'03/M/J/05 Q1

4. In this question you will investigate how the force required to maintain equilibrium of a suspended mass depends on the angle between the line of action of the force and the horizontal.

You are supplied with a piece of string that has a loop at each end and one in the middle.

(a) **(i)** Suspend the mass from the middle loop and attach the other loops to a mounted boss and a newton-meter as shown in Fig. 1.1. The body of the newton-meter must be clamped so that it is along the line of action of force *F*. You may need to rotate the clamp in order to achieve this. The section AB of the string should be horizontal and the bases of the stands should be clamped to the bench.

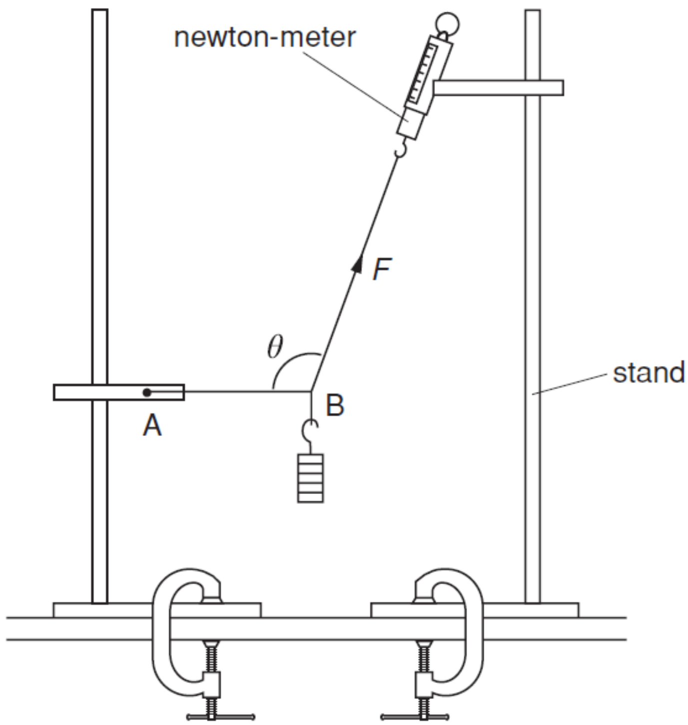

Fig. 1.1

(ii) Using the protractor, measure the angle θ. Record the value of θ and the reading F from the newton-meter.

θ = ...

F = ...

(iii) Determine the percentage uncertainty in the value of θ.

percentage uncertainty in θ = ...

(b) State two difficulties that you had when making measurements of F and θ.

1 ....

....

2 ....

....

(c) Change the height of one of the bosses above the bench and adjust the separation of the stands to give new values of θ and F. The section AB must remain horizontal. You will need to loosen a G-clamp in order move a stand. Measure and record the new values of θ and F. Repeat the procedure until you have six sets of readings for θ and F. You **must** ensure that, when you are taking readings, the body of the newton-meter is along the line of action of the force F and that it does not go off scale.

Include all six sets of values of F, θ and $1/\sin\theta$ in your table of results.

(d) Plot a graph of F (y-axis) against $1/\sin\theta$ (x-axis) and draw the best straight line through the points.

(e) Determine the gradient and y-intercept of the line.

gradient = ...

y-intercept = ...

(f) The equation that relates F and θ is

$$F = \frac{mg}{\sin\theta} + k$$

where m is the mass of the load, k is a constant and g is the acceleration of free fall. You may take the value of g to be $9.81\ \mathrm{m\,s^{-2}}$.

Use your answers from **(e)** to determine values for m and k. Include appropriate units.

m = ...

k = ...

5. In this experiment, you will investigate how the force required to pull a block up an inclined plane depends on the angle between the inclined plane and the bench.

(a) **(i)** Place the board on the bench.

(ii) Place the block with attached masses on the board, and attach the newton-meter as shown in Fig. 2.1.

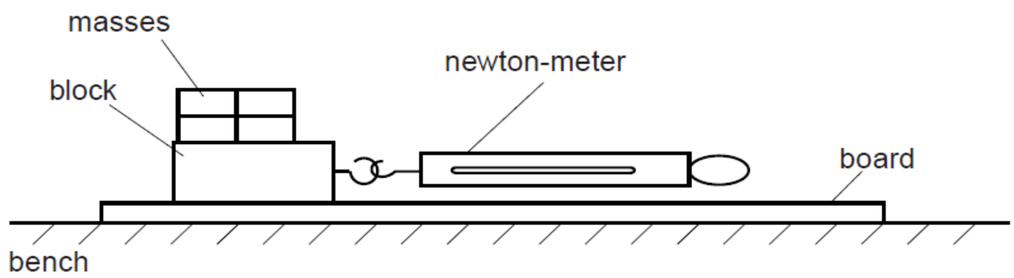

Fig. 2.1

(iii) Gently pull the newton-meter until the block just starts to move.

