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4: The forces acting on a person sitting on a chair are weight and normal contact force.

Which of the following gives a reason why these forces do **not** form a Newton's third law pair?

- ☒ **A** The chair is stationary.
- ☒ **B** The forces act in opposite directions.
- ☒ **C** The forces act on the same object.
- ☒ **D** The forces have the same magnitude.

(Total for Question 4 = 1 mark)

8 A student is determining the acceleration of free-fall, g.

The student uses a stopwatch to measure the time taken for a ball bearing to fall a measured distance.

The student calculates a value of g that is greater than $9.81\,m\,s^{-2}$.

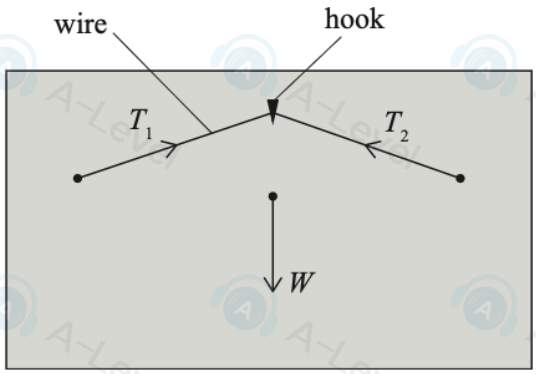
Which of the following could be an explanation for the student's result?

- ☒ **A** The ball bearing is moving downwards when the student starts the stopwatch.
- ☒ **B** The ball bearing is moving upwards when the student starts the stopwatch.
- ☒ **C** The student starts the stopwatch before the ball bearing is dropped.
- ☒ **D** The student stops the stopwatch after the ball bearing lands.

(Total for Question 8 = 1 mark)

5: A wire is used to hang a picture from a hook on a wall.

The wire exerts forces T_1 and T_2 on the picture. The picture has weight W, as shown.



Not to scale

Which of the following describes the relationship between the forces when the picture is hanging on the wall?

- ☒ **A** $\vec{W} = \vec{T_1} + \vec{T_2}$
- ☒ **B** $\vec{W} + \vec{T_1} + \vec{T_2} = 0$
- ☒ **C** $\vec{W} = \vec{T_1} - \vec{T_2}$
- ☒ **D** $\vec{W} + \vec{T_1} - \vec{T_2} = 0$

(Total for Question 5 = 1 mark)

2 An object of mass 8.2 kg, initially at rest, falls a vertical distance of 25 m through the air and has a final velocity of 20 m s^{-1}.

Which of the following gives the energy in joules dissipated by air resistance?

- ☒ **A** $8.2 \times 9.81 \times 25$
- ☒ **B** $0.5 \times 8.2 \times 20^2 + 8.2 \times 9.81 \times 25$
- ☒ **C** $8.2 \times 9.81 \times 25 - 0.5 \times 8.2 \times 20^2$
- ☒ **D** $0.5 \times 8.2 \times 20^2 - 8.2 \times 9.81 \times 25$

(Total for Question 2 = 1 mark)

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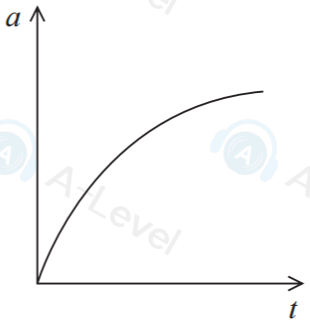
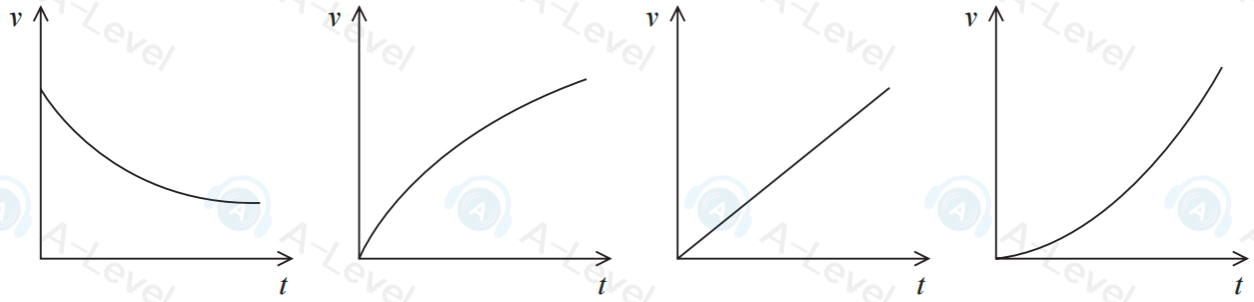
3 The graph shows how the acceleration a of an object varies with time t.



