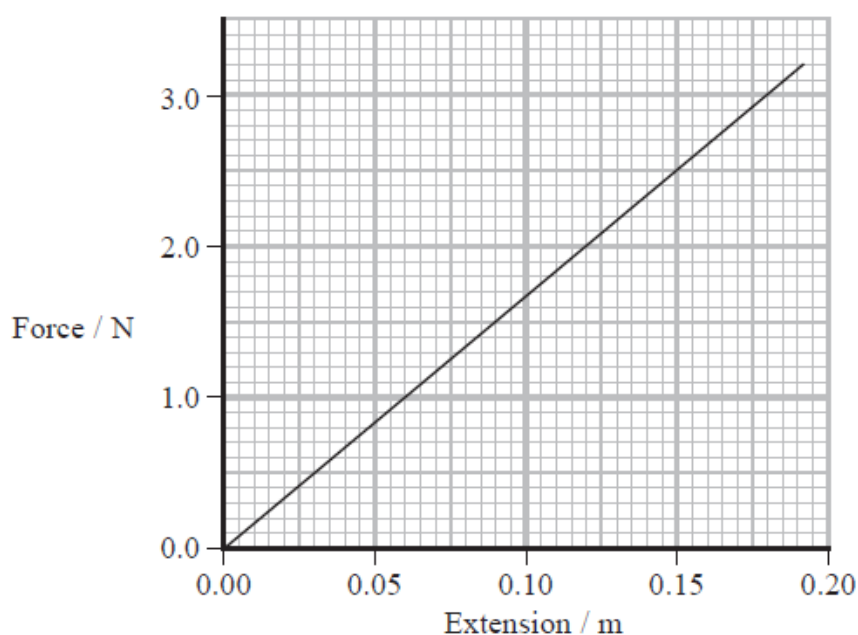


Questions

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

A force-extension graph for a spring is shown.



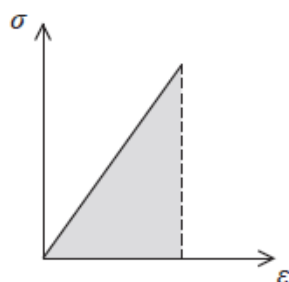
Which of the following gives the work done, in joules, in extending the spring by 0.15 m from its original length?

- ☒ A 0.15×2.5
- ☐ B $0.5 \times 0.15 \times 2.5$
- ☐ C $\frac{2.5}{0.15}$
- ☐ D $\frac{0.15}{2.5}$

(Total for question = 1 mark)

Q2.

A force was applied across the ends of an iron bar. The following stress-strain graph was obtained.



The shaded area represents

- ☐ A $\frac{\text{work done}}{2 \times \text{volume}}$
- ☐ B $\frac{\text{work done}}{\text{volume}}$
- ☐ C $\frac{2 \times \text{work done}}{\text{volume}}$
- ☐ D work done

(Total for question = 1 mark)

Q3.

A sample of steel in the form of a wire is subjected to an increasing load.

Which of the following is the best description of the elastic limit of the steel?

- ☐ A The stress at which the steel undergoes an increase in strain with no increase in stress.
- ☐ B The stress beyond which the stress and strain are no longer proportional.
- ☐ C The stress beyond which the steel becomes permanently deformed.
- ☐ D The stress at which the steel breaks.

(Total for question = 1 mark)

Q4.

A spring obeys Hooke's law. A force of 2.0 N extends the spring by 0.30 m.

The energy stored in the spring when a force of 2.0 N is applied is

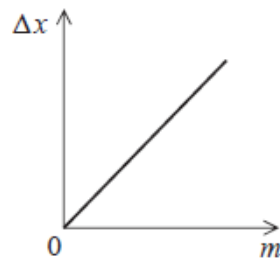
- ☐ **A** 0.09 J
- ☐ **B** 0.30 J
- ☐ **C** 0.60 J
- ☐ **D** 0.90 J

(Total for question = 1 mark)

Q5.

A spring is hung vertically and masses are added to the lower end.

The graph shows how the extension Δx of the spring varies with the mass m added.



The work done in extending the spring can be expressed as

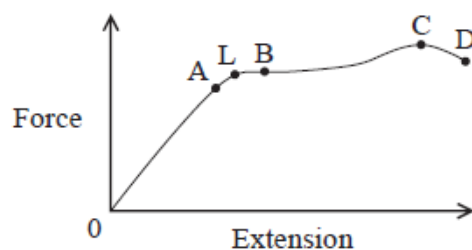
(1)

- ☐ **A** $mg\Delta x$
- ☐ **B** $\frac{mg}{\Delta x}$
- ☐ **C** $\frac{1}{2}mg\Delta x$
- ☐ **D** $\frac{mg}{2\Delta x}$

(Total for question = 1 mark)

Q6.

The diagram shows a force-extension graph for a wire.



L is the elastic limit.

Which point represents the yield point?

(1)

☐ A

☐ B

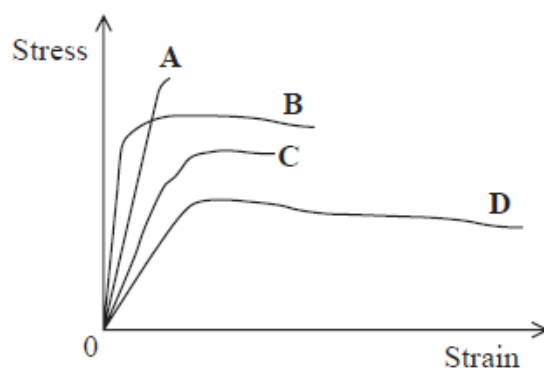
☐ C

☐ D

(Total for question = 1 mark)

Q7.

Stress-strain graphs are drawn for four different materials, **A**, **B**, **C** and **D**.



Which of the materials has the greatest strength?

☐ A

☐ B

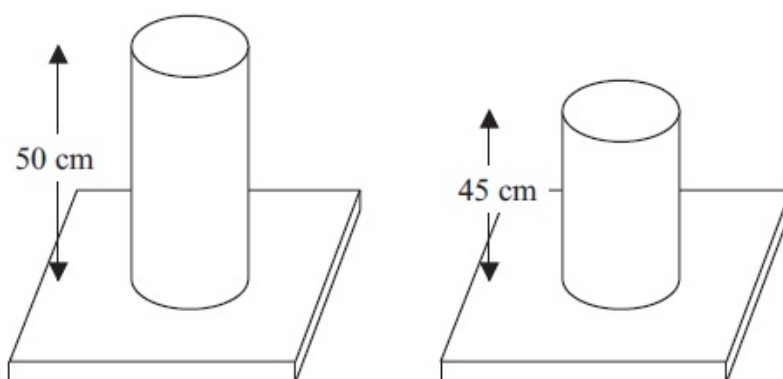
☐ C

☐ D

(Total for question = 1 mark)

Q8.

A cylinder of length 50 cm has a force applied to it. The new length of the cylinder is 45 cm.



The quantity determined using is $\frac{5 \text{ cm}}{50 \text{ cm}}$ is

☐ A compressive strain.

☐ B compressive stress.

☐ C tensile strain.

☐ D tensile stress.

(Total for question = 1 marks)

Q9.

