1)

(a) State Hooke's law.

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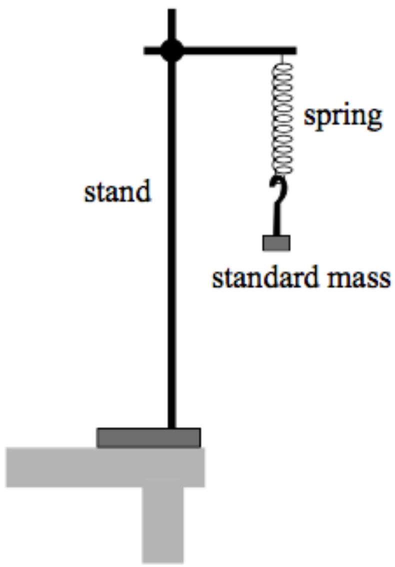
(2 marks)

(b) A student is asked to measure the mass of a rock sample using a steel spring, standard masses and a metre rule. She measured the unstretched length of the spring and then set up the arrangement shown in **Figure 2**.

Figure 2



(b) (i) Describe how you would use this arrangement to measure the mass of the rock sample. State the measurements you would make and explain how you would use the measurements to find the mass of the rock sample.
The quality of your written communication will be assessed in this question.

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(6 marks)

(b) (ii) State and explain **one** modification you could make to the arrangement in **Figure 2** to make it more stable.

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(2 marks)

2)

(a) Describe how to obtain, accurately by experiment, the data to determine the Young modulus of a metal wire.

A space is provided for a labelled diagram.

The quality of your written answer will be assessed in this question.

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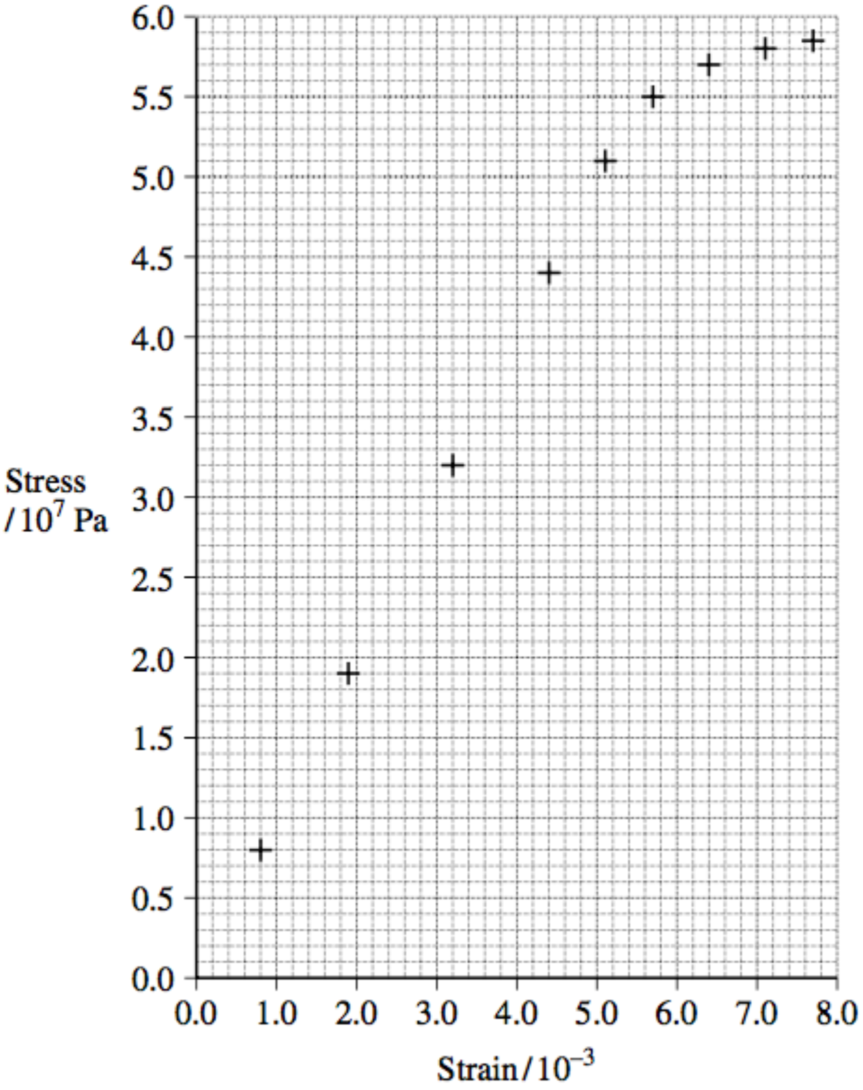
(6 marks)

(b) **Figure 7** is a plot of some results from an experiment in which a metal wire was stretched.

