This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 01

06NOV2023

Do NOT write in this box. Your MARK will be placed here.

Subject :	A Level : Physics 1 : RB
Class :	11A and 12A
Teacher :	Dr Ruth Brett
Duration :	1 hour

Write your answers in the spaces provided on this question paper. Give your final answers to an appropriate number of significant figures and write the unit if there is one. You should have a physics formula booklet.

Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

Answer multiple choice questions 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 ☒. Each of these questions is 1 mark.

Q1. One end of a 50 cm length of wire is attached to a support. A load is attached to the free end of the wire, which extends by 2 mm.

Which of the following is the strain for the length of wire?

☒ **A** 0.004

☒ **B** 0.04

☒ **C** 25

☒ **D** 250

Q2. A wire breaks when a tensile force T is applied. A second wire, made of the same material, has twice the diameter.

Which of the following is the force required to break the second wire?

☒ **A** $4T$

☒ **B** $2T$

☐ C $\frac{T}{2}$

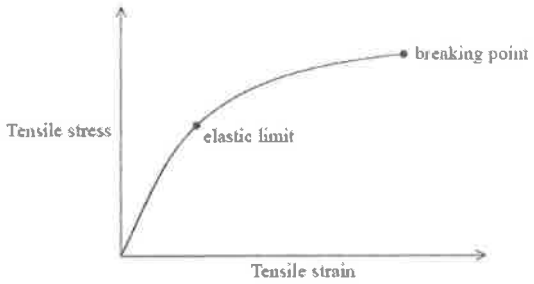
☐ D $\frac{T}{4}$

Q3. The stiffness constant (k) and the Young modulus are terms used in physics.

Which row of the table shows the correct application of these terms?

	Stiffness constant applies to	Young modulus applies to
☒ A	materials	materials
☒ B	objects	objects
☒ C	materials	objects
☒ D	objects	materials

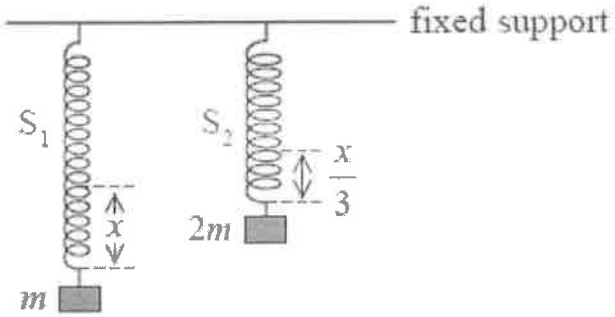
Q4. The graph shows the relationship between tensile stress and tensile strain for a material.



Which of the following gives the Young modulus of the material?

- ☒ **A** the area under the line up to the breaking point
- ☒ **B** the area under the line up to the elastic limit
- ☒ **C** the gradient of the tangent to the line at the origin
- ☒ **D** the stress divided by the strain at the breaking point

Q5. Two different springs, S_1 and S_2, are suspended from a fixed support. Masses are attached to the bottom of S_1 and S_2 as shown.



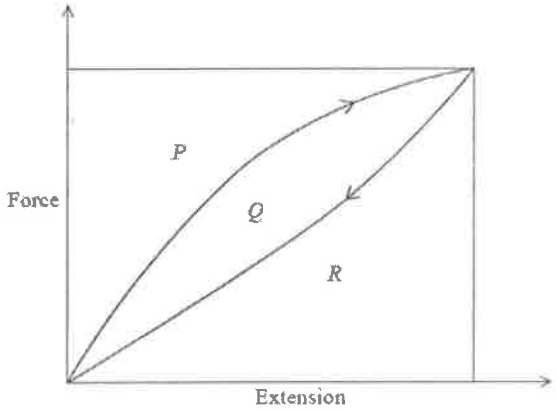
The extension of S_1 is x, and the extension of S_2 is $\frac{x}{3}$. The elastic strain energy in spring S_1 is E.

Which of the following is the elastic strain energy in spring S_2?

- ☐ **A** $6E$
- ☐ **B** $\frac{3E}{2}$
- ☐ **C** $\frac{2E}{3}$
- ☐ **D** $\frac{E}{6}$

Q6. A rubber band is initially stretched by an increasing force. When the force is gradually decreased, the rubber band returns to its original length.

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



P, *Q* and *R* represent different areas of the graph.

Which of the following gives the work done in stretching the rubber band up to its maximum extension?

- ☒ **A** $P+Q$
- ☒ **B** $Q+R$
- ☒ **C** R
- ☐ **D** Q

Q7. When compressed by a force of 50 N, a spring had a length of 12.0 cm.

When compressed by a force of 70 N, the same spring had a length of 7.1 cm.

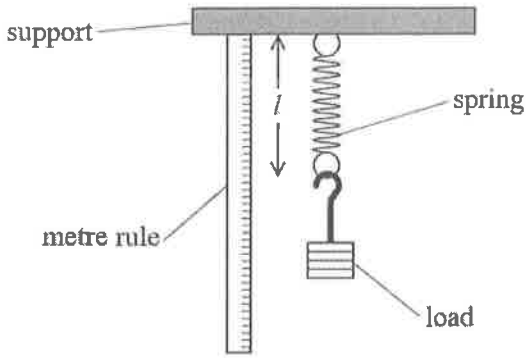
Which of the following expressions gives the stiffness k of the spring in N cm^{-1}?