Which of the following graphs shows how the velocity v of the object varies with t?

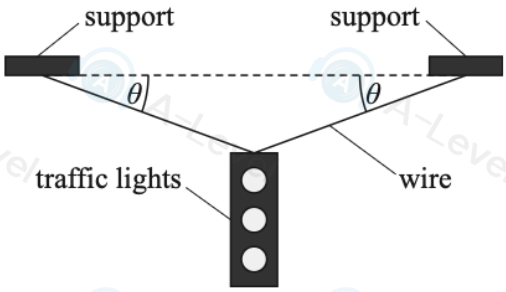


A **B** **C** **D**

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 3 = 1 mark)

10 Traffic lights of weight W are suspended from a wire.
The wire is held at an angle θ to the horizontal by two supports, as shown.



Which of the following expressions gives the tension in the wire?

☒ **A** $2W \sin\theta$

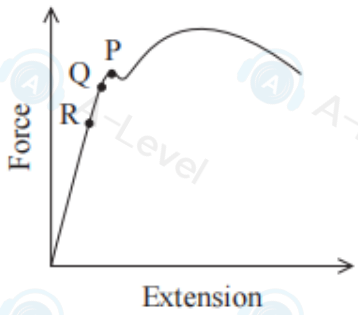
☒ **B** $\dfrac{W}{2\sin\theta}$

☒ **C** $2W \cos\theta$

☒ **D** $\dfrac{W}{2\cos\theta}$

(Total for Question 10 = 1 mark)

9 A length of steel wire is fixed at one end. An increasing force is applied to the other end of the wire. The force extension graph for the wire is shown.



Which row of the table identifies points P, Q and R on the graph?

	P	Q	R
☐ **A**	elastic limit	limit of proportionality	yield point
☐ **B**	elastic limit	yield point	limit of proportionality
☐ **C**	yield point	elastic limit	limit of proportionality
☐ **D**	yield point	limit of proportionality	elastic limit

(Total for Question 9 = 1 mark)

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3 A block of mass m is placed on a bench and a horizontal force F is applied to the block. The block accelerates along the bench, travels a distance d in time t and reaches a velocity v.

The work done by the force F on the block is

☒ **A** Fd

☒ **B** Ft

☒ **C** Fv

☒ **D** mgd

(Total for Question 3 = 1 mark)

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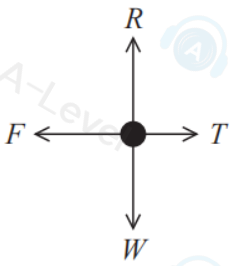
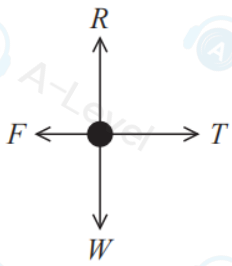
6 A car pulls a caravan at a slow but increasing velocity along a horizontal road.

The four forces acting on the car are weight W, reaction force R of the road on the car, tension T in the tow-bar and friction F between the car tyres and the road.

