Experiment 2

TENSILE TEST OF MATERIALS

A:Metals

B:Ploymers

Experiment 2-A

Metallic Materials

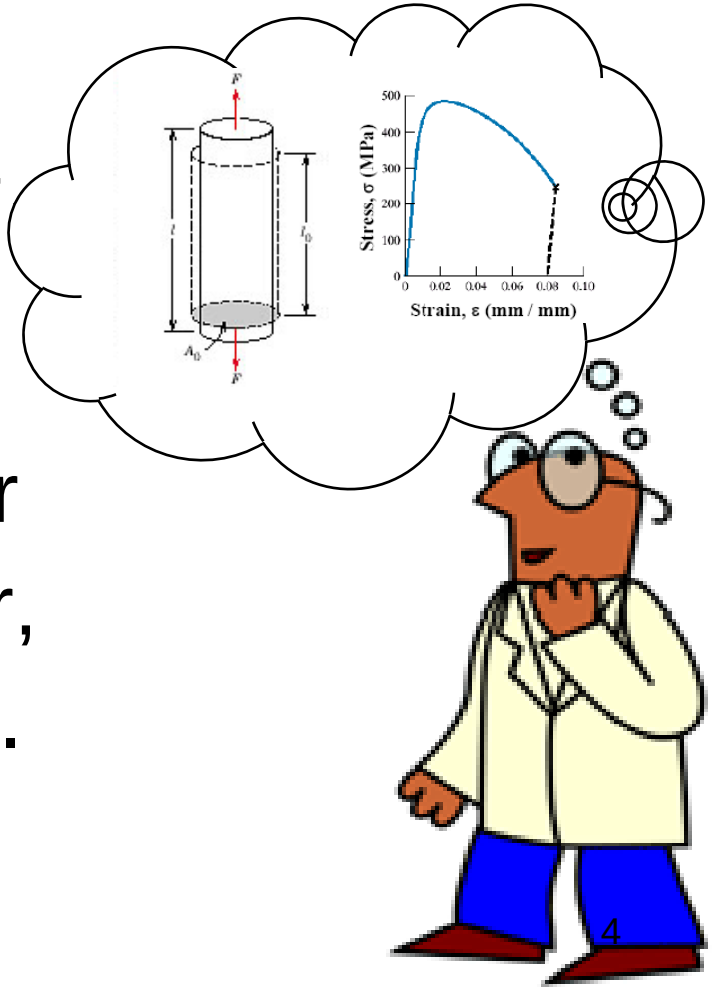
Objectives

- Conduct the tensile test.
- Plot the **Stress-Strain Diagrams** for the tested materials.
- Measure the various ***Mechanical Properties*** of each material. These include:

1. **Modulus of elasticity E**,
2. **Yield strength**,
3. **Ultimate strength**,
4. **Ductility**,
5. **Modulus of resilience** and
6. **Modulus of toughness**.