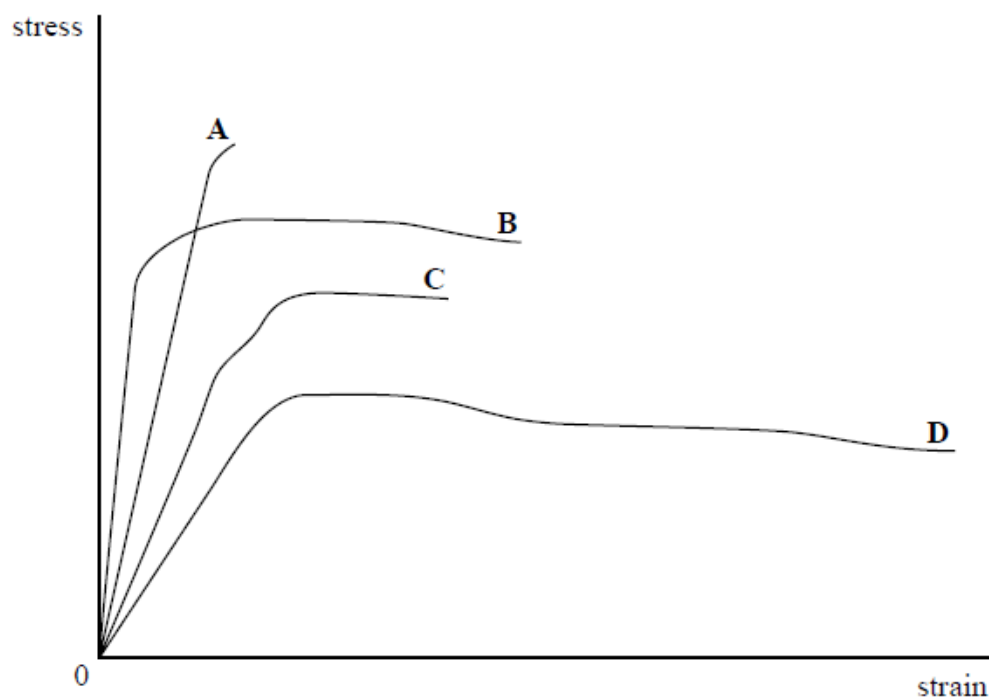
A spring with a spring constant 140 Nm^{-1} is extended. The elastic potential energy stored is 1.6 J

The extension of the wire is found using

- ☐ A $\frac{1.6}{140}$
- ☐ B $\frac{2 \times 1.6}{140}$
- ☐ C $\sqrt{\frac{1.6}{140}}$
- ☐ D $\sqrt{\frac{2 \times 1.6}{140}}$

(Total for question = 1 mark)

Q10.



Which of the materials represented in the graph has the largest value of the Young Modulus?

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for question = 1 mark)

Q11. Which pair of quantities does **not** contain a vector and a scalar?

- ☐ **A** acceleration and time
- ☐ **B** force and displacement
- ☐ **C** mass and acceleration
- ☐ **D** velocity and time

(Total for Question = 1 mark)

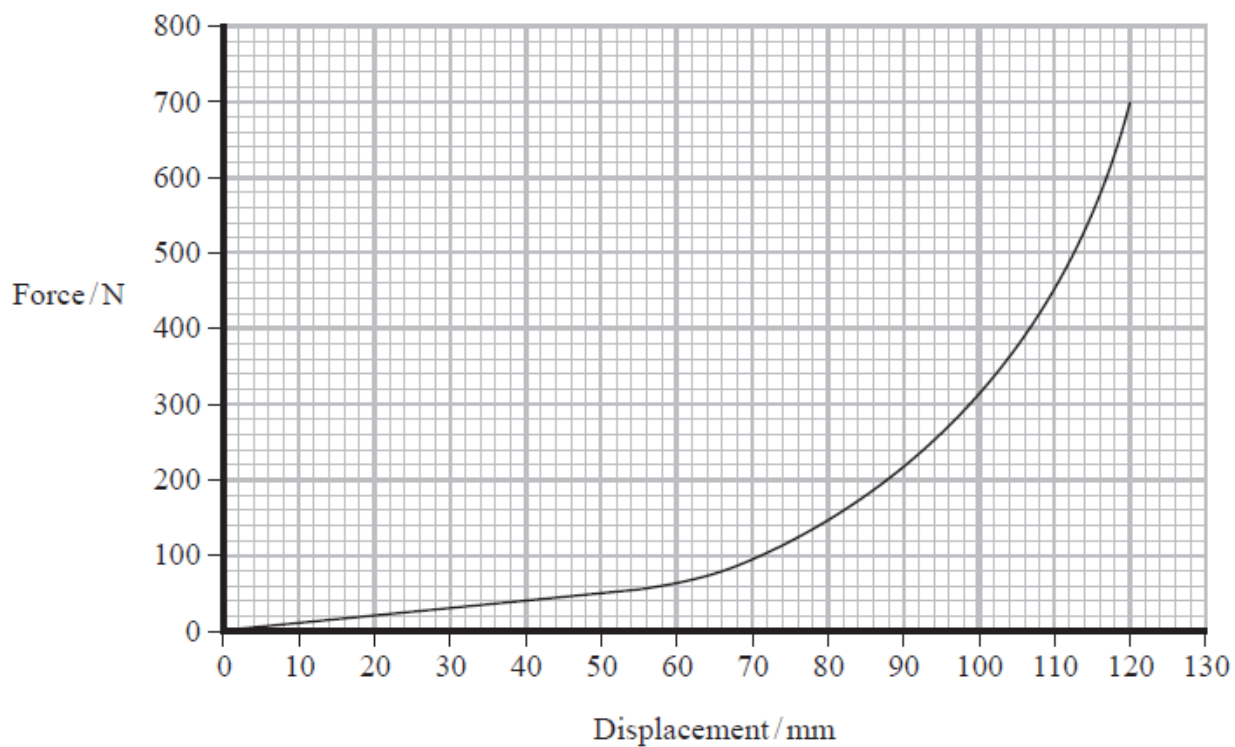
Q12.

In a conical spring the diameter of the coils increases over its length. The spring can be designed so that each coil fits into the inner diameter of the next coil so they take up minimal space when fully compressed.



(Source: © Anatolii Riabokon/Alamy Stock Vector)

A conical spring is compressed against a flat surface. The graph shows the force-displacement graph for the spring as the compression force increases from 0 N to the point when the spring is fully compressed.



The spring obeys Hooke's law for small compression forces.

Determine a value for the spring constant of the spring for compression forces up to 60 N.

(2)

.....

.....

.....

.....

Spring constant =

(Total for question = 2 marks)

Q13.

A student is investigating the extension of a spring.

A force of 29 N is applied to the spring and it extends by 32 cm. The spring obeys Hooke's law.

Calculate the work done on the spring.

(2)

.....

.....

.....

.....

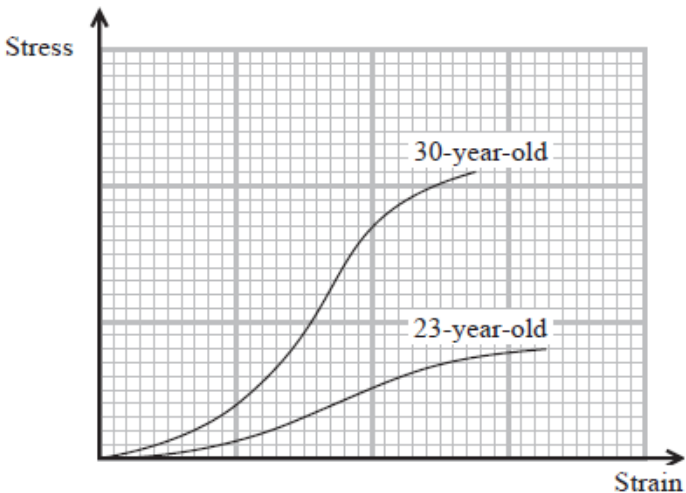
Work done =

(Total for question = 2 marks)

Q14.

The power of the lens in the human eye changes as the lens changes shape. This enables a person to see objects at different distances clearly. To change the shape, muscles in the eye put the lens under stress.

A stress-strain graph for the eye lens for people of different ages is shown.



(i) State one difference between the lens of a 23-year-old and the lens of a 30-year-old.

(1)

.....

.....

(ii) Give a reason for your answer, making reference to the graph.

(1)

.....

.....

(Total for question = 2 marks)

Q15.

Concrete is a material used in buildings due to its high compressive strength.

Another concrete post is reinforced with steel rods, to increase its tensile strength.
A steel rod is under a tensile load of 130 N and extends by 4.0×10^{-4} m.
The steel has not reached its elastic limit.

Calculate the elastic strain energy in the steel rod.

(2)

.....

.....

.....

Elastic strain energy =

(Total for question = 2 marks)

Q16.

