Forces and elasticity

Questions

Name: ______________________

Class: ______________________

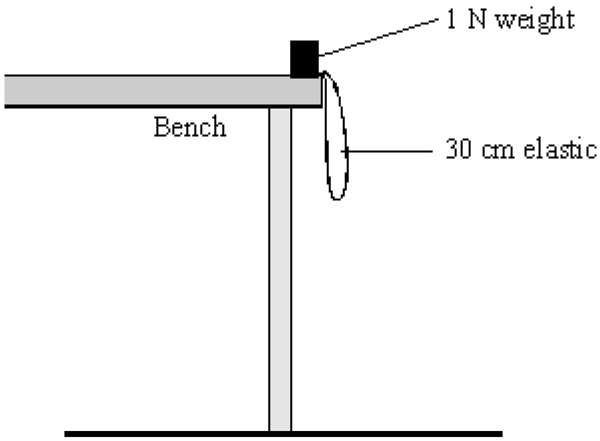
Date: ______________________

Time: **94 minutes**

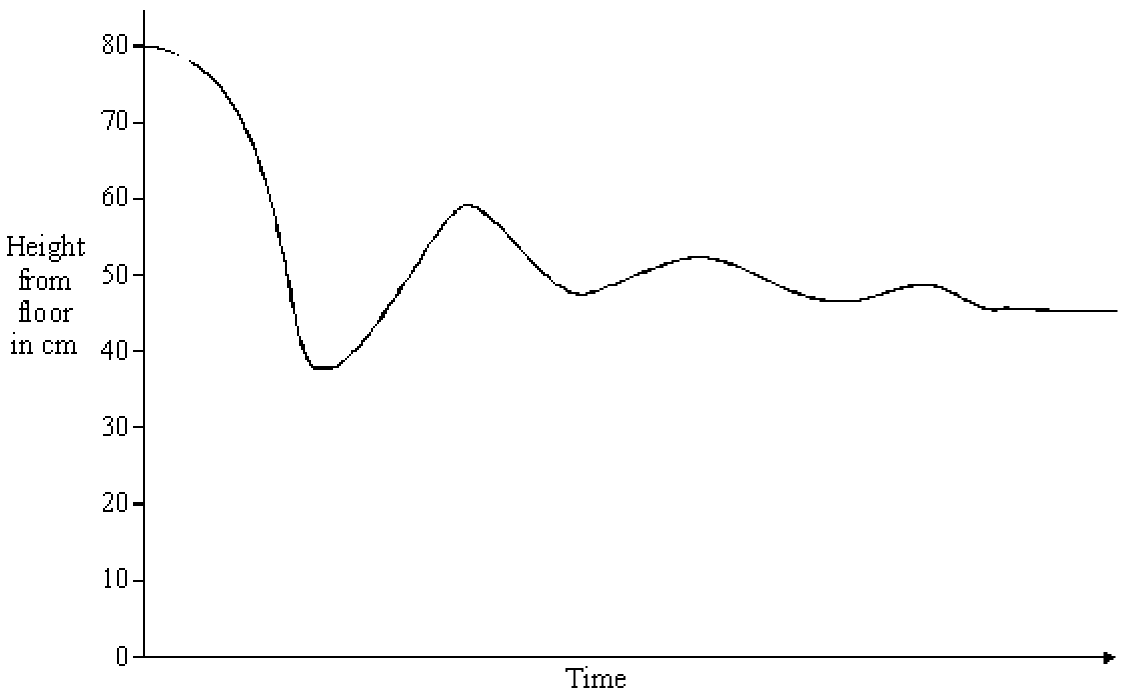
Marks: **90 marks**

Comments:

1 A 1 N weight is tied to a 30 cm long piece of elastic. The other end is fixed to the edge of a laboratory bench. The weight is pushed off the bench and bounces up and down on the elastic.



The graph shows the height of the weight above the floor plotted against time, as it bounces up and down and quickly comes to rest.



(a) Mark on the graph a point labelled **F**, where the weight stops falling freely.

(1)

(b) Mark on the graph a point labelled **S**, where the weight finally comes to rest.

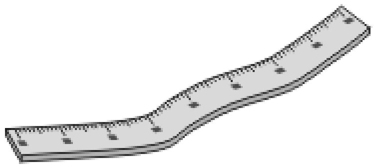
(1)

(c) Mark **two** points on the graph each labelled **M**, where the weight is momentarily stationary.

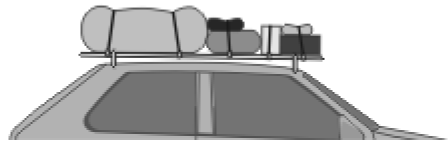
(1)

(Total 3 marks)

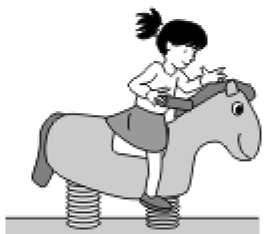
2 (a) The pictures show four objects. Each object has had its shape changed.



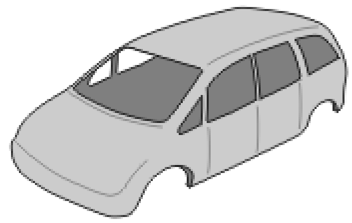
Bent metal ruler
A



Stretched bungee cords
B



Springs on a playground ride
C



Moulded plastic model car body
D

Which of the objects are storing elastic potential energy?

____

Explain the reason for your choice or choices.

