LONDON SCIENCE COLLEGE

Name:

Date:

WORK, ENERGY AND POWER
TEST 1

AS-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 A cyclist travelling along a level road at a constant speed of 15 m s^{-1} experiences a resistive force of 12 N due to air resistance.

(a) Calculate the power output of the cyclist maintaining this constant speed.

power output ______________________ W

(2)

(b) State and explain any change in the power output of the cyclist when cycling at a higher, constant speed.

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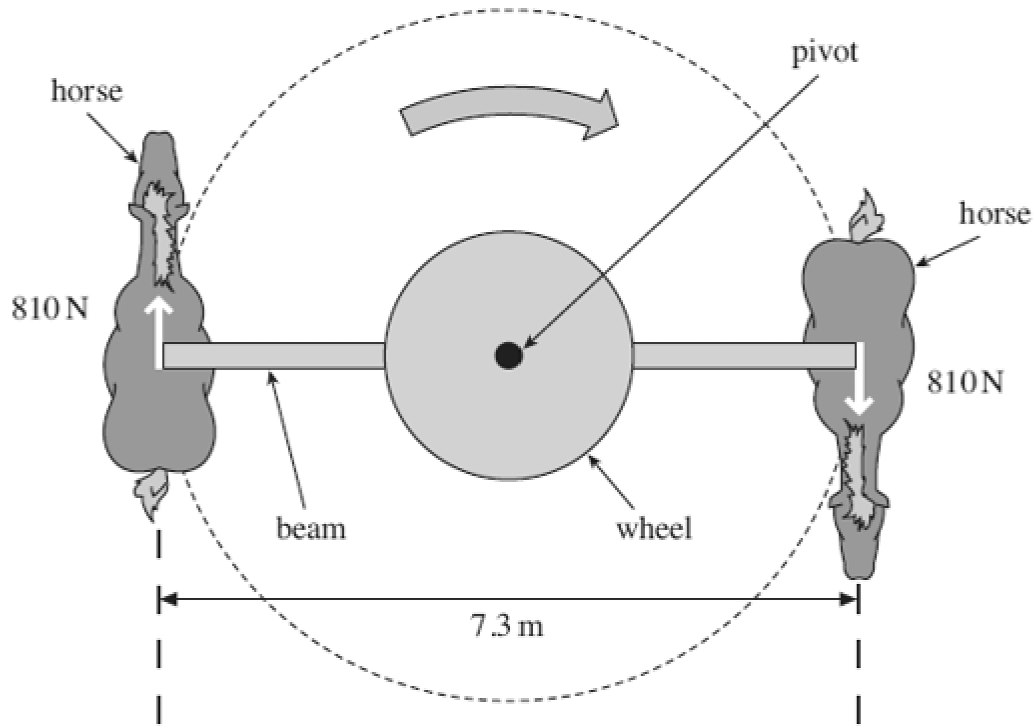
(2)

(Total 4 marks)

2 Horses were once used to power machinery in factories, mines and mills. The figure below shows two horses attached to a beam which turns a wheel. This wheel drives machinery.



(a) Each horse exerts a force of 810 N and the length of the beam is 7.3 m.

(i) Define the moment of a couple.

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(2)

(ii) Calculate the moment of the couple exerted by the horses, stating an appropriate unit.

answer = ______________________

(2)

(b) The horses move at a constant speed of $0.91 ms^{-1}$. Calculate the combined power output of the two horses. Give your answer to an appropriate number of significant figures.

answer = ______________________ W

(3)

(c) During the Industrial Revolution in the 19th Century, James Watt became well known for developing and improving steam engines to replace horses. He defined the unit of power called '*horsepower*' by studying a system similar to the one shown in the figure above.

Suggest why Watt decided to use *horsepower* as a unit of power.