Measure and record the reading F_0 on the newton-meter, at the instant the block just starts to move.

F_0 = ... [2]

(iv) Estimate the percentage uncertainty in your value of F_0.

percentage uncertainty = ... [1]

(v) Calculate μ where $\mu = \frac{F_0}{W}$.

W is the value of the weight of the block and masses written on the card.

μ = ... [1]

(b) **(i)** Place the board and supporting block as shown in Fig. 2.2. The longer edge of the supporting block should be vertical.

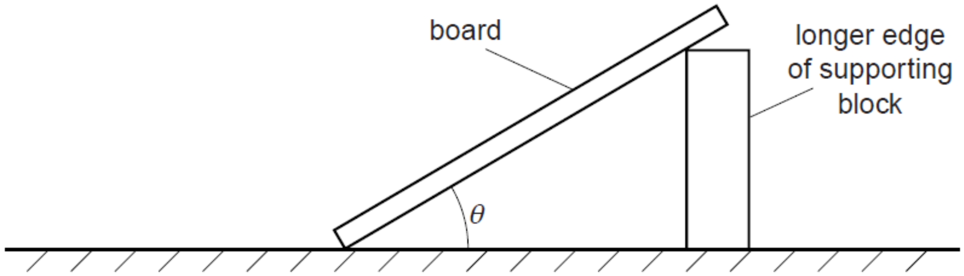

Fig. 2.2

(ii) Using the protractor, measure and record the angle θ between the board and the bench.

θ = ... [1]

(iii) Using your values from **(a)(v)** and **(b)(ii)**, calculate $(\sin\theta + \mu\cos\theta)$.

$(\sin\theta + \mu\cos\theta)$ = ... [1]

(c) **(i)** Place the block with masses on the board and attach it to the newton-meter, as shown in Fig. 2.3.

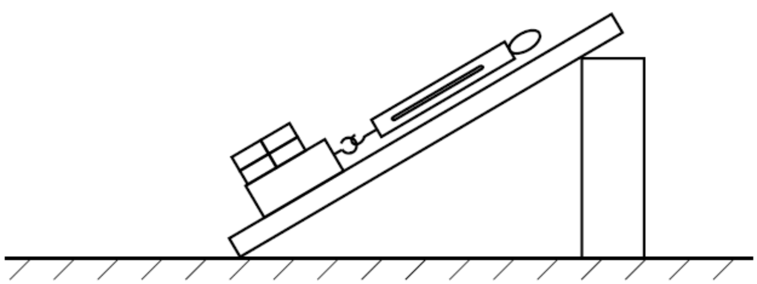

Fig. 2.3

(ii) Pull the newton-meter until the block just starts to move.

Measure and record the reading F on the newton-meter.

F = ... [1]

(d) Place the supporting block as shown in Fig. 2.4 with a shorter edge vertical.

Repeat **(b)(ii)**, **(b)(iii)** and **(c)**.

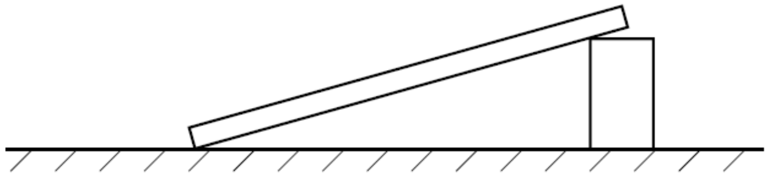

Fig. 2.4

θ = ...

($\sin\theta + \mu\cos\theta$) = ...

F = ... [3]

(e) It is suggested that the relationship between F and θ is

$$F = k(\sin\theta + \mu\cos\theta)$$

where k is a constant and μ is the value calculated in **(a)(v)**.

(i) Using your data, calculate two values of k.

first value of k = ...

second value of k = ... [1]

(ii) Explain whether your results support the suggested relationship.

....

....

....

.... [1]

(f) (i) Describe four sources of uncertainty or limitations of the procedure for this experiment.

1. ....

....

2. ....

....

3. ....

....

4. ....

....

