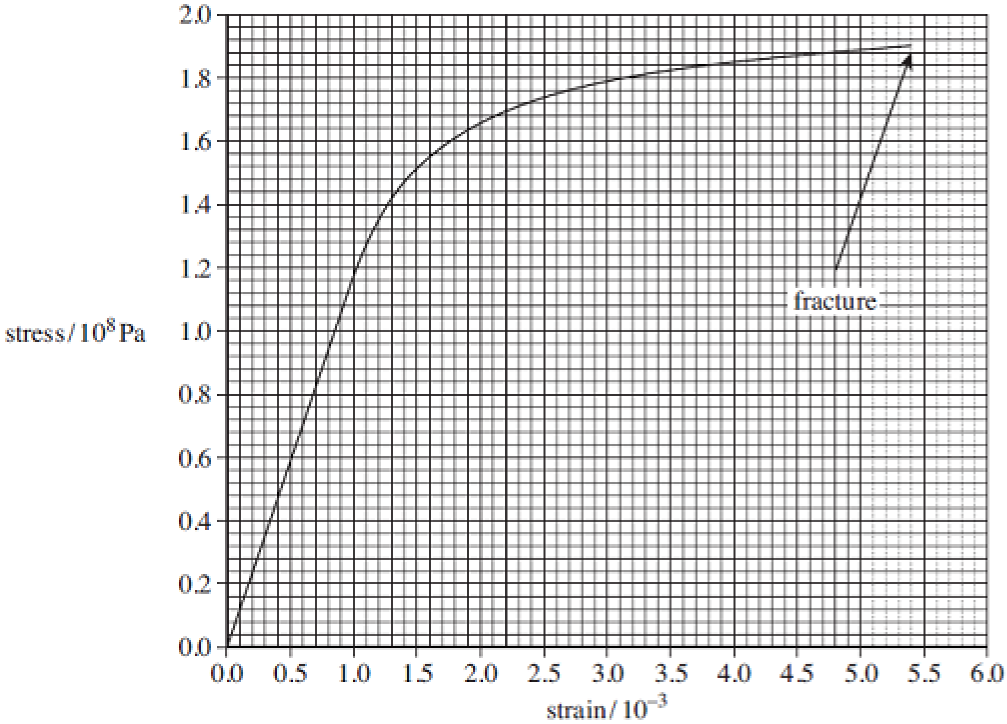
1 The figure below shows a stress-strain graph for a copper wire.



(a) Define tensile strain.

____

____

(1)

(b) State the breaking stress of this copper wire.

answer = ________________________ Pa

(1)

(c) Mark on the figure above a point on the line where you consider plastic deformation may start.
Label this point **A**.

(1)

(d) Use the graph to calculate the Young modulus of copper. State an appropriate unit for your answer.

answer = ________________________

(3)

(e) The area under the line in a stress-strain graph represents the work done per unit volume to stretch the wire.

(i) Use the graph to find the work done per unit volume in stretching the wire to a strain of 3.0×10^{-3}.

answer = ______________________ J m^{-3}

(2)

(ii) Calculate the work done to stretch a 0.015 kg sample of this wire to a strain of 3.0×10^{-3}.

The density of copper = 8960 kg m^{-3}.

answer = ______________________ J

(2)

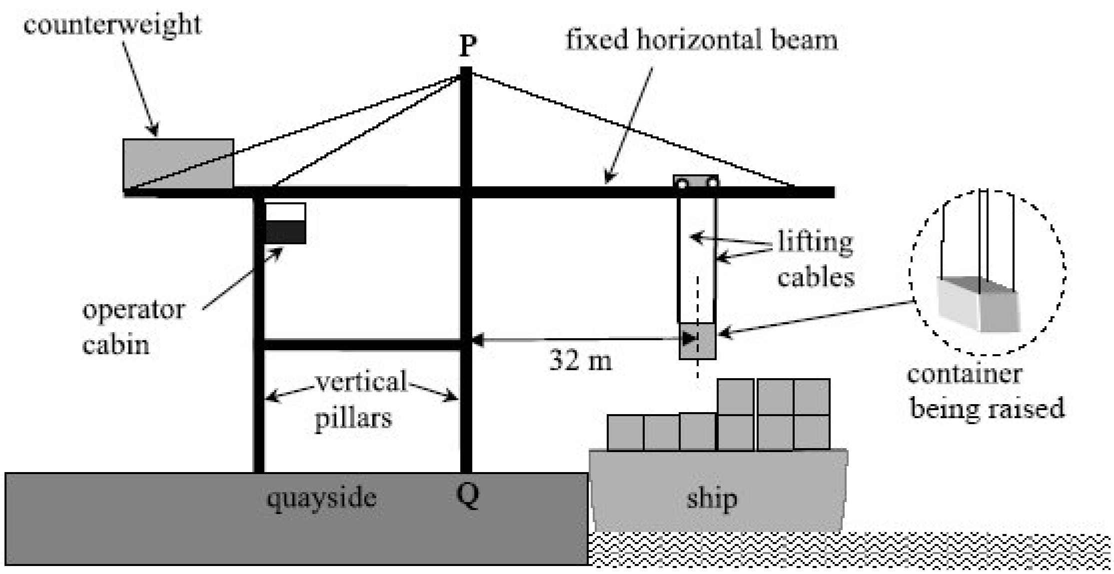
(f) A certain material has a Young modulus greater than copper and undergoes brittle fracture at a stress of 176 MPa.

