HOOKE'S LAW

1 **(a)** A spring of original length 3.0 cm is extended to a total length of 5.0 cm by a force of 8.0 N.

Assuming the limit of proportionality of the spring has not been reached, calculate the force needed to extend it to a total length of 6.0 cm.

force = ... [3]

(b) Fig. 3.1 shows the arrangement for an experiment on moments.

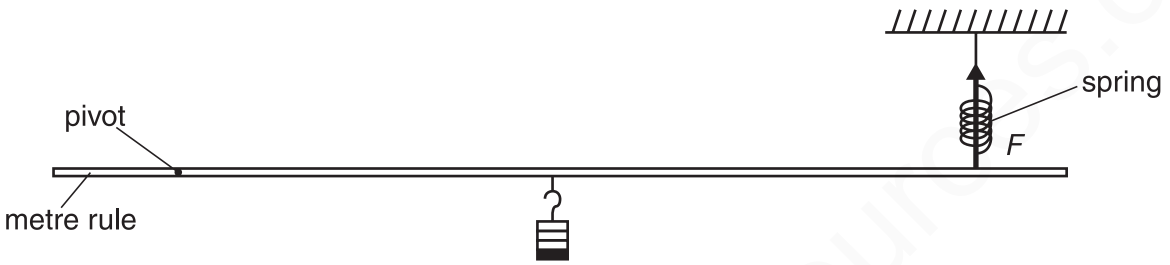

Fig. 3.1

The spring exerts a force *F* on the metre rule.

(i) On Fig. 3.1, mark another quantity which must be measured to find the moment of the force *F*. [1]

(ii) State how the moment of the force *F* is calculated.

....

.... [1]

[Total: 5]

(a)		any logical method e.g. extension is 2 cm for 8 N or 1 cm for 4 N final extension is 3 cm need 12 N to extend to 6 cm	 C1 C1 A1
(b)	**(i)**	shown on diagram: distance from pivot to *F* OR value of weights OR dist from weights to pivot	 B1
	(ii)	force/weight of load × distance from pivot to force (accept symbols if clear)	 B1

[Total: 5]

2 In an experiment, forces are applied to a spring as shown in Fig. 2.1a. The results of this experiment are shown in Fig. 2.1b.

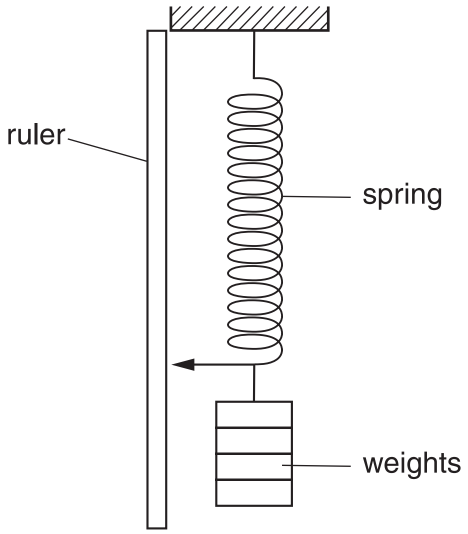

Fig. 2.1a

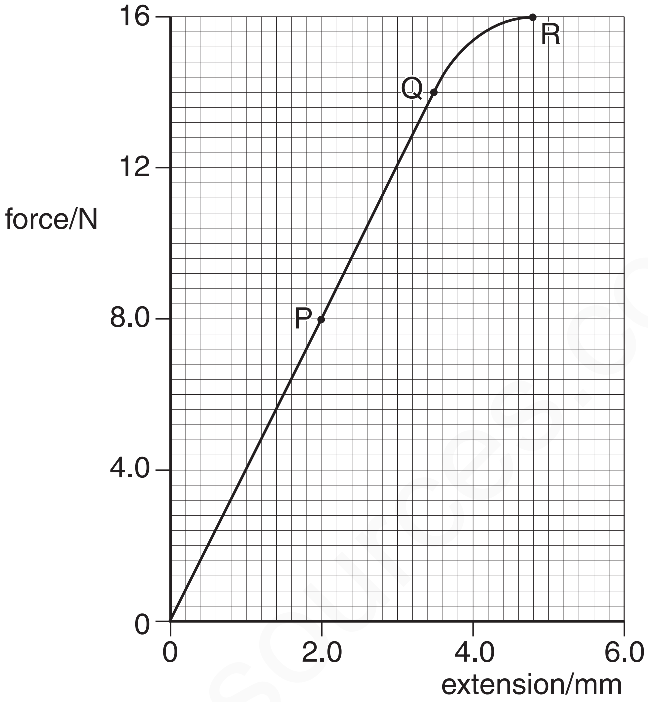

Fig. 2.1b

(a) What is the name given to the point marked Q on Fig. 2.1b?