- ☐ **A** $\frac{70}{12.0} - \frac{50}{7.1}$
- ☐ **B** $\frac{(70-50)}{(12.0-7.1)}$
- ☐ **C** $\frac{50}{7.1} - \frac{70}{12.0}$
- ☐ **D** $\frac{(70-50)}{(12.0-4.9)}$

(Total for question = 1 mark)

Q8. A student investigated the stretching of a spring.

(a) The student added a load to the spring and measured the stretched length l of the spring, as shown.



Describe two techniques the student should use to make this measurement as accurate as possible.

(2)

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(b) The student determined the weight W of different loads and the corresponding values of l. He recorded the results in the following table:

W/N	l/cm
0	5.20
0.2	7.9
0.39	12
0.59	13.4
0.78	16.0

(i) Criticise the **recording** of these results. (1)

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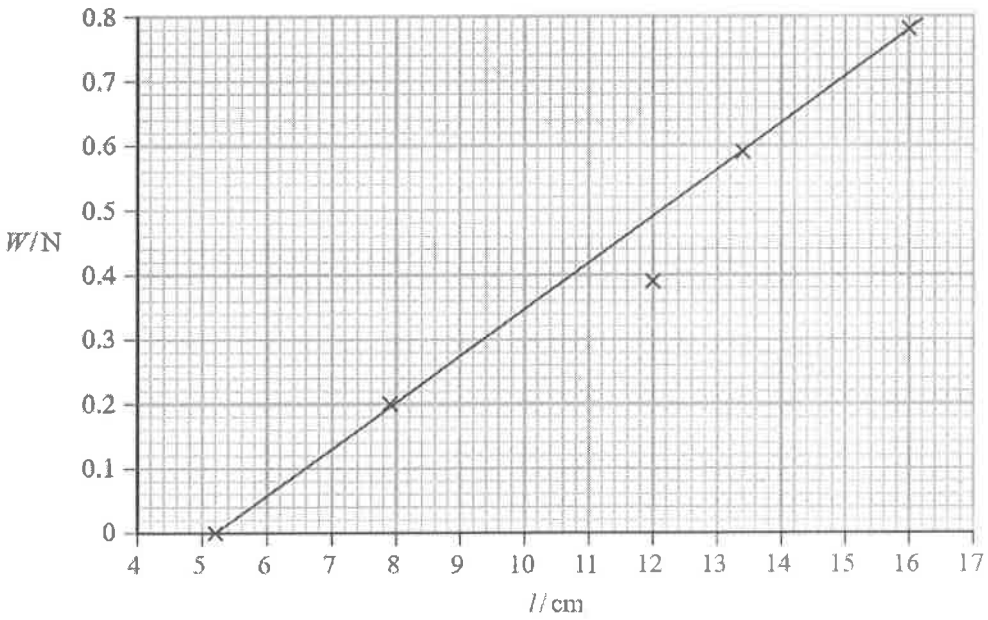
(ii) The student plotted the graph below. State and explain which value he should check. (2)

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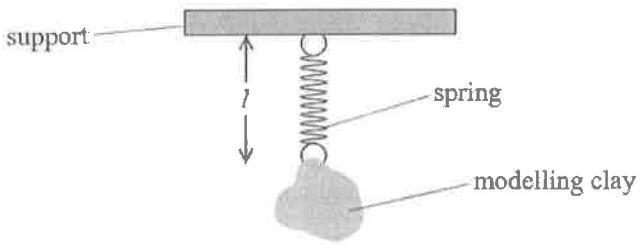
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(iii) The student replaced the load with a small piece of modelling clay, as shown.



He measured l to be 8.4 cm.

Determine the weight W of the piece of modelling clay.

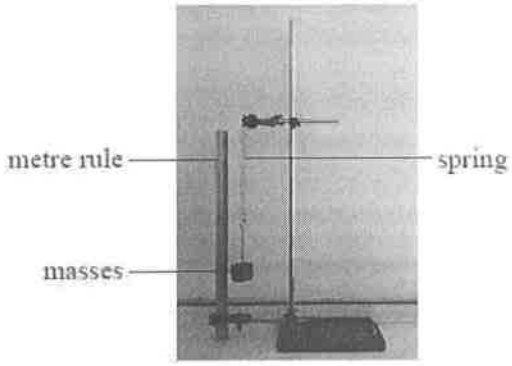
(1)

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W = ...

(Total for question = 6 marks)

Q9. A student used standard equipment as shown below to investigate the behaviour of a spring.



The student recorded the position of the spring on a metre rule for increasing loads.

Another student repeated the investigation using two new springs connected in series as shown.



The springs were identical to the spring used in the original investigation.
Explain why the spring constant for this arrangement of the springs would be half that for one spring.