____

____

____

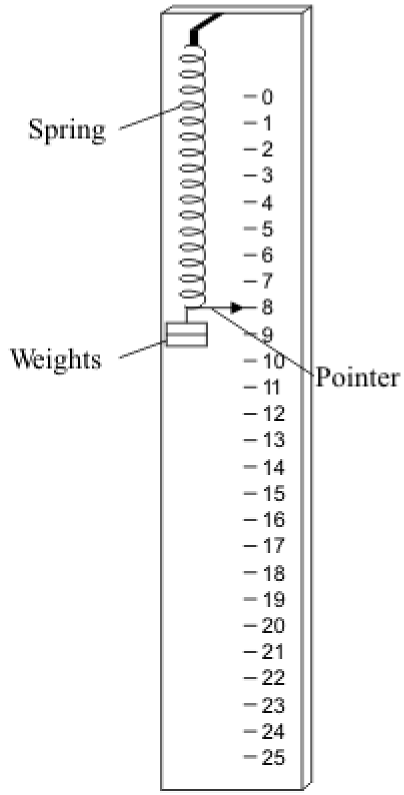
____

____

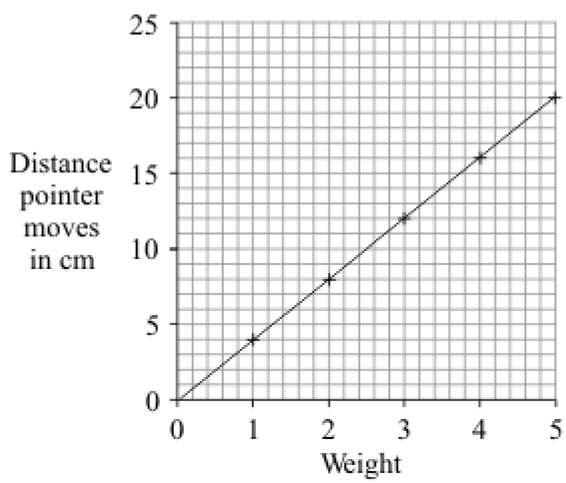
____

(3)

(b) A student makes a simple spring balance. To make a scale, the student uses a range of weights. Each weight is put onto the spring and the position of the pointer marked



The graph below shows how increasing the weight made the pointer move further.



(i) Which **one** of the following is the unit of weight?.

Draw a ring around your answer.

joule **kilogram** **newton** **watt**

(1)

(ii) What range of weights did the student use?

____

(1)

(iii) How far does the pointer move when 4 units of weight are on the spring?

____

(1)

(iv) The student ties a stone to the spring. The spring stretches 10 cm.

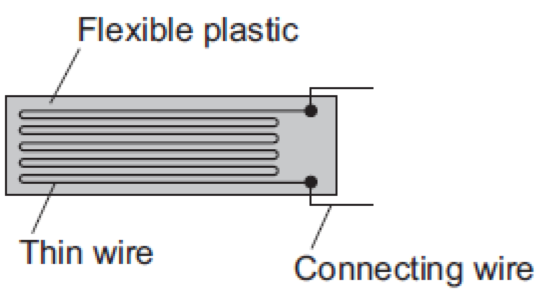
What is the weight of the stone?

____

(1)
(Total 7 marks)

3 The diagram shows a strain gauge, which is an electrical device used to monitor a changing force.

Applying a force to the gauge causes it to stretch.
This makes the electrical resistance of the wire change.



(a) (i) Using the correct symbols, **add** to the diagram to show how a battery, an ammeter and a voltmeter can be used to find the resistance of the strain gauge drawn above.

(2)

(ii) When in use, the strain gauge is always connected to a d.c. power supply, such as a battery.

How is a d.c. (direct current) power supply different from an a.c. (alternating current) power supply?

____

____

____

(1)

(b) Before any force is applied, the unstretched gauge, correctly connected to a 3.0 V battery, has a current of 0.040 A flowing through it.

(i) Calculate the resistance of the unstretched gauge.

Show clearly how you work out your answer.

____

____

Resistance = ________________________________ Ω

(2)

(ii) Stretching the gauge causes the current flowing through the gauge to decrease.

What happens to the resistance of the gauge when it is stretched?

____

____

(1)

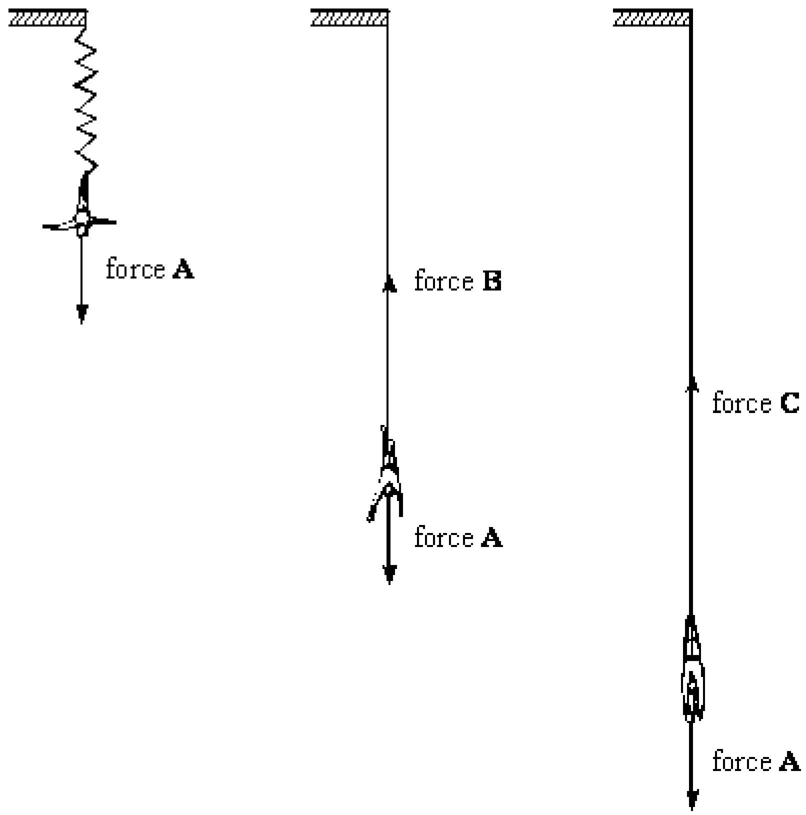
(iii) What form of energy is stored in the gauge when a force is applied and the gauge stretches?