[4]

(ii) Describe four improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

1. ....

....

2. ....

....

3. ....

....

4. ....

....

[4]

6. In this experiment, you will investigate how the equilibrium position of a pivoted wooden strip changes when a horizontal force is applied.

(a) Thread the string over the pulley and suspend the mass hanger from the end loop of the string, as shown in Fig. 1.1.

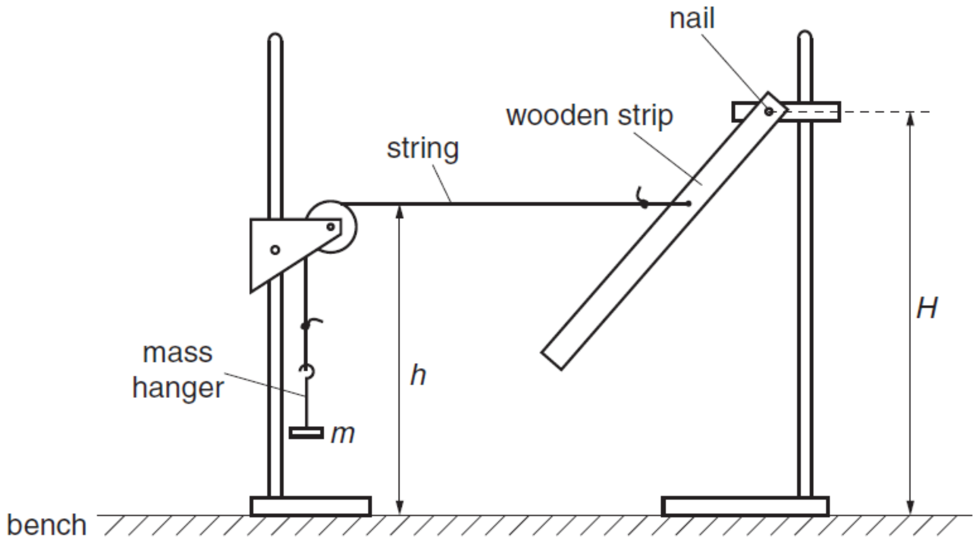

Fig. 1.1

(b) Measure and record the height H of the nail above the bench.

H = ... cm [1]

(c) Record the mass m that is suspended from the string.

m = ...

(d) (i) Adjust the height of the pulley until the string is parallel to the bench. Measure and record the height h of the string above the bench.

h = ... cm [1]

(ii) Calculate the value of $(H-h)$.

$(H-h)$ = ... cm

(e) By adding masses to the hanger, change the total suspended mass m. Repeat **(c)** and **(d)** until you have six sets of values for m and h.

In your table of results include columns for the values of m^2 and $\frac{1}{(H-h)^2}$.

[10]

(f) **(i)** Plot a graph of $\frac{1}{(H-h)^2}$ on the y-axis against m^2 on the x-axis. [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient and y-intercept of this line.

gradient = ...

y-intercept = ...

[2]

(g) It is suggested that the quantities h, H and m are related by the equation

$$\frac{1}{(H-h)^2} = abm^2 + b$$

where a and b are constants.

Using your answers from **(f)(iii)**, determine the values of a and b.
Give appropriate units.

a = ...

b = ...
[2]

7. In this experiment, you will investigate a system in equilibrium due to several turning forces.

(a) Measure and record the distance L between the two holes in the wooden strip as shown in Fig. 1.1.

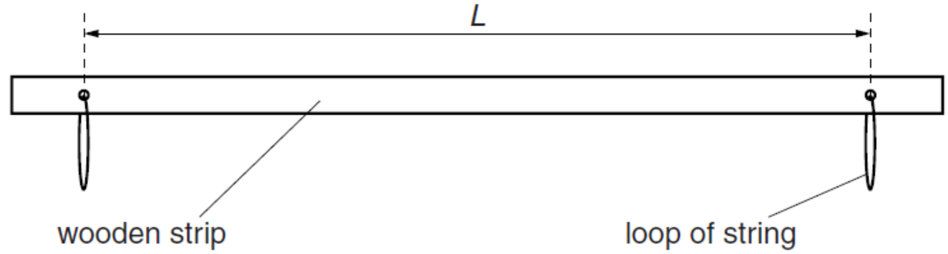

Fig. 1.1

L = ... m [1]

(b) Write down the mass M given on the card.

M = ... kg

(c) **(i)** Set up the apparatus as shown in Fig. 1.2, with mass $m = 0.040$ kg.