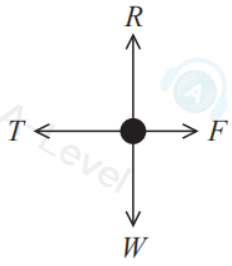
Which of the following could be the free-body force diagram for the car?



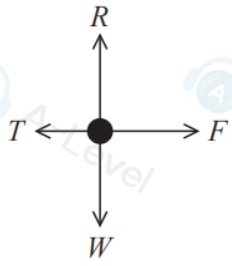
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(Total for Question 6 = 1 mark)

10 A locomotive pulls a train at constant speed against a force of 8400 kN. The output power of the locomotive is 70 MW.

Which of the following gives the time in seconds for the locomotive to pull the train a distance of 1 km?

☒ **A** $\frac{70 \times 10^6}{8400 \times 10^3}$

☒ **B** $\frac{70}{8400 \times 10^3}$

☒ **C** $\frac{8.4 \times 10^6 \times 10^3}{7 \times 10^7}$

☒ **D** $\frac{8400}{70 \times 1000}$

(Total for Question 10 = 1 mark)

16 The photograph shows a fireboat used to put out fires on ships at sea. A pump, fixed to the boat, pumps water from the sea. The seawater is projected at high speed out of a pipe connected to the pump.

(Source: © Konrad Zelazowski/age fotostock/Superstock)

(a) The mass of seawater pumped each second is 300 kg. The pipe has a radius of 5.0 cm.

density of seawater = 1030 kg m^{-3}.

Show that the speed at which the seawater is projected from the pipe is about 37 m s^{-1}.

(4)

(b) Projecting water from the pipe causes a force to be exerted on the pump.

Explain the direction of the force on the pump.

(2)

(c) Initially the pump is turned off and the fireboat moves forwards through the water at a constant speed. The boat's engine provides a constant forward force.
When the pump is turned on, water is projected forwards and the fireboat slows to a lower constant speed.

Explain why the boat now has a lower constant speed.

(3)

(Total for Question 16 = 9 marks)

13 Stokes' law can be used to determine the magnitude of the viscous drag for small, spherical objects moving through a fluid.

(a) State one other condition that must be met in order for Stokes' law to apply to the moving object.

(1)

(b) A sphere falls through water at a constant speed of $0.50\,\text{m s}^{-1}$.

Assess whether Stokes' law can be applied to the falling sphere.

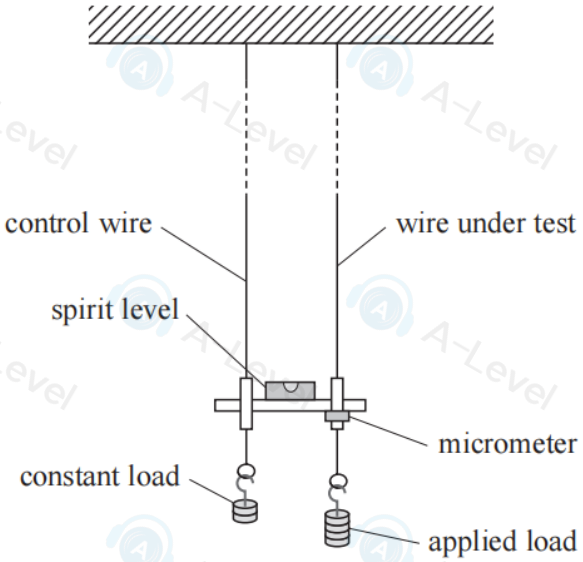
You should include calculations in your answer.

diameter of sphere $= 6.0 \times 10^{-3}$ m
mass of sphere $= 9.1 \times 10^{-4}$ kg
upthrust on sphere $= 1.1 \times 10^{-3}$ N
viscosity of water $= 8.9 \times 10^{-4}$ Pa s.

