ; [2]

**(ii)** suitable scale and label on *x* axis;
not starting *y* axis at 0 ;
smooth curve drawn ; [3]

**(iii)** 0.0417 or 0.042 cm / g;
0.01 or 0.010 cm / g; [2]

**(b)** **(i)** (allows aorta to stretch) to allow surge of blood through / recoil propels blood between beats / smoothes out blood flow / <u>change</u> in pressure ; [1]

**(ii)** resistant to bursting / breaking / tearing ; [1]

**(c)** e.g. same width of sample taken / same part of body of animal / same animal ; [1]

**[Total: 10]**

**4** Two students investigate the speed of a trolley running down a smooth slope. The trolley has a mass of 1 kg. The angle of the smooth slope can be adjusted by raising one end. The arrangement of apparatus is shown in Fig. 6.1.

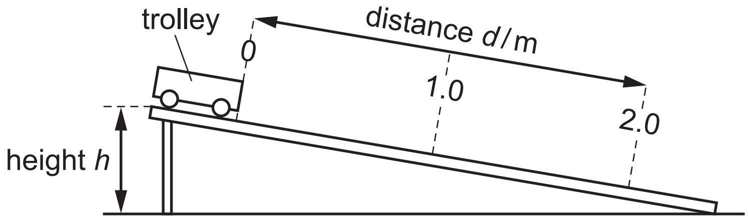



**Fig. 6.1**

**method**

- the height $h$ is initially set at 2 cm.
- The trolley is placed at the top end of the slope as shown in Fig. 6.1.
- The trolley is released and a timer is started.
- When the trolley passes the 1 m mark, the time $t_1$ is noted and recorded in Table 6.1.
- When the trolley reaches the 2 m mark, the time $t_2$ is noted and recorded in Table 6.1.
- The experiment is repeated using different heights of 4 cm and 5 cm.

**(a)** Explain the best way for the students to work together to obtain the data recorded in Table 6.1 for each experiment.

..........................................................................................................................................

.......................................................................................................................................... [1]

**(b)** The timer displays for the missing values of $t_1$ and $t_2$ are shown in Fig. 6.2. Read the displays and record the times in the correct places in Table 6.1.

You will have to decide which reading goes in which column. [1]


**Fig. 6.2**

**Table 6.1**

| height $h$ / cm | time $t_1$ / s for 1 m | time $t_2$ / s for 2 m |
|---|---|---|
| 2 | 3.5 | 4.9 |
| 4 | | |
| 5 | 2.0 | 3.1 |

**(c) (i)** Use data for $h$ = 2 cm from Table 6.1, to show that the trolley accelerates as it runs down the slope. Show your working.

[2]

**(ii)** Use data from Table 6.1 to show that the trolley reaches a greater speed over 2 m when the height of the slope is greater. Show your working.

[2]

**(d)** The students repeat the experiments using a trolley of mass 2 kg. Predict how the results of this set of experiments will compare with the results in Table 6.1. Justify your answer.

..........................................................................................................................................

..........................................................................................................................................

.................................................................................................................................... [2]

**(e)** One of the students suggests that the height $h$ is increased to 30 cm. Suggest why the results may be inaccurate for this experiment.

..........................................................................................................................................

.................................................................................................................................... [1]

**(f)** State the energy transformation that occurs as the trolley runs down the slope.

..........................................................................................................................................