Figure 7



(b) (i) Draw a best-fit line using the data points.

(1 mark)

(b) (ii) Use your line to find the Young modulus of the metal, stating an appropriate unit.

answer = ...

(4 marks)

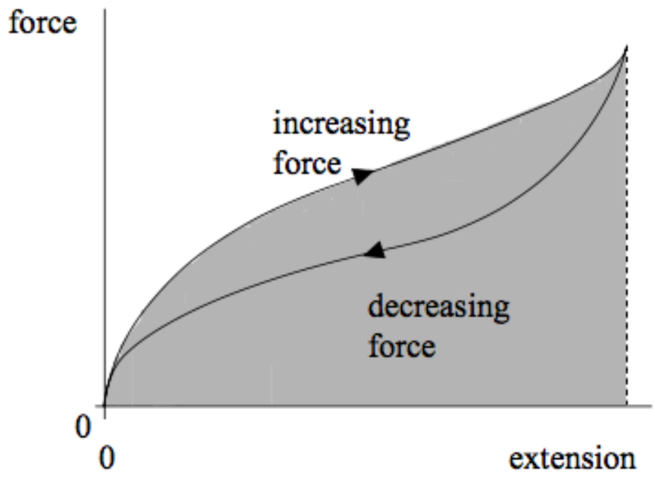
(c) After reaching a strain of 7.7×10^{-3}, the wire is to be unloaded. On **Figure 7**, sketch the line you would expect to obtain for this.

(1 mark)

3)

A student investigated how the extension of a rubber cord varied with the force used to extend it. She measured the extension for successive increases of the force and then for successive decreases. **Figure 5** shows a graph of her results.

Figure 5



(a) (i) Give a reason why the graph shows the rubber cord does not obey Hooke's law.

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(1 mark)

(a) (ii) Give a reason why the graph shows the rubber cord does not exhibit plastic behaviour.

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(1 mark)

(a) (iii) What physical quantity is represented by the area shaded on the graph between the loading curve and the extension axis?

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(1 mark)

(b) Describe, with the aid of a diagram, the procedure and the measurements you would make to carry out this investigation.

The quality of your written answer will be assessed in this question.

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(6 marks)

4)

(a) Describe an experiment to accurately determine the spring constant k of a spring that is thought to reach its limit of proportionality when the load is about 20 N.

Include details of the necessary measurements and calculations and describe how you would reduce uncertainty in your measurements. A space is provided for a labelled diagram should you wish to include one.

The quality of your written communication will be assessed in this question.

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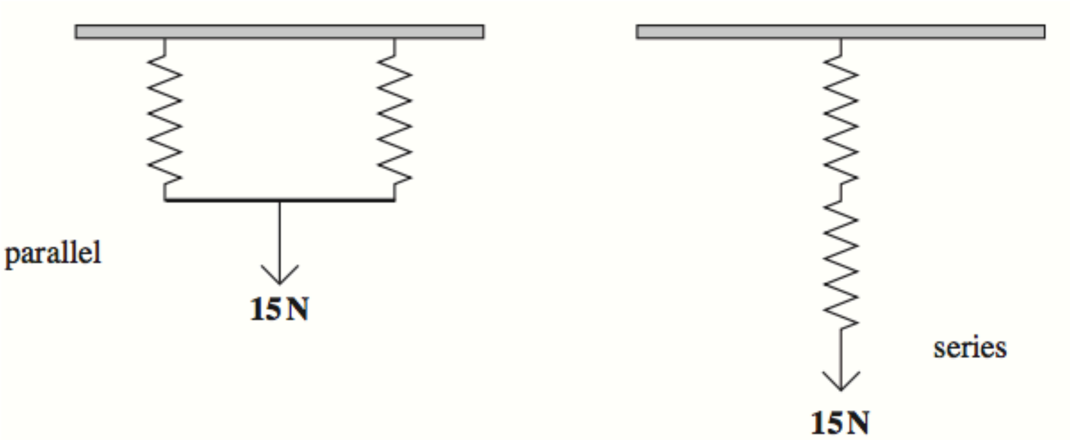
(6 marks)

(b) Two identical springs, each having a spring constant of $85\,\text{N m}^{-1}$, are shown arranged in parallel and series in **Figure 7**.

Figure 7



A load of 15 N is attached to each arrangement.

(b) (i) Calculate the extension for the parallel arrangement when the load is midway between the lower ends of the springs.

answer = ... m
(2 marks)

(b) (ii) Calculate the extension for the series arrangement.

answer = ... m
(2 marks)

(b) (iii) Calculate the energy stored in the parallel arrangement.

answer = ... J
(2 marks)

(b) (iv) Without further calculation, discuss whether the energy stored in the series arrangement is less, or greater, or the same as in the parallel arrangement.