(5)

(Total for Question 13 = 6 marks)

17 A student determined the Young modulus of a material, in the form of a wire, using the equipment shown. A control wire, with a constant load, was used as a comparison for measuring the extension of the wire under test.



Every time a known weight was added to the applied load the micrometer was adjusted until the spirit level was horizontal. The movement of the applied load was the same as the movement of the micrometer.

(a) List any additional measurements that are required for the student to determine a value for the Young modulus of the material.

(2)

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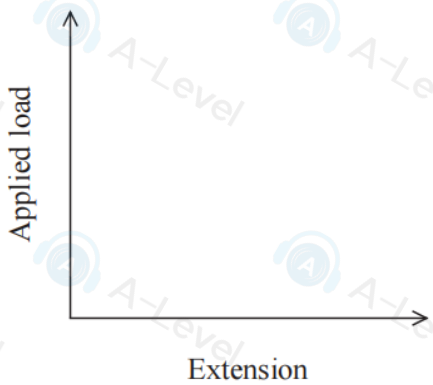
(b) The student plotted a graph of the applied load against the extension of the wire.

(i) Sketch the graph that you would expect the student to obtain.

(1)

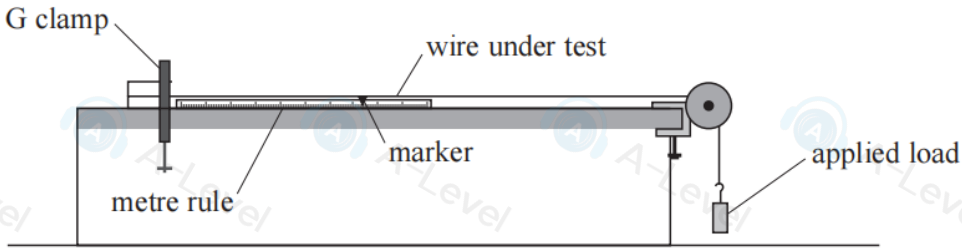


(ii) Explain how the student can use the graph to determine the Young modulus of the material.

(2)

(c) A simpler method to determine the Young modulus of a material in the form of a wire is shown.

The position of a marker along a metre rule is recorded each time the applied load is increased.

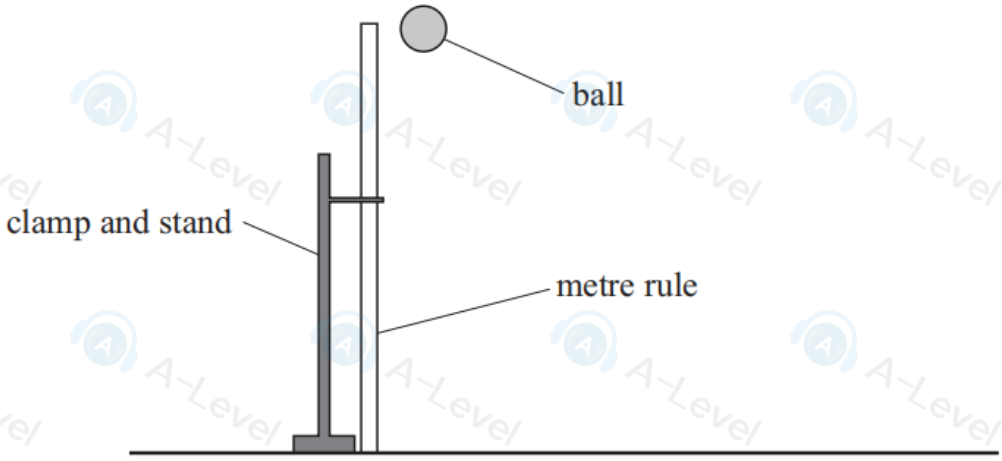


Explain two advantages of using the first method, rather than the second method, to determine the Young modulus.

