# BioMechanics and BioMaterials Lab
# (BME 541)
# Mechanical Prosperities of Biomaterials
## Experiment #1
## Tensile Test

## Objectives

1. To be familiar with the universal testing machine(810LE4) and provide a practical exercise for using it to determine the mechanical properties of different materials.
2. To understand the principle of tensile test.
3. To understand the Stress-Strain curve and learn how to use it in determining various mechanical properties of different materials (Aluminum, Copper and PMMA): modulus of elasticity, yield strength, ultimate tensile strength and elongation (ductility).

## Background

Mechanical properties are of interest to engineers utilizing materials in any application where forces are applied. Three fundamental mechanical properties of materials are the elastic modulus (E), the yield point ($\boldsymbol{\sigma_y}$), and the ultimate strength ($\boldsymbol{\sigma_{ult}}$).

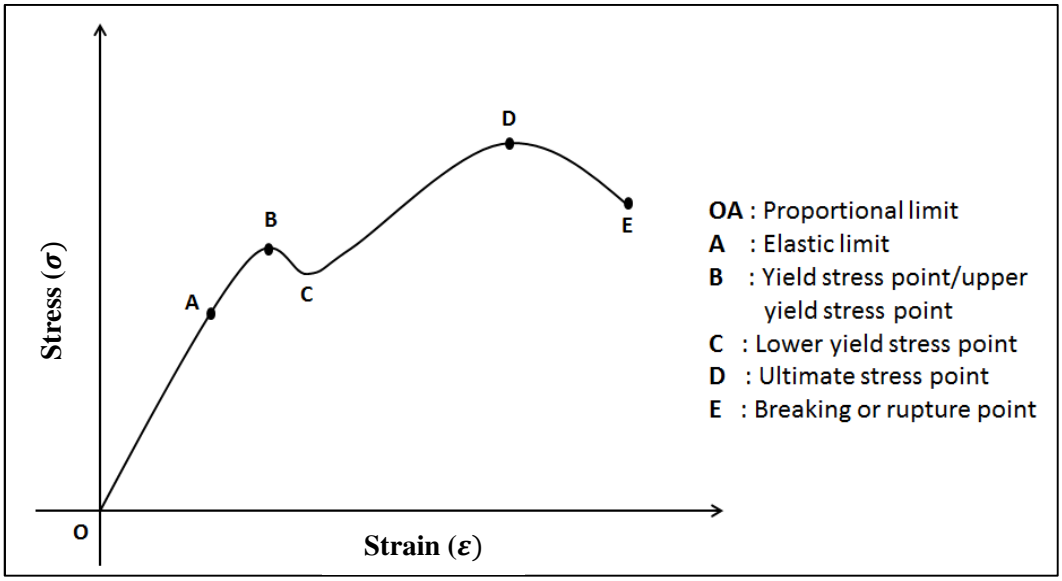
A tensile test, also known as tension test, is probably the most fundamental type of mechanical test you can perform on material to recognize its strength and its mechanical behavior.
Tension test, in which a strip or cylinder of the material, having length L and cross-sectional area A, is anchored at one end and subjected to an axial load P (a load acting along the specimen's long axis) at the other (uniaxial tensile load). As the load is increased gradually, the axial deflection δ of the loaded end will increase also. Eventually the test specimen breaks or does something else catastrophic, often fracturing suddenly into two or more pieces.

The strain resulting from the stress applied is proportional to the stress and is directly related to it with a proportionality constant called the Elastic Modulus/ Young's Modulus. This constant is material dependent and only applies in what is called the **"elastic region"** of a material's behavior through the following equation:

$$\sigma = E\varepsilon$$

**Where ($\sigma$) is the Stress in Pascal, ($\varepsilon$) is the Strain and (E) is the Elastic Modulus or Young's Modulus**

A typical stress-strain curve is shown in the figure below:




**Stress versus Strain Curve**

Note that stress - strain proportionality only applies in the elastic region (up to the yield stress point), also note that this curve assumes a constant cross-sectional area and does not take into consideration the Poisson's Ratio. The Poisson's Ratio(ν) is the ratio of transverse contraction strain to longitudinal extension strain in the direction of stretching force and is approximated to be 1/3 for isotropic metals and ½ for anisotropic polymers.

