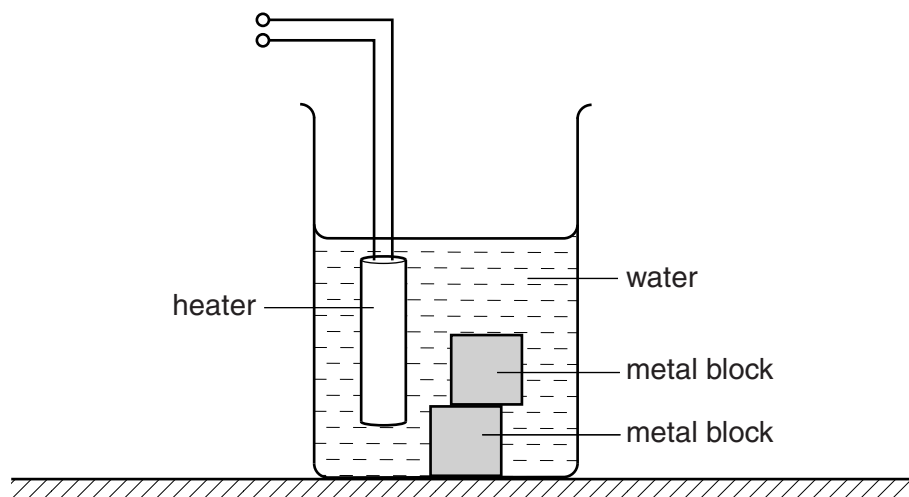




- 1 A beaker contains water and some metal blocks as shown in Fig. 1.1.



**Fig. 1.1**

A student uses an electrical heater to produce a particular temperature increase in the water.

It is suggested that the electrical energy  $E$  supplied to the heater is related to the mass  $m$  of metal blocks by the relationship

$$E = am + b$$

where  $a$  and  $b$  are constants.

Design a laboratory experiment to test the relationship between  $E$  and  $m$ . Explain how your results could be used to determine values for  $a$  and  $b$ . You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to

- (a) the procedure to be followed,
- (b) the measurements to be taken,
- (c) the control of variables,
- (d) the analysis of the data,
- (e) the safety precautions to be taken.

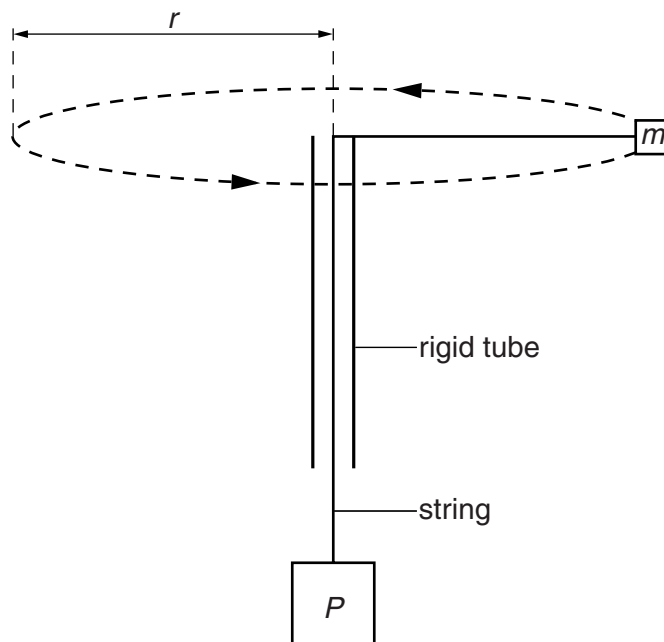
[15]





2 A student is investigating circular motion.

A small mass  $m$  attached to a larger mass  $P$  is rotated at constant speed in a horizontal circle, as shown in Fig. 2.1.



**Fig. 2.1**

The student changes the radius  $r$  of the circle and measures the time  $t$  for ten revolutions. The student then determines the period  $T$  of a revolution and then the speed  $v$ .

It is suggested that  $v$  and  $r$  are related by the equation

$$Pg = \frac{mv^2}{r}$$

where  $g$  is the acceleration of free fall.

- (a) A graph is plotted of  $v^2$  on the  $y$ -axis against  $r$  on the  $x$ -axis.  
Determine an expression for the gradient.

gradient = .....[1]

(b) The speed  $v$  is given by

$$v = \frac{2\pi r}{T}$$

Values of  $r$  and  $t$  are given in Fig. 2.2.