....[1]

(b) For the part OP of the graph, the spring obeys Hooke's Law.
State what this means.

....

....[1]

(c) The spring is stretched until the force and extension are shown by the point R on the graph. Compare how the spring stretches, as shown by the part of the graph OQ, with that shown by QR.

....

....[1]

(d) The part OP of the graph shows the spring stretching according to the expression

$$F = kx.$$

Use values from the graph to calculate the value of k.

k =..................................[2]

(a)	limit of proportionality (allow elastic limit)	B1	[1]
(b)	force is proportional to extension or in terms of doubling	B1	[1]
(c)	(up to Q extension proportional to force applied) Q to R extension/unit force more however expressed	B1	[1]
(d)	k = force/extension or 8/2 or other correct ratio = 4.0 N/mm	C1 A1	 [2]

[Total: 5]

3 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]

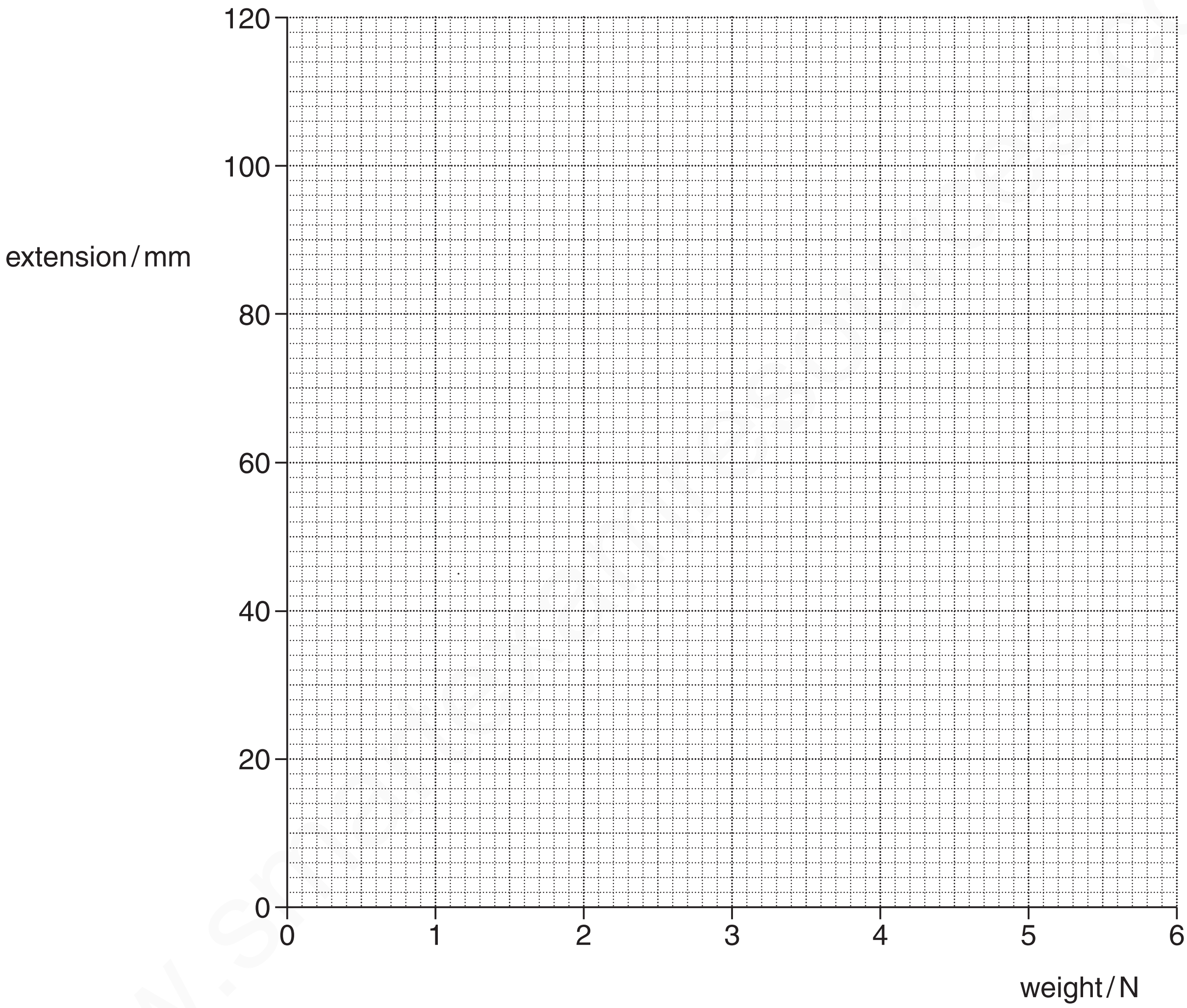

Fig. 3.1

(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]

(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 ∝ 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 straightened OR will have broken OR no longer elastic or wtte	B1

[8]

4 Fig. 1.1 shows apparatus that may be used to compare the strengths of two springs of the same size, but made from different materials.