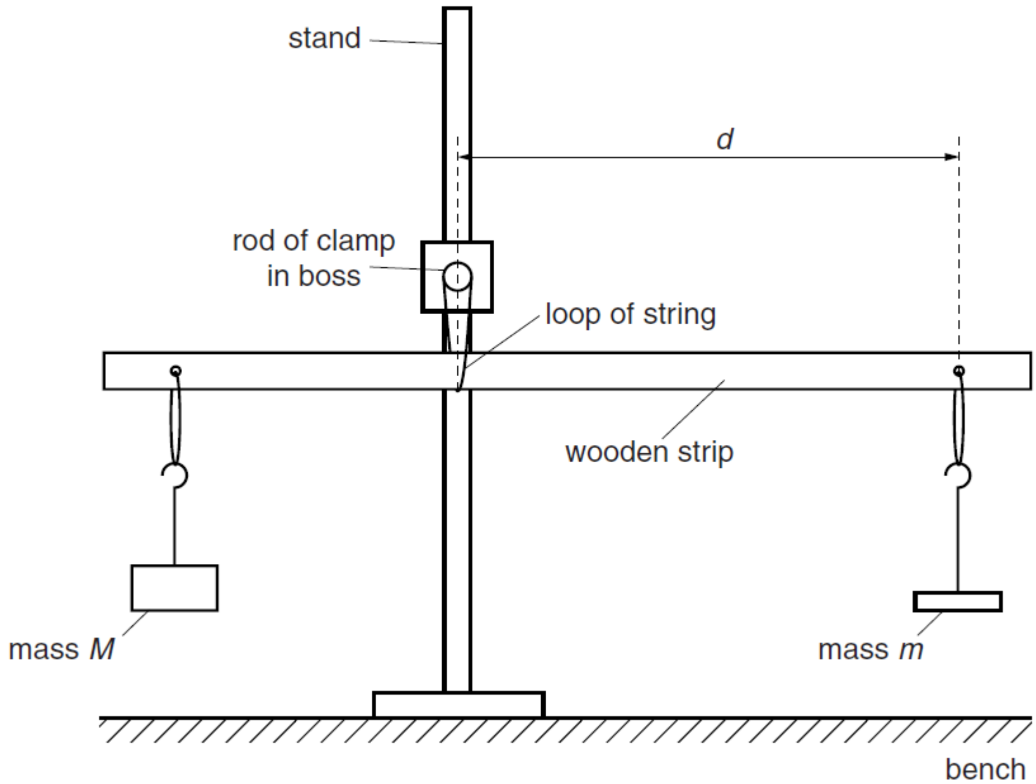

Fig. 1.2

(ii) Adjust the position of the wooden strip until it balances.

Measure and record the distance d, as shown in Fig. 1.2.

d = ... m [1]

(d) Vary m and repeat **(c)(ii)** until you have six sets of readings of m and d.

Include values of $\frac{1}{d}$ in your table.

[10]

(e) **(i)** Plot a graph of $\frac{1}{d}$ on the y-axis against m on the x-axis. [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient and y-intercept of this line.

gradient = ...

y-intercept = ...

[2]

(f) The quantities d and m are related by the equation

$$\frac{1}{d} = Pm + Q$$

where P and Q are constants.

Using your answers in **(e)(iii)**, determine the values of P and Q.
Give appropriate units.

P = ...

Q = ...
[1]

(g) The constant P is related to L and M by

$$P = \frac{1}{kML}$$

where k is a constant.

Using your answers in **(a)**, **(b)** and **(f)**, calculate a value for k.
You need not include units for k.

k = ...[1]

8. In this question you will investigate how the force required to maintain equilibrium of a horizontal rule depends on the position of a mass suspended from the rule.

(a) **(i)** Suspend a rule horizontally using two loops of string and a newton-meter, as shown in Fig. 1.1. The strings must be vertical.

