

GCSE Physics (9 – 1)

Elastic Potential Energy

Name:

Group:



Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.

For markers use	
Question	Mark
1	/8
2	/6
3	/6
4	/6
5	/12
6	/12
Total	/50
%	
Grade	

Information

- The maximum mark for this paper is 50 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



1. When you pull back a rubber band or squash a spring, the work you do is stored as elastic potential energy. Elastic potential energy is the name we give to the energy transferred to an object when we change its shape. Circle the letter of the correct answer for each for the following questions.

a) Which of the following scenarios best describes an object possessing elastic potential energy?

- A** A ball rolling down a frictionless hill.
- B** A skydiver falling at terminal velocity.
- C** An archer drawing a bowstring back before releasing an arrow.
- D** A heavy box sitting motionless on a high shelf.

(1 mark)

b) A student carries out an experiment to investigate how a steel spring stretches when different weights are attached to it. The results are recorded in the table below:

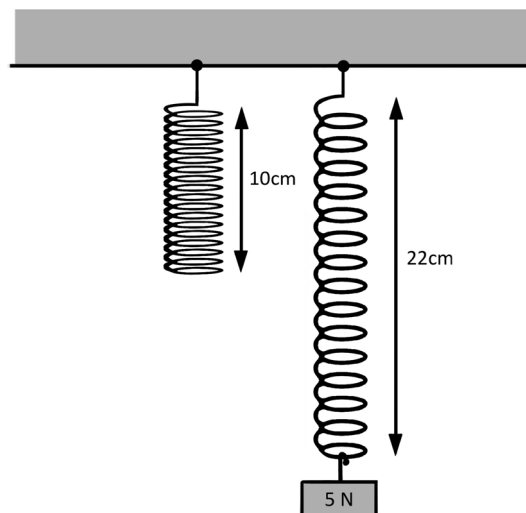
Force (N)	0	2	4	6
Length	20.0	21.5		26.0
Extension	0.0	1.5	3.5	6.0

Which value is missing from the table?

- | | | | |
|----------|----------|----------|----------|
| A | B | C | D |
| 21.5 | 23.5 | 24.0 | 25.0 |

(1 mark)

c) The diagram below shows an unstretched spring and the same spring with a weight attached to it. The unstretched length of the spring is 10 cm.



When a weight of 5.0 N is attached, the length increases to 22 cm. Calculate the elastic potential energy stored in the spring.

- | | | | |
|----------|----------|----------|----------|
| A | B | C | D |
| 0.30 J | 0.50 J | 25 J | 50 J |

(1 mark)

d) The formula for elastic potential energy is $E_e = \frac{1}{2} k \times e^2$

If the distance a spring is compressed (e) is doubled, what happens to the stored elastic potential energy?

A

It remains the same

B

It doubles

C

It quadruples

D

It halves

(1 mark)

e) A spring with a spring constant $k = 200 \text{ N/m}$ is stretched by 0.5 m from its starting position. How much elastic potential energy is stored in the spring?

A

25 J

B

50 J

C

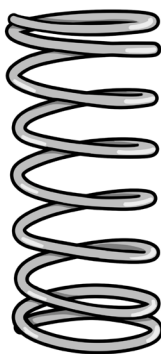
100 J

D

200 J

(1 mark)

f) A toy spring stores 2.0 J of energy when it is compressed by 10 cm . What is the spring constant (k) of this spring?



A

400 N/m

B

40 N/m

C

4000 N/m

D

40000 N/m

(1 mark)

(Total for Question 1 is 6 marks)

2. Calculate the elastic potential energy for each of the following questions.

- a) A spring has a spring constant of 20 N/m. It is extended by 2.0 m.
Calculate the elastic potential energy stored.

Energy = ... J
(2 marks)

- b) A shock absorber has a spring constant of 100 N/m. It is compressed by 0.5 m.
Calculate the elastic potential energy stored.

Energy = ... J
(2 marks)

- c) A bungee cord has a spring constant of 60 N/m. It is stretched by 3.0 m.
Calculate the elastic potential energy stored.

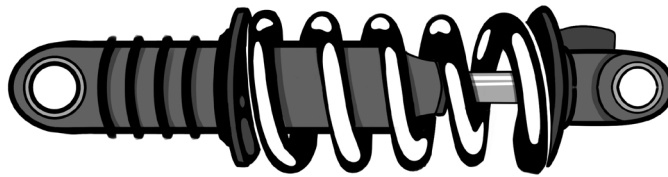
Energy = ... J
(2 marks)

- d) A toy spring has a spring constant of 50 N/m. It is extended by 10 cm.
Calculate the elastic potential energy stored.

Energy = ... J
(2 marks)

(Total for Question 2 is 8 marks)

3. A mountain bike has a suspension spring fitted to the rear wheel to absorb bumps.
The spring has a spring constant of 40 000 N/m.



- a) Write down the equation that links elastic potential energy (E_e), spring constant (k) and extension (e).

.....

(1 mark)

- b) The rider sits on the bike and the spring compresses by 5 cm.
Calculate the elastic potential energy stored in the spring.

Energy = ... J

(3 marks)

- c) Later in the ride, the cyclist hits a large bump and the spring compresses by 10 cm (double the original compression).

Without a full calculation, suggest how the energy stored in the spring now compares to your answer in part (b).

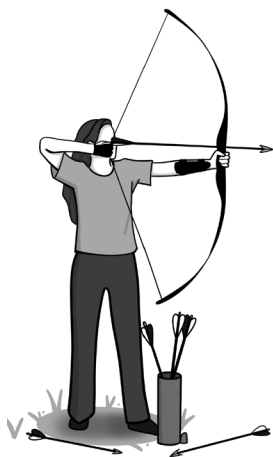
Explain your answer.

