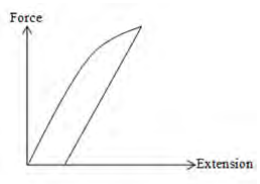
Question Number	Answer		Mark
1(a)	Ductile	**(1)**	
	Produces a large plastic deformation **Or** will deform permanently	**(1)**	
	under tension **Or** tensile stress **Or** tensile force	**(1)**	**3**
1(b)(i)	Use of density = $\frac{\text{mass}}{\text{volume}}$ **Or** see upthrust = ρVg	**(1)**	
	Use of upthrust = mass of water displaced x g	**(1)**	
	Upthrust = 0.026 N	**(1)**	
	Idea that the effect of the upthrust is more significant for the nylon than for the copper (e.g. a quantitative comparison made between the 2 net forces **Or** a sensible comment linking the upthrust to the 2 weights)	**(1)**	
	Or		
	Use of density = $\frac{\text{mass}}{\text{volume}}$	**(1)**	
	Use of weight = mass × g	**(1)**	
	Density $_{\text{copper}}$ = 8625 kg m^{-3} **Or** density $_{\text{nylon}}$ = 1098 kg m^{-3}	**(1)**	
	Comparison of the densities of both copper and nylon to that of sea water e.g. the density of nylon is only just greater than that of sea water so it almost floats whilst the density of copper is much greater than that of sea water so it will fall rapidly	**(1)**	**4**
	<u>Example of calculations</u> Mass of water displaced by either line = 1030 kg m^{-3}× 1.30 × 10 $^{-7}$ m^2 × 20.0 m = 2.68 × 10^{-3} kg Upthrust = 2.68 × 10^{-3} kg × 9.81 N kg^{-1} = 0.0263 N Net downwards force on Copper = 0.220 N – 0.0263N = 0.194 N Net downwards force on nylon = 0.0280 N – 0.0263 N = 0.00170 N		

(b)(ii)	Use of either stress = $\frac{\text{load}}{\text{cross sectional area}}$ **Or** strain = $\frac{\text{extension}}{\text{original length}}$ **Or** see $E = \frac{Fx}{A\triangle x}$ Use of Young modulus = $\frac{\text{stress}}{\text{strain}}$ **Or** use of $E = \frac{Fx}{A\triangle x}$ Extension = 0.0775 m <u>Example of calculation</u> Stress = $\frac{65.0\text{ N}}{1.30 \times 10^{-7}\ \text{m}^2}$ = 5.00×10^8 Pa **Or** strain = $\frac{\text{extension}}{20.0\text{ m}}$ 129×10^9 Pa = 5.00×10^8 Pa ÷ $\frac{\text{extension}}{20.0\text{ m}}$ Extension = 0.0775 m	**(1)** **(1)** **(1)**	**3**
(c)(i)	Loading graph to include elastic(straight) line and some plastic(curved) section Unloading line showing a permanent extension Unloading line to be parallel to the loading line  	**(1)** **(1)** **(1)**	**3**
(c)(ii)	Line becomes more sensitive **Or** all work done is used to reel in fish **Or** no/less work done on extending the line **Or** all force supplied pulls in fish **Or** less force required (to reel in fish) **Or** less (elastic /plastic) stretch **Or** elastic limit increases	**(1)**	**1**
	Total for question		**14**

Question Number	Acceptable Answers	Mark
2 (a)(i)	**Hard** resistant to indentation/scratching **Or** <u>surface</u> is resistant to plastic deformation **(1)**	**1**

Question Number	Acceptable Answers	Mark
2 (a)(ii)	**Stiff** high Young's Modulus **Or** large force / load / stress for (small) extension / strain / deformation **Or** (large) force / load / stress for small extension / strain / deformation **(1)** (not "resistant to", "hard to bend")	**1**

Question Number	Acceptable Answers	Mark
2 (a)(iii)	**High tensile strength** withstand/bear/undergo a large stress/force (under tension) before breaking/fracture. **(1)**	**1**

