3.17 (a) From the definition of the APF

$$\mathrm{APF} = \frac{V_S}{V_C} = \frac{n\left(\frac{4}{3}\pi R^3\right)}{a^2 c}$$

we may solve for the number of atoms per unit cell, n, as

$$n = \frac{(\mathrm{APF})a^2 c}{\frac{4}{3}\pi R^3}$$

$$= \frac{(0.693)(4.59)^2(4.95)\left(10^{-24}\ \mathrm{cm}^3\right)}{\frac{4}{3}\pi\left(1.625 \times 10^{-8}\ \mathrm{cm}\right)^3}$$

= 4.0 *atoms/unit cell*

(b) In order to compute the density, we just employ Equation (3.5) as

$$\rho = \frac{nA_{In}}{a^2 c N_A}$$

$$= \frac{(4\ \text{atoms/unit cell})(114.82\ \text{g/mol})}{\left[\left(4.59 \times 10^{-8}\ \mathrm{cm}\right)^2\left(4.95 \times 10^{-8}\ \mathrm{cm}\right)/\text{unit cell}\right]\left(6.023 \times 10^{23}\ \text{atoms/mol}\right)}$$

$= 7.31\ \mathrm{g/cm^3}$

3. 18 (a) We are asked to calculate the unit cell volume for Be. From the solution to Problem 3.7

$$V_C = 6R^2c\sqrt{3}$$

But, c = 1.568a, and a = 2R, or c = 3.14R, and

$$V_C = (6)(3.14)\,R^3\sqrt{3}$$

$$= (6)(3.14)\left(\sqrt{3}\right)\left[0.1143 \times 10^{-7}\ \text{cm}\right]^3 = 4.87 \times 10^{-23}\ \text{cm}^3/\text{unit cell}$$

(b) The density of Be is determined as follows:

$$\rho = \frac{nA_{Be}}{V_C N_A}$$

For HCP, n = 6 atoms/unit cell, and for Be, A_{Be} = 9.01 g/mol. Thus,

$$\rho = \frac{(6\ \text{atoms/unit cell})(9.01\ \text{g/mol})}{\left(4.87 \times 10^{-23}\ \text{cm}^3/\text{unit cell}\right)\left(6.023 \times 10^{23}\ \text{atoms/mol}\right)}$$

$$= 1.84\ \text{g/cm}^3$$

The value given in the literature is 1.85 g/cm^3.

6.42 For a brass alloy, the following engineering stresses produce the corresponding plastic engineering strains, prior to necking:

Engineering Stress (MPa)	*Engineering Strain*
315	0.105
340	0.220

On the basis of this information, compute the *engineering* stress necessary to produce an *engineering* strain of 0.28.

6.42 For this problem we first need to convert engineering stresses and strains to true stresses and strains so that the constants K and n in Equation (6.19) may be determined. Since $\sigma_T = \sigma(1 + \varepsilon)$ then

$$\sigma_{T_1} = (315\ \text{MPa})(1 + 0.105) = 348\ \text{MPa}$$

$$\sigma_{T_2} = (340\ \text{MPa})(1 + 0.220) = 415\ \text{MPa}$$

Similarly for strains, since $\varepsilon_T = \ln(1 + \varepsilon)$ then

$$\varepsilon_{T_1} = \ln\,(1 + 0.105) = 0.09985$$

$$\varepsilon_{T_2} = \ln\,(1 + 0.220) = 0.19885$$

Taking logarithms of Equation (6.19), we get

$$\log \sigma_T = \log K + n \log \varepsilon_T$$

which allows us to set up two simultaneous equations for the above pairs of true stresses and true strains, with K and n as unknowns. Thus

$$\log (348) = \log K + n \log (0.09985)$$

$$\log (415) = \log K + n \log (0.19885)$$

Solving for these two expressions yields K = 628 MPa and n = 0.256.

Now, converting **ε** = 0.28 to true strain

$$\varepsilon_T = \ln (1 + 0.28) = 0.247$$

The corresponding $\boldsymbol{\sigma}_T$ to give this value of $\boldsymbol{\varepsilon}_T$ [using Equation (6.19)] is just

$$\sigma_T = K\varepsilon_T^n = (628\ \text{MPa})(0.247)^{0.256} = 439\ \text{MPa}$$

Now converting this $\boldsymbol{\sigma}_T$ to an engineering stress

$$\sigma = \frac{\sigma_T}{1 + \varepsilon} = \frac{439\ \text{MPa}}{1 + 0.28} = 343\ \text{MPa}$$

**6.29 A cylindrical specimen of aluminum having a diameter of 0.505 in. (12.8 mm) and a gauge length of 2.000 in. (50.800 mm) is pulled in tension. Use the load–elongation characteristics tabulated below to complete parts (a) through (f).