(4)

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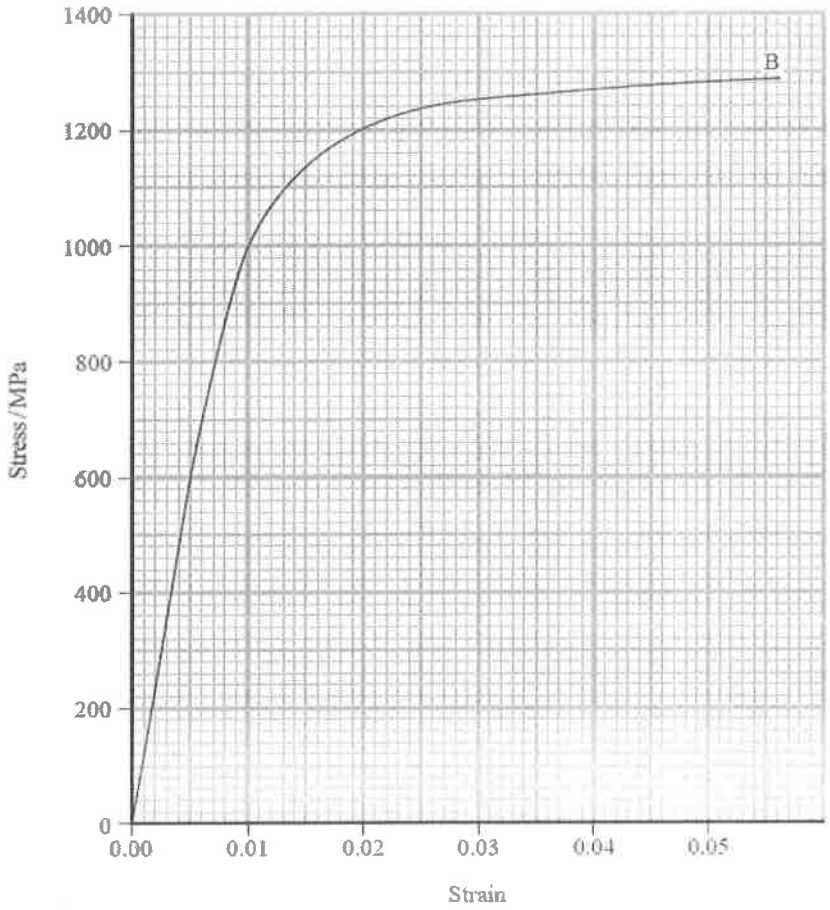
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(Total for question = 4 marks)

Q10. A steadily increasing tensile force was applied to a sample of a titanium alloy.

The sample had an original length of 40.0 cm and diameter of 5.05 mm.

(a) The graph shows how stress varied with strain for the sample.



(i) Determine the Young modulus of the sample. Show your work clearly, including on the graph.

(3)

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Young modulus = ...

(ii) The sample broke at point B.
Determine the force required to break the sample.

(4)

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Force = ...

(iii) Explain how the amount of work required to break the titanium alloy sample can be estimated from the graph. You do not need to use any values or give a numerical answer, but you should describe and explain the steps you would follow.

(3)

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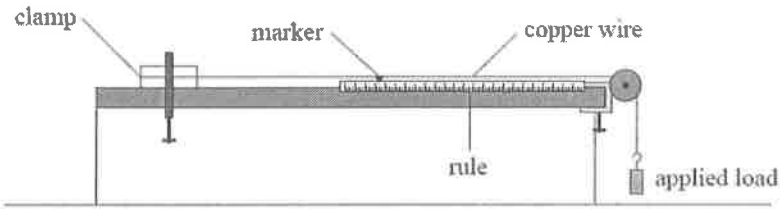
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(Total for question = 10 marks)

Q11. A student carried out an experiment to determine the Young modulus of copper. She used the apparatus below to observe the position of a marker as a copper wire extended under increasing applied loads.



(a) Describe how the diameter of the wire should have been determined.

(3)

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(b) Explain why the sample of wire used in this experiment should be long and thin.

(6)

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(Total for question = 9 marks)

Q12. When an increasing force is applied to a steel cable it will eventually reach its elastic limit.

(a) State what is meant by the elastic limit.

(1)

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(b) The elastic limit of a steel cable was reached when a force of 13.4×10^6 N was applied. The extension of the cable was 0.126 m.

length of cable = 6.00 m cross-sectional area of cable = 9.60×10^{-3} m^2

(i) Calculate the strain of the cable at its elastic limit.

(2)

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Strain = ...

(ii) Calculate the stress in the cable at its elastic limit.

(2)

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Stress = ...

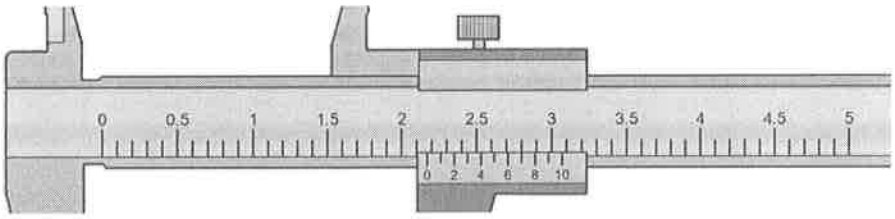
(Total for question = 5 marks)

Q13 This question is about scales used to make linear measurements.

a) What is the resolution of a Vernier scale? Write your answer in the gap in the sentence below.