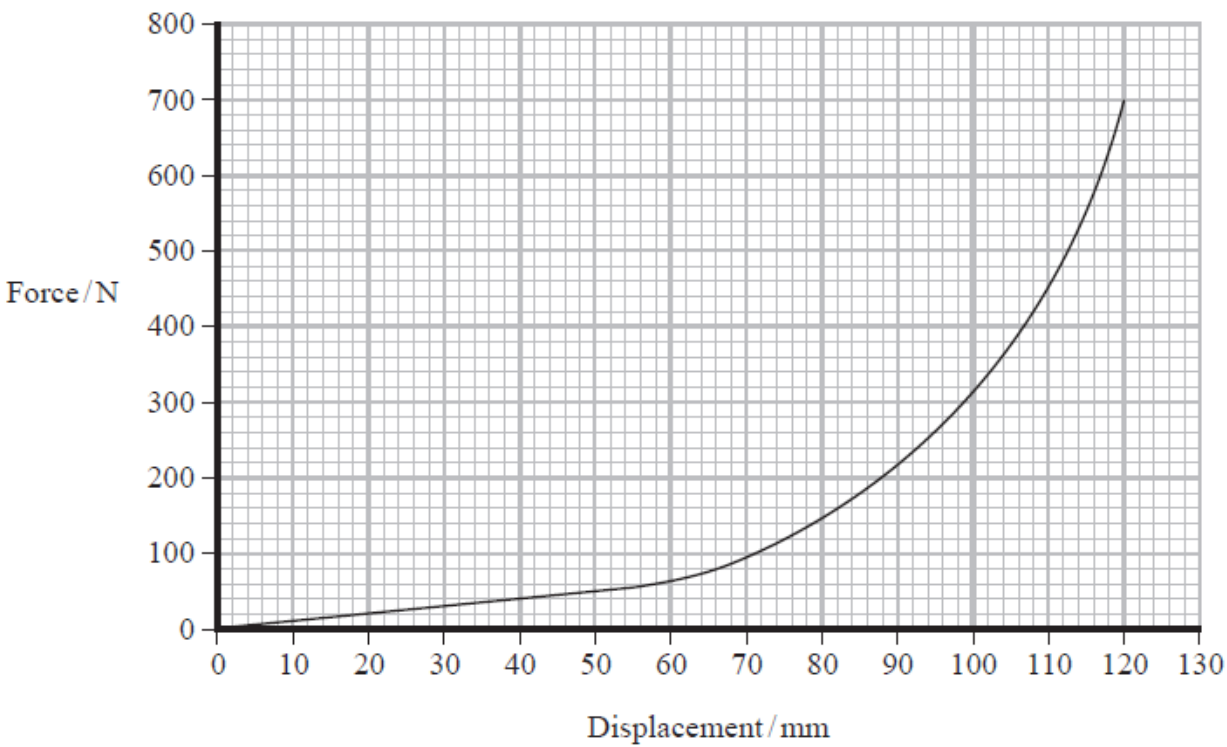
In a conical spring the diameter of the coils increases over its length. The spring can be designed so that each coil fits into the inner diameter of the next coil so they take up minimal space when fully compressed.



(Source: © Anatolii Riabokon/Alamy Stock Vector)

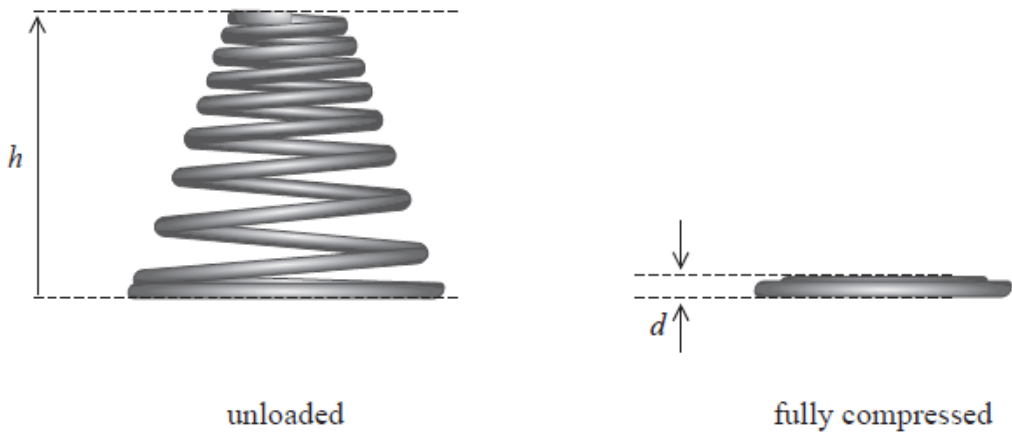
A conical spring is compressed against a flat surface. The graph shows the force-displacement

graph for the spring as the compression force increases from 0 N to the point when the spring is fully compressed.



The spring obeys Hooke's law for small compression forces.

When fully compressed all the coils lie flat inside each other.



The height h of the spring when unloaded is 126 mm.

Calculate the diameter d of the wire in the spring.

(2)

.....

.....

.....

.....

Diameter =

(Total for question = 2 marks)

Q17.

b) A molecule of carbon monoxide consists of one atom of carbon bonded to one atom of oxygen.

The bond between the two atoms can be modelled as a spring as shown.



The spring has a stiffness constant k .

At equilibrium the distance d between the two atoms is 12 nm.

External forces caused d to increase to 18 nm.

Calculate the increase in the potential energy between the two atoms.

$$k = 1195 \text{ N m}^{-1}$$

(2)

.....

.....

.....

.....

Increase in potential energy =

(Total for question = 2 marks)

Q18.

In an investigation to determine the Young modulus of a material in the form of a wire, a tensile force of 14 N was applied to the wire. The length of the wire was 2.0 m. The diameter of the wire

was 2.5 mm. The length of the wire increased by 0.20%.

Calculate the energy stored in the stretched wire.

(2)

.....

.....

.....

.....

Energy stored =

(Total for question = 2 marks)

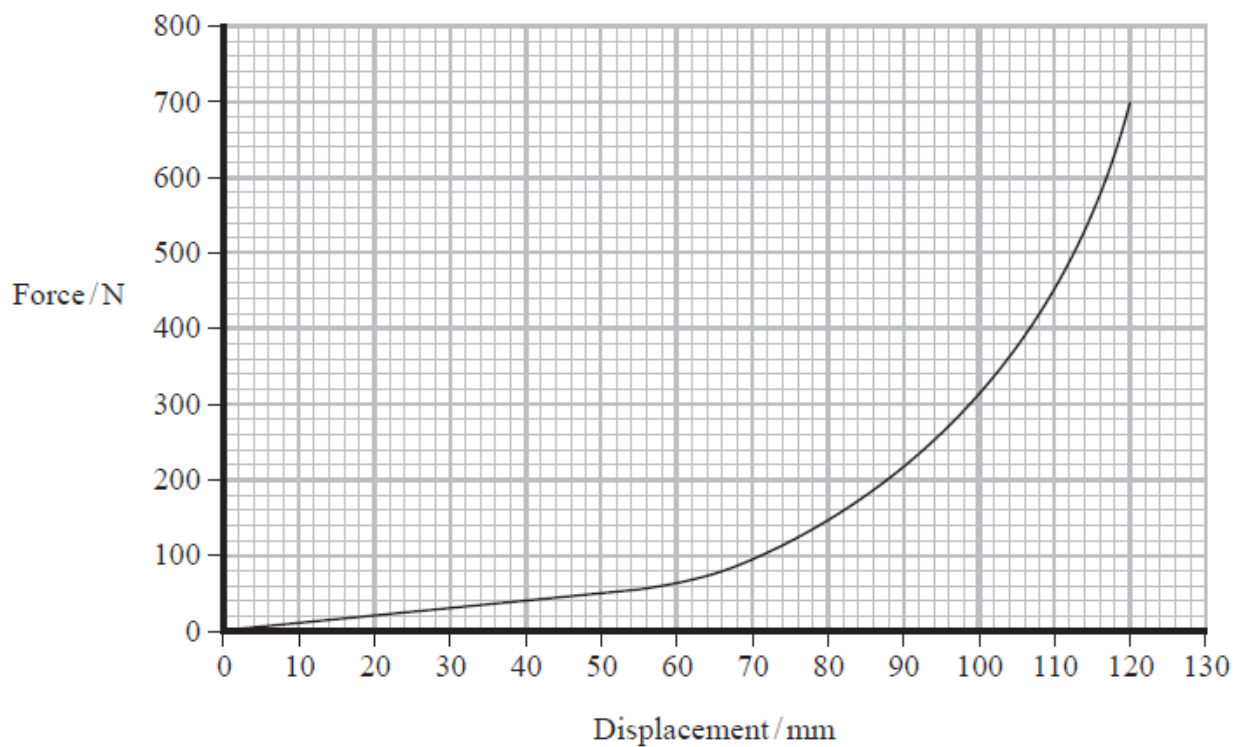
Q19.

