CAMBRIDGE INTERNATIONAL AS & A LEVEL PHYSICS · 9702

PHYSICS



MARK SCHEME

6 DEFORMATION OF SOLIDS

SCORE	PERCENTAGE
/	%

STEMUP

These questions belong to CIE, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Cambridge International (CIE). They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with CIE and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. CIE has not endorsed, approved or been involved in the production of it. CIE and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

CIE publishes its past papers, mark schemes and examiner reports. Always check the current syllabus at cambridgeinternational.org before you revise.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Paper 1 Multiple Choice Answers: Deformation of Solids

Question	Paper	Q. No.	Answer
638	9702_m20_qp_12	19	B
639	9702_s20_qp_11	16	C
640	9702_s20_qp_11	20	B
641	9702_s20_qp_12	18	C
642	9702_s20_qp_12	19	B
643	9702_s20_qp_13	20	A
644	9702_m19_qp_12	19	B
645	9702_m19_qp_12	20	D
646	9702_s19_qp_11	20	A
647	9702_s19_qp_11	21	B
648	9702_s19_qp_12	18	A
649	9702_s19_qp_12	20	A
650	9702_s19_qp_13	11	A
651	9702_s19_qp_13	19	B
652	9702_w19_qp_11	19	D
653	9702_w19_qp_12	18	A
654	9702_w19_qp_13	19	D
655	9702_m18_qp_12	20	C
656	9702_s18_qp_11	18	B
657	9702_s18_qp_11	19	B
658	9702_s18_qp_12	20	D
659	9702_s18_qp_12	21	D
660	9702_s18_qp_13	18	D
661	9702_w18_qp_11	16	B
662	9702_w18_qp_11	18	B
663	9702_w18_qp_11	19	B
664	9702_w18_qp_12	20	D
665	9702_w18_qp_13	19	D
666	9702_m17_qp_12	20	B
667	9702_s17_qp_11	20	D
668	9702_s17_qp_12	20	D
669	9702_s17_qp_13	18	D
670	9702_w17_qp_12	20	D
671	9702_w17_qp_12	21	A
672	9702_m16_qp_12	19	B
673	9702_s16_qp_11	20	C
674	9702_s16_qp_12	20	D
675	9702_s16_qp_13	21	D
676	9702_s16_qp_13	22	C
677	9702_w16_qp_11	22	A
678	9702_w16_qp_12	22	B
679	9702_w16_qp_13	22	A
680	9702_s15_qp_12	21	A
681	9702_s15_qp_12	23	C
682	9702_s15_qp_13	22	A
683	9702_s15_qp_13	24	D

Paper 1 Multiple Choice Answers: Deformation of Solids (continued)

Question	Paper	Q. No.	Answer
684	9702_m20_qp_12	20	C
685	9702_s20_qp_11	21	D
686	9702_s20_qp_12	20	B
687	9702_s20_qp_13	21	A
688	9702_m19_qp_12	13	D
689	9702_m19_qp_12	21	C
690	9702_s19_qp_12	22	B
691	9702_s19_qp_13	20	C
692	9702_w19_qp_11	20	D
693	9702_w19_qp_12	19	B
694	9702_w19_qp_13	20	C
695	9702_m18_qp_12	19	A
696	9702_s18_qp_13	19	C
697	9702_w18_qp_11	20	C
698	9702_w18_qp_12	21	D
699	9702_w18_qp_13	20	B
700	9702_m17_qp_12	21	A
701	9702_s17_qp_11	21	A
702	9702_s17_qp_12	19	A
703	9702_s17_qp_12	21	B
704	9702_s17_qp_13	19	B
705	9702_s17_qp_13	20	A
706	9702_w17_qp_11	20	A
707	9702_w17_qp_11	21	D
708	9702_w17_qp_13	20	D
709	9702_w17_qp_13	21	A
710	9702_m16_qp_12	18	D
711	9702_s16_qp_11	21	B
712	9702_s16_qp_12	21	D
713	9702_s16_qp_13	20	C
714	9702_w16_qp_11	21	D
715	9702_w16_qp_12	21	D
716	9702_w16_qp_13	21	D
717	9702_s15_qp_11	22	A
718	9702_s15_qp_11	23	B
719	9702_s15_qp_12	22	B
720	9702_s15_qp_13	23	C

103. 9702_s15_qp_23 Q: 3

(a) (power =) work done / time (taken) or rate of work done — A1 [1]

(b) (i) $F - R = ma$ — C1

$F = 1500 \times 0.82 + 1200$ — C1

$= 2400\ (2430)\ \text{N}$ — A1 [3]

(ii) $P = Fv$ — C1

$= (2430 \times 22) = 53\,000\ (53\,500)\ \text{W}$ — A1 [2]

(c) (there is maximum power from car and) resistive force = force produced by car hence no acceleration
or
suggestion in terms of power produced by car and power wasted to overcome resistive force — B1 [1]

---

104. 9702_m20_qp_22 Q: 3

	Answer	Mark
(a)	force × displacement in the direction of the force	B1
(b)(i)	displacement = 4.4×30	C1
	work done = $140 \cos 30° \times 4.4 \times 30$	C1
	$= 1.6 \times 10^4$ J	A1
(b)(ii)	$p = F / A$	C1
	$F = 860 - 140 \sin 30°$ (= 790)	C1
	$A = 790 / 2400$ $= 0.33\ \text{m}^2$	A1
(b)(iii)	$\sigma = F / A$ or $F / \pi r^2$ or $4F / \pi d^2$	C1
	$9.6 \times 10^6 = 4 \times 140 / \pi d^2$ $d = 4.3 \times 10^{-3}$ m	A1

	Answer	Mark
(c)	$E = \frac{1}{2}Fx$ or $\frac{1}{2}kx^2$ or area under graph	C1
	$(\Delta)E = \frac{1}{2} \times (140 + 210) \times 0.20 \times 10^{-3}$ or $(\Delta)E = (\frac{1}{2} \times 210 \times 0.60 \times 10^{-3}) - (\frac{1}{2} \times 140 \times 0.40 \times 10^{-3})$ or $(\Delta)E = (140 \times 0.20 \times 10^{-3}) + (\frac{1}{2} \times 0.20 \times 10^{-3} \times 70)$ or $(\Delta)E = [\frac{1}{2} \times 3.5 \times 10^5 \times (0.60 \times 10^{-3})^2] - [\frac{1}{2} \times 3.5 \times 10^5 \times (0.40 \times 10^{-3})^2]$	C1
	$\Delta E = 0.035$ J	A1