**Definitions**

- **Gauge Length (L)** - length of the test specimen on which elongation is measured at any moment during the test [m]
- **Original Gauge Length ($L_0$)** - gauge length before application of load [m]
- **Final Gauge Length ($L_u$)** - gauge length after rupture of the test specimen [m]
- **Elongation** - increase in the original gauge length at the end of the test
- **Stress (σ)**- load at any moment during the test divided by the original cross-sectional area of the test specimen [Pa/ ($N/m^2$)]
- **Strain**- It is the ratio of change in length to the original length ($\boldsymbol{\varepsilon = \frac{\Delta L}{L_0}}$)
- **Elastic Modulus-**a measure of the stiffness of the material, but it only applies in the linear region of the stress – strain curve ( $E = \sigma/\varepsilon$) , [Pa]

- **Yield Stress ($\sigma_y$)-**when the material exhibits a yield phenomenon, a point is reached during the test at which plastic deformation occurs without any increase in the load [Pa/($N/m^2$)]
- **Ultimate Tensile Stress ($\sigma_u$)-**the maximum load the specimen sustains during the test [Pa/ ($N/m^2$)]

## Materials and Methods

1. PC Computer
2. Universal Testing Machine (810LE4)
3. Vernier Caliper and scale
4. Tested Specimens (Aluminum, Copper and PMMA)

## Universal Testing Machine (UTM) Overview

Universal testing machine is used to generate force and measure fatigue, fracture, tensile and compression test results on mechanical test samples. They are capable of producing static and cyclic loads in tension or compression and operate to speeds of depending on the system performance

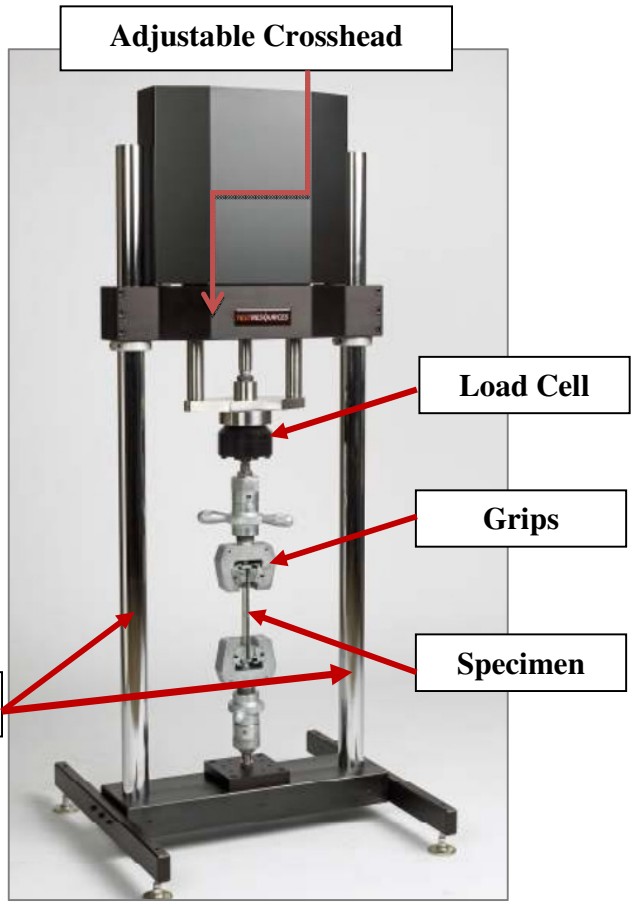
### System Components

Test system typically consists of:

1. Load frame: Two strong supports for the machine
2. Load cell: A force transducer to measure the load and it is mounted directly onto the actuator.
3. Cross head: A movable cross-head is controlled to move up and down.
4. Grips or fixtures: To mount the specimen.
5. Output device: controller with interconnect cables to provide and analyze the test results.