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(3 marks)

5)

(a) Fig. 7.1 shows a length of tape under tension.

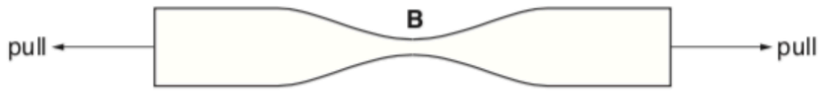

Fig. 7.1

(i) Explain why the tape is most likely to break at point **B**.

....

.... **[1]**

(ii) Explain what is meant by the statement:

'the tape has gone beyond its elastic limit'.

....

....

.... **[1]**

(b) Fig. 7.2 shows one possible method for determining the Young modulus of a metal in the form of a wire.

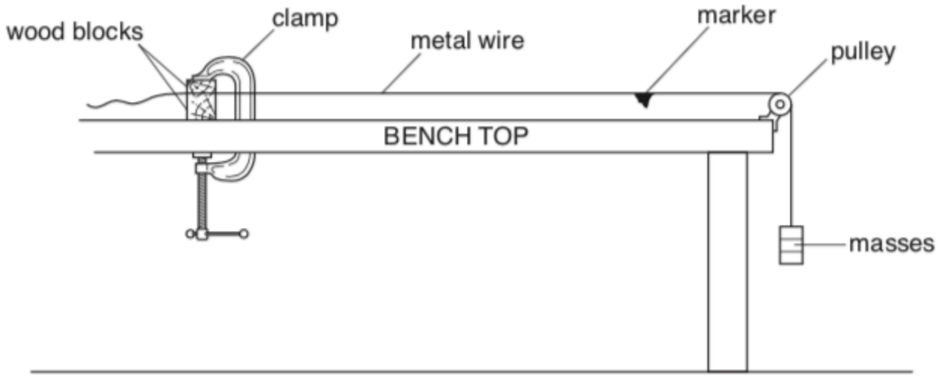

Fig. 7.2

Describe how you can use this apparatus to determine the Young modulus of the metal. The sections below should be helpful when writing your answers.

The **measurements** to be taken:

In your answer, you should use appropriate technical terms, spelled correctly.

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The **equipment** used to take the measurements:

In your answer, you should use appropriate technical terms, spelled correctly.

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How you would **determine** Young modulus from your measurements:

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[8]

6 A student is investigating how the extension of a loaded wire depends on the diameter of the wire

. The apparatus is set up as shown in Fig. 2.1.

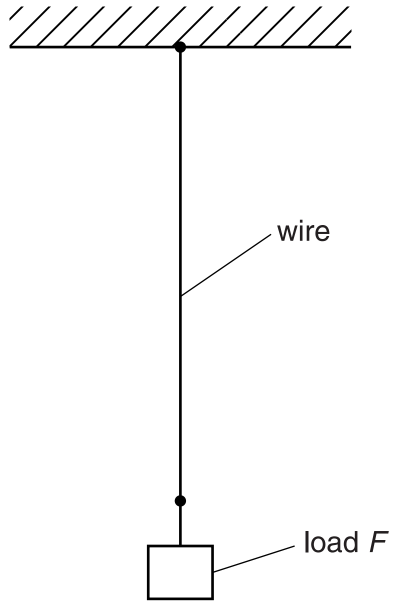


Fig. 2.1

A load F is applied to the wire and the extension e is measured.

The experiment is repeated for wires of the same material and same initial length L but different diameter d.

It is suggested that e and d are related by the equation

$$e = \frac{4LF}{\pi E d^2}$$

where E is a constant.

(a) A graph is plotted of e on the y-axis against $\frac{1}{d^2}$ on the x-axis.

Determine an expression for the gradient.

gradient = ...[1]

(b) Values of d and e are given in Fig. 2.2.

$d / 10^{-3}$ m	$e / 10^{-3}$ m	
0.28 ± 0.02	11.3	
0.32 ± 0.02	8.6	
0.38 ± 0.02	6.0	
0.46 ± 0.02	4.1	
0.56 ± 0.02	2.7	
0.72 ± 0.02	1.7	

Fig. 2.2

Calculate and record values of $\frac{1}{d^2}$ / 10^6 m^{-2} in Fig. 2.2.

