Q1.(a) Define the moment of a force about a point.

....

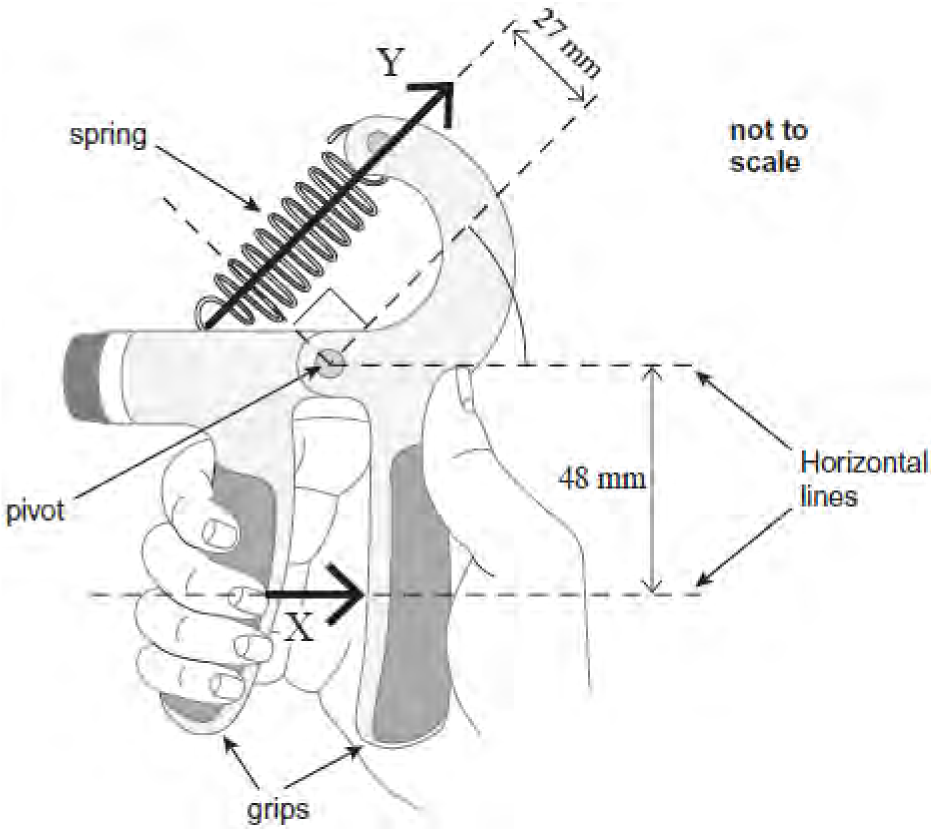
....

....

....

(2)

(b) The diagram shows a gripper which is used for hand strengthening exercises.



The diagram shows the gripper being squeezed. In this situation, the gripper is in equilibrium. The force produced by the fingers is equivalent to the single force **X** of magnitude 250 N acting in the direction shown above. A force, **Y**, is exerted by the spring which obeys Hooke's law.

(i) Calculate the moment of force **X** about the pivot. State an appropriate unit.

moment = ... unit ....

(2)

(ii) Calculate force **Y**.

force = ... N

(2)

(iii) The extension of the spring is 15 mm.

Calculate the spring constant k of the spring. Give your answer in N m^{-1}.

spring constant = ... N m^{-1}

(2)

(iv) Calculate the work done on the spring to squeeze it to the position shown in the diagram.

work done = ... J

(2)

(Total 10 marks)

Q2. An aerospace engineer has built two differently designed wings. One wing is made from an aluminium alloy and the other is made from a carbon fibre composite.

