HOOKE'S LAW

1 A student investigated the stretching of a spring by hanging various weights from it and measuring the corresponding extensions. The results are shown below.

weight/N	0	1	2	3	4	5
extension/mm	0	21	40	51	82	103

(a) On Fig. 3.1, plot the points from these results. Do not draw a line through the points yet. [2]

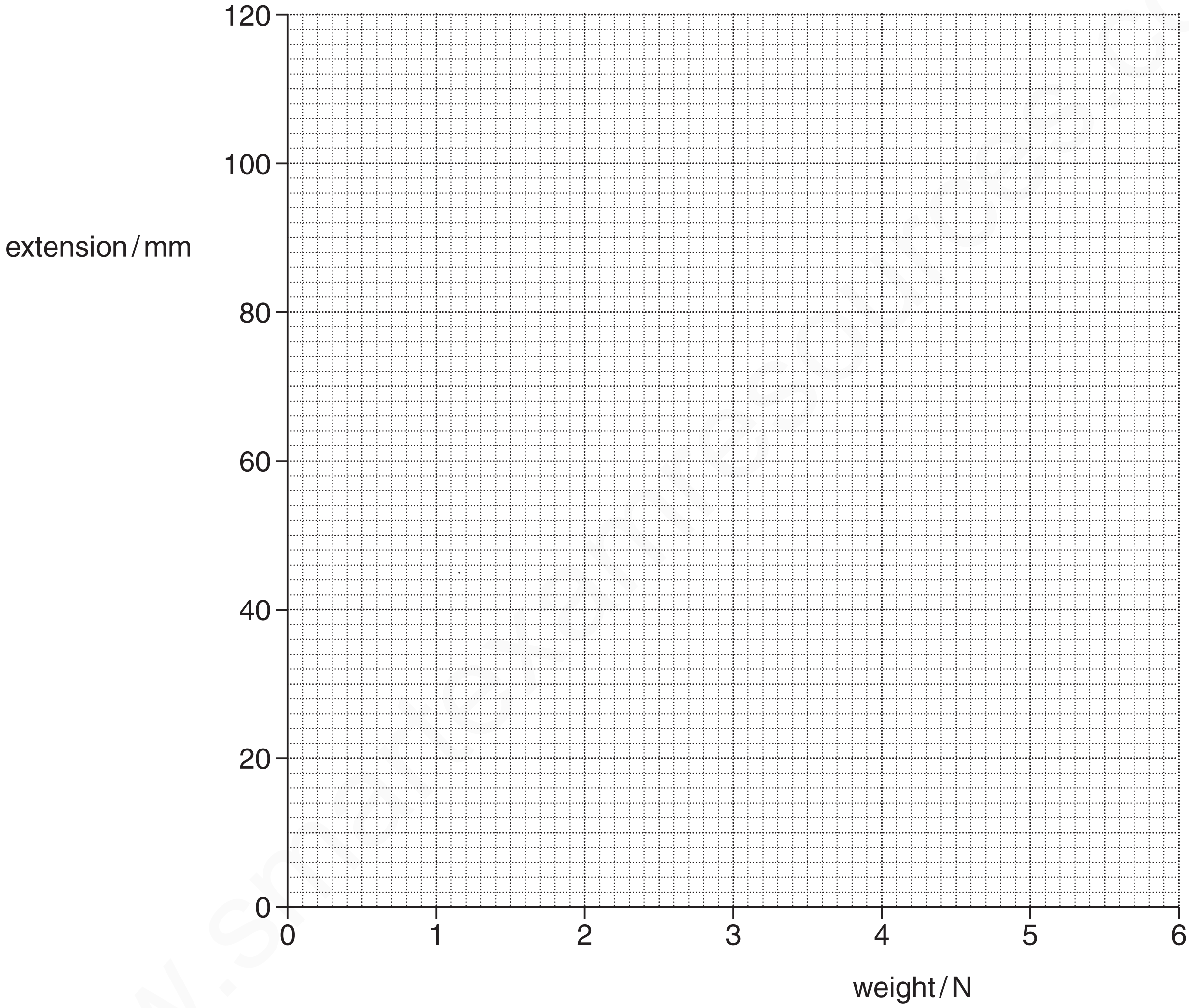

Fig. 3.1

(b) The student appears to have made an error in recording one of the results.

Which result is this?

.... [1]

(c) Ignoring the incorrect result, draw the best straight line through the remaining points. [1]

(d) State and explain whether this spring is obeying Hooke's Law.

....

....

....

....

.... [2]

(e) Describe how the graph might be shaped if the student continued to add several more weights to the spring.

....

....

....

.... [1]

(f) The student estimates that if he hangs a 45 N load on the spring, the extension will be 920 mm.

Explain why this estimate may be unrealistic.

....

....

....