(4)

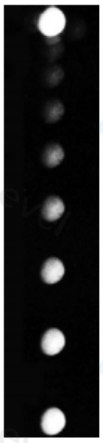
(Total for Question 17 = 9 marks)

14 A student clamped a metre rule so that it was vertical. She dropped a ball from rest near the top of the metre rule, as shown.



A strobe emits flashes of light. The time interval between flashes is constant.

The student photographed the falling ball using strobe lighting. The ball can be seen at different heights in the photograph, as shown.



(Source: © sciencephotos/Alamy Stock Photo)

For each flash of light, the student determined the distance fallen by the ball.

(a) She took one photograph using a strobe app on a mobile phone.
She took a second photograph using a laboratory strobe.

The time interval between flashes was the same for the strobe app and for the laboratory strobe. Each flash of light from the laboratory strobe has a smaller duration than each flash from the mobile phone.

Explain how the smaller duration of each flash from the laboratory strobe affected the uncertainty in the measurement of the distance fallen.

(2)

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(b) The student recorded the distances s fallen by the ball and corresponding values of the time t.

(i) Explain why a graph of s against t^2 gives a straight line.

(2)

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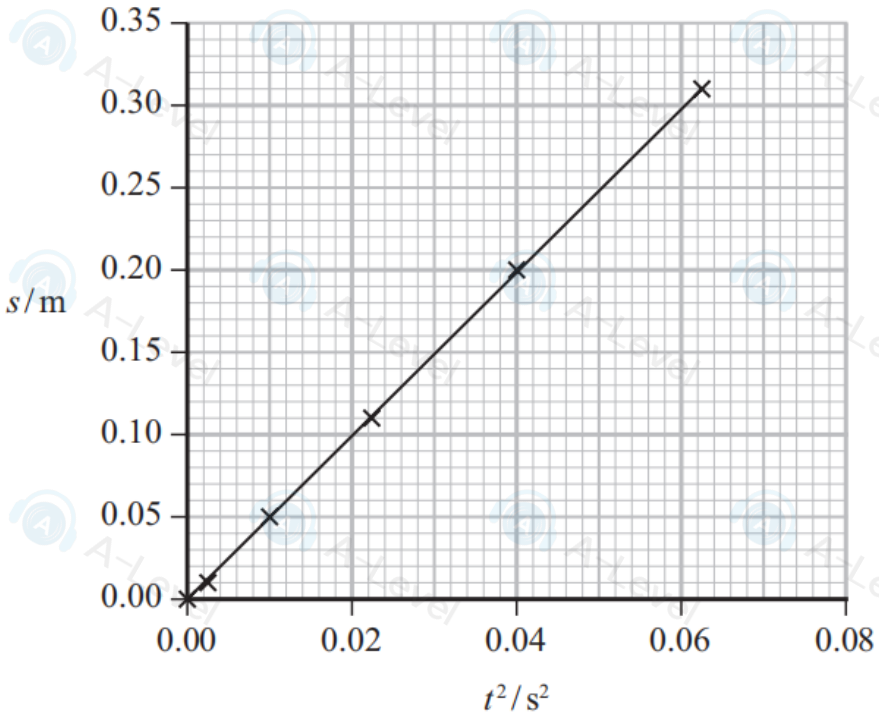
(ii) The student plotted a graph of s against t^2, as shown.



Determine the acceleration of free fall, g, using the student's graph.

(2)

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g = ...

(Total for Question 14 = 6 marks)

13 A ball is dropped and reaches the ground after 0.42 s. The ball bounces and is caught at the same height from which it was dropped.

Draw, on the graph paper below, the velocity-time graph for the motion of the ball. You may assume that the time the collision with the ground takes and all frictional forces are negligible. Show your working in the space provided.

