Question 21 (Answer: **D**)

- The extension is $2.10 - 2.00 = 0.10$ m, so the strain is $0.10/2.00 = 0.050$.
- Young modulus is stress divided by strain.
- $E = 1.6 \times 10^5/0.050 = 3.2 \times 10^6$ Pa.

Question 21 (Answer: **A**)

- The spring is *shorter* after the box is added, so x is the decrease in its length.
- A change in length under a squashing load is the compression.
- Load is the force itself, strain is a ratio with no unit, and stress is force per unit area.

Question 22 (Answer: **A**)

- Rearranging $E = (F/A)(L/x)$ gives the spring constant $k = F/x = EA/L$.
- $A = \pi(0.32 \times 10^{-3})^2 = 3.22 \times 10^{-7}$ m^2 – note the radius, not the diameter.
- $k = (1.2 \times 10^{11})(3.22 \times 10^{-7})/1.7 = 2.3 \times 10^4$ N m^{-1}.

Question 20 (Answer: **D**)

- Stress is force over area, so the *maximum* stress occurs where the area is smallest.
- The narrowest point has diameter 0.60 cm, so $A = \pi(0.30 \times 10^{-2})^2 = 2.83 \times 10^{-5}$ m^2.
- $\sigma = 363/(2.83 \times 10^{-5}) = 1.3 \times 10^7$ Pa; the original 1.5 cm diameter gives A.

Question 23 (Answer: **C**)

- The spring constant is the force per unit extension, $k = F/x$.
- It is the gradient of a force–extension graph.
- A and B are products with the units of energy, not a ratio.

3(a)	ratio of stress to strain
3(b)(i)	$R_0 = \rho L / A$
3(b)(ii)	$k = F / x$
	$E = FL / Ax = ((F / x) \times (L / A)) = kL / A$ leading to $k_0 = EA / L$
3(c)(i)	straight line with positive gradient starting at (0, R_0)
3(c)(ii)	straight horizontal line starting at (0, k_0)
3(d)(i)	$L = [0.034 \times \pi \times (0.80 \times 10^{-3})^2] / 1.8 \times 10^{-8} = 3.8$ (m)
3(d)(ii)	$k = [1.3 \times 10^{11} \times \pi \times (0.80 \times 10^{-3})^2] / 3.8$ **or** $k = EA / [RA / \rho] = E\rho / R$ $= [1.3 \times 10^{11} \times 1.8 \times 10^{-8}] / 0.034$
	$k = 6.9 \times 10^4$ N m^{-1}

Question 21 (Answer: **D**)

- The graph plots *length*, not extension, so subtract the natural length first.
- At $F = 0$ the length is 0.20 m and at $F = 2.4$ N it is 0.60 m, so the extension is 0.40 m.
- $k = F/x = 2.4/0.40 = 6.0$ N m^{-1}; C comes from dividing by the length 0.60 m instead.

Question 22 (Answer: **C**)

- Both curves start and finish at the origin: when the force returns to zero, so does the extension.
- That means the wire recovers completely, so the deformation at Q is still elastic.
- The loading line is curved, so Hooke's law fails along PQ; note the axes are swapped, so the work done to P is the area under the curve, not force × extension.

Question 23 (Answer: **D**)

- Young modulus is stress over strain: $E = (F/A)/(x/L) = (F/x)(L/A)$.
- F/x is the spring constant k, and the area is $A = \pi d^2/4$.
- So $E = kL/(\pi d^2/4) = 4kL/\pi d^2$.

Question 21 (Answer: **A**)

- Stress is F/A, and both the load and the cross-section are the same, so the stresses are equal.
- The extensions differ and the lengths are equal, so the strains differ.
- Young modulus is a property of the material, so copper and steel differ there too.