Tutorial Class 2 – Week 3

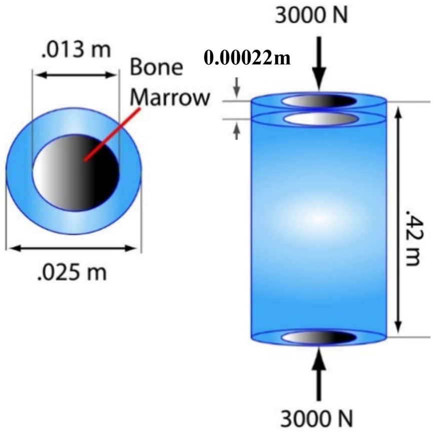
Aims:

Upon successfully completing these tutorial exercises, students should be able to:

- Demonstrate and understanding of mechanical properties of materials
- Perform calculations to determine mechanical properties of materials

Mechanical properties

Exercise 2.1 A runner experiences an impact force of 3000 N that causes the 0.42 m tibia to shorten (compress by 0.22 mm). The tibia has an area of 0.000358 m^2. Compute the axial stress ($\boldsymbol{\sigma}$), strain ($\boldsymbol{\varepsilon}$) and Young's modulus (E).



Note: change all units to m or mm. (Pa = N/m^2), (MPa = N/mm^2)

Typical Exam Question

Exercise 2.2 Below is data from AISI 1020 HR steel tensile test, using engineering stress and strain data.

- Figure 1 gives a full set of data until material fracture. Strain scale (0 - 0.4)
- Figure 2 is the same data as Figure 1 but focuses on the initial part of the graph. i.e. it shows the yield plot in the elastic region. Strain scale (0 – 0.005)
- Figure 3 shows a smaller strain scale (0 – 0.0025) use this graph to calculate Young's Modulus

