Force and extension of a spring

Answers, marking points and revision notes | AQA Combined Science 8464 and AQA GCSE Physics 8463

GCSE science required practicals

This practical online

Answers

1 Look at Priya's investigation.

a. Name the independent variable.

b. Name the dependent variable.

c. Give one control variable.

(3 marks)

a. The force (weight) hung on the spring.
b. The extension of the spring.
c. Using the same spring every time.

Marking points

- Independent: force or weight on the spring (or mass added)
- Dependent: extension of the spring
- Control: same spring (or same ruler position, same pointer position)

2 Priya taped a pointer to the bottom of the spring and read where it lined up on the ruler. Explain why she kept her eye level with the pointer when she took each reading.

(2 marks)

If she looked from above or below, the pointer would seem to line up with the wrong mark on the scale. Keeping her eye level stops this parallax error, so the length readings are more accurate.

Marking points

- Looking from an angle makes the pointer appear against the wrong mark (parallax)
- Eye level gives more accurate readings of length

3 Give one hazard in this investigation and one way to reduce the risk from it.

(2 marks)

The masses could fall off the hanger onto someone's foot. Priya should keep her feet away from under the masses and put a cushioned tray on the floor beneath them.

Marking points

- Hazard: falling masses, snapping spring or toppling stand
- Matching control: feet clear and tray or cushion underneath, or clamp the stand down, or goggles

4 Show how Priya worked out the extension when the mass on the spring was 200 g.

(2 marks)

Extension = 12.9 - 4.0 = 8.9 cm

extension = new length - original length

extension = 12.9 - 4.0

extension = 8.9 cm

Marking points

- Takes the original length from the new length: 12.9 - 4.0
- 8.9 cm

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5 Calculate the weight of a 250 g mass. Gravitational field strength = 9.8 N/kg. (2 marks)

Weight = 0.250 × 9.8 = 2.45 N

mass = 250 g = 0.250 kg

weight = mass × gravitational field strength

weight = 0.250 × 9.8

weight = 2.45 N

Marking points

- Converts 250 g to 0.250 kg and multiplies by 9.8
- 2.45 N

6 Describe the relationship between the weight and the extension for loads up to 250 g. Use data from the table. (2 marks)

The extension increases by about the same amount, roughly 2.2 cm, for every extra 0.49 N. Doubling the weight from 0.98 N to 1.96 N roughly doubles the extension from 4.4 cm to 8.9 cm, so extension is directly proportional to weight.

Marking points

- Extension is directly proportional to weight (or increases in equal steps)
- Data used to support it, for example doubling 0.98 N to 1.96 N about doubles the extension

7 Priya says the spring went past its limit of proportionality. Use the table to explain how she can tell. (2 marks)

Up to 250 g each extra 50 g stretched the spring by about 2.2 cm. From 250 g to 300 g it stretched 3.0 cm, and from 300 g to 350 g it stretched 3.5 cm. The extension is no longer proportional to the force, so the graph would curve after about 250 g.

Marking points

- After about 250 g the extension increases by more than about 2.2 cm per 50 g (3.0 cm, then 3.5 cm)
- So extension is no longer proportional to force (the graph stops being straight)

8 Use the results for 0 g and 200 g to calculate the spring constant of the spring. Give your answer to 2 significant figures. Show your working. (4 marks)

Change in force = 1.96 N. Change in extension = 8.9 cm = 0.089 m. Spring constant = 1.96 ÷ 0.089 = 22.0..., so about 22 N/m.

force = 1.96 N

extension = 8.9 cm = 0.089 m

force = spring constant × extension, so spring constant = force ÷ extension

spring constant = 1.96 ÷ 0.089

spring constant = 22.02...

spring constant = 22 N/m (2 s.f.)

Marking points

- Force 1.96 N and extension 8.9 cm used
- Extension converted to 0.089 m
- k = 1.96 ÷ 0.089
- 22 N/m (2 significant figures)

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9 The spring constant is 22 N/m. Calculate the extension, in cm, when a force of 1.20 N stretches the spring. Give your answer to 2 significant figures.

(2 marks)

Extension = 1.20 ÷ 22 = 0.0545 m = 5.5 cm

force = spring constant × extension, so extension = force ÷ spring constant

extension = 1.20 ÷ 22

extension = 0.0545... m

extension = 5.5 cm (2 s.f.)

Marking points

- extension = 1.20 ÷ 22 = 0.0545 m
- 5.5 cm

10 **Higher tier**

The spring constant is 22 N/m. Calculate the energy stored in the spring when the extension is 8.9 cm. Give your answer to 2 significant figures.

elastic potential energy = 0.5 × spring constant × (extension)^2

Show your working.

(3 marks)

Extension = 0.089 m. Energy = 0.5 × 22 × 0.089^2 = 0.0871 J, so about 0.087 J.

extension = 8.9 cm = 0.089 m

elastic potential energy = 0.5 × 22 × 0.089^2

elastic potential energy = 0.5 × 22 × 0.007921

elastic potential energy = 0.0871... J

elastic potential energy = 0.087 J (2 s.f.)

Marking points

- Extension converted to 0.089 m
- 0.5 × 22 × 0.089^2 (squaring the extension)
- 0.087 J

11 **Higher tier**

After the 350 g load was removed, the pointer read 4.6 cm instead of 4.0 cm. Explain what this shows about the spring.

(2 marks)

The spring did not go back to its original length, so it has been permanently stretched. It was deformed inelastically because it was loaded beyond its elastic limit.