____

(1)

(Total 7 marks)

4 When a bungee-jump is made the jumper steps off a high platform. An elastic cord from the platform is tied to the jumper.
The diagram below shows different stages in a bungee-jump.
Forces **A**, **B** and **C** are forces acting on the jumper at each stage.



moving down large acceleration	moving down small acceleration	moving down slowing acceleration
diagram **X**	diagram **Y**	diagram **Z**

(a) Name force **A**.

____

(1)

(b) The motion of the jumper is shown in the diagrams.
By comparing forces **A**, **B** and **C**, state how the motion is caused in:

(i) diagram **X**;

____

(ii) diagram **Y**;

____

(iii) diagram **Z**.

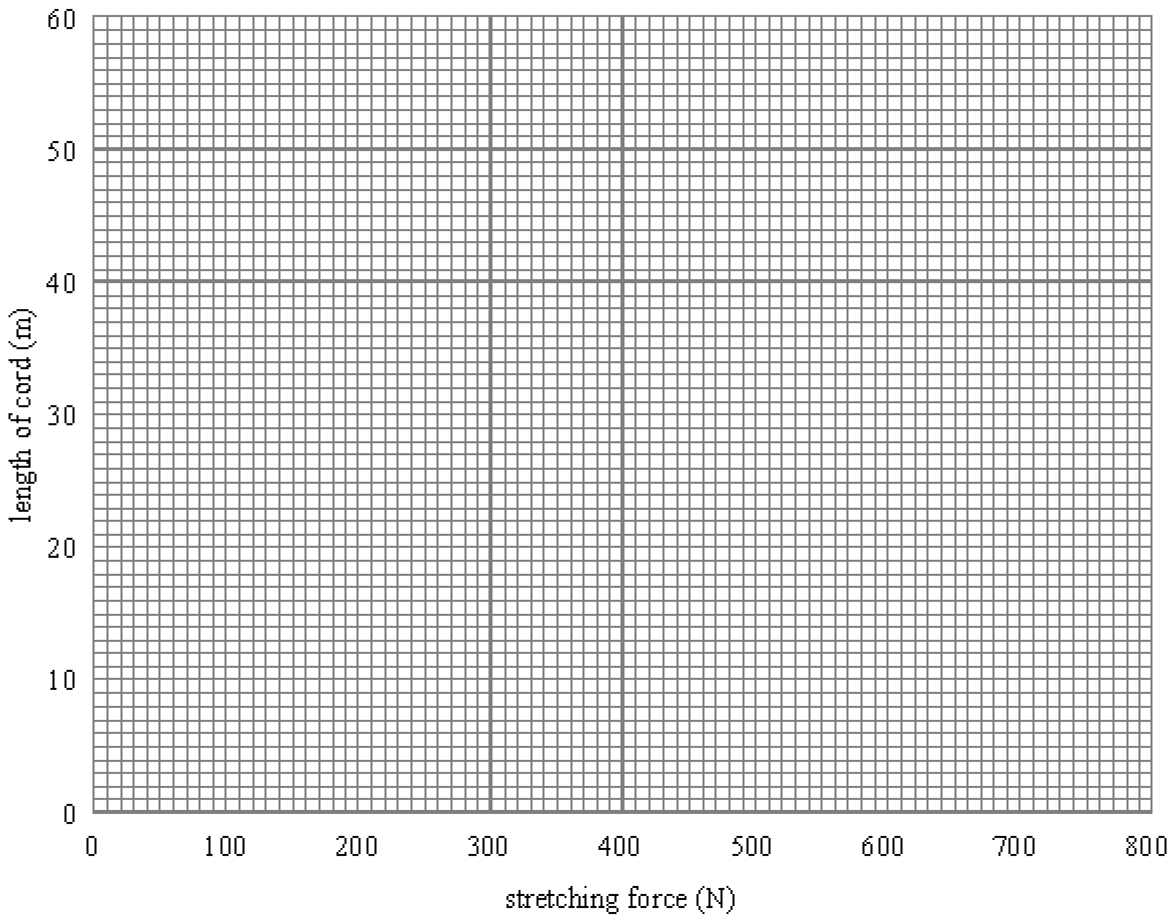
____

(3)

(c) The table gives results for a bungee cord when it is being stretched.

STRETCHING FORCE (N)	100	200	400	600	800
LENGTH OF CORD (m)	20	24	32	40	48

(i) Plot a graph of these results on the graph paper.



(3)

(ii) Use the graph to find the length of the cord before it was stretched.

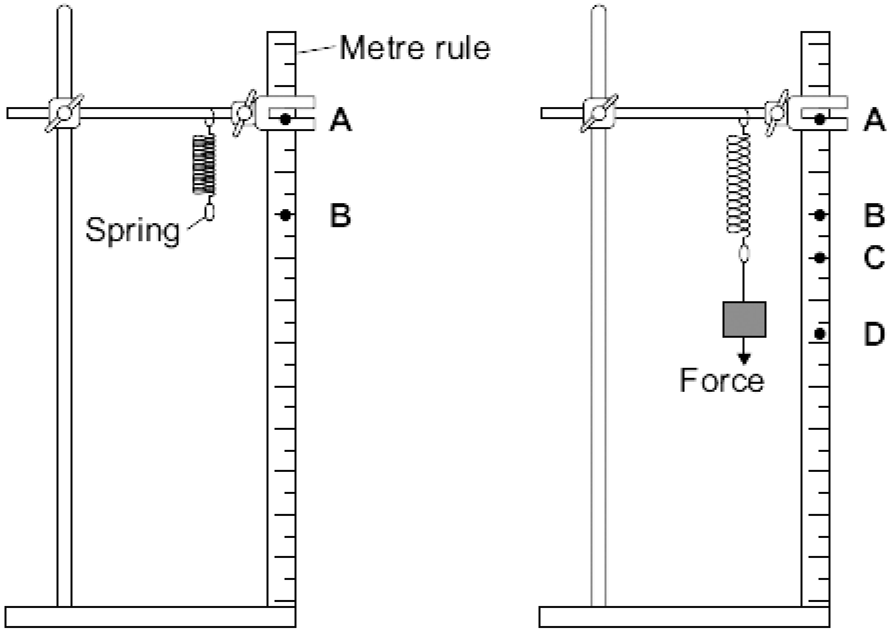
Length ___________ m

(1)

(Total 8 marks)

5 A student investigated how the extension of a spring depends on the force applied to the spring.

The diagram shows the spring before and after a force had been applied.