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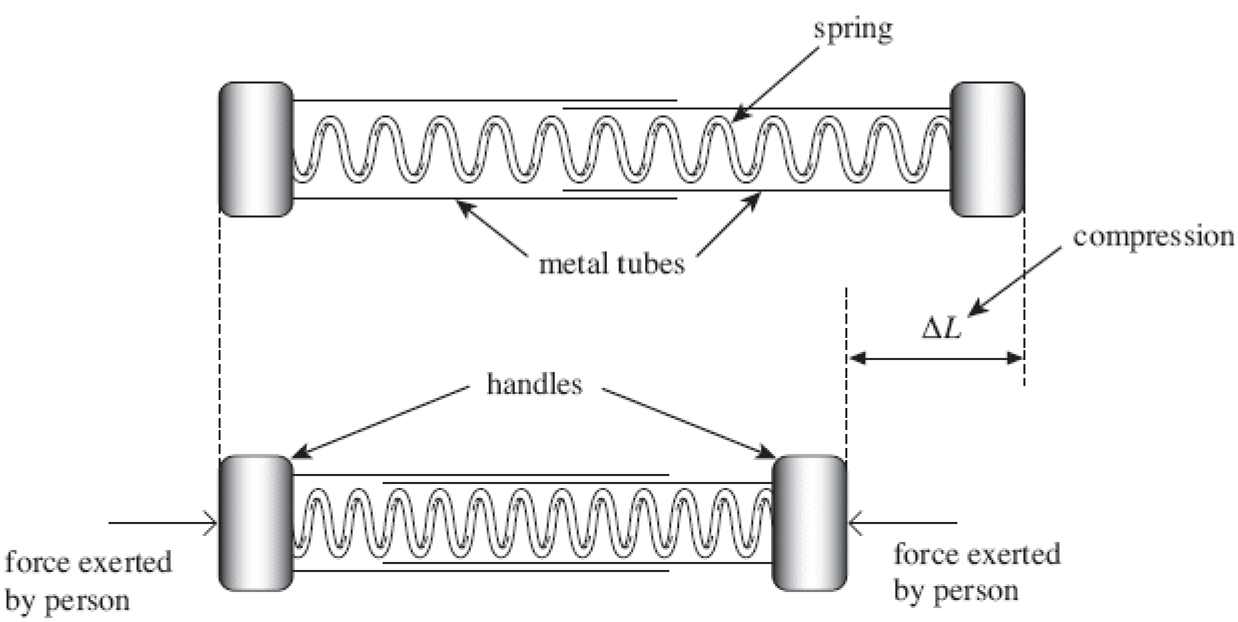
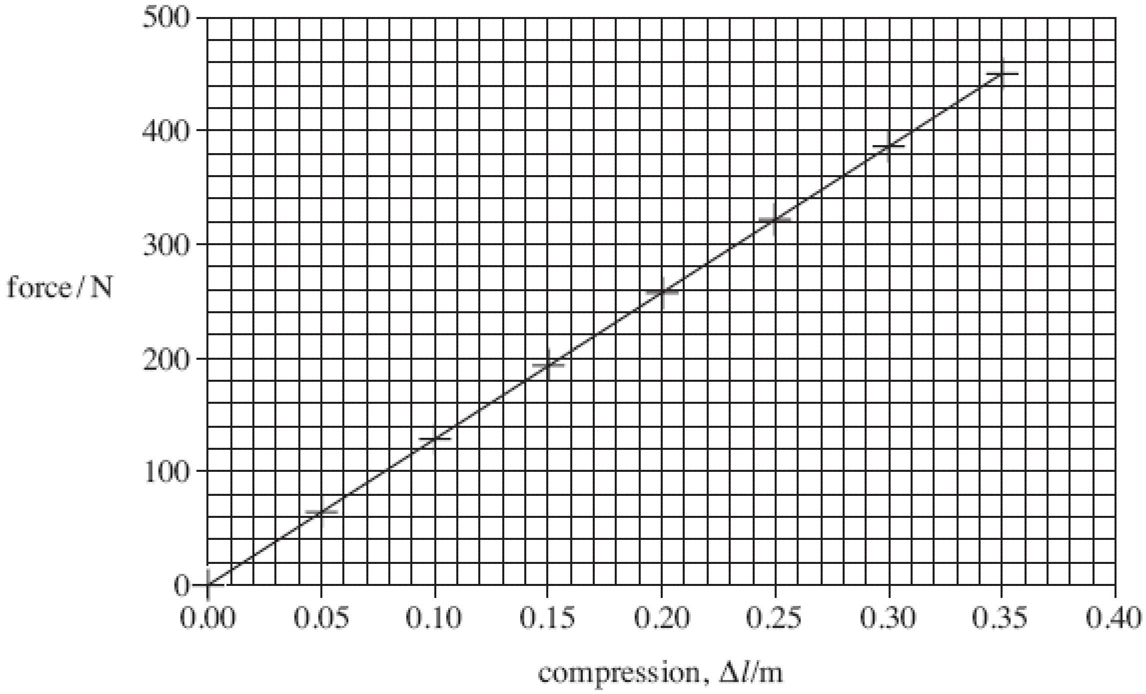
(1)