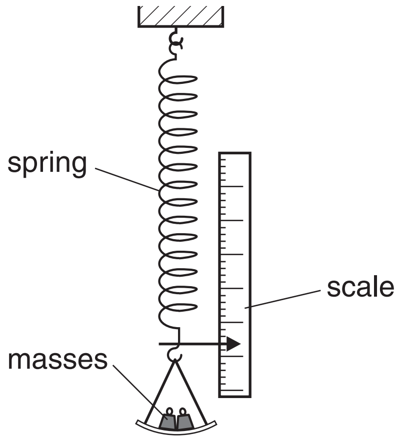

Fig. 1.1

(a) (i) Explain how the masses produce a force to stretch the spring.

....

(ii) Explain why this force, like all forces, is a vector quantity.

....

....
[2]

(b) Fig. 1.2 shows the graphs obtained when the two springs are stretched.

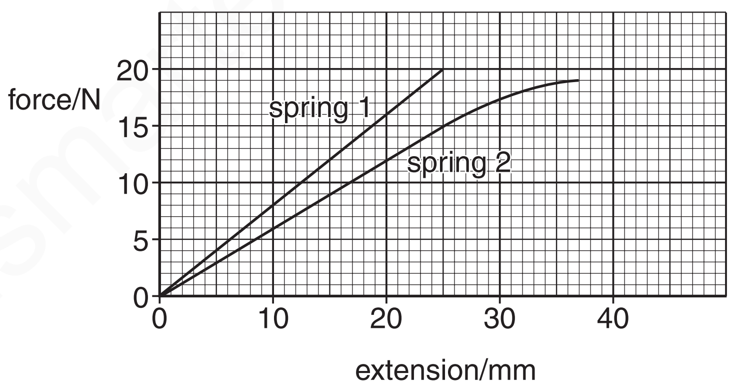

Fig. 1.2

(i) State which spring is more difficult to extend. Quote values from the graphs to support your answer.

....

....

....

....

(ii) On the graph of spring 2, mark a point P at the limit of proportionality. Explain your choice of point P.

....

....

....

(iii) Use the graphs to find the difference in the extensions of the two springs when a force of 15 N is applied to each one.

difference in extensions = ...

[6]

(a)	**(i)**	force of gravity acts on masses/weight of masses	**B1**	
	(ii)	vector has direction/force has direction	**B1**	**2**
(b)	**(i)**	spring 1 (more difficult)	**M1**	
		any correct relevant pair of values	**A1**	
	(ii)	P marked at extension 25 mm to 28 mm	**A1**	
		explanation in terms of end of proportionality	**B1**	
	(iii)	each graph read at 15 N, approx. 25 mm, 19 mm	**C1**	
		difference correct, 6 mm +/- 1 mm	**A1**	**6**
				[8]

5 A large spring is repeatedly stretched by an athlete to increase the strength of his arms. Fig. 3.1 is a table showing the force required to stretch the spring.

extension of spring / m	0.096	0.192	0.288	0.384
force exerted to produce extension / N	250	500	750	1000

Fig. 3.1

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

....

....[1]

(ii) Use the results in Fig. 3.1 to show that the spring obeys Hooke's law.

[1]

(b) Another athlete using a different spring exerts an **average** force of 400 N to enable her to extend the spring by 0.210 m.

(i) Calculate the work done by this athlete in extending the spring once.

work done = ...

