# Homework # 4 – Material Selection

**Instructions:**
Upload your homework as a PDF to Gradescope. Due dates are posted in Gradescope. Please make sure that your uploaded PDF file is readable. Show your work, no credit will be given for the answer only. Include your Matlab code of applicable (with comments).

**Problem 1** (10 points, 5 points each part)

a) You are designing the front fork for a road bike. (See image below if you are not sure what this is.) What material properties are likely important in the selection of the material for this part? Explain why these properties would be important.

b) Briefly explain what types of parts you would design in metal versus plastic versus fiber composite and why.

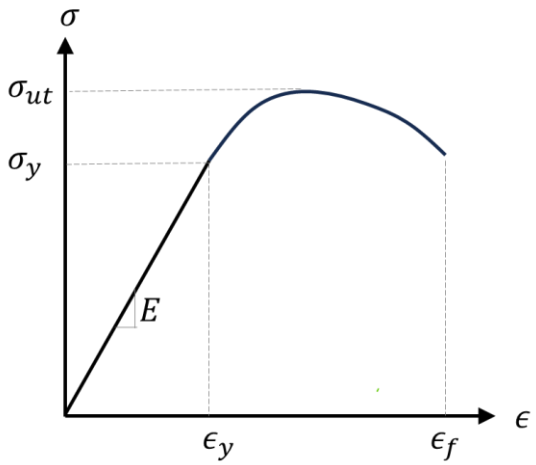

**Problem 2** (15 points, 5 points each part)

Refer to the following stress/strain diagram in which $\sigma_y = 110\ MPa,\ \sigma_{ut} = 180\ MPa,$ $E = 68\ GPa,$ and $\epsilon_f = 2.5\epsilon_y$.

a) What is the modulus of resilience for this material?

b) What is the modulus of toughness?

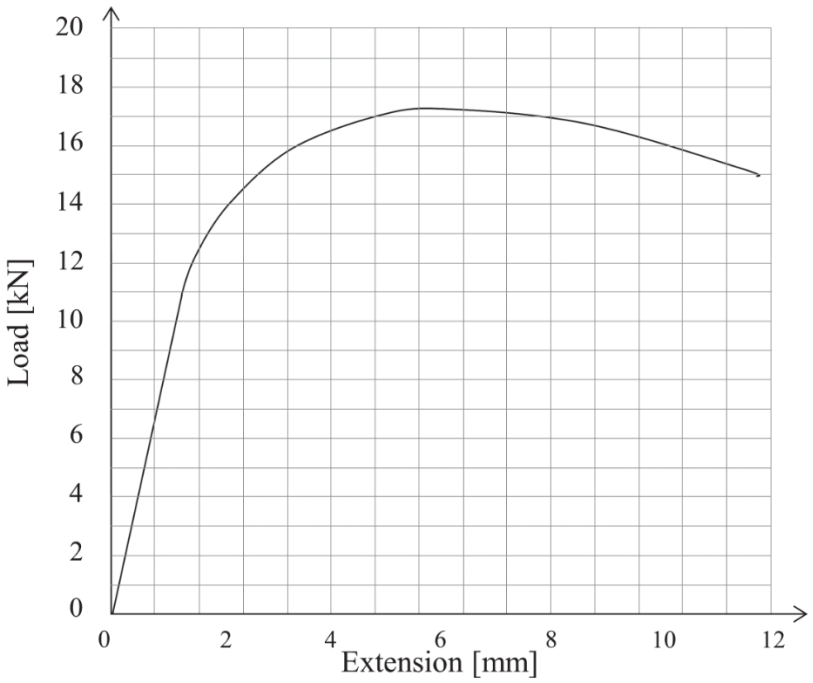
c) Draw a stress-strain diagram for a brittle ceramic in tension? Assuming the same values for $\sigma_y$ and $E$ (but not necessarily for $\sigma_{ut}$), estimate the modulus of toughness.



**Problem 3** (15 points)

The figure below shows the engineering load-extension diagram of an aluminum alloy. The original length of the test specimen is $L_0 = 200\ mm$ and the diameter is $D_0 = 5\ mm$. Estimate the elastic modulus $E$, the ultimate tensile stress ($\sigma_{ut}$), the yield stress ($\sigma_y$), the modulus of resilience ($U_R$), and the modulus of toughness ($U_T$).

(Hint, note that the total volume of the specimen cannot change.)




**Problem 4** (15 points, 5 points each part)

Consider a rectangular bar of 1018 annealed steel. The bar is 1 m long and has a rectangular cross section of 4 cm wide and 2 cm thick.

a) What are the resulting values of the yield strength and the ultimate strength if 15% cold-work is applied to the plate?

b) Plot a graph that displays yield strength (y-axis) versus amount of cold-work (x-axis) for $\epsilon_i \leq m$. (You can use Matlab, Python, Excel, etc. Do not plot this by hand.)

c) What is the yield strength that is obtained after cold-working the bar with $\epsilon_i = m$.

**Problem 5** (10 points, 5 points each part)

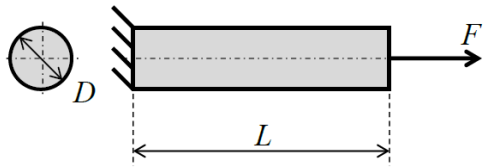
Consider a cylinder made from 1212 hot rolled (HR) steel. The diameter is 2 cm and the length is 10 cm.

a) Determine the percentage of cold-work needed to increase the yield strength by 40%.

b) What is the new cross-sectional area after the cold-work?

**Problem 6** (15 points)

A bar with a circular cross-section is anchored in a wall, and is subject to an axial load $F = 20\ kN$, as shown in the figure. The length of the bar is $L = 0.5\ m$, and the diameter after cold-work is $D = 10\ mm$. The bar is made from 304 stainless steel. How much cold-work was performed on the bar such that, in its current post cold-work state, an implied safety factor of $n = 2$ is achieved?




**Problem 7** (10 points, 5 points each part)

Consider a rod of 1144 annealed steel with length $L = 500\ mm$, and circular cross-section with diameter $D = 20\ mm$.

a) Calculate the yield strength $S'_y$ and the ultimate tensile strength $S'_{ut}$ after applying $W = 2.5\%$ cold work to the material.

b) Calculate the length of the rod after applying $W = 2.5\%$ cold work to the material.