IME 100 -.MECHANICAL PROPERTIES

BASIC CLASS NOTES **OCTOBER 9, 2015**

Mechanical Properties Module

Outline

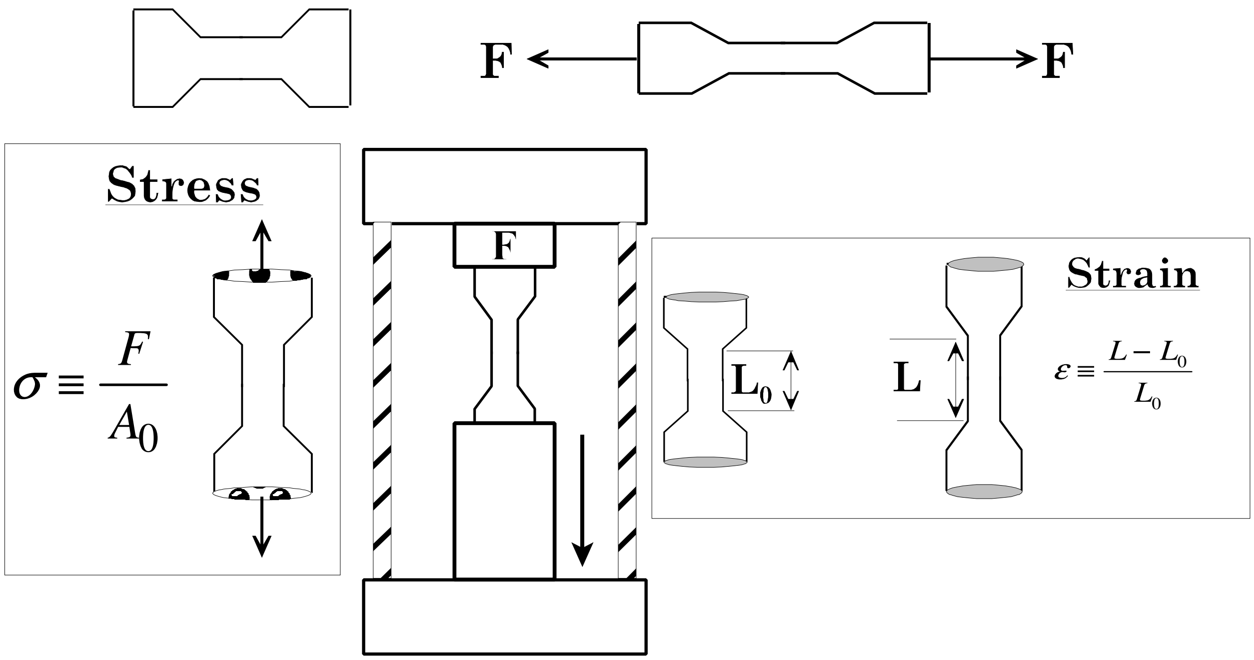
- Mechanical Testing
  - Tensile Test and Mechanical Properties
  - Hardness Test

