General Instructions

Due Date: Sunday, October 30th, 2022 by 11:59pm (submit via Zybooks)

Assignment Summary Instructions:
This assignment has one problem, summarized below. You will use MATLAB as a tool to solve the problem for the given test cases, ensuring that your code is flexible for any additional test cases that might be used to evaluate it.

- Stress/Strain Tensile Test (Application of Mechanical Engineering)

zyBooks Submission Instructions:
After completing this assignment in MATLAB, to receive credit, you must submit your code in Zybooks. The following components must be submitted under the specified chapter of the course Zybooks before the deadline to receive credit.

- Chapter 35.1 MA6: Main Script

To submit your script, copy and paste your code into the submission window, making sure to remove any housekeeping commands. You may submit to Zybooks as many times as you want before the deadline, without any penalty. The highest score attained before the deadline will be graded. All components are due before the due date. No credit will be given if it is not submitted through the Zybooks platform before the deadline. Credit for each component will be awarded based upon the percentage of successfully completed assessments.

Proficiency Time: Times are included with the Background and Task sections. These times are the estimated amount of time it should take you to **redo** an assignment once you are fully proficient in material that it covers. To practice, reread the background in the given Comprehension Time and attempt to complete the problem in the given Proficiency Time.

Academic Honesty Reminder

The work you submit for this assignment should be your work alone. You are encouraged to support one another through collaboration in brainstorming approaches to the problem and troubleshooting. In this capacity, you are permitted to view other students' solutions, however, copying of another student's work is strongly discouraged.

This assignment will be checked for similarity using a MATLAB code. The similarity code will check each submission for likeness between other student submissions, past student submissions, the solution manual, and online resources and postings. If your submission is flagged for an unreasonably high level of similarity, it will be reviewed by the ENGI 1331 faculty, and action will be taken by faculty if deemed appropriate.

NOTE: Since this is an automated system for all sections, if any of your work is not your own, you will be caught. Changing variable names, adding comments, or spacing will not trick the similarity algorithm.

Background: Comprehension Time: 10 – 15 min

To find the best use and applications of materials, it's important to understand their strengths. One way to determine the strength of a material is through a tensile test, in which a sample of the material with known length and cross-sectional area is pulled until it fractures. A machine measures (every second or few seconds) the force applied to the material and the length of the sample. As more force is applied, the sample stretches until it eventually fractures. This test allows the engineer to find the stress and strain that act on the specimen and develop a curve that is used to determine the material's strengths. The general stress and strain equations are

$$\sigma = \frac{F}{A} \qquad \varepsilon\,[\%] = \frac{\Delta L}{L_0} * 100$$

where the stress σ is equal to the force applied F divided by the cross-sectional area of the sample A, and the strain ε is equal to the ratio between the change in length ΔL and the original length L_0. The strain is often multiplied by 100 to express it as a percentage, rather than as a ratio. By plotting stress against strain, we get a stress-strain curve for a given material.

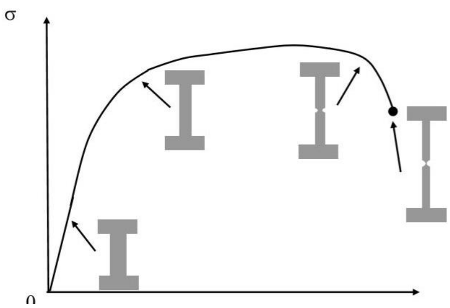


Figure 1: Example of a Stress-Strain Curve

For many materials, the stress-strain curve looks like Figure 1. Each gray bar represents the appearance of a sample being pulled apart during the tensile test. Notice that the curve starts out linear, then begins to change as the sample deforms in the test. The beginning, mostly linear portion of the curve is the elastic region of the material, where the material can still return to its original state; the rest of the curve is the plastic region, where the material has deformed permanently.

The stress-strain curve extends from the origin to the point where the tensile test sample fractured. The way this curve behaves in its different regions can help determine the various strengths of the material being tested. Figure 2 shows some of the critical points that can be found on a stress-strain curve. The right diagram denotes three key values found on a stress-strain curve: the yield strength σ_y (the stress at which the material starts to deform plastically), the tensile strength σ_{TS} (the maximum stress the material can withstand), and the fracture strain ε_F (the maximum strain the material can withstand).

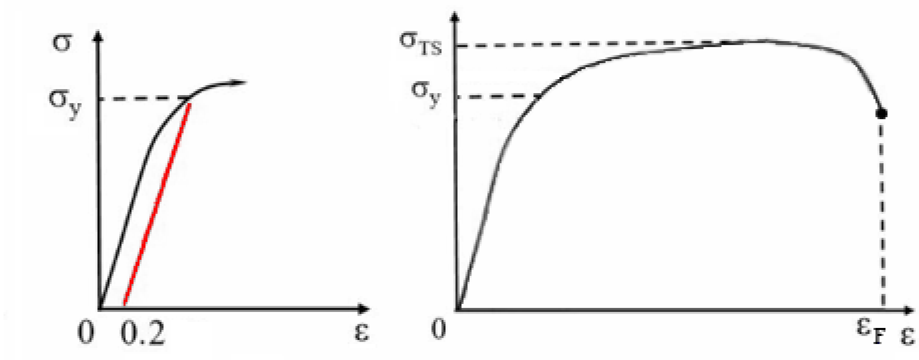


Figure 2: Example of Significant Points on a Stress-Strain Curve

In a typical tensile test, the data taken at the start of the test is not perfectly linear. To better define the point that plastic deformation begins, a 0.2% offset curve is used. In the left diagram, the red line indicates the 0.2% offset curve, which starts at $\varepsilon = 0.2\%$, runs parallel to the linear portion of the stress-strain diagram, and stops where the curve would intersect the non-linear portion of the stress-strain diagram. Where this red offset curve intersects the stress-strain diagram is the yield strength σ_y.