Question Number	Acceptable Answers Reject	Mark
***2(b**	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) (Large stretching) force/stress/tension applied **Or** wire is being stretched/taut **(1)** High elastic limit:(can be implied from the stem) Will not plastically /permanently deform **Or** will return to original length (when force removed) **Or** Low elastic limit: (must be stated) Will plastically/permanently deform **Or** will not return to original length (when force removed) **(1)** Idea that the pitch/frequency/tone/tune/sound/note will alter. **(1)**	**3**
	Total for Question	**6**

Question Number	Acceptable Answers		Mark
3(a)(i)	Use of $E_{grav} = mgh$	**(1)**	
	$E_{grav} = 48 \times 10^3$ J	**(1)**	**2**
	Example of calculation Work done = 810 kg × 9.81 N kg $^{-1}$ × 6.0 m Work done = 47 700 (J)		

Question Number	Acceptable Answers		Mark
3(a)(ii)	(useful) energy transferred = 0.4 × total energy transferred	**(1)**	
	Use of work done against resistive forces of the ground = $F\Delta s$	**(1)**	
	Force = 9.5 / 9.6 × 10^4 N (ecf) (ignore any −)	**(1)**	**3**
	(It is possible to calculate v from K.E., then a and use $F = m\,a$)		
	Example of calculation Useful energy transferred from driver = $\frac{40}{100}$ × 47 700 J = 19 100 J Resistive force = $\frac{19100\,\text{J}}{0.20\,\text{m}}$ = 9.6 × 10^4 N		

Question Number	Acceptable Answers	Mark
3(b)(i)	Use of Stress = $\frac{\text{force}}{\text{area}}$ **Or** Use of Strain = $\frac{\text{extension}}{\text{original length}}$ **(1)** Correctly use $E = \frac{\text{stress}}{\text{strain}}$ with $E = 120 (\times 10^6)$, $F = 7(\times 10^5)$, $x = 0.4$ correctly substituted **(1)** (Use of $E = (F \times x) / (A \times \Delta x)$ scores MP1 for quoting formula and MP2 for 'use of') $\Delta x = 0.008(3)$ (m) **(1)** <u>Example of calculation</u> $\sigma = \frac{7.0 \times 10^5 \text{ N}}{\pi \times (0.30\text{m})^2} = 2.48 \times 10^6 \text{ Pa}$ $\varepsilon = \frac{\Delta x}{0.40 \text{ m}}$ $\Delta x = \frac{2.48 \times 10^6 \text{ Pa} \times 0.40\text{m}}{120 \times 10^6 \text{ Pa}}$ Δx (compression) = 0.0083 (m)	**3**

Question Number	Acceptable Answers	Mark
3(b)(ii)	Use of $E_{el} = ½F\Delta x$ **(1)** Energy stored = 2.8×10^3 J or 2.9×10^3 J (ecf) **(1)** <u>Example of calculation</u> $E_{el} = ½ \times 7.0 \times 10^5 \text{ N} \times 0.0083 \text{ m}$ $E_{el} = 2.9 \times 10^3$ J	**2**

Question Number	Acceptable Answers	Mark
***3(b)(iii)1**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** [Only apply if both 1. and 2. get full marks] <u>Graph:</u> Permanent/plastic compression/deformation **Or** does not return to its original length/shape **(1)** <u>Effect:</u> Becomes too thin **Or** will not compress **Or** no longer elastic **Or** becomes brittle **(1)**	**2**

Question Number	Acceptable Answers	Mark
***3(b)(iii)2**	More work done in loading than unloading the wood **Or** more energy is absorbed/stored than released **Or** the area between the lines shows energy is dissipated **Or** the area while applying the force > the area while releasing **Or** (the area in) the hysteresis loop shows energy is dissipated **(1)** (these should be marked if written in 1. above)	**1**
	Total for question	**13**

