10 A spring is stretched by hanging on it a variable mass m. The mass m is always at rest. The spring obeys Hooke's law.

What is the relationship between the elastic potential energy E in the spring and the mass m?

A $E \propto m^{-1}$

B $E \propto m^{-2}$

C $E \propto m$

D $E \propto m^{2}$

Your answer ☐ **[1]**

[1]

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13 The Young modulus E of a metal can be determined using the expression $E = \frac{4F}{\varepsilon\pi d^2}$, where F is the tension in the wire, d is the diameter of the wire and ε is the strain of the wire.

Here is some data.

Quantity	Percentage uncertainty
F	5.3
ε	1.2
d	1.0

What is the percentage uncertainty in the calculated value of E?

A 2.1 %

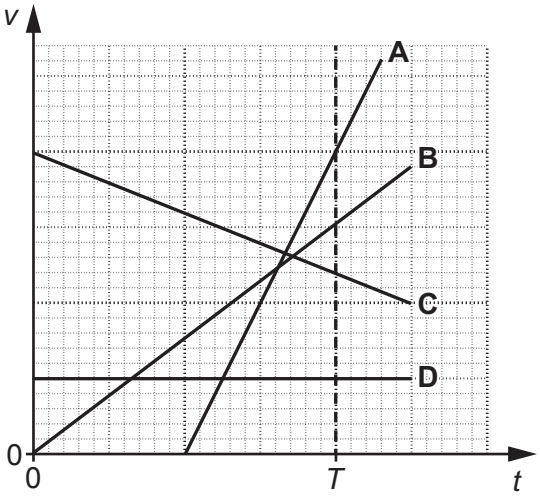
B 6.4 %

C 7.5 %

D 8.5 %

Your answer ☐ **[1]**

14 The velocity v against time t graphs for four objects **A**, **B**, **C** and **D** are shown below.



Which object travels the greatest distance between $t = 0$ and $t = T$?

Your answer ☐ **[1]**

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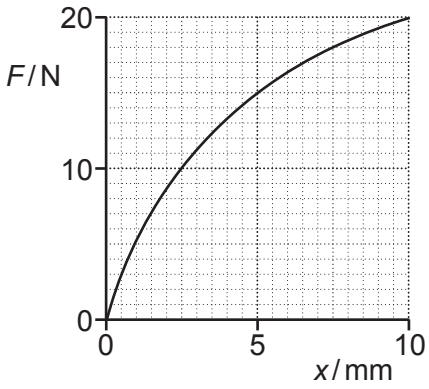
13 The force F against extension x graph for a material being stretched is shown.



What is best estimate for the energy stored in the material when the extension is 10 mm?

A 0.07 J

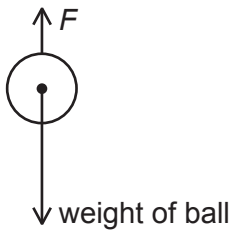
B 0.10 J

C 0.13 J

D 0.20 J

Your answer ☐ **[1]**

14 A ball of mass m is falling vertically through the air.



The total upward force acting on the ball is F. The force F is less than the weight of the object. The acceleration of free fall is g.

Which expression is correct for the acceleration a of the ball?

A $a = 0$

B $a = \frac{mg - F}{m}$

C $a = \frac{mg + F}{m}$

D $a = g$

Your answer ☐ **[1]**

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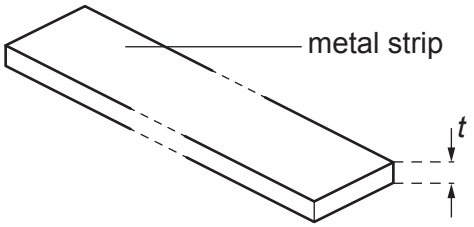
17 **(a)** A metal strip has thickness *t*, as shown below.



Five measurements of the thickness *t* at different positions along the length of the strip are shown below.

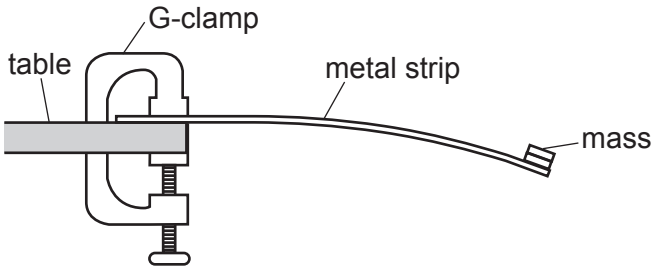
1.86 mm 1.88 mm 1.85 mm 1.89 mm 1.88 mm

Determine the percentage uncertainty in the thickness *t*.

percentage uncertainty = ... % **[3]**

(b)* A student wants to determine the Young modulus *E* of the metal of the strip in **(a)**.

The student clamps the metal strip to the edge of a table using a G-clamp. A mass is **permanently** fixed to the end of the strip as shown.



The mass oscillates freely when it is moved away from its equilibrium position and then released.

The Young modulus *E* of the metal can be determined using the equation $E = \frac{16\pi^2 mL^3}{wt^3T^2}$, where *m* is the mass fixed to the end of the strip, *L* is the length of the strip from the end of the table to the centre of the mass, *w* is the width of the strip, *t* is the thickness of the strip, and *T* is the period of oscillations.

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13

Describe how an experiment may be safely conducted, and how the data can be analysed to determine an accurate value for *E*. **[6]**

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Additional answer space if required.

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SECTION B

Answer **all** the questions.

16 **(a)** Describe how an experiment can be carried out to determine the force constant of an elastic cord in the laboratory by plotting a suitable graph. You may assume that the cord obeys Hooke's law.

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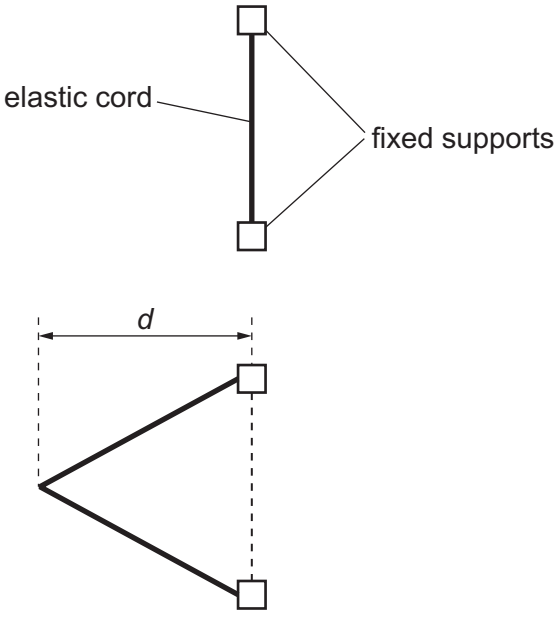
..... **[4]**

(b) A simple catapult is made by an elastic cord fixed to two supports, as shown below.



The unstretched length of the cord is the same as the distance between the supports.
The distance that the centre of the cord has been pulled back is d.

The cord has a force constant of $500\,\text{N}\,\text{m}^{-1}$.

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