Theory

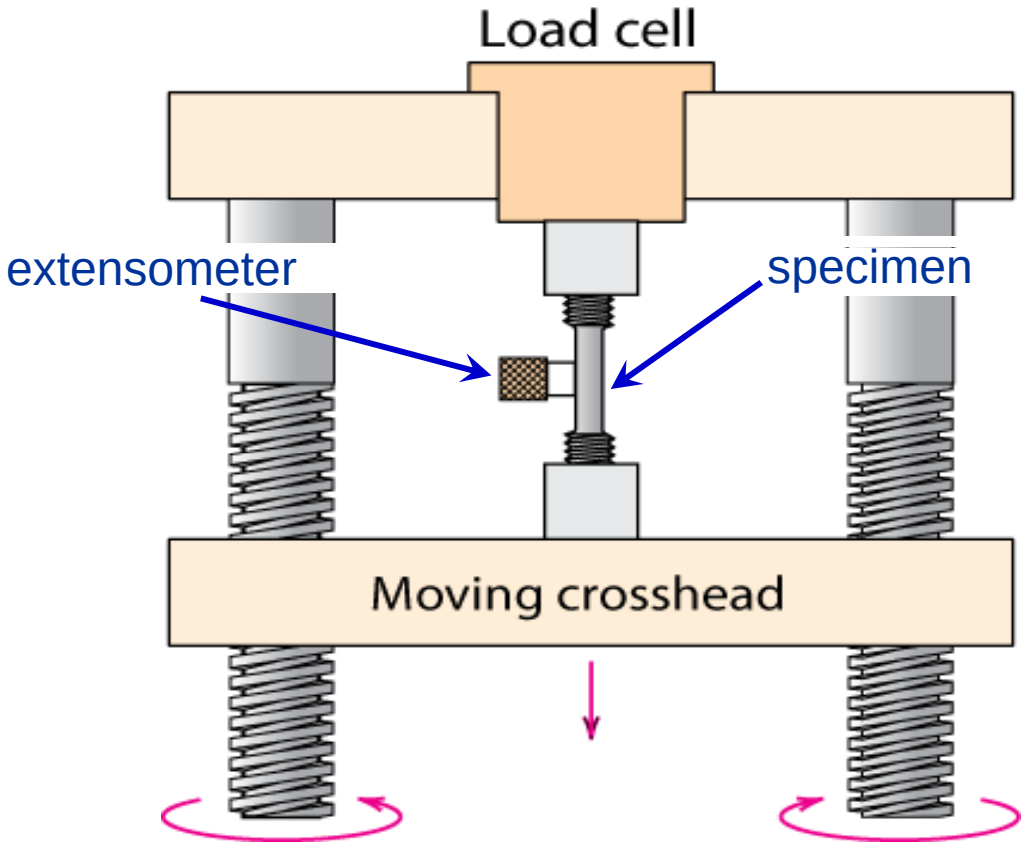
- The way to determine how materials behave when they are subjected to loads is to perform experiments in laboratory.
- Each material exhibits different mechanical properties.



For example, metals show higher strength than polymers. However, polymers tend to be more ductile.

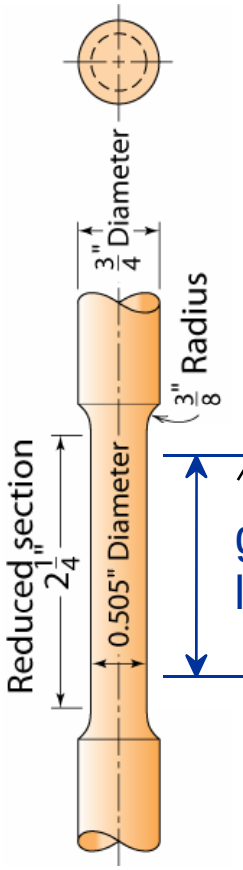
Stress-Strain Testing

- **Typical tensile test machine**



Adapted from Fig. 6.3, *Callister 7e.* (Fig. 6.3 is taken from H.W. Hayden, W.G. Moffatt, and J. Wulff, *The Structure and Properties of Materials*, Vol. III, *Mechanical Behavior*, p. 2, John Wiley and Sons, New York, 1965.)