(a) (i) Complete the following sentence using letters, **A**, **B**, **C** or **D**, from the diagram.

The extension of the spring is the distance between the positions labelled

___________and ___________ on the metre rule.

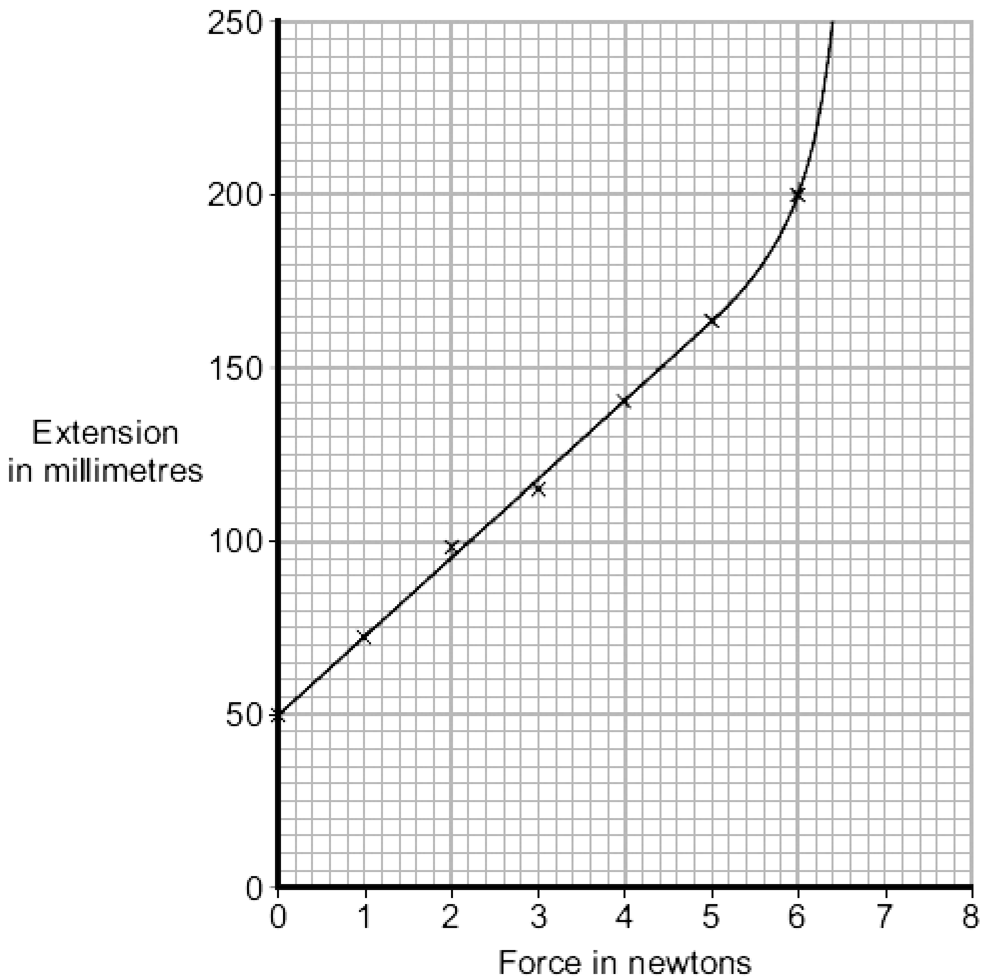
(1)

(ii) What form of energy is stored in the stretched spring?

____

(1)

(b) The results from the investigation are plotted on the following graph.



(i) The graph shows that the student has made an error throughout the investigation.

What error has the student made?

____

____

Give the reason for your answer.

____

____

(2)

(ii) The student has loaded the spring beyond its *limit of proportionality*.

Mark on the graph line the *limit of proportionality* of the spring. Label the point **P**.

Give the reason for choosing your point **P**.

____

____

____

(2)

(c) The student uses a different spring as a spring balance. When the student hangs a stone from this spring, its extension is 72 mm.

The spring does not go past the limit of proportionality.

Calculate the force exerted by the stone on the spring.

spring constant = 25 N/m

Show clearly how you work out your answer.

____

____

Force = ___________________________ N

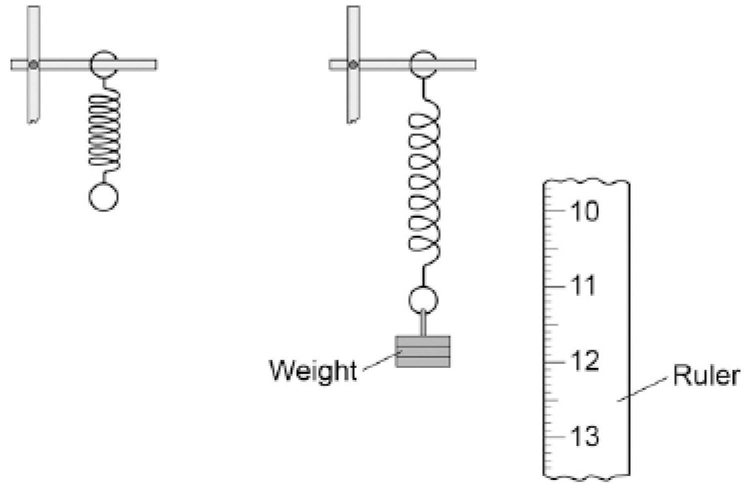
(2)

(Total 8 marks)

6 A student suspended a spring from a laboratory stand and then hung a weight from the spring.

Figure 1 shows the spring before and after the weight is added.