(Total 8 marks)

3 A type of exercise device is used to provide resistive forces when a person applies compressive forces to its handles. The stiff spring inside the device compresses as shown in the figure below.



(a) The force exerted by the spring over a range of compressions was measured. The results are plotted on the grid below.



(i) State Hooke's law.

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(2)

(ii) State which two features of the graph confirm that the spring obeys Hooke's law over the range of values tested.

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(2)

(iii) Use the graph to calculate the spring constant, stating an appropriate unit.

answer = ______________________

(3)

(b) (i) The formula for the energy stored by the spring is

$$E = \frac{1}{2}F\Delta L$$

Explain how this formula can be derived from a graph of force against extension.

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(3)

(ii) The person causes a compression of 0.28 m in a time of 1.5 s. Use the graph in part (a) to calculate the average power developed.

answer = ______________________ W

(3)

(Total 13 marks)

4 A climber falls 2.3 m before being stopped by his climbing rope that is secured above him. The weight of the climber is 840 N.

(a) Calculate the loss in gravitational potential energy of the climber.

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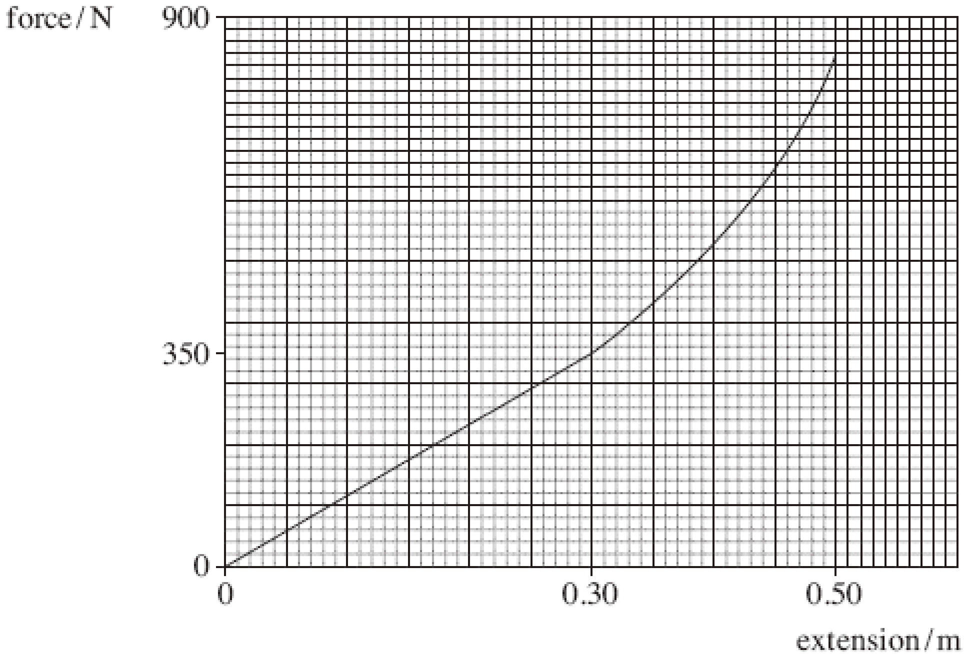
loss in potential energy ______________________ J

(2)

(b) The figure below shows a force-extension graph for the rope being used.



(i) Use the figure above to find the stiffness of the rope when it is being used with forces up to 350 N. Give the appropriate unit.