Vernier scales measure to the nearest ..... (1)

Write down the reading on the Vernier scale below. Each number on the main scale is 1 cm.



Measurement = ... ± ..... Unit ..... (2)

b) What is the resolution of a micrometer? Write your answer in the gap in the sentence below.

A micrometer measures to the nearest ..... (1)

Write down the reading on the micrometer below. Each number on the main scale is 1 mm.



Measurement = ... ± ..... Unit ..... (2)

(Total for question = 6 marks)

Q14. A student carried out an experiment to determine the Young modulus of a sample of stainless steel in the form of a wire. The student added weights to the wire and measured the corresponding extensions.

The wire had an unstretched length of 2.6 m. The diameter of the wire was 5.6×10^{-4} m.

The student plotted a graph of weight against extension. The graph showed that the limit of proportionality was not exceeded.

(a) State what is meant by the limit of proportionality.

(1)

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(b) The breaking stress for this stainless steel is known to be 480 MPa.

Deduce whether it is safe for the student to increase the weight to 100.0 N.

(3)

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(Total for question = 4 marks)

Q15. A student carried out an experiment to determine the Young modulus of copper.

She added a mass m to the free end of a sample of copper in the form of a long thin wire and the corresponding extension Δx was measured. This was repeated for increasing masses.

(a) State the meaning of the term Young modulus.

(1)

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(b) The student repeated the measurement of the diameter of the wire at different positions and orientations of the wire. She obtained the following results.

Diameter / mm	0.230	0.235	0.230	0.240

(i) Determine the cross-sectional area of the sample of wire used.

(3)

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Cross-sectional area = ...

(ii) The student plotted a graph of m against Δx. She measured the gradient and obtained a value of 195 kg m^{-1}.

Determine the Young modulus of the copper.

length of sample of copper used = 3.50 m

(3)

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Young modulus = ...

(c) The experiment was repeated by another student, using a 2.00 m length of the copper wire.

(i) Suggest how the values obtained for the gradient of the graph of mass against extension will differ between the students.

(1)

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(ii) Suggest how the values obtained for the Young modulus will differ between the students.

(1)

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.....

(Total for question = 9 marks)

Answer multiple choice questions 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 ☒. Each of these questions is 1 mark.

Q1. One end of a 50 cm length of wire is attached to a support. A load is attached to the free end of the wire, which extends by 2 mm.

Which of the following is the strain for the length of wire?

(1) ☒ **A** 0.004

☐ **B** 0.04

☐ **C** 25

☐ **D** 250

$\varepsilon = \frac{\Delta x}{x} = \frac{2 \times 10^{-3}}{50 \times 10^{-2}} = 4 \times 10^{-3}$

Q2. A wire breaks when a tensile force T is applied. A second wire, made of the same material, has twice the diameter.

Which of the following is the force required to break the second wire?

(1) ☒ **A** $4T$

☐ **B** $2T$

☐ **C** $\frac{T}{2}$

☐ **D** $\frac{T}{4}$

$\sigma = \frac{F}{A}$

if r doubles

new $A = 4A_0$

$F = \sigma A$

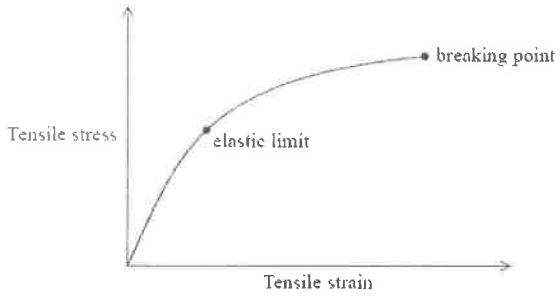
So new $F = 4F_0$ or $4T$

Q3. The stiffness constant (k) and the Young modulus are terms used in physics.

Which row of the table shows the correct application of these terms?

	Stiffness constant applies to	Young modulus applies to
☐ A	materials	(materials)
☐ B	(objects)	objects
☐ C	materials	objects
(1) ☒ D	(objects)	(materials)

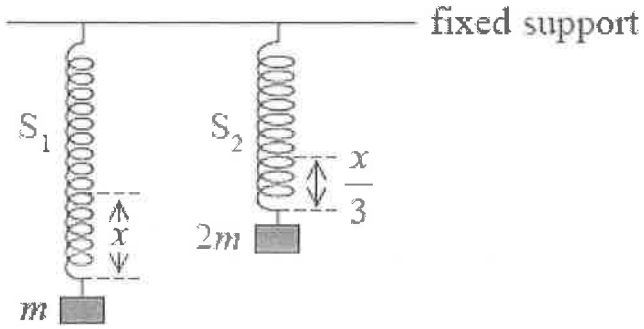
Q4. The graph shows the relationship between tensile stress and tensile strain for a material.



Which of the following gives the Young modulus of the material?

- ☐ **A** the area under the line up to the breaking point
- ☐ **B** the area under the line up to the elastic limit
- ① ☒ **C** the gradient of the tangent to the line at the origin
- ☐ **D** the stress divided by the strain at the breaking point

Q5. Two different springs, S_1 and S_2, are suspended from a fixed support. Masses are attached to the bottom of S_1 and S_2 as shown.



The extension of S_1 is x, and the extension of S_2 is $\frac{x}{3}$. The elastic strain energy in spring S_1 is E.

Which of the following is the elastic strain energy in spring S_2?

- ☐ **A** $6E$
- ☐ **B** $\frac{3E}{2}$
- ① ☒ **C** $\frac{2E}{3}$
- ☐ **D** $\frac{E}{6}$

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

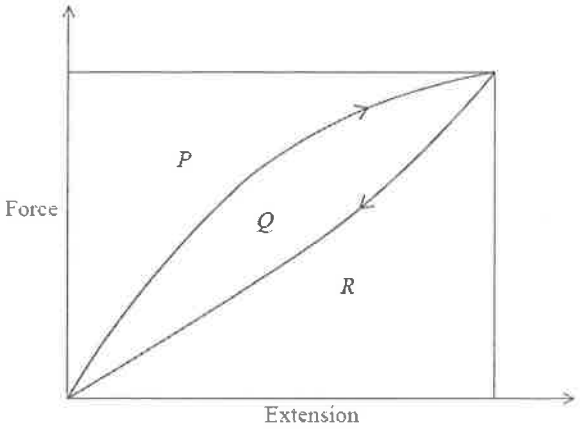
For S_1 $E = \frac{mgx}{2}$

For S_2 $E_2 = \frac{1}{2}(2mg)\left(\frac{x}{3}\right) = \frac{mgx}{2}\left(\frac{2}{3}\right)$

$E_2 = \frac{2}{3} E$

Q6. A rubber band is initially stretched by an increasing force. When the force is gradually decreased, the rubber band returns to its original length.

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



P, Q and R represent different areas of the graph.

Which of the following gives the work done in stretching the rubber band up to its maximum extension?

- ☐ **A** $P + Q$
- (1) ☒ **B** $Q + R$
- ☐ **C** R
- ☐ **D** Q

Q7. When compressed by a force of 50 N, a spring had a length of 12.0 cm.

When compressed by a force of 70 N, the same spring had a length of 7.1 cm.

Which of the following expressions gives the stiffness k of the spring in N cm^{-1}?

- ☐ **A** $\frac{70}{12.0} - \frac{50}{7.1}$
- (1) ☒ **B** $\frac{(70 - 50)}{(12.0 - 7.1)}$
- ☐ **C** $\frac{50}{7.1} - \frac{70}{12.0}$
- ☐ **D** $\frac{(70 - 50)}{(12.0 - 4.9)}$

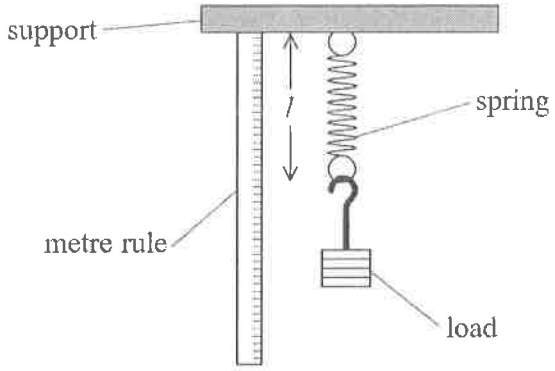
$F = k \Delta x$

$k = \frac{F}{\Delta x} = \frac{(70 - 50)}{(12 - 7.1)}$

(Total for question = 1 mark)

Q8. A student investigated the stretching of a spring.

(a) The student added a load to the spring and measured the stretched length *l* of the spring, as shown.



Describe **two** techniques the student should use to make this measurement as accurate as possible.

(2)

View the scale at right angles (to reduce parallax errors) ①

Use a set square to make sure the metre rule is vertical ①

(b) The student determined the weight *W* of different loads and the corresponding values of *l*. He recorded the results in the following table:

W/N	*l*/cm
0	5.20
0.2	7.9
0.39	12
0.59	13.4
0.78	16.0

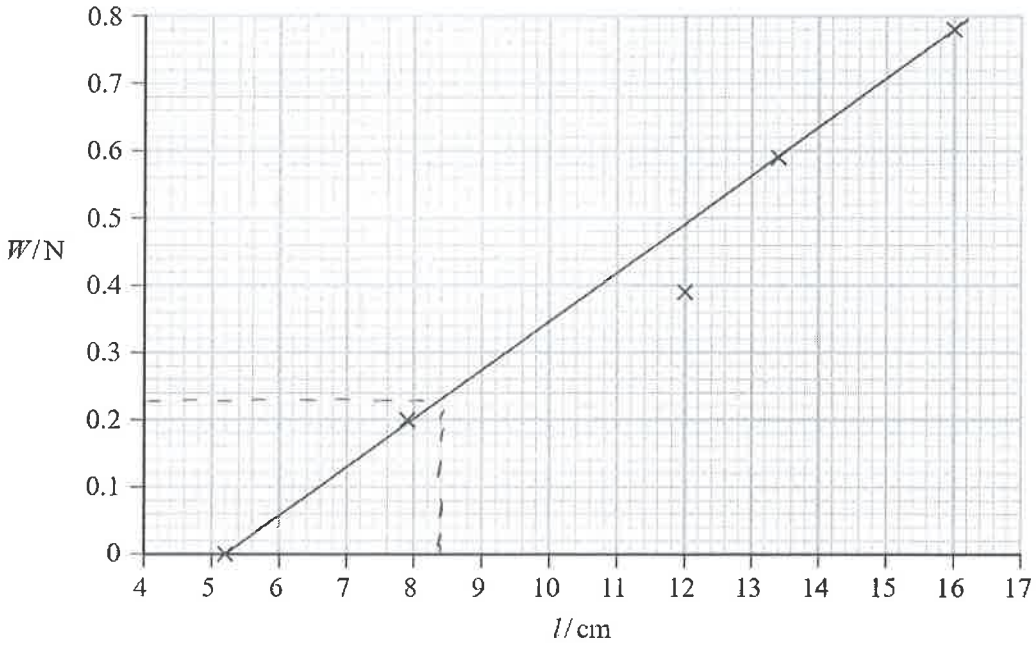
(i) Criticise the **recording** of these results. (1)