Each system includes a power pack with the following operator indicators and switches:

• System ON/OFF
• System Enable LED
• Emergency Stop



## Safety Warnings

1. Excessive side load on the output rod of the actuator will dramatically reduce the life of the Actuator and should be avoided completely. Side load can be caused from misalignment or Loading of the specimen which is not in line with the axis of motion.
1. The equipment may be so heavy. Don't move it.
2. Never lift the equipment by the actuator rod.
3. Never use the system if it appears damaged in any way.
4. This equipment may contain sensitive position sensors and should be handled with care.

## General Safety Concerns

Mechanical testing is an inherently dangerous activity since the product being tested may behave or fail in a way that is not expected. The nature of testing is to determine what happens when various conditions are present that have never been tested before In addition, servo-controlled systems, by their nature have many variables that must be factored in real time by the operator of the machine. In many cases, the person wanting to operate the machine may be lacking in training or experience and so may choose to place a sample in a dangerous mode. This is the nature of performing research on new products and materials. Since all materials and products fail in different modes, the user is responsible to determine the risk and to solve the problem of minimizing it.

**For example,** if the material tested is brittle and fails in a catastrophic and dangerous manner, a safety enclosure is recommended to contain the product being tested.

1. Prepare Test Specimen: During the lab different materials with different properties will be used.

   Specify the specimen geometry as the table below:

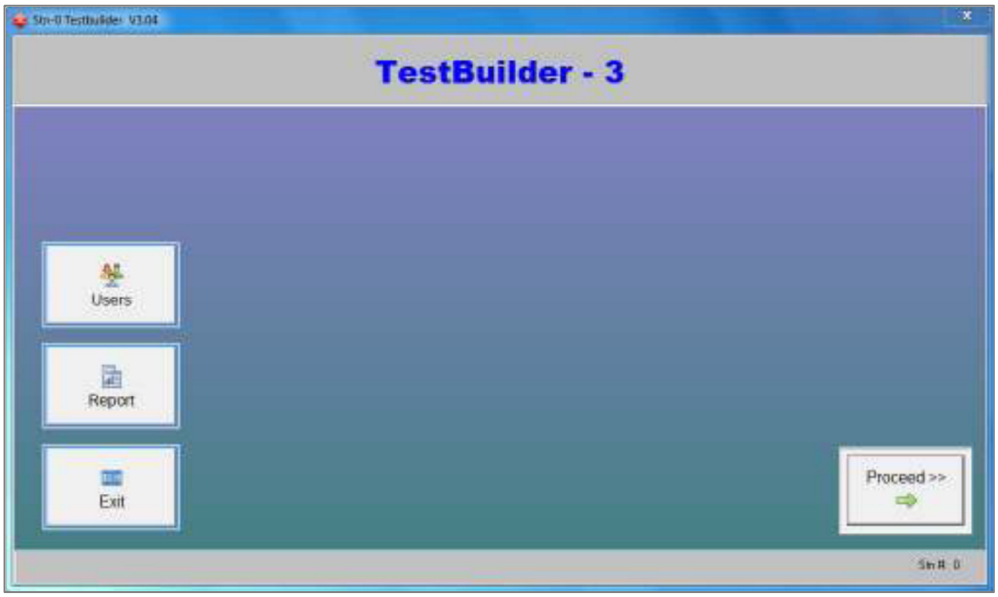
| **Parameter** | **Type of Test Specimen** ---------- | **Type of Test Specimen** ---------- | **Type of Test Specimen** ---------- |
|---|---|---|---|
| Gauge length ($L_0$) (mm) | | | |
| Width (w) (mm) | | | |
| Thickness (t) (mm) | | | |

2. Check that all cables are properly and securely connected. Switch on all power Switches in the following sequence:
   a) Main power switch
   b) Control Power
   c) Computer.