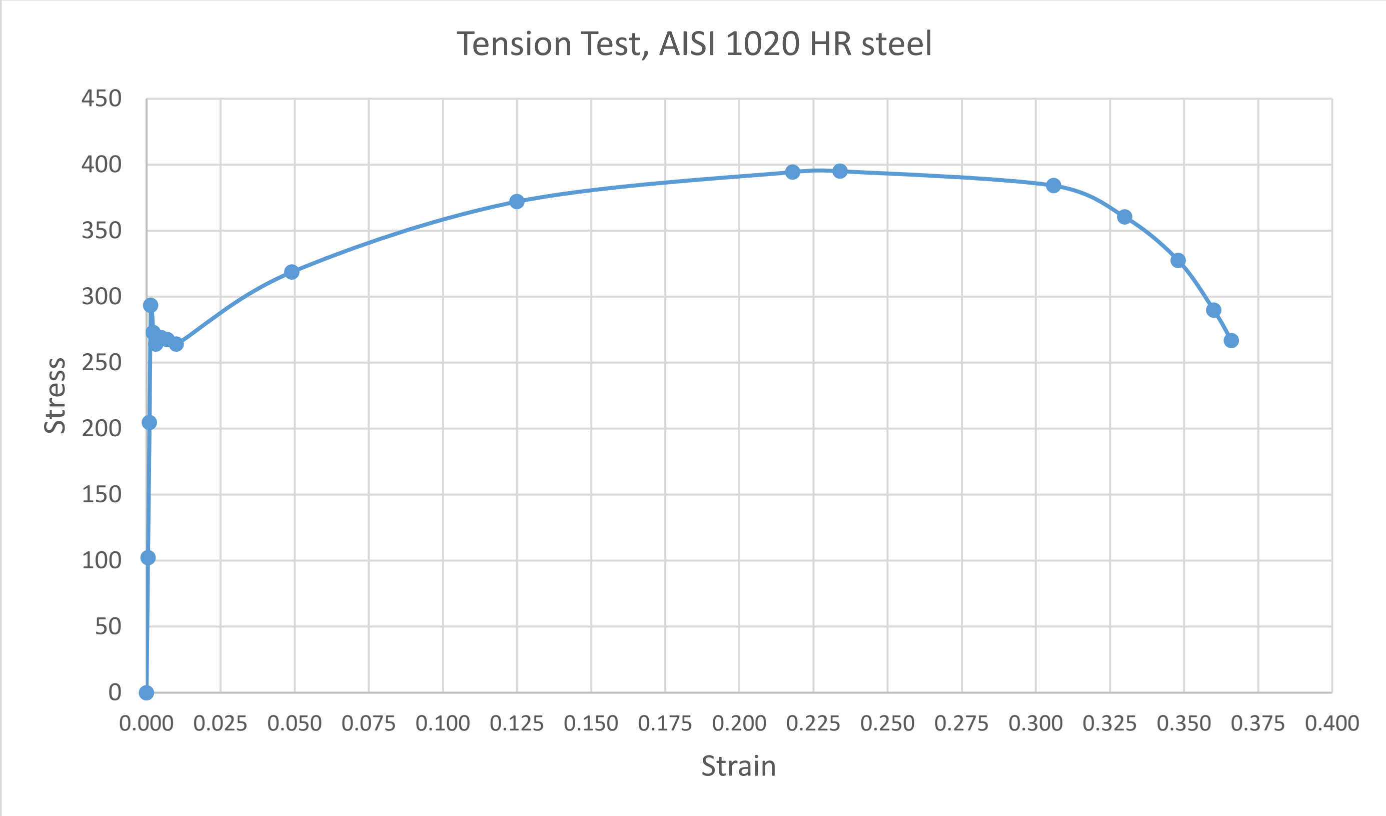


Figure 1: Tension Test plot, AISI 1020 HR steel

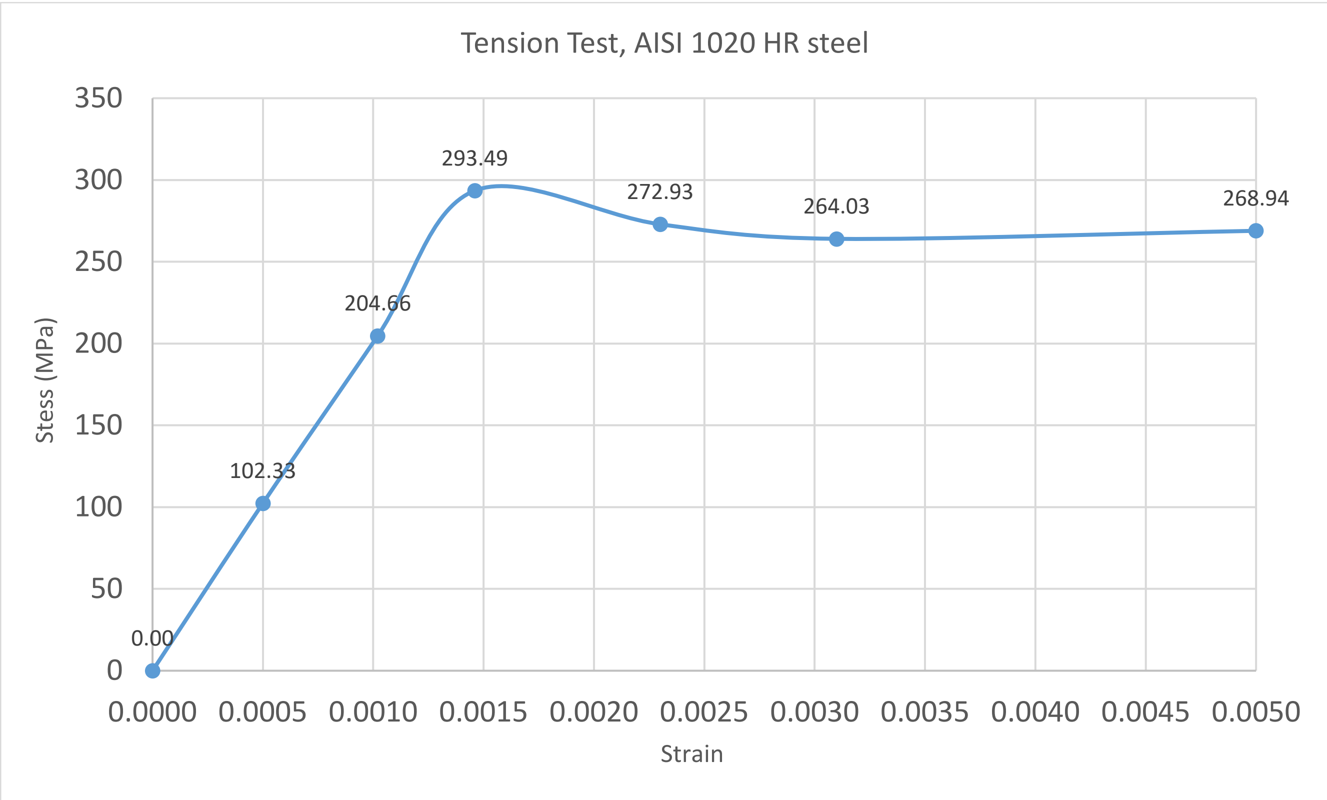


Figure 2: Elastic region and yield point

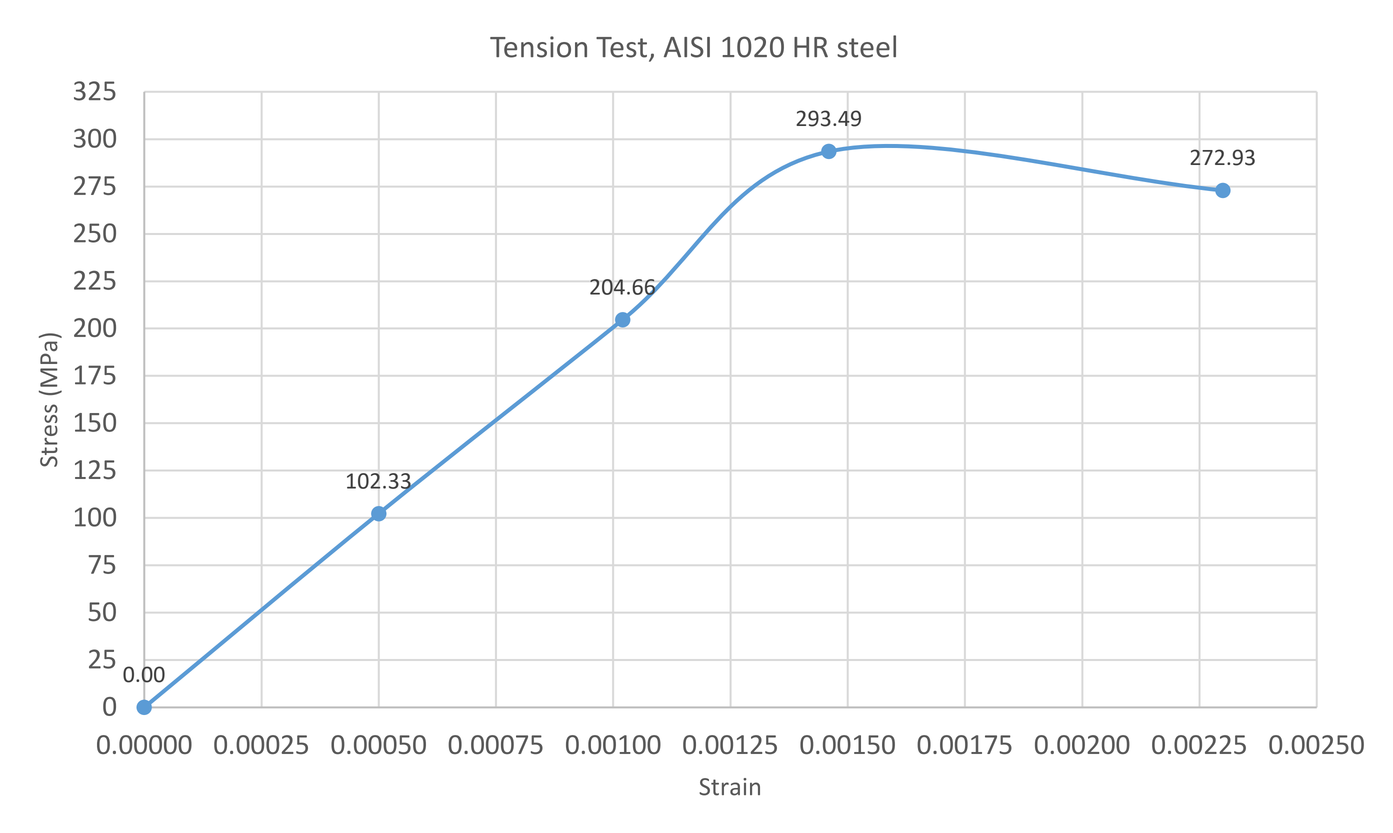


Figure 3: Elastic region and yield point

Using the data plotted calculate the following

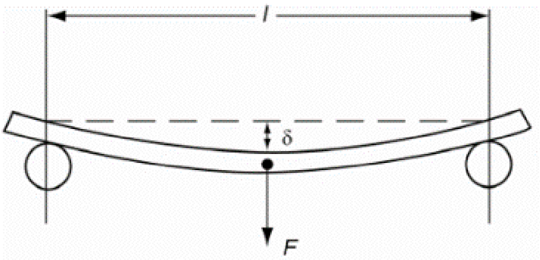
1. Young's modulus, (E, GPa) (modulus of elasticity): use Figure 3.
2. 0.2% offset yield stress, (σ_o, MPa): use Figure 2.
3. The point of fracture, i.e. stress value (σ_f, MPa) and strain value (ε_f) at fracture point: use Figure 1.
4. The Ultimate tensile strength (σ_u, MPa): use Figure 1.

Exercise 2.3 If the data in the figure above was obtained from a rod with a circular cross-section shape having an initial diameter of $D_o = 9.5\ mm$ and with a gauge length of $L_o = 90\ mm$, calculate the length of the sample (L_f) when loaded to $F = 12500\ N$.

Exercise 2.4 A simply supported steel beam (E = 207 GPa) with a span L = 12 m is seen to deflect by δ = 8 mm at its mid-span under a centrally applied load. If the second moment of area of the beam is I = 15,300x10^6 mm^4, determine the load F (in kN) required to cause this deflection.

The equation for deflection (δ) of a simply supported beam is

$$\delta = \frac{1}{48}\frac{FL^3}{EI}$$



where: δ is the amount of deflection during bending,
F is the applied force,
L is the length of the beam between the supports,
E is Young's modulus, and
I is the second moment of area.