In a conical spring the diameter of the coils increases over its length. The spring can be designed so that each coil fits into the inner diameter of the next coil so they take up minimal space when fully compressed.



(Source: © Anatolii Riabokon/Alamy Stock Vector)

A conical spring is compressed against a flat surface. The graph shows the force-displacement graph for the spring as the compression force increases from 0 N to the point when the spring is fully compressed.



The spring obeys Hooke's law for small compression forces.

The compression force is increased from 60 N to 220 N.

Determine a value for the additional energy stored in the spring due to this increase in force.

(3)

.....

.....

.....

.....

.....

.....

.....

Additional energy =

(Total for question = 3 marks)

A manufacturer gives the following information about a spring.

1. Follows Hooke’s law up to loads of 5 N

2. Maximum extension without permanent deformation 0.4 m

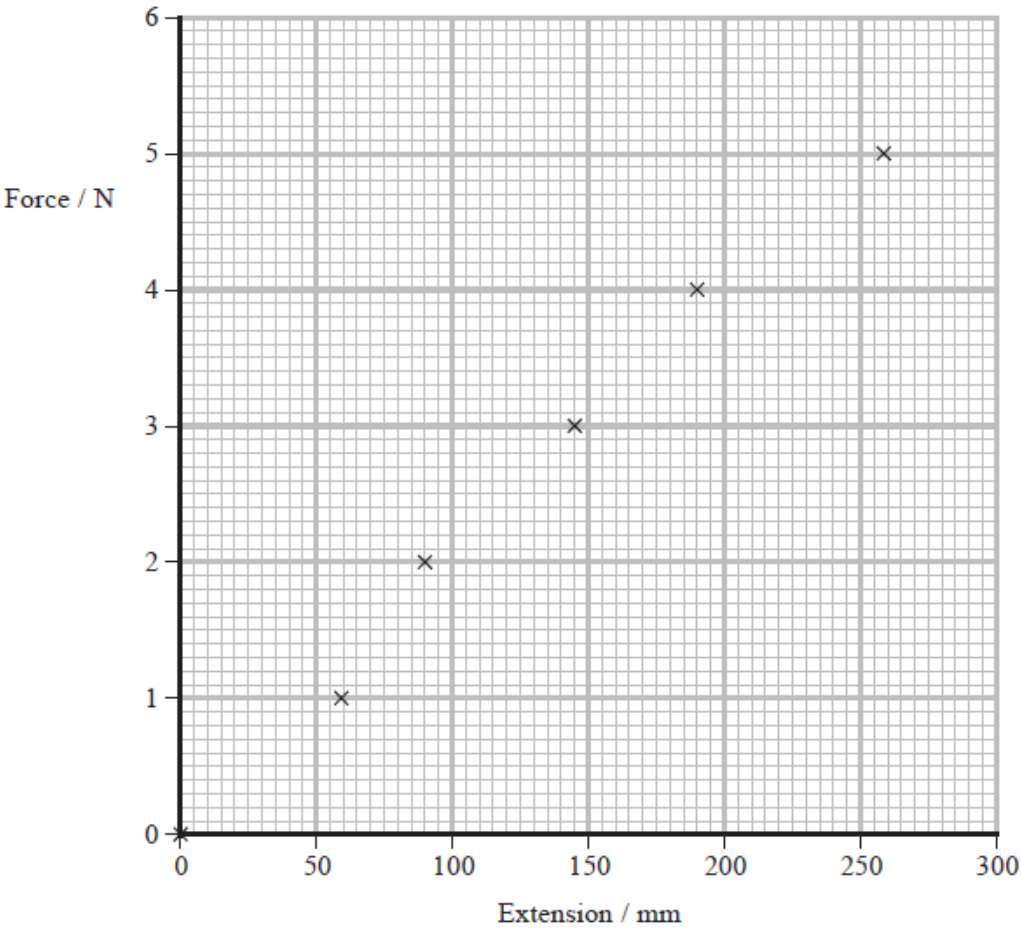
3. Stiffness $21\text{ N m}^{-1} \pm 5\%$

4. Stores up to 1.6 J

A student carried out an investigation on the spring to test this information.

She applied a range of forces from 0 N to 5 N to the spring. She measured the length of the spring and recorded the extension for each force.

She plotted a graph of force against extension.



Determine the stiffness of the spring.

(3)

.....

.....

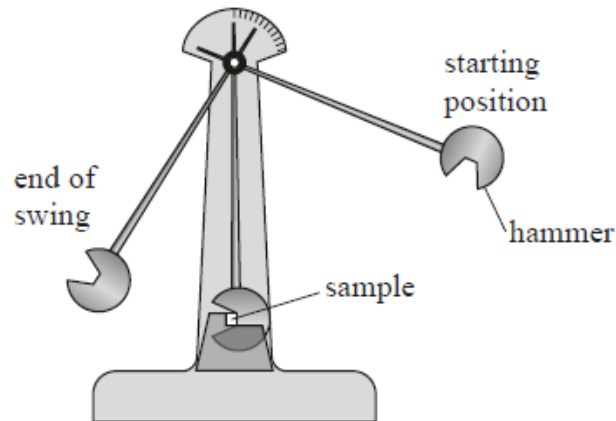
.....

.....

Stiffness =

Q21.

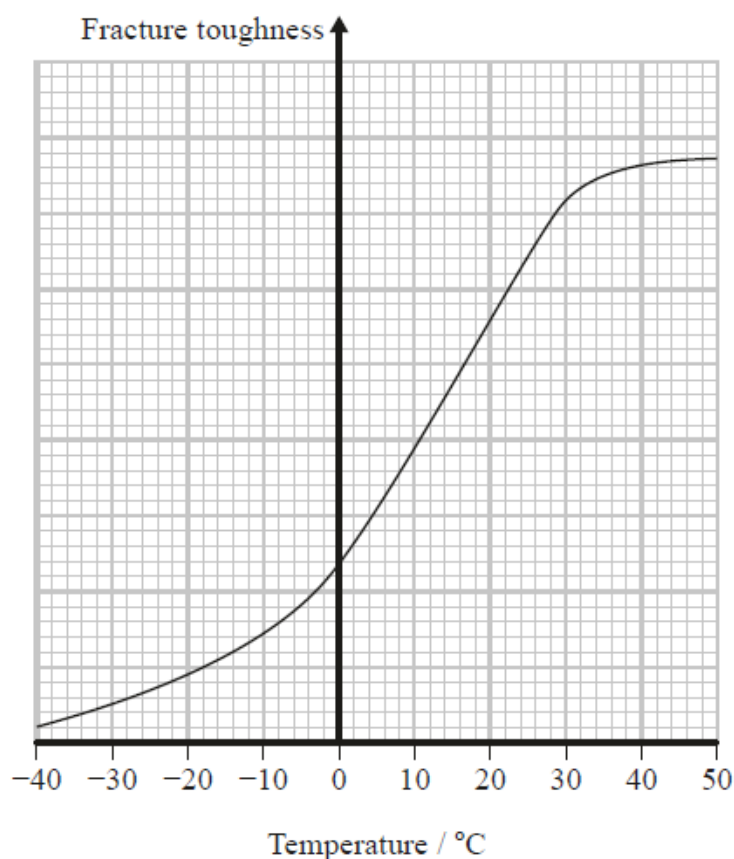
Read the passage and answer the questions below.



(ref: Physics Review April 2015 p22)

The Charpy test is used by scientists to measure the fracture toughness of a material. A simple pendulum, with a hammer on the end, is held high and released so that it swings down and strikes the sample. The height from which the hammer is released is increased until the sample fractures. Some energy is absorbed by the sample in the impact but the hammer continues to move until it comes to rest at the top of its swing. Due to the law of conservation of energy the hammer will not swing up as high as its starting position. The difference in height between the start and end is proportional to the energy absorbed in the impact – the fracture toughness.

The sketch graph shows how the fracture toughness of a sample of steel varies with temperature.



A material with a low fracture toughness can absorb less energy before fracture than a material with high fracture toughness.