**A Five minute warm up period is necessary before starting your test.**

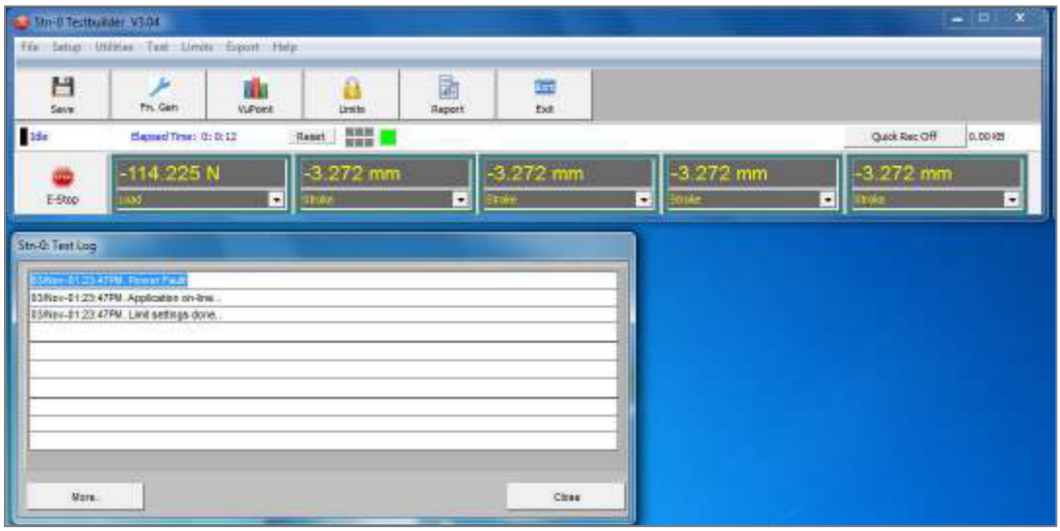
3. Start the Software*:*

a. Double click on the “TestBuilderV3” icon. The software will connect automatically.

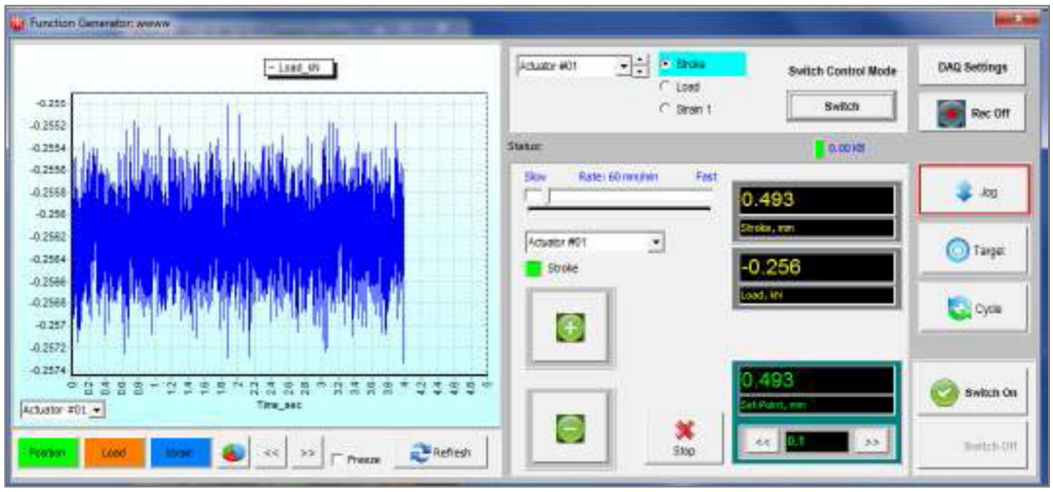



b. Click on the "proceed " button

c. The TestBuilderV3 main screen will appear as shown below.