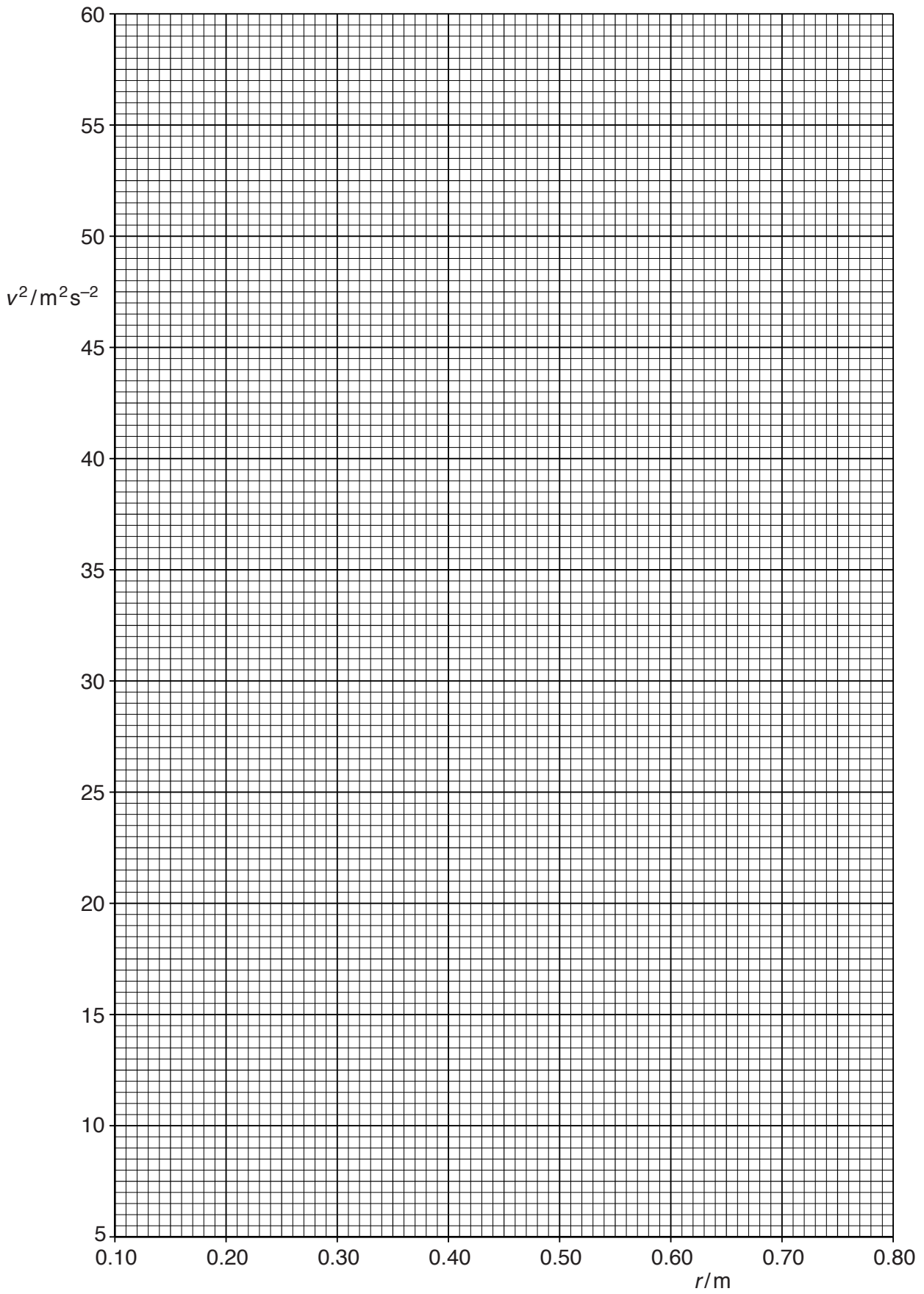
$r/\text{m}$	$t/\text{s}$			
0.160	$3.4 \pm 0.2$			
0.280	$4.0 \pm 0.2$			
0.400	$4.8 \pm 0.2$			
0.520	$5.4 \pm 0.2$			
0.640	$6.0 \pm 0.2$			
0.760	$6.6 \pm 0.2$			


**Fig. 2.2**

Calculate and record values of  $T/\text{s}$ ,  $v/\text{ms}^{-1}$  and  $v^2/\text{m}^2\text{s}^{-2}$  in Fig. 2.2. Include the absolute uncertainties in  $v^2$ . [3]

- (c) (i) Plot a graph of  $v^2/\text{m}^2\text{s}^{-2}$  against  $r/\text{m}$ . Include error bars for  $v^2$ . [2]
- (ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [2]
- (iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = ..... [2]

- (d) (i) Using your answers to (a) and (c)(iii), determine the value of  $P$ . Include an appropriate unit.

Data:  $g = 9.81 \text{ m s}^{-2}$  and  $m = 0.025 \pm 0.001 \text{ kg}$ .

$P = \dots\dots\dots$  [2]


- (ii) Determine the percentage uncertainty in your value of  $P$ .

percentage uncertainty =  $\dots\dots\dots$  % [1]

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- (e) (i) The experiment is repeated with a small mass  $m$  of 0.040 kg. Determine the speed  $v$  when the radius  $r$  is  $0.500 \pm 0.005 \text{ m}$ .

$v = \dots\dots\dots \text{ m s}^{-1}$  [1]

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- (ii) Determine the percentage uncertainty in your value of  $v$ .

percentage uncertainty =  $\dots\dots\dots$  % [1]

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