On the figure above draw a line showing the possible variation of stress with strain for this material.

(2)

(Total 12 marks)

2 The diagram below shows a dockside crane that is used to lift a container of mass 22000 kg from a cargo ship onto the quayside. The container is lifted by four identical 'lifting' cables attached to the top corners of the container.



(a) When the container is being raised, its centre of mass is at a horizontal distance 32 m from the nearest vertical pillar **PQ** of the crane's supporting frame.

(i) Assume the tension in each of the four lifting cables is the same. Calculate the tension in each cable when the container is lifted at constant velocity.

answer ____________________ N

(2)

(ii) Calculate the moment of the container's weight about the point **Q** on the quayside, stating an appropriate unit.

answer ____________________

(3)

(iii) Describe and explain one feature of the crane that prevents it from toppling over when it is lifting a container.

____

____

____

____

____

(2)

(b) Each cable has an area of cross–section of 3.8×10^{-4} m^2.

(i) Calculate the tensile stress in each cable, stating an appropriate unit.

answer ______________________

(3)

(ii) Just before the container shown in the diagram above was raised from the ship, the length of each lifting cable was 25 m. Show that each cable extended by 17 mm when the container was raised from the ship.

Young modulus of steel = 2.1×10^{11} Pa

(2)

(Total 12 marks)

3 (a) (i) Explain what is meant by the spring constant *k* of a spring.

____

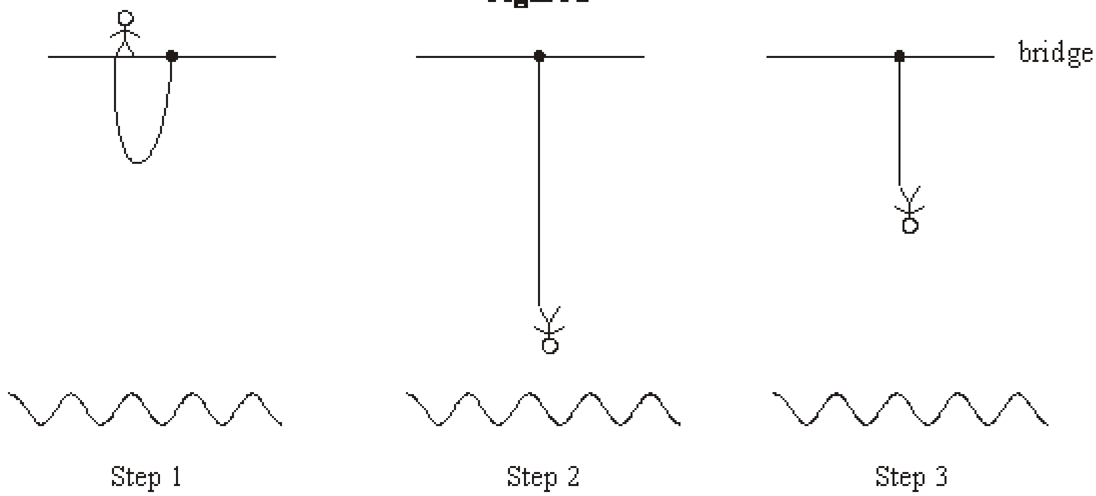
(ii) Give the unit of *k*.

____

(2)

(b) The figure below shows the stages in a bungee jump.

Figure 5



In bungee jumping, the participant jumps from a high point attached to an elastic cord (step 1). After a period of free fall, the cord slows the fall of the jumper (step 2) with the system eventually undergoing oscillation (step 3).
A bungee jump is to be set up from a suspension bridge with the jumper of weight 700 N falling towards the river below. The roadway of the bridge is 76 m above the river surface. The bungee cord is adjusted so that the jumper just reaches the river surface at the bottom of the first oscillation.

The unstretched length of the elastic cord is to be 12 m.

(i) Calculate the time taken before the cord begins to stretch.

(ii) Show that, when jumping from the bridge to the river, the jumper loses about 53 kJ of gravitational potential energy.

(iii) Calculate the extension of the cord when the jumper is at the bottom of the first oscillation.

(iv) The gravitational potential energy is stored in the bungee cord.
Calculate the spring constant of the cord.

(v) Calculate the time period of oscillation of the jumper.

(12)

(c) (i) Calculate the tension in the cord when the jumper comes to rest for the first time.

(ii) Forces on astronauts and 'thrill seekers' are often specified in terms of the *g* force acting on the participants.

1*g* is equivalent to an acceleration of 9.8 m s^{-2}.

Calculate the maximum *g* force that acts on the jumper.

(iii) Hardened thrill seekers prefer their sports to generate 3*g* or more. Without carrying out detailed calculations, suggest the changes that would need to be made to the cord in order to produce a greater *g* force for the 700 N jumper.

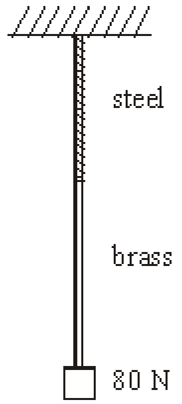
(6)

(Total 20 marks)

4 (a) State *Hooke's law* for a material in the form of a wire and state the conditions under which this law applies.

(2)

(b) A length of steel wire and a length of brass wire are joined together. This combination is suspended from a fixed support and a force of 80 N is applied at the bottom end, as shown in the figure below.



Each wire has a cross-sectional area of 2.4×10^{-6} m^2.

length of the steel wire = 0.80 m
length of the brass wire = 1.40 m
the Young modulus for steel = 2.0×10^{11} Pa
the Young modulus for brass = 1.0×10^{11} Pa

(i) Calculate the total extension produced when the force of 80 N is applied.

____

____

____

____

____

____

(ii) Show that the mass of the combination wire = 4.4×10^{-2} kg.

density of steel = 7.9×10^3 kg m^{-3}
density of brass = 8.5×10^3 kg m^{-3}

____

____

____

____

____

(7)

(c) A single brass wire has the same mass and the same cross-sectional area as the combination wire described in part (b). Calculate its length.

____

____

____

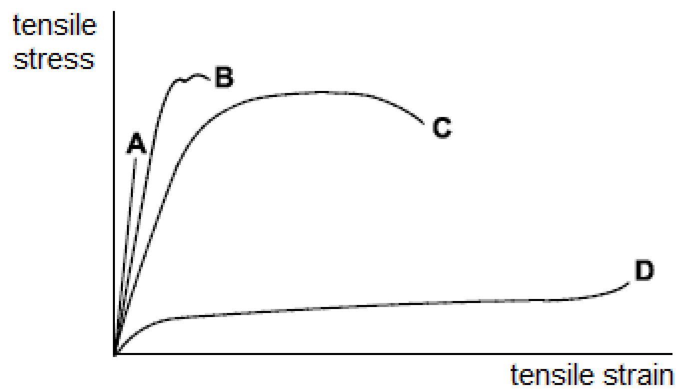
____

____

(2)

(Total 11 marks)

5 The diagram below shows the tensile stress–tensile strain graphs for four materials, **A**, **B**, **C** and **D**, up to their breaking stress.



(a) State what is meant by tensile stress and tensile strain.

tensile stress ____

____

____

tensile strain ____

____

____

(2)

(b) Identify a property of material **A** using evidence from the graph to support your choice.

property ____

evidence ____

____

____

____

(2)

(c) A cylindrical specimen of material **A** under test has a diameter of 1.5×10^{-4} m and a breaking stress of 1.3 GPa.

Calculate the tensile force acting on the specimen at its breaking point.

tensile force = ____________________ N

(3)

(d) Discuss which of the four materials shown on the graph is most suitable for each of the following applications:

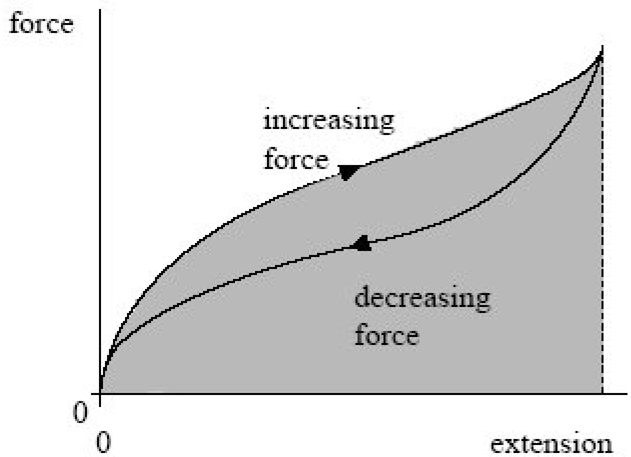
- the cable supporting a lift in a tall building
- a rope or cable attached to a person doing a bungee jump.

For each application, you should discuss the reason for your choice and why you rejected the other materials.

(6)

(Total 13 marks)

6 A student investigated how the extension of a rubber cord varied with the force used to extend it. She measured the extension for successive increases of the force and then for successive decreases. The diagram below shows a graph of her results.



(a) (i) Give a reason why the graph shows the rubber cord does not obey Hooke’s law.

____

____

(1)

(ii) Give a reason why the graph shows the rubber cord does not exhibit plastic behaviour.

____

____

(1)

(iii) What physical quantity is represented by the area shaded on the graph between the loading curve and the extension axis?

____

____

(1)