The number of decimal places varies ① for W and l.

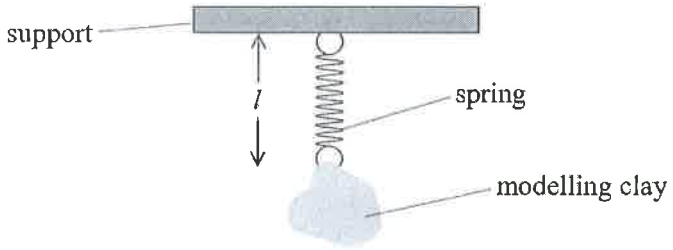
(ii) The student plotted the graph below. State and explain which value he should check. (2)

W = 0·39N, l = 12cm (1)

Because it is furthest from the line of best fit (1)



(iii) The student replaced the load with a small piece of modelling clay, as shown.



He measured l to be 8.4 cm.

Determine the weight W of the piece of modelling clay.

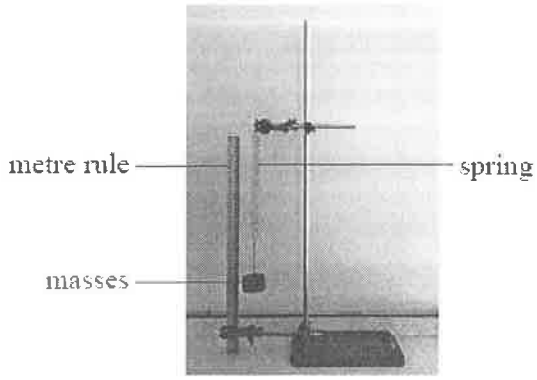
(1)

W = 0·23N (1)

0·22 → 0·24N

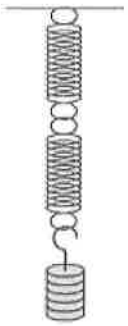
(Total for question = 6 marks)

Q9. A student used standard equipment as shown below to investigate the behaviour of a spring.



The student recorded the position of the spring on a metre rule for increasing loads.

Another student repeated the investigation using two new springs connected in series as shown.



The springs were identical to the spring used in the original investigation.
Explain why the spring constant for this arrangement of the springs would be half that for one spring.

(4)

The same force (1) acts through both springs, so each has the same extension (1) that one spring would have for that force.

Therefore the total extension is doubled (1)

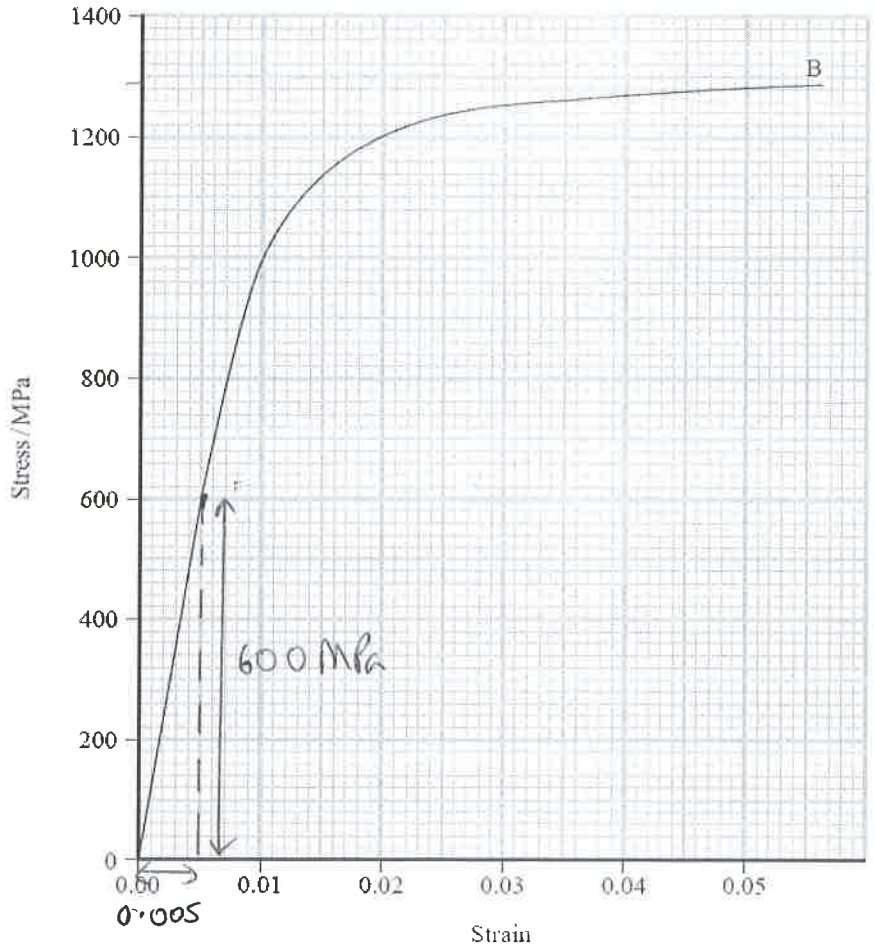
$F = k\Delta x$ if Δx is doubled, k must be halved (1)