.................................................................................................................................... [1]

# MARKING SCHEME

**(a)** one student times the 1-metre run and the other times the 2-metre run ;
**OR**
one student releases and the other times at 1 m and 2 m ; [max 1]

**(b)** 2.6 (s) **AND** 3.5 (s) recorded in correct place ; [1]

**(c) (i)** $\frac{1}{3.5}$ = 0.29 (m/s) ;
$\frac{2}{4.9}$ = 0.41 (m/s) **or** $\frac{1}{1.4}$ = 0.71 (m/s) (so must have accelerated) ;
**OR**
same distance (1 m) ;
in less time quoting 1.4 s ;
**OR**
correct calculation of acceleration ;; [max 2]

**(ii)** height = 2 cm. average speed = 0.41 (m/s) ;
height = 4 cm, average speed = 0.57 (m/s) ;
height = 5 cm, average speed = 0.65 (m/s) ; [max 2]

**(d)** since acceleration due to gravity is independent of mass ;
the results will be the same ;
**OR**
more friction ;
slower ; [max2]

**(e)** (speeds too great) difficult to measure time / reaction time now significant ; [1]

**(f)** (gravitational) potential energy **to** kinetic energy ; [1]

**[Total: 10]**

**5** A student finds the mass of a piece of modelling clay using a balancing method.

She moulds the piece of modelling clay until it is roughly cube-shaped.

She places the modelling clay on a metre rule so that its centre is 15.0 cm from the zero end of the rule, as shown in Fig. 3.1.

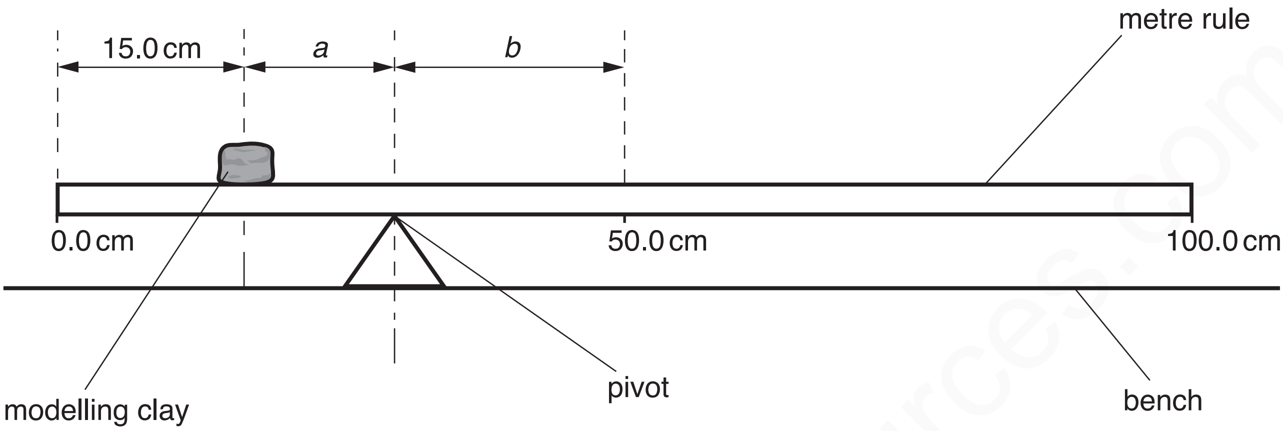



**Fig. 3.1** (not to scale)

**(a)** Describe how the student ensures that the centre of the modelling clay is directly above the 15.0 cm mark on the rule. You may draw a diagram to help your answer.

.......................................................................................................................................

.......................................................................................................................................

.......................................................................................................................................[1]

**(b)** The student adjusts the position of the pivot so that the rule balances on it as shown in Fig. 3.2 (seen from above).