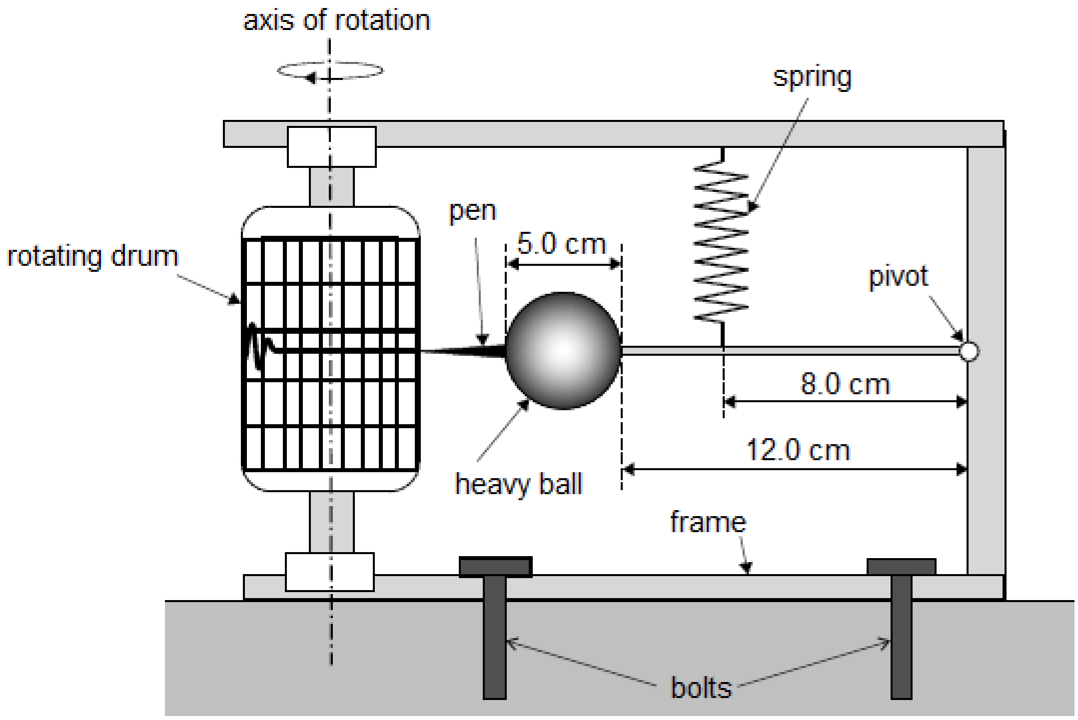
(b) Describe, with the aid of a diagram, the procedure and the measurements you would make to carry out this investigation.

The quality of your written answer will be assessed in this question.

(6)

(Total 9 marks)

7 A seismometer is a device that is used to record the movement of the ground during an earthquake. A simple seismometer is shown in the diagram.



A heavy spherical ball is attached to a pivot by a rod so that the rod and ball can move in a vertical plane. The rod is suspended by a spring so that, in equilibrium, the spring is vertical and the rod is horizontal. A pen is attached to the ball. The pen draws a line on graph paper attached to a drum rotating about a vertical axis. Bolts secure the seismometer to the ground so that the frame of the seismometer moves during the earthquake.

(a) The ball is made of steel of density 8030 kg m^{-3} and has a diameter of 5.0 cm.

Show that the weight of the ball is approximately 5 N.

(3)

(b) The distance from the surface of the ball to the pivot is 12.0 cm, as shown in the diagram above.

Calculate the moment of the weight of the ball about the pivot when the rod is horizontal. Give an appropriate unit for your answer.

moment = ____________________ unit = __________

(3)

(c) The spring is attached at a distance of 8.0 cm from the pivot and the spring has a stiffness of 100 N m^{-1}.

Calculate the extension of the spring when the rod is horizontal and the spring is vertical. You may assume the mass of the pen and the mass of the rod are negligible.

extension = ____________________ m

(3)

(d) Before an earthquake occurs, the line being drawn on the graph paper is horizontal.

Explain what happens to the line on the graph paper when an earthquake is detected and the frame of the seismometer accelerates rapidly downwards.

____

____

____

____

____

____

____

(2)

(Total 11 marks)

8 A wire of length L and cross-sectional area A is stretched a distance e by a tensile force. The Young modulus of the material of the wire is E.

Which expression gives the elastic energy stored in the stretched wire?

A $\frac{1}{2}\frac{EAe^2}{L}$ ☐

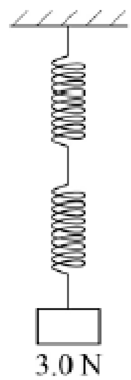
B $\frac{1}{2}\frac{L}{Ae}$ ☐

C $\frac{1}{2}\frac{Ae^2}{EL}$ ☐

D $\frac{1}{2}\frac{EAL}{e}$ ☐

(Total 1 mark)

9 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 ☐

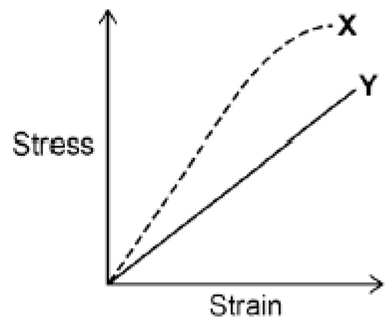
B 0.6 J ☐

C 0.9 J ☐

D 1.2 J ☐

(Total 1 mark)

10 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.

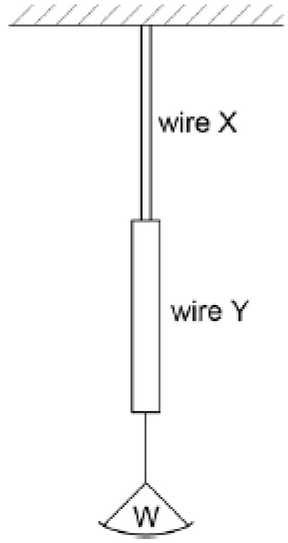


Which of the following is incorrect?

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)

11 Two vertical copper wires X and Y of equal length are joined as shown. Y has a greater diameter than X. A weight W is hung from the lower end of Y.



Which of the following is correct?

A The strain in X is the same as that in Y.

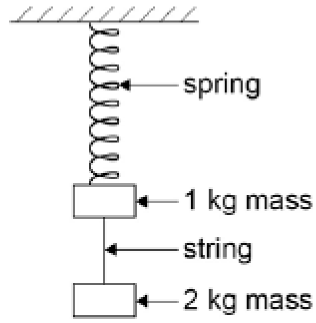
B The stress in Y is greater than that in X.

C The tension in Y is the same as that in X.