Mechanical Properties

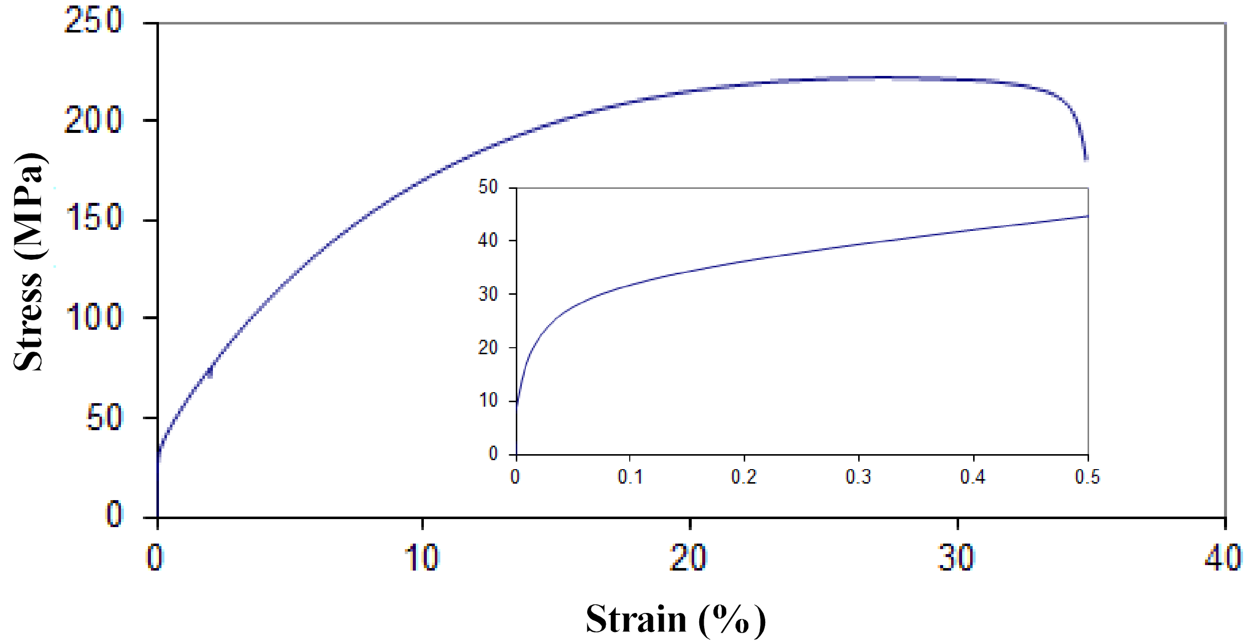
- Effect Both Design and Manufacturing
- Properties of Interest
  - Strength
  - Stiffness
  - Hardness
  - Creep Resistance
  - Fatigue Resistance
  - Fracture Toughness
- Focus On
  - Properties
  - Measurement