The ship *Titanic* sank in 1912 following a collision with an iceberg in the icy waters of the Atlantic. The steel hull of the ship was fractured by the impact.

Deduce why the steel was likely to have been fractured by the impact.

(3)

.....

.....

.....

.....

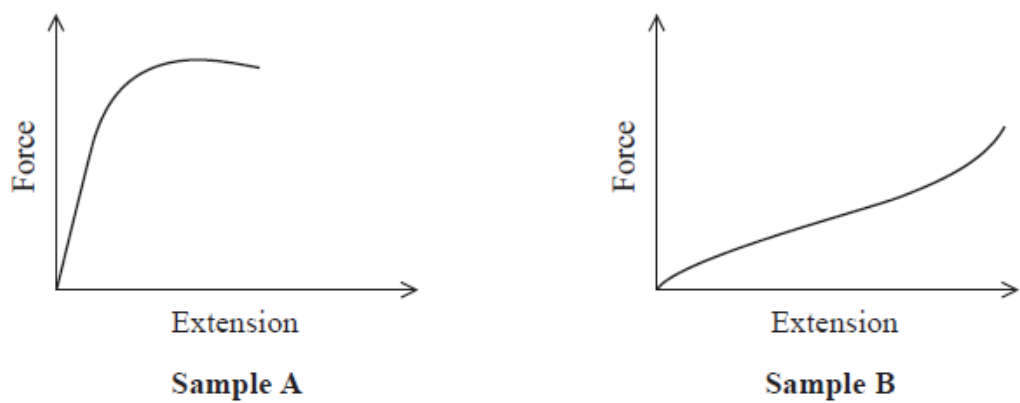
.....

.....

(Total for question = 3 marks)

Q22.

In a physics lesson the following graphs are given to the students. The graphs show the relationship between force and extension for samples of two different materials, A and B.



A student states that sample A obeys Hooke's law for small extensions and sample B does not. Use the graphs to explain the validity of the student's statement.

(3)

.....

.....

.....

.....

.....

.....

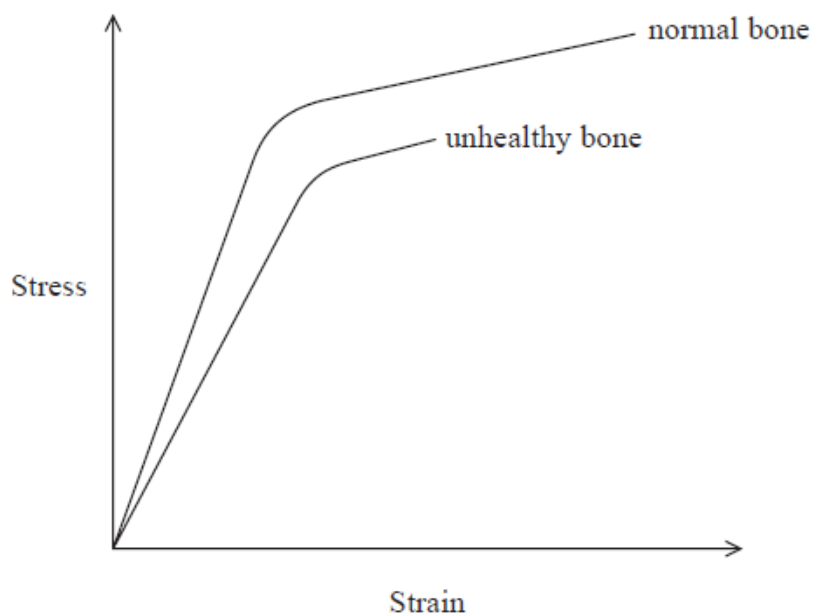
.....

(Total for question = 3 marks)

Q23.

Some sports place high stresses on the bones in the body, which can result in injury.

The graph shows how stress varies with strain for normal bone and for unhealthy bone.



Describe how the graph shows that unhealthy bone under stress is more likely to break than normal bone.

(3)

.....

.....

.....

.....

.....

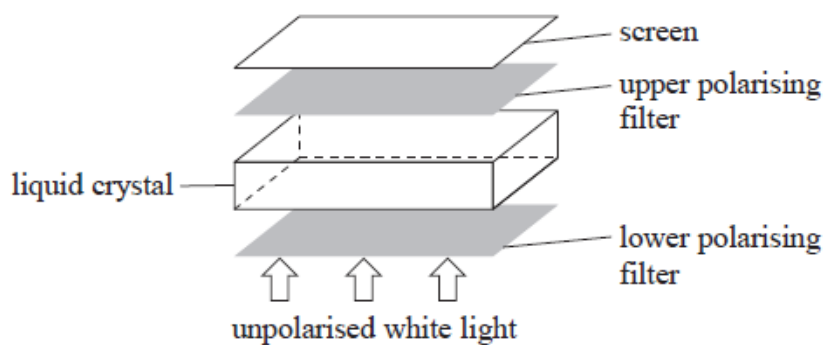
.....

(Total for question = 3 marks)

Q24.

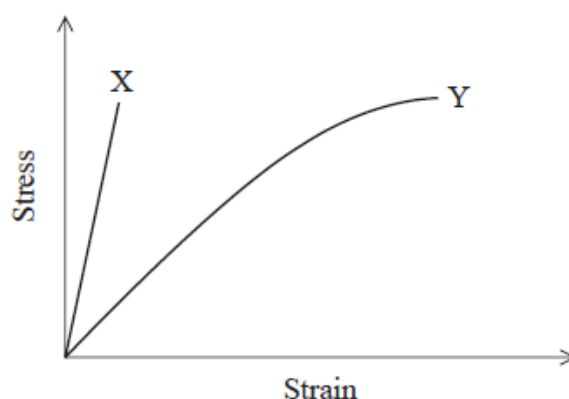
A liquid-crystal display uses a series of segments to form letters and numbers on a screen.

The construction of a display segment is shown.



- Unpolarised white light passes through the lower polarising filter and becomes plane polarised.
- When there is no potential difference (p.d.) across the liquid crystal, the molecules in the liquid crystal rotate the plane of polarisation by 90° .
- Light then passes through the upper polarising filter and appears on the screen.
- When a p.d. is applied across the liquid crystal, the molecules no longer rotate the plane of polarisation. The light will not pass through the upper polarising filter and the screen appears dark.

Manufacturers are developing new materials for flexible screens for liquid-crystal displays. The graph shows how stress varies with strain for two materials X and Y up to typical stresses that would be applied to the screens in normal use. Both materials behave elastically over the ranges shown.



Deduce which material would be more suitable to use for the flexible screen in liquid-crystal displays.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

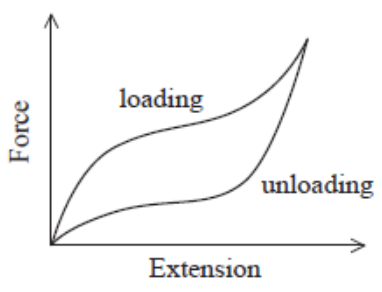
(Total for question = 4 marks)

Q25.

* A resistance band is a length of an elastic material that can be used for exercise. The user repeatedly applies an increasing tensile force (loading) and then releases the force (unloading).



The force-extension graph for the resistance band is shown.



The user finds that the band gets warm during use.

Describe, with reference to the graph, the behaviour of the resistance band when it is repeatedly loaded and unloaded.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q26.

Read the following article and then answer the questions that follow.

"The fastest, tallest and longest dive coaster, on which amusement park thrill seekers can experience free fall, is set to open next summer at Cedar Point in Sandusky, Ohio. Valravn is designed to take riders up to a 66 m peak from which they plummet vertically with an acceleration g and feel weightless.

The advent of steel-frame roller coasters in 1959 made taller structures possible.

