Deformation of Materials – 2 - Answers

1.

(a)(i)	stress = force / (cross sectional) area	B1
(ii)	strain = extension / (original) length	B1
(b) (i)	elastic returns to its original length/shape when the force/load is removed	B1
	plastic does not regain its original length/size when the load is removed	B1
	(allow ½ if removal of load is not specified but remainder is clear)	
(ii)	force/stress/strain/extension beyond which the material does not return to its original length (when the load is removed)	B1 B1
	(point beyond….scores one only)	
(c)(i)	unit: Pa / N m^{-2}	B1
(ii)	Any seven from:	

- Appropriate arrangement drawn — B1
- Measure length — B1
- Apply force and measure the extension — B1
- Take a series of readings — B1
- Measure the diameter — B1
- Graph of stress against strain / force-extension graph — B1
- Gradient for E / E = stress/strain / Gradient = $EA/_L$ — B1
- Point of detail e.g. second wire, micrometer used for diameter, Vernier for extension, very long wire — B1

2.

(a)	force / load if proportional to extension	B1
(b)(i)	force constant = 100 / (40 x 10^{-3}) or equivalent	C1
	= 2500 N m^{-1} / kg s^{-2} (2.5 N mm^{-1})	A1
	unit penalty	-1
(ii)	work done = area under graph / (force x extension) / 2	C1
	= (120 x 48 x 10^{-3}) / 2	M1
	= 2.88 (2.9 to 2sf) (J)	A0
(c)(i)	k.e = ½ mv^2	C1
	v^2 = (2.9 x 2) / 0.015	C1
	v = 19.7 (ms^{-1}) (19.6 if 2.88 J is used)	A1

(ii)	(energy lost due to) friction <u>in the gun</u>	B1
	air resistance	B1
	(allow energy loss if type identified and place given)	
	(allow recoil of the gun)	
	Total	[10]

3.

(a)(i)	Young modulus = tensile stress / tensile strain (stress / strain scores 1, with definitions of stress and strain scores 2)	B2
(ii)	elastic limit: maximum force / load / stress / strain / extension which can be applied to an object and it will regain its original length when the force / load stress is removed	B2
(iii)	elastic returns to original length when load is removed	B1
	plastic returns some deformation (when load is removed)	B1
	penalise 'when load is removed' once only in (ii) and (iii)	
(b)	a. brittle substance / glass / cast iron / perspex	B1
	b. ductile substance / metal / polythene	B1
	c. polymeric substance / rubber / elastic	B1
	extends uniformly and then breaks for a	B1
	plastic behaviour for b	B1
	elastic but energy stored in the material when load removed for c / elastic but not uniform	B1

4.

(a)	stress/ strain	M1
	with qualification e.g. elastic limit, within limit of proportionality tensile stress, tensile strain, Hooke's law obeyed	A1
(b)(i)	$e/l = 0.55 \times 10^{-3} / 1.8$	C1
	$= 3.1 \times 10^{-4}$ (3.056)	
(ii)	$E = F \times l / A \times e$	
	$F = 2 \times 10^{11} \times 3.1 \times 10^{-4} \times 1.2 \times 10^{-7}$	C1
	$F = 7.33$ (N)	A1
(c)(i)	E is half therefore e will be twice	C1
	e = 1.1 (mm)	A1
	(or suitable calculation)	
(ii)	limit of proportionality not exceeded / elastic limit is not exceeded / temperature of wires the same / Hooke's law applies	B1

5.

(a)	load / force is proportional to extension		B1
(b)(i)	E	= (F x 1) / (e x A) / E = stress / strain	C1
		= (gradient of graph x 1.7) / 1.8 x 10^{-7}	C1
		(grad = 29.0/1.6 x 10^{-3} or use of two points on line)	C1
	= 1.71 x 10^{11} (Pa)		A1
(ii)	W	= area under line / W = ½ Fe	C1
		= ½ x 29 x 1.6 x 10^{-3}	C1
		= 0.023 (J)	A1

6.

(a)	(E) = stress/strain	**B1**
(b)(i)	strain = extension/length	**C1**
	= 4.2 x 10^{-3} / 0.75	
	= 5.6 x 10^{-3}	**A1**
(b)(ii)	E = force / (area x strain)	**C1**
	F = E x A x strain	
	= 2 x 10^{11} x 4.5 x 10^{-7} x 5.6 x 10^{-3}	**C1**
	= 504 (N)	**A1**
(c)	larger extension in words scores 1 (twice the extension) 8.4 scores 2	**B2**
(d)(i)	density = mass / volume	**B1**
(ii)	volume larger hence density less	**B1**

7.

(a) tensile stress: force/tension per unit cross-sectional area or $\frac{F}{A}$ with F and A defined ✓

tensile strain: extension per unit length or $\frac{e}{l}$ with e and l defined ✓

the Young modulus: $\frac{\text{tensile stress}}{\text{tensile strain}}$ ✓ (*3*)

(b)(i) $E_S = \frac{F_S}{A}\frac{l}{e}$ and $E_B = \frac{F_B}{A}\frac{l}{e}$ ✓ hence $\frac{E_S}{E_B} = \frac{F_S}{F_B}$

(ii) $\frac{E_S}{E_B} = 2$ ✓

$\therefore F_S = 2F_B$ ✓

$F_S + F_B = 15\,\text{N}$ ✓ gives $F_S = 10\,\text{N}$

[or any alternative method]

(iii) $\left(E = \dfrac{F}{A}\dfrac{l}{e} \text{ gives}\right) \quad e = \left(\dfrac{F}{A}\dfrac{l}{E}\right) = \dfrac{10 \times 1.5}{1.4 \times 10^{-6} \times 2.0 \times 10^{11}}$ ✓

$= 5.36 \times 10^{-5}$ m ✓ (6)

(9)

Quality of Written Communication marks: Q2 (a) (ii) and Q2 (b) ✓✓ (2)

(2)