1: Skills for physics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
1	2017	June	21
1	2017	June	33
2	2017	June	33

The mark scheme for each question is provided at the end of the document.

1 **(a)** Determine the SI base units of stress.
Show your working.

base units ....[2]

(b) A beam PQ is clamped so that the beam is horizontal. A mass M of 500 g is hung from end Q and the beam bends slightly, as illustrated in Fig. 1.1.

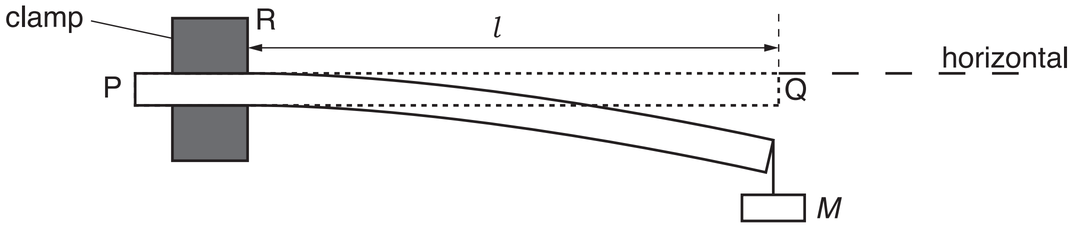

Fig. 1.1

The length l of the beam from the edge of the clamp R to end Q is 60.0 cm. The width b of the beam is 30.0 mm and the thickness d of the beam is 5.00 mm. The material of the beam has Young modulus E.

The mass M is made to oscillate vertically. The time period T of the oscillations is 0.58 s.

The period T is given by the expression

$$T = 2\pi \sqrt{\frac{4Ml^3}{Ebd^3}}.$$

(i) Determine E in GPa.

E = ...GPa [3]

1 In this experiment, you will investigate the motion of a chain of paper clips.

(a) You have been provided with a chain of fifteen paper clips with a sphere of modelling clay attached to one end of the chain.

Measure and record the length L of one paper clip as shown in Fig. 1.1.

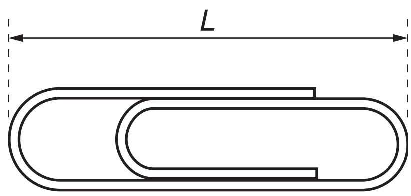

Fig. 1.1

L = ... [1]

(b) **(i)** Set up the apparatus as shown in Fig. 1.2.

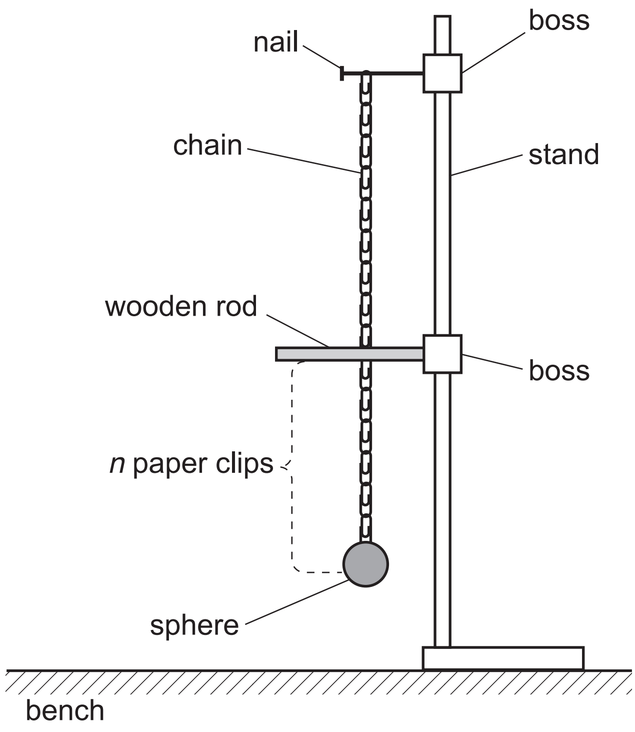

Fig. 1.2

The chain should be suspended from the nail.

The wooden rod should be positioned so that the chain, when hanging vertically, just touches the rod with 6 paper clips below the rod.

(ii) Record the number *n* of paper clips below the rod.

n = ...

(c) Move the sphere towards you through a distance of approximately 10 cm.
Release the sphere. The chain will oscillate and hit the rod during these oscillations.