Marking points

- The spring has not returned to its original shape (it is permanently stretched by 0.6 cm)
- It was stretched past its elastic limit, so the deformation was inelastic

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12 The metre ruler has a resolution of 1 mm. Suggest one improvement to how the length is read, and explain why it helps.

(2 marks)

Use a set square resting on the ruler, lined up with the bottom of the pointer. This makes sure the reading is taken straight across from the pointer, so each reading is more accurate and the readings are more consistent.

Marking points

- A specific improvement, such as a set square from the pointer to the scale, or a ruler with a fixed pointer close to the scale
- Reason: reduces parallax or reading error so readings are more accurate or precise

13 Priya's friend Callum hung a different spring of the same type in the same way and got very similar extensions. Is this repeatable or reproducible? Explain your answer.

(2 marks)

Reproducible. A different person with different equipment got similar results, which is what reproducible means. Repeatable would mean Priya getting similar results when she does it again herself.

Marking points

- Reproducible
- Because a different person (with different equipment) got similar results

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14 A pupil wants to find out whether two identical springs hung side by side (both holding the same hanger) are stiffer than one spring on its own. Describe a method the pupil could use. Include how they would use the results to compare the two arrangements.

(6 marks)

Hang one spring from a clamp on a stand that is clamped to the bench. Fix a metre ruler upright next to it and tape a pointer to the bottom. Read the pointer at eye level with no load to get the original length. Add 50 g masses one at a time, up to about 300 g, reading the pointer each time after the spring has stopped moving. Work out each weight using W = mg with g = 9.8 N/kg and each extension as new length minus original length. Next, hang two identical springs side by side from the same clamp, joined at the bottom by a short bar holding the hanger and pointer. Repeat the same readings with the same masses. Repeat each set of readings and find a mean extension. Plot force against extension for both arrangements on the same axes. The gradient of each straight line is the spring constant, so the steeper line is the stiffer arrangement. Two springs side by side should give about double the spring constant. Wear goggles and keep feet away from below the masses.

Marking points (any 6, with the method in a logical order)

- Clamp the spring and an upright ruler with a pointer, stand clamped to the bench
- Record the original length with no load
- Add masses in equal steps and read the new length each time, eye level with the pointer
- Calculate weight with W = mg and extension = new length - original length
- Repeat with two springs side by side using the same masses and the same pointer method
- Repeat readings and work out means
- Plot force against extension for both and compare gradients (spring constant = gradient) or calculate force ÷ extension
- Stay below the limit of proportionality, for example by using small loads
- A safety step, such as goggles or keeping feet clear

How it is marked

- 5-6 marks: a clear, logical method that would work, covering measuring original length, loading in steps, calculating extension and comparing spring constants of the two arrangements with a fair test
- 3-4 marks: a workable method for measuring extensions with some detail, but the comparison or the calculation of spring constant is missing or vague
- 1-2 marks: a few relevant steps, such as adding masses and measuring the spring, without a clear order or a way to compare

Revision notes: the method

Aim: To find out how the extension of a spring depends on the force stretching it, and to use the results to find the spring constant.

Equipment

- Spring with a loop at each end
- Clamp stand, two bosses and two clamps
- Metre ruler held upright in a clamp
- Slotted mass hanger and 50 g slotted masses
- Pointer (a strip of card or a splint taped to the bottom of the spring)
- Set square
- Heavy weight or G-clamp to hold the stand to the bench
- Safety goggles

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Method

1. Clamp the stand firmly to the bench and hang the spring from a clamp near the top.
2. Clamp the metre ruler upright beside the spring so its scale is next to the pointer.
3. Fix the pointer to the bottom of the spring so it sticks out horizontally over the ruler scale.
4. Read the position of the pointer with your eye level with it. This is the original length reading with no load.
5. Hang the empty mass hanger (or the first 50 g) on the spring, wait for it to stop moving, then read the pointer again.
6. Add masses 50 g at a time, reading the pointer each time once the spring is still.
7. Work out the weight of each load using weight = mass × gravitational field strength, with the mass in kilograms.
8. Work out each extension by taking the original length away from the new length.
9. Remove the masses one at a time and check the spring goes back to its original length.
10. Plot a graph of weight (force) on the y-axis against extension on the x-axis and draw a line of best fit.

Variables

- **Independent:** The force on the spring (the weight of the masses hung on it)
- **Dependent:** The extension of the spring, found by measuring the new length on the ruler and subtracting the original length
- **Control:** The same spring is used throughout, because a different spring could have a different stiffness; The ruler stays in the same position so every reading is taken from the same zero; The pointer stays fixed in the same place on the spring

Hazards

Hazard	What could happen	How to reduce the risk
Masses falling off the hanger or the spring snapping	Heavy masses could land on feet and cause bruising or a broken toe	Stand while working, keep feet away from under the masses and put a tray or cushion on the floor below
The clamp stand toppling over when loaded	The stand and masses could fall onto someone	Clamp or weigh down the base of the stand so it cannot tip
A stretched spring flicking back	The spring or a mass could hit someone in the eye	Wear safety goggles and do not overstretch the spring

Key points

- Extension is the increase in length: new length minus original length, never the length itself
- Change mass in grams to kilograms before working out weight (W = mg, g = 9.8 N/kg)
- Change extension in cm to metres before using F = ke, or the spring constant is 100 times too small
- The spring constant is the gradient of a force against extension graph (or force ÷ extension on the straight part)
- Force and extension are directly proportional only up to the limit of proportionality, where the graph stops being a straight line through the origin
- Read the pointer with your eye level with it to avoid parallax error

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