105. 9702_w19_qp_23 Q: 4

	Answer	Mark
(a)(i)	$p = mv$	C1
	$= 0.2(00) \times 6.(00) \times \sin 60(.0)°$ **or** $0.2(00) \times 6.(00) \times \cos 30(.0)°$ $= 1.04\ \text{kg m s}^{-1}$	A1
(a)(ii)	$0.300 \times v_x \times \sin 60.0° = 1.04$ $v_x = 4.00\ \text{m s}^{-1}$	A1
(a)(iii)	$0.30 \times 4.0 \times \cos 60°$ **or** $0.20 \times 6.0 \times \cos 60°$ **or** $(0.30 + 0.20)v$ **or** $0.50v$	C1
	$0.30 \times 4.0 \times \cos 60° + 0.20 \times 6.0 \times \cos 60° = (0.30 + 0.20)v$ **or** $0.50v$ so $v = 2.4\ \text{m s}^{-1}$	A1
(b)(i)	$E = ½mv^2$	C1
	$½ \times 0.50 \times 2.4^2 = ½ \times 72 \times x^2$	C1
	$x = 0.20\ \text{m}$	A1
(b)(ii)	**1.** straight line from the origin sloping upwards	B1
	2. line drawn from a positive value of E_k at $x = 0$ to a positive value of x at $E_k = 0$	M1
	line has an increasing downwards slope	A1

106. 9702_m18_qp_22 Q: 3

	Answer	Mark
(a)(i)	force / (cross-sectional) area	B1
(a)(ii)	extension / original length	B1
(b)(i)	measure / determine / find diameter	B1
	using a micrometer / digital calipers	B1
	several measurements in different places / along the wire / around the circumference (and average them)	B1
(b)(ii)	$E = \sigma / \varepsilon$ or $E = FL / Ax$ or E = gradient × (L / A) $E = (4 \times 2.5) / (0.8 \times 10^{-3}) \times (9.4 \times 10^{-8})$	C1
	$= 1.3 \times 10^{11}\ \text{Pa}$	A1

	Answer	Mark
(b)(iii)	$E = ½Fx$ or $E = ½kx^2$ or E = area under graph $E = ½ \times (2+4) \times 0.4 \times 10^{-3}$ or $E = (½ \times 4 \times 0.8 \times 10^{-3}) - (½ \times 2 \times 0.4 \times 10^{-3})$ or $E = [\,½ \times 5000 \times (0.8 \times 10^{-3})^2\,] - [\,½ \times 5000 \times (0.4 \times 10^{-3})^2\,]$	C1
	$E = 1.2 \times 10^{-3}\ \text{J}$	A1
(c)	straight line from the origin and above the original line	M1
	straight line passes through (0.80, 8.0)	A1

107. 9702_s18_qp_21 Q: 2

	Answer	Mark
(a)	a body continues at (rest or) constant velocity unless acted upon by a resultant force	B1
(b)(i)1.	from 0–2 s, distance = ½ × 2 × 6.8 (= 6.8 m) **and** from 2–3 s, distance = ½ × 1 × 3.4 (= 1.7 m)	C1
	magnitude of displacement = 5.1 m	A1
	direction of displacement is down(wards)	B1
(b)(i)2.	$(\Delta E) = mg\Delta h$ **or** $(E) = mgh$ **or** $(E) = Wh$	C1
	$(\Delta)E = 15 \times 5.1$ $= (-)\ 77\ J$	A1
(b)(ii)	$a = (v - u)/t$ **or** a = gradient **or** $a = dv/dt$	C1
	$a = 3.4\ m\ s^{-2}$	A1
(b)(iii)	$T - W = ma$ **or** $T - mg = ma$	C1
	$T = 15 + (15/9.81) \times 3.4 = 20\ N$ or $20.2\ N$	A1
(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
(b)(v)	block is in equilibrium/has no resultant force	B1
	block could be stationary (**or** have constant velocity/speed) (so no, not possible to deduce)	B1

108. 9702_s18_qp_22 Q: 5

	Answer	Mark
(a)	$\rho = m/V$	C1
	$= (560/9.81)/(1.2 \times 0.018)$ $= 2600\ kg\ m^{-3}$	A1
(b)	$(\Delta)p = 940 \times 9.81 \times 1.2$	C1
	(upthrust =) $940 \times 9.81 \times 1.2 \times 0.018 = 200\ N$	A1
(c)(i)	tension $= 560 - 200$ $= 360\ N$	A1
(c)(ii)	$P = Fv$	C1
	$= 360 \times 0.020$ $= 7.2\ W$	A1
(d)(i)	upthrust decreases	B1
	tension (in wire) increases	M1
	power (output of motor) increases	A1
(d)(ii)	there is work done (on the cylinder) by the upthrust **or** GPE of oil decreases (as it fills the space left by cylinder and so total energy is conserved)	B1

109. 9702_w18_qp_23 Q: 1

	Answer	Mark
(a)	current temperature (**allow** amount of substance, luminous intensity) *any two correct answers, 1 mark each*	**B2**
(b)(i)	$W = 2 \times (150 \times \sin 17°)$ **or** $2 \times (150 \times \cos 73°)$	**C1**
	$W = 88\,\text{N}$	**A1**
(b)(ii)	**1.** $\sigma = F/A$	**C1**
	$= 150/(7.5 \times 10^{-6})$ $= 2.0 \times 10^{7}\,\text{Pa}$	**A1**
	2. $\varepsilon = \sigma / E$	**C1**
	$= 2.0 \times 10^{7}/(2.1 \times 10^{11})$ $= 9.5 \times 10^{-5}$	**A1**

110. 9702_s17_qp_22 Q: 3

	Answer	Mark
(a)	E = stress / strain **or** $(F/A)/(e/l)$	**C1**
	$= [\text{gradient} \times 3.5] / [\pi \times (0.19 \times 10^{-3})^2]$ e.g. $E = [\{(40 - 5)/([11.6 - 3.2] \times 10^{-3})\} \times 3.5] / [\pi \times (0.19 \times 10^{-3})^2]$ **or** $[4170 \times 3.5] / [\pi \times (0.19 \times 10^{-3})^2]$	**C1**
	$E\ (= 1.3 \times 10^{11}) = 0.13$ TPa (*allow answers in range 0.120–0.136 TPa*)	**A1**
(b)	a larger <u>range</u> of F required **or** <u>range</u> greater than 35 N	**B1**

111. 9702_w17_qp_21 Q: 4

	Answer	Mark
(a)	(strain =) extension / <u>original</u> length	**B1**
(b)(i)	$E = \sigma/\varepsilon$	**C1**
	maximum stress $= 2.1 \times 10^{11} \times 4.0 \times 10^{-4}$ $= 8.4 \times 10^{7}\,\text{Pa}$	**A1**
(b)(ii)	$\sigma = F/A$	**C1**
	minimum area $= 8.0 \times 10^{3}/8.4 \times 10^{7}$ $= 9.5 \times 10^{-5}\,\text{m}^2$	**A1**

112. 9702_w17_qp_22 Q: 3

	Answer	Mark
(a)	$p = 1000 \times 9.81 \times 7.0 \times 10^{-2}$ **or** $1000 \times 9.81 \times 1.9 \times 10^{-2}$	**C1**
	$\Delta p = 1000 \times 9.81 \times (7.0 \times 10^{-2} - 1.9 \times 10^{-2})$ **or** 686 – 186 = 500 Pa	**A1**
(b)	$F = pA$ **or** $(\Delta)F = \Delta p \times A$	**C1**
	upthrust = $500 \times (5.1 \times 10^{-2})^2 = 1.3$ N **or** upthrust = $(686 - 186) \times (5.1 \times 10^{-2})^2 = 1.3$ N **or** upthrust = $1000 \times 9.81 \times 5.1 \times 10^{-2} \times (5.1 \times 10^{-2})^2 = 1.3$ N	**A1**
(c)	force = 4.0 – 1.3 = 2.7 N	**A1**