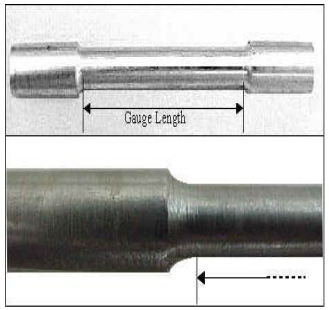
- **Typical tensile specimen**



Adapted from Fig. 6.2, *Callister 7e.*

All Dimensions are according to ASTM

Procedure



Measurements

Testing

Data Analysis

Measurements

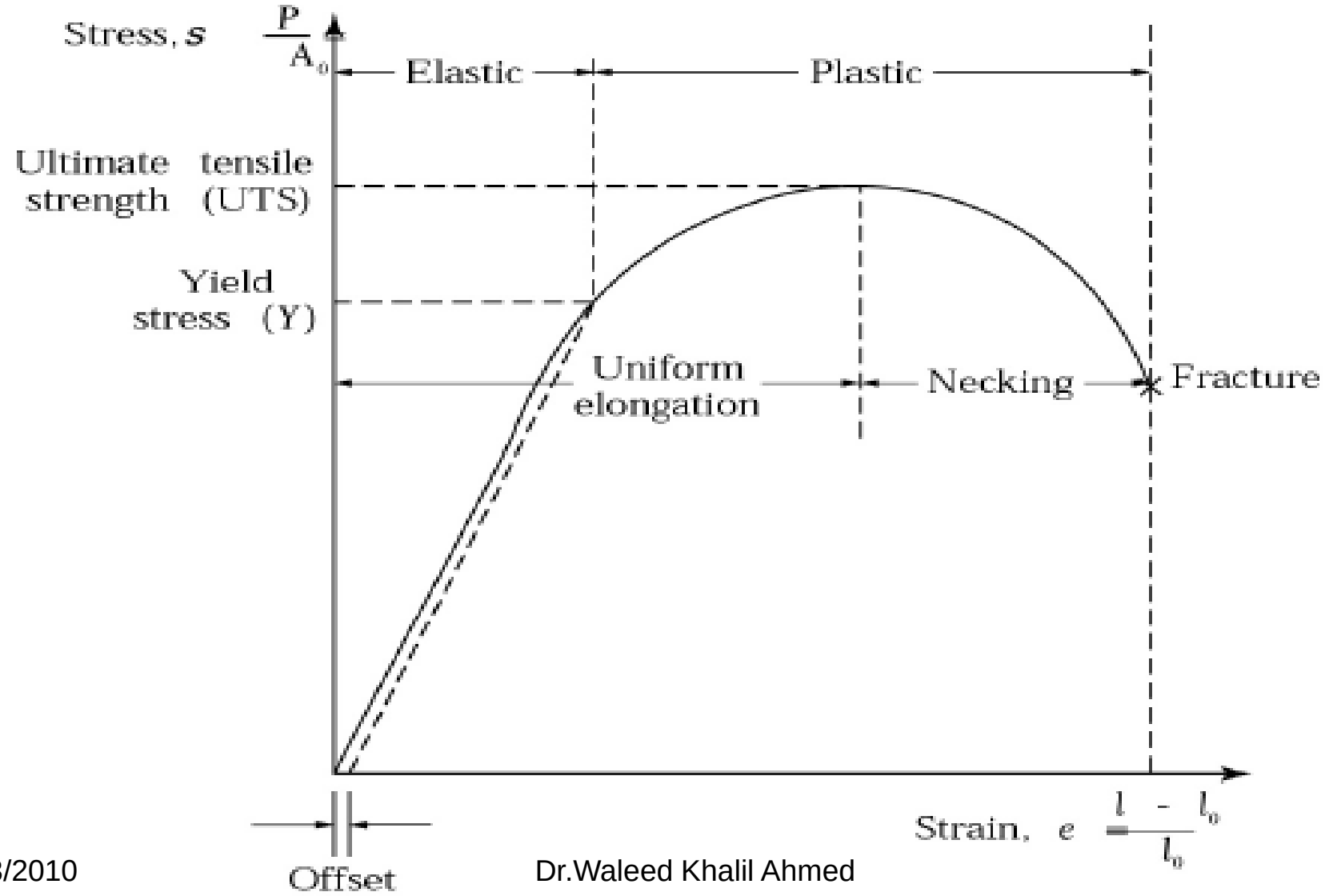
- The following dimensions should be measured 3 times and take the average for **(Aluminum & Steel)** in order to prepare the data for testing and analyzing.
- These dimensions are:

1. Diameter (d_o)
2. Gauge length (l_o)

Metal sample	d_o (mm)	A_o (mm^2)	L_o (mm)
Steel			
Aluminum			

$$A_o = \frac{\pi d_o^{\,2}}{4}$$

Stress – Strain Curve



Engineering Stress and Strain

- Engineering Stress:

$$\sigma = \frac{F}{A_0}$$

Units

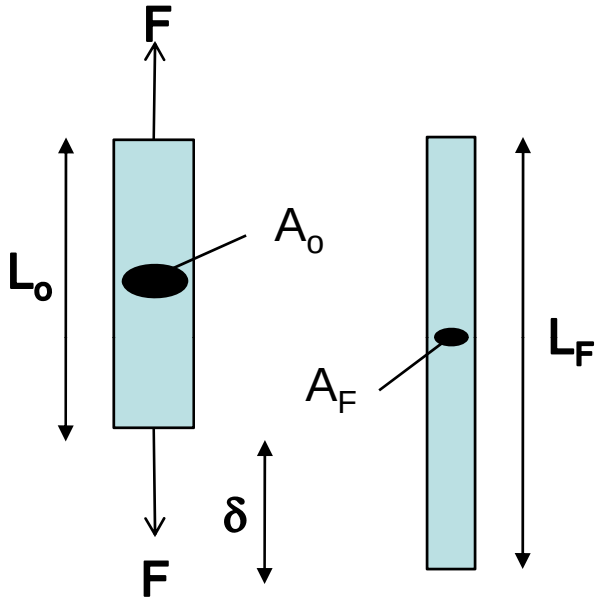
$$\frac{Force}{Area} = \frac{N}{m^2} = Pa$$

$$1 N/mm^2 = 10^6 Pa = 1 MPa$$

- Engineering Strain:

$$\varepsilon = \frac{l - l_0}{l_0}$$

$$\frac{Length}{Length} = [-] \quad (also \times 100\%)$$

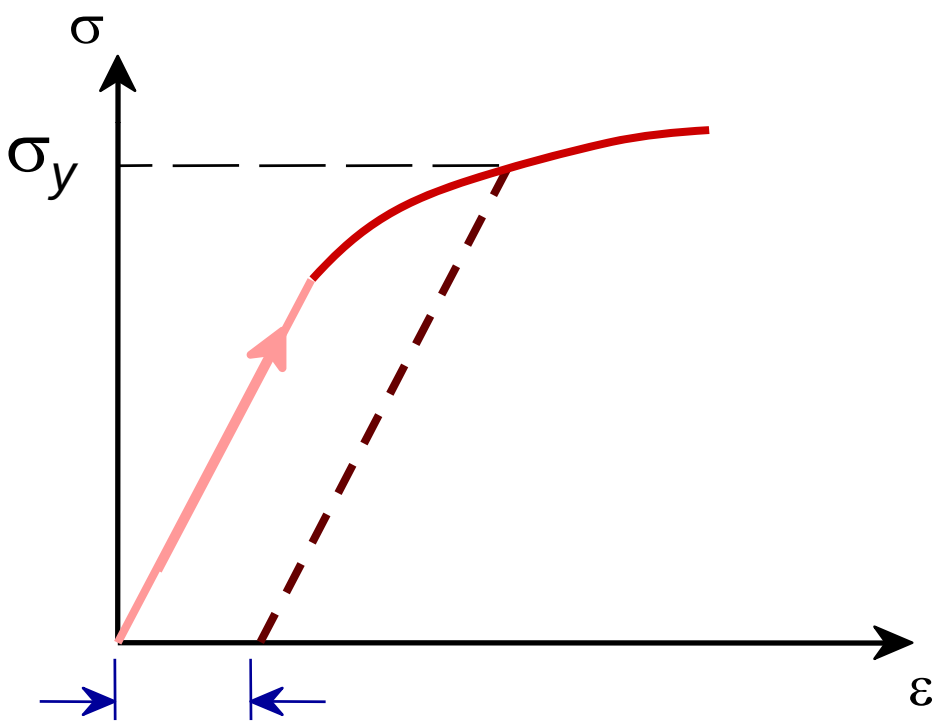


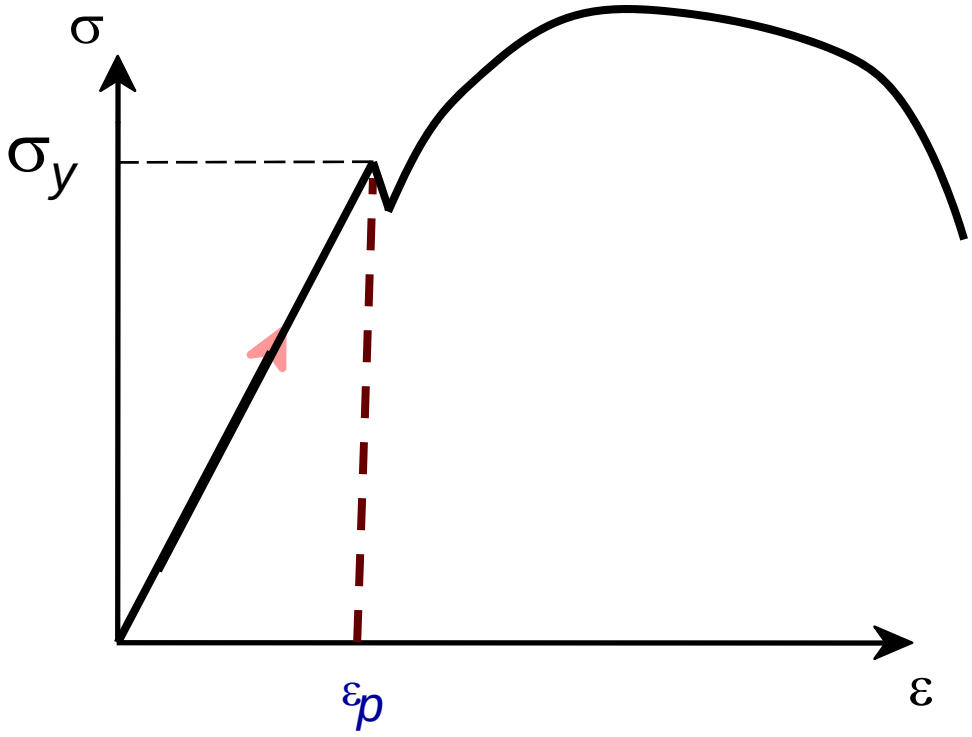
$L_F > L_o$
$A_o > A_F$

Yield Strength, σ_y

- **Stress at which *noticeable* plastic deformation has occurred.**

σ_y = yield strength



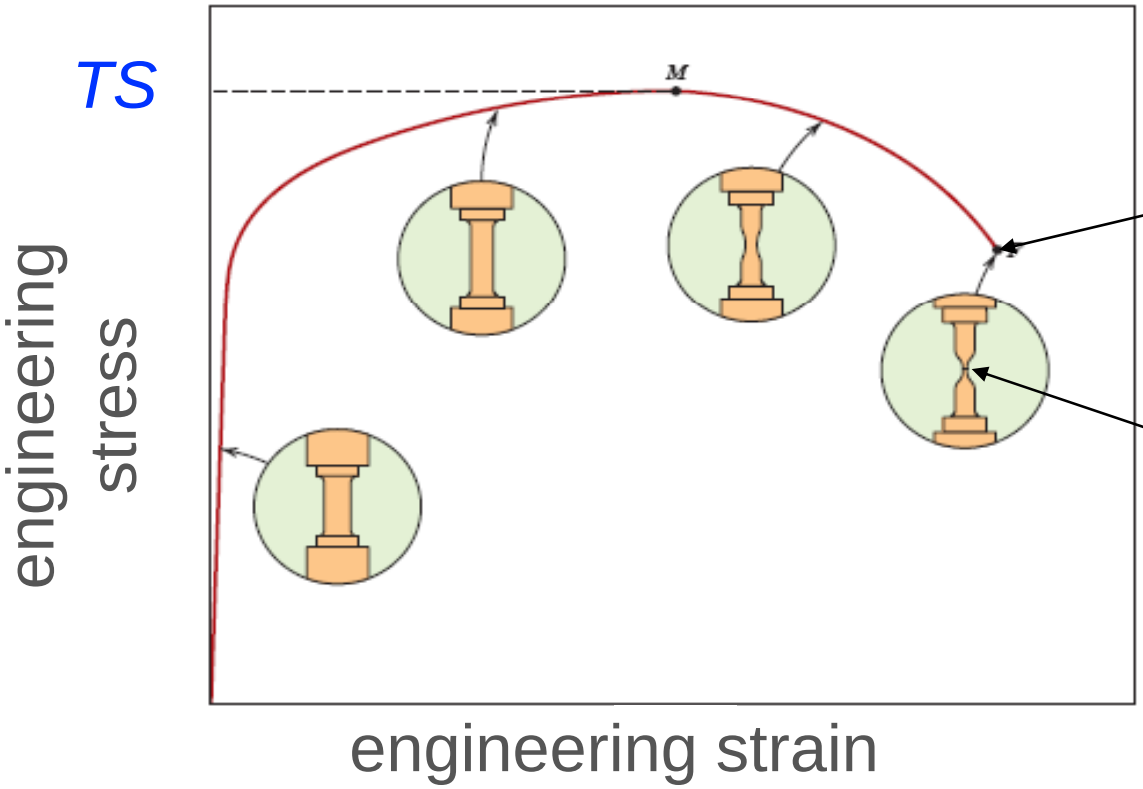


εp = 0.002 or 0.2%ε

Adapted from Fig. 6.10 (a), *Callister 7e.*

Tensile Strength, TS

• Maximum stress on engineering stress-strain curve.



