


# University of Jordan

# Faculty of Engineering

# Industrial Engineering Department

# Manufacturing Processes Lab

**Prepared by: Dr. Abdul Kareem Abdul Jawwad**

# Manufacturing Processes Laboratory Manual

## Forward

This manual has been prepared in line with the theoretical content of the Manufacturing Processes course in order that students get a practical insight of the topics being covered.

The manual follows, when and as appropriate, the sequence of knowledge development throughout the subject so that strong ties between theoretical and practical/experimental sides are concurrently built within the students' body of knowledge.

The lab starts by the basic mechanical behavior experiment, which is mutually important for all engineering students and also forms the basis for most of the following experiments.

The metallic extrusion experiment is introduced after mechanical behavior as an example of bulk deformation processes and their practical issues and calculations.

The manual then discusses some sheet-metal experiments explaining most relevant processing terms such as shearing and bending operations. Machining processes are covered in terms of process, tool life and tool wear concepts as well as effects of process parameters on the quality of the machined surfaces.

Finally arc welding experiments are presented explaining the types of different arc welding processes and discussing the effects of different process parameters on the resulting properties of welded joints.

The presentation style adopted in this manual starts by setting the main objectives of each experiment and presenting relevant theoretical background. A list of all needed equipment, tools, and specimens is also included in each experiment. The manual provides labelled tables so that data entry and recording becomes an easy and straightforward part of the experiment.

At the end of each experiment, a list of requirements has been specified in terms of presentation and discussion of the results and drawing appropriate conclusions.

Experimental safety measures and procedures are emphasized throughout this manual.

**Dr. Abdul Kareem Abdul Jawwad**

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# Experiment No.: 1

# Experiment title: Mechanical Behaviour of Metallic Materials

**Objectives**:

- Familiarity with mechanical testing of metallic materials
- Familiarity with the type of equipment and specimens used for tensile testing
- Interpretation of tensile testing results
- Appreciation of Engineering Stress-Strain and True Stress-Strain Curves
- Appreciation of the elastic and plastic regions
- Appreciation of different mechanical properties obtained through tensile testing

**Expected outcomes:** at the end of this experiment the students should be able to:

- Draw and/or (plot using different software) the Engineering Stress-Strain and the True Stress-Strain curves
- Determine some mechanical properties such as: Yield Strength, Modulus of Elasticity, Modulus of Resilience, Ultimate Tensile Strength (UTS), Fracture Stress, Ductility and Toughness of metallic materials
- Determine the Mechanical Behaviour Equation for metallic materials
- Convert between Engineering Stress Strain values to True Stress Strain values
- Determine sources of error in the experiment

**Theoretical background:**

Engineering stress: $\sigma_{ENG} = F/A_o$

Engineering strain: $\varepsilon_{ENG} = (l_f - l_o)/l_o = \Delta l/l_o$

True Stress: $\sigma_{True} = F/A$

True Strain: $\varepsilon_{True} = \ln(l_f/l_o) = \ln(A_o/A_f)$

True Stress: $\sigma_{True} = \sigma_{ENG} .EXP(\varepsilon_{True})$; within the uniform elongation regime

True Strain: $\varepsilon_{True} = \ln(1 + \varepsilon_{ENG})$; within the uniform elongation regime

$UTS = F_{max}/A_o$

Ductility = $(\Delta l/l_o) \times 100\%$

Ductility = $(\Delta A/A_o) \times 100\%$

General Mechanical Behaviour Equation (only for True Stress-Strain Curves): $\sigma = K\varepsilon^n$

**Materials and Equipment:**

- Universal Tensile Testing Machine (UTM); Figure (1)
- Steel tensile specimens of different thicknesses; Figure (2), (two specimens for each thickness)
- Aluminium tensile specimens of different thicknesses; Figure (2), (two specimens for each thickness)

**Experimental Procedure:**

1- Take a photo of each specimen before testing

2- Measure the width and thickness of each specimens at two different locations and calculate the cross sectional area. Find the average and record your values in both $m^2$ and $mm^2$; Table (1)

3- Measure the gauge length of each specimen and record your values in Table (1)

4- Observe the laboratory technician loading the different specimens onto the UTM and take necessary notes

5- Observe the tensile test (both on the machine and on the associated computer screen) for each specimen and record notes as appropriate

6- Observe the change of mechanical load values and take a record of the maximum value

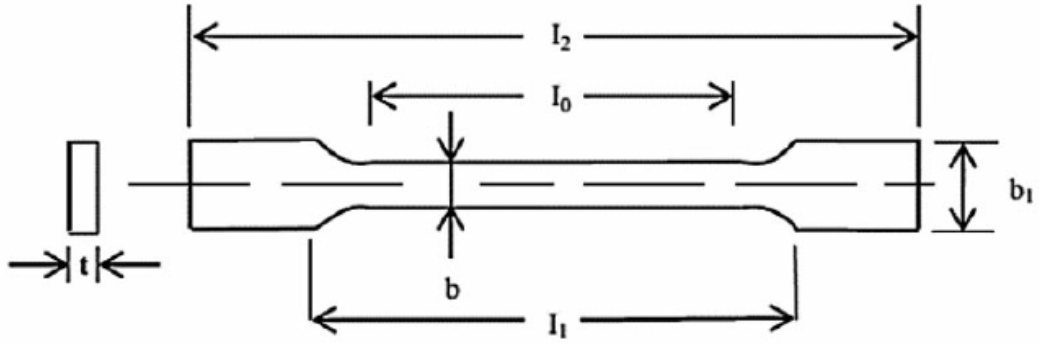
7- After the final breakage of each specimen observe the technician unloading the specimen with proper safety precautions

8- For each specimen measure / record the following:

- Take a record of the final value of the mechanical load at fracture
- Observe the reading of the extensometer and record your data in Table (1)
- Bring the two halves of each specimen close (but not touching) to each other and take a photo
- Measure the width and thickness at the fracture location on both halves of the specimen and calculate the final cross sectional area, then find the average and record your data in Table (1)
- Produce both the Engineering Stress-Strain and the True Stress-Strain curves
- Fill in the remaining values for the different mechanical properties in Table (2)
- Derive the mechanical behaviour equation showing your calculations on a separate sheet
- Explain the difference in experimental results
- Include a photo of each specimen before and after fracture and comment on these images
- List expected sources of error
- Right your own conclusions and comment on the results



Figure (1): Tensile Testing Machine (UTM)




| Symbol | Description | Dimension(mm) |
|---|---|---|
| $I_0$ | Gauge length | 25 |
| $I_1$ | Grip distance | 66 |
| $I_2$ | Overall length | 88 |
| b | Width of narrow parallel portion | 8 |
| $b_1$ | Width at ends | 12 |
| t | Thickness | 3 |

Figure (2): Terminology and dimensions of tensiletest specimens

Table (1): Experimental measurements for the tensile test specimens

| Material | $A_o$: $mm^2$ ($m^2$) | $L_o$: mm (m) | $A_f$: $mm^2$ ($m^2$) | $L_f$: mm (m) | $F_{Max}$ (kN) | $F_{Fracture}$ (kN) |
|---|---|---|---|---|---|---|
| Al (1) | | | | | | |
| Al (2) | | | | | | |
| Steel (1) | | | | | | |
| Steel (2) | | | | | | |

Table (2): