Exercise 11

Consider a tube of length L filled with gas, pressure p, the radius is R and the thickness is d. Assume that $d \ll R \ll L$.
a) What is the stress σ_z along the tube axis z?
b) What is the tangential stress σ_x (hoop stress)?
c) From your above derived relations, explain how pressurized tubes normally crack.

Exercise 12

The average time step used in kinetic Monte Carlo can be derived from the residence time algorithm. The probability density function of escape can be found from the staying probability by integrating

$$\int_0^{t'} P(t)dt = 1 - P_{\text{stay}}(t')$$

Derive the average time step, Δt, in KMC from the above *P(t)*.

Exercise 13

Plastic deformation of a crystal is always locally resolved in a shear deformation. Imagine an experiment in which a single fcc crystal is loaded with a tensile stress σ_T acting in the direction $n_T = [k\ l\ m]$. This force is resolved in a specific glide (or slip) system as $\sigma_S = \sigma_T \cos(\varphi) \cos(\theta)$, where φ is the angle between the glide plane vector and n_T , and θ is the angle between the glide direction and n_T . The factor cos(φ)cos(λ) is called the Schmid factor, and we see that the resolved shear stress is always smaller than the applied tensile stress.

a) How should the glide plane and glide direction be oriented in order to maximize the Schmid factor?

b) For the specific case of $n_T = [1,2,3]$, calculate the Schmid factor for each of the 12 glide systems in the fcc crystal. The glide system with the largest Schmid factor (take the absolute value!) is the one that will be active. Which glide system is that, and what is the corresponding shear stress, assuming that $\sigma_T = 100$ MPa?

Exercise 14

Determine the critical void embryo size for 316 stainless steel ($a_0 = 0.3$ nm, $\gamma = 1.75$ J/m²) irradiated at 500 °C so as to produce a vacancy supersaturation of S_v=1000.

Exercise 15

Electron-microscopic examination of a 316 stainless steel specimen that has been irradiated at 400 °C in a fast neutron fluence of 10^{22} n/cm^2 (E > 0.1 MeV) reveals voids with an average diameter of 40 nm and a number density of 2.2×10^{15} cm^{-3}. In addition, SIA loops of a diameter of 16 nm are present at a number density of 1.8×10^{15} cm^{-3} . The shear modulus is: G= 80 GPa; and the Burgers' vector length b is 2.5 Å.

Assuming that both types of defects act as hard barriers ($\alpha = 1$ for voids, $\alpha = 1/2$ for faulted loops) and are distributed in regular, square arrays:
(a) Calculate the change in the critical resolved shear stress ($\Delta\tau$) due to irradiation.
(b) What is the interparticle spacing of the square arrays?
(c) Which causes greater hardening: the void or loop population?

Exercise 16

What is the steady-state supersaturation of vacancies in bcc Fe irradiated at 1000°C with a monoenergetic 1 MeV neutron flux of 10^{15} cm^{-2}s^{-1}? Use the simplest rate theory model (1000°C is a typical high temperature case), assuming the only sinks are neutral voids, with average radius 5 nm and concentration of 10^{17} m^{-3}. The total scattering cross section of the neutrons is 3 barns.