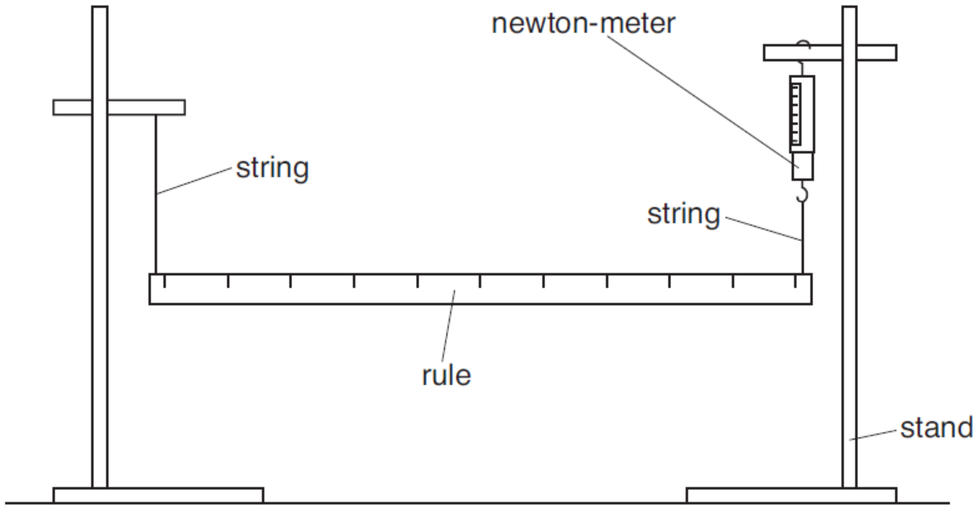

Fig. 1.1

(ii) Suspend the mass at a distance *d* from the newton-meter using a loop of string. You will need to adjust the position of the clamps to ensure that the rule remains horizontal. The arrangement should now be as shown in Fig. 1.2.

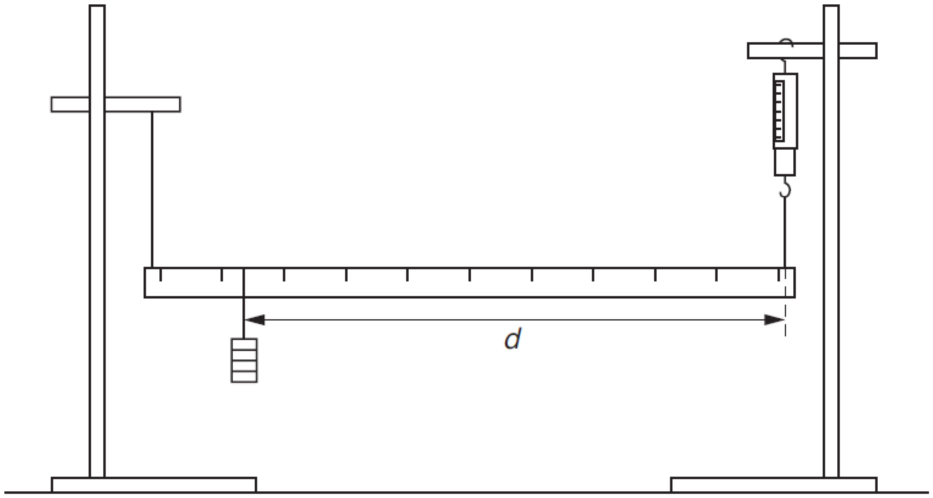

Fig. 1.2

(b) **(i)** Measure and record the value of d and the reading F from the newton-meter.

d = ...

F = ...

(ii) Determine the percentage uncertainty in the value of d.

percentage uncertainty in d = ...

(iii) Explain how you ensured that the rule was horizontal when the measurements were taken.

....

....

....

....

(c) Slide the suspended mass to a new position on the rule and repeat **(b)(i)** until you have six sets of readings for *d* and *F*. You should ensure when you are taking readings that the rule is horizontal and that the newton-meter does not go off scale.

Include all six sets of values of *d* and *F* in your table of results.

(d) Plot a graph of *F* (*y*-axis) against *d* (*x*-axis) and draw the best straight line through the points.

(e) Determine values for the gradient and *y*-intercept of the line.

gradient = ...

y-intercept = ...

(f) The equation that relates F and d is

$$F = \frac{-Wd}{L} + \frac{mg}{2} + W$$

where W is the weight of the suspended mass, m is the mass of the rule, $L = 0.980\,\text{m}$, and $g = 9.81\,\text{m s}^{-2}$.

Use your answers from **(e)** to determine values for W and m. Include appropriate units.

W = ...

m = ...

9. In this experiment you will investigate the equilibrium position of a metre rule with a mass attached to one end.

(a) **(i)** Use a loop of string to balance the metre rule as shown in Fig. 1.1.