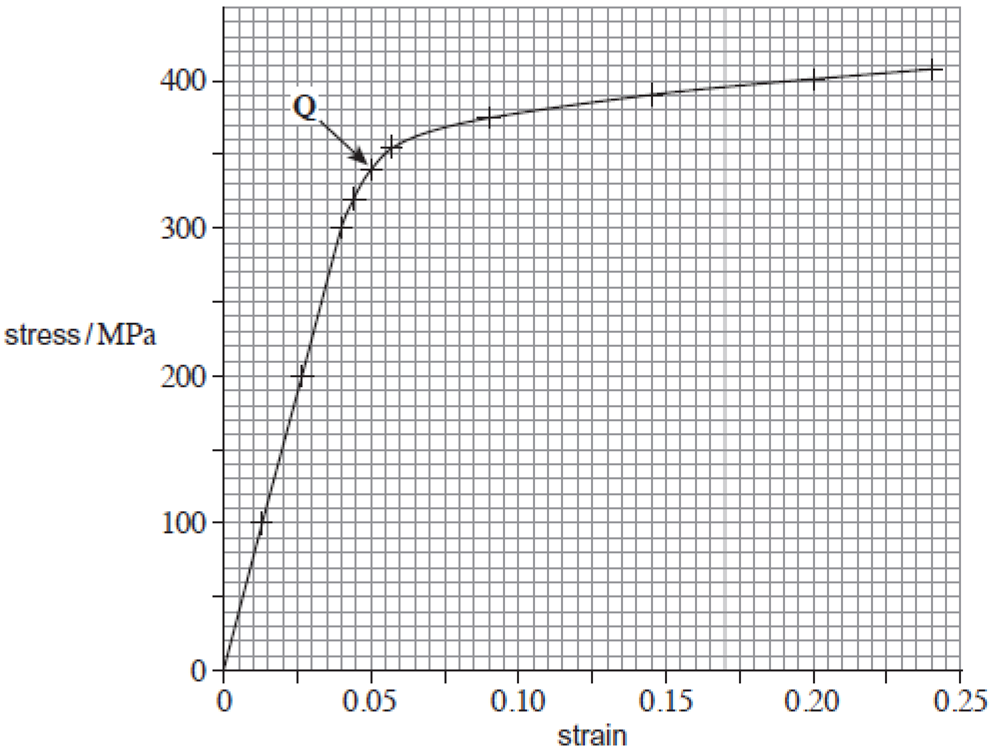
The engineer tests a sample of each material by applying a varying stress.

(a) Tick (✓) **two** of the boxes in the table below to indicate which are properties of the material from which the wing is made.

breaking stress	
stiffness constant, k	
tensile strain	
tensile stress	
Young modulus	

(1)

(b) Below is the stress−strain graph that the engineer obtains for the aluminium alloy.



(i) The engineer has labelled a point **Q** on the graph. This is a point beyond which the behaviour of the material changes irreversibly. State the name for this point.

....

(1)

(ii) Use the graph to determine the Young modulus of the aluminium alloy. Show your working.

Young modulus = ... Pa

(2)

(c) The engineer who carried out the experiment to obtain the stress−strain graph decided to stretch another sample to a strain of 0.10. She then gradually reduced the stress to zero.

Show by drawing on the graph how you would expect the stress to vary with strain as the stress is reduced.

(2)

(d) Calculate the volume of 25.0 kg of the aluminium alloy.

density of aluminium alloy = 2.78×10^{3} kg m^{-3}.

volume = ... m^{3}

(1)

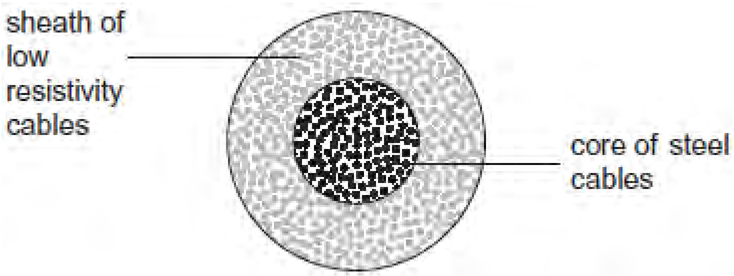
(e) 1.28% of the aluminium alloy's volume is copper.
Calculate the mass of pure aluminium needed to make 25.0 kg of the aluminium alloy.

density of pure aluminium = 2.70×10^3 kg m^{-3}.

mass of pure aluminium = ... kg

(2)
(Total 9 marks)

Q3. The overhead cables used to transmit electrical power by the National Grid usually consist of a central core of steel cables surrounded by a sheath of cables of low resistivity material, such as aluminium.