(5)

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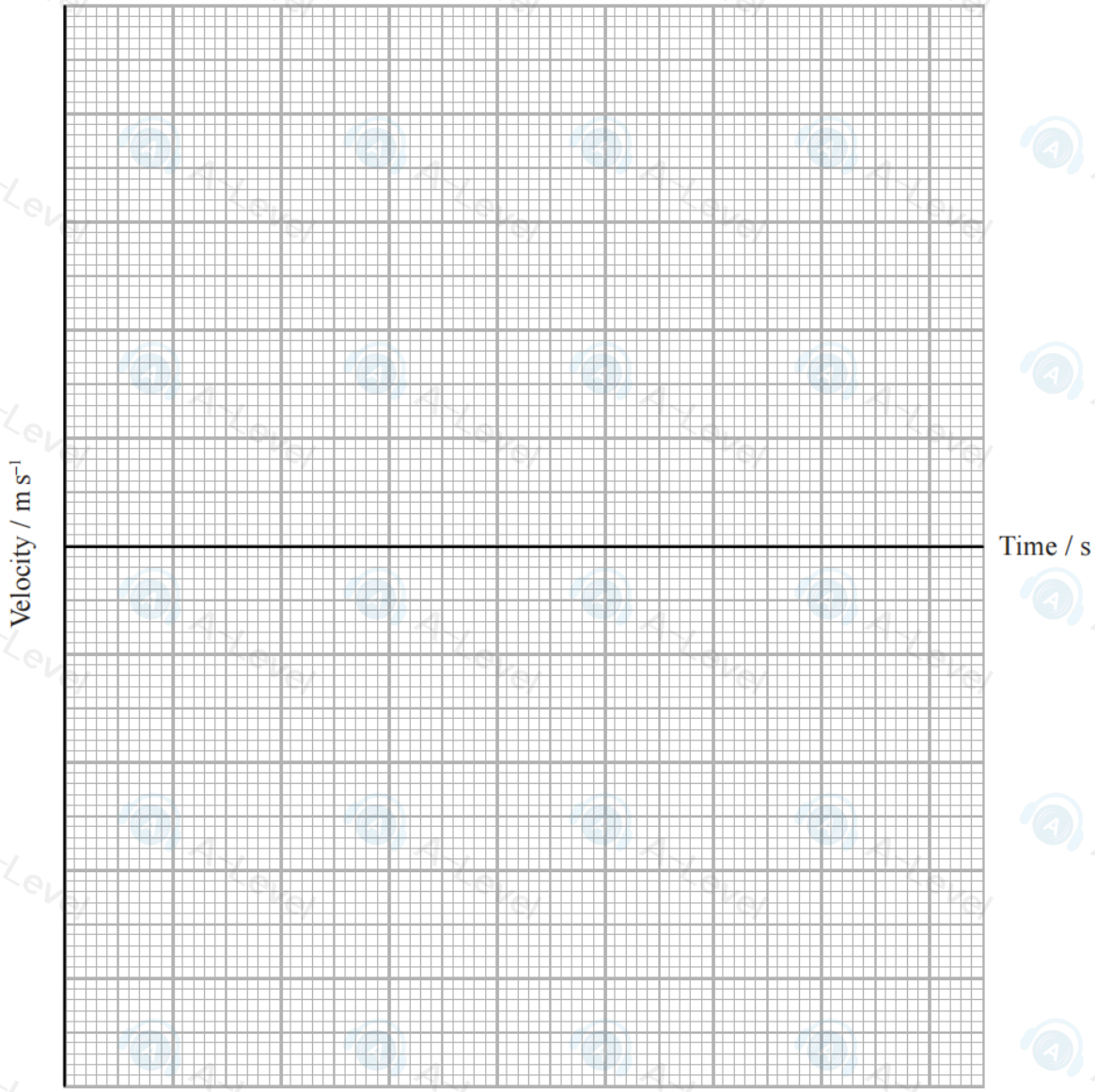
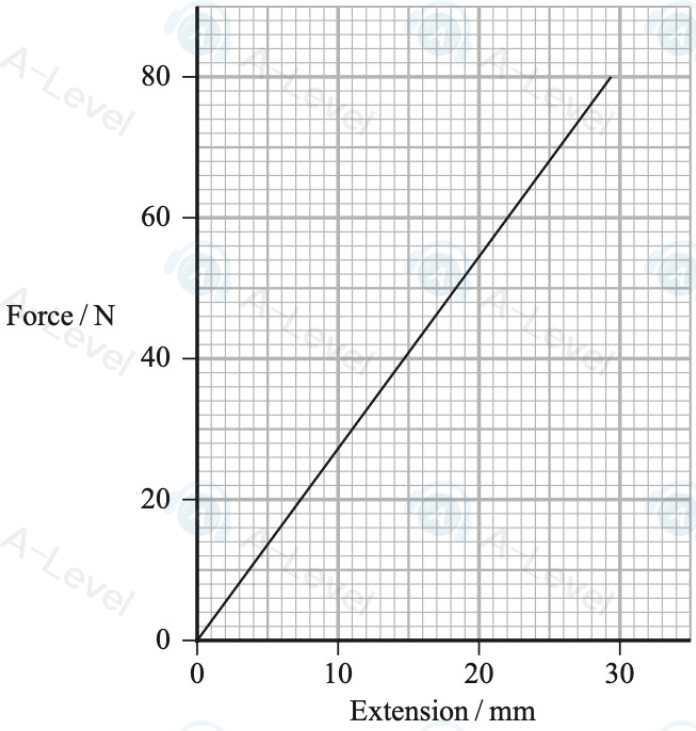


