Question 1

(b) (i) Readings **2/1/0**

Write the number of readings as a ringed total by the results table.
6 sets of values for V and I ($I \neq 0$) scores one mark.
Check a value for lg(I/A) and a value for lg(V/V). Underline checked values.
Ignore small rounding errors. Tick if correct and score one mark.
If incorrect then write in correct value. In values will not score this mark.
If minor help is given (e.g. voltmeter in series), then -1.
If excessive help is given (i.e. circuit constructed for candidate) 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.

(b) (i) Quality of results **2/1/0**

Judge by scatter of points about the line of best fit.
Six good trend plots will score two marks.
Five good trend plots, or some scatter of six plots will score one mark.
Large scatter/no trend score zero.
These marks cannot be scored if lg V or lg I values have been miscalculated (but accept ln values).

(b) (i) Column headings **2/1/0**

The columns for I and V must be headed with a quantity and a unit. One mark each.
There must be some distinguishing mark between the quantity and its unit.
(e.g. 'I/A' or 'I(A)' or 'I in A' or 'current in Amperes' are all allowable;
'I A' or '(I) A' or 'I_A' or 'A' (on its own) are not allowable.)
Please ✓ each correct column heading to show that it has been seen.
Ignore the column headings for lg (I/A) and lg (V/V).

(b) (i) Consistency of raw readings in the table of results **2/1/0**

Apply to I, V only. One mark each.
All raw readings of a particular quantity must be given to the same degree of precision (e.g. if the measurement of one particular quantity is given to 2 decimal places then all the readings of that particular quantity should be given to 2 decimal places). Do not allow an unreasonable degree of precision to be given which is inconsistent with the apparatus used.
Indicate using $\checkmark_C$ at the foot of each column of raw readings if correct.
Ring any inconsistency found, and write x_C at the foot of the column.
Do not allow values $\geq$ 3 d.p.

(b) (ii) Largest percentage uncertainty in I **2/1/0**

One mark for using the smallest value of I.
One mark for correct ratio idea, sensible $\square I$ (0.01 for digital meters) and 'x 100'.
If repeats done then ΔI can be half the range.

(c) (i) Axes **2/1/0**

Each axis must be labelled with a quantity.
Scales must be such that the plotted points occupy at least 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, 8:10 etc.).
One mark for each correct axis.

(c) (i) Plotting of points **2/1/0**

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 these marks 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 for two marks.
If the error is more than half a small square but not more than one small square, then score one mark.

(c) (i) Line of best fit **2/1/0**

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.
These marks can only be awarded if a straight line has been drawn through a linear trend

(c) (ii) Measurement of gradient **2/1/0**

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 and the ratio must be correct.
Please indicate the vertices of the triangle used by labelling with Δ.
If the triangle is of an appropriate size then $\checkmark_{\Delta}$.
One mark for appropriate size of triangle.
One mark for read-offs and ratio correct.

(c) (ii) *y*-intercept **2/1/0**

Check the read-off. Allow errors up to and including half a small square for two marks.
If the error is between half a small square and one small square, then score one mark.
Correct substitution from a point on the line into $y = mx + c$ scores two marks.
If the point is not on the line, then this method can score one mark.
If a false origin has been used, or incorrect gradient in $y = mx + c$, then score zero.
Do not allow second graph to be drawn to find the intercept.
A bald intercept with no working/read off from graph scores zero.

(d) $\lg I = n \lg V + \lg k$ **1**
Allow $\ln I = n \ln V + \ln k$.
Can be implied from the working.

(d) Value for n (from gradient) **1**

(d) Value for k (from $10^{y\text{-intercept}}$) **1**
Method of working must be checked.
Allow $e^{y\text{-intercept}}$ if ln values have been used.

(e) Comment on suggested relationship **2/1/0**
Log graph is a straight line (one mark) so relationship is valid (one mark).
Allow values to be compared by substitution into the equation.
Do not award these marks is there is a clear curved trend/no trend.
If log values have not been found then these marks cannot be awarded.
Score zero if the candidate states that the relationship is invalid.
Bald 'relationship is valid' with no explanation scores zero.

(f) (i) Correct power calculation **2/1/0**
Correct substitution into an I-V equation to give I and use of $P = IV$ scores one mark.
Value for P in range 50 W to 150 W scores one mark.
This second mark will be lost if the candidate has inverted the axes (i.e. has plotted lg V against lg I).

(f) (ii) Sensible comment **1**
(e.g. filament melts/bulb blows/bulb fails/bulb breaks etc.).
Answer must refer to bulb or filament in some way. Do not allow vague 'power is too high' or 'meters would go off scale' etc.

28 marks in total.

Question 2

(b) (ii) Time for five oscillations recorded to 2 or 3 sf scores one mark. **2/1/0**
Calculation of T (= t/n) to 2 or 3 sf and within 10% of SV scores one mark.
If no SV then use 0.50 s $\leq T \leq$ 0.60 s. Misread stopwatch loses both of these marks.

(c) Justification for number of sf in T **1**
i.e. same sf as t (allow 'raw data' ideas) or sensible reference to human reaction time.
If t used in **(b) (ii)** instead of T (i.e. no calculation done) then do not award this mark.

(d) Pendulum behaviour/mass flies off spring/stand vibrates/problem with torsional oscillations/period independent of amplitude/time taken to come to rest is longer/ spring hits support/acceleration of mass at extreme ends is larger/initial rate of decrease of amplitude is larger. **2/1/0**
Allow vague 'mass oscillates at a greater speed' and 'it moves faster'.
Do not allow 'the oscillations are larger'.
Do not allow 'the period increases/decreases' or 'frequency increases/decreases'

(f) Repeated readings of raw times for second value of T **1**

(g) Ratio T^2/n is constant **2/1/0**
One mark for ratio idea, or calculation of k's
One mark for conclusion that T^2 is directly proportional to n which follows from the reasoning (only if k values are within 10% of each other).
Vague 'T^2 might be directly proportional to n' or 'T^2 is not directly proportional to n' does not score this second mark.

(h) Evaluation of procedure **6**
Relevant points must be underlined and ticked. Some of these might be:
Top spring has different load to bottom spring due to weight of bottom spring
Time taken for five oscillations is too short
Time more oscillations
Use larger mass to increase the period
Springs may not be identical
Problems with varying amplitude
Hang mass on spring and wait for torsion osc to cease before vertically displacing mass
Hard to see when the oscillation begins/ends (or human error in timing)
Two readings is not enough to draw a conclusion
Take several/many readings
Use a fiducial marker
Place the marker at the centre of the oscillation
Use motion sensor (with datalogger and/or computer)

Do not allow marks to be awarded for problems with large oscillations
Do not allow vague 'use light gates', 'use a computer', 'repeat the readings' or 'video the mass'
Do not allow vague 'draughts', 'do the experiment in a vacuum'
Allow other relevant points (6 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, **2**
Spelling, punctuation and grammar

16 marks maximum to be awarded.