.... [1]

[Total: 8]

MARKING SCHEME:

(a)	5 points correctly plotted ±½ small square –1 e.e.o.o. (ignore 0,0)	B2
(b)	3 N one, however identified OR 3rd value OR 4th value	B1
(c)	good straight line through origin and candidate's remaining points	B1
(d)	straight line / constant gradient does obey Hooke's Law OR special case: obeys Hooke's law because force $\propto$ extension or wtte	M1 A1 B1
(e)	graph becomes non-linear / curves / bends Ignore reference to direction of curve or bend.	B1
(f)	will have exceeded / reached proportional / elastic limit OR permanently deformed or equiv OR staightened OR will have broken OR no longer elastic or wtte	B1

[8]

2 A bucket is full of oil. The total mass of the bucket of oil is 5.4 kg and the gravitational field strength is 10 N/kg.

(a) Calculate the total weight of the bucket of oil.

weight = ... [1]

(b) The bucket of oil is hung from a spring of unstretched length 20 cm. The limit of proportionality of the spring is not exceeded and its length increases to 35 cm.

(i) State what is meant by the *limit of proportionality*.

....

.... [1]

(ii) The oil is poured into a measuring tank. The empty bucket stretches the spring to a length of 25 cm.

Calculate

1. the force that stretches the spring to a length of 25 cm,

force = ... [3]

2. the mass of the oil in the measuring tank.

mass = ... [2]

(iii) The volume of the oil in the measuring tank is 0.0045 m^3. Calculate the density of the oil.

density = ... [2]

(c) Explain, in terms of their molecules, why the density of the oil is greater than that of air.

....

.... [1]

[Total: 10]

MARKING SCHEME:

(a)	54 N *Unit penalty applies		B1	
(b) (i)	(the point where) proportionality between force/weight and extension/Hooke's Law stops		B1	
(ii)	35 – 20 **or** 15 (cm) **or** 25 – 20 **or** 5 (cm)		C1	
	(F =) k*x* **or** 54/15 × 5 **or** 54/15 **or** 5/15	ecf from **2(a)**	C1	
	18 N *Unit penalty applies	ecf from **2(a)**	A1	
	54 – 18 **or** 36 **or** 5.4 – 1.8	ecf from **2(b)(ii)1.**	C1	
	3.6 kg *Unit penalty applies	ecf from **2(b)(ii)1.**	A1	
(iii)	(ρ =)m/V **or** 3.6/0.0045	ecf from **2(b)(ii)2.**	C1	
	800 kg/m^3 *Unit penalty applies	ecf from **2(b)(ii)2.**	A1	
(c)	air molecules further apart **or** oil molecules closer together		B1	**[10]**

*Apply unit penalty once only

3 **(a)** State Hooke's law.

....

.... [1]

(b) Fig. 1.1 shows a graph of the stretching force F acting on a spring against the extension x of the spring.

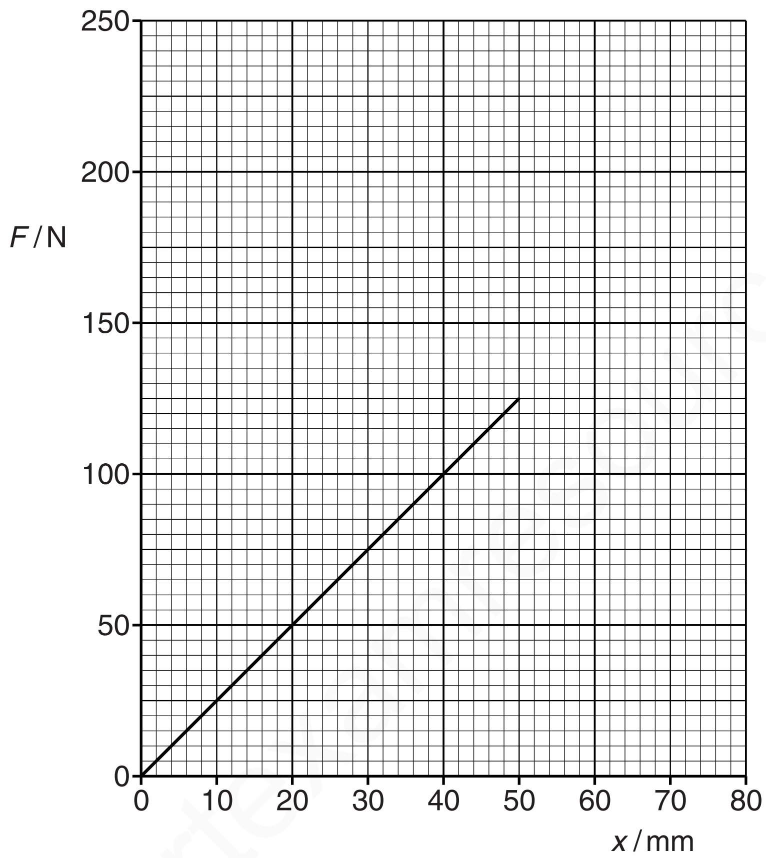

Fig. 1.1

(i) State the features of the graph that show that the spring obeys Hooke's law.