Adapted from Fig. 6.11, *Callister 7e.*

F = fracture or ultimate strength

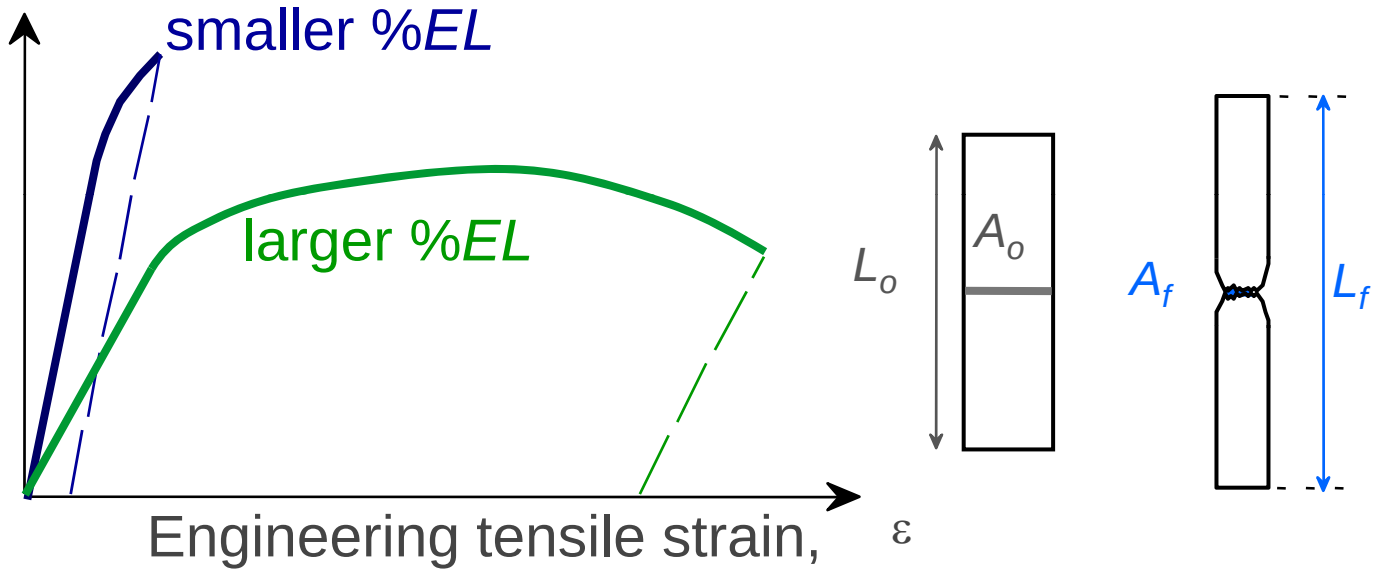
Neck – acts as stress concentrator

- Metals: occurs when noticeable necking starts.
- Polymers: occurs when polymer backbone chains are aligned and about to break.

Ductility

- Plastic tensile strain at failure:

$$\%\,EL = \frac{L_f - L_o}{L_o} \times 100$$



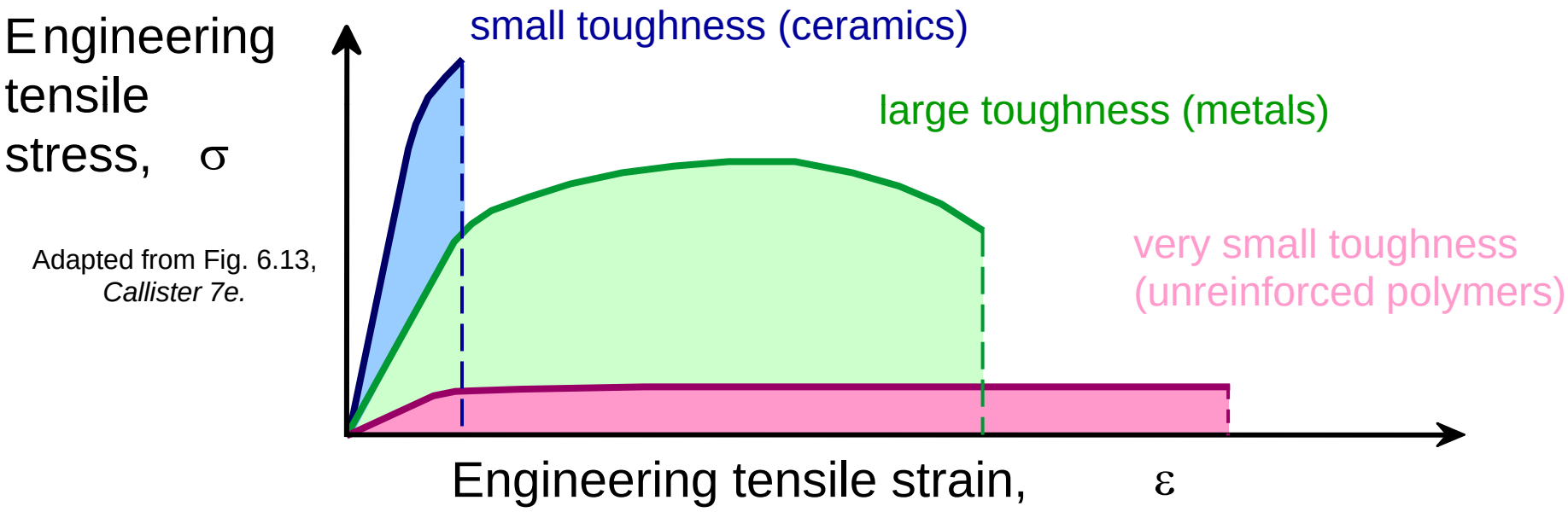
Adapted from Fig. 6.13, *Callister 7e.*

- Another ductility measure:

$$\%RA = \frac{A_o - A_f}{A_o} \times 100$$

Toughness

- Energy to break a unit volume of material
- Approximate by the area under the stress-strain curve.