Question Number	Answer	Mark
4(a)(i)	The increase in extension is constant for a fixed increase in mass **Or** mass is proportional to extension **Or** extension is proportional to mass **Or** graph is a rising/increasing straight line **(1)** The wire obeys Hooke's law **(1)**	**2**
4(a)(ii)	Use of area under the graph **Or** use of ½ $F\Delta x$ (with m or F) **(1)** Identify that the limit of proportionality is at 2.6 ± 0.1 kg **(1)** Elastic potential energy = 0.5 J **(1)** (accept 0.40 J to 0.50 J) Example of calculation Area under the graph = ½ × 3.5×10^{-2} m × 2.6 kg = 0.046 kg m Area × g = 0.046 kg m × 9.81 N kg^{-1} Elastic potential energy = 0.45 J	**3**
4(a)(iii)	The wire will experience a large (increase in) extension/strain for a small (increase in applied) force/stress/mass **(1)** The wire will not return to its original length/shape (once the force is removed) **Or** the wire will be permanently deformed **Or** the wire will exhibit plastic deformation/behaviour **(1)**	**2**
4(b)(i)	Thinner wire **Or** smaller CSA/ diameter/radius **Or** longer wire **Or** wire with a lower stiffness/k/spring constant **Or** wire that is more ductile **Or** wire with a lower Young modulus **(1)** (comments must be comparative)	**1**
4(b)(ii)	**Max 2** Use a pointer on the wire/masses **(1)** Sensible suggestion to reduce parallax e.g. read at eye level **Or** place the rule as near as possible to the mass/wire **(1)** Use a set square to ensure rule is vertical **(1)** Wait for the extension to finish **(1)** Add masses gently **(1)**	**2**
	Total for question	**10**

Question Number	Answer	Mark
5(a)(i)	Brittle **(1)**	**1**
5(a)(ii)	Smaller pieces have a greater surface area (to volume ratio) **(1)**	**1**
5(b) (i)	Resistant to indentation/scratching **Or** surface is resistant to plastic deformation **(1)**	**1**
5(b)(ii)	There is less friction (between the blade and the ice)for cold/hard ice **Or** There is more friction (between the blade and the ice) for warm ice **(1)** There is less indentation/sinking/scratching for cold ice **Or** There is more indentation/sinking/scratching for warm ice **(1)**	**2**
	Total for question	**5**

Question Number	Answer		Mark
6(a)(i)	See (or use of) $E = \dfrac{F \times x}{A \times \Delta x}$ in any arrangement (accept *l* for *x*) (accept seeing or use of E = $\frac{F/A}{\Delta x/x}$) $\dfrac{\Delta x_C}{\Delta x_S} = \dfrac{E_S A_S}{E_C A_C}$ **Or** Calculate $E_C A_C$ (104) and $E_S A_S$ (234) or their reciprocals (962 and 427) (ignoring powers of ten at this stage) $\dfrac{\Delta x_C}{\Delta x_S} = 2.2 / 2.3$ Or ratio is 2.2/2.3:1 <u>Example of calculation</u> $\dfrac{\Delta x_C}{\Delta x_S} = \dfrac{E_S A_S}{E_C A_C}$ $\dfrac{\Delta x_C}{\Delta x_S} = \dfrac{1.3\times10^{-6}\ \text{m}^2 \times 1.8\times10^{11}\ \text{Pa}}{0.8\times10^{-6}\ \text{m}^2 \times 1.3\times10^{11}\ \text{Pa}}$ $\dfrac{\Delta x_C}{\Delta x_S} = 2.25$	**(1)** **(1)** **(1)**	**3**
6(a) (ii)	Use of $\Delta x_C + \Delta x_S = 0.01$ **Or** use of ratio 2.25:1 with 0.01 m Extension = 6.9×10^{-3} m to at least 2 SF (ecf from part (a)(i)) (show that value gives extension = 6.7×10^{-3} m) <u>Example of calculation</u> $2.25x + x = 0.01$ $\frac{0.01 \times 2.25}{3.25} = 6.92 \times 10^{-3}$ m	**(1)** **(1)**	**2**
6(b)	Ductility/ductile	**(1)**	**1**
	Total for question		**6**

Question Number	Answer	Mark
7*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Plastic: doesn't return to original shape **OR** stays stretched **OR** permanently deformed **OR** stays bent **(1)** … when force/stress removed **(1)** This is <u>brittle</u> behaviour **(1)** Breaks/fails/cracks/snaps with little/no plastic deformation **OR** breaks under stress due to propagation of cracks **OR** breaks just beyond elastic limit / limit of proportionality **(1)**	**4**
	Total for question	**4**