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___

stiffness ___

unit ___

(4)

(ii) Use the figure above to determine the energy stored in the rope when it is stretched by 0.25 m.

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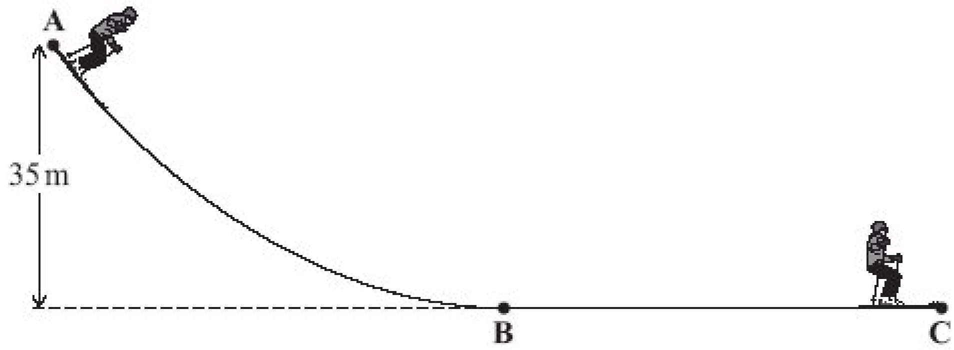
energy ___ J

(3)

(Total 9 marks)

5 The diagram below shows the path of a skier who descends a slope **AB**.



The skier starts from rest at **A** and eventually comes to rest again at **C** on the horizontal surface **BC**.

(a) (i) The slope **AB** has a vertical height of 35 m. The total mass of the skier is 65 kg.

Show that the skier's loss in gravitational potential energy is about 20 kJ.

(1)

(ii) The kinetic energy of the skier at point **B** is 11 000 J.
Show that the skier's speed at point **B** is about 18 m s^{-1}.

(2)

(iii) The average retarding force acting on the skier is 140 N.
Calculate the distance travelled between **A** and **B.**

distance travelled ____________________ m

(2)

(iv) Describe **two** ways in which the retarding force may arise.

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(3)

(b) The skier decelerates uniformly between **B** and **C** at 2.8 m s^{-2}.

(i) Calculate the time taken to travel from **B** to **C**.

time ____________________ s

(2)

(ii) Calculate the distance **BC**.

distance ____________________ m

(2)

(Total 12 marks)

6 In the leisure pursuit called parascending a person attached to a parachute is towed by a towrope attached to a motor boat as shown in **Figure 1**.

Figure 1

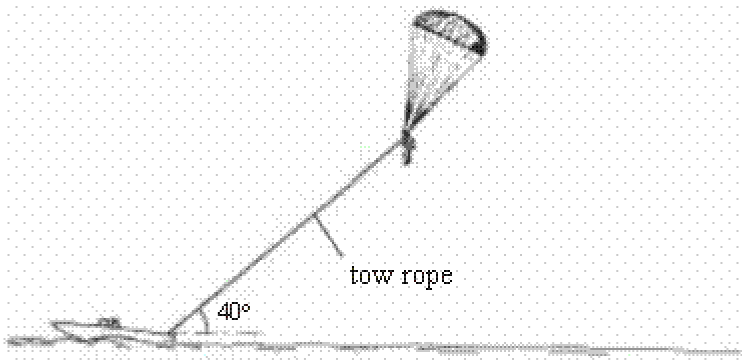

Figure 2

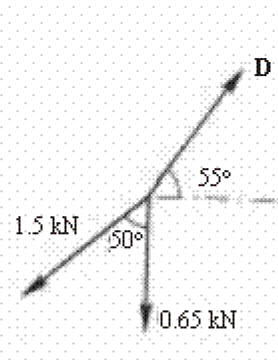

Figure 2 shows the directions of the forces acting on a person of weight 0.65 kN when being towed horizontally at a constant speed of 8.5 m s^{-1}.

The tension in the tow rope is 1.5 kN and *D* is resultant force exerted by the parachute on the parascender.

(a) (i) State why the resultant force on the parascender must be zero.

