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WORKSHEETS
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Hooke’s law and elastic energy worksheet

AQA AS 7407 and first-year A Level 7408 | OCR A AS H156 and A Level H556

35–40 minutes independent practice + 15–20 minutes review | 40 marks

Specification points covered

- AQA 7407 / 7408: 3.4.2.1 selected Hooke’s law, deformation graphs and elastic energy; 3.4.1.8 selected kinetic and gravitational transfers.
- OCR A H156 / H556: 3.4.1(a)–(d)(ii), 3.4.2(a)–(b); 3.3.2(a)–(b) selected energy calculations. No SHM equations are required.

The Asteria mirror support tests

Model the stated cartridges and stages as having negligible moving mass. Guides carry no vertical load. Use blank space for calculations and ruled lines for explanations.

1. Language and Hooke’s law [4 marks]

The Asteria Observatory uses spring cartridges to protect a segmented telescope mirror.

(a) A loaded cartridge becomes shorter. State the type of deformation. [1 mark]

(b) State Hooke’s law, including the condition for it to apply. [2 marks]

(c) Define the force constant k and state its SI unit. [1 mark]

2. One cartridge under load [2 marks]

During a bench test, a compressive force of 1.50 kN acts on one cartridge of force constant 120 kN m^{-1}. It remains in its linear elastic range.

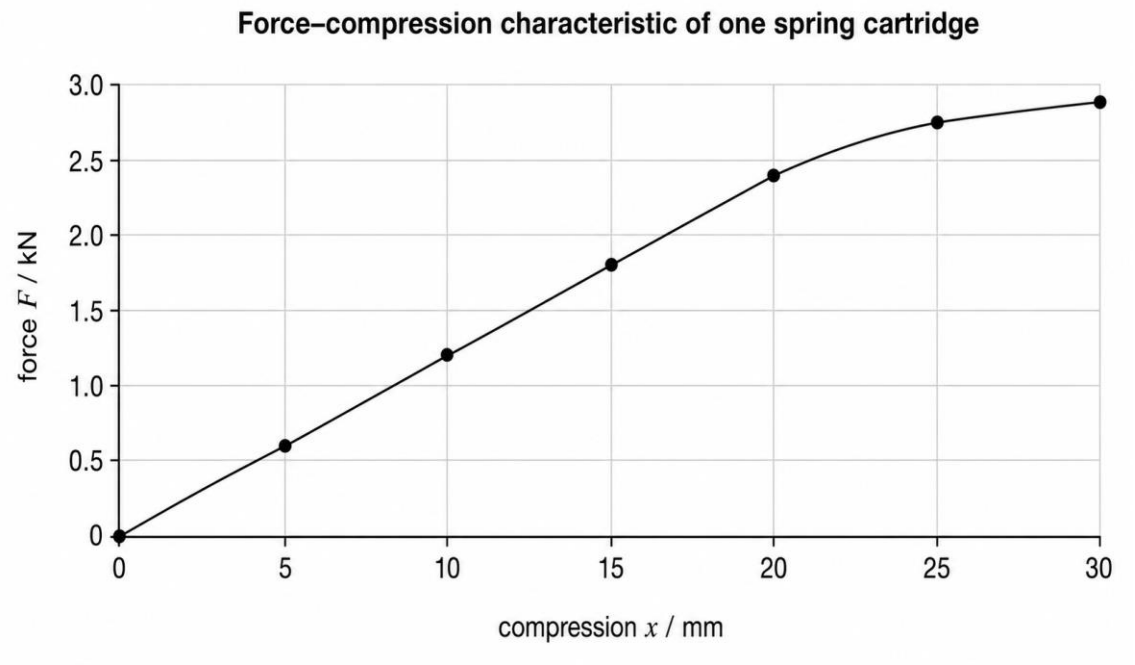
(a) Calculate the compression in mm. [1 mark]

(b) Calculate the elastic energy stored. [1 mark]

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3. Calibrating a cartridge [6 marks]

The force–compression graph describes one cartridge. Use its straight-line region when finding k.



(a) Use two points on the straight-line region to calculate k in N m^{-1}. Show the changes in force and compression. [2 marks]

(b) State the compression and force at the limit of proportionality. [1 mark]

