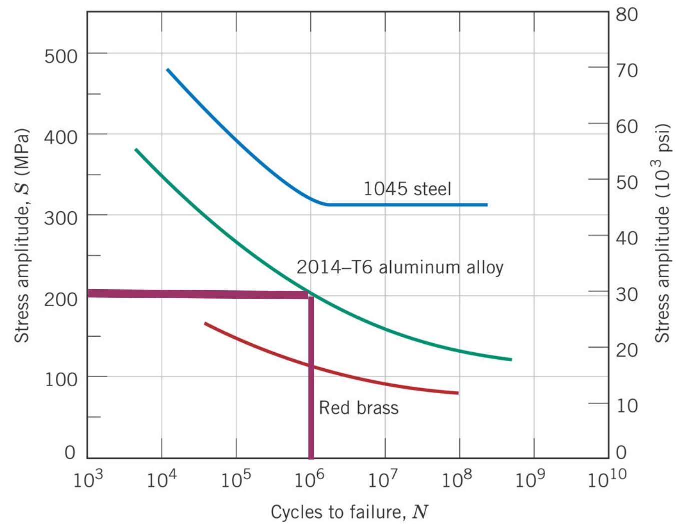
MAE 20
Exam #2(c) solutions

Problem 1
A 4 mm diameter cylindrical rod fabricated from a 2014-T6 aluminum alloy (see figure) is subjected to reversed tension-compression load cycling along its axis. If the maximum tensile and compressive loads are +2500 N and -2500 N, respectively, determine its fatigue life.



$$P = \pm 2{,}500\ N$$

$$\sigma = \frac{P}{A} = \frac{\pm 2{,}500\ N}{\pi\left(2\times 10^{-3}\, m\right)^2} = \pm 199\ \text{MPa}$$

$$S = \sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2} = \frac{199 - (-199)}{2} = 199\ MPa$$

$$\textit{From plot, fatigue life} = 10^6\ \textit{cycles}$$

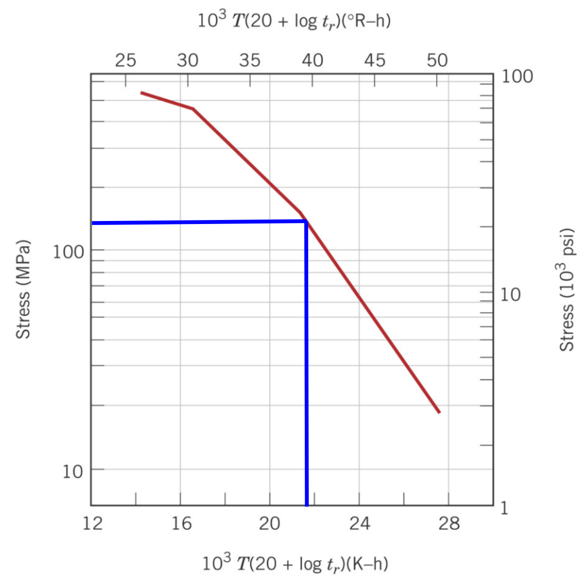
Problem 2
A tensile test is performed on a metal specimen, and it is found that a true plastic strain of 0.15 is produced when a true stress of 500 MPa is applied; for the same metal, the value of the strain hardening coefficient is 600 MPa. Calculate the true strain that results from the application of a true stress of 550 MPa.

$$\varepsilon_T = 0.15 \qquad \sigma_T = 500\ MPa$$
$$K = 600\ MPa$$
$$When\ \sigma_T = 550\ MPa,\ what\ is\ \varepsilon_T\,?$$
$$Use\ \sigma_T = K\varepsilon_T^n,\ solve\ for\ n$$

$$500\ MPa = 600\ MPa\left(0.15\right)^n$$
$$Take\ \log\ of\ each\ side$$
$$\log(500) = \log 600 - n\log(0.15)$$
$$n = 0.096$$

$$Plug\ in\ n:$$
$$550\ MPa = 600\ MPa(\varepsilon_T)^{0.096}$$
$$\varepsilon_T = \left(\frac{550}{600}\right)^{1/0.096}$$
$$\varepsilon_T = 0.40$$

Problem 3
For an 18-8 Mo stainless steel (see figure), predict the time to rupture for a component that is subjected to a stress of 138 MPa at 500°C.



$\sigma = 110\ MPa$

$T = 500^\circ C = 773\ K$

$From\ plot,\ T\left(20 + \log t_R\right) = 21.8 \times 10^3 K - hr$

$773K\left(20 + \log t_R\right) = 21.8 \times 10^3 K - hr$

$t_R = 10^{\left(\frac{21.8\times10^3}{773} - 20\right)} = 1.6 \times 10^8\, hrs \approx 18{,}000\ years$

Problem 4

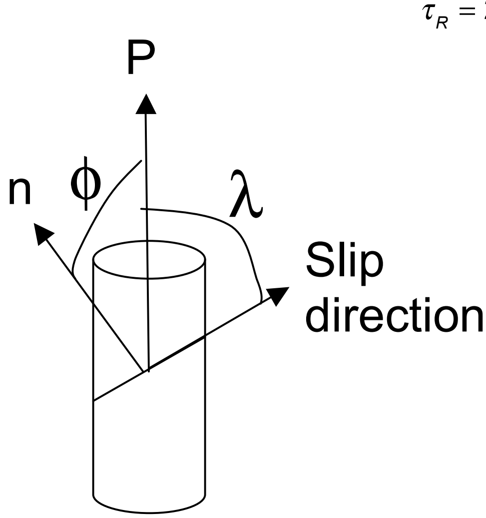
Consider a single crystal of silver oriented such that a tensile stress is applied along a [010] direction. If slip occurs on a (110) plane and in the $[1\bar{1}0]$ direction, and is initiated at an applied tensile stress of 2.2 MPa, compute the resolved shear stress.

P in [010] direction, P = 2.2 MPa
Slip plane = (110), slip plane normal in [110] direction
Slip direction $[1\bar{1}0]$

$$\tau_R = \sigma \cos\phi \cos\lambda$$

$$[010]\bullet[1\bar{1}0] = -1 = \sqrt{2}\cos\lambda$$
$$[110]\bullet[010] = 1 = \sqrt{2}\cos\phi$$

$$\tau_R = 2.2\ MPa \bullet \frac{-1}{\sqrt{2}} \bullet \frac{1}{\sqrt{2}} = -1.1\ MPa$$



Problem 5
Put your answer in the boxes to the right.

	(answer)
The resilience of a metal is given as the area under the engineering stress-strain curve up to the: (a) fracture strength (b) yield strength (c) tensile strength (d) none of the above	**b**
The ductile to brittle transition is a function of: (a) number of cycles to failure (b) temperature (c) dislocation density (d) fracture toughness	**b**
If the motion of dislocations is impeded during a tensile test, then: (a) the fracture toughness increases (b) the strain to failure increases (c) the yield strength increases (d) all of the above	**c**
T/F. The fracture toughness, K_{IC}, is a function of the critical applied stress.	**F**
T/F. Most metal failures occur by fatigue failure.	**T**