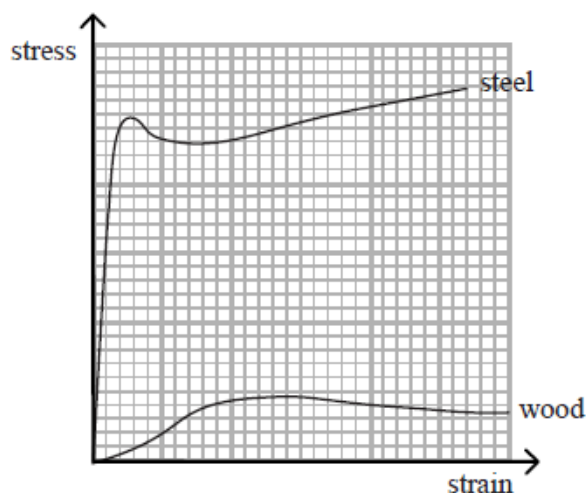
Whereas height remains one of the best ways to attain intense speeds, a coaster car can also be shot from its starting point via electromagnetic propulsion or a catapult. Cars on these launched coasters have the potential to go from zero to 130 km h^{-1} in two seconds.

Although coasters can definitely go faster, they're limited by the acceleration those higher speeds would require. Roller coasters reach their peak speeds in a matter of seconds. The achieved acceleration is what causes g -forces, which allows riders to feel an increased or decreased sense of their mass. These g -forces can be dangerous but they are also well understood by physicists, so roller coasters are built according to strict standards that keep them well within safe levels.

Coasters are only permitted to accelerate up to $6g$."

(Source: *Shriek Science: Simple Physics Powers Extreme Roller Coasters* Hackett Jennifer, Oct 14, 2015)

The graph shows typical stress-strain curves for wood and steel.



Discuss how the use of steel, rather than wood, has made the construction of faster and taller roller coasters possible.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

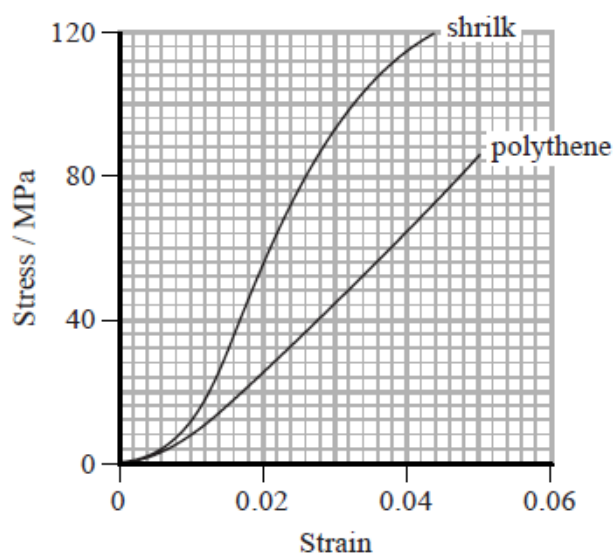
(Total for question = 5 marks)

Q27.

Shrilk is a new material made from discarded shrimp shells. It is biodegradable and is easily moulded into different shapes. Shrilk is an alternative to polythene and could be used to make waste bags in the future.

The graph shows a stress-strain curve for a 25.0 cm length of shrilk and for a similar length of

polythene, up to breaking point.



(a) (i) Calculate the force applied to the shrilk at a strain of 0.02

cross-sectional area = $1.2 \times 10^{-6} \text{ m}^2$

(3)

.....

.....

.....

.....

Force =

(ii) Determine the extension of the shrilk at a strain of 0.04

(2)

.....

.....

.....

.....

Extension =

(b) Deduce whether shrilk or polythene is better for making waste bags.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 8 marks)

Q28.

In 2010, Andre Geim and Konstantin Novoselov were awarded the Nobel Prize in Physics for producing, identifying and studying graphene.

Graphene is a form of carbon which exists only as a single atomic layer of graphite. It has a breaking stress of 130 GPa compared to 0.5 GPa for steel. Some scientists claim that graphene is the strongest material ever measured.

(a) Explain why graphene, despite its greater strength, is unlikely to replace steel in many applications.

(2)

.....

.....

.....

.....

.....

.....

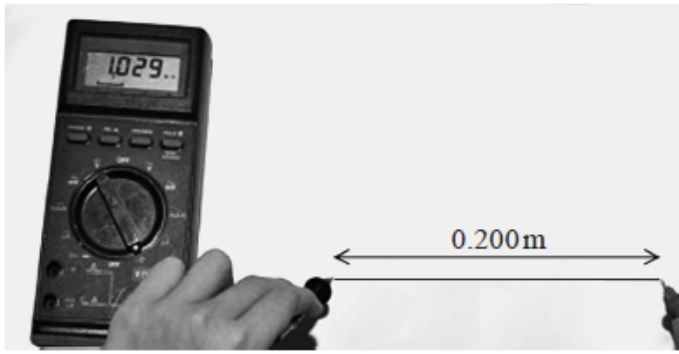
.....

.....

(b) Graphite used in pencils consists of many layers of carbon. It can be assumed that a pencil deposits approximately 100 layers of carbon atoms when drawn across a piece of paper.

A student carried out an experiment to determine the resistivity of the graphite in a pencil.

A line of length 0.200m and width 0.50mm was drawn on a piece of paper. An ohmmeter was then used to measure the resistance of the graphite line.



Calculate the resistivity of graphite.

resistance = $1.029 \times 10^6 \, \Omega$
 diameter of carbon atom = $1.4 \times 10^{-10} \, \text{m}$

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Resistivity of graphite =

(c) Photocells traditionally use silicon to generate electricity using visible light. Research demonstrates that unlike silicon, graphene is able to respond at all wavelengths and releases multiple electrons as it absorbs one photon.

Deduce why it would be an advantage to use graphene in photocells to generate electricity.

(3)

.....

.....

.....

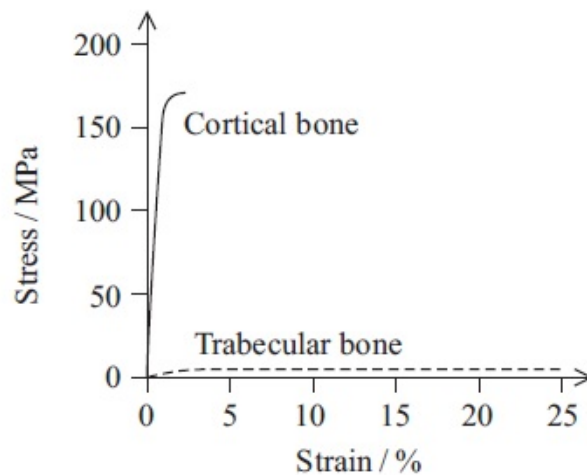
.....

.....

(Total for question = 9 marks)

Q29.

The graph shows the stress-strain curve for two types of human bone under compression.



(a) Use the graph to identify and describe **one** property of cortical bone.

(2)

(b) The table gives the following information for the two types of bone.

Material	Young modulus / GPa	Maximum compressive stress / MPa	Maximum tensile stress / MPa
Cortical bone	17.9	170	120
Trabecular bone	0.076	2.2	

(i) State the difference between compressive stress and tensile stress.

(1)

.....
.....
.....
(ii) State how the graph could be used to confirm the value of the Young modulus for cortical bone.

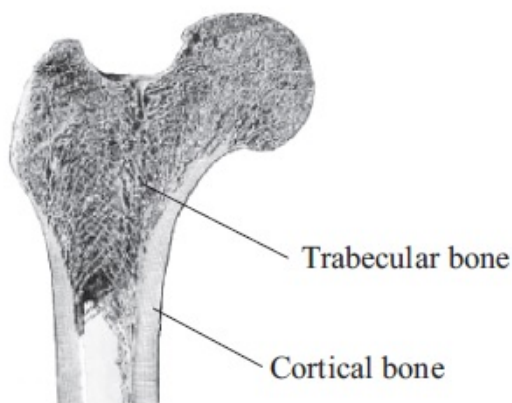
(1)

.....
.....
(iii) A person of mass 90 kg stands on one foot. Show that the maximum weight which can be supported is about 70 times this person's weight. Assume all the weight is supported by the femur (thigh bone) and that it is made of cortical bone.

cross-sectional area of femur = $3.7 \times 10^{-4} \text{ m}^2$

(4)

.....
.....
.....
.....
.....
.....
.....
.....
.....
(iv) It is stated in a text book that a femur can support about 30 times a person's weight.



Explain how the structure shown in the diagram would account for the difference from the calculated value.

.....

.....

.....

.....

