EGN 3365
Review on Mechanical Properties

FLORIDA INTERNATIONAL UNIVERSITY

Expectations on Chapter 6

❑Chapter 6

- Understand the concepts/physical meanings of stress, strain, elastic modulus, shear modulus, and Poison's ratio
- Be able to use Hooke's law (stress-strain relationship) and do simple calculations and understand it is only applicable for linear elastic deformation under low stress
- Understand stress-strain behavior including elastic deformation, plastic deformation, and, eventually, fracture
- Understand the features of the stress-strain curve for typical engineering materials and the concepts of yield strength, tensile strength, elastic modulus, ductility (%*EL*) and how they can be determined from a given tensile curve
- Understand ductility and, as a result, percentage elongation or reduction in area
- Understand the concept of toughness
- Understand the difference between engineering stress and strain versus true stress and strain
- Understand the concept of hardness
- Understand design factor or safety factor need to be incorporated in engineering structure design

Expectations on Chapter 7

❑Chapter 7

- Understand metals plastically deform through dislocations through the crystal
- Understand why ceramics typically do not display plastic deformation due to difficulty with dislocation movement in ceramic materials
- Understand the four major strengthening mechanism for metals: grain size reduction; solid solution strengthening; strain (or work) hardening, and precipitate (or 2^{nd} phase particle) hardening
- Understand the limitation of cold working in shaping metallic materials and the impacts of post cold-working heat treatment (also called annealing) on mechanical property (strength and ductility) of metallic materials and its use

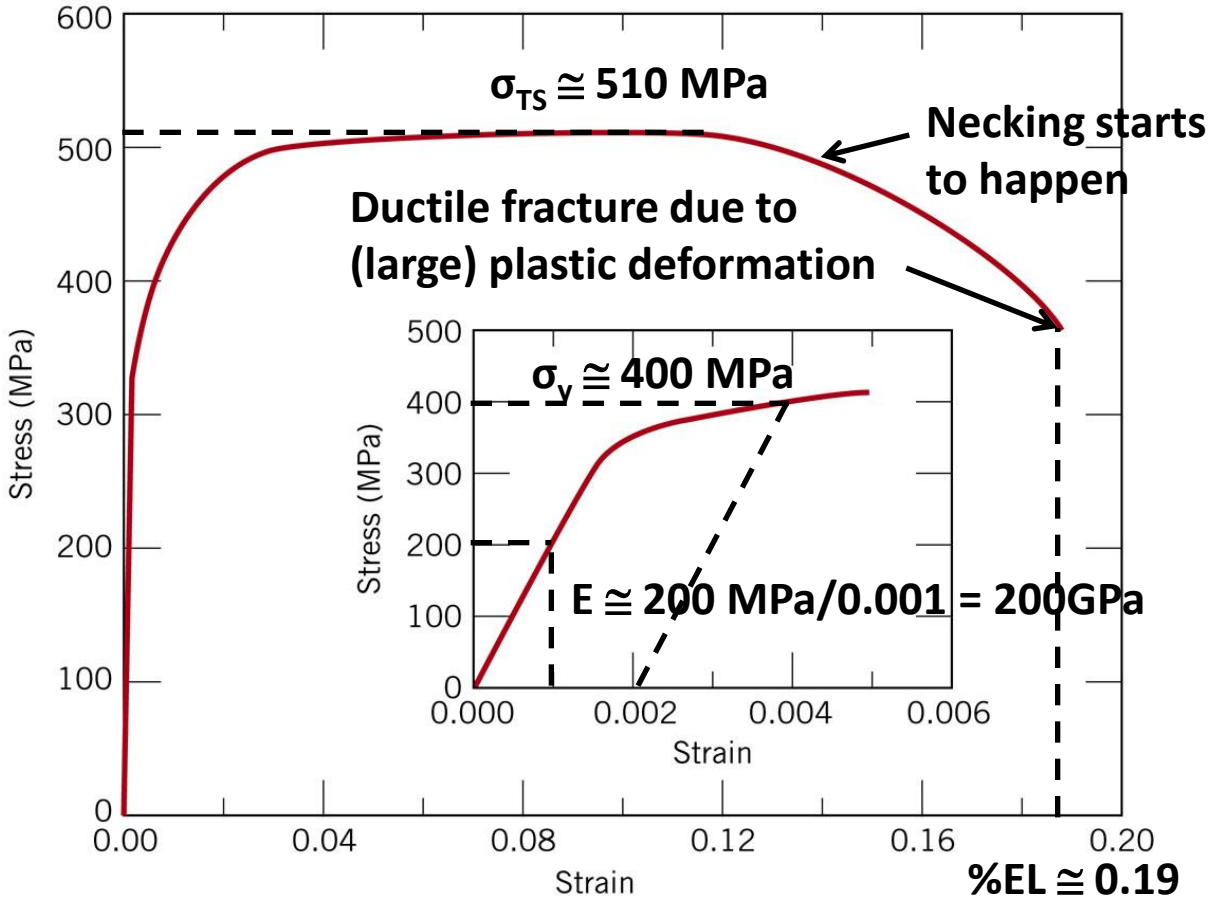
Expectations on Chapter 8

❑Chapter 8

- Understand mechanical failure of materials may involve different modes of fracture, fatigue, or creep
- Understand the concept of fracture and know the differences between ductile fracture and brittle fracture
- Understand that fracture in engineering materials, especially metals occur via micro-crack growth or propagation. Understand that the local stress at the tip of a micro-crack is significantly larger than the overall stress, and that when local stress exceeds the critical stress (a material property), crack grows or propagates, eventually leading to fracture.
- Understand the phenomenon of ductile to brittle transition and it is influenced by materials composition
- Understand the concept of fatigue as a failure that occurs due to repeated stress cycles at levels much lower than tensile stress and understand its features such as impacts of stress level (mean and amplitude) and cycle frequency
- Understand the concept of creep
- Understand the effect of temperature and stress on creep rate