(Total for question = 4 marks)

Q10. A steadily increasing tensile force was applied to a sample of a titanium alloy.

The sample had an original length of 40.0 cm and diameter of 5.05 mm.

(a) The graph shows how stress varied with strain for the sample.



(i) Determine the Young modulus of the sample.

(3)

Gradient of linear part of line (1)

$E = \frac{600 \times 10^6}{0.005} = 1.2 \times 10^{11}$ Pa (1)

(Not above $\varepsilon = 0.005$ or $\sigma = 600$ MPa)

Young modulus = 1.2×10^{11} Pa (1)

[115 → 125 GPa]

(ii) The sample broke at point B.
Determine the force required to break the sample.

(4)

At B $\sigma = 1280$ MPa (1) (1280 → 1290 MPa)

$A = \pi r^2$ $r = \frac{5.05 \times 10^{-3}}{2} = 2.525 \times 10^{-3}$ m

$A = \pi r^2 = \pi (2.525 \times 10^{-3})^2 = 2.003 \times 10^{-5}$ m^2 (1)

$\sigma = \frac{F}{A}$ $F = \sigma A = 1280 \times 10^6 \times 2.003 \times 10^{-5} = 25638$ N (1)

Force = 25.6 kN (1) (25.6 → 25.8 kN)

(iii) Explain how the amount of work required to break the titanium alloy sample can be estimated from the graph. You do not need to use any values or give a numerical answer, but you should describe and explain the steps you would follow.

(3)

Find the area under the line on the graph (1). This is the work done per unit volume.

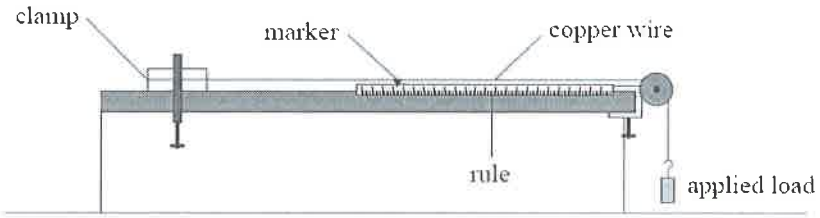
Calculate the volume of the sample (1) ($V = \pi r^2 l$)

Work done = area under line x volume of sample

or Work done = work done per unit volume x volume (1)

(Total for question = 10 marks)

Q11. A student carried out an experiment to determine the Young modulus of copper. She used the apparatus below to observe the position of a marker as a copper wire extended under increasing applied loads.



(a) Describe how the diameter of the wire should have been determined.

Use a micrometer (1) to measure the diameter at 3 points (1) along the wire. Calculate the mean (1) value. (3)

(b) Explain why the sample of wire used in this experiment should be long and thin.

The extension should be as large as possible (1) so that it is measurable and the percentage uncertainty in this measurement will be lower. For a thin wire, the stress will be greater for the same load since $\sigma = F/A$. This also means a smaller load can be used. (1) If the stress is greater, the strain will be greater (1) since the Young modulus is constant and $E = \sigma/\varepsilon$. (1) ← and therefore extension

So a smaller area means a bigger extension.

The wire should be long since then the extension will be greater for the same strain (1) as $\varepsilon = \Delta x / x$ so $\Delta x \propto x$. (1) (6)

(Total for question = 9 marks)

Q12. When an increasing force is applied to a steel cable it will eventually reach its elastic limit.

(a) State what is meant by the elastic limit.

(1)

It is the force (or stress) beyond which the cable will not return to its original length when the force is removed. (1)

(b) The elastic limit of a steel cable was reached when a force of 13.4×10^6 N was applied. The extension of the cable was 0.126 m.

length of cable = 6.00 m cross-sectional area of cable = 9.60×10^{-3} m^2

(i) Calculate the strain of the cable at its elastic limit.

(2)

$\varepsilon = \frac{\Delta x}{x} = \frac{0.126}{6.00} = 0.021$ (1)

Strain = 0.021 (1)

(ii) Calculate the stress in the cable at its elastic limit.