What is the main purpose of the steel core?

A To force more current into the outer sheath.

B To provide additional current paths through the cables.

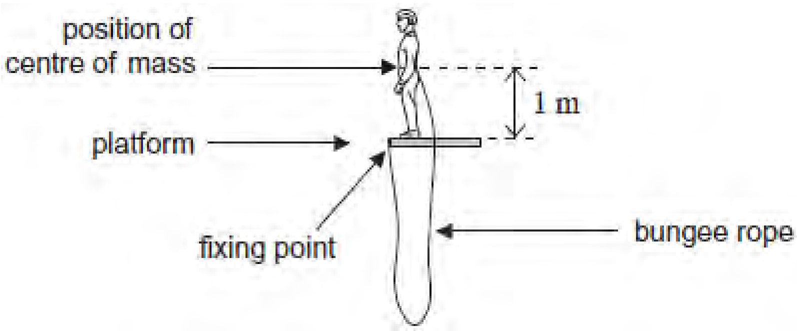
C To reduce the power lost from the cables.

D To increase the mechanical strength of the cables.

(Total 1 mark)

Q4. The diagram below shows a bungee jumper of mass 75 kg about to step off a raised platform. The jumper comes to a halt for the first time when his centre of mass has fallen through a distance of 31 m.
The bungee rope has an unextended length of 19 m and a stiffness of 380 N m^{-1}.

Ignore the effects of air resistance and the mass of the rope in this question.
Treat the jumper as a point mass located at the centre of mass.



(a) (i) Calculate the extension of the bungee rope when the centre of mass of the jumper has fallen through 31 m.

extension .... m

(1)

(ii) Calculate the resultant force acting on the jumper when he reaches the lowest point in the jump.

resultant force .... N

(2)

(b) Calculate the extension of the rope when the jumper's acceleration is zero.

extension .... m

(2)

(c) The extension of the bungee rope is 5.0 m when the jumper's centre of mass has fallen through a distance of 25 m.

Use the principle of conservation of energy to calculate the speed of the jumper in this position.

speed .... $m\ s^{-1}$

(4)

(d) The bungee jump operator intends to use a bungee rope of the same unextended length but with a much greater stiffness. The rope is to be attached in the same way as before.

Explain, with reference to the kinetic energy of the jumper, any safety concerns that may arise as the jumper is slowed down by the new rope.

....

....

....

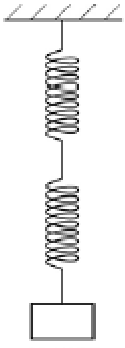
....

....

....

(3)
(Total 12 marks)

Q5. A load of 3.0 N is attached to a spring of negligible mass and spring constant 15 N m^{-1}.



What is the energy stored in the spring?

A 0.3 J

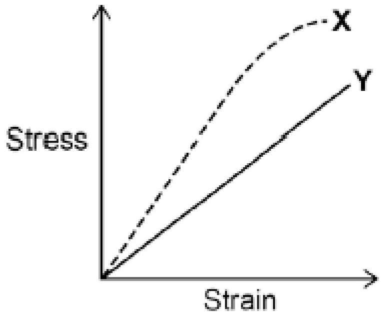
B 0.6 J

C 0.9 J

D 1.2 J

(Total 1 mark)

Q6. The diagram shows how the stress varies with strain for metal specimens X and Y which are different. Both specimens were stretched until they broke.



Which of the following is incorrect?

A	X is stiffer than Y	☐
B	X has a higher value of the Young modulus	☐
C	X is more brittle than Y	☐
D	Y has a lower maximum tensile stress than X	☐

(Total 1 mark)