Tensile Test Equipment

- Apply a Load to a Material it Elongates



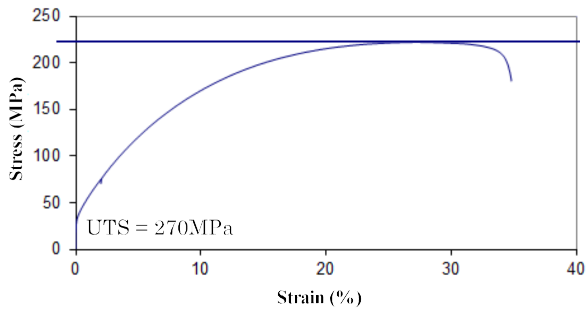
Stress-Strain Curve



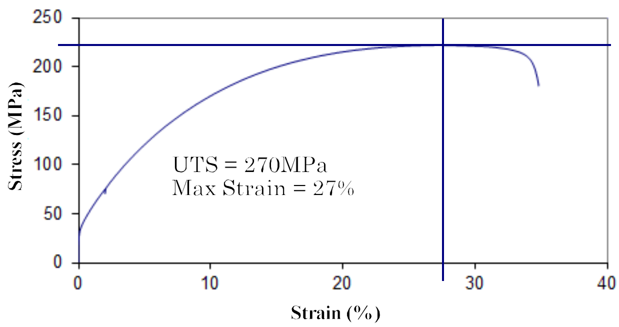
Mechanical Properties

- Ductility, Max Strain, UTS

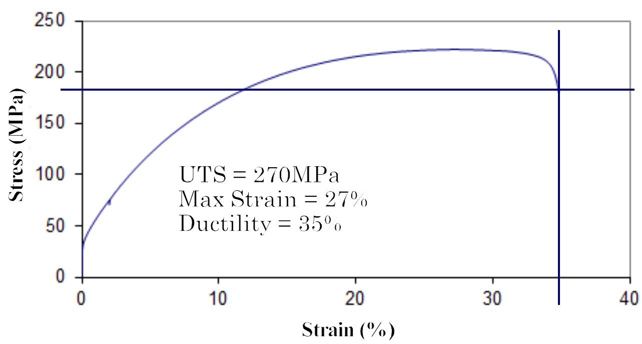
Ultimate Tensile Strength



Max Strain

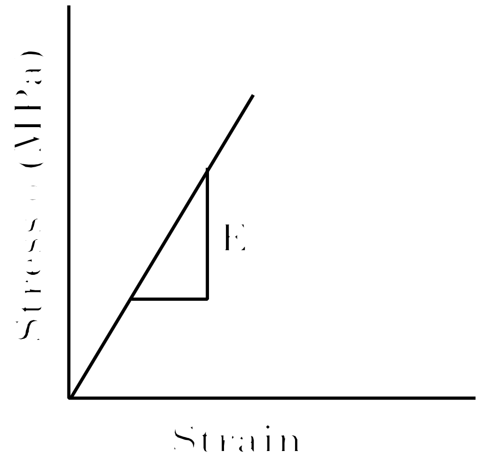


Ductility

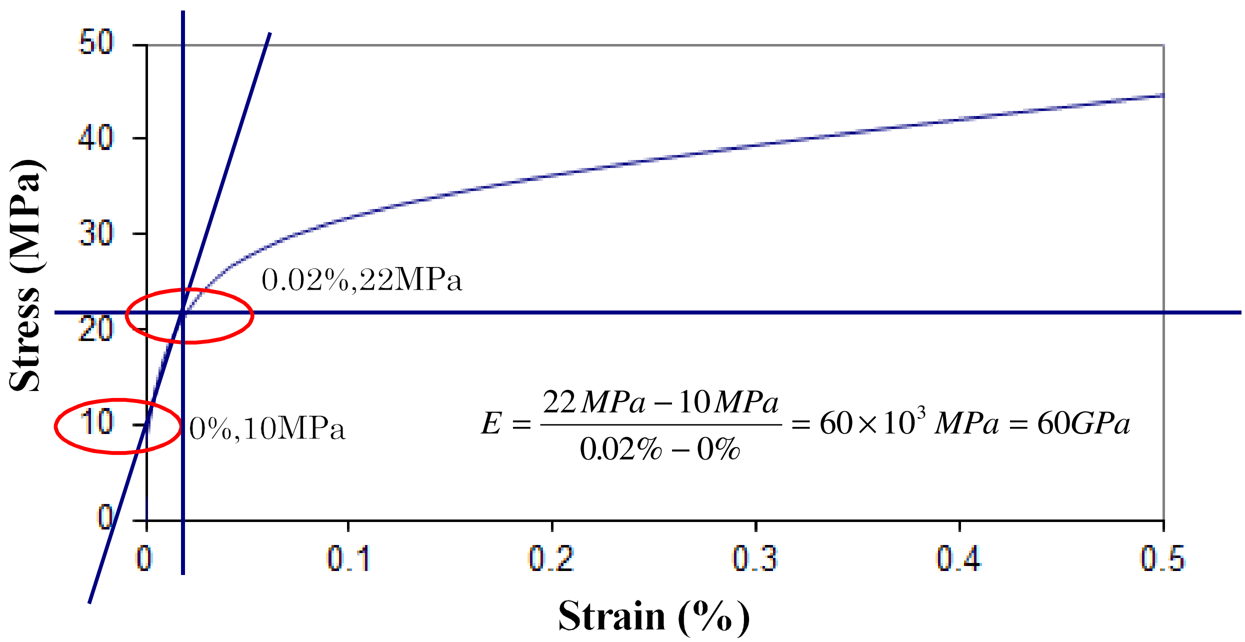


Elastic Modulus
- Energy is Recovered
- Hooke's Law
  - Force is Proportional to Elongation
  - Stress is Proportional to Strain