	Answer	Mark
(d)	extension/x/e = 2.7 / 30	**C1**
	= 0.09 (m) **or** 9 (cm)	**C1**
	height above surface = 9 – 7 = 2 cm	**A1**
(e)(i)	mass = 4.0 / 9.81	**C1**
	acceleration = 2.7 / (4.0 / 9.81) = 6.6 m s^{-2}	**A1**
(e)(ii)	viscous force <u>increases</u> (and then becomes constant)	**M1**
	(weight and upthrust constant so) acceleration decreases (to zero)	**A1**

113. 9702_s16_qp_22 Q: 3

(a) Young modulus = stress / strain B1 [1]

(b) (i) $E = (F \times l) / (A \times e)$ or $e = (F \times l) / (A \times E)$ B1

$e \propto 1 / E$
or
ratio $e_C / e_S = E_S / E_C$ or $(1.9 \times 10^{11}) / (1.2 \times 10^{11})$ or 19 / 12 C1

(ratio =) 1.6 (1.58) A1 [3]

(ii) two straight lines from (0,0) with **S** having the steepest gradient B1 [1]

114. 9702_w16_qp_22 Q: 3

(a) resultant force (in any direction) is zero — B1
resultant moment/torque (about any point) is zero — B1 [2]

(b) (i) force = 33 sin 52° *or* 33 cos 38°
= 26 N — A1 [1]

(ii) 26×0.30 *or* $W \times 0.20$ *or* 12×0.40 — C1

$26 \times 0.30 = (W \times 0.20) + (12 \times 0.40)$ — C1

$W = 15$ N — A1 [3]

(c) (i) $E = \Delta\sigma / \Delta\varepsilon$ *or* $E = \sigma / \varepsilon$ — C1

$\Delta\sigma = 2.0 \times 10^{11} \times 7.5 \times 10^{-4}$
$= 1.5 \times 10^{8}$ Pa — A1 [2]

(ii) $\Delta\sigma = \Delta F / A$ *or* $\sigma = F / A$ — C1

$A = 78 / 1.5 \times 10^{8}$ $(= 5.2 \times 10^{-7}\ \text{m}^2)$ — C1

$5.2 \times 10^{-7} = \pi d^2 / 4$

$d = 8.1 \times 10^{-4}$ m — A1 [3]

---

115. 9702_s20_qp_23 Q: 3

	Answer	Mark
(a)	for a body in (rotational) equilibrium	**B1**
	sum/total of clockwise moments about a point = sum/total of anticlockwise moments about the (same) point	**B1**
(b)(i)	$(W \times 0.45)$ **or** (19×1.3) **or** $(W \times 1.85)$ **or** (22×2.6)	**C1**
	$(W \times 0.45) + (19 \times 1.3) + (W \times 1.85) = (22 \times 2.6)$ so $W = 14$ N	**A1**
(b)(ii)	magnitude = 19 + 14 + 14 – 22 = 25 N	**A1**
	direction: vertically upwards	**A1**
(c)(i)	the extension is zero when the force is zero	**B1**
	graph is a straight line and (so) Hooke's law obeyed	**B1**
(c)(ii)	$k = F / x$ **or** k = gradient	**C1**
	e.g. $k = 60 / (1.00 - 0.25)$ $k = 80$ N m^{-1}	**A1**
(c)(iii)	area shaded below graph line between $L = 0.25$ m and $L = 0.75$ m	**B1**

116. 9702_w20_qp_21 Q: 4

	Answer	Mark
(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
(b)(iii)	**1.** shaded area below the graph line and between the two vertical dashed lines	B1
	2. remove the force/F/F_2 and the wire goes back to original length/zero extension	B1
(b)(iv)	values have a large range	B1

117. 9702_w20_qp_22 Q: 3

	Answer	Mark
(a)(i)	$F = kx$	C1
	$F_1 = 800 \times 0.045$ $= 36$ N	A1
(a)(ii)	(E =) $½kx^2$ **or** $½Fx$ **or** area under graph	C1
	$½ \times 800 \times (0.045)^2$ **or** $½ \times 36 \times 0.045 = 0.81$ (J)	A1
(b)(i)	efficiency = $(0.72 / 0.81) \times 100$ $= 89\%$	A1
(b)(ii)	$E = ½mv^2$	C1
	$p = mv$	C1
	$0.72 = ½ \times 0.020 \times v^2$ and $p = 0.020 \times v$ $p = 0.17$ N s	A1
(c)(i)	$(\Delta)E = mg(\Delta)h$	C1
	$h = 0.60 / (0.020 \times 9.81) = 3.1$ m	A1
(c)(ii)	$F = (0.72 - 0.60) / 3.1$	C1
	$= 0.039$ N	A1
(c)(iii)	resultant force on ball is less (than that with air resistance) so time (taken) is more (than T)	B1

118. 9702_w20_qp_23 Q: 4

	Answer	Mark
(a)	compression/extension is proportional to force (provided limit of proportionality is not exceeded)	B1
(b)	$(E) = ½Fx$ **or** $½kx^2$ **or** area under graph	C1
	$= ½ \times 8 \times 16 \times 10^{-2} = 0.64$ (J) **or** $= ½ \times 50 \times (16 \times 10^{-2})^2 = 0.64$ (J)	A1
(c)(i)	$(E) = ½mv^2$	C1
	$0.64 = ½ \times 0.076 \times v^2$ $v = 4.1\ \text{m s}^{-1}$	A1
(c)(ii)	$(\Delta)(E) = mg(\Delta)h$	C1
	$= 0.076 \times 9.81 \times 0.24$ $(= 0.18\ (\text{J}))$	C1
	kinetic energy = 0.64 – 0.18 = 0.46 J	A1
(c)(iii)	$v = 4.1\ \text{m s}^{-1}$	A1
(d)	$W = Fs$	C1
	$d = 0.30 + (2\pi \times 0.12) + 0.25$ (= 1.3 m)	C1
	$F = 0.23 / 1.3$ = 0.18 N	A1

119. 9702_s19_qp_21 Q: 3

	Answer	Mark
(a)(i)	$E = ½Fx$ **or** $E = ½kx^2$ **or** E = area under graph	C1
	$E = ½ \times 4.0 \times 0.32 = 0.64$ J **or** $E = ½ \times 12.5 \times (0.32)^2 = 0.64$ J	A1
(a)(ii)	$E = mgh$ **or** $E = Wh$ $= 2.5 \times 0.32$	C1
	= 0.80 J	A1
(b)(i)	kinetic energy = 0.80 – 0.64 = 0.16 J	A1
(b)(ii)	$E = ½mv^2$ $0.16 = ½ \times (2.5 / 9.81) \times v^2$	C1
	$v = 1.1\ \text{m s}^{-1}$	A1