Determine the period *T* of the oscillations.

T = ... [2]

(d) Change n by moving the wooden rod vertically and repeat **(b)(ii)** and **(c)** until you have six sets of values of n and T.

Record your results in a table. Include values of $\sqrt{n}$ to three significant figures in your table.

[8]

(e) **(i)** Plot a graph of T on the y-axis against $\sqrt{n}$ 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) It is suggested that the quantities T and n are related by the equation

$$T = P\sqrt{n} + Q$$

where P and Q are constants.

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

P = ...

Q = ...
[2]

(g) Theory suggests that

$$P = \pi\sqrt{\frac{L}{g}}$$

where g is the acceleration of free fall.

Use your values in **(a)** and **(f)** to determine a value for g.
Give an appropriate unit.

g = ... [1]

[Total: 20]

2 In this experiment, you will investigate the equilibrium of a balanced metre rule and determine its mass.

(a) You have been provided with a metre rule with a hole close to each end as shown in Fig. 2.1.

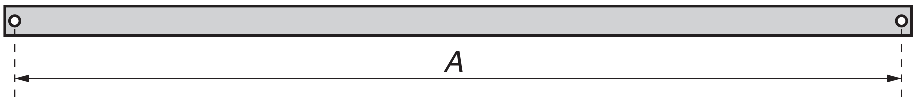

Fig. 2.1

The distance between the centres of the holes is *A*.

Measure and record *A*.

A = ... [1]

(b) **(i)** Set up the apparatus as shown in Fig. 2.2.

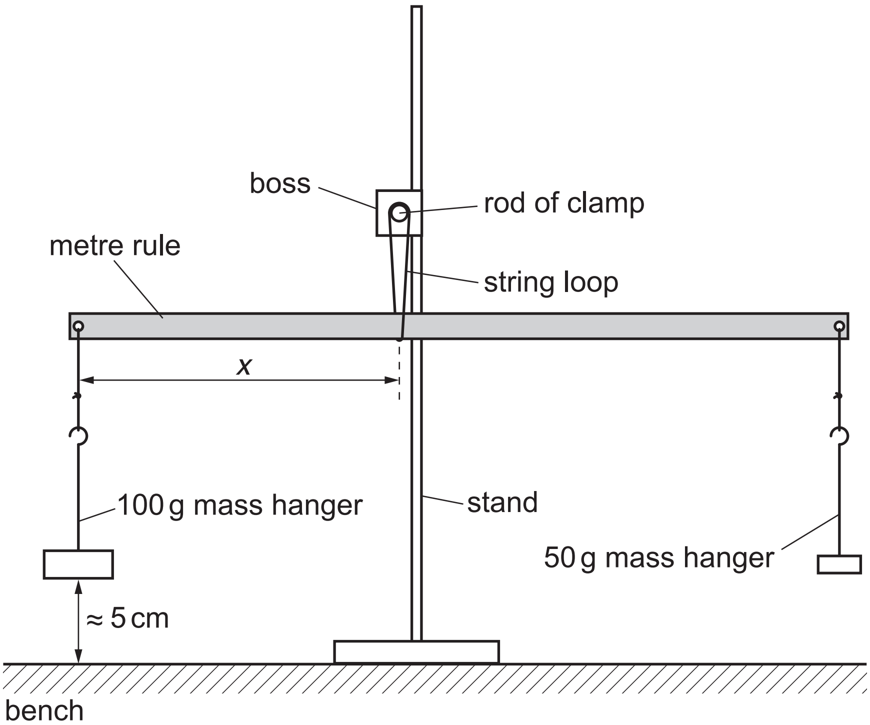

Fig. 2.2

Adjust the position of the rule until it is balanced.

The distance between the centre of the hole from which the 100 g mass hanger is supported and the position of the central string loop is *x*.

(ii) Measure and record *x*.

x = ... [1]

(c) (i) Add a 10 g slotted mass to each mass hanger.

(ii) Adjust the position of the rule until it is balanced.
The distance between the centre of the hole from which the 100 g mass hanger is supported and the position of the central string loop is now *y* as shown in Fig. 2.3.