$$\frac{F}{A_0} = E\frac{\Delta L}{L_0}$$
$$\sigma = E\varepsilon$$

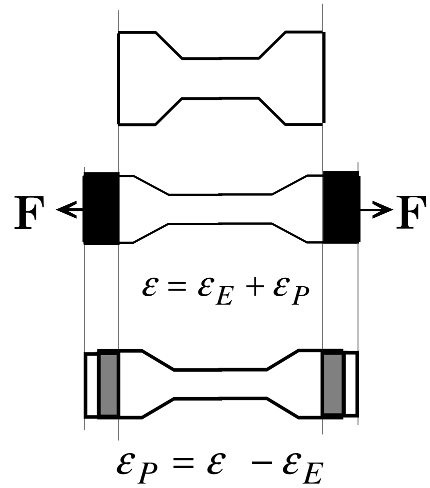


Elastic Modulus
- Slope of σ(ε) When Elastic



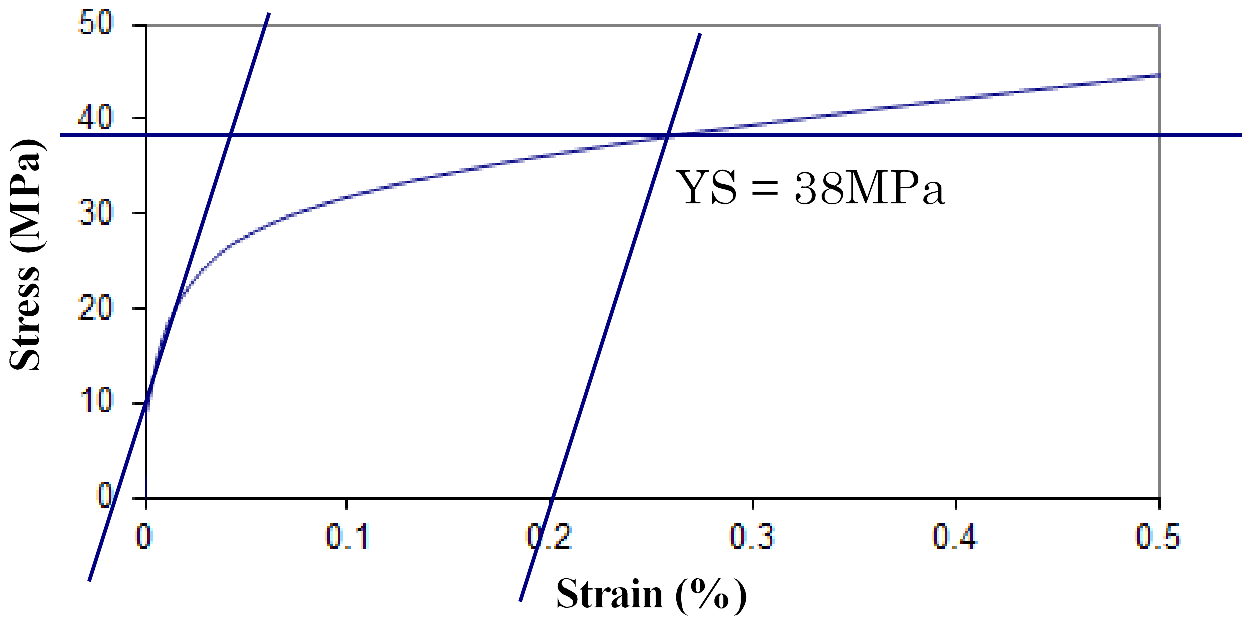
Yield Stress

- Definition
  - Stress Required for Plastic Deformation
- Practical Definition
  - Stress Required for Minimum Observed Plastic Deformation
- Elastic Recovery
  - On UnLoading



