

- (b) (ii) Repeats of raw times 1
- (b) (ii) Calculation of period 1
- (b) (iii) Calculation of frequency 1
- (b) (iv) Justification of sf in frequency 1
- (c) (i) Readings 3
- Write the number of readings as a ringed total by the results table.  
6 sets of readings scores 1 mark.  
Check a value for  $\lg(f/\text{Hz})$  and a value for  $\lg(l/\text{m})$ . Underline checked values.  
Ignore small rounding errors. Tick if correct. Score one mark each. Ln values then -1.  
If incorrect then write in correct value and -1.  
If minor help is given, then -1. If excessive help is given then -2.  
Please indicate when help has been given to a candidate by writing **SR** at the top of the front page of the candidate's script. Also, please indicate the type of help that has been given by writing a brief comment by the table of results.
- (c) (i) Most raw times  $> 10$  s 1
- (c) (i) Quality of results 1
- Judge by scatter of points about the line of best fit.  
6 trend plots needed.
- (c) (i) Column headings 1
- There must be some distinguishing mark between the quantity and its unit.  
Please  $\checkmark$  each correct column heading to show that it has been seen.
- (c) (i) Consistency of raw readings in the table of results 1
- Apply to  $l$  and  $t$  only.  
Expect to see  $t$  to either 0.01 s or 0.1 s.  
Expect to see all the values of  $l$  given to the nearest millimetre.  
Indicate using  $\checkmark_c$  at the foot of each column of raw readings if correct.
- (c) (ii) Blade oscillators too quickly to time oscillations manually 1
- (d) (i) Axes 1
- Each axis must be labelled with a quantity and a unit.  
Scales must be such that the plotted points occupy more than half the graph grid in both the  $x$  and  $y$  directions. Do not allow more than 3 large squares between scale markings. Do not allow awkward scales (e.g. 3:10, 6:10, 7:10, etc.).
- (d) (i) Plotting of points 1
- Count the number of plots on the grid and write this value by the line and ring it.  
Do not allow plots in the margin area.  
The number of plots must correspond to the number of observations.  
Do not award this mark if the number of plots is less than the number of observations.

Check one suspect plot. Circle this plot. Tick if correct. If incorrect then mark the correct position with a small cross and use an arrow to indicate where the plot should have been. Allow errors up to and including half a small square.

- (d) (i) Line of best fit 1  
 There must be a reasonable balance of points about the line of best fit.  
 If one of the plots is a long way from the trend of the other plots then allow this plot to be ignored when the line is drawn.  
 One mark can be awarded if the line of best fit is 'reasonable', but not quite right.
- (d) (ii) Measurement of gradient 1  
 The hypotenuse of the triangle must be greater than half the length of the drawn line.  
 Read-offs must be accurate to half a small square.  
 Please indicate the vertices of the triangle used by labelling with  $\Delta$ .
- (d) (ii)  $y$ -intercept 1  
 Check the read-off.  
 Accept correct substitution from a point on the line into  $y = mx + c$ .
- (e)  $\lg f = n \lg l + \lg k$  1  
 This can be implied from the working.
- (e) Value for  $n$  (from gradient) 1
- (e) Value for  $k$  (from  $10^y$ -intercept) 1
- (e) SF in  $n$  and  $k$ . Allow 2 or 3 sf in both quantities 1
- (f) (i) Value of  $d$  ( $\pm 0.04$  mm of SV) 1
- (f) (ii) Micrometer screw gauge 1
- (f) (iii) Percentage uncertainty in  $d^3$  2  
 One mark for correct ratio idea; one mark for  $\times 3$ .
- (g)  $E = 16\pi^2 k^2 M/bd^3$  1
- (g) Value of  $E$  1  
 Check the substitution and consistency of units.  
 Value should be ...  $\times 10^{11}$
- (g) Unit of  $E$  1

**28 marks** for this question.

## Question 2

- First pointer position (using a.c.) 1
- Second pointer position (using a.c.) 1

Change in pointer reading ( $\pm 50\%$ of SV)	1
d.c. current in range 2.5 A to 3.5 A	1
Percentage difference in current readings	1
Failure of method for current $> 20$ A (i.e. wire melts)	1
Evaluation of procedure	8
Relevant points must be underlined and ticked. Some of these might be:	
Parallax error in pointer reading	
Place tip of pointer in contact with scale on rule	
Draughts affect the pointer reading	
Draughts produce cooling of the wire	
Close windows/don't breathe on equipment/sit still when taking readings etc.	
Vertical movement is very small/need larger vertical movement	
Use travelling microscope	
Use larger currents to give bigger vertical movement of pointer	
Use thinner wire	
Use longer wire to increase vertical movement	
Wire slips in the crocodile clips	
Use screw terminals (or equivalent) instead of crocodile clips	
Creep in the wire	
Stands move slightly changing the pointer reading	
Repeat the readings	

Allow other relevant points (8 maximum). Marks can be awarded on the basis of 'one for the problem and one for the solution'.

**2 marks** are reserved for quality of written communication (SPAG) **2**

**16 marks** maximum to be awarded.