D The elastic energy stored in X is less than that stored in Y.

(Total 1 mark)

12 Two masses hang at rest from a spring, as shown in the diagram. The string separating the masses is burned through.



Which of the following gives the accelerations of the two masses as the string breaks?

acceleration of free fall = g

	acceleration of 1 kg mass upwards in m s^{-2}	acceleration of 2 kg mass downwards in m s^{-2}	
A	3 g	1 g	⬭
B	2 g	2 g	⬭
C	2 g	1 g	⬭
D	1 g	1 g	⬭

(Total 1 mark)

1

(a) extension divided by its **original** length ✓

do not allow symbols unless defined ✓

1

(b) 1.9×10^8 (Pa) ✓

1

(c) point on line **marked 'A'** between a strain of 1.0×10^{-3} and 3.5×10^{-3} ✓

1

(d) clear evidence of gradient calculation for **straight section**
eg $1.18\ (1.2) \times 10^8 / 1.0 \times 10^{-3}$ ✓

= 120 GPa **and stress used $\geq$ 0.6 × 10^8 Pa** ✓ allow range 116 − 120 GPa

Pa or Nm^{-2} or N/m^2 ✓

3

(e) (i) clear attempt to calculate correct area (evidence on graph is sufficient) ✓

(32 whole squares + 12 part/2 = 38 squares)

(38 × 10000 =) 380000 (J m^{-3}) ✓ allow range 375000 to 400000

2

(ii) $V = m/\rho$ **or** 0.015/8960 **or** 1.674×10^{-6} (m^3) ✓

380 000 × 1.674×10^{-6} = 0.64 (0.6362 J) ✓ ecf from ei

2

(f) straight line passing through origin (small curvature to the right only above 160 MPa is acceptable) end at 176 MPa ✓ (allow 174 to 178)

straight section to the left of the line for copper (steeper gradient) ✓

2

[12]

2

(a) (i) weight of container (= mg = 22000 × 9.8(1)) = 2.16×10^5 (N) **(1)**

tension (= ¼ *mg*) = (5.39) 5.4×10^4 (N) or divide a weight by 4 **(1)**

(ii) moment (= force × distance) = 22000 *g* × 32 **(1)** ecf weight in (a) (i)

= 6.9 or 7.0×10^6 **(1)** **N m** or correct base units **(1)** not J, nm, NM

(iii) the counterweight **(1)**

provides a (sufficiently large) anticlockwise moment (about Q) or moment in opposite direction (to that of the container to prevent the crane toppling clockwise) **(1)**

or
left hand pillar pulls (down) **(1)**
and provides anticlockwise moment

or
the centre of mass of the crane('s frame and the counterweight) is between the two pillars **(1)**

which prevents the crane toppling **clockwise**/to right **(1)**

7

(b) (i) (tensile) stress $\left(= \frac{\text{tension}}{\text{csa}}\right) = \frac{5.4 \times 10^{4}}{3.8 \times 10^{-4}}$ ecf (a) (i) **(1)**

$= 1.4(2) \times 10^{8}$ **(1)** **Pa** (or N m^{-2}) **(1)**

(ii) extension = $\frac{\text{length} \times \text{stress}}{E}$ or $\frac{FL}{EA}$ **(1)**

$= \frac{25 \times 1.4 \times 10^{8}}{2.1 \times 10^{11}}$ and ($= 1.7 \times 10^{-2}$ m) = 17 (mm) **(1)**

5

[12]

3 (a) (i) *k = force/extension* **(1)**

(ii) N m^{-1} **(1)**

2

(b) (i) $s = ut + ½ at^2$ or alt used **(1)**

$t^2 – 12/4.9$ **(1)**

1.6 s **(1)**

(ii) weight × height change seen **(1)**

53200 J **(1)**

(iii) 76 – 12 = 64 m **(1)**

12

(iv) ½ kx^2 = *energy stored* seen **(1)**

$k = 2 \times 53200 / (64)^2$ **(1)**

25.9 N **(1)**

(v) $T = 2\pi\sqrt{(k/m)}$ seen **(1)**

subst **(1)**

1.2 s **(1)**

(c) (i) $F = kx$ seen **(1)**

$= 25.9 \times 64 = 1660$ N **(1)**

(ii) 1660/700 seen **(1)**

2.4 *g* **(1)**

(iii) stiffer cord **(1)**

less elongation so longer natural length **(1)**

6

[20]

4

(a) Hooke's law: the extension is proportional to the force applied **(1)**
up to the limit of proportionality or elastic limit
[or for small extensions] **(1)**

2

(b) (i) (use of $E = \frac{F}{A}\frac{l}{\Delta L}$ gives) $\Delta L_s = \dfrac{80 \times 0.8}{2.0 \times 10^{11} \times 2.4 \times 10^{-6}}$ **(1)**

$= 1.3 \times 10^{-4}$ (m) **(1)** (1.33×10^{-4} (m))

$\Delta L_b = \dfrac{80 \times 1.4}{1.0 \times 10^{11} \times 2.4 \times 10^{-6}} = 4.7 \times 10^{-4}$ (m) **(1)** (4.66×10^{-4} (m))

total extension = 6.0×10^{-4} m **(1)**

(ii) $m = \rho \times V$ **(1)**
$m_s = 7.9 \times 10^3 \times 2.4 \times 10^{-6} \times 0.8 = 15.2 \times 10^{-3}$ (kg) **(1)**
$m_b = 8.5 \times 10^3 \times 2.4 \times 10^{-6} \times 1.4 = 28.6 \times 10^{-3}$ (kg) **(1)**
(to give total mass of 44 or 43.8×10^{-3} kg)