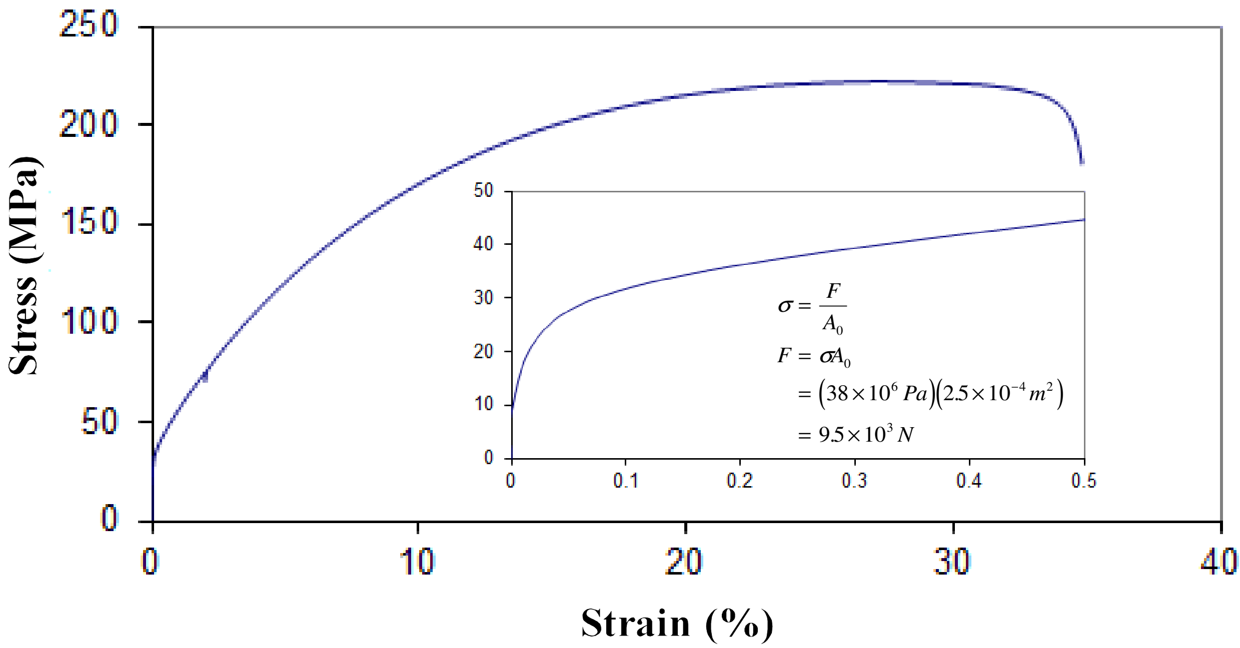
Yield Strength

- 0.2% Permanent Deformation



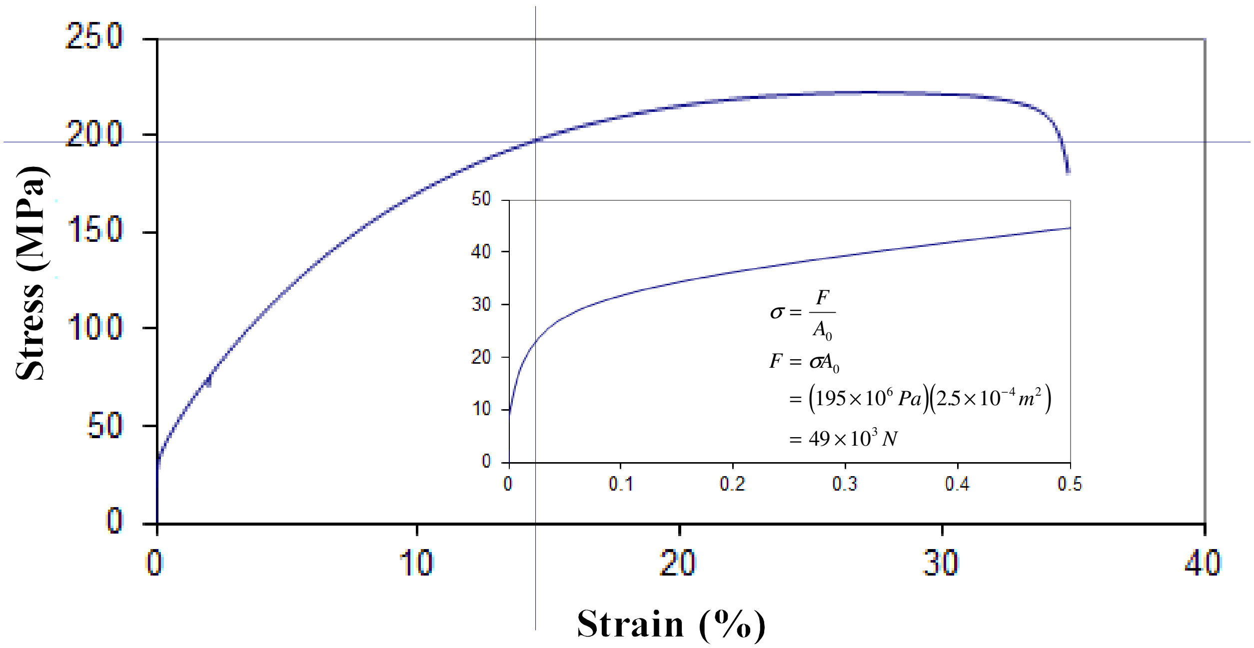
Force Required for Permanent Deformation