Figure 1



(a) Measure the extension of the spring shown in **Figure 1**.

Extension = ________________________ mm

(1)

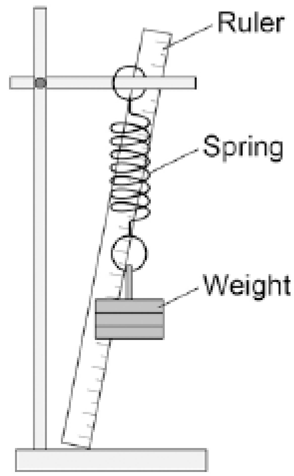
(b) The student used the spring, a set of weights and a ruler to investigate how the extension of the spring depended on the weight hanging from the spring.

Before starting the investigation the student wrote the following prediction:

The extension of the spring will be directly proportional to the weight hanging from the spring.

Figure 2 shows how the student arranged the apparatus.

Figure 2



Before taking any measurements, the student adjusted the ruler to make it vertical.

Explain why adjusting the ruler was important.

____

____

____

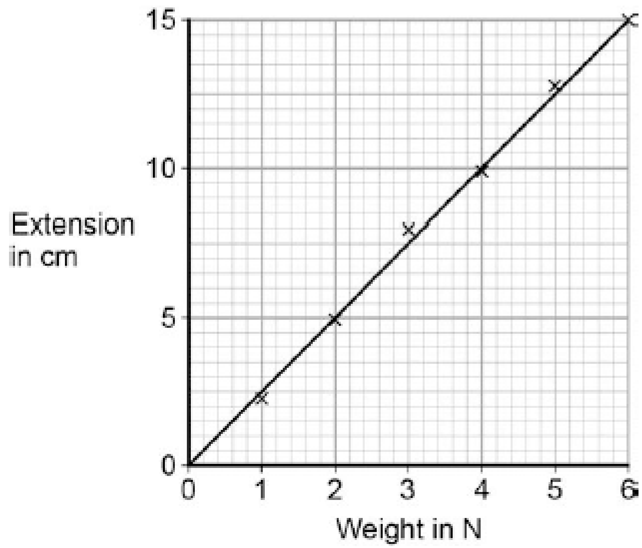
____

(2)

(c) The student measured the extension of the spring using a range of weights.

The student's data is shown plotted as a graph in **Figure 3**.

Figure 3



What range of weight did the student use?

____

(1)

(d) Why does the data plotted in **Figure 3** support the student's prediction?

____

____

(1)

(e) Describe **one** technique that you could have used to improve the accuracy of the measurements taken by the student.

____

____

____

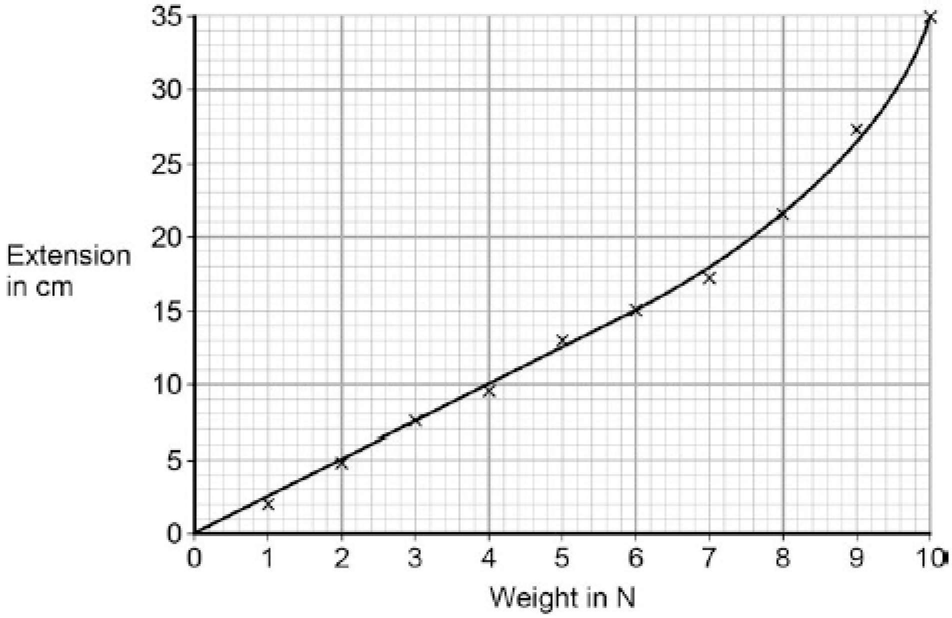
____

(2)

(f) The student continued the investigation by increasing the range of weights added to the spring.

All of the data is shown plotted as a graph in **Figure 4**.

Figure 4



At the end of the investigation, all of the weights were removed from the spring.

What can you conclude from **Figure 4** about the deformation of the spring?

____

____

Give the reason for your conclusion.

____

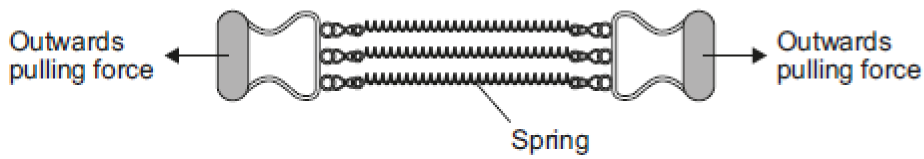
____

(2)

(Total 9 marks)

7 **Figure 1** shows an exercise device called a chest expander. The three springs are identical.