120. 9702_s18_qp_23 Q: 4

	Answer	Mark
(a)	(Young modulus =) stress / strain	B1
(b)(i)	$k = F / \Delta L$ **or** 1 / gradient	C1
	$= 90 \times 10^3 / (2 \times 10^{-3})$ (*or other point on line*) $= 4.5 \times 10^7\ \text{N m}^{-1}$	A1
(b)(ii)	$E = \frac{1}{2} F \Delta L$ **or** $E = \frac{1}{2} k (\Delta L)^2$	C1
	$= \frac{1}{2} \times 90 \times 10^3 \times 2 \times 10^{-3}$ **or** $\frac{1}{2} \times 4.5 \times 10^7 \times (2 \times 10^{-3})^2$	C1
	$= 90\ \text{J}$	A1
(c)	straight line starting from (0, 150) and below original line	M1
	line ends at (90, 147)	A1

121. 9702_m17_qp_22 Q: 2

	Answer	Mark
(a)	sum / total momentum of bodies is constant *or* sum / total momentum of bodies before = sum / total momentum of bodies after	M1
	for an isolated / closed system / no (resultant) external force	A1
(b)(i)	EPE = area under graph or $\frac{1}{2} F x$ or $\frac{1}{2} k x^2$ and $F = kx$	C1
	energy $= \frac{1}{2} \times 12.0 \times 8.0 \times 10^{-2} = 0.48\ \text{J}$ *or* energy $= \frac{1}{2} \times 150 \times (8.0 \times 10^{-2})^2 = 0.48\ \text{J}$	A1
(b)(ii)1	$4.0\ v_A = 6.0\ v_B$	C1
	$E_K = \frac{1}{2} m v^2$	C1
	ratio $= \frac{0.50 \times 4.0}{0.50 \times 6.0}\left(\frac{6.0}{4.0}\right)^2 = 1.5$ *or* ratio $= \frac{1}{1.5} \times (1.5)^2 = 1.5$	A1
(b)(ii)2	$0.48 = E_K$ of A + E_K of B $= E_K$ of A + (E_K of A / 1.5) = 5/3 × E_K of A	C1
	E_K of A = 0.29 (0.288) J	A1
(b)(iii)	curve starts from origin and has decreasing gradient	M1
	final gradient of graph line is zero	A1

122. 9702_s17_qp_23 Q: 4

	Answer	Mark
(a)	the straight line does not go through the origin/the force is not proportional to extension (so does not obey Hooke's law)	A1
(b)	elastic potential energy	B1
(c)	remove the force/masses and the spring returns to its original length if elastic	B1
(d)	work done is represented by/linked to area under the line (× *g*)	C1
	work $= \frac{1}{2} (145 + 70) \times 10^{-3} \times 9.81 \times 120 \times 10^{-3}$	C1
	$= 0.13\ (0.127)\ \text{J}$	A1

123. 9702_m16_qp_22 Q: 3

(a) (i) (work =) force × distance moved in the direction of the force. B1

(ii) the energy stored (in an object) due to extension / compression / change of shape B1

(b) (i) $E_K = ½mv^2$ C1
$= 0.5 \times 0.40 \times 0.30^2$
$= 1.8 \times 10^{-2}$ (J) A1

(ii) (change in) kinetic energy = work done on spring / (change in) elastic potential energy C1
$1.8 \times 10^{-2} = ½ \times F \times 0.080$ C1
$F_{MAX} = 0.45$ (N) A1

(iii) $a = F / m = 0.45 / 0.40$
$= 1.1\,(m\,s^{-2})$ A1

(iv) **1.** constant velocity / resultant force is zero, so in equilibrium B1

2. decelerating / resultant force is not zero, so not in equilibrium B1

(c) curved line from the origin M1
with decreasing gradient A1

124. 9702_s16_qp_21 Q: 4

(a) the energy (stored) in a body due to its extension/compression/deformation/ change in shape/size B1 [1]

(b) (i) two values of F/x are calculated which are the same
e.g. 10.4 / 40 = 0.26 and 6.5 / 25 = 0.26 B1

or

ratio of two forces and the ratio of the corresponding two extensions are calculated which are the same
e.g. 5.2 / 10.4 = 0.5 and 20 / 40 = 0.5 (B1)

or

gradient of graph line calculated and coordinates of one point on the line used with straight line equation $y = mx + c$ to show $c = 0$ (B1)

(so) force is proportional to extension (and so Hooke's law obeyed) B1 [2]

(b) (ii) 1. $k = F / x$ or k = gradient C1

gradient or values from a single point used e.g. $k = 10.4 / (40 \times 10^{-2})$

$k = 26\,\text{N m}^{-1}$ A1 [2]

2. work done = area under graph
or $\frac{1}{2}Fx$ or $\frac{1}{2}(F_2 + F_1)(x_2 - x_1)$
or $\frac{1}{2}kx^2$ or $\frac{1}{2}k(x_2^2 - x_1^2)$ C1

= $\frac{1}{2} \times 10.4 \times 0.4 - \frac{1}{2} \times 5.2 \times 0.2$
or $\frac{1}{2} \times (5.2 + 10.4) \times 20 \times 10^{-2}$
or $\frac{1}{2} \times 26 \times (0.4^2 - 0.2^2)$ C1

= 1.6 J A1 [3]

(c) remove the force and the spring goes back to its original length B1 [1]

STEMUP.CO.UK

125. 9702_w16_qp_21 Q: 3

(a) force/load is proportional to extension/compression (provided proportionality limit is not exceeded) B1 [1]

(b) (i) $k = F/x$ *or* k = gradient C1

$k = 600\,\text{N m}^{-1}$ A1 [2]

(ii) (W =) ½kx^2 *or* (W =) ½Fx *or* (W =) area under graph C1

(W =) $0.5 \times 600 \times (0.040)^2 = 0.48\,\text{J}$ *or* (W =) $0.5 \times 24 \times 0.040 = 0.48\,\text{J}$ A1 [2]

(iii) **1.** (E_K =) ½mv^2 C1

$= ½ \times 0.025 \times 6.0^2$

$= 0.45\,\text{J}$ A1 [2]

2. (work done against resistive force =) 0.48 – 0.45 [= 0.03(0) J] C1

average resistive force = 0.030 / 0.040 C1

$= 0.75\,\text{N}$ A1 [3]

(iv) efficiency = [useful energy out / total energy in] (×100) C1

= [0.45 / 0.48] (×100)

= 0.94 *or* 94% A1 [2]

126. 9702_w16_qp_23 Q: 3

(a) force/load is proportional to extension/compression (provided proportionality limit is not exceeded) B1 [1]

(b) (i) $k = F/x$ *or* k = gradient C1

$k = 600\,\text{N m}^{-1}$ A1 [2]

(ii) $(W =)\ ½kx^2$ *or* $(W =)\ ½Fx$ *or* $(W =)$ area under graph C1

$(W =)\ 0.5 \times 600 \times (0.040)^2 = 0.48\,\text{J}$ *or* $(W =)\ 0.5 \times 24 \times 0.040 = 0.48\,\text{J}$ A1 [2]

(iii) **1.** $(E_K =)\ ½mv^2$ C1

$= ½ \times 0.025 \times 6.0^2$

$= 0.45\,\text{J}$ A1 [2]