- Determine the Minimum Force Required to Cause a 2.5cm^2 Bar to Yield



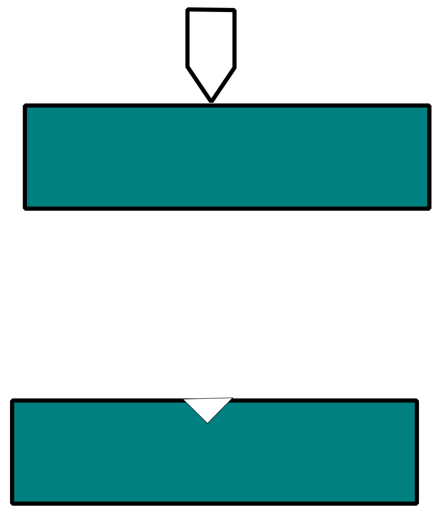
Force for Required Strain

- Determine the Force Required to Strain a $2.5cm^2$ Bar to 15%



Hardness

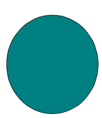
- Defined as Resistance to Penetration
- Measured by
  - Penetrating Material
  - Measuring Resistance
- Empirical Scales
- Correlation With Strength



Various Hardness Tests

Brinell

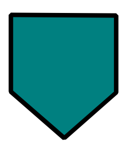
3000 kg



10 mm dia.

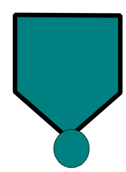
Rockwell C

150 kg



Rockwell B

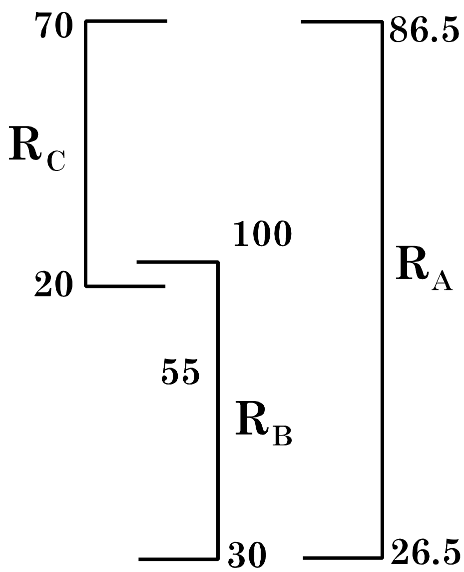
100 kg



1/16 in dia.

<u>Relation Between Scales</u>

- Rockwell
  - More Precise
  - C Harder Than B
  - A Overlaps
- Brinell
  - Broad



<u>Hardness and Strength</u>

- Correlations Exist
  - Specific to Alloy Systems
- Hardness Tests
  - Less Expensive than Tensile Tests
  - More Reproducible
- Hardness Often Used as Quality Control Measure

<u>In-Class Question 1</u>

Identify and Justify the Correct Answer and Explain why each Incorrect is Wrong.

Which statement best describes hardness testing?

☐ A hard object of known geometry is pressed into the surface of a test specimen and based on the dimensions of the indentation the hardness is determined.

☐ A hard object of known geometry is pressed into the surface of a test specimen and based on the energy (force x distance) to create the indentation the hardness is determined.