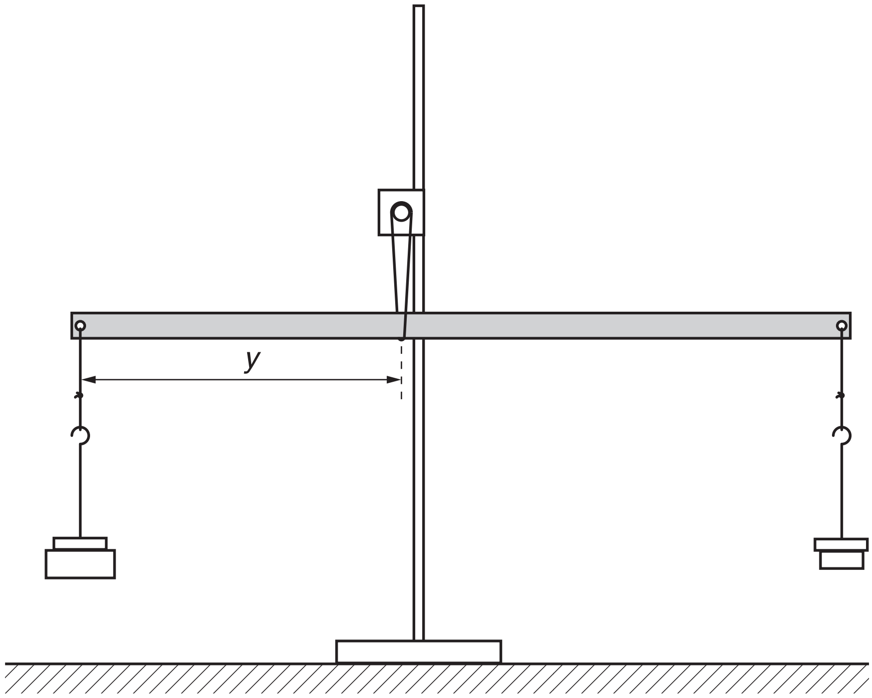

Fig. 2.3

(iii) Measure and record *y*.

y = ... [1]

(iv) Calculate (*y* – *x*).

(*y* – *x*) = ... [1]

(v) Estimate the percentage uncertainty in your value of (*y* – *x*).

percentage uncertainty = ... [1]

(d) (i) Calculate $m(A - 2y)$ where $m = 10.0$ g.

$m(A - 2y) =$ .... [1]

(ii) Justify the number of significant figures that you have given for your value of $m(A - 2y)$.

....

....

.... [1]

(e) (i) Add another 10 g mass to each of the mass hangers and repeat **(c)(ii)**, **(c)(iii)** and **(c)(iv)**.

$y =$ ....

$(y - x) =$ ....
[2]

(ii) Calculate $m(A - 2y)$ where $m = 20.0$ g.

$m(A - 2y) =$ ....

(f) It is suggested that the relationship between y, x, m and A is

$$(y - x) = km(A - 2y)$$

where k is a constant.

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

first value of k = ...

second value of k = ...
[1]

(ii) Explain whether your results in **(f)(i)** support the suggested relationship.

....

....

....

....[1]

(g) Using your second value of k, calculate the mass M of the metre rule using the relationship

$$k = \frac{1}{B + M}$$

where B = 150 g.

M = ... g [1]

(h) (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]

[Total: 20]

