MAE 20
Exam #2(a) Solutions

Problem 1
A tensile test is performed on a metal specimen, and it is found that a true plastic strain of 0.20 is produced when a true stress of 575 MPa is applied; for the same metal, the value of the strain hardening coefficient is 860 MPa. Calculate the true strain that results from the application of a true stress of 600 MPa.

$$\varepsilon_T = 0.20 \qquad \sigma_T = 575\ MPa$$
$$K = 860\ MPa$$
$$When\ \sigma_T = 575\ MPa,\ what\ is\ \varepsilon_T\ ?$$
$$Use\ \sigma_T = K\varepsilon_T^n,\ solve\ for\ n$$

$$575\ MPa = 860\ MPa\left(0.20\right)^n$$
$$Take\ \log\ of\ each\ side$$
$$\log(575) = \log 860 - n\log(0.20)$$
$$n = 0.25$$

$$Plug\ in\ n:$$
$$600\ MPa = 860\ MPa(\varepsilon_T)^{0.25}$$
$$\varepsilon_T = \left(\frac{600}{860}\right)^{1/0.25}$$
$$\varepsilon_T = 0.24$$

Problem 2

Consider a single crystal of silver oriented such that a tensile stress is applied along a [001] direction. If slip occurs on a (111) plane and in the $[\bar{1}01]$ direction, and is initiated at an applied tensile stress of 1.1 MPa, compute the resolved shear stress.

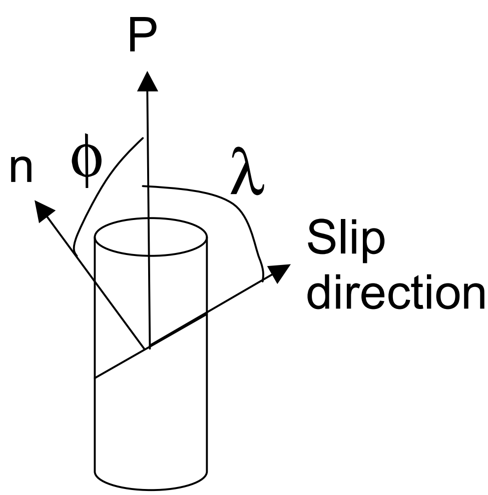
P in [001] direction, P = 1.1 MPa
Slip plane = (111), slip plane normal in [111] direction
Slip direction $\left[\bar{1}01\right]$

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

$$\left[001\right] \bullet \left[\bar{1}01\right] = 1 = \sqrt{2}\cos\lambda$$

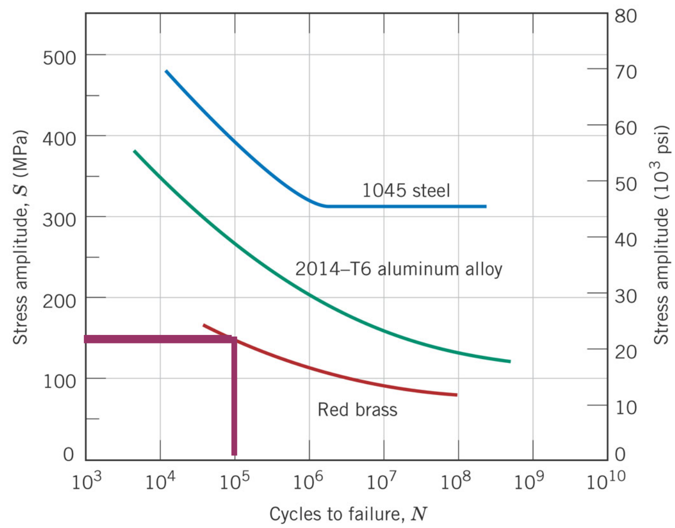
$$\left[111\right] \bullet \left[001\right] = 1 = \sqrt{3}\cos\phi$$

$$\tau_R = 1.1\,MPa \bullet \frac{1}{\sqrt{2}} \bullet \frac{1}{\sqrt{3}} = 0.45\ MPa$$



Problem 3

An 8.0 mm diameter cylindrical rod fabricated from a red brass alloy (see figure) is subjected to reversed tension-compression load cycling along its axis. If the maximum tensile and compressive loads are +7500 N and -7500 N, respectively, determine its fatigue life.



$$P = \pm 7{,}500\ N$$

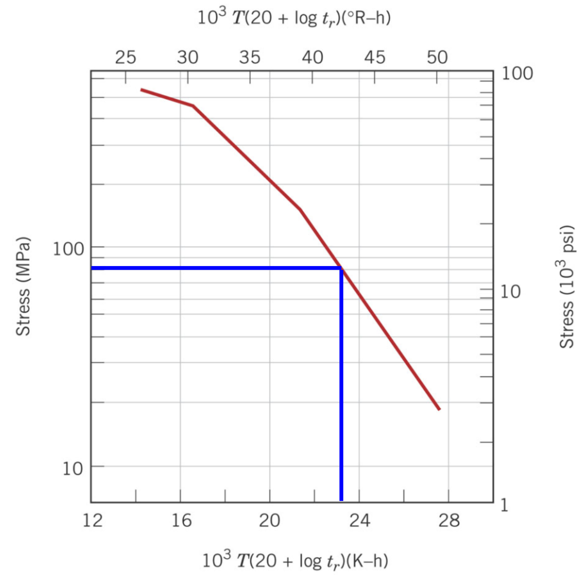
$$\sigma = \frac{P}{A} = \frac{\pm 7{,}500\ N}{\pi\left(4\times 10^{-3} m\right)^2} = \pm 149\text{ MPa}$$

$$S = \sigma_a = \frac{\sigma_{\max} - \sigma_{\min}}{2} = \frac{149-(-149)}{2} = 149\ MPa$$

$$\textit{From plot, fatigue life} = 10^5\ \textit{cycles}$$

Problem 4

For an 18-8 Mo stainless steel (see figure), predict the time to rupture for a component that is subjected to a stress of 80 MPa at 700°C.



$$\sigma = 80\ MPa$$
$$T = 700^{\circ}C = 973\ K$$

$$From\ plot,\ T\left(20 + \log t_R\right) = 23.5 \times 10^3 K - hr$$
$$973K\left(20 + \log t_R\right) = 23.5 \times 10^3 K - hr$$
$$t_R = 10^{\left(\frac{23.5\times10^3}{973} - 20\right)} = 1.42 \times 10^4\, hrs = 1.62\ years$$

Problem 5

Put your answer in the boxes to the right.

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