Equation Number	Equation	Description
6.1	$\sigma = \frac{F}{A_0}$	Engineering stress
6.2	$\varepsilon = \frac{l_i - l_0}{l_0} = \frac{\Delta l}{l_0}$	Engineering strain
--	$\varepsilon_t = \varepsilon_p + \varepsilon_e$	Relationship between total, elastic, and plastic engineering strain
6.5	$\sigma = E\varepsilon$	Hooke's Law
6.6	$E \propto \left(\frac{dF}{dr}\right)_{r_0}$	Relationship between E and force-atomic separation curve
6.8	$\nu = -\frac{\varepsilon_x}{\varepsilon_z} = -\frac{\varepsilon_y}{\varepsilon_z}$	Poisson's ratio
6.10	$E = \text{slope} = \frac{\Delta\sigma}{\Delta\varepsilon} = \frac{\sigma_2 - \sigma_1}{\varepsilon_2 - \varepsilon_1}$	Young's modulus
6.11	$\%EL = \left(\frac{l_f - l_0}{l_0}\right) \times 100$	Ductility, percent elongation
--	$\%EL = \left(\varepsilon_t^f - {}^{\sigma_f}/_{E}\right) \times 100$	Ductility, percent elongation
--	$\%EL = \left(\varepsilon_p^f\right) \times 100$	Ductility, percent elongation
6.13a	$U_r = \int_0^{\varepsilon_y} \sigma d\varepsilon$	Definition of modulus of resilience
6.13b	$U_r = \frac{1}{2}\sigma_y\varepsilon_y$	Modulus of resilience for linear elastic behavior
6.14	$U_r = \frac{1}{2}\sigma_y\varepsilon_y = \frac{1}{2}\sigma_y\left(\frac{\sigma_y}{E}\right) = \frac{\sigma_y^2}{2E}$	Modulus of resilience for linear elastic behavior
--	$U_t = \int_0^{\varepsilon_f} \sigma d\varepsilon$	Definition of modulus of toughness
6.15	$\sigma_T = \frac{F}{A_i}$	Definition of true stress
6.16	$\varepsilon_T = \ln\frac{l_i}{l_0}$	Definition of true strain
6.17	$A_i l_i = A_0 l_0$	If volume and cross-sectional area are constant
6.18a	$\sigma_T = \sigma(1 + \varepsilon)$	True stress, if volume and cross-sectional area are constant

6.18b	$\varepsilon_T = \ln(1+\varepsilon)$	True strain, alternate equation
--	$\varepsilon_T = \ln\left(\frac{A_0}{A_i}\right)$	True strain, if volume and cross-sectional area are constant
6.19	$\sigma_T = K\varepsilon_T^n$	Relationship between true stress, true strain, and strain hardening exponent
6.20a	$\mathrm{TS\ (MPa)} = 3.45 \times \mathrm{HB}$	Relationship between HB and TS for steel
6.20b	$\mathrm{TS\ (psi)} = 500 \times \mathrm{HB}$	Relationship between HB and TS for steel
--	$HR = 100 - \frac{h}{0.002\ \mathrm{mm}}$	Rockwell Hardness (diamond cone indenter; A, C, and D scales)
--	$HR = 130 - \frac{h}{0.002\ \mathrm{mm}}$	Rockwell Hardness (ball indenter; all other scales)

Equation Number	Equation	Description
3.1	$a = 2R\sqrt{2}$	Unit cell edge length for FCC
3.2	$N = N_i + \frac{N_f}{2} + \frac{N_c}{8}$	Number of atoms per unit cell (for cubic unit cells)
3.3	$APF = \frac{\text{volume of atoms in a unit cell}}{\text{total unit cell volume}}$	Atomic packing factor
3.4	$a = \frac{4R}{\sqrt{3}}$	Unit cell edge length for BCC
3.5	$N = N_i + \frac{N_f}{2} + \frac{N_c}{6}$	Number of atoms per unit cell (for hexagonal unit cells)
3.6	$V_C = a^3$	Unit cell volume for cubic unit cells
3.7a	$V_c = \frac{3a^2c\sqrt{3}}{2}$	Unit cell volume for hexagonal unit cells
--	$a = 2R$	Unit cell edge length of basal (hexagonal) plane in hexagonal unit cell
3.8	$\rho = \frac{nA}{V_C N_A}$	Theoretical density of a metallic crystalline solid
7.7	$\sigma_y = \sigma_0 + k_y d^{-1/2}$	Hall-Petch equation
7.8	$\%\text{CW} = \left(\frac{A_0 - A_d}{A_0}\right) \times 100$	Percent cold work
7.9	$d^n - d_0^n = Kt$	Grain growth equation
--	$\bar{l} = \frac{L_T}{PM}$	Mean intercept length, $\bar{l}$, where L_T is the total line length, P is the total number of intercepts, and M is the magnification
--	$d = (\#\ \text{atoms})(2R)$	Relationship between grain diameter, number of atoms across, and atomic radius

Equation Number	Equation	Description
5.1	$J = \frac{M}{At}$	Definition of diffusion flux
5.2	$J = -D\frac{dC}{dx}$	Fick's first law of diffusion
5.4b	$\frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2}$	Fick's second law of diffusion
5.5	$\frac{C_x - C_0}{C_s - C_0} = 1 - \mathrm{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$	Solution to Fick's second law for the condition of constant surface concentration (for a semi-infinite solid)
5.8	$D = D_0 \exp\left(\frac{-Q_d}{RT}\right)$	Diffusion coefficient equation
--	$Q_d = -2.3R(\mathrm{slope}) = -2.3R\left(\frac{\log D_1 - \log D_2}{\frac{1}{T_1} - \frac{1}{T_2}}\right)$	Activation energy for diffusion (based on two data points)
--	$\%\ \mathrm{difference} = \left(\frac{r_{solute} - r_{solvent}}{r_{solvent}}\right) \times 100$	Atomic size difference equation for use with Hume-Rothery rules