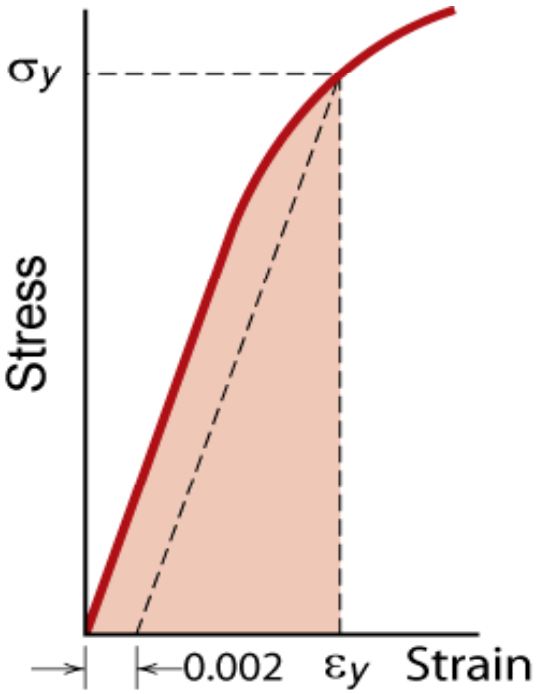


Adapted from Fig. 6.13, *Callister 7e.*

Brittle fracture: elastic energy
Ductile fracture: elastic + plastic energy

Resilience, U_r

- Ability of a material to store energy
- Energy stored best in elastic region –



$$U_r = \int_0^{\varepsilon_y} \sigma d\varepsilon$$

If we assume a linear stress-strain curve this simplifies to

$$U_r \cong \frac{1}{2}\sigma_y \varepsilon_y$$

Adapted from Fig. 6.15, *Callister 7e.*

Data Analysis

- **Determine the following mechanical properties:**

1. ***Young's modulus or Elastic modulus (E)***
2. ***Yield stress (σ_y)***
3. ***Ultimate strength (σ_u)***
4. ***Fracture stress (σ_f)***
5. ***Ductility based on elongation and area***
6. ***Modulus of Resilience (U_r)***
7. ***Toughness (U_t)***

- **Compare the obtained properties with the corresponding reported data in your text book.**

- **Compare between the mechanical behaviors of all tested materials. (Steel & Aluminum)**

Experiment 2-B

Polymeric Materials

Measurements

- The following dimensions should be measured 3 times and take the average for **(Polyethylene & Polypropylene)** in order to prepare the data for testing and analyzing.

- These dimensions are:

1. Width (w_o)
2. Thickness (t_o)
3. Gauge length (l_o)

Polymer sample	w_o (mm)	t_o (mm)	A_o (mm^2)	l_o (mm)
Polyethylene				
Polypropylene				

$$A_o = w_o * t_o$$

Data Analysis

- **Determine the following mechanical properties:**

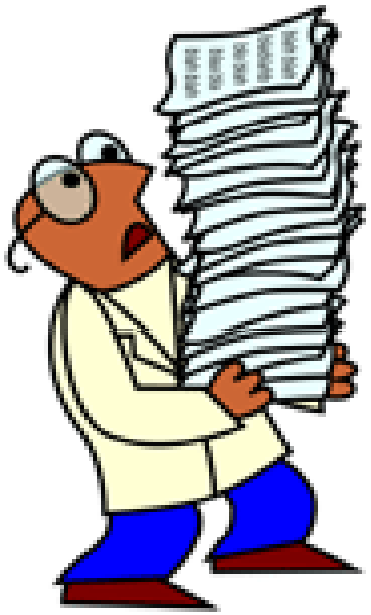
  1. ***Young's modulus or Elastic modulus (E)***
  2. ***Yield stress (σ_y)***
  3. ***Ultimate strength (σ_u)***
  4. ***Fracture stress (σ_f)***
  5. ***Ductility based on elongation and area***
  6. ***Modulus of Resilience (U_r)***
  7. ***Toughness (U_t)***

- **Compare the obtained properties with the corresponding reported data in your text book.**

- **Compare between the mechanical behaviors of all tested materials. (Polyethylene & Polypropylene)**

Discussion & Conclusion

- Write a concise account of the experiment and the results obtained.



- Be in Groups and work as a **teamwork**