6. Deformation of Solids

6.1 Stress and strain

Paper 2

Marking Scheme

Q1.

(a)	extension / original length	**B1**
(b)(i)	Young modulus = stress / strain	**C1**
	= (18 / 4.5 × 10^{-7}) / (1.4 × 10^{-3} / 4.0)	**C1**
	= (4.0 × 10^{7}) / (3.5 × 10^{-4}) = 1.1 × 10^{11} Pa	**A1**
(b)(ii)	straight line through the origin	**B1**
	ending at the point (3.5, 4.0)	**B1**
(c)		**B2**

	greater in second wire	less in second wire	the same in both wires
stress		✓	
strain		✓	

Q2.

(d)	$E = \sigma / \varepsilon$	**C1**
	$x = \sigma L / E$ = 1.9 × 10^{6} × 0.12 / (1.3 × 10^{11})	**C1**
	= 1.8 × 10^{-6} m	**A1**

Q3.

(a)	stress per unit strain	**B1**
(b)(i)	straight line with positive gradient passing through origin	**B1**
(b)(ii)	spring constant	**B1**
(c)	length (of Q) is half (the length of P)	**B1**
	extension is proportional to length, and inversely proportional to area and Young modulus	**B1**
	extension of Q is = ½ / (2 × 2) = ⅛ times the extension of P	**B1**

Q4.

(a)(i)	$E = \sigma / \varepsilon$ **or** E = gradient	**C1**
	E = e.g. 12 × 10^{7} / 0.0050 = 2.4 × 10^{10} Pa	**A1**
(a)(ii)	cross drawn at (1.0%, 24 × 10^{7} Pa), labelled Q	**B1**
(c)(ii)	$\sigma = F / A$	**C1**
	πr^2 = 46 / (1.5 × 10^{7}) r = 9.9 × 10^{-4} m	**A1**

Q5.

(a)	Hooke's (law)	**B1**
(b)	$k = F / x$ **or** k = gradient	**C1**
	= e.g. 12.0 / (0.240 – 0.08) = 75 N m^{-1}	**A1**

Q6.

(c)(i)	(extension =) $2.5 \times 2.4 \times 10^{-5} = 6.0 \times 10^{-5}$ (m)	**A1**
(c)(iii)	longer extension **or** smaller spring constant	**M1**
	elastic potential energy is greater	**A1**

Q7.

(a)	$k = F / \Delta L$ **or** F / x **or** gradient	**C1**
	= e.g. 30 / (0.60 – 0.20)	**A1**
	= 75 N m^{-1}	

Q8.

(d)(i)	$T = kx$ where k is a constant **or** $T = (EA / L)x$ where A is (cross-sectional) area, E is Young modulus, L is (original/unstretched) length	**B1**

Q9.

(b)(iii)	$k = F / x$ **or** k = gradient	**C1**
	e.g. $k = 6.4 / 10 \times 10^{-2}$	**A1**
	= 64 N m^{-1} (*allow 63–65 N m^{-1}*)	

Q10.

(b)(v)	$\sigma = F / A$	**C1**
	$\sigma = F / \pi r^2$ or $4F / \pi d^2$	**A1**
	so $\sigma = 5.3 \times 10^7 \times \pi r^2 / \pi (3r)^2$	
	$= 5.3 \times 10^7 / 9$	
	$= 5.9 \times 10^6$ Pa	

Q11.

(c)(iii)	$\sigma = F / A$ **or** T / A	**C1**
	$= 15 / (3.2 \times 10^{-6})$	**A1**
	$= 4.7 \times 10^6$ Pa	

Q12.

(a)(i)	$\sigma = F / xy$	**B1**
(a)(ii)	$\varepsilon = (z - w) / w$	**B1**
(a)(iii)	$E = \sigma / \varepsilon$	**C1**
	$= Fw / xy(z - w)$	**A1**
(b)(i)	extension = 2.2 mm (*allow* 2.0–2.4 mm)	**A1**

Q13.

(b)(ii)	$\sigma = T / A$ **or** $\sigma = F / A$	**C1**
	$A = \pi d^2 / 4$ **or** $A = \pi r^2$	**C1**
	$\sigma = 3.0 \times 4 / [\pi \times (0.50 \times 10^{-3})^2]$ $= 1.5 \times 10^7$ Pa	**A1**

Q14.

(a)	Hooke's (law)	**B1**
(b)(i)	$\sigma = F / A$	**C1**
	$= 36 / (4.1 \times 10^{-7})$ $= 8.8 \times 10^7$ Pa	**A1**
(b)(ii)	Young modulus = σ / ε **or** $F / A\varepsilon$	**C1**
	$\varepsilon = 8.8 \times 10^7 / (1.7 \times 10^{11})$ $= 5.2 \times 10^{-4}$	**A1**

Q15.

(a)(i)	(stress =) force / cross-sectional area	**B1**
(a)(ii)	(strain =) extension / original length	**B1**
(b)(i)	$E = FL / Ax$	**C1**
	$= GL / A$	**A1**
(b)(ii)	straight line from origin above the original line	**M1**
	line ends at point (4 small squares, F_1).	**A1**

Q16.

(a)(i)	$F = kx$	**C1**
	$F_1 = 800 \times 0.045$ $= 36$ N	**A1**

Q17.

(c)	$E = \sigma / \varepsilon$	**C1**
	$E = (F / A) / (\Delta L / L)$ **or** $E = FL / A\Delta L$	**C1**
	$\Delta L = (480 \times 0.48) / (3.0 \times 10^{-4} \times 2.2 \times 10^{11})$ $= 3.5 \times 10^{-6}$ m	**A1**

Q18.

(a)	$k = F / x$ **or** k = gradient	**C1**
	e.g. $k = 4.0 / 0.050$ $k = 80$ N m^{-1}	**A1**

Q19.

(b)(iv)	$E = F / A\varepsilon$ **or** $E = \sigma / \varepsilon$ and $\sigma = F / A$	**C1**
	$\varepsilon = 20 / (2.8 \times 10^{-5} \times 1.7 \times 10^{11})$	**C1**
	$= 4.2 \times 10^{-6}$	**A1**