Question	Answer	Marks
1 (a)	(stress =) force / area **or** kg m s^{-2} / m^2	**1**
	= kg m^{-1} s^{-2}	**1**
1 (b) (i)	$0.58 = 2\pi \times [(4 \times 0.500 \times 0.600^3) / (E \times 0.0300 \times 0.00500^3)]^{0.5}$	**1**
	$E = [4\pi^2 \times 4 \times 0.500 \times (0.600)^3] / [(0.58)^2 \times 0.0300 \times (0.00500)^3]$ $= 1.35 \times 10^{10}$ (Pa)	**1**
	= 14 (13.5) GPa	**1**
1 (b) (ii) 1.	(accuracy determined by) the closeness of the value(s)/measurement(s) to the true value	**1**
	(precision determined by) the range of the values/measurements	**1**
1 (b) (ii) 2.	l is (cubed so) 3 $\times$ (percentage/fractional) uncertainty **and** T is (squared so) 2 $\times$ (percentage / fractional) uncertainty **and** (so) l contributes more	**1**
		Total: 8
1 (a)	Value of L with unit to the nearest mm in the range 2.5–3.5 cm.	**1**
1 (c)	Value of T with unit in the range 0.7 s to 1.5 s.	**1**
	Evidence of repeated timings. Must see nT repeated where $n \geqslant 5$.	**1**
1 (d)	Six sets of readings of n (different values) and time with correct trend and without help from Supervisor scores 4 marks, five sets scores 3 marks etc.	**4**
	Range of $n \geqslant 9$.	**1**
	Column headings: Each column heading must contain a quantity and a unit where appropriate. The presentation of quantity and unit must conform to accepted scientific convention e.g. T / s. No unit for n or $\sqrt{n}$.	**1**
	Consistency: All values of raw time must be given to either 0.1 s or 0.01 s.	**1**
	Significant figures: All values of $\sqrt{n}$ must be given to 3 significant figures.	**1**
1 (e) (i)	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10 or fractions). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labelled with the quantity that is being plotted. Scale markings should be no more than three large squares apart.	**1**
	Plotting of points: All observations must be plotted on the grid. Diameter of plotted points must be $\leqslant$ half a small square (no "blobs"). Points must be plotted to an accuracy of half a small square.	**1**
	Quality: All points in the table must be plotted for this mark to be awarded. It must be possible to draw a straight line that is within ±0.10 on the $\sqrt{n}$ axis of all plotted points.	**1**

Question	Answer	Marks
1 (e) (ii)	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	**1**
	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. Method of calculation must be correct. Do not allow Δx / Δy. Both read-offs must be accurate to half a small square in both *x* and *y* directions.	**1**
	y-intercept: Correct read-off from a point on the line substituted correctly into $y = mx + c$ or an equivalent expression. Read-off accurate to half a small square in both *x* and *y* directions. **or** Intercept read directly from the graph, with read-off at $x = 0$, accurate to half a small square in *y* direction.	**1**
1 (f)	Value of *P* = candidate's gradient **and** value of *Q* = candidate's intercept. The values must not be fractions.	**1**
	Units for *P* and *Q* both s.	**1**
1 (g)	Correct calculation of $g = L\pi^2 / P^2$ with consistent unit.	**1**
		Total: 20
2 (a)	Value(s) of *A* with unit in the range 97.5–99.5 cm.	**1**
2 (b) (ii)	Values of all raw *x* to nearest mm.	**1**
2 (c) (iii)	Value of $y > x$.	**1**
2 (c) (iv)	Correct calculation of $(y – x)$.	**1**
2 (c) (v)	Percentage uncertainty in $(y – x)$ based on absolute uncertainty of 2–5 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty.	**1**
2 (d) (i)	Correct calculation of $m(A – 2y)$.	**1**
2 (d) (ii)	Justification for s.f. in $m(A – 2y)$ linked to s.f. in *A*, *y* and *m* **or** $(A – 2y)$ and *m*.	**1**
2 (e) (i)	Second value of *y*.	**1**
	Quality: second value of *y* > first value of *y*.	**1**
2 (f) (i)	Two values of *k* calculated correctly.	**1**
2 (f) (ii)	Valid comment consistent with calculated values of *k*, testing against a criterion specified by the candidate.	**1**
2 (g)	Correct calculation of $M = 1 / k – B$.	**1**

Question	Answer		Marks
2 (h) (i)	A	Two readings are not enough to draw a (valid) conclusion (**not** “not enough for accurate results”, “few readings”).	**4**
	B	Difficult to measure *x* or *y* with reason e.g. markings on rule obscured because of thickness of string / twist in string / ruler oscillating / ruler swinging / rule slides in loop / string not vertical.	
	C	Large (%) uncertainty in ($y – x$) **or** ($y – x$) is small.	
	D	Little difference in *y* values.	
	E	Difficult to balance rule.	
	1 mark for each point up to a maximum of 4.		
2 (h) (ii)	A	Take more readings and plot a graph / take more readings and compare *k* values (**not** “repeat readings” on its own).	**4**
	B	Use thinner string / tie a knot in loop / use two loops / use a hook / use longer loop / string.	
	C	Heavier (added/slotted) masses (**not** heavier hangers).	
	D	Use wider range of (added) masses.	
	E	Suspend rule from its top edge / balance on fulcrum / use thicker string with reason such as to make easier to balance / prevent rule from slipping.	
	1 mark for each point up to a maximum of 4.		
			Total: 20

Notes about the mark scheme are available separately.