2. (work done against resistive force =) 0.48 – 0.45 [= 0.03(0) J] C1

average resistive force = 0.030 / 0.040 C1

$= 0.75\,\text{N}$ A1 [3]

(iv) efficiency = [useful energy out / total energy in] (×100) C1

= [0.45 / 0.48] (×100)

= 0.94 *or* 94% A1 [2]

---

127. 9702_s15_qp_21 Q: 4

(a) (i) two sets of co-ordinates taken to determine a constant value (F/x) M1

F/x constant hence obeys Hooke's law A1 [2]

or
gradient calculated and one point on line used to show no intercept hence obeys Hooke's law (M1) (A1)

(ii) gradient or one point on line used e.g. $4.5 / 1.8 \times 10^{-2}$ C1

$(k =)\ 250\,\text{N m}^{-1}$ A1 [2]

(iii) work done or E_P = area under graph or $½Fx$ or $½kx^2$ C1

$= 0.5 \times 4.5 \times 1.8 \times 10^{-2}$ or $0.5 \times 250 \times (1.8 \times 10^{-2})^2$ C1

$= 0.041\ (0.0405)\,\text{J}$ A1 [3]

(b) KE = $½mv^2$

$½mv^2 = 0.0405$ or KE = 0.0405 (J) C1

$(v = [2 \times 0.0405 / 1.7]^{1/2} =)\ 0.22\ (0.218)\,\text{m s}^{-1}$ A1 [2]

---

128. 9702_w15_qp_22 Q: 3

(a) (i) $k = F/x$ **or** 1/gradient — C1

$(k = 4.4/(5.4 \times 10^{-2}) =) 81\ (81.48)\,\text{N m}^{-1}$ — A1 [2]

(ii) work done = area under line **or** $\frac{1}{2}Fx$ **or** $\frac{1}{2}kx^2$ — C1

$(= 0.5 \times 4.4 \times 5.4 \times 10^{-2} =) 0.12\ (0.119)\,\text{J}$ — A1 [2]

(b) (i) kinetic energy/E_k of trolley/T (and block) changes to EPE/strain energy/elastic energy of spring — B1

EPE changes to KE of trolley/T and KE of block **or** to give lower KE to trolley — B1 [2]

(ii) change in momentum $= m(v + u)$ — C1

$= 0.25\ (0.75 + 1.2) = 0.49\ (0.488)\,\text{N s}$ — A1 [2]

---

129. 9702_w20_qp_21 Q: 5

	Answer	Mark
(a)	$v = \lambda / T$ **or** $v = f\lambda$ **and** $f = 1/T$	C1
	$v = 8.0 \times 10^{-2} / 0.40$ $= 0.20\ \text{m s}^{-1}$	A1
(b)	$I \propto A^2$	C1
	ratio $= 2^2 / 4^2$	C1
	$= 0.25$	A1

---

130. 9702_w15_qp_21 Q: 2

(a) ps $= 10^{-12}$(s) **or** $T = 4 \times 50 \times 10^{-12}$(s) — B1

$v = f\lambda$ **or** $v = \lambda / T$ — C1

$\lambda = 3.0 \times 10^8 \times 4 \times 50 \times 10^{-12}$ — C1

$= 0.06(0)\,\text{m}$ — A1 [4]

(b) $1500 = 3.0 \times 10^8 \times 4 \times$ time-base setting **or** $T = 5 \times 10^{-6}\,\text{s}$ — C1

time-base setting $= 1.3\ (1.25)\,\mu\text{s cm}^{-1}$ — A1 [2]

ELASTIC PROPERTIES

Q. No.	Answer
1	**C**
2	**B**
3	**B**
4	**B**
5	**C**
6	**B**
7	**B**
8	**D**
9	**D**
10	**C**
11	**A**
12	**C**
13	**A**
14	**A**
15	**A**
16	**D**
17	**D**
18	**C**
19	**C**
20	**C**
21	**B**
22	**B**
23	**B**
24	**C**
25	**B**
26	**A**
27	**B**
28	**B**
29	**A**
30	**C**
31	**D**
32	**B**
33	**A**
34	**C**
35	**A**
36	**D**
37	**A**
38	**C**
39	**C**
40	**C**
41	**D**
42	**C**
43	**B**
44	**D**
45	**C**
46	**B**
47	**D**
48	**D**
49	**A**
50	**D**
51	**A**
52	**D**
53	**A**
54	**C**
55	**D**
56	**D**
57	**-**
58	**D**
59	**A**
60	**B**
61	**A**
62	**A**
63	**A**
64	**D**
65	**B**
66	**B**
67	**A**
68	**C**
69	**B**
70	**A**
71	**B**
72	**B**
73	**C**
74	**B**
75	**C**
76	**C**
77	**C**
78	**A**
79	**B**
80	**B**
81	**C**
82	**B**
83	**B**
84	**B**
85	**C**
86	**B**
87	**B**
88	**D**
89	**C**
90	**B**
91	**C**
92	**A**
93	**B**
94	**B**
95	**B**
96	**C**
97	**A**
98	**A**
99	**B**
100	**B**
101	**C**
102	**B**
103	**A**
104	**D**
105	**A**
106	**D**
107	**A**
108	**C**
109	**B**
110	**C**
111	**D**
112	**D**
113	**A**
114	**A**
115	**C**
116	**D**
117	**D**
118	**B**
119	**C**
120	**C**
121	**A**
122	**A**
123	**A**
124	**A**
125	**C**
126	**D**
127	**B**
128	**A**
129	**C**
130	**B**

Q1.

3 (a) (i) ductile B1

(ii)1 L shown at end of straight line B1

(ii)2 reciprocal of gradient of straight line region ..... B1 [3]

(b) (i)1 circumference = 3π cm or arc = $r\theta$ C1
extension = (6.5/360) x 3π = 1.5 sin (or tan) 6.5.....M1
= 0.17 cm A0

(i)2 strain = extension/length..... C1
= 0.17/250
= 6.8×10^{-4}..... A1 [4]

(ii) stress = force/area..... C1
= $(6.0 \times 9.8)/(7.9 \times 10^{-7})$ C1
= 7.44×10^{7} Pa ..... A1 [3]

(iii) Young modulus = stress/strain..... C1
= $(7.44 \times 10^{7})/(6.8 \times 10^{-4})$
= 1.1×10^{11} Pa ..... A1 [2]

(iv) remove extra load and see if pointer returns to original position or wire returns to original length ..... B1 [1]

Q2.

4 (a) brittle B1 [1]

(b) (i) stress = force/area C1
= $60/(7.9 \times 10^{-7})$
= 7.6×10^{7} Pa A1 [2]

(ii) Young modulus = stress/strain C1
limiting strain = 0.03/24 (= 1.25×10^{-3}) C1
Young modulus = $(7.6 \times 10^{7})/(1.25 \times 10^{-3}) = 6.1 \times 10^{10}$ Pa A1 [3]

(iii) energy = ½ × 60 × 3.0×10^{-4} C1
= 9.0×10^{-3} J A1 [2]

(c) If hard, ball does not deform (much) B1
and either (all) kinetic energy converted to strain energy B1
If soft, E_k becomes strain energy of ball and window B1
(no mention of strain energy, max 2 marks)
or impulse for hard ball takes place over shorter time (B1)
larger force/greater stress (B1) [3]

Q3.

