Theory of Plasticity – MECH 942 – Project 1, Spring 2022

Consider the thermodynamic theory of plasticity in the attached PPT. Use the example for thermodynamic plasticity presented in the notes as your starting point.

1. Modify the example in the handout on thermodynamics of plasticity to include temperature dependent yield stress. That is, assume P_{y_o} in the model is now a function $P_{y_o}(\theta)$. Include your calculations in Appendix 1, and the summary of the model in the report. The summary should include everything one needs to do calculations with the model.
2. Develop a program (using your programing method of choice; e.g., MatLab, Excel, C, C++, C#, Java, Python, Maple, Mathematica, …) that calculates the stress and entropy response of the model given the strain and temperature histories. For your simulations, assume the temperature dependence of the parameters are linear and given relative to values at the reference temperature θ_o by

$$
\begin{aligned}
&G(\theta) = G_o - \Delta G_o\left(\theta - \theta_o\right) \\
&G^b(\theta) = G_o^b - \Delta G_o^b\left(\theta - \theta_o\right) \\
&P_y(\theta) = P_{y_o} - \Delta P_{y_o}\left(\theta - \theta_o\right) \\
&A = A_o \\
&k = k_o \\
&\alpha = \alpha_o \\
&c = c_o
\end{aligned}
$$

The program MUST be based on the methodology described in the notes. Provide a short description of how you integrate to calculate the parameters (see chapter 1 for examples of integration methods)

3. Use your program to evaluate the response under the following conditions
   a. Isothermal response at θ_o due to constant strain rate: $\varepsilon = \dot{\varepsilon}_o t$
   b. Constant strain $\varepsilon = 0$ and constant heating/cooling $\theta = \dot{\theta}_o t$. Will it yield in both heating and cooling?
   c. Isothermal response at θ_o on cyclic straining $\varepsilon = at\,\mathrm{Sin}(\omega t)$. Select parameters a and ω to give you response below yield for the first cycle and go beyond yield in the second cycle.
   d. Make a combined thermo-mechanical loading (each student should make a different example)

   In your report include the loading parameters you selected for the loading and provide a plot of the response in each case. Use the material parameters (change as needed to make effective demonstrations):

$$G(\theta) = 500 \times (1 - 0.002 \times \theta)$$
$$G^b(\theta) = 100 \times (1 - 0.001 \times \theta)$$
$$P_{y_o}(\theta) = 10 \times (1 - 0.002 \times \theta)$$
$$A = 1$$
$$\alpha = 1.2 \times 10^{-4}$$
$$c = 1$$

Your report should include

1. Title, author, date
2. Abstract/Summary: No more than 7 lines, focused on your problem, and the most important thesis, concepts and results
3. Introduction: No more than 20 lines, describing the problem and your organization of results
4. Description of the model: No more than a one page summary (any details should be in Appendix 1, but everything you need to calculate the response should be here)
5. How you programmed the integration of variables: No more than one page (any additional details should be in the Appendix)
6. Results: No more than two pages giving the descriptions and plots of the simulations (plots should have captions including all the facts needed, but should not repeat what is already on the plot)
7. Discussion: No more than a page evaluating your results (don’t repeat the plots in words, discuss what they tell/teach you)
8. Conclusion: No more than 10 lines describing your main findings
9. Appendix/References as needed