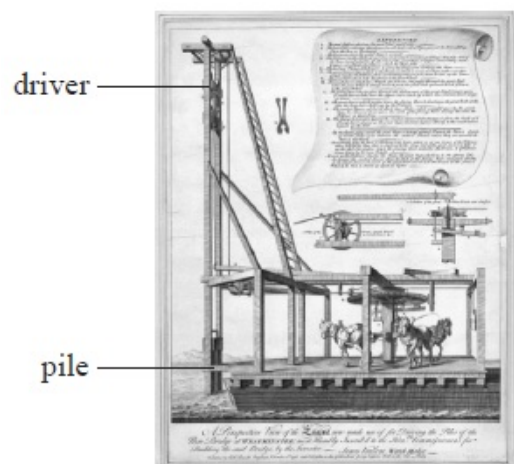
.....

.....

(Total for question = 10 marks)

Q30. Pile drivers have been used for centuries to push piles into the ground for use as foundations of buildings and other structures. A large mass (the driver) is raised and then dropped onto an object (the pile) which is pushed into the ground.

The picture shows the pile driver that was used to build a London bridge in the 17th century.



(a) (i) The driver on the pile driver above had a mass of 810 kg and could be dropped a maximum distance of 6.0 m onto the pile.

Show that the energy transferred from the driver is about 50 kJ.

(2)

.....

.....

.....

(ii) In one instance, 40% of this energy is used usefully to drive in the pile. The pile moves 0.20 m into the ground.

Determine the average resistive force acting on the pile as it moves through the ground.

.....

.....

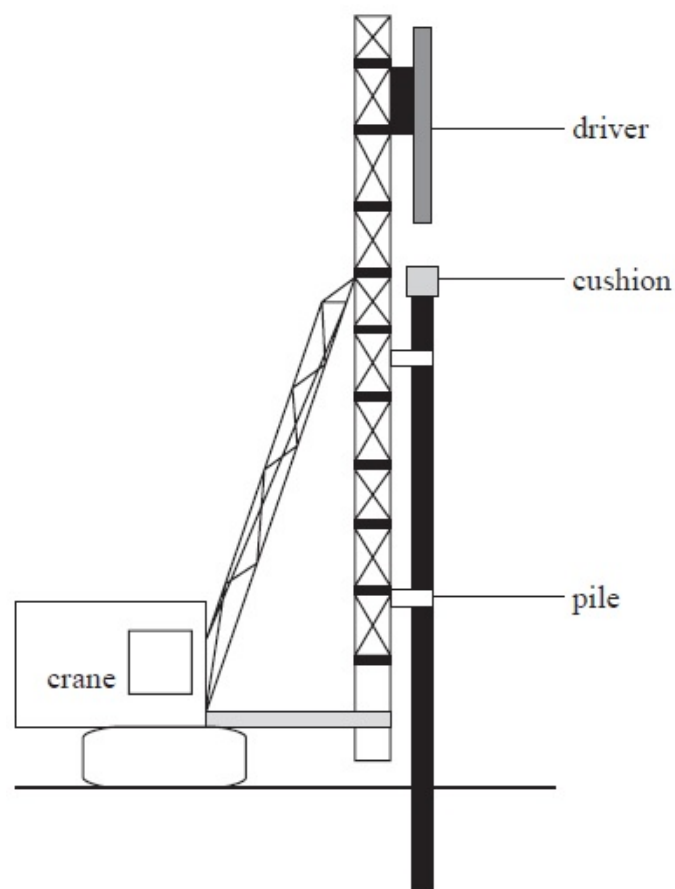
.....

.....

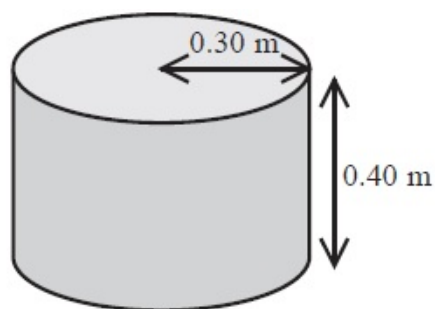
.....

Average resistive force =

(b) In order to protect the driver on modern pile drivers, a cushion made of wood is placed on the pile.



The cushion is a cylindrical piece of wood of Young modulus = 120 MPa



The cushion is compressed when hit by the driver.

(i) The maximum compressive force applied to the wood during impact is 7.0×10^5 N. Show that

the compression of the cushion is about 0.01 m.

(3)

.....

.....

.....

.....

.....

(ii) Calculate the energy stored in the cushion under compression.

(2)

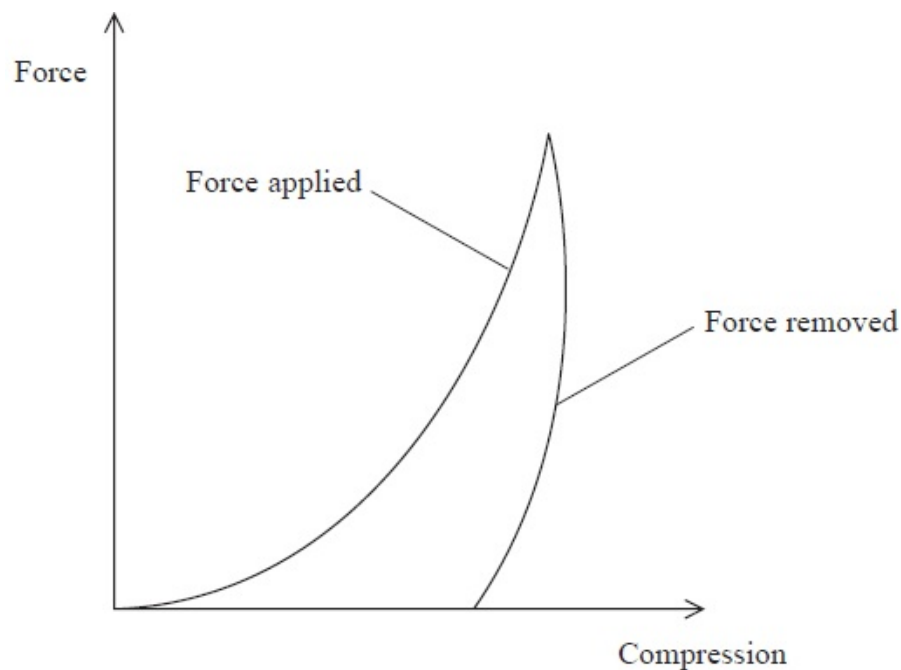
.....

.....

.....

Energy stored =

*(iii) The graph shows how the compression of the wooden cushion varies with force, as the force is applied and removed during an impact.



Use the graph to explain the following:

1. the wooden cushion has to be replaced after a few hundred impacts,

(2)

.....

.....

.....

.....

2. with each impact the temperature of the wooden cushion rises slightly.

(1)

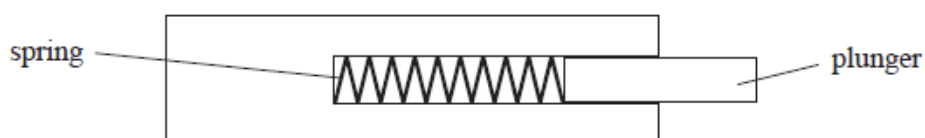
.....

.....

(Total for Question = 13 marks)

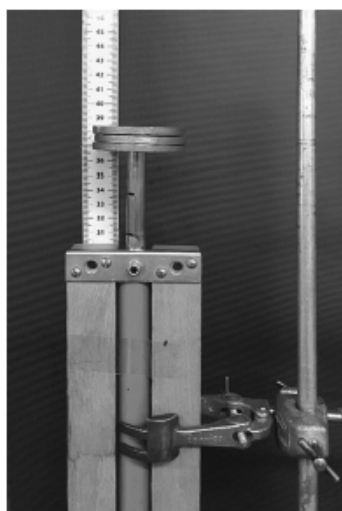
Q31.

A school dynamics trolley has a plunger attached to a spring. When the plunger is pushed in, the spring is compressed. When the plunger is released, it is pushed back out by the spring.



(a) A student investigated the spring to determine whether it obeys Hooke's law in compression.

The trolley was placed vertically in front of a scale and weights were added in turn to the top of the plunger, as shown. The position of the end of the plunger was recorded each time.