7

(c) (use of $m = \rho A l$ gives) $l = \dfrac{44 \times 10^{-3}}{8.5 \times 10^{3} \times 2.4 \times 10^{-6}}$ **(1)**

$= 2.2$ m **(1)** (2.16 m)

(use of mass = 43.8×10^{-3} kg gives 2.14 m)

2

[11]

5 (a) tensile stress is the force exerted per/over cross sectional area ✓

can use equation but must define terms

1

tensile strain is the extension per/over original length ✓

NOT compared to

1

(b) material is brittle ✓

2nd mark dependent on first

1

shown on graph by little or no of plastic behaviour OR by linear behaviour/straight line to breaking stress ✓
OR
material has high Young modulus OR material is stiff ✓
shown on graph by large gradient/steep line (compared to other materials) ✓

1

(c) area = $\pi \times (1.5 \times 10^{-4})^2/4 = 1.77 \times 10^{-8}$ ✓

1

tensile force = 1.77×10^{-8} ✓

1

= 23 (N) ✓

1

if use diameter as radius −1

if use incorrect formula (d^2 $2\pi r$ etc. −2)

range 22.5 – 24

power of ten error −1

if calculated area incorrectly get following answers

diameter as radius = 92 (2 marks)

d^2 = 7.3 (1 mark)

$2\pi r$ = 610 000 (1 mark)

if use d for area then zero

(d) **The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist marking this question.**

Level 3

Correct materials selected for **each** application (B/C for lift and D for bungee). One reason for choices given for **each** application and explanation why at least one other material would be rejected for **each** application. 6

Correct materials selected for **each** application (B/C for lift and D for bungee). One reason for choices given for **each** application and explanation why at least one other material would be rejected for **one** application. 5

The student presents relevant information coherently, employing structure, style and sp&g to render meaning clear. The text is legible.

Level 2

Correct material selected for **one** application (B/C for lift and D for bungee). **One** reason for choice given for one application and explanation why at least one other material would be rejected for **one** application. 4

Correct material selected for **one** application (B/C for lift and D for bungee). **One** reason for choices given application.
OR
Correct materials selected for **each** application (B/C for lift and D for bungee). One reason for choices given for **each** application 3

The student presents relevant information and in a way which assists the communication of meaning. The text is legible. Sp&g are sufficiently accurate not to obscure meaning.

Level 1

No correct material selected but at least **two** properties necessary for an application given. 2

No correct material selected but at least **one** property necessary for an application given. 1

The student presents some relevant information in a simple form. The text is usually legible. Sp&g allow meaning to be derived although errors are sometimes obstructive.

Level 0

No correct material selected and no properties necessary for an application given

The student's presentation, spelling and grammar seriously obstruct understanding. 0

The following statements may be present for cable supporting a lift

material B/C is used for the lift because it has a high breaking stress and a high Young modulus

material A not chosen because lower breaking stress

material A not chosen because fails without warning

material C not chosen because has a lower breaking stress

material D not chosen as larger increase in strain for a given increase in stress

material D not chosen as low breaking stress.

material D a given stress produces a large strain meaning large extension

The following statements may be present for rope or cable used for bungee jump

material D chosen as due large strain for given stress
time taken to come to rest lengthens

material D is chosen because D can store a large amount of energy before failure

not A ,B or C because high Young Modulus so sudden stop resulting in large forces

not A as brittle and therefore limited strain and sudden failure

not C because requires a large strain before plastic behaviour

not C because if behaves plastically will not return to original length

[13]

6 (a) (i) the lines are not straight (owtte) **(1)**

(ii) there is no permanent extension **(1)**
(or the overall/final extension is zero or the unloading curve returns to zero extension)

(iii) (area represents) **work done** (on or energy transfer to the rubber cord) or **energy** (stored) **(1)** not heat/thermal energy

3

(b) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

QWC	descriptor	mark range
good-excellent	The candidate provides a comprehensive and coherent description which includes nearly all the necessary procedures and measurements in a logical order. The descriptions should show awareness of how to apply a variable force. They should know that measurements are to be made as the force is increased then **as it is decreased**. In addition, they should know how to calculate/measure the extension of the cord. **At least five different masses/'large number' of masses are used. Minimum 7 masses to reach 6 marks**. The diagram should be detailed.	**5-6**
modest-adequate	The description should include most of the necessary procedures including **how to apply a variable force** and should include the necessary measurements. They may not have described the procedures in a logical order. They may not appreciate that measurements are also to be made as the cord is unloaded. They should know **that the extension** of the cord must be found and name a **suitable measuring instrument (or seen in diagram – label need not be seen)/how to calculate**. The diagram may lack some detail.	**3-4**
poor-limited	The candidate knows that the **extension or cord length** is to be measured for **different forces –** may be apparent from the diagram. They may not appreciate that measurements are also to be made as the cord is unloaded. They may not state how to calculate the extension of the cord. The diagram may not have been drawn.	**1-2**
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	**0**

The explanation expected in a competent answer should include a coherent selection of the following physics ideas.