.....
.....
.....
.....
.....

(2 marks)

(Total for Question 3 is 6 marks)

4. An archer uses a bow to shoot an arrow.
When the archer pulls the string back, the bow stores elastic potential energy.
The figure below shows an archer drawing their bow.



- a) State the unit used for the spring constant (k).

.....
(1 mark)

- b) The bow has a spring constant of 800 N/m . The archer pulls the string back by 40 cm .
Calculate the elastic potential energy stored in the bow.

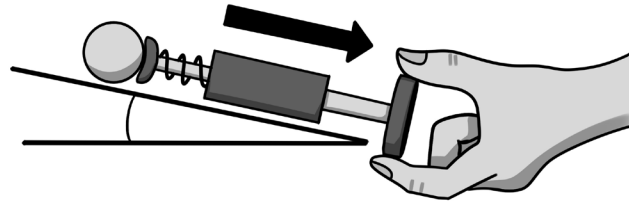
Energy = ... J
(3 marks)

- c) The archer swaps to a different, stiffer bow.
When this new bow is stretched by 0.50 m , it stores 150 J of energy.
Calculate the spring constant (k) of this new bow.

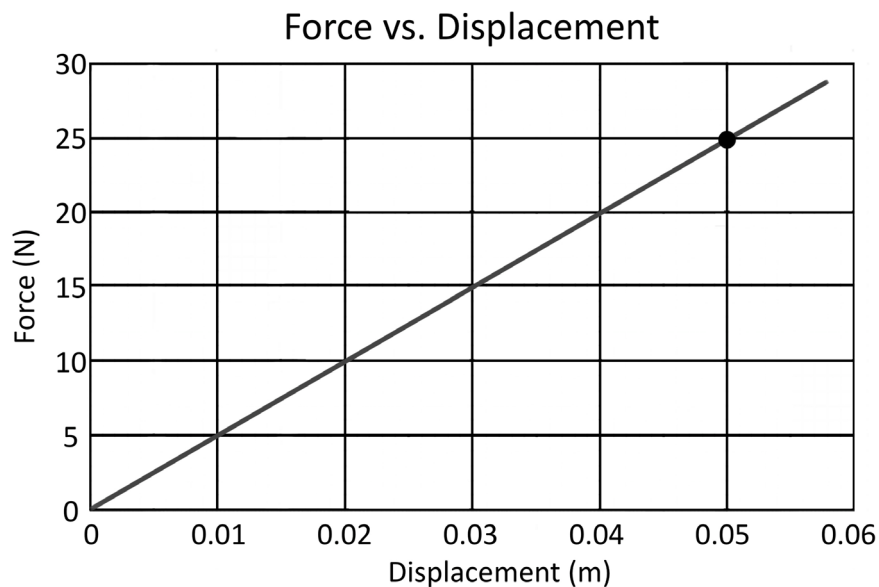
Spring constant = ... N/m
(2 marks)

(Total for Question 4 is 6 marks)

5. A student is investigating the properties of a spring inside a pinball machine launcher. The figure below shows the spring that's used inside a pinball machine to launch a ball.



The student applies different forces to the spring and measures the extension. The results are plotted in the figure below.



- a) Calculate the spring constant (k) of the spring.

Spring constant = ... N/m
(2 marks)

- b) To launch the pinball, the player pulls the plunger back, compressing the spring by 8.0 cm. Calculate the elastic potential energy stored in the spring at this compression.

Energy = ... J
(3 marks)

- c) The pinball has a mass of 50 g. When the spring is released, the ball is fired vertically up a ramp. Assuming there is no friction or air resistance, calculate the maximum vertical height the ball could reach. (Gravitational field strength, $g = 9.8 \text{ N/kg}$)

Maximum height = ... m
(4 marks)

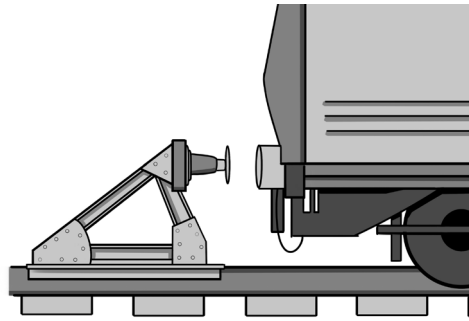
- d) In reality, the ball only reaches a height of 2.8 m.

Calculate the percentage efficiency of the energy transfer from the spring to the gravitational potential store of the ball.

Efficiency = ...%
(2 marks)

(Total for Question 5 is 12 marks)

6. A safety engineer is testing a new spring-loaded "buffer stop" for a miniature railway line. The purpose of the buffer is to stop the train if the brakes fail. The figure below shows the model of the buffer that was used.



The miniature train has a mass of 120 kg. The train is travelling at a speed of 4.0 m/s when it collides with the buffer.

- a) Calculate the kinetic energy of the train just before impact.

Kinetic energy = ... J
(2 marks)

- b) The buffer contains a stiff spring.
Upon impact, the train compresses the spring by 25 cm before coming to a complete stop.

Assuming that 100% of the train's kinetic energy is transferred to the spring's elastic potential store, calculate the spring constant (k) of the spring.

Spring constant = ... N/m
(4 marks)

- c) Calculate the maximum force exerted on the train by the spring at the moment of maximum compression (25 cm).

Force = ... N
(3 marks)

- d) In a second test, the engineer greases the wheels of the train to reduce friction.
The train hits the buffer at the same speed but the spring compresses by 20 cm instead of 25 cm.
Calculate how much energy was lost to friction in the first test (part b).

Energy lost to friction = ... J
(3 marks)

(Total for Question 6 is 12 marks)