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(2)

(ii) Calculate the magnitude of *D*.

magnitude of ____________________ kN

(2)

(b) (i) Calculate the horizontal resistance to motion of the boat produced by the tow rope.

resistance ____________________ kN

(1)

(ii) The horizontal resistance to the motion of the boat produced by the water is 1200 N. Calculate the total power developed by the boat.

power ____________________

(4)

(c) State and explain the initial effect on the boat if the tow rope were to break.

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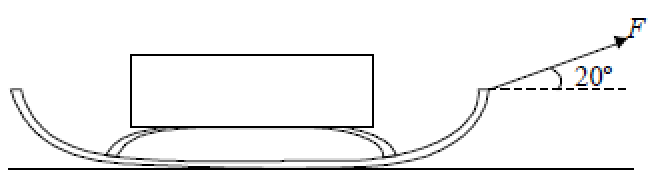
(2)

(Total 11 marks)

7 A heavy sledge is pulled across snowfields. The diagram shows the direction of the force F exerted on the sledge. Once the sledge is moving, the average horizontal force needed to keep it moving at a steady speed over level ground is 300 N.



(a) Calculate the force F needed to produce a horizontal component of 300 N on the sledge.

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(1)

(b) (i) Explain why the work done in pulling the sledge **cannot** be calculated by multiplying F by the distance the sledge is pulled.

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(ii) Calculate the work done in pulling the sledge a distance of 8.0 km over level ground.

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(iii) Calculate the average power used to pull the sledge 8.0 km in 5.0 hours.

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(6)

(c) The same average power is maintained when pulling the sledge uphill. Explain **in terms of energy transformations** why it would take longer than 5.0 hours to cover 8.0 km uphill.

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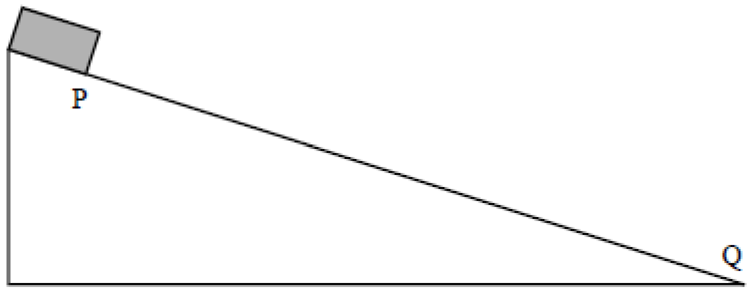
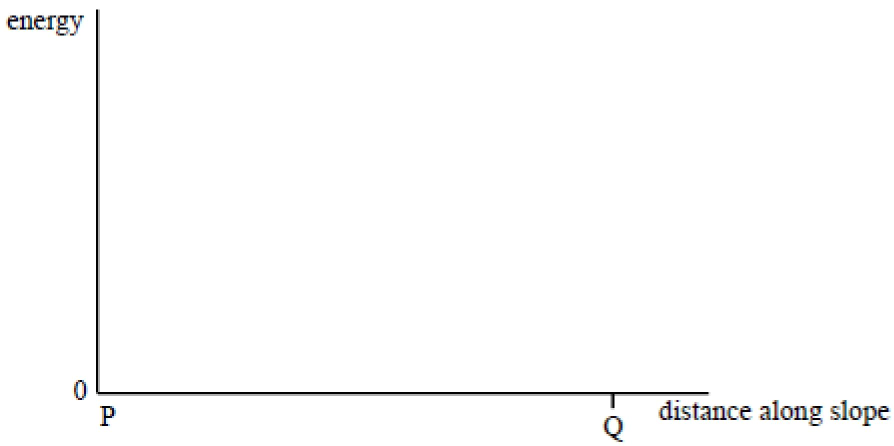
(3)

(Total 10 marks)

8 (a) The diagram shows an object at rest at the top of a straight slope which makes a fixed angle with the horizontal.



(i) The object is released and slides down the slope from P to Q with negligible friction. Assume that the potential energy is zero at Q. Sketch a graph showing the potential energy at different distances measured along the slope, and label it A. On the same set of axes, sketch a second graph showing the kinetic energy of the object at different distances along the slope and label it B.



(ii) Using the same axes as in part (i), sketch a third graph, labelled C, showing the kinetic energy at different distances along the slope when there is a constant frictional force between the object and the surface.