STEMUP.CO.UK

5 **(a)** no hysteresis loop/no permanent deformation — M1
(do not allow 'force proportional to extension')
so elastic change — A0 **[1]**

(b) work done = area under graph line OR average force × distance — B1
$= \frac{1}{2}Fx$ $\frac{1}{2}(F_2 + F_1)(x_2 - x_1)$ — A1
$F = kx$, so work done = $= \frac{1}{2}kx^2$ $\frac{1}{2}k(x_2 + x_1)(x_2 - x_1)$ — A1
work done = $\frac{1}{2}k(x_2^2 - x_1^2)$ — A0 **[3]**

(c) gain in energy of trolley $= \frac{1}{2}k(0.060^2 - 0.045^2) + \frac{1}{2}k(0.030^2 - 0.045^2)$ — C1
$= 0.36$ J — C1
kinetic energy $= \frac{1}{2} \times 0.85 \times v^2 = 0.36$ — C1
$v = 0.92$ m s^{-1} — A1 **[4]**

Q4.

2 **(a)** **(i)** k is the reciprocal of the gradient of the graph — C1
k = {32 / (4 × 10^{-2}) = } 800 N m^{-1} — A1 [2]

(ii) *either* energy = average force × extension *or* $\frac{1}{2}kx^2$
or area under graph line — C1
energy = $\frac{1}{2} \times 800 \times (3.5 \times 10^{-2})^2$ *or* $\frac{1}{2} \times 28 \times 3.5 \times 10^{-2}$ — M1
energy = 0.49 J — A0 [2]

(b) **(i)** momentum before cutting thread = momentum after — C1
$0 = 2400 \times V - 800 \times v$ — M1
$v / V = 3.0$ — A0 [2]

(ii) energy stored in spring = kinetic energy of trolleys — C1
$0.49 = \frac{1}{2} \times 2.4 \times (\frac{1}{3}v)^2 + \frac{1}{2} \times 0.8 \times v^2$ — C1
v = 0.96 m s^{-1} — A1 [3]
(if only one trolley considered, or masses combined, allow max 1 mark)

Q5.

4 **(a)** **(i)** **1.** stress = force / (cross-sectional) area — B1 [1]
2. strain = extension / original length — B1 [1]
3. Young modulus = stress / strain — B1 [1]
(ratios must be clear in each answer)

(ii) *either* fluids cannot be deformed in one direction / cannot be stretched
or fluids can only have volume change
or no fixed shape — B1 [1]

(b) *either* unless Δp is very large *or* 2.2×10^9 is a large number — M1
ΔV is very small *or* $\Delta V/V$ is very small, (so 'incompressible') — A1 [2]

(c) $\Delta p = h\rho g$
$1.01 \times 10^5 = h \times 1.08 \times 10^3 \times 9.81$ — C1
$h = 9.53$ m — C1
$\Delta h / h = 0.47 / 10$ *or* $0.47 / 9.53$
error = 4.7% *or* 4.9% *or* 5% — A1 [3]

Q6.

STEMUP.CO.UK

4 **(a)** **(i)** change of shape / size / length / dimension C1
when (deforming) force is removed, returns to original shape / size A1 [2]

(ii) $L = ke$ ..... B1 [1]

(b) $2e$ B1
$\frac{1}{2}k$ …(*allow e.c.f. from extension*) B1

$\frac{1}{2}e$ and $2k$ B1

$\frac{3}{2}e$ …(*allow e.c.f. from extension in part 2*) B1
$\frac{2}{3}k$ …(*allow e.c.f. from extension*) ..... B1 [5]

Q7.

3 **(a)** *either* energy (stored)/work done represented by area under graph
or energy = average force × extension B1
energy = $\frac{1}{2} \times 180 \times 4.0 \times 10^{-2}$ C1
= 3.6 J ..... A1 [3]

(b) **(i)** *either* momentum before release is zero M1
so sum of momenta (of trolleys) after release is zero A1
or force = rate of change of momentum (M1)
force on trolleys equal and opposite (A1)
or impulse = change in momentum (M1)
impulse on each equal and opposite (A1) [2]

(ii) **1** $M_1V_1 = M_2V_2$ ..... B1 [1]

2 $E = \frac{1}{2} M_1V_1^2 + \frac{1}{2} M_2V_2^2$ ..... B1 [1]

(iii) **1** $E_K = \frac{1}{2}mv^2$ and $p = mv$ combined to give M1
$E_K = p^2 / 2m$ ..... A0 [1]

2 m smaller, E_K is larger because p is the same/constant M1
so trolley B ..... A0 [1]

Q8.

5 **(a)** **(i)** Young modulus = stress/strain C1
data chosen using point in linear region of graph M1
Young modulus = $(2.1 \times 10^8)/(1.9 \times 10^{-3})$
= 1.1×10^{11} Pa ..... A1 [3]

(ii) This mark was removed from the assessment, owing to a power-of-ten inconsistency in the printed question paper.

(b) area between lines represents energy/area under curve represents energy .. M1
when rubber is stretched and then released/two areas are different A1
this energy seen as thermal energy/heating/difference represents energy released as heat ..... A1 [3]

STEMUP.CO.UK

Q9.

4	(a)	(i)	*stress* is force / area	B1	[1]
		(ii)	*strain* is extension / original length	B1	[1]
	(b)	(i)	$E = [F / A] \div [e / l]$	C1	
			$e = (25 \times 1.7) / (5.74 \times 10^{-8} \times 1.6 \times 10^{11})$	C1	
			$e = 4.6 \times 10^{-3}$ m	A1	[3]
		(ii)	A becomes $A/2$ or stress is doubled	B1	
			$e \propto l / A$ or substitution into full formula	B1	
			total extension increase is $4e$	A1	[3]

Q10.

4	(a)	clamped horizontal wire over pulley or vertical wire attached to ceiling with mass attached	B1	
		details: reference mark on wire with fixed scale alongside	B1	[2]
	(b)	measure original length of wire to reference mark with metre ruler / tape	(B1)	
		measure diameter with micrometer / digital calipers	(B1)	
		measure initial and final reading (for extension) with metre ruler or other suitable scale	(B1)	
		measure / record mass or weight used for the extension	(B1)	
		good physics method: measure diameter in several places / remove load and check wire returns to original length / take several readings with different loads	(B1)	
		MAX of 4 points	B4	[4]
	(c)	determine extension from final and initial readings	(B1)	
		plot a graph of force against extension	(B1)	
		determine gradient of graph for F / e	(B1)	
		calculate area from $\pi d^2 / 4$	(B1)	
		calculate E from $E = F l / e A$ or gradient $\times l / A$	(B1)	
		MAX of 4 points	B4	[4]

Q11.

