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| <b>8</b> | <p><b>8. The only correct answer is B</b></p> <p><i>A is not correct because a larger diameter wire would produce a smaller stress, a smaller strain and hence a smaller extension.</i></p> <p><i>C is not correct because a larger diameter wire would produce a smaller stress, a smaller strain and hence a smaller extension. For the same strain, a shorter wire would also produce a smaller extension.</i></p> <p><i>D is not correct because, for the same strain, a shorter wire would produce a smaller extension.</i></p> | <b>(1)</b> |
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| <b>10</b> | <p>The only correct answer is C</p> <p>C is correct because half the force is on each spring so the spring constant is doubled, which will halve the extension for a given load.</p> <p>A is not correct because the extension is halved, not doubled.</p> <p>B is not correct because the spring constant is doubled, not halved.</p> <p>D is not correct because the spring constant is doubled, not halved.</p> | <b>1</b> |
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| <b>9</b> | <p><b>C is the correct answer</b></p> <p>A is not correct because P has a smaller breaking stress than Q</p> <p>B is not correct because P has a smaller breaking strain than Q</p> <p>D is not correct because graph P has an initial gradient greater than graph Q</p> | <b>1</b> |
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| <b>9</b> | <p><b>The correct answer is B (The second wire had a longer length)</b></p> <p>A is incorrect because the wire would break at the same extension</p> <p>C is incorrect because the wire would break at the same extension</p> <p>D is incorrect because the wire would break at a smaller extension</p> | <b>1</b> |
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| <b>2</b> | <p><b>The only correct answer is D (50 N m<sup>-1</sup>)</b></p> <p>A is not correct because <math>k = \frac{\Delta F}{\Delta x} = \frac{1.5 \text{ N}}{0.030 \text{ m}} = 50 \text{ N m}^{-1}</math></p> <p>B is not correct because <math>k = \frac{\Delta F}{\Delta x} = \frac{1.5 \text{ N}}{0.030 \text{ m}} = 50 \text{ N m}^{-1}</math></p> <p>C is not correct because <math>k = \frac{\Delta F}{\Delta x} = \frac{1.5 \text{ N}}{0.030 \text{ m}} = 50 \text{ N m}^{-1}</math></p> | <b>1</b> |
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| <b>5</b> | <p><b>The correct answer is D (<math>\frac{R}{q-p}</math>)</b></p> <p>A is incorrect because stiffness is not extension / force</p> <p>B is incorrect because stiffness is not length / force</p> <p>C is incorrect because stiffness is not force / length</p> | <b>1</b> |
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| <b>3</b> | <p><b>A is the correct answer</b></p> <p>B is not correct because the answer should not be square rooted</p> <p>C is not correct because the answer is inverted and should not be square rooted</p> <p>D is not correct because the answer is inverted</p> | <b>1</b> |
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| <b>9</b> | <p><b>9. The only correct answer is C</b></p> <p><i>A is incorrect because the percentage uncertainty should only be quoted to the same number of sf as the absolute uncertainty i.e. 1 sf</i></p> <p><i>B is incorrect because this is 2 times the correct percentage uncertainty and it has been quoted to 2 sf</i></p> <p><i>D is incorrect because this is 2 times the correct percentage uncertainty</i></p> | <b>(1)</b> |
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| Question Number              | Answer  | Mark  |
|------------------------------|---|---|
| <b>16(a)</b>                 | Use of $F = k\Delta x$<br>$\Delta x = 0.049$ (m)<br><br><u>Example of calculation</u><br>$0.88 \text{ N} = 18 \text{ N m}^{-1} \times \Delta x$<br>$\Delta x = 0.0489 \text{ m}$  | (1)<br>(1)<br><br><b>2</b>                      |
| <b>16(b)(i)</b>              | Upthrust increases<br><b>Or</b> upthrust is no longer negligible<br><b>Or</b> there is upthrust in water<br><br>Weight = tension + upthrust<br><br>The tension (in the spring) decreases so the extension/ $\Delta x$ decreases<br><br>(allow converse explanation for lower in air and all symbols other than $\Delta x$ must be defined)  | (1)<br>(1)<br>(1)<br><br><b>3</b>               |
| <b>16(b)(ii)</b>             | <b>Either</b><br>Use of $W = mg$ <b>and</b> $\rho = m/V$<br><b>Or</b> see Upthrust = $\rho Vg$<br><b>Or</b> see $U = 0.334 \text{ N}$<br><br>Tension = $0.88 - U$<br><br>Use of $y = 0.050 - \Delta x$<br>(allow use of $(0.05 - y)$ for $\Delta x$ in Hooke's law equation)<br><br>$y = 0.020 \text{ m}$ (0.018 m to 0.020 m)<br><br><u>Example of calculation</u><br>$U = 1.0 \times 10^3 \text{ kg m}^{-3} \times 3.4 \times 10^{-5} \text{ m}^3 \times 9.81 \text{ N kg}^{-1}$<br>$U = 0.334 \text{ N}$<br>$18 \text{ N m}^{-1} \times \Delta x = 0.88 \text{ N} - 0.334 \text{ N}$<br>$\Delta x = 0.0303 \text{ m}$<br>$y = 0.050 \text{ m} - 0.0303 \text{ m} = 0.0197 \text{ m}$ | (1)<br>(1)<br>(1)<br>(1)<br>(1)<br><br><b>4</b> |
| <b>*16(c)</b>                | <b>(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)</b><br><br>The density of oil is less (than the density of water)<br><br>The upthrust is lower<br>(do not award if a greater density in oil described)<br><br>The tension/force in the spring is greater  | (1)<br>(1)<br>(1)<br><br><b>3</b>               |
| <b>Total for question 16</b> |   | <b>12</b>                                       |