Figure 1



A person pulls outwards on the handles and does work to stretch the springs.

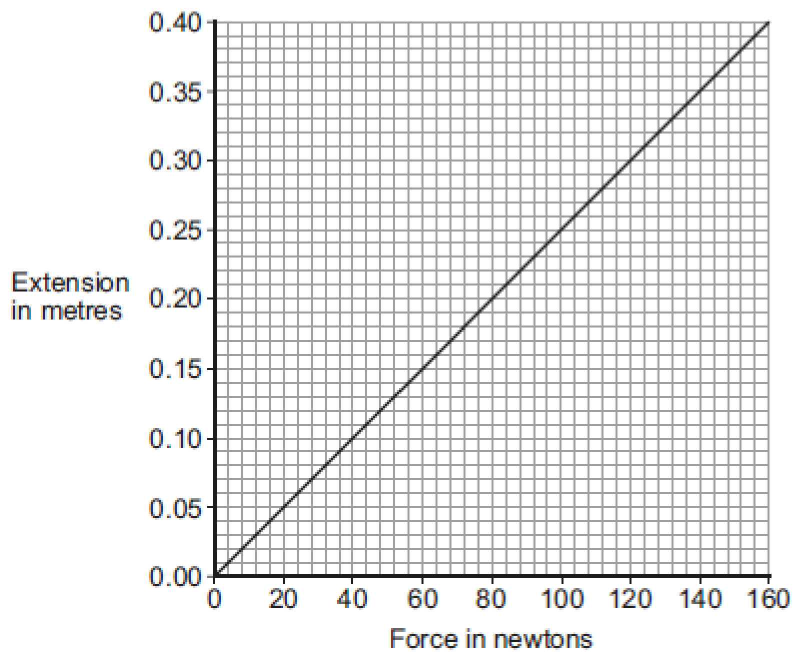
(a) Complete the following sentence.

When the springs are stretched ____________ ____________ energy is stored in the springs.

(1)

(b) **Figure 2** shows how the extension of a single spring from the chest expander depends on the force acting on the spring.

Figure 2



(i) How can you tell, from **Figure 2**, that the limit of proportionality of the spring has not been exceeded?

____

____

(1)

(ii) Use data from **Figure 2** to calculate the spring constant of the spring.
Give the unit.

___

___

___

Spring constant = ___________ Unit ___________

(3)

(iii) Three identical resistors joined in parallel in an electrical circuit share the total current in the circuit.

In a similar way, the three springs in the chest expander share the total force exerted.

By considering this similarity, use **Figure 2** to determine the total force exerted on the chest expander when each spring is stretched by 0.25 m.

___

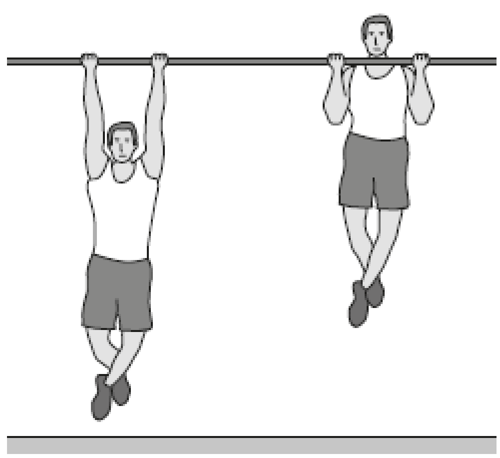
___

Total force = ___________ N

(2)

(c) The student in **Figure 3** is doing an exercise called a chin-up.

Figure 3



Each time the student does one chin-up he lifts his body 0.40 m vertically upwards.
The mass of the student is 65 kg.
The student is able to do 12 chin-ups in 60 seconds.

Calculate the power developed by the student.

Gravitational field strength = 10 N/kg

____

____

____

____

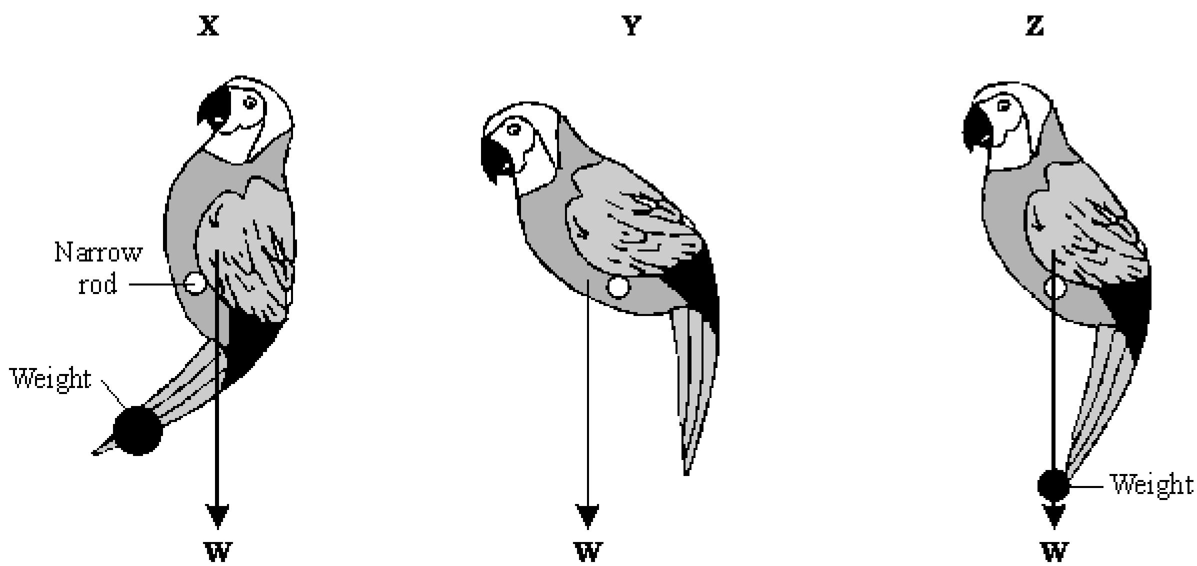
____

Power = ___________ W

(3)

(Total 10 marks)

8 (a) The diagram shows three similar toys. Each toy should be able to balance on a narrow rod. The arrows show the direction in which the weight of the toy acts.