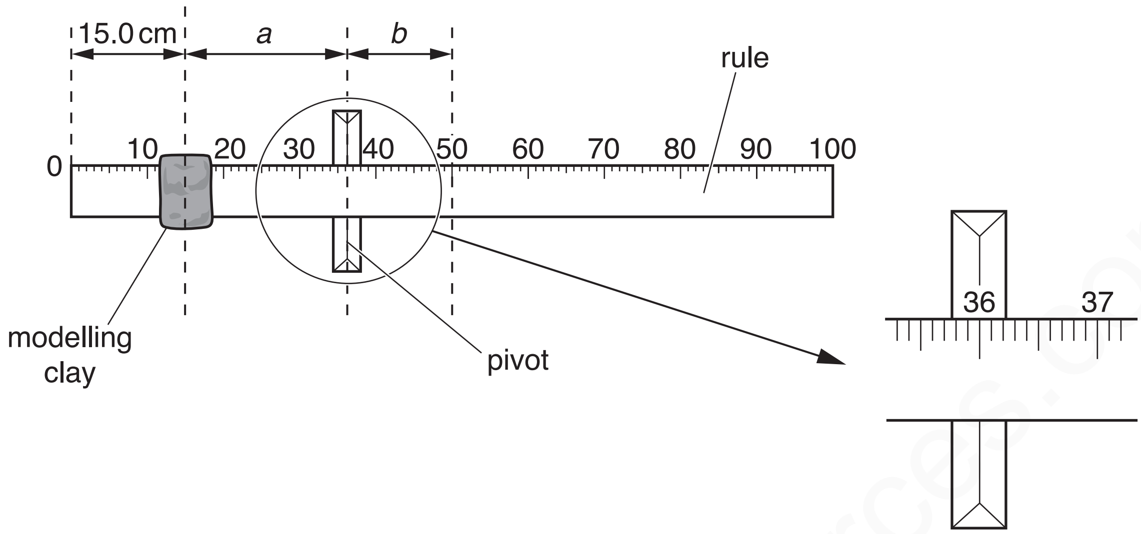



**Fig. 3.2**

**(i)** Record the position of the pivot on the rule to the nearest 0.1 cm.

position of pivot = .................................................. cm [1]

**(ii)** Calculate the distance *a*.

*a* = .................................................. cm [1]

**(iii)** Calculate the distance *b*.

*b* = .................................................. cm [1]

**(c)** The student then uses a balance to measure the mass *M* of the metre rule. Fig. 3.3 shows the reading on the balance.

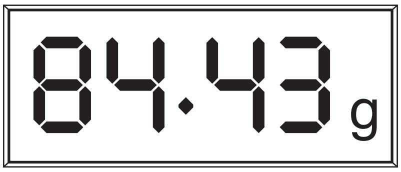



**Fig. 3.3**

**(i)** Write down the mass *M* of the metre rule to the nearest 0.1 g.

*M* = ...................................................... g [1]

**(ii)** She uses the equation, shown below, to calculate the mass *m* of the modelling clay.

$$m = M \times \frac{b}{a}$$

Calculate the mass of the modelling clay, giving your answer to an appropriate number of significant figures.

*m* = ...................................................... g [2]

**(d)** Even if the student carried out the experiment very carefully, her value for the mass of the modelling clay will only be approximate.

Suggest **two** reasons, based upon the practical method used, why this might be so. Assume that the balance used to find the mass of the rule is accurate.

1 ...........................................................................................................................

...........................................................................................................................

2 ...........................................................................................................................

...........................................................................................................................

[2]

**(e)** The experiment is repeated with a heavier piece of modelling clay. State how the distances *a* and *b* will change.

...........................................................................................................................

...........................................................................................................................[1]

# MARKING SCHEME

| | | |
|---|---|---|
| (a) | note the reading on either side and find mean / shown on a diagram / measure cube and mark the mid point ; | 1 |
| (b)(i) | 36 (.0 ) ; | 1 |
| (b)(ii) | 21 (.0) cm ; | 1 |
| (b)(iii) | 14 (.0) cm ; | 1 |
| (c)(i) | 84.4 g ; | 1 |
| (c)(ii) | 56 to 56.2666… ;<br>56 / 56.3 g (2 / 3 significant figures) ; | 2 |
| (d) | any 2<br>centre of gravity of the rule not at the 50 cm mark ; difficulty in obtaining balance of ruler ; pivot not at right angles to edge of rule ; cube irregular ; ruler mass rounded ; | **max 2** |
| (e) | *a* smaller and *b* greater ; | 1 |
| | **Total:** | **10** |