Include the absolute uncertainties in $\frac{1}{d^2}$. [3]

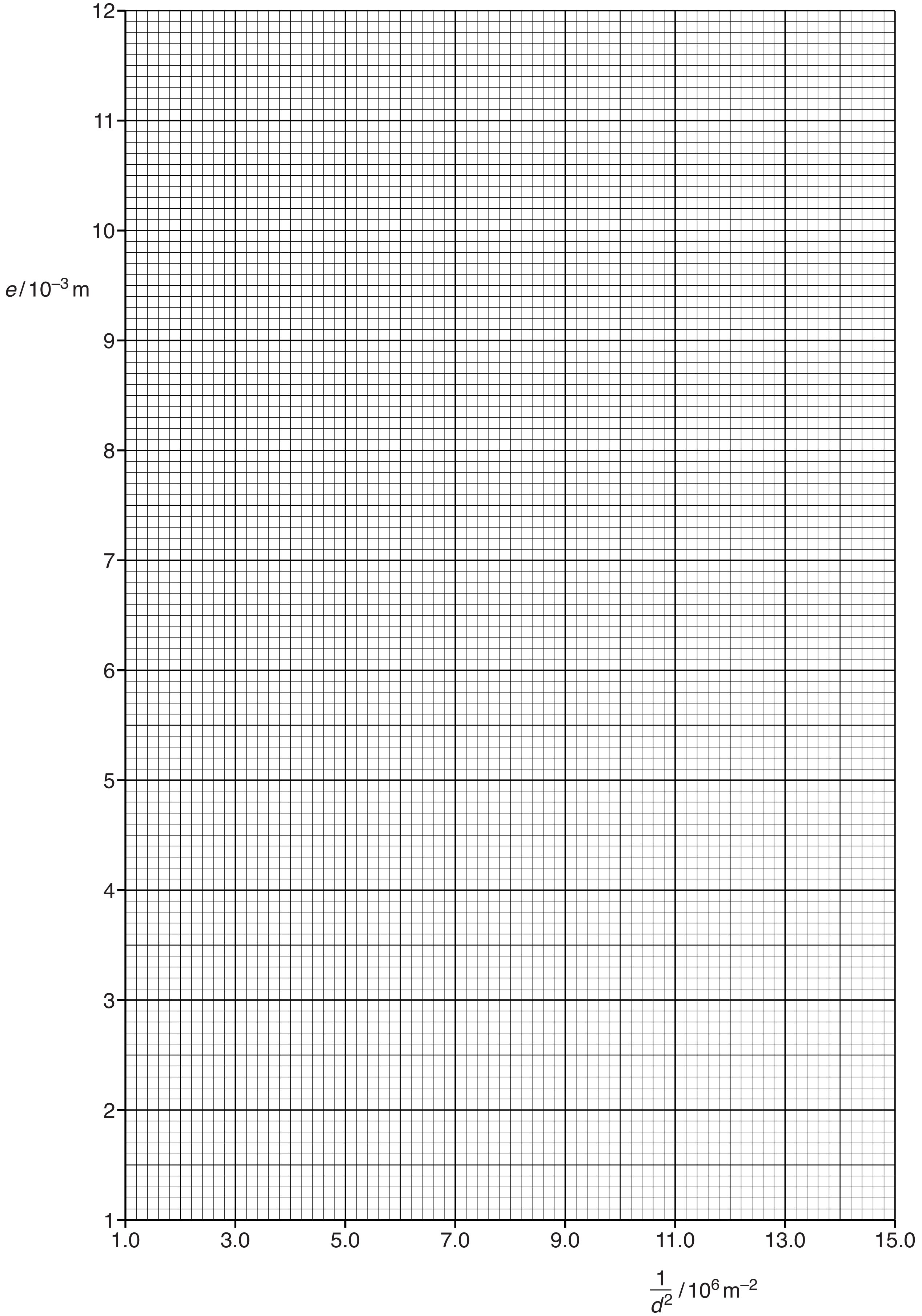
(c) **(i)** Plot a graph of e / 10^{-3} m against $\frac{1}{d^2}$ / 10^6 m^{-2}.

Include error bars for $\frac{1}{d^2}$. [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]


12
11
10
e / 10⁻³ m
9
8
7
6
5
4
3
2
1
1.0
3.0
5.0
7.0
9.0
11.0
13.0
15.0
$\frac{1}{d^2}$ / 10⁶ m⁻²

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

Data: $L = 2.50 \pm 0.01\,\text{m}$ and $F = 19.0 \pm 0.5\,\text{N}$.

E = ...[2]

(ii) Determine the percentage uncertainty in *E*.

percentage uncertainty in *E* = ... % [1]

(e) The experiment is repeated with a thinner wire of diameter $0.23 \pm 0.02\,\text{mm}$. The wire is of the same material and initial length.

Determine the extension *e* of the wire when the same load is added to it. Include the absolute uncertainty in your answer.

e = ...m [2]

[Total: 15]