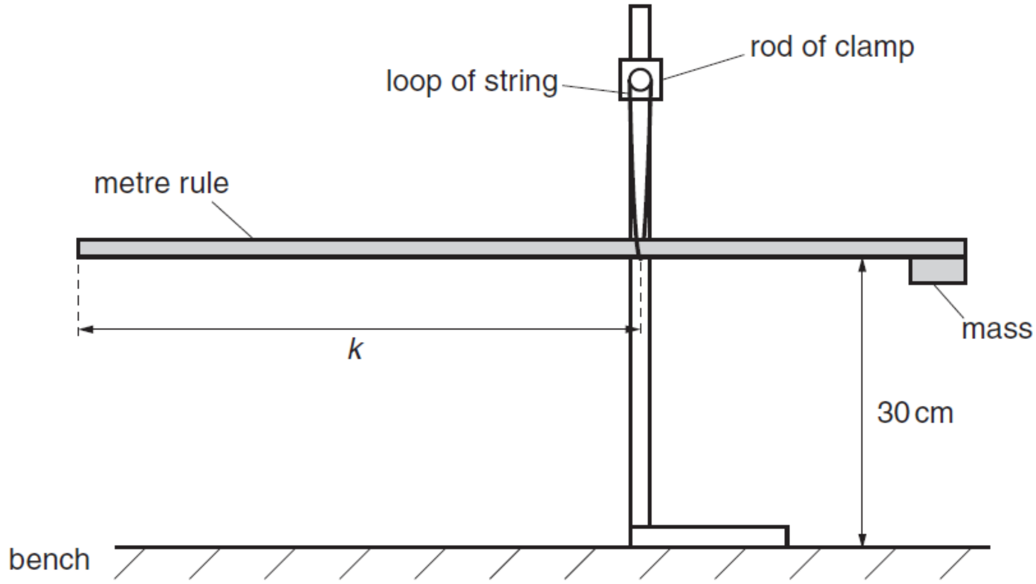

Fig. 1.1

(ii) Measure and record distance k between the loop and the end of the rule as shown in Fig. 1.1.

k = ... cm [1]

(b) (i) Use the other loop of string to attach the mass hanger at a distance *d* from the end of the rule as shown in Fig. 1.2. The value of *d* should be approximately 5 cm.

(ii) For this value of *d*, adjust the position of the rule so that it balances.
The new distance between the first loop and the end of the rule is *D*, as shown in Fig. 1.2.

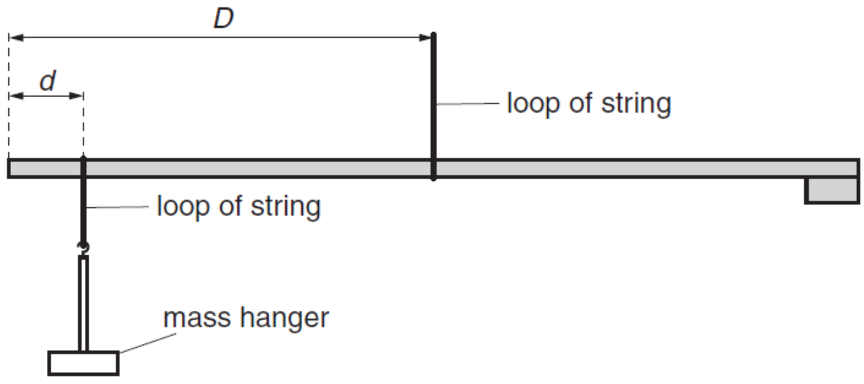

Fig. 1.2

(iii) Measure and record lengths *d* and *D*.

d = ...

D = ...
[1]

(iv) Calculate the value of $\frac{(D - d)}{D}$.

$\frac{(D - d)}{D}$ = ...

(c) By moving the mass hanger along the metre rule, repeat **(b)(ii)**, **(b)(iii)** and **(b)(iv)** until you have six sets of values of d and D.

Include values of $\frac{1}{D}$ and $\frac{(D-d)}{D}$ in your table.

[10]

(d) **(i)** Plot a graph of $\frac{(D-d)}{D}$ on the y-axis against $\frac{1}{D}$ on the x-axis. [3]

(ii) Draw the straight line of best fit. [1]

(iii) Determine the gradient and y-intercept of this line.

gradient = ...

y-intercept = ...

[2]

(e) The quantities d and D are related by the equation

$$\frac{(D-d)}{D} = \frac{A}{D} - B$$

where A and B are constants.

Use your answers in **(d)(iii)** to determine the value of $\frac{A}{B}$.
Give appropriate units.

$\frac{A}{B}$ = ... [2]