Only one of the toys balances on the rod, the other two fall over. Which **one** of the toys is balanced? Explain the reason for your choice.

____

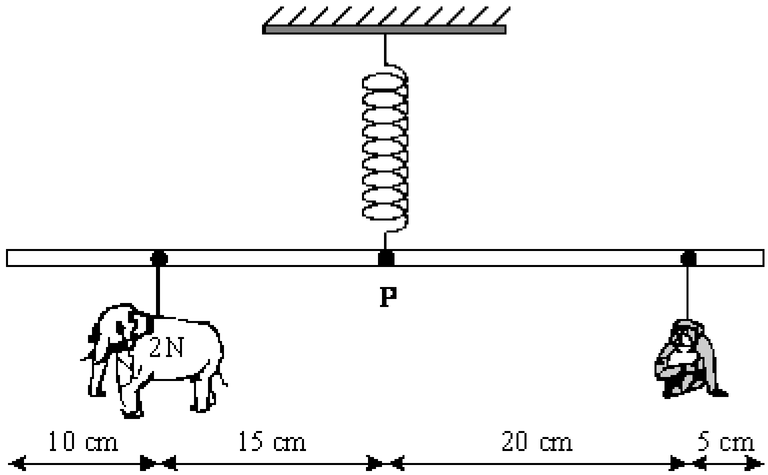
____

____

____

(3)

(b) The diagram shows a simple toy. Different animal shapes can be positioned so that the 50 cm rod balances horizontally.



(i) Calculate the moment exerted by the elephant shape of weight 2N about the pivot **P**. Show clearly how you work out your answer and give the unit.

____

____

Moment = ____________________

(3)

(ii) Use the following relationship to calculate the weight of the monkey shape.

total clockwise moment = total anticlockwise moment

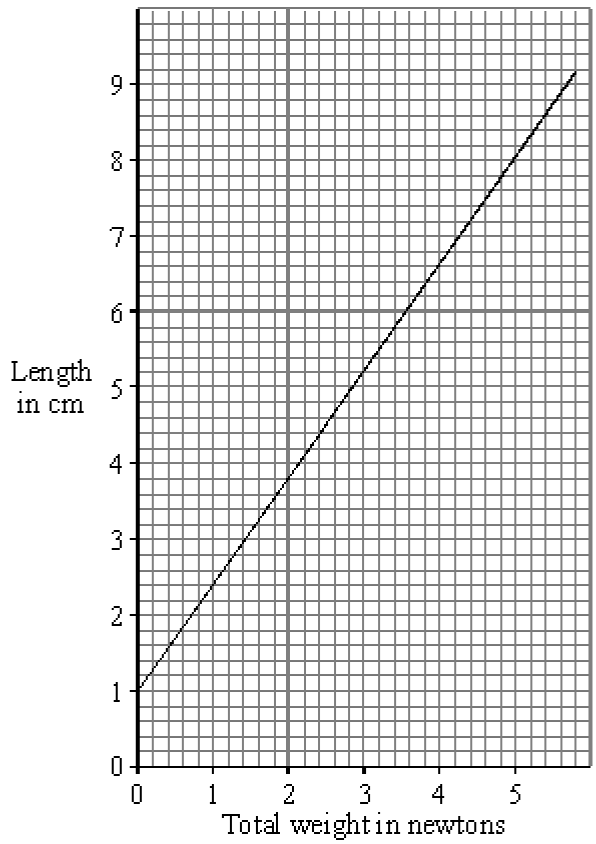
____

____

Weight = ________________ N

(2)

(c) The graph shows how the length of the spring changes as the total weight of the different animal shapes change.



Use the graph to find how much the spring extends when the elephant shape and the monkey shape are hung from the rod. Show how you get your answer.

____

____

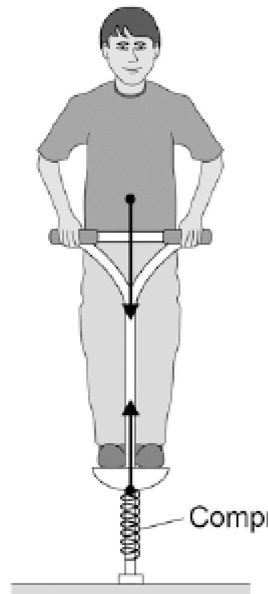
Extension of spring = __________ cm

(2)

(Total 10 marks)

9 The figure below shows the forces acting on a child who is balancing on a pogo stick.

The child and pogo stick are not moving.



(a) The downward force of the child on the spring is equal to the upward force of the spring on the child.

This is an example of which one of Newton's Laws of motion?

Tick **one** box.

First Law ☐

Second Law ☐

Third Law ☐

(1)

(b) Complete the sentence.

Use an answer from the box.

elastic potential	**gravitational potential**	**kinetic**

The compressed spring stores ______________________ energy.

(1)

(c) The child has a weight of 343 N.

Gravitational field strength = 9.8 N / kg

Write down the equation which links gravitational field strength, mass and weight.

____

(1)

(d) Calculate the mass of the child.

____

____

____

Mass = ___________________________ kg

(3)

(e) The weight of the child causes the spring to compress elastically from a length of 30cm to a new length of 23cm.

Write down the equation which links compression, force and spring constant.

____

(1)

(f) Calculate the spring constant of the spring.

Give your answer in newtons per metre.

