

Spring required practical graphs and limits

AQA GCSE Combined Trilogy 8464 / Separate Physics 8463 | Foundation and Higher

Estimated/untrials: 35–40 min independent +15–20 review | 23 parts | 44 marks

Specification points covered

8463 4.5.3 / 8464 6.5.3: forces and elasticity; spring investigation RP6 / RP18 (Physics Paper 2)

8463 4.5.1.3 / 8464 6.5.1.3: mass, weight and gravitational field strength (Physics Paper 2)

8463 4.1.1.2 / 8464 6.1.1.2: elastic potential energy within the proportional range (Paper 1 link)

A parcel-testing workshop calibrates a model tension-spring buffer for a fragile instrument. Loads are added slowly and allowed to settle; these are not drop tests. Choose a repeatable working range from the evidence.

Use $g = 10 \text{ N/kg}$ throughout. $W = mg$; $F = ke$; elastic potential energy = $0.5 k e^2$ within the proportional range. Use extension e in metres for these equations. Unloaded readings exclude the hanger; loaded total masses include it.

1 Checking length and load

The unloaded length is 12.0 cm. With 150 g of slotted masses on a 30 g hanger, the length is 15.6 cm. Use the combined hanging mass, not just the slotted masses.

1(a) Calculate the extension of the loaded spring in cm. **[1 mark]**

1(b) Calculate the total downward force applied by the hanger and slotted masses. **[2 marks]**

1(c) A technician uses only 150 g and labels this load 1.5 N. State the size of the force error and explain its cause. **[2 marks]**

1(d) The stretched spring remains stationary. Explain why the downward pull at its lower end is not the only force needed to stretch it in this test. **[2 marks]**



2 Making the readings valid

Figure 1 shows the bench apparatus. Its ruler has unnumbered ticks: do not measure a numerical reading from this schematic. The pointer is fixed to the lower end of the spring, above the mass hanger.

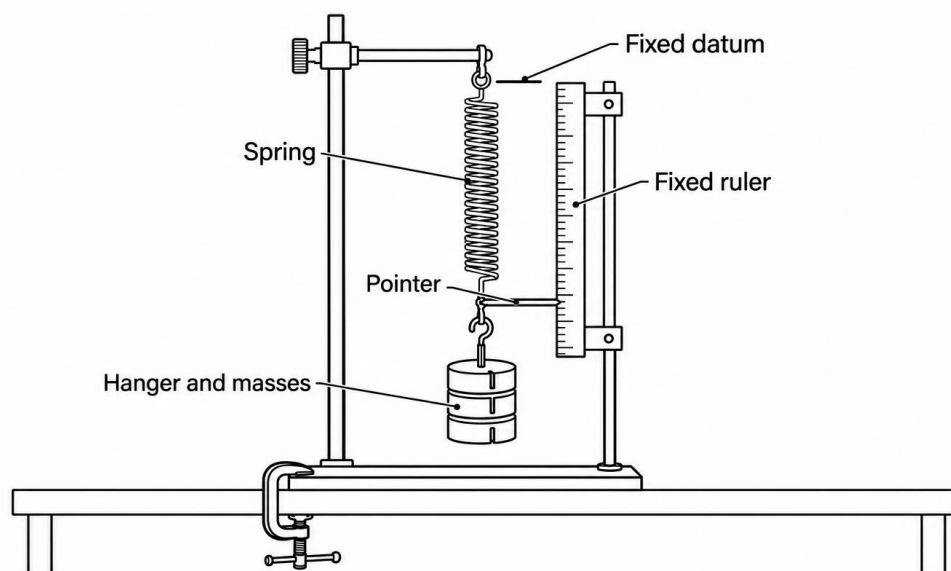


Figure 1

2(a) Describe two actions that improve the pointer reading before it is recorded. **[2 marks]**

2(b) A technician repositions the ruler between the unloaded and loaded readings. Explain why this can spoil the extension calculation and state how to prevent the problem. **[2 marks]**

2(c) Explain one way the G-clamp securing the stand reduces a risk in this investigation. **[1 mark]**



3 Building the calibration graph

Table 1 gives idealised loading data for a fresh spring with unloaded length 12.0 cm. Total mass includes the hanger except at zero load, when it is removed. Use $g = 10 \text{ N/kg}$.