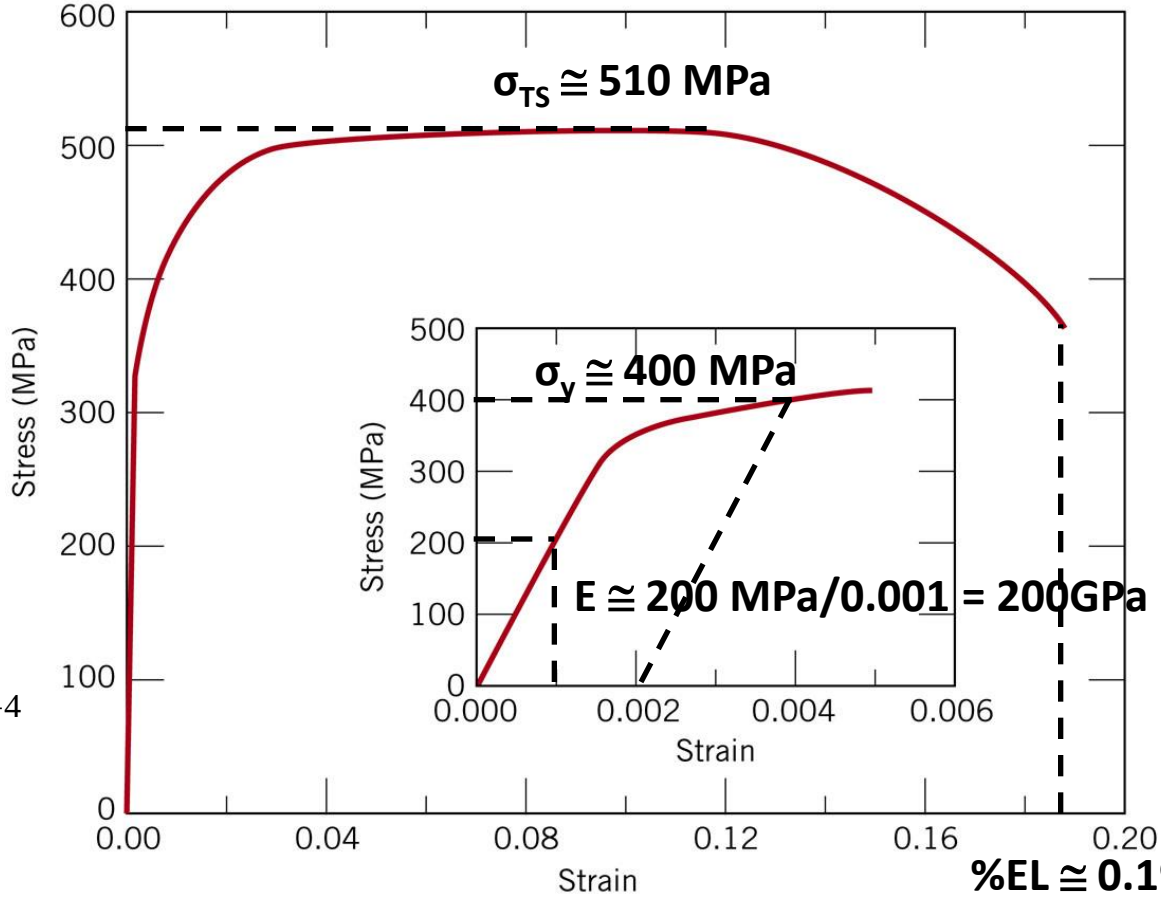
Stress-Strain Curve Exercise (1)

- **Based on engineering stress-strain curve below for a type of steel sample below, determine the following**
  - Yield strength
  - Tensile strength
  - Elastic modulus
  - Total relative elongation at fracture?
- **Indicate why stress starts to decrease at strain of ~0.12?**
- **Is the fracture ductile or brittle?**



Stress-Strain Curve Exercise (2)

- Based on the same tensile curve, if knowing the sample has cross-section area of 1 cm² and initial length of 200mm and tensile load of 2000N, please calculate the change in sample length



Stress

$$\sigma = \frac{F}{A} = \frac{2000N}{1cm^2} =$$

$$\frac{2000N}{10^{-4}m^2} = 2\times10^7\,Pa$$

Strain

$$\varepsilon = \frac{\sigma}{E} = \frac{2\times10^7\,Pa}{200\times10^9\,Pa} = 1\times10^{-4}$$

Change in sample length

$$\delta_L = \varepsilon \cdot L_0 = 1\times10^{-4}\times200mm = 0.02mm = 20\mu m$$

Class Exercise

- **Explain why the theoretical shear stress for material to display plastic deformation is much higher than the measured yield strength?**

Hint: thinking of dislocation

- **Explain why the theoretical tensile strengthen for practical materials is usually much higher than what is measured?**

Hint: think of presence of micro-cracks

- **Explain the four common types of ways to strengthen a material?**

Class Exercise

- **Explain the following concepts**
  - Fracture
  - Fatigue
  - Creep