(ii) She is able to extend the spring by this amount and to release it 24 times in 60 s. Calculate the power used by this athlete while doing this exercise.

power = ...
[4]

				[7]
(a)	**(i)**	Extension proportional to load however expressed	**B1**	
	(ii)	Any relevant arithmetic to show direct proportion (or straight line graph with values)	**B1**	**2**
(b)	**(i)**	Work done = force x distance / 400 x 0.210	**C1**	
		84.0 J	**A1**	
	(ii)	(total) work/time or (24 x) 84/60 (apply e.c.f from **(i)**)	**C1**	
		33.6 W	**A1**	**4**
				[6]

6 Fig. 2.1 shows the extension-load graph for a spring.

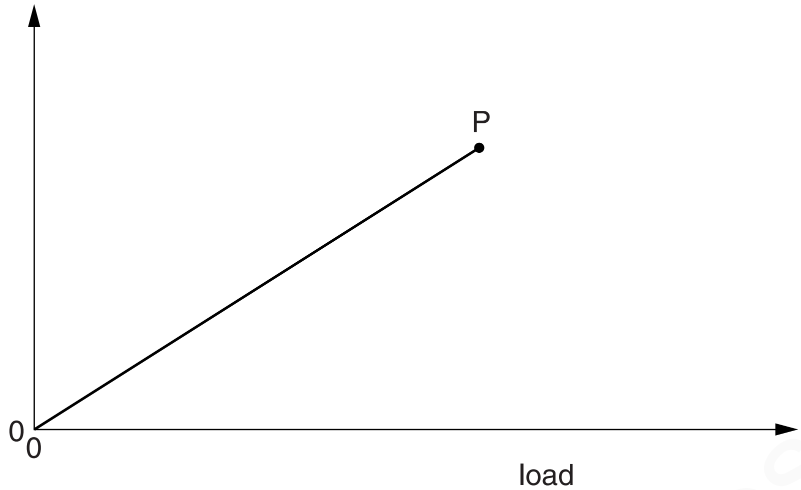

Fig. 2.1

Point P is the limit of proportionality.

(a) **(i)** Name the law obeyed by the spring from the origin to P.

.... [1]

(ii) Describe two features **of the graph** which show that the law is obeyed.

1. ....

2. ....
[2]

(b) On Fig. 2.1, sketch a possible continuation of the graph when the spring is loaded beyond the limit of proportionality. [1]

[Total: 4]

(a) **(i)**	Hooke's Law	B1	[1]
(ii)	straight line (graph) / constant gradient	B1	
	through origin/(0,0)	B1	[2]
	ignore through zero		
	ignore extension proportional to load		
(b)	curved extension to graph with increasing gradient, condone decreasing NOT if any part of curve is vertical/horizontal or has negative gradient	B1	[1]

[Total: 4]

7 Four students, A, B, C and D, each have a spring. They measure the lengths of their springs when the springs are stretched by different loads.

Their results are shown in Fig. 2.1.

	student A	student B	student C	student D
load / N	spring length / cm	spring length / cm	spring length / cm	spring length / cm
0.5	6.7	9.2	9.1	10.0
1.0	7.7	10.0	9.9	11.1
1.5	8.7	10.8	10.7	12.2
2.0	9.7	11.6	11.5	13.3
2.5	10.7	12.6	12.3	14.4
3.0	11.7	13.8	13.1	15.5
3.5	12.7	15.2	13.9	16.6
4.0	13.7	16.8	14.7	17.7

Fig. 2.1

(a) **(i)** State which student had loaded the spring beyond the limit of proportionality.

.... [1]

(ii) Explain how you obtained your answer to **(a)(i)**.

....

....

.... [2]

(b) For the spring used by student A, calculate

(i) the extra extension caused by each additional 0.5 N,

extra extension = ... [1]

(ii) the unloaded length of the spring.

unloaded length = ... [1]

(c) Student A obtains a second spring that is identical to his first spring. He hangs the two springs side by side, as shown in Fig. 2.2.

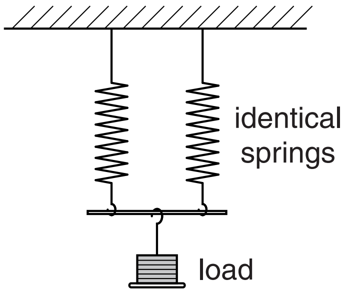

Fig. 2.2

Use the table to calculate the length of each of the springs when a load of 2.5 N is hung as shown in Fig. 2.2. Show your working.

length = ... [2]

[Total: 7]

(a) Mark **(i)** and **(ii)** together. Note both M1s required to score the A1 mark

(i) B — M1

(ii) idea of greater / different (NOT less) increase in length for each additional load accept load not proportional to extension or reverse argument — M1

at 4th or 5th reading / value between 2.0 – 2.5 N / 11.6 – 12.6 cm — A1

(b) **(i)** 1.0 cm — B1

(ii) 5.7 cm — B1

(c) 2.5 (cm) OR 1.25 (N) OR 5.0(cm) ignore 2.5N — e.c.f. from **(b)** if clear — C1
8.2 cm — e.c.f. from **(b)** if clear — A1
e.g. 10.7/2 (= 5.35) scores 0/2 — [7]