Question	Answer	Marks
1	D	1
2	C	1
3	C	1
4	Energy = $\frac{1}{2}$ × 5 N × 0.09 m = 0.2 J	1 1
5 a	Taking the gradient of the linear section of the graph $\frac{140\,\text{MPa} - 0\,\text{MPa}}{0.005}$ 280 000 MPa (2.8 × 10^{11} Pa)	1 1
5 b	The non-linear section shows plastic deformation.	1
6 a	Brittle material fracture with little plastic deformation and break into sharp fragments	1 1
6 b	Any reasonable example, for example: a wine glass	1
6 c	Any reasonable example of a material and a situation in which toughness is important, for example steel. In crumple zones.	1 1
7	Cross-sectional area of wire = 2.8 × 10^{-6} m^2 Radius of wire = 9.44… × 10^{-4} m Diameter = 1.9 × 10^{-3} m. Examiners will give full credit for correct final answer	1 1 1
8 a	The graph is a straight line through the origin.	1 1
8 b	Choosing a data pair from the graph for example 10.0 N, 1.1 mm $E = \frac{\sigma}{\varepsilon} = \frac{FL}{xA} \Rightarrow A = \frac{FL}{xE} = \frac{10.0\,\text{N} \times 1.9\,\text{m}}{1.1 \times 10^{-3}\,\text{m} \times 1.8 \times 10^{11}\,\text{N}\,\text{m}^{-2}}$ = 9.59 × 10^{-8} m^2 Diameter = 2 × $\sqrt{\frac{A}{\pi}}$ = 3.5 × 10^{-4} m (2 s.f.)	1 1 1
8 c i	Yield stress is the stress at which plastic deformation begins. Breaking stress is the stress at which the material fractures (breaking stress is often referred to as fracture stress).	1 1
8 c ii	breaking stress = breaking force ÷ cross-sectional area $\frac{18.0\,\text{N}}{9.59 \times 10^{-8}\,\text{m}^2}$ = 1.9 × 10^8 Pa	1 1
8 c iii	Yield strength is important because, for example, a suspension bridge must not yield under its load. Yielding can be just as damaging and dangerous as breaking.	1
9 a i	% uncertainty of extension measurement = 6(.25)% % uncertainty of length measurement = 0.7 % The extension measurement gives the greatest % uncertainty.	1 1 1
9 a ii	The % uncertainty can be reduced by using a longer original length of band. The same absolute uncertainty will produce a smaller % uncertainty because the absolute value of extension will be greater for a given load when using a longer band.	1 1
9 b i	$E = \frac{\sigma}{\varepsilon} = \frac{FL}{xA}$ Hence, choose the largest possible values for *F* and *L*, and the smallest possible values for *x* and *A*. Largest *F* = 0.505 N	1

	Smallest A = 3.88 mm^{-2} = 3.88 × 10^{-6} m^2 Largest L = 0.146 m Smallest x = 0.0075 Value of E from these values = 2.5(3) × 10^6 Pa	1 1 1
9 b ii	percentage uncertainty = $\frac{2.5(3)\times10^6 - 2.3\times10^6}{2.3\times10^6}$ = 10%	2
9 b iii	Ignoring the uncertainty in length in the calculation from **i** gives a result of 2.5(2) × 10^6 Pa. This gives a percentage uncertainty of 9.6%, showing that the uncertainty in length contributes very little to the overall uncertainty.	1