Question Number	Answer	Mark
1(a)	Describe terms tough – able to absorb energy without failure (accept breaking/cracking etc) / able to absorb a lot of energy in the plastic region / withstand impact forces/shocks **(1)** brittle – tends to shatter when subject to impact / fails with little or no plastic deformation/behaviour/just beyond elastic limit **(1)**	**(2)**
1(b)	State type of behaviour Plastic (deformation) **(1)**	**(1)**
	Total for question	**3**

Question Number	Answer	Mark
2 (a)	Show that this gives ultimate tensile strength of about 6 x 10^7 Pa Use of $W = mg$ **(1)** (do not award this mark if g = 10 N/kg) Use of stress = force / area **(1)** Correct answer [6.3 x 10^7 (Pa) to at least 2 sf] **(1)** **[no ue]** (if F/A = 84/1.3 x 10^{-5} m^2 or they write 84 N/1.3 x 10^{-5} m^2 allow second mark only) *Example of calculation* $W = mg$ = 84 kg x 9.81 N/kg = 824 N stress = force/area = 824 N/1.3 x 10^{-5} m^2 = 6.3 x 10^7 Pa (N.B. 'reverse show that', i.e. using 6 x 10^7 Pa to get 79.5 kg gets 2 marks max)	**(3)**
2 (b)	Explain why the value for the sample may be lower Explains Masses added in 2 kilograms **(1)** Required mass may have been between 82 and 84 kg / required mass may have been less than 84 kg / may need less than 2 kg extra **(1)**	**(2)**
2 (c)	Explain why the wood sample has the shape shown Any of the following to a maximum of 2: Maximum stress in the centre **(1)** So it breaks in the right place **(1)** (Wide at ends) for firm grip by supports **(1)** Narrow in centre because breaking force proportional to area **(1)** For a given force you get a larger stress **(1)** So a smaller force/mass/weight is required to break it **(1)**	**(Max 2)**
2 (d)	What should be done to ensure reliable results Repeat and average / repeat and identify anomalies / repeat to check **(1)**	**(1)**
	Total for question	**8**

Question Number	Answer	Mark
3 (a)	Explain whether the band obeys Hooke's law. States: Line not straight / line curves / gradient not constant / k not constant **(1)** (But) Hooke's law states extension or change in length is proportional to force **(1)** [Allow both marks for: No, because extension is not proportional to force] [Accept coherent references to 'the variables' for force and extension]	**(2)**
3(b)	Show that energy stored is below 0.8 J Indication of use of area (could be marks on graph) / use of ½ *Fx* **(1)** Calculation of value as good as triangle approximation (0.6 J) **(1)** More detailed, e.g. counting squares, for correct answer (0.76 J) **(1)** (accept answers above from 0.7 J to just below 0.8 J) [If a candidate shows it is less than 0.8 J by drawing a shape with area of 0.8 J, 1st mark as above, 2nd mark for correct 0.8 J shape, 3rd for making comparison.]	**(3)**
3(c)	Calculate of initial speed of aeroplane Equates stored energy with initial kinetic energy of aeroplane **(1)** Use of ke = $1/2\ mv^2$ **(1)** Correct answer (7.5 m s^{-1}) **(1)** *Example of calculation* 0.76 J = $1/2\ mv^2$ $v = \sqrt{(2 \times 0.76\ J / 0.027\ kg)}$ = 7.5 m s^{-1} [Allow use of 0.8 J for energy instead of ecf from 19 (b), or allow an obvious 'less than 0.8 J' if a candidate hasn't got their own value and is attempting to continue, but it must not be less than 0.6 J] [Use of 0.6 J gives 6.7 m s^{-1}; use of 0.8 J gives 7.7 m s^{-1}]	**(3)**
3(d) (i)	Describe energy transfers energy transferred to (elastic) strain energy / elastic potential energy of band (and some heat) **(1)** (elastic) strain energy / elastic potential energy / this energy decreases and some energy transferred to heat **(1)** [Ignore references to sound]	**(2)**

3(d) (ii)	Explain effect on initial speed (QWC – Work must be clear and organised in a logical manner using technical wording where appropriate to be eligible for the 3rd Physics mark) Area under graph for increasing force > area for decreasing force / one line higher than the other / gap between lines **(1)** Work done by band less than calculated energy stored / energy stored > energy retrieved / area between lines is energy transferred to heat/ area between lines is energy dissipated **(1)** not all energy is transferred to kinetic energy **(1)**	**(3)**
	Total for question	**13**

Question Number	Answer	Mark
4 (a)	Explain what is meant by each of the following terms limit of proportionality – stress proportional to strain / obeys Hooke's law / Force proportional to extension up to this point (1) tensile strength – greatest <u>stress</u> before fracturing (1) yield point – point at which plastic deformation begins / point at which material shows a larger increase in strain for a smaller increase in stress (1)	**3**
4 (b)	Mark 'limit of proportionality' and the 'yield point' on the graph. L shown at end of linear part (1) Y shown beyond L and up to maximum stress (1)	**2**
	Total for question	**5**