| Question Number              | Answer   | Mark      |
|------------------------------|--|-----------|
| <b>18(a)</b>                 | Use of $W = mg$  | (1)       |
|                              | Use of $\sigma = F/A$  | (1)       |
|                              | Use of $E = \sigma/\epsilon$   | (1)       |
|                              | $\epsilon = 3.8 \times 10^{-3}$ or 0.38 %  | (1)       |
|                              | <u>Example of calculation:</u><br>$W = 0.960 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 9.42\text{N}$<br>$\sigma = \frac{9.42 \text{ N}}{(1.0 \times 10^{-2} \text{ m})(1.0 \times 10^{-4} \text{ m})} = 9.42 \times 10^6 \text{ Pa}$<br>$\epsilon = \frac{9.42 \times 10^6 \text{ Pa}}{2.5 \times 10^9 \text{ Pa}}$<br>$\epsilon = 3.77 \times 10^{-3}$ | <b>4</b>  |
| <b>18(b)</b>                 | The greater tension caused a greater extension   | (1)       |
|                              | There is plastic/permanent deformation   | (1)       |
|                              | The idea that the outside or side with greater tension is left longer so it bends to produce the curling.  | (1)       |
| <b>18(c)(i)</b>              | The greater the tension/stress, the smaller the diameter of the ribbon coil formed   | (1)       |
| <b>18(c)(ii)</b>             | The idea that the greater the area of the blade, the greater the diameter e.g. the sharper the edge, the smaller the diameter  | (1)       |
| <b>18(c)(iii)</b>            | Force/stress applied for a greater time <b>Or</b> ribbon stretched for greater time  | (1)       |
|                              | There is a greater difference between the extensions (and the diameter decreases)  | (1)       |
| <b>Total for question 18</b> |  | <b>11</b> |

### Indicative content

IC1 Measure the original length (from clamp to marker)

IC2 Measure distance moved by marker from original position to determine extension.

**Or** Measure new length and subtract original length to determine extension

IC3 Calculate weight of masses using  $W = mg$

**Or** Use a newtonmeter to measure weight of masses

IC4 Use diameter to calculate cross-sectional area

IC5 Calculate stress using  $\frac{\text{force}}{\text{area}}$  **and** calculate strain using  $\frac{\text{extension}}{\text{original length}}$  (allow symbol equations if terms defined)

**Or** plot a graph of stress against strain

**Or** plot a graph of force against extension

IC6 Calculate Young Modulus using  $\frac{\text{stress}}{\text{strain}}$  (allow symbol equations if terms defined)

