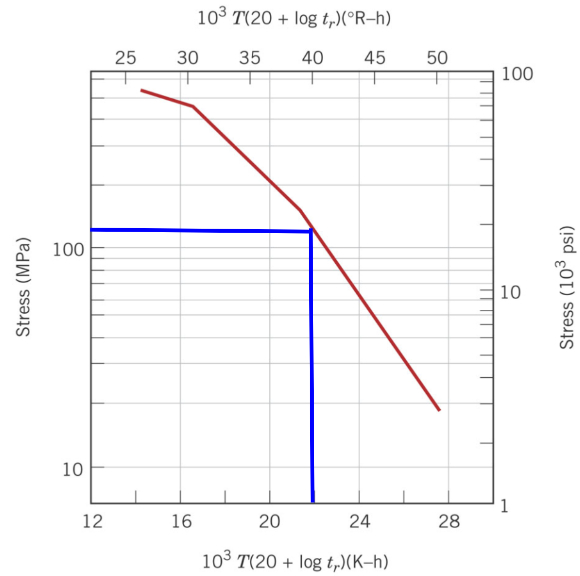
MAE 20
Exam #2(b) solutions

Problem 1
For an 18-8 Mo stainless steel (see figure), predict the time to rupture for a component that is subjected to a stress of 110 MPa at 500°C.

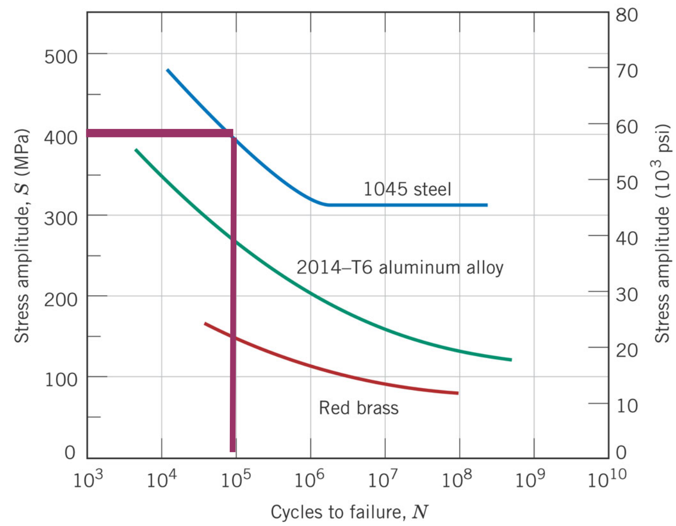


$\sigma = 110\ MPa$
$T = 500^{\circ}C = 773\ K$

From plot, $T\left(20 + \log t_R\right) = 22 \times 10^3 K - hr$
$773K\left(20 + \log t_R\right) = 21.8 \times 10^3 K - hr$
$t_R = 10^{\left(\frac{22\times10^3}{773} - 20\right)} = 2.9 \times 10^8\, hrs \approx 33{,}000\ years$

Problem 2

A 6 mm diameter cylindrical rod fabricated from a 1045 steel (see figure) is subjected to reversed tension-compression load cycling along its axis. If the maximum tensile and compressive loads are +11,300 N and -11,300 N, respectively, determine its fatigue life.



$$P = \pm 11{,}300\ N$$

$$\sigma = \frac{P}{A} = \frac{\pm 11{,}300\ N}{\pi\left(3 \times 10^{-3} m\right)^2} = \pm 400\ \text{MPa}$$

$$S = \sigma_a = \frac{\sigma_{\max} - \sigma_{\min}}{2} = \frac{400 - (-400)}{2} = 400\ MPa$$

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

Problem 3

Consider a single crystal of silver oriented such that a tensile stress is applied along a [100] 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 3.1 MPa, compute the resolved shear stress.

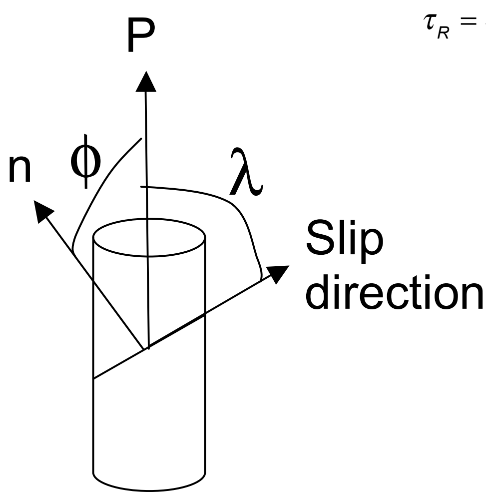
P in [100] direction, P = 3.1 MPa
Slip plane = (110), slip plane normal in [110] direction
Slip direction $[1\bar{1}0]$

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

$$[100] \bullet [1\bar{1}0] = 1 = \sqrt{2}\cos\lambda$$

$$[110] \bullet [100] = 1 = \sqrt{2}\cos\phi$$

$$\tau_R = 3.1\ MPa \bullet \frac{1}{\sqrt{2}} \bullet \frac{1}{\sqrt{2}} = 1.55\ MPa$$



Problem 4

A tensile test is performed on a metal specimen, and it is found that a true plastic strain of 0.25 is produced when a true stress of 600 MPa is applied; for the same metal, the value of the strain hardening coefficient is 900 MPa. Calculate the true strain that results from the application of a true stress of 800 MPa.

$\varepsilon_T = 0.25 \qquad \sigma_T = 600\ MPa$

$K = 900\ MPa$

$When\ \sigma_T = 800\ MPa,\ what\ is\ \varepsilon_T\,?$

$Use\ \sigma_T = K\varepsilon_T^n,\ solve\ for\ n$

$600\ MPa = 900\ MPa\left(0.25\right)^n$

$Take\ \log\ of\ each\ side$

$\log(600) = \log 900 - n\log(0.25)$

$n = 0.29$

$Plug\ in\ n:$

$800\ MPa = 900\ MPa(\varepsilon_T)^{0.29}$

$$\varepsilon_T = \left(\frac{800}{900}\right)^{1/0.29}$$

$\varepsilon_T = 0.67$

Problem 5

Put your answer in the boxes to the right.

	(answer)
If the motion of dislocations is impeded during a tensile test, then: (a) the yield strength increases (b) the strain to failure increases (c) the fracture toughness increases (d) all of the above	**a**
The resilience of a metal is given as the area under the engineering stress-strain curve up to the: (a) yield strength (b) fracture strength (c) tensile strength (d) none of the above	**a**
T/F. Most metal failures occur by fatigue failure.	**T**
The ductile to brittle transition is a function of: (a) number of cycles to failure (b) dislocation density (c) fracture toughness (d) temperature	**d**
T/F. The fracture toughness, K_{IC}, is NOT a function of the applied stress.	**T**