Load		Length	
lb_f	N	in.	mm
0	0	2.000	50.800
1,650	7,330	2.002	50.851
3,400	15,100	2.004	50.902
5,200	23,100	2.006	50.952
6,850	30,400	2.008	51.003
7,750	34,400	2.010	51.054
8,650	38,400	2.020	51.308
9,300	41,300	2.040	51.816
10,100	44,800	2.080	52.832
10,400	46,200	2.120	53.848
10,650	47,300	2.160	54.864
10,700	47,500	2.200	55.880
10,400	46,100	2.240	56.896
10,100	44,800	2.270	57.658
9,600	42,600	2.300	58.420
8,200	36,400	2.330	59.182
	Fracture		

(a) Plot the data as engineering stress versus engineering strain.

(b) Compute the modulus of elasticity.

(c) Determine the yield strength at a strain offset of 0.002.

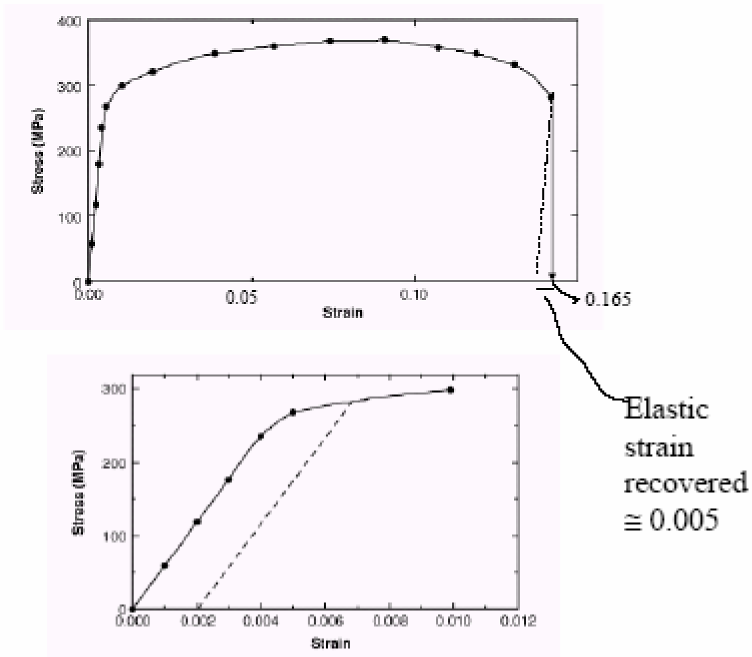
(d) Determine the tensile strength of this alloy.

(e) What is the approximate ductility, in percent elongation?

(f) Compute the modulus of resilience.

Construct a table of F , ΔL, ε and σ

F	ΔL(l-lo)	$\varepsilon = \Delta L/lo$	σ=F/Ao
0	0		
7330	50.851-50.8	0.051/50.8	7330/ [(π/4) d^2]
15100	50.902-50.8		



(b) The elastic modulus is the slope in the linear elastic region as

$$E = \frac{\Delta \sigma}{\Delta \varepsilon} = \frac{200 \text{ MPa} - 0 \text{ MPa}}{0.0032 - 0} = 62.5 \times 10^3 \text{ MPa} = 62.5 \text{ GPa} \quad \left(9.1 \times 10^6 \text{ psi}\right)$$

(c) For the yield strength, the 0.002 strain offset line is drawn dashed. It intersects the stress-strain curve at approximately 285 MPa (41,000 psi).

(d) The tensile strength is approximately 370 MPa (53,500 psi), corresponding to the maximum

(e) The ductility, in percent elongation, is just the plastic strain at fracture, multiplied by one-hundred. The total fracture strain at fracture is 0.165; subtracting out the elastic strain (which is about 0.005) leaves a plastic strain of 0.160. Thus, the ductility is about 16%EL.

(f) From Equation (6.14), the modulus of resilience is just

$$U_r = \frac{\sigma_y^2}{2E}$$

which, using data computed in the problem, yields a value of

$$U_r = \frac{(285 \text{ MPa})^2}{(2)\left(62.5 \times 10^3 \text{ MPa}\right)} = 6.5 \times 10^5 \text{ J/m}^3 \quad \left(93.8 \text{ in.-lb}_f/\text{in.}^3\right)$$