Question Number	Answer	Mark
5(a)	Force diagram Accept free body or triangle/parallelogram of forces Downward arrow labelled Weight/*W*/*mg* (1) Arrows parallel to both lines, at least one labelled tension/*T*(1) Minus 1 for each additional force	**2**
5(b) (i)	Show that downward vertical force is about 11 N Correct answer (10.8 N) (1) [no ue] *Example of calculation* *W* = *mg* = 1.1 kg x 9.81 N kg^{-1} = 10.8 N	**1**
5(b)(ii)	Show that the angle is about 84°. Correct use of sides in right angled triangle (1) Correct answer [84.2°] (1) [no ue] *Example of calculation* tan θ = 4.80 m / 0.485 m Angle = 84.2° (Accept use of cos instead of tan)	**2**

5(b) (iii)	Show that the tension on the line is less than 60 N Use of trigonometrical function for vertical component of tension (1) Correct answer [53 N] (1) [allow ecf] [no ue] Example of calculation $T_v = T \cos \theta$ $W = 2\ T \cos \theta$ T = 10.8 N / 2 x cos 84.2 = 53.4 N Alternative answers range from 51 N to 55 N	**2**
5(b) (iv)	Calculate the strain Calculate extension (1) correct answer [2.6 x 10^{-2}] (1) *Example of calculation* extension = 9.847 m – 9.6 m = 0.247 m strain = 0.247 m / 9.6 m = 2.6 x 10^{-2} [2.6%]	**2**
5(c)	Calculate Young's modulus Use of stress = force / area (1) Use of E = stress / strain (1) Correct answer [3.1 x 10^8 Pa] [3.1 x 10^8 N m^{-2}] (1) [allow ecf, including use of F = 60 N] [Substituting into $E = (F/A)/(e/l)$ in one go gets both use of marks] $E = (F/A)/(e/l)$ = (53.4 N / 6.6 x 10^{-6} m^2) / 2.6 x 10^{-2} = 3.1 x 10^8 Pa (accept answers in range 3.0 x 10^8 Pa to 3.6 x 10^8 Pa for alternative F values)	**3**
	Total for question	**12**

Question Number	Answer	Mark
6(a)	Use of $W = mg$ (1) Use of $F = (-)\ kx$ (1) k = 123 (N m^{-1}) (1) (use of g = 10 N kg^{-1} → 125 (N m^{-1}) scores 2 marks) <u>Example of calculation</u> W = 0.1 kg × 9.81 N kg^{-1} = 0.981 N (−) 0.981 N = (−) k × 0.008 m k = 122.6 N m^{-1}	**3**
6(b)	(If the load is too high) the <u>elastic limit</u> (of the spring) will be exceeded **Or** the maximum load is at the <u>elastic limit</u> (1) (accept 1.2 kg/12 N for maximum load) The spring will not return to its original length/position **Or** the spring will be permanently deformed (1) The idea that the calibrations of the scale will not be correct e.g. the calibration/scale is now incorrect/inaccurate **Or** the spring constant will change (1) (Accept converse argument for keeping the load below the maximum load)	**3**
	Total for question	**6**

Question Number	Answer	Mark
7(a)	Add labelled arrows to show the other forces on the submarine. Label upthrust, weight and viscous drag: 3 correct (2), 1 or 2 correct (1) (Accept unambiguous single letter labels, e.g. U, W and V/F/D/VD) (Accept *mg* for weight but do not accept 'gravity')	**2**
7(b)	State two equations to show the relationship between the forces Upthrust = (-)Weight (1) Thrust = (-)Viscous drag (1)	**2**
7(c)	Show that the submarine has a weight of about 7×10^7 N. Use of density = m/V (1) Correct answer [7.2×10^7 N to at least 2 s.f.] (1) [no ue] **Example of calculation** calculate weight of water as U = W m = density x volume = 1030 kg m^{-3} x 7 100 m^3 = 7.3×10^6 kg W = mg $W = 7.3 \times 10^6$ kg x 9.81 N kg^{-1} = 7.2×10^7 N	**2**
7(d) (i)	Explain what is meant by compressive strain. decrease in length / original length (1)	**1**
7(d) (ii)	Explain the action that should be taken pump out water / replace water in tanks with air (1) to decrease weight (accept mass) / to compensate for decreased upthrust / to make density the same as water (1)	**2**
7(d) (iii)	Suggest why a material like fibreglass would be unsuitable **QWC – Work must be clear and organised in a logical manner using technical wording where appropriate** A much greater (compressive) strain will be produced / compresses more easily (1) producing a larger decrease in volume/upthrust/deformation (1)	**2**
	Total for question	**11**