Elastic potential energy

Worked solutions

GCSE science calculations

This topic online

1 A spring has a spring constant of 40 N/m. It is stretched so that its extension is 0.15 m.

Calculate the elastic potential energy stored in the spring. (2 marks)

Elastic potential energy = 0.5 x spring constant x (extension)^2

$E_e = 0.5 \times 40 \times 0.15^2$

$E_e = 0.5 \times 40 \times 0.0225$

0.45 J

2 A garage door spring has a spring constant of 200 N/m. When the door is closed the extension of the spring is 0.30 m.

Calculate the elastic potential energy stored in the spring. (2 marks)

Elastic potential energy = 0.5 x spring constant x (extension)^2

$E_e = 0.5 \times 200 \times 0.30^2$

$E_e = 0.5 \times 200 \times 0.09$

9.0 J

3 At the bottom of a bungee jump, the rope has an extension of 16 m. The spring constant of the rope is 150 N/m.

Calculate the elastic potential energy stored in the rope. (2 marks)

Elastic potential energy = 0.5 x spring constant x (extension)^2

$E_e = 0.5 \times 150 \times 16^2$

$E_e = 0.5 \times 150 \times 256$

19 200 J

4 In a Year 10 practical, Zara stretches a spring with a spring constant of 60 N/m. The extension of the spring is 8.0 cm.

Calculate the elastic potential energy stored in the spring. (3 marks)

Elastic potential energy = 0.5 x spring constant x (extension)^2

8.0 cm = 8.0 ÷ 100 = 0.080 m

$E_e = 0.5 \times 60 \times 0.080^2$

$E_e = 0.5 \times 60 \times 0.0064$

0.192 J

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5 A spring in a door latch has a spring constant of 1500 N/m. When the latch is pressed, the spring is compressed by 12 mm.

Calculate the elastic potential energy stored in the spring.

(Treat the compression as the extension.)

(3 marks)

Elastic potential energy = 0.5 × spring constant × (extension)²

12 mm = 12 ÷ 1000 = 0.012 m

$E_e = 0.5 \times 1500 \times 0.012^2$

$E_e = 0.5 \times 1500 \times 0.000144$

0.108 J

6 A spring has an unstretched length of 12.0 cm. When a weight is hung on it, its length becomes 18.5 cm. The spring constant is 30 N/m.

Calculate the elastic potential energy stored in the spring.

Give your answer to 2 significant figures.

(3 marks)

Extension = stretched length - original length

e = 18.5 - 12.0 = 6.5 cm

e = 6.5 ÷ 100 = 0.065 m

Elastic potential energy = 0.5 × spring constant × (extension)²

$E_e = 0.5 \times 30 \times 0.065^2$

$E_e = 0.063375$ J

0.063 J

7 A spring stores 2.4 J of elastic potential energy when its extension is 0.20 m.

Calculate the spring constant of the spring.

(3 marks)

Elastic potential energy = 0.5 × spring constant × (extension)²

$2.4 = 0.5 \times k \times 0.20^2$

$2.4 = 0.02 \times k$

Divide both sides by 0.02

$k = 2.4 \div 0.02$

120 N/m

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8 The elastic band of a catapult stores 3.0 J when it is pulled back so that its extension is 15 cm.

Calculate the spring constant of the elastic band.

Give your answer to 2 significant figures.

(3 marks)

Elastic potential energy = 0.5 x spring constant x (extension)^2

15 cm = 15 ÷ 100 = 0.15 m

$3.0 = 0.5 \times k \times 0.15^2$

$3.0 = 0.01125 \times k$

Divide both sides by 0.01125

$k = 3.0 \div 0.01125$

$k = 266.66...$ N/m

270 N/m

9 **Higher tier**

A spring with a spring constant of 50 N/m stores 0.25 J of elastic potential energy.

Calculate the extension of the spring. Show your working.

(3 marks)

Elastic potential energy = 0.5 x spring constant x (extension)^2

$0.25 = 0.5 \times 50 \times e^2$

$0.25 = 25 \times e^2$

Divide both sides by 25

$e^2 = 0.25 \div 25 = 0.01$

Square root both sides

$e = \sqrt{0.01}$

0.10 m

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10 A force of 6.0 N stretches a spring. The spring constant is 80 N/m. The spring does not go past its limit of proportionality.

a. Calculate the extension of the spring.

b. Calculate the elastic potential energy stored in the spring. Show your working. (4 marks)

a)

Force = spring constant x extension

$6.0 = 80 \times e$

Divide both sides by 80

$e = 6.0 \div 80$

0.075 m

b)

Elastic potential energy = 0.5 x spring constant x (extension)^2

$Ee = 0.5 \times 80 \times 0.075^2$

$Ee = 0.5 \times 80 \times 0.005625$

0.225 J

11 Dev pulls back the elastic band of a catapult. The spring constant of the band is 250 N/m and its extension is 12 cm.

a. Calculate the elastic potential energy stored in the band.

b. When the band is released, 70% of this energy is transferred to the kinetic energy store of a pebble. Calculate the kinetic energy of the pebble. Show your working. (4 marks)

a)

Elastic potential energy = 0.5 x spring constant x (extension)^2

$12 \text{ cm} = 12 \div 100 = 0.12 \text{ m}$

$Ee = 0.5 \times 250 \times 0.12^2$

$Ee = 0.5 \times 250 \times 0.0144$

1.8 J

b)

Efficiency = useful output energy ÷ total input energy

$70\% = 0.70$

useful output $= 0.70 \times 1.8$

1.26 J

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12 **Higher tier**

A toy launcher uses a spring with a spring constant of 400 N/m. The spring is compressed by 5.0 cm and then released, firing a ball of mass 0.020 kg.

Assume all of the elastic potential energy is transferred to the kinetic energy store of the ball. Treat the compression as the extension.

Calculate the speed of the ball as it leaves the launcher.

Give your answer to 2 significant figures. Show your working.

(5 marks)

Elastic potential energy = 0.5 x spring constant x (extension)^2

5.0 cm = 5.0 ÷ 100 = 0.050 m

$E_e = 0.5 \times 400 \times 0.050^2$

$E_e = 0.50$ J

All of this becomes kinetic energy

Kinetic energy = 0.5 x mass x (speed)^2

$0.50 = 0.5 \times 0.020 \times v^2$

$0.50 = 0.010 \times v^2$

Divide both sides by 0.010

$v^2 = 50$

Square root both sides

$v = \sqrt{50} = 7.07...$ m/s

7.1 m/s

13 A trampoline is held up by springs. Each spring has a spring constant of 3000 N/m. When Ellie, of mass 35 kg, lands on the trampoline, the length of one spring increases from 16.0 cm to 21.0 cm.

Calculate the elastic potential energy stored in this spring.

(3 marks)

Use the extension, not the length. The 35 kg is not needed

e = 21.0 - 16.0 = 5.0 cm

1 m = 100 cm

e = 5.0 ÷ 100 = 0.050 m

Elastic potential energy = 0.5 x spring constant x (extension)^2

$E_e = 0.5 \times 3000 \times 0.050^2$

$E_e = 0.5 \times 3000 \times 0.0025$

3.75 J

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