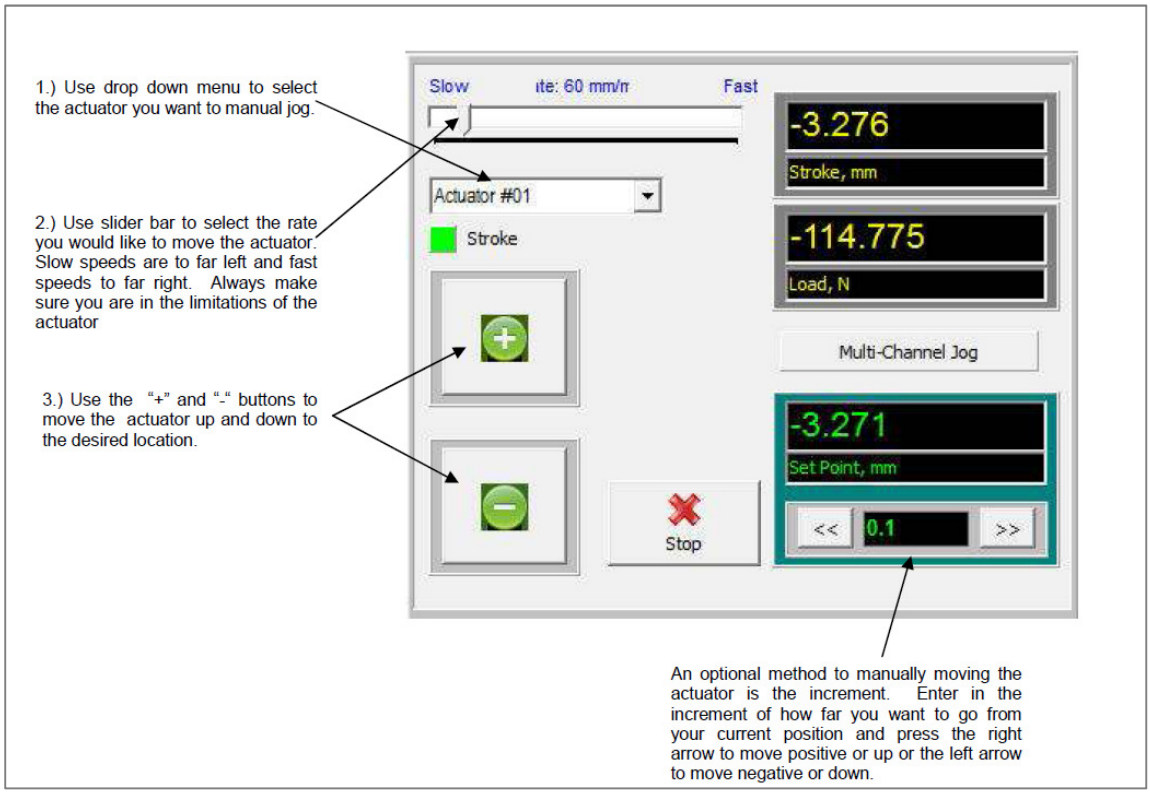


d. Click on the "Function Generator" The function generator application is intended for simple movement of the actuator.




e. Use position mode to jog the load cell and fixtures


f. Select the Jog button down the right hand side of the software screen. The Jog panel allows you to manual move the actuator into place to load your specimen into the grips as shown below: (to adjust the grips to fit the size of the specimen).



g. Tare readout: In most cases before you insert your sample into the fixtures on the test machine you will want to tare or zero the weight of the fixture, because this is not load seen by the sample. To tare or zero the weight of the fixture. Click on the setup on the top menu bar as shown below and click on "offset Readout".

4. Start the tensile test (Tension) by carrying out the following procedure:
    - Click the DAQ button enter the DAQ rate use 50 for static test then save your folder
    - Start you test by switch on the function generator

**Note:** You could always stop a test by pressing the Emergency Stop Button, which isa large, round, red button located on the front of the load frame. Press this button to Stop crosshead travel immediately when a condition develops that could affect the Safety of persons operating the system, or could damage the specimen or the test fixtures. Pressing the Emergency Stop Button stops the system instantly and disables The frame's drive motor.

5. Once you've completed your test Click on the Report icon to generate a report and export to excel.


6. Once tensile testing is complete, remove the test specimen from fixtures.
7. Repeat the procedure for the second and third specimens.