____

____

____

Spring constant = ___________________________ N / m

(4)

(Total 11 marks)

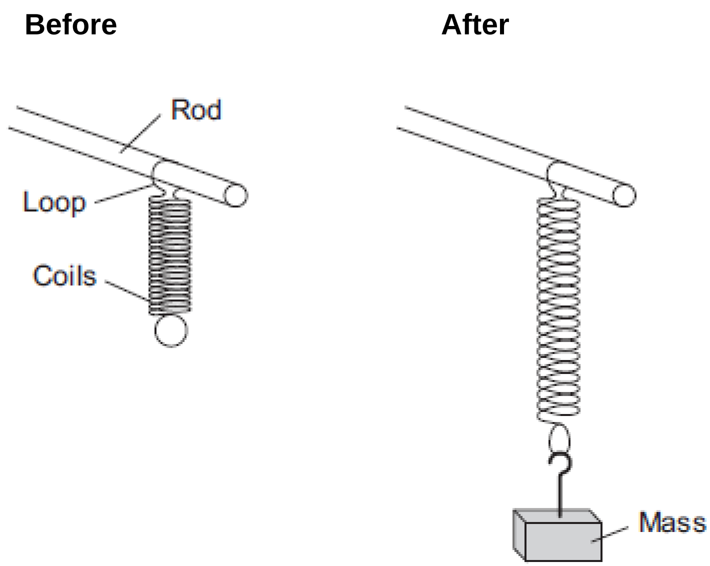
10 A student investigated the behaviour of springs. She had a box of identical springs.

(a) When a force acts on a spring, the shape of the spring changes.

The student suspended a spring from a rod by one of its loops. A force was applied to the spring by suspending a mass from it.

Figure 1 shows a spring before and after a mass had been suspended from it.

Figure 1



(i) State **two** ways in which the shape of the spring has changed.

1. ____

2. ____

(2)

(ii) No other masses were provided.

Explain how the student could test if the spring was behaving elastically.

____

____

____

____

(2)

(b) In a second investigation, a student took a set of measurements of force and extension.

Her results are shown in **Table 1** .

Table 1

Force in newtons	0.0	1.0	2.0	3.0	4.0	5.0	6.0
Extension in cm	0.0	4.0		12.0	16.0	22.0	31.0

(i) Add the missing value to **Table 1**.

Explain why you chose this value.

____

____

____

____

(3)

(ii) During this investigation the spring exceeded its limit of proportionality.

Suggest a value of force at which this happened.

Give a reason for your answer.

Force = __________________ N

Reason ____

____

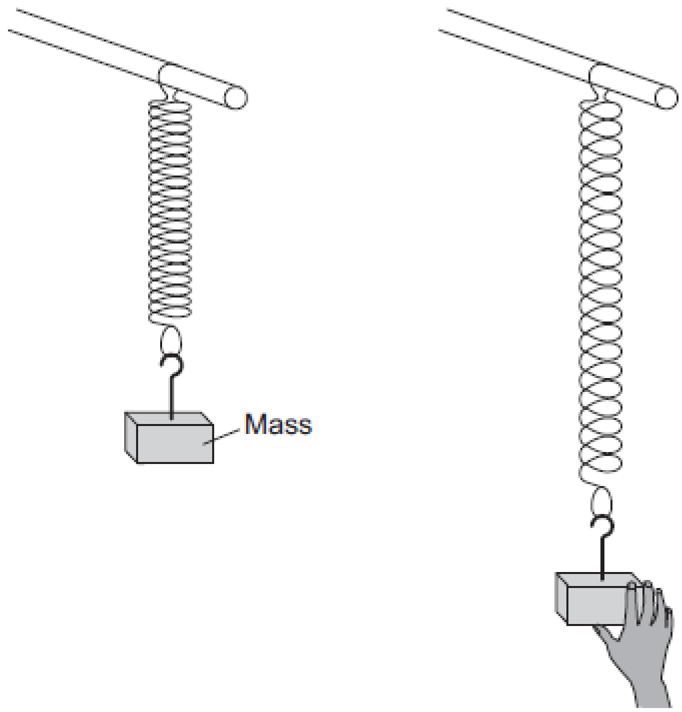
____

(2)

(c) In a third investigation the student:

- suspended a 100 g mass from a spring
- pulled the mass down as shown in **Figure 2**
- released the mass so that it oscillated up and down
- measured the time for 10 complete oscillations of the mass
- repeated for masses of 200 g, 300 g and 400 g.

Figure 2



Her results are shown in **Table 2**.

Table 2

	Time for 10 complete oscillations in seconds			
Mass in g	**Test 1**	**Test 2**	**Test 3**	**Mean**
100	4.34	5.20	4.32	4.6
200	5.93	5.99	5.86	5.9
300	7.01	7.12	7.08	7.1
400	8.23	8.22	8.25	8.2

(i) Before the mass is released, the spring stores energy.

What type of energy does the spring store?

Tick (✓) **one** box.

	Tick (✓)
Elastic potential energy	
Gravitational potential energy	
Kinetic energy	

(1)

(ii) The value of time for the 100 g mass in **Test 2** is anomalous.

Suggest **two** likely causes of this anomalous result.

Tick (✓) **two** boxes.

	Tick (✓)
Misread stopwatch	
Pulled the mass down too far	
Timed half oscillations, not complete oscillations	
Timed too few complete oscillations	
Timed too many complete oscillations	

(2)

(iii) Calculate the correct mean value of time for the 100 g mass in **Table 2**.

____

____

Mean value = ____________________ s

(1)

(iv) Although the raw data in **Table 2** is given to 3 significant figures, the mean values are correctly given to 2 significant figures.

Suggest why.

(2)

(v) The student wanted to plot her results on a graph. She thought that four sets of results were not enough.

What extra equipment would she need to get more results?

(2)

(Total 17 marks)