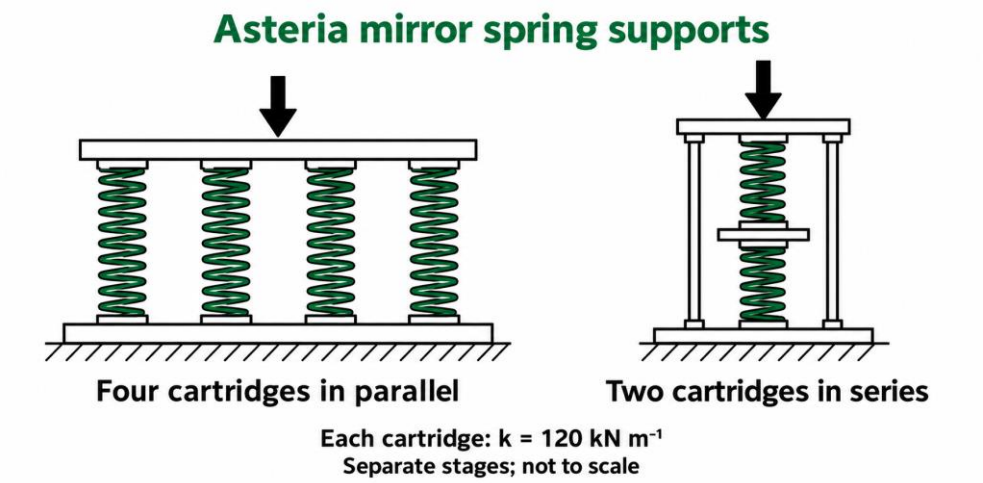
(c) Describe how the graph shows that Hooke's law is no longer obeyed beyond that point. [2 marks]

(d) Calculate the elastic energy stored at a compression of 20.0 mm. [1 mark]

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4. Four supports in parallel [4 marks]

A rigid plate keeps four identical cartridges at the same compression. They share the weight of a 650 kg mirror cradle equally. Each has k = 120 kN m^{-1}. Use g = 9.81 N kg^{-1}.



(a) Calculate the cradle's weight. [1 mark]

(b) Calculate the force carried by each cartridge. [1 mark]

(c) Use F = kx for one cartridge to calculate the common compression in mm. [1 mark]

(d) Use K = total force/common compression to calculate the force constant of the whole stage. [1 mark]

5. Two supports in series [5 marks]

A separate guided stage has two identical cartridges stacked end to end with a negligible-mass spacer. The same 1.80 kN compressive force passes through both. Each has k = 120 kN m^{-1}. The guide carries no vertical load.

(a) State the compressive force acting on each cartridge. [1 mark]

(b) Calculate the compression of each cartridge. [1 mark]

(c) Add the compressions to find the stage's total compression. Decide whether it meets a maximum total compression of 28.0 mm. [2 marks]

(d) Use K = stage force/total compression to calculate the stage's force constant. [1 mark]

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6. Horizontal release test [5 marks]

In a guarded test, one cartridge of k = 120 kN m^{-1} is compressed 12.0 mm against an 18.0 kg calibration sled initially at rest. At separation the cartridge is uncompressed and its moving mass has negligible kinetic energy. During release 2.16 J is dissipated; all remaining released elastic energy becomes sled kinetic energy. After separation it coasts horizontally into a receiver with negligible resistance.

(a) Calculate the initial elastic energy. [1 mark]

(b) Calculate the sled's kinetic energy at separation. [1 mark]

(c) Calculate the sled's speed as it enters the receiver. [2 marks]

(d) The receiver accepts entry speeds no greater than 0.900 m s^{-1}. Decide whether this test meets the limit. [1 mark]

7. Vertical release test [6 marks]

A separate enclosed test uses one cartridge of k = 120 kN m^{-1} compressed 15.0 mm. It releases a total moving mass of 1.50 kg vertically from rest. Heights are measured from the mass's initial centre-of-mass position. It separates when the cartridge is uncompressed. Contact dissipates 1.50 J; there are no subsequent losses. At maximum height the mass is at rest. Use g = 9.81 N kg^{-1}.

(a) Calculate the initial elastic energy. [1 mark]

(b) Determine the maximum height and assess a designer's claim that the mass rises through 0.850 m. [3 marks]

(c) Calculate the mass's speed when it is 0.500 m above its starting position. [2 marks]

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8. Additional compression in transit [3 marks]

A transport fixture uses six cartridges in parallel and has a measured total force constant of 720 kN m^{-1}. During a disturbance its compression increases from 4.00 mm to 12.0 mm, entirely within the linear elastic range.

(a) Calculate the increase in elastic energy stored in the fixture. [2 marks]

(b) State what this increase represents during the additional compression. [1 mark]

9. Checking the spring model [5 marks]

For a classroom-scale test, a low-force training cartridge is mounted vertically between a fixed base and a negligible-mass guided top plate. The guide has negligible friction. A millimetre ruler, balance and small known masses are available. Keep the supported load below 5 N and secure it against falling; this is not the full-scale 120 kN m^{-1} cartridge.

(a) Describe how to obtain reliable force–compression data and determine the force constant and limit of proportionality. [4 marks]

(b) Explain how to check whether permanent deformation has occurred after loading. [1 mark]

Review: identify the deformation, check the linear range and write a complete energy account before choosing equations. A combination's total deformation is not the deformation of each cartridge.

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