Question	Answer	Marks	Guidance
1 (a)	the density of a material is the mass per unit volume	1	Quoting the equation density = (mass/ volume) would be acceptable.
1 (b) (i)	volume of copper = $0.70 \times 0.80 \times 10^{-3}$ $= 0.56 \times 10^{-3}\ m^3$ mass of copper $= \rho_C V_C = 8.9 \times 10^3 \times 0.56 \times 10^{-3}$ = 5.0 kg mass of zinc $= \rho_Z V_Z = 7.1 \times 10^3 \times 0.30 \times 0.80 \times 10^{-3}$ = 1.7 kg	1 1 1	To find the mass of each constituent metal in the alloy you must first find the volume of each metal that is required. Once you have seen how to find the mass of copper, you simply repeat the same steps for zinc.
1 (b) (ii)	mass of brass in the rod = 5.0 + 1.7 = 6.7 kg density of brass $= \dfrac{\text{mass}}{\text{volume}} = \dfrac{6.7}{0.80 \times 10^{-3}}$ $= 8.4 \times 10^3\ kg\ m^{-3}$	1 1	The density of brass is the total mass divided by the total volume for the rod made from 70 % of copper and 30 % of zinc by volume.
2	force applied to spring = weight of lorry = mg $= 1.2 \times 10^3 \times 9.81 = 1.18 \times 10^4$ N energy stored $= \frac{1}{2} F \Delta L$ $= \frac{1}{2} \times 1.18 \times 10^4 \times 0.030$ = 180 J	1 1 1	There are two things to bear in mind in this question. The first is that the applied force is the weight of the lorry, not its mass. The second is that the energy stored in a spring is $\frac{1}{2} F \Delta L$, not just $F \Delta L$.
3 (a) (i)	material X obeys Hooke's law until it fractures because stress is proportional to strain over the whole line	1 1	Hooke's law is only obeyed if stress ∝ strain, requiring the graph to be a straight line through the origin. The graph for Y curves.
3 (a) (ii)	Y is the weaker material because its breaking stress is lower than that of X	1 1	A weaker material will fracture at a lower value of stress.
3 (a) (iii)	material Y is ductile because it exhibits plastic behaviour	1 1	Material X is brittle, because it fractures without showing any plastic deformation.
3 (a) (iv)	material Y has the greater strain energy for a given tensile stress because the area under its graph is greater **for a given tensile stress**	1 1	You may need to draw (or imagine the effect of) a horizontal straight line at a particular value of tensile stress in order to spot this.
3 (b) (i)	cross-sectional area = $0.64\ mm^2$ $= 0.64 \times 10^{-6}\ m^2$ tension in cord $F = \dfrac{E_Y A \Delta L}{L}$ $= \dfrac{2.0 \times 10^7 \times 0.64 \times 10^{-6} \times 30 \times 10^{-3}}{160 \times 10^{-3}}$ = 2.4 N	1 1 1	It is easy to get this wrong. Note that $1\ mm^2 = 1\ mm \times 1\ mm = (10^{-3})^2 = 10^{-6}\ m^2$ The tension is the stretching force, which you can find from the Young modulus equation (given in the Data Booklet).
3 (b) (ii)	energy stored in cord	1	This is the energy stored **at this extension**, which is (190 − 160)

Question	Answer	Marks	Guidance
	$= \frac{1}{2} F \Delta L$ $= \frac{1}{2} \times 2.4 \times 30 \times 10^{-3}$ $= 3.6 \times 10^{-2}$ J	 1	mm = 30×10^{-3} m.
4 (a)	Graph plotted to include: • at least 9 points plotted correctly • all 12 points plotted correctly • correct graph for increasing loads, linear up to about 80 N and with curved part for higher loads >80 N • correct linear graph for decreasing loads, with permanent extension for zero load	4	The scales you choose should make good use of the graph paper, so that you are using more than half of the area of the paper. 1 cm ≡ 10 N for forces and 1 cm ≡ 1 mm for extensions would be suitable on normal A4 metric graph paper. Always plot in pencil in case you make mistakes.
4 (b)	Relevant points include: • initially the wire obeys Hooke's law (or behaves elastically) • this continues up to the limit of proportionality • the elastic limit is reached beyond the limit of proportionality • the wire then undergoes plastic deformation • which produces a permanent extension • extension varies linearly with load as the load is decreased	4	Once you have seen and understood a load-extension (or a stress-strain) graph for a material taken beyond its elastic limit, interpreting the graph should be fairly simple. Note that in the topic of elasticity it is conventional to plot the independent variable (load) on the vertical axis and the dependent variable (extension) on the horizontal axis. This is contrary to the normal convention when plotting graphs.
4 (c)	gradient of graph $= \frac{F}{\Delta L} = \frac{80}{7.2 \times 10^{-3}}$ $= 1.11\ (\pm 0.03) \times 10^{4}$ N m^{-1} Young modulus $E_Y = \frac{FL}{A\Delta L} = \frac{L}{A} \times$ gradient $= \frac{3.0 \times 1.11 \times 10^{4}}{2.8 \times 10^{-7}} = 1.2 \times 10^{11}$ Pa	1 1 1	You should find the gradient by taking readings from the line on your graph, **not** from the points in the table you are given. (Points may not be on the line.) Don't forget to show your working, and don't forget to include the unit of the Young modulus (N m^{-2} would be acceptable).
5 (i)	extension $\Delta L = \frac{F_S L}{E_S A} = \frac{F_B L}{E_B A}$ is the same for both wires, as are L and A hence $\frac{E_S}{E_B} = \frac{F_S}{F_B}$	1	The starting point is a rearrangement of the Young modulus equation to make its subject ΔL. Then both L and A cancel out because they are the same for these two wires.
5 (ii)	$\frac{F_S}{F_B} = \frac{E_S}{E_B} = \frac{2.0 \times 10^{11}}{1.0 \times 10^{11}} = 2.0$ $\therefore F_S = 2 F_B$ $F_S + F_B = 15$ gives $F_S = 10$ N	1 1 1	There is no need to go back to first principles: you have already completed most of the first stage in part **(i)**, so you just have to apply it. Note that the total of the two forces must equal the weight of the suspended mass.
5 (iii)	extension ΔL $= \frac{F_S L}{E_s A} = \frac{10 \times 1.5}{2.0 \times 10^{11} \times 1.4 \times 10^{-6}}$ $= 5.4 \times 10^{-5}$ m	1 1	Once again, you should have done most of the work for this already in part **(i)**. The extension will be the same whether you substitute the data for the steel or the data for the brass.