**Or** Correctly relate gradient of (straight section of) graph to Young Modulus.

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| <b>16(b)</b>                 | <p>Calculates cross-sectional area (1)</p> <p>Use of <math>\sigma = \frac{F}{A}</math> (1)</p> <p>Use of <math>E = \frac{\sigma}{\epsilon}</math> <b>and</b> use of <math>\epsilon = \frac{\Delta x}{x}</math> (1)</p> <p><math>\Delta x = 4.6 \times 10^{-4} \text{ m}</math> (1)</p> <p><u>Example calculation</u></p> $A = \pi \times \left( \frac{0.56 \times 10^{-3} \text{ m}}{2} \right)^2 = 2.46 \times 10^{-7} \text{ m}^2$ $\sigma = \frac{5.0 \text{ N}}{2.46 \times 10^{-7} \text{ m}^2} = 2.03 \times 10^7 \text{ Pa}$ $\epsilon = \frac{2.03 \times 10^7 \text{ Pa}}{1.1 \times 10^{11} \text{ Pa}} = 1.85 \times 10^{-4}$ $\Delta x = 1.85 \times 10^{-4} \times 2.5 = 4.61 \times 10^{-4} \text{ m}$ | <p>(1)</p> <p>(1)</p> <p>(1)</p> <p>(1)</p> <p><b>4</b></p> |
| <b>Total for question 16</b> |  | <b>10</b>   |

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| <b>11(a)</b>                 | <p>When the force was removed the rubber band returned to its original length.<br/> <b>Or</b><br/> When the force was removed the extension was 0.<br/> <b>Or</b><br/> The decreasing force line returns to the origin. (1)</p>  | <p><b>1</b></p>                                  |
| <b>11(b)</b>                 | <p>Indication that <math>E_{el} = \text{area under force-extension graph}</math>. (1)</p> <p>Uses area between graph lines to determine energy. (1)</p> <p>Energy = 0.048 J (allow a range from 0.0425 J to 0.053 J) (1)</p> <p><u>Example of calculation</u></p> <p>1 cm<sup>2</sup> on graph <math>\equiv 0.5 \text{ N} \times 0.005 \text{ m} = 0.0025 \text{ J}</math></p> <p>Area between graphs <math>\approx 19 \text{ cm}^2</math></p> <p>Energy that caused heating = <math>19 \text{ cm}^2 \times 0.0025 \text{ J cm}^{-2} = 0.0475 \text{ J}</math></p> | <p>(1)</p> <p>(1)</p> <p>(1)</p> <p><b>3</b></p> |
| <b>Total for question 11</b> |  | <b>4</b>   |

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| <b>11(a)</b>                 | When the force was removed the rubber band returned to its original length.<br><b>Or</b><br>When the force was removed the extension was 0.<br><b>Or</b><br>The decreasing force line returns to the origin.   | (1)               | <b>1</b> |
| <b>11(b)</b>                 | Indication that $E_{el} = \text{area under force-extension graph}$ .<br><br>Uses area between graph lines to determine energy.<br><br>Energy = 0.048 J (allow a range from 0.0425 J to 0.053 J)<br><br><u>Example of calculation</u><br>$1 \text{ cm}^2 \text{ on graph} \equiv 0.5 \text{ N} \times 0.005 \text{ m} = 0.0025 \text{ J}$<br><br>Area between graphs $\approx 19 \text{ cm}^2$<br><br>Energy that caused heating = $19 \text{ cm}^2 \times 0.0025 \text{ J cm}^{-2} = 0.0475 \text{ J}$ | (1)<br>(1)<br>(1) | <b>3</b> |
| <b>Total for question 11</b> |  |                   | <b>4</b> |

| Question Number              | Answer   | Mark       |          |
|------------------------------|--|------------|----------|
| <b>11(a)</b>                 | Plot a graph of the force/mass/weight of the load against length/extension<br><b>Or</b> plot a graph of length/ extension against force/mass/weight of the load<br><br>Calculate the gradient (of the linear section of the graph) | (1)<br>(1) | <b>3</b> |
|                              | Multiple the gradient by $g$ to obtain the spring constant<br><b>Or</b> other method consistent with graph plotted to obtain $g$   | (1)        |          |
| <b>11(b)</b>                 | Pointer to reduce parallax<br><br>Graph plotted to identify/remove anomalous results<br><b>Or</b> graph acts as an averaging tool  | (1)<br>(1) | <b>2</b> |
| <b>Total for question 11</b> |  |            | <b>5</b> |