(2)

$\sigma = \frac{F}{A} = \frac{13.4 \times 10^6}{9.6 \times 10^{-3}} = 1.396 \times 10^9$ (1)

Stress = 1.40×10^9 Pa (1)

or GPa

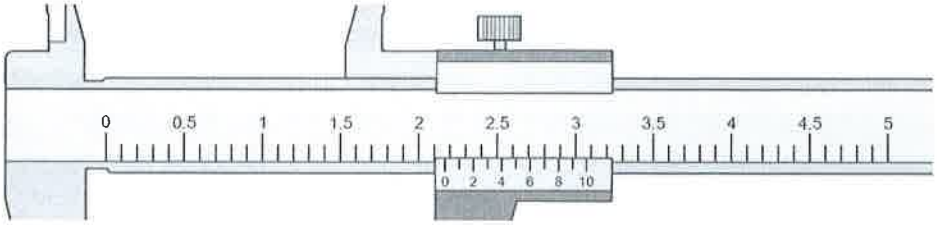
(Total for question = 5 marks)

Q13 This question is about scales used to make linear measurements.

a) What is the resolution of a Vernier scale? Write your answer in the gap in the sentence below.

Vernier scales measure to the nearest ...0·1mm (1) ✓

Write down the reading on the Vernier scale below. Each number on the main scale is 1 cm.



Measurement = 2·17 (1) ± 0·005 (1) Unit cm (2) ✓

↑ If different, the measurement must be adjusted correctly

b) What is the resolution of a micrometer? Write your answer in the gap in the sentence below.

A micrometer measures to the nearest ~~0·01mm~~ (1) 0·01mm (1) ✓

Write down the reading on the micrometer below. Each number on the main scale is 1 mm.



6·5
+0·34
6·84

Measurement = 6·84 (1) ± 0·005 (1) Unit mm (2) ✓

(Total for question = 6 marks)

Q14. A student carried out an experiment to determine the Young modulus of a sample of stainless steel in the form of a wire. The student added weights to the wire and measured the corresponding extensions.

The wire had an unstretched length of 2.6 m. The diameter of the wire was 5.6×10^{-4} m.

The student plotted a graph of weight against extension. The graph showed that the limit of proportionality was not exceeded.

(a) State what is meant by the limit of proportionality.

(1)

Point beyond which the line on the graph is no longer straight. (1)

(b) The breaking stress for this stainless steel is known to be 480 MPa.

Deduce whether it is safe for the student to increase the weight to 100.0 N.

(3)

Area $= \pi r^2$ $r = \frac{5.6 \times 10^{-4}}{2}$ $A = \pi (2.8 \times 10^{-4})^2$

$A = 2.463 \times 10^{-7}\ m^2$

$\sigma = \frac{F}{A}$ If $F = 100N$ $\sigma = \frac{100}{2.463 \times 10^{-7}}$ (1) $= 406\ MPa$ (1)

406 MPa < 480 MPa so 100N would be safe.

(1) THERE MUST BE A COMPARISON

(Total for question = 4 marks)

Q15. A student carried out an experiment to determine the Young modulus of copper.

She added a mass m to the free end of a sample of copper in the form of a long thin wire and the corresponding extension Δx was measured. This was repeated for increasing masses.

(a) State the meaning of the term Young modulus.

(1)

Young modulus is the ratio of stress to strain (1)

(b) The student repeated the measurement of the diameter of the wire at different positions and orientations of the wire. She obtained the following results.

Diameter / mm	0.230	0.235	0.230	0.240

(i) Determine the cross-sectional area of the sample of wire used.

(3)

Mean diameter $= \frac{(0.230 + 0.235 + 0.235 + 0.240)}{4} = 0.234$ mm (1)

$r = \frac{0.234\text{mm}}{2} = 0.117 \times 10^{-3}$ m

$A = \pi r^2 = \pi (0.117 \times 10^{-3})^2 = 4.30 \times 10^{-8}$ (1)

Cross-sectional area = 4.30×10^{-8} m^2 (1)

(ii) The student plotted a graph of m against Δx. She measured the gradient and obtained a value of 195 kg m^{-1}.

Determine the Young modulus of the copper.

length of sample of copper used = 3.50 m

$F = mg$

(3)

$E = \frac{\sigma}{\varepsilon} = \frac{F/A}{\Delta x/x} = \frac{Fx}{A\Delta x} = \frac{mgx}{A\Delta x}$ (1)

Gradient $= \frac{m}{\Delta x}$ so E is gradient $\left(\frac{gx}{A}\right)$ (1)

$E = \frac{195 \times 9.81 \times 3.5}{4.3 \times 10^{-8}} = 1.56 \times 10^{11}$

Young modulus = 1.56×10^{11} Pa (1)

or 156 GPa

(c) The experiment was repeated by another student, using a 2.00 m length of the copper wire.

(i) Suggest how the values obtained for the gradient of the graph of mass against extension will differ between the students.

(1)

Extension will be less, so the gradient will be greater. (1)

(ii) Suggest how the values obtained for the Young modulus will differ between the students.

(1)

Young modulus is independent of shape, so will be the same. (1)

(Total for question = 9 marks)