diagram showing rubber cord fixed at one end supporting a weight at the other end or pulled by a force **(1)**

means of applying variable force drawn or described (eg use of standard masses or a newtonmeter) **(1)**

means of measuring cord drawn or described **(1)**

procedure

measured force applied (or known weights used) **(1)**

cord extension measured or calculated **(1)**

repeat for increasing then decreasing length (or force/weight) **(1)**

extension calculated from cord length – initial length **(1)**

[9]

7 (a) use of $V = \frac{4}{3}\pi r^3$ to give $V = \frac{4}{3}\pi(2.5 \times 10^{-2})^3$ ✓ $= 6.5 \times 10^{-5}$ m^3

use of $\rho = \frac{m}{V}$ to give $m = \rho V = 8030 \times 6.5 \times 10^{-5}$ ✓ = 0.53 kg

use of $W = mg$ to give $W = 0.53 \times 9.81 = 5.2$ (N) ✓

the first mark is for making some attempt to calculate the volume; ignore power of ten errors.

the second mark is for the correct substitution or for the calculation of mass

the third mark is for going on to calculate the weight

allow ce for incorrect volume or mass but 2 errors = 0/3

no sf penalty but g = 10 N kg^{-1} loses mark

3

(b) distance of line of action of weight to pivot = (0.120 + 0.025) = 0.145 m ✓

moment = force × distance = 5.2 × 0.145 = 0.75 ✓

unit Nm ✓

the first mark is for identifying that the weight of the ball will act through its centre; use of 0.12 m loses this mark

the second is for correctly calculating the moment; allow ce for wrong distance; condone force = 5 N (which leads to 0.725)

allow suitable unit consistent with calculation, eg N cm

reject 'nm' or 'NM' etc

3

(c) taking moments about the pivot
clockwise moment from spring = anticlockwise moment from ball
$F \times 0.080 = 0.75$ ✓
$F = 9.4$ N ✓
use of $F = kx$ to give $x = \frac{F}{k} = \frac{9.4}{100} = 0.094$ m ✓

allow ce from (b)

the first mark is for the use of the moment equation

the second mark is for calculating the force on the spring; condone 9.35 and 9.3

the third mark is for calculating the extension; allow calculation in cm

allow ce from the second mark ie use of wrong force; condone 1 sf 0.09 m if (1 sf) 5 N used in (b)

3

(d) the line / pen (initially) moves up; ignore subsequent motion ✓
(the downwards acceleration of the ball is much less than that of the frame and) the ball does not move (very far in the time taken for the frame to move down) ✓

the first mark is for stating the correct direction of the line / pen; allow 'diagonally up', 'up then down' but reject 'up and down'

the second mark is for an explanation which shows some understanding of the relative displacement of the ball and frame; this mark is consequential on the first being correct; condone 'ball has inertia'

2

[11]

8 A

[1]

9 A

[1]

10 C

[1]

11 C

[1]

12 C

[1]

Examiner reports

1 In part (a), many students confused strain with stress and there were many vague descriptions rather than definitions, for example ‘amount of extension due to a force applied’. The definition has to describe how a correct strain would be calculated. Therefore, it is essential that the ‘original’ length is specified and the phrase ‘divided by’ rather than ‘compared to’ needs to be used. Some students used the word ‘from’ to convey ‘divided by’ for example, ‘the extension from the original length’. This was not accepted. ‘The ratio of the extension from the original length’ was acceptable.

Only 1.9×10^8 was accepted as an answer to part (b). Few students strayed from 1.9. However, many lost the mark by missing out the power of ten.

Most students did very well on part (c). Nearly all put the point in a sensible place just beyond the linear section but a few did not include a suitable label and therefore they did not get the mark.

Most students were very successful in part (d). Most chose the straight section for the gradient calculation and most chose a large enough section of it. Some went to a stress of 1.3 or more where the line was clearly curving. The unit was usually correct but a few had capital M or m^{-1}. Surprisingly, a significant number missed the unit out altogether.

Part (e)(i) should have been a straightforward question. Most students identified the correct area to evaluate but either did not use an accurate method or did not recognise the value of each square they counted. A very common answer was 38 rather than 38×10^5. Many divided the area into two triangles and a rectangle, leaving out a significant area from their calculation. With a number of similar examples of area approximation on past papers, it was surprising that very few were able to score both marks here. Many students do not know how to find the area under a curve to a sufficient accuracy.

Many students obtained the volume in answer to part (e) (i) but did not realise that they then needed the value they calculated from part (e) (i).

In part (f), many students did not recognise that a higher Young Modulus would give a steeper line and many who did realise this did not stop their line at 176 MPa. Many showed excessive curvature not characteristic of a brittle material.

2 A surprisingly large number of candidates divided the mass by four to get a .weight. of 5500 kg in part (a) (i). Many also forgot to divide by four in what should have been a fairly uncomplicated question.

In part (a) (ii), many candidates simply multiplied the mass of 22000 kg by 32, indicating a surprising confusion between weight and mass. For the unit mark there were many common errors such as N, NM, Nm^{-1}, Nm^{-2}, J, nm, kg and Nkg^{-1}.

A very easy mark for mentioning the .counterweight. was picked up by most candidates in part (a) (iii). However, not many went on to discuss the .anticlockwise moment. that this provides.

Most picked up the first two marks to part (b) (i), some as a result of the ecf for the tension. Many candidates used wrong units; pa, PA, Nm^{-1}, being common rather than Pa.

