Answers prepared by Leong Yee Pak
Deformation of Matters

Stress, strain
Section A

***1 June 02 P1 Q22** C

****2 June 02 P1 Q23** B Young modulus E = $\frac{\sigma}{\varepsilon}$ = $\frac{F}{A} x \frac{L}{e}$. For the 1st wire, E = $\frac{60}{A} x \frac{L}{8}$. For the 2nd wire, E = $\frac{60}{4A} x \frac{2L}{e_2}$. Equating and solve for e_2

***3 June 03 P1 Q21** B

****4 June 03 P1 Q22** D For each spring, tension = $\frac{1}{3}$W. Apply Hooke's law, F = kx, $\frac{1}{3}$ W = kx. Hence k = $\frac{1}{3} x \frac{W}{x}$. For the 2nd case, fro ech spring, tension = W. Hence W = kx_2. Solve the 2 equations.

***5 Nov 03 P1 Q21** D

****6 June 04 P1 Q23** C Apply stress, $\sigma = \frac{F}{A}$ where A = πr^2

***7 Nov 04 P1 Q21** A

****8 Nov 04 P1 Q22** A Apply stress, $\sigma = \frac{F}{A}$ and test answer one by one.

***9 June 05 P1 Q20** 36 A Consider tension in each spring and its extension.

10 June 05 P1 Q22 D Apply Young modulus E = $\frac{\sigma}{\varepsilon} = \frac{F}{A} x \frac{L}{e}$.

For wire P, E = $\frac{T_P}{A} x \frac{l}{e}$.......(1)

For wire Q, E = $\frac{T_Q}{\left(A/2\right)} x \frac{2l}{e}$. Hence E = $\frac{2T_Q}{A} x \frac{2l}{e}$ ....(2).

Solve the 2 equations

****11 Nov 05 P1 Q21** C Apply E = $\frac{\sigma}{\varepsilon} = \frac{F}{A} x \frac{L}{e}$ where A = πr^2. For the 1st wire, E = $\frac{60}{\pi r^2} x \frac{L}{8}$. For the 2nd wire, E = $\frac{60}{\pi\left(r/2\right)^2} x \frac{\left(1/4\right)L}{e_2}$. E = $\frac{60}{\pi r^2} x \frac{4x\left(1/4\right)L}{e_2}$. Solve the 2 equations

***12 June 06 P1 Q21** C

***13 Nov 06 P1 Q22** B

***14 Nov 06 Q23** C

****15 June 07 P1 Q20** B

****16 June 08 P1 Q24** C Young modulus depends only on the type of material

****17 Nov 08 P1 Q20** C

***18 Nov 08 P1 Q22** C

****19 June 09 P1 Q20** D Apply E = (F/A) / (e/L) to wire P and Q. Form 2 equations and solve it.

Stress and Strain
Section B

1 June 03 P2 Q3

(a) (i) ductile because it undergoes a large plastic deformation.

(ii) 1. mark a point just at the end of the straight portion of the graph.

2. Determine the gradient of the graph. Spring constant = $\frac{1}{gradient}$. Note that the graph is **not** force against extension, but it is extensiton against force.

(b) (i) 1. Extension = arc length turned through.

Arc length, s = rθ where θ is in radian. Convert 6.5^o into radian. OR take ratio.

$\frac{s}{2\pi r} = \frac{6.5}{360}$ where s = extension, e

2. stain $\varepsilon = \frac{e}{L}$ where e = 0.17 x 10^{-2} cm, L = 2.5 m

(ii) Stress, $\sigma = \frac{F}{A}$ where F = mg = 6.0 x 9.81 N and A = 7.9 x 10^{-7} m^2

(iii) Young modulus, E = $\frac{\sigma}{\varepsilon}$ =

(iv) Release the load and measure the original length. If the original length does not change, there is no permanent extension and the elastic limit is not exceeded.

Elastic and plastic behaviour
Section A

****1 June 02 P1 Q24** B Work done = area under the graph F-e.

***2 Nov 02 P1 Q23** C

****3 Nov 02 P1 Q24** C Work done W = ½ Fx and F = kx. Hence W = ½ kx^2/ For spring P, W_P = ½ (2k) x^2. For spring Q, W_Q = ½ kx^2. Dividing and solve

****4 Nov 03 P1 Q22** C Strain energy = area under graph F-e. Hence starin energy = area of triangle of the top left corner = area of triangle of the bottom right corner.