Table 1

Total mass / g	Loaded length / cm	Force / N	Extension / cm
0	12.0		
50	13.0		
100	14.0		
150	15.0		
200	16.0		
250	17.8		
300	20.0		

3(a) Complete the force and extension columns of Table 1. Use the original 12.0 cm length for every extension, not the previous row. **[2 marks]**

3(b) Plot all seven points on Figure 2, estimating 5.8 cm carefully between the ticks. Add light subdivisions if useful. Draw a straight best-fit line for the proportional region only. Leave the two higher-load measurements as unjoined points. **[3 marks]**

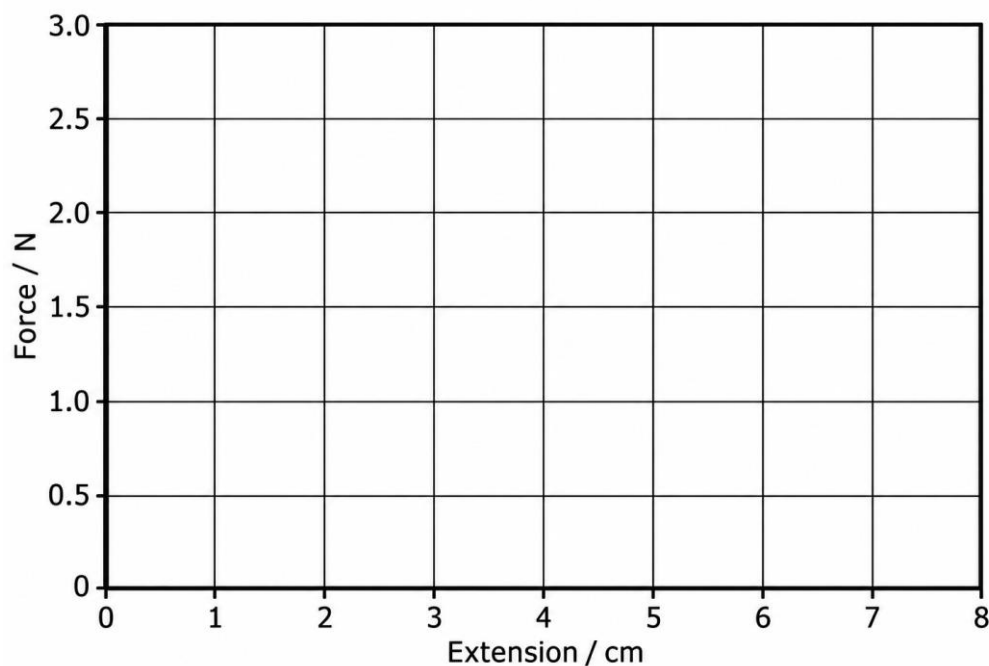


Figure 2

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



3 Building the calibration graph continued

3(c) Which two measured force values do not fit the original straight-line trend in Figure 2? [1 mark]

4 Using only the linear region

Use your completed graph on page 3. Extension is horizontal in cm; force is vertical in N. Keep the linear calibration separate from the non-linear measurements.

4(a) Determine k in N/m from the gradient of the straight part of your graph. Use two widely separated points and show the unit conversion. [2 marks]

4(b) A small test package gives a loaded length of 15.0 cm from the 12.0 cm original length. Calculate its downward force using the linear calibration. [2 marks]

4(c) A technician extends the straight-line calibration to 3.0 N. Show the extension it would predict and use the actual loading data to explain why that prediction is not valid. [2 marks]

4(d) Do the measurements establish that the limit of proportionality is exactly 2.0 N? State what interval the data support. [1 mark]

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk



5 Checking recovery after unloading

Table 2 gives separate trials on fresh identical model springs. Each starts at 12.0 cm and has the loading behaviour in Table 1. All load is removed after reaching the stated peak. The workshop requires both proportional calibration and return to the original length.

Table 2

Trial	Peak force / N	Final unloaded length / cm
A	2.0	12.0
B	2.5	12.0
C	3.0	12.6

5(a) Calculate the permanent extension left after trial C. **[1 mark]**

5(b) Trial B was non-proportional during loading but returned to 12.0 cm. Explain why a curved loading graph alone does not prove permanent deformation. **[2 marks]**

5(c) Choose the largest tested peak load that satisfies both workshop conditions: proportional calibration and return to the original length. Justify the choice using both kinds of evidence. **[2 marks]**

5(d) Within a supervisor's prechecked safe range, suggest two changes that would locate the first departure from proportionality more precisely and test whether it causes permanent deformation. Do not propose very large overloads. **[2 marks]**



6 Using repeats and checking energy

At a total force of 1.5 N, four recorded loaded lengths are 15.0 cm, 15.1 cm, 14.9 cm and 17.5 cm. The unloaded length is 12.0 cm. Use $k = 50 \text{ N/m}$ for the proportional region.

6(a) Before rejecting the 17.5 cm reading as anomalous, what should the technician do? **[1 mark]**

6(b) A check confirms 17.5 cm was a transcription error. Use the three valid readings to find the mean loaded length, then the mean extension in metres. **[2 marks]**

6(c) Calculate the elastic potential energy at the mean extension from (b), using $k = 50 \text{ N/m}$. **[1 mark]**

6(d) At the 8.0 cm extension the technician quotes $0.5 \times 50 \times (0.080)^2 = 0.16 \text{ J}$ as recoverable elastic energy. Give two reasons why the earlier calibration does not justify this answer. **[2 marks]**