☐ A hard object of known geometry is pressed into the surface of a test specimen and based on the energy (dent volume x specific energy) to create the indentation the hardness is determined. In this case the specific energy of a material is the energy per unit volume required to displace material.

☐ A hard object of known geometry is allowed to scratch the surface of a material. Based on the dimensions of the scratch the hardness is determined.

<u>In-Class Question 2</u>

Identify and Justify the Correct Answer and Explain why each Incorrect is Wrong.

You are given 4 numbers from a tensile test. The person wrote the numbers down and forgot to write down the properties. These numbers are 15%, 23%, 120MPa, and 310MPa. Which statement represents the properties.

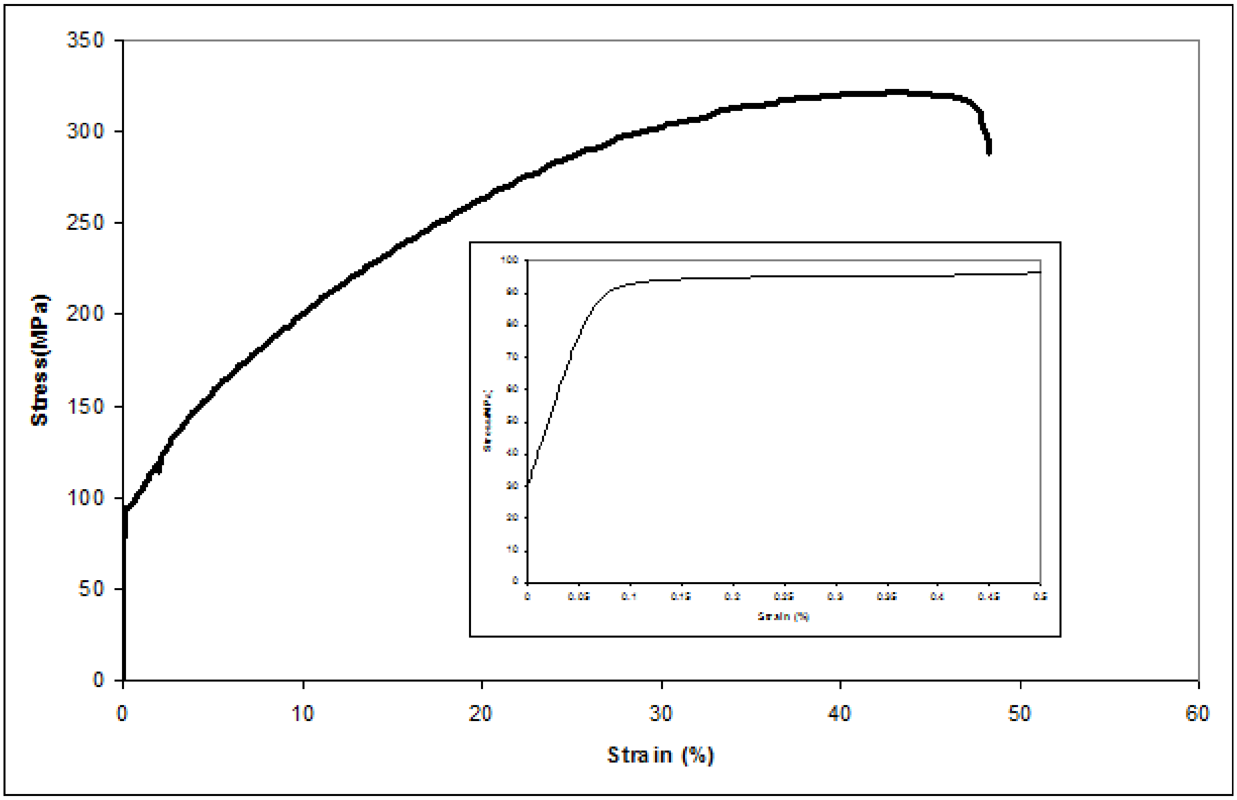
☐ ductility = 15%, max strain= 23%, UTS = 120 MPa, and Yield Strength = 310 MPa