****5 June 04 P1 Q22** A

****6 Nov 04 P1 Q22** A Apply stress, $\sigma = \frac{F}{A}$ and test answer one by one.

****7 Nov 04 P1 Q23** A Work done = area under the graph < area of trianlge

****8 June 05 P1 Q21** D

***9 Nov 05 P1 Q19** B

***10 Nov 05 P2 Q20** B

****11 June 06 P1 Q22** B Total work done = total area under the graph = area of triangle + area of the trapezium = $\frac{1}{2}$ x (10x10^{-3}) x 500 + $\frac{1}{2}$(500 + 550_ x (2 x 10^{-3})

***12 June 07 P1 Q17** C

***13 June 07 P1 Q18** B

****14 June 07 P1 Q19** A Work done = area under the graph

***15 Nov 07 P1 Q19** B

What is the maximum strain energy in this deformed rubber cord?

A 2.5 J **B** 5.0 J **C** 7.5 J **D** 10 J

****16 Nov 07 P1 Q20** A Note that the graph is length - force and **not** force – length.

****17 June 08 P1 Q22** B

****18 June 08 P1 Q23** C Energy stored = area of trapezium = ½ (12 + 6) x (30 x 10^{-3}) J

***19 Nov 08 P1 Q19** D

****20 Nov 08 P1 Q23** C

****21 June 09 P1 Q19** A

****22 June 09 P1 Q21** A Estimate the area under the graph using trapezium rule.

Elastic and plastic behaviour
Section B

1 June 05 P2 Q4

(a) ductile, as it does not undergo plastic deformation.

(b) (i) ultimate tensile stress, = maximum stress before breakage = max force / area of cross-section = 60/ (7.9 x 10^{-7})

(ii) Young modulus E = $\dfrac{\sigma}{\varepsilon}$ where σ is calculated in (b) and ε = e/L = 3 x 10^{-4} /0.24

(iii) maximum strain energy = $\dfrac{1}{2}F_{max}\,e$

(c) Soft ball has a larger deformation. Hence time of impact is longer. Force = momentum change / time of impact. Hence impulsive force is smaller. The reverse is true for the hard ball.

2 June 06 Q5

(a) Elastic change. There is no permenant extension since the spring returns to its original length as the force is removed. M1

(b) Wrork done, W = area under the graph F-x = area of trapezium B1

$= \dfrac{1}{2}(F_1 + F_2)(x_2 - x_1)$ A1

Apply Hooke's law, F = kx. Sustituting, $W = \dfrac{1}{2}(kx_2 + kx_1)(x_2 - x_1)$

$W = \dfrac{1}{2}k(x_2 + x_1)(x_2 - x_1) = \dfrac{1}{2}k(x_2^2 - x_1^2)$ A1

(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]**

3 Nov 07 P2 Q4

4 (a) brittle B1 [1]

(b) Young modulus = stress / strain C1
= $(9.5 \times 10^8) / 0.013$
= 7.3×10^{10} Pa (*allow* $\pm 0.1 \times 10^{10}$ *Pa*) A1 [2]

(c) stress = force / area C1
(minimum) area = $(1.9 \times 10^3) / (9.5 \times 10^8)$
= 2.0×10^{-6} m^2 C1
(max) area of cross-section = $(3.2 - 2.0) \times 10^{-6}$
= 1.2×10^{-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]

4 June 08 P2 Q2

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 = ½ × 800 × (3.5 × 10^{-2})^2 *or* ½ × 28 × 3.5 × 10^{-2}	M1	
		energy = 0.49 J	A0	[2]
(b)	(i)	momentum before cutting thread = momentum after	C1	
		0 = 2400 × V – 800 × v	M1	
		v / V = 3.0	A0	[2]
	(ii)	energy stored in spring = kinetic energy of trolleys	C1	
		0.49 = ½ × 2.4 × ($\frac{1}{3}v$)^2 + ½ × 0.8 × v^2	C1	
		v = 0.96 m s^{-1}	A1	[3]
		(if only one trolley considered, or masses combined, allow max 1 mark)		

5 June 08 P2 Q4

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)		Δp = $h\rho g$		
		1.01 × 10^5 = h × 1.08 × 10^3 × 9.81	C1	
		h = 9.53 m	C1	
		Δh / h = 0.47 / 10 *or* 0.47 / 9.53		
		error = 4.7% *or* 4.9% *or* 5%	A1	[3]

6 June 09 P2 Q4

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]