(iii) Use your knowledge of the principle of conservation of energy to explain the important features of the graphs you have drawn in part (i) and part (ii).

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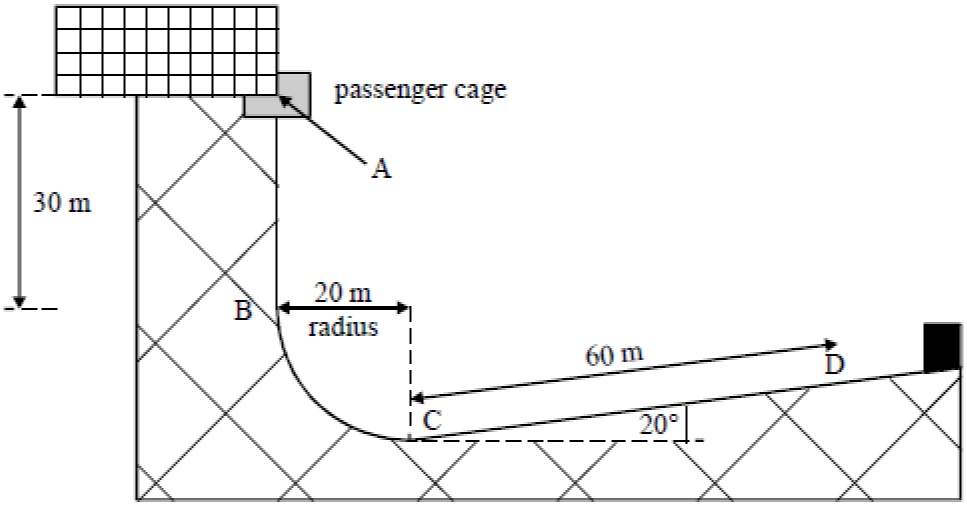
(6)

(b) In a theme park ride, a cage containing passengers falls freely a distance of 30 m from A to B and travels in a circular arc of radius 20 m from B to C. Assume that friction is negligible between A and C. Brakes are applied at C after which the cage with its passengers travels 60m along an upward sloping ramp and comes to rest at D. The track, together with relevant distances, is shown in the diagram. CD makes an angle of 20° with the horizontal



(i) Calculate the speed of the cage at C.

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(ii) Calculate the force required on a passenger of mass 80 kg for circular motion at C and state the direction of this force.

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(iii) If the mass of the cage and passengers is 620 kg, determine the gain in gravitational potential energy in travelling from C to D.

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(iv) Calculate the average resistive force exerted by the brakes between C and D.

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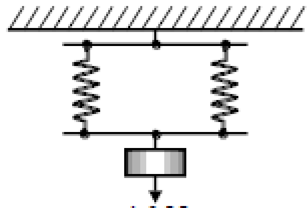
(9)
(Total 15 marks)

9 A load of 4.0 N is suspended from a parallel two-spring system as shown in the diagram.



The spring constant of each spring is 20 N m^{-1}. The elastic energy, in J, stored in the system is

A 0.1

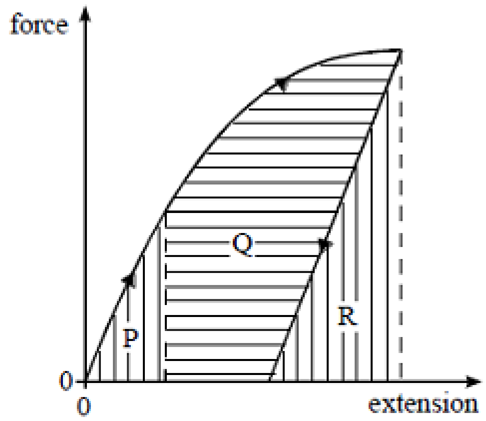
B 0.2

C 0.4

D 0.8

(Total 1 mark)

10 The force on a sample of a material is gradually increased and then decreased. The graph of force against extension is shown in the diagram.



The increase in thermal energy in the sample is represented by area

A R

B $P + Q$

C $P + Q + R$

D $P + Q - R$

(Total 1 mark)