☐ ductility = 23%, max strain= 15%, UTS = 120 MPa, and Yield Strength = 310 MPa

☐ ductility = 15%, max strain= 23%, UTS = 310 MPa, and Yield Strength = 120 MPa

☐ ductility = 23%, max strain= 15%, UTS = 310 MPa, and Yield Strength = 120 MPa

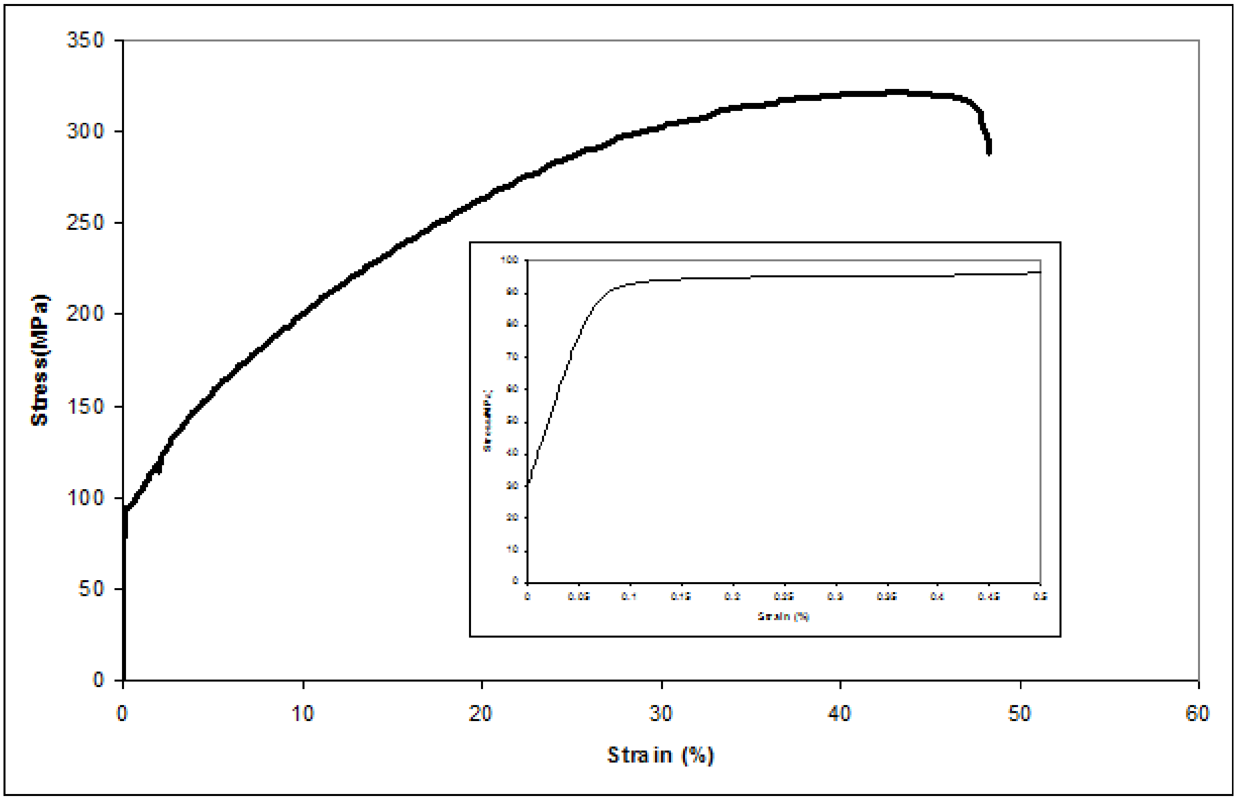
<u>In-Class Question 3</u>



Determine the Following Properties of the Material based on the Tensile Test Curve Shown Above

- Ductility
- Maximum Strain
- Modulus
- Ultimate Tensile Strength
- Yield Strength

In-Class Question 4



A bar of this material has a cross-sectional area of $1.3x10^{-4}m^2$. Determine the force required to stretch a 30cm bar to a length of 36cm (under load).

Note: $1MPa=10^6Pa$ and $1Pa=1N/m^2$