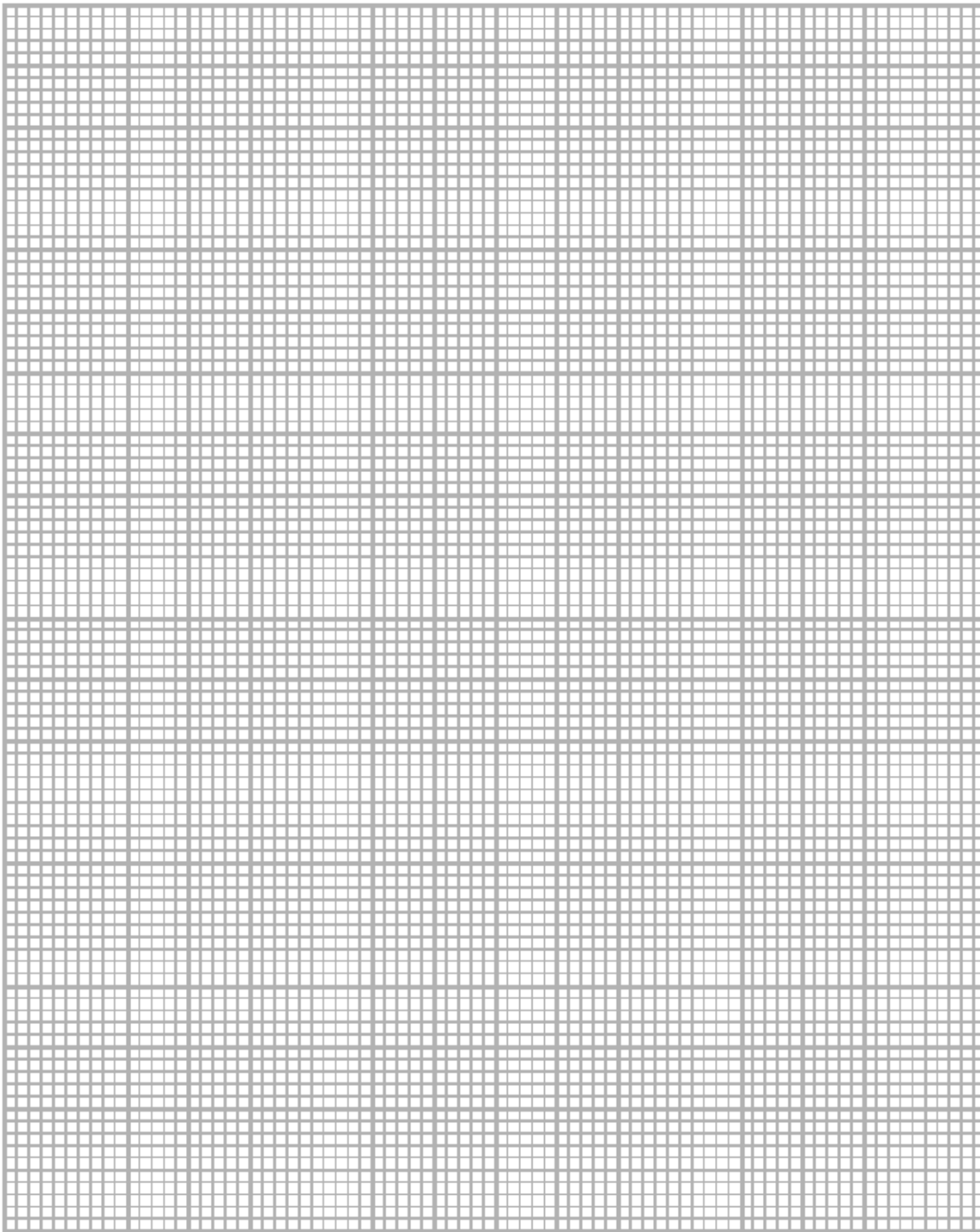


The recorded results are shown in the table.

Weight / N	Position of plunger / cm	
0.00	37.3	
2.00	37.0	
4.00	36.6	
6.00	36.2	
8.00	35.9	
10.00	35.5	

(i) Use the results to plot a graph of weight against compression. You may use the additional column for your processed data.

(5)



(ii) The student concluded that the spring obeys Hooke's law with a spring constant of about 600 N m^{-1} .

Determine whether the student's conclusion is justified.

(4)

.....

.....

.....

.....

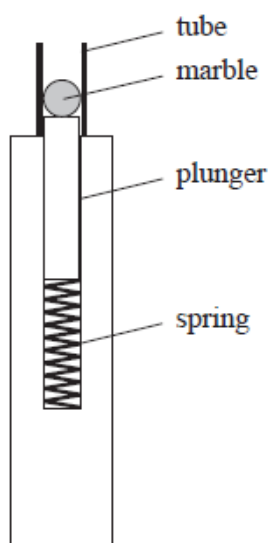
.....

.....

.....

.....

(b) Another trolley was adapted by placing a tube around the plunger so that it could be used to launch marbles. A marble was placed in the tube while the plunger was depressed. When the plunger was released it launched the marble.



Determine the maximum possible launch velocity of the marble when the spring is compressed by 5.4 cm.

spring constant = 610 N m^{-1}

mass of marble = 4.1 g

mass of plunger = 35.4 g

(4)

.....

.....

.....

.....

.....

.....

.....

Maximum launch velocity =

(c) The launch velocity was measured using a light gate and data logger. This produced a smaller value for the launch velocity than that calculated in (b).

Give a reason why this method produced a smaller value for the launch velocity.

(1)

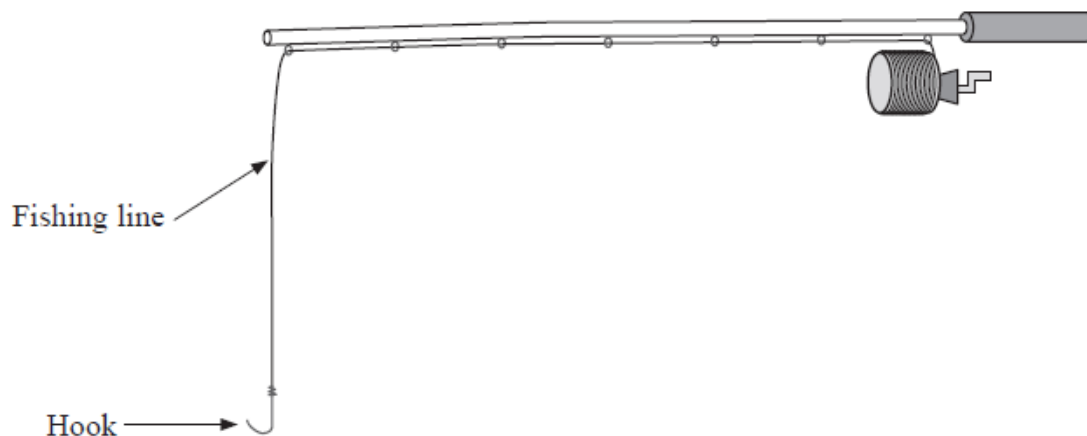
(Total for question = 14 marks)

Q32.

The following three properties can be used to describe copper.

Ductile Malleable Tough

(a) Both nylon and copper can be used to make fishing lines. Copper fishing lines sink faster than those made of nylon. This makes copper fishing lines more suitable for deep water fishing.



(i) By considering the forces acting on the submerged line, explain why nylon is less suitable than copper for deep water fishing. Include a suitable calculation in your answer.

Both lines have the same cross-sectional area.

cross-sectional area of lines = $1.30 \times 10^{-7} \text{ m}^2$

density of saltwater = 1030 kg m^{-3}

weight of 20.0 m of copper line = 0.220 N

weight of 20.0 m of nylon line = 0.0280 N

(4)

.....
.....
.....
.....
.....
(ii) A fish becomes caught on the hook and the copper line extends. Calculate the extension produced.

cross-sectional area of copper line = $1.30 \times 10^{-7} \text{ m}^2$

load on line = 65.0 N

original length of line = 20.0 m

Young modulus of copper = 129 GPa

(3)

.....
.....
.....
.....
.....
Extension =

(b) Some people use fishing lines that have been pre-stretched by loading and unloading.

(i) Sketch the force-extension graph for a copper line during the process of pre-stretching.

(3)



(ii) Suggest a reason why some people prefer to use this type of line.

.....

.....

.....

.....

(Total for question = 11 marks)