STEMUP.CO.UK

4	(a)	force is proportional to extension	B1	[1]
	(b) (i)	gradient of graph determined (e.g. $50 / 40 \times 10^{-3}$) = 1250 $N m^{-1}$	A1	[1]
	(ii)	$W = ½ k x^2$ or W = ½ final force × extension	M1	
		$= 0.5 \times 1250 \times (36 \times 10^{-3})^2$ or $0.5 \times 45 \times 36 \times 10^{-3}$	M1	
		= 0.81 J	A0	[2]
	(c) (i)	$0.81 = ½ mv^2$	C1	
		v = 8.0 (8.0498) $m s^{-1}$	A1	[2]
	(ii)	4 × KE / 4 × WD or 3.24 J	C1	
		hence twice the compression = 72 mm	A1	[2]
	(iii)	Max height is when all KE or WD or elastic PE is converted to GPE	C1	
		ratio = 1/4 or 0.25	A1	[2]

Q12.

3	(a)	Resultant force (and resultant torque) is zero	B1	
		Weight (down) = force from/due to spring (up)	B1	[2]
	(b) (i)	0.2, 0.6, 1.0 s (*one of these*)	A1	[1]
	(ii)	0, 0.8 s (*one of these*)	A1	[1]
	(iii)	0.2, 0.6, 1.0 s (*one of these*)	A1	[1]
	(c) (i)	Hooke's law: extension is proportional to the force (*not mass*)	B1	
		Linear/straight line graph hence obeys Hooke's law	B1	[2]
	(ii)	Use of the gradient (*not just F = kx*)	C1	
		$K = (0.4 \times 9.8) / 15 \times 10^{-2}$	M1	
		= 26(.1) $N m^{-1}$	A0	[2]
	(iii)	*either* energy = area to left of line *or* energy = $½ ke^2$	C1	
		$= ½ \times [(0.4 \times 9.8) / 15 \times 10^{-2}] \times (15 \times 10^{-2})^2$	C1	
		= 0.294 J (*allow 2 s.f.*)	A1	[3]

Q13.

STEMUP.CO.UK

5 **(a)** E = stress / strain — B1 [1]

(b) **(i)** 1. diameter / cross sectional area / radius
2. original length — B1 [1]

(ii) measure original length with a metre ruler / tape — B1
measure the diameter with micrometer (screw gauge) — B1 [2]
allow digital vernier calipers

(iii) energy = ½ Fe or area under graph or ½ kx^2 — C1
= ½ × 0.25 × 10^{-3} × 3 = 3.8 × 10^{-4} J — A1 [2]

(c) straight line through origin below original line — M1
line through (0.25, 1.5) — A1 [2]

Q14.

1 **(a)** the wire returns to its original length (*not 'shape'*) — M1
when the load is removed — A1 [2]

Q15.

4 **(a)** **(i)** stress = force / cross-sectional area — B1 [1]

(ii) strain = extension / original length — B1 [1]

(b) **(i)** E = stress / strain — C1
E = 0.17 × 10^{12} — C1
stress = 0.17 × 10^{12} × 0.095 / 100 — C1
= 1.6(2) × 10^{8} Pa — A1 [4]

(ii) force = (stress × area) = 1.615 × 10^{8} × 0.18 × 10^{-6} — C1
= 29(.1)N — A1 [2]

Q16.

STEMUP.CO.UK

9 (a) (i) stress = F / A C1
= $25 / (1.7 \times 10^{-6})$
= 1.47×10^{7} Pa .....(do not allow 1 sig fig) A1

(ii) stress = $E \times$ strain C1
$1.47 \times 10^{7} = 7.1 \times 10^{10} \times (\Delta l / 1.8)$
Δl = 0.37 mm ..... A1 [4]

(b) $R = \rho l / A$ OR $R \propto L$ C1
so, $\Delta R / R = \Delta l / l$ C1
$\Delta R = (3.7 \times 10^{-4} / 1.8) \times 0.03 = 6.2 \times 10^{-6}\ \Omega$ ..... A1 [3]

May calculate $\rho = 2.833... \times 10^{-8}\ \Omega$ m
giving new R as $3.0006167 \times 10^{-2}\ \Omega$
hence ΔR - full credit possible

However, if rounds off ρ as $2.83 \times 10^{-8}\ \Omega$ m,
then $R_{new} < R_{old}$!
Allow 1 mark only for $R \propto L$

Q17.

5 (a) (i) F/A **B1**

(ii) ΔL/L **B1**

(iii) FL/A.ΔL **B1 [3]**

(b) (i) ΔL = 0.012 x 0.62 x 350 **M2**

= 2.6 mm **A0 [2]**

(ii) $2.0 \times 10^{11} = (F \times 0.62)/(7.9 \times 10^{-7} \times 2.6 \times 10^{-3})$ **C1**

F = 660 N **A1 [2]**

STEMUP.CO.UK

(iii) *either* stress when cold = $660/(7.9 \times 10^{-7})$ = 840 MPa

or tension at uts = 198 N **M1**

either this is greater than the ultimate tensile stress

or tension at uts is less then tension in **(ii)** **A1**

the wire will snap **A1** **[3]**

(Allow possibility for the two 'A' marks to be scored as long as some quantitative answer – even if incorrect – has been given for the 'M' mark)

Q18.

6	**(a)**	**(i)**	$R = \rho L / A$	B1	
		(ii)	strain = $\Delta L / L$	B1	
			either $\Delta R = \rho \Delta L / A$ *or* $R \propto L$ with ρ and A constant	B1	
			dividing, $\Delta R / R = \Delta L / L$	A0	[3]
	(b)		Young modulus = stress / strain	C1	
			strain = $72.0 / (1.20 \times 10^{-7} \times 2.10 \times 10^{11})$	C1	
			$= 2.86 \times 10^{-3}$ *(allow 1/350*	A1	
			$\Delta R = 2.86 \times 10^{-3} \times 4.17 = 1.19 \times 10^{-2}\ \Omega$	A1	
			answer given to 3 sig. fig	B1	[5]

Q19.

4	**(a)**	brittle	B1	[1]
	(b)	Young modulus = stress / strain	C1	
		$= (9.5 \times 10^{8}) / 0.013$		
		$= 7.3 \times 10^{10}$ Pa (*allow* $\pm 0.1 \times 10^{10}$ *Pa*)	A1	[2]
	(c)	stress = force / area	C1	
		(minimum) area = $(1.9 \times 10^{3}) / (9.5 \times 10^{8})$		
		$= 2.0 \times 10^{-6}\ m^2$	C1	
		(max) area of cross-section = $(3.2 - 2.0) \times 10^{-6}$		
		$= 1.2 \times 10^{-6}\ m^2$	A1	[3]
	(d)	when bent, 'top' and 'bottom' edges have different extensions	M1	
		with thick rod, difference is greater (than with a thin rod)	A1	
		so breaks with less bending	A0	[2]

Q20.

STEMUP.CO.UK

4 (a) (i) returns to original shape / size / length etc. B1
when load / distorting forces / weight / strain is removed ..... B1 [2]

(ii) 1 $R = \rho L / A$ ..... B1 [1]
2 $E = WL / Ae$ ..... B1 [1]

(b) $E = WR / e\rho$ C1
$= (34 \times 0.44) / (7.7 \times 10^{-4} \times 9.2 \times 10^{-8})$ C1
$= 2.1 \times 10^{11}$ Pa ..... A1 [3]

[Total: 7]

Q21.