Those with an ecf in (b) (i) generally failed to get both marks to part (b) (ii) because they did not arrive at 17 mm. This may have given some candidates a clue that one of their previous answers was incorrect. The candidates who were successful on the first parts of the question invariably scored both marks here.

4 Hooke's law, in part (a), was generally known to candidates although many did not state the condition under which it applied. Many introduced temperature into the argument.

The calculation in part (b) was usually correct with comparatively few candidates adding the two lengths or adding the values of the Young moduli to perform just one calculation. Questions on density, similar to those in part (b) (ii), are usually done well, and this question was no exception. Full marks were quite common in part (b).

Part (c) also proved to be relatively easy with the large majority of candidates obtaining the correct answer. Those who failed were usually those who tried to tackle it from a Young modulus point of view.

5 Part (a) required students to state the meaning of tensile stress and tensile strain. Marks were frequently lost due to a lack of precision in technical language. For example it was common to see force per unit area rather than cross-sectional area and change in length per length rather than extension per original length. In (b) a significant proportion of students were able to select an appropriate property for material but only about half of those correctly identifying the property were then able to give a suitable explanation. The calculation in part (c) was well done with over half the students being awarded full marks. The main errors were an incorrect calculation of cross-sectional area due to using the diameter as a radius or a power of ten error when using GPa. Question 3.4 was a level of response marked question and some very impressive answers were seen. About 30% of students were placed in the top band. Some answers were spoilt when students did not give complete answers. This was because although they correctly identified the material for the applications they did not explain why other materials would be rejected. Generally students were more successful in the selection of material for the lift cable than they were for the rope for bungee jumping. This was in part due to them thinking that in order for a material to be elastic it had to obey Hooke's law and thus have linear stress strain characteristics. This led them to think that material D was not behaving elastically and therefore should be rejected for both applications. Overall however, this question seemed to generate better answers than has been the case with extended prose questions in previous specifications.

6 Most scored very well on parts (a) (i) and (ii), which were fairly straightforward questions, though occasionally the answers to (a) (i) and (a) (ii) were given the wrong way round.

In part (b) Quality of Written Communication was assessment. Many candidates did not specify a distance measuring instrument (a ruler); perhaps failing to state the obvious.

Very few recognised the need to specify a suitable number of different loads over the complete range. This would be important in order to obtain the true shape of the curve; six marks were only awarded if the candidate specified seven or more loads.

Many candidates forgot to include the unloading of the rubber cord in their answers and would have benefited greatly from re-reading the question and their answer here.

Candidates in a few centres appeared to use mnemonics to remember the elements necessary in answering this type of question; this seemed to work quite well.

7 This question required students to apply their knowledge and understanding of physics to a simple seismometer. Although the diagram contained a lot of information, and there was a relatively long stem to the question, there was no evidence to suggest that students found the context particularly demanding.

(a) This was a multi-step calculation that most students found fairly straight forward. The common errors seen were wrong substitution of diameter (or use of a wrong formula for volume) and power of ten errors arising from calculation of volume in cm^3. Students who have difficulty converting between cm^3 and m^3 would be better advised to work in m from the outset. Generally “show that” questions are used to provide unsuccessful students the data they would need to complete further parts of the question. Students should be reminded to provide at least 1 sf more than the “show that” value, and they should be discouraged from trying to calculate an answer backwards. Another error is forcing their answer to be near the “show that” value: many students were denied consequential error marks when, having made an error, they attempted to manipulate their answer to obtain a numerical value near 5. For example, students who used 5 cm for the radius could obtain a value of 4.2 kg for the mass. Many would then miss out the step (multiplying by g) to determine the weight, as they had already reached a value near to 5 perhaps. Many modern calculators generate results as fractions or surds. No credit is given for final answers given in such a form or with recurring notation but there is no penalty for this with intermediate results. However students should be discouraged from doing this because it makes the work less transparent and inhibits error-checking. The rounding down of intermediate results compromises the chance of full credit; any rounding down, e.g. to the same significant figures as that of the least accurate data should not be done until the final stage is complete.

(b) There were two potential errors in answers that often led students to lose at least one mark. Many students did not take the centre of mass of the ball into account, and therefore did not include the radius when calculating the distance to the pivot. Some students worked through their answers in cm, but wrote the moment unit as Nm.

(c) Many good answers were seen to this multi-step calculation and this was a good discriminator. Some students were unable to suggest much beyond picking $F = 5\ N$ and rearranging $F = k\Delta l$ (given on the data sheet) to produce $\Delta l = 0.05$ m. Spotting that this was a 3 mark question may have led some of them to realise that a more complicated calculation was needed. Others tried to calculate the extension by dividing turning moment by stiffness or by multiplying distance from the pivot by stiffness. A number of students did not attempt this question.

(d) This was a fairly demanding question that aimed to get students to think about the reason for having the heavy ball in the seismometer. Successful answers were able suggest that, in the very short length of time involved, the ball would barely move and therefore the arm holding the pen would pivot about the ball, causing the upwards line. Many incorrect answers were seen: some students were convinced there was a third law or conservation of momentum explanation while others said the spring, having become compressed, then pulled the arm up. It seemed that many felt that the downwards accelerating seismometer took the ball with it and so the line went downwards. No credit was earned for saying the pen or the arm did not move, likewise any suggestion of an ‘up and down’ motion of the pen (although ‘up then down’ could earn a mark).