Equation Number	Equation	Description
8.1	$\sigma_m = 2\sigma_0\left(\frac{a}{\rho_t}\right)^{1/2}$	Maximum stress at tip of elliptical crack with radius ρ_t and length $2a$ under applied stress σ_0
8.2	$K_t = \frac{\sigma_m}{\sigma_0} = 2\left(\frac{a}{\rho_t}\right)^{1/2}$	Stress concentration factor for an elliptical crack with radius ρ_t and length $2a$ under applied stress σ_0
--	$B \geq 2.5\left(\frac{K_{Ic}}{\sigma_y}\right)^2$	Thickness of specimen under which plane strain behavior occurs
8.5	$K_{Ic} = Y\sigma\sqrt{\pi a}$	Plane strain fracture toughness
8.14	$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$	Mean stress
8.15	$\sigma_r = \sigma_{max} - \sigma_{min}$	Range of stress
8.16	$\sigma_a = \frac{\sigma_r}{2} = \frac{\sigma_{max} - \sigma_{min}}{2}$	Stress amplitude
8.17	$R = \frac{\sigma_{min}}{\sigma_{max}}$	Stress Ratio
8.18	$\sigma_{max} = \frac{16FL}{\pi d_0^3}$	Maximum stress in rotating-bending test of cylindrical bar
--	$\dot{\varepsilon}_s = \frac{\Delta\varepsilon}{\Delta t}$	Steady-state creep rate

Equation Number	Equation	Description
12.7a	$\sigma_{fs} = \frac{3F_f L}{2bd^2}$	Flexural strength in 3-point bending for rectangular cross-section of width b and thickness d
12.7b	$\sigma_{fs} = \frac{F_f L}{\pi R^3}$	Flexural strength in 3-point bending for circular cross-section of radius R
--	$\Delta y = \frac{FL^3}{4Ebd^3}$	Maximum displacement under 3-point bending for rectangular cross-section of width b and thickness d
--	$\Delta y = \frac{FL^3}{12\pi ER^4}$	Maximum displacement under 3-point bending for circular cross-section of radius R
--	$P_S(V_0) = 1 - P_F(V_0) = \exp\left(-\left(\frac{\sigma}{\sigma_0}\right)^m\right)$	Two-parameter Weibull distribution
--	$-\ln\ln\left(\frac{1}{P_S}\right) = -m\ln\sigma + m\ln\sigma_0$	Double logarithm of two-parameter Weibull distribution
--	$P_S(j) = 1 - \frac{j}{(N+1)}$	Probability of survival for the j-th specimen
19.3b	$\Delta L = \alpha(T_1 - T_2)L$	Change in length of unconstrained rod after changing from T_1 to T_2
8.20, 19.8	$\sigma_{th} = E\alpha(T_1 - T_2)$	Thermal stress in constrained rod after changing from T_1 to T_2
--	$\sigma_{th} = \frac{E\alpha(T_1 - T_2)}{1-\nu}$	Thermal stress in constrained plate after changing from T_1 to T_2
--	$\sigma_{th} = \frac{E\alpha ch(\Delta T)}{k(1-\nu)}$	Thermal stress due to temperature gradient ΔT across plate caused by moderate quench of one side, where c is a function of geometry, h is the heat transfer coefficient between the cooling fluid and the solid plate, and k is the thermal conductivity of the plate
--	$R' = \frac{\sigma_f k(1-\nu)}{E\alpha}$	Thermal shock resistance parameter

Equation Number	Equation	Description
14.5a	$\bar{M}_n = \Sigma x_i M_i$	Number-average molecular weight, where x_i is the number fraction of polymer chains in size range i and M_i is the mean molecular weight in size range i.
14.5b	$\bar{M}_w = \Sigma w_i M_i$	Weight-average molecular weight, where w_i is the weight fraction of polymer chains in size range i and M_i is the mean molecular weight in size range i.
14.6	$DP = \frac{\bar{M}_n}{m}$	Degree of polymerization, where m is the molecular weight of the repeat unit
15.1	$E_r(t) = \frac{\sigma(t)}{\varepsilon_0}$	Relaxation modulus
--	$E_c(t) = \frac{\sigma_0}{\varepsilon(t)}$	Creep modulus
--	$\rho_c = V_f \rho_f + V_m \rho_m$	Average density of a fiber-reinforced composite based on volume fractions and densities of fiber and matrix phases
16.10a	$E_c = E_f V_f + E_m V_m$	Elastic modulus of a fiber-reinforced under isostrain conditions (longitudinal loading)
16.16	$E_c = \frac{E_m E_f}{(1 - V_f)E_f + V_f E_m}$	Elastic modulus of a fiber-reinforced under isostress conditions (transverse loading)
16.17	$\sigma_{cl}^* = \sigma_f^* V_f + \sigma_m'(1 - V_f)$	Strength of a continuous, aligned fiber composite, where σ_f^* is the stress at which isolated fibers would fail in tension at a strain of ε_f^*, and σ_m' is the stress that the isolated matrix material would experience at a strain of ε_f^*.
16.3	$l_c = \frac{\sigma_f r}{\tau_c} = \frac{\sigma_f d}{2\tau_c}$	Critical fiber length