4 (a) ability to do work B1
as a result of a change of shape of an object/stretched etc ..... B1 [2]

(b) work = average force ×distance moved (in direction of the force) B1
either work = $\frac{1}{2} \times F \times x$
or work is area under F/x graph which is $\frac{1}{2}Fx$ B1
$F = kx$ B1
so work / energy = $\frac{1}{2}kx^2$ ..... A0 [3]

(c) (i) spring constant $= \frac{3.8}{2.1}$ M1
$= 1.8$ N cm^{-1} ..... A0 [1]

(ii) 1 $\Delta E_P = mg\Delta h$ *or* $W\Delta h$ C1
$= 3.8 \times 1.5 \times 10^{-2}$
$= 0.057$ J ..... A1 [2]
2 $\Delta E_S = \frac{1}{2} \times 1.8 \times 10^2 (0.036^2 - 0.021^2)$ M1
$= 0.077$ J ..... A0 [1]
3 work done $= 0.077 - 0.057$
$= 0.020$ J ..... A1 [1]
(*allow e.c.f. if* $\Delta E_S > \Delta E_P$)

[Total: 10]

Q22.

STEMUP.CO.UK

4 **(a)** **(i)** F / A B1 [1]

(ii) $\Delta L / L$ B1 [1]

(iii) allow $FL / A\Delta L$ B1 [1]

(iv) allow $\rho L / A$ or $\rho(L + \Delta L) / A$ B1 [1]

(b) **(i)** $\Delta L = FL / EA$
$= (30 \times 2.6) / (7.0 \times 10^{10} \times 3.8 \times 10^{-7})$ M1
$= 2.93 \times 10^{-3}$ m = 2.93 mm A0 [1]

(ii) $\Delta R = \rho\Delta L / A$ C1
$= (2.6 \times 10^{-8} \times 2.93 \times 10^{-3}) / (3.8 \times 10^{-7})$
$= 2.0 \times 10^{-4}\ \Omega$ A1 [2]

(c) change in resistance is (very) small M1
so method is not appropriate A1 [2]

Q23.

4 **(a)** energy = average force × extension B1
$= ½ \times F \times x$ B1
(Hooke's law) extension proportional to (applied) force B1
hence $F = kx$ B1
so $E = ½kx^2$ A0 [4]

(b) **(i)** correct area shaded B1 [1]

(ii) 1.0 cm^2 represents 1.0 mJ or correct units used in calculation C1
$E_S = 6.4 \pm 0.2$ mJ A2 [3]
(for answer > ±0.2 mJ but ≤ ±0.4 mJ, then allow 2/3 marks)

(iii) arrangement of atoms / molecules is changed B1 [1]

Q24.

STEMUP.CO.UK

5 **(a)** **(i)** Fig. 5.2 B1 [1]

(ii) Fig. 5.3 B1 [1]

(b) kinetic energy increases from zero then decreases to zero B1 [1]

(c) **(i)** $\Delta E_p = mg\Delta h$ / mgh C1
$= 94 \times 10^{-3} \times 9.8 \times 2.6 \times 10^{-2}$ using $g = 10$ then -1
$= 0.024\,J$ A1 [2]

(ii) *either* $0.024 = \frac{1}{2} k \times (2.6 \times 10^{-2})^2$ *or* $\frac{1}{2} kd^2 = \frac{1}{2}k \times (2.6 \times 10^{-2})^2 - \frac{1}{2}kd^2$ C1
$0.012 = \frac{1}{2}k \times d^2$ $kd^2 = \frac{1}{2}k \times (2.6 \times 10^{-2})^2$ C1
$d = 0.018\,m$ $d = 0.018\,m$
$= 1.8\,cm$ $= 1.8\,cm$ A1 [3]

Q25.

6 **(a)** extension is proportional to force (for small extensions) B1 [1]

(b) **(i)** point beyond which (the spring) does not return to its original length when the load is removed B1 [1]

(ii) gradient of graph = $80\,N\,m^{-1}$ A1 [1]

(iii) work done is area under graph / $\frac{1}{2} Fx$ / $\frac{1}{2} kx^2$ C1
$= 0.5 \times 6.4 \times 0.08 = 0.256$ (allow 0.26) J A1 [2]

(c) **(i)** extension = 0.08 + 0.04 = 0.12 m A1 [1]

(ii) spring constant = 6.4 / 0.12 = $53.3\,N\,m^{-1}$ A1 [1]

Q26.

3 **(a)** **(i)** stress = force / (cross-sectional) area B1 [1]

(ii) strain = extension / <u>original</u> length **or** change in length / <u>original</u> length B1 [1]

(b) <u>point</u> beyond which material does not return to the original length / shape / size when the load / force is removed B1 [1]

STEMUP.CO.UK

(c) UTS is the maximum force / <u>original</u> cross-sectional area M1
wire is able to support / before it breaks A1 [2]

allow one: maximum stress the wire is able to support / before it breaks

(d) **(i)** straight line from (0,0) M1
correct shape in plastic region A1 [2]

(ii) only a straight line from (0,0) B1 [1]

(e) **(i)** ductile: initially force proportional to extension then a large extension for small change in force B1
brittle: force proportional to extension until it breaks B1 [2]

(ii) **1.** does not return to its original length / permanent extension (as entered plastic region) B1
2. returns to original length / no extension **(as no plastic region / still in elastic region)** B1 [2]

Q27.

5 **(a)** when the load is removed then the wire / body object does not return to its original shape / length B1 [1]

(b) **(i)** stress = force / area C1
$F = 220 \times 10^6 \times 1.54 \times 10^{-6} = 340\ (338.8)\,\text{N}$ A1 [2]

(ii) $E = (F \times l) / (A \times e)$ C1
$e = (90 \times 10^6) \times 1.75 / (1.2 \times 10^{11}) = 1.31 \times 10^{-3}\,\text{m}$ A1 [2]

(c) the stress is no longer proportional to the extension B1 [1]

Q28.

6 **(a)** extension is proportional to force / load B1 [1]

(b) $F = mg$ C1
$x = (mg / k) = 0.41 \times 9.81 / 25 = (4.02 / 25)$ M1
$x = 0.16\,\text{m}$ A0 [2]

(c) **(i)** weight and (reaction) force from spring (which is equal to tension in spring) B1 [1]

(ii) F – weight or $0.06 \times 25 = ma$ C1
$F = 0.2209 \times 25 = 5.52$ (N) or $0.22 \times 25 = 5.5$
$a = (5.52 - 0.41 \times 9.81) / 0.41$ or $1.5 / 0.41$ and $(5.5 - 4.02)$ C1
$a = 3.7\ (3.66)\,\text{m s}^{-2}$ gives $3.6\,\text{m s}^{-2}$ A1 [3]

(d) elastic potential energy / strain energy to kinetic energy and gravitational potential energy B1
stretching / extension reduces and velocity increases / height increases B1 [2]

STEMUP.CO.UK