....

.... [1]

(ii) Calculate k, the force per unit extension of the spring.

k = ... [3]

(iii) The limit of proportionality of the spring is reached at an extension of 50 mm.

Continue the graph in Fig. 1.1 to suggest how the spring behaves when the stretching force is increased to values above 125 N. [1]

(iv) Another spring has a smaller value of *k*. This spring obeys Hooke's law for extensions up to 80 mm.

On the grid of Fig. 1.1, draw a possible line of the variation of *F* with *x* for this spring. [1]

[Total: 7]

MARKING SCHEME:

(a)		extension (of spring) proportional to load / force (applied) OR load / force (applied) proportional to extension OR force = constant × extension OR extension = constant × force OR $F = kx$ in any form with symbols explained	B1
(b)	**(i)**	graph is through the origin AND is a straight line / has a constant gradient	B1
	(ii)	$F = kx$ in any form OR $(k =)\ F/x$ use of a point anywhere on graph e.g. 50 / 20 2.5 N / mm OR 2500 N / m	C1 C1 A1
	(iii)	from 50 mm extension, graph curves with no negative gradient	B1
	(iv)	straight line through origin with smaller gradient than graph shown finishing at more than 50 mm	B1

[Total: 7]

4 Fig. 3.1 shows part of the extension-load graph for a spring.

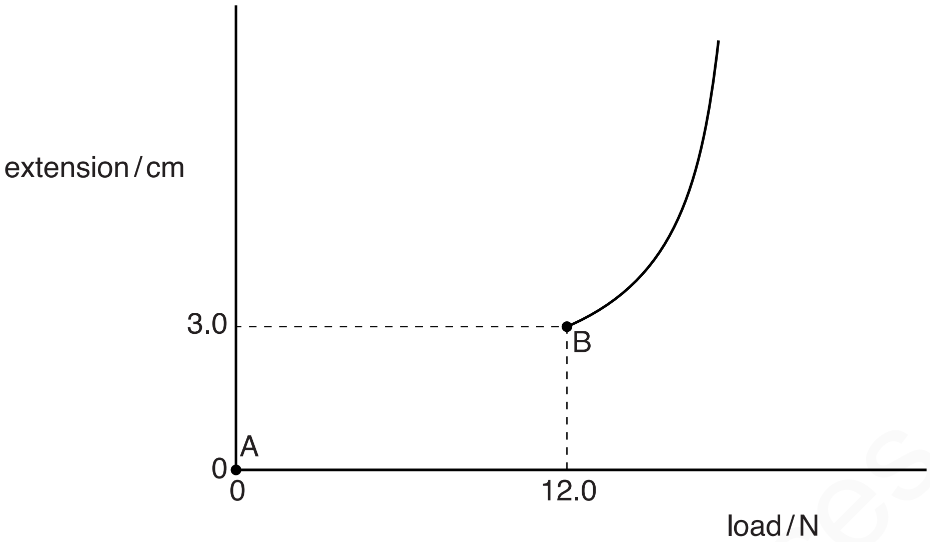

Fig. 3.1

The spring obeys Hooke's law between points A and B.

(a) **(i)** On Fig. 3.1, complete the graph between A and B. [1]

(ii) State the name of point B.

....[1]

(b) The average value of the load between A and B is 6.0 N.

Calculate the work done in extending the spring from A to B.

work done = ...[2]

(c) The spring has an unstretched length of 4.0 cm.

An object is hung on the spring and the spring length increases from 4.0 cm to 6.0 cm.

(i) Calculate the mass of the object.

mass = ...[3]

(ii) The object is immersed in a liquid but remains suspended from the spring.

The liquid exerts an upward force on the object and the length of the spring decreases to 5.0 cm.

Calculate the upward force exerted on the object by the liquid.

upward force = ...[2]

[Total: 9]

MARKING SCHEME:

(a)	**(i)**	straight line between A and B	B1
	(ii)	limit of proportionality	B1
(b)		(WD =) $\frac{1}{2}\ F \times d$ OR $F_{ave} \times d$ OR 6.0×0.030 OR 18 (J)	C1
		0.18 J	A1
(c)	**(i)**	(x =) 2.0 (cm) OR 6.0 – 4.0 OR $F = kx$ OR 4.0 (N / cm)	C1
		$12.0 \times 2.0 / 3.0$ OR 4.0×2.0 OR 8.0 (N)	C1
		0.80 kg OR 800 g	A1
	(ii)	(e =) 1.0 (cm) OR (Δe = –)1.0 (cm)	C1
		4.0 N OR 4.0 N	A1

[Total: 9]