Tasks: Proficiency Time: 45 min – 1 hr 10 min

TASK 1: Calculate Experimental Stress and Strain (4 – 7 min)

Load in **Elongation.csv** and **Force.csv** that contain change in length ΔL [mm] and force F [N], respectively. Prompt the user to input the initial length, width, and height of a rectangular sample as a 1x3 vector [mm]. Using this information, calculate the experimental stress σ [MPa] and strain ε [%] as vectors for each value of elongation and force. Plot stress vs. strain.

Your plot should include the following formatting:

- Title, axis labels (which include the symbols σ and ε), and gridlines
- Scatter plot of the stress-strain curve with solid red markers

TASK 2: Develop the Stress/Strain Curve (18 – 25 min)

The stress-strain curve can be modeled using the tensile test data and three theoretical curves. Approximate the stress-strain curve on a new figure, using linear, power, and exponential curves. Develop the linear curve with the first third of the experimental stress-strain data, the power curve with the second third of the data, and the exponential curve with the last third of the data (assume the data can always be split evenly into thirds). The linear curve should be plotted from the first experimental strain value to the linear and power curves' intersection, the power curve should be plotted from the linear/power intersection to the power and exponential curves' intersection, and the exponential curve should be plotted from the power/exponential intersection to the last experimental strain value.

Your new plot should include the following formatting:

- Title, axis labels (which include the symbols σ and ε), and gridlines
- The three curves as described above, with a line thickness of 3 and colored black
- Fixed axis limits from the x and y axes to 10% above the max experimental stress and strain values

TASK 3: Identify Points on the Curve (10 – 15 min)

On the stress-strain diagram, plot a linear offset curve as described in the Background. This curve has the same slope as the linear curve and will extend from the point (0.2%, 0 [MPa]) on the diagram to the offset curve's intersection with the power curve and should be plotted in red with a line width of 2. Then, find the yield strength, tensile strength, and fracture point of the stress-strain curve. Output these three values to the command window and mark these points on the stress-strain diagram with blue diamonds and appropriate labels.

TASK 4: Classifying Other Samples (13 – 23 min)

Using the stress-strain curve, properties of other samples of the same material can be determined. Prompt the user to enter the number of test measurements that will be used to evaluate other samples of the material. Then, prompt the user to enter each of these test measurements (one at a time) in the format [strain (%), stress (MPa)], and plot them on the stress-strain diagram as solid red circles. Classify each of the test measurements using the below information and formulate a table in the command window with the user inputted points and their classifications (see sample output for a sample table).

- If the measurement is to the left of the yield strength, the sample is in the elastic region. Otherwise, it is in the plastic region.
- If the measurement is within 5% of the theoretical stress, the sample is nominal. Otherwise, it is irregular.

NOTE: If a test measurement is at the boundary of one of the above classifications, the sample is considered to be the first of the two options given. For example, a sample with a test measurement at the yield strength is considered elastic.

Sample Output

<u>Sample output for given data:</u>

- Additional test case scenarios are described in the Additional Resources folder accompanying this prompt.

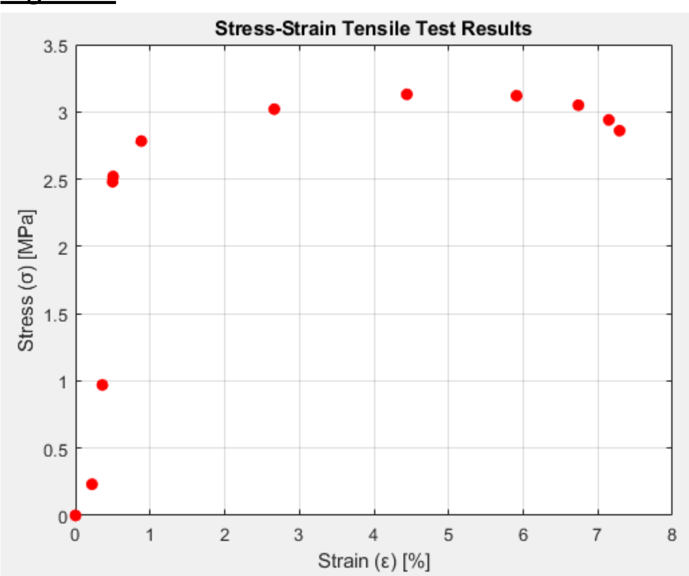
```
Command Window
Enter the length, width, and height of the sample as a 1x3 vector [mm]: [50 10 10]

The yield strength of the material is 2.67 [MPa].
The tensile strength of the material is 3.22 [MPa].
The strain at fracture point of the material is 7.29 [%].

Enter the number of test measurements that will be evaluated: 5
Enter test measurement #1 of the format [%, MPa]: [0.25, 1.5]
Enter test measurement #2 of the format [%, MPa]: [0.50, 2]
Enter test measurement #3 of the format [%, MPa]: [1.5, 3]
Enter test measurement #4 of the format [%, MPa]: [3, 3]
Enter test measurement #5 of the format [%, MPa]: [7, 3]

  Stress [MPa]  Strain [%]  Region    Quality
  1.50          0.25        Elastic   Irregular
  2.00          0.50        Elastic   Nominal
  3.00          1.50        Plastic   Irregular
  3.00          3.00        Plastic   Nominal
fx 3.00          7.00        Plastic   Nominal>>
```

<u>Figure 1:</u>



<u>Figure 2:</u>