17: A violin is a musical instrument that has four strings, as shown.

(Source: © bob_sato_1973/Getty Images)

(a) A force-extension graph for a sample of one of the strings is shown below.



The table shows the stiffness for samples of three of the strings on the violin.

Each sample was the same original length as the sample used to obtain the graph.

String	Stiffness / N m^{-1}
X	1700
Y	2700
Z	6100

Deduce which string was used to obtain the force-extension graph.

(4)

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(Source: © bob_sato_1973/Getty Images)

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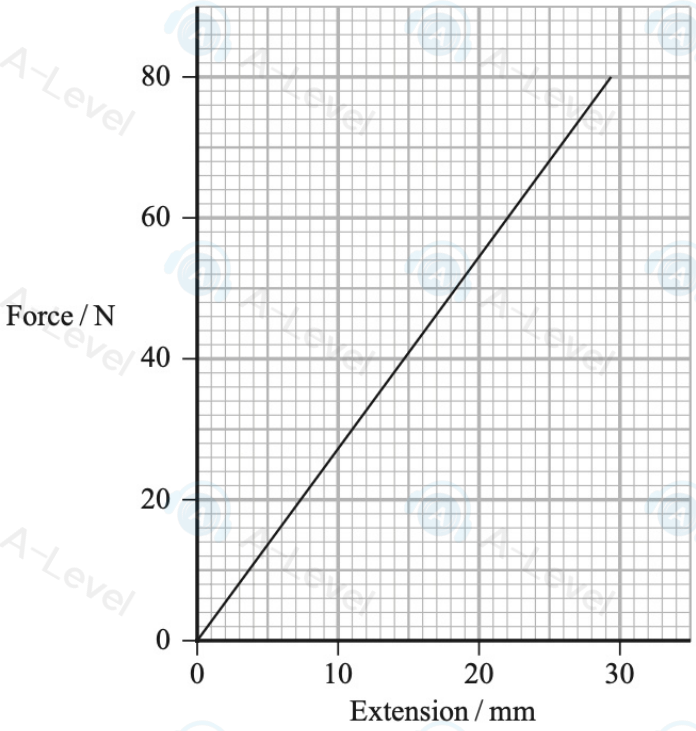

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String	Stiffness / N m^{-1}
X	1700
Y	2700
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Deduce which string was used to obtain the force-extension graph.

(4)

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