ME 8253 Spring 2023
Homework #3
Due Date: Monday February 6th, 2023

Please submit your homework through CANVAS as a PDF file. For all problems with calculation, present all calculation details.

Problem 1 (*30 points*)
The initial part of the load-displacement curve from the tension test of a 6061-T6 aluminum alloy is shown. The load-displacement curve was digitized, and values are given in Table 1. A cylindrical specimen with an initial gage section diameter of 6.3 mm and an initial uniform gage section length of 12.7 mm was used. After fracture, which occurred at a load of 7.2 kN, the minimum diameter in the neck region, $D_{\min}$, and the neck radius, R, were measured to be 4.2 mm and 3.3 mm, respectively.

(a) Obtain and superimpose plots of engineering and true stress-strain curves using Table 1 values.
(b) Determine the following monotonic tensile properties:
- Module of elasticity *E*,
- Yield strength S_y at 0.2 percent offset**,**
- Ultimate tensile strength S_u**,**
- True fracture strength σ_f,
- True fracture strain or ductility ε_f, and
- Percent reduction in area *%RA.*

(c) Determine the strength coefficient, K, and the strain hardening exponent, n.

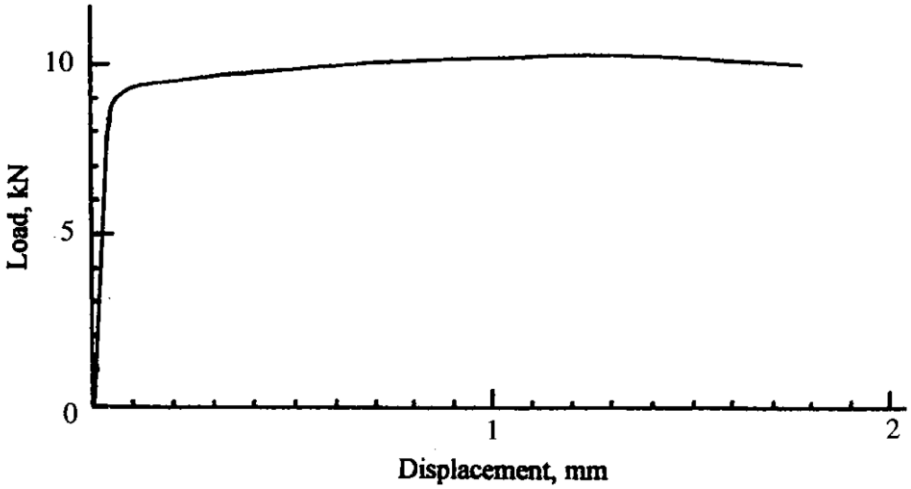

Figure 8 – Load vs. Displacement curve

Table 1 – Data points, stresses and strains values from the Load-Displacement plot.

Displacement Δl in mm	**Load *P* in N**	**Displacement Δl in mm**	**Displacement Δl in mm**	**Displacement Δl in mm**	**Load *P* in N**
0.000	0	0.500	9910	1.250	10330
0.050	8600	0.600	9970	1.300	10320
0.075	9100	0.700	10100	1.400	10300
0.100	9350	0.800	10150	1.500	10270
0.150	9470	0.900	10200	1.600	10200
0.200	9550	1.000	10230	1.700	10140
0.300	9700	1.100	10280	1.780	10060
0.400	9800	1.200	10330		

Problem 2 (*70 points*)

Using the data in Table A.2. of 1038 Normalized steels:

(a) Superimpose plots of elastic, plastic, and total strain versus life curves (***20 pts***)

(b) Determine the total, elastic, and plastic strain amplitudes for smooth uniaxial test specimens for life to (***10 pts***):

1. 10^3 cycles and
2. 10^5 cycles

Note: One cycle equals two reversals.

(c) Repeat (b) using the equation of the Method of Universal Slopes:

$$\frac{\Delta\varepsilon}{2} = \frac{\Delta\varepsilon_e}{2} + \frac{\Delta\varepsilon_p}{2} = 0.623\left(\frac{S_u}{E}\right)^{0.832}\left(2N_f\right)^{-0.09} + 0.0196\left(\varepsilon_f\right)^{0.155}\left(\frac{S_u}{E}\right)^{-0.53}\left(2N_f\right)^{-0.56}$$

and comment on any differences from (b) and their significance (***15 pts***).

(d) If the mean stress is $\sigma_m = +0.2\sigma_f'$, what approximate effect does this have on Man-Ten steel strain amplitude for 10^3 and 10^5 cycles using the following three mean stress equations:

– Morrow's parameter (***5 Pts***):

$$\frac{\Delta\varepsilon}{2} = \varepsilon_a = \frac{\sigma_f' - \sigma_m}{E}\left(2N_f\right)^b + \varepsilon_f'\left(2N_f\right)^c$$

– Alternative version of Morrow's mean stress parameter (***5 Pts***):

$$\frac{\Delta\varepsilon}{2} = \varepsilon_a = \frac{\sigma_f' - \sigma_m}{E}\left(2N_f\right)^b + \varepsilon_f'\left(\frac{\sigma_f' - \sigma_m}{\sigma_f'}\right)^{\frac{c}{b}}\left(2N_f\right)^c$$

– Smith, Watson, and Topper (SWT parameter) (***10 Pts***):

$$\sigma_{\max}\varepsilon_a E = \left(\sigma_f'\right)^2\left(2N_f\right)^{2b} + \sigma_f'\varepsilon_f' E\left(2N_f\right)^{b+c}$$

where $\sigma_{\max} = \sigma_m + \sigma_a$ and ε_a is the alternating strain (strain amplitude).

Note: In the SWT parameter case, the stress amplitude σ_a and the strain amplitude ε_a are found solving both the SWT nonlinear equation and the following Ramberg-Osgood nonlinear equation:

$$\varepsilon_a = \frac{\sigma_a}{E} + \left(\frac{\sigma_a}{K'}\right)^{1/n'}$$

Note: One method to solve a nonlinear equation $y = f(x)$ in Excel is to move all the terms on the left-hand side, (or right-hand side), such as

$$y - f(x) = 0 \quad \longrightarrow \quad R(x) = y - f(x) = 0$$

plot the residual $R(x)$ and find the x value that corresponds to $R(x) = 0$ (See Lecture 10 Slides 37, 48 and 51).

(e) Compare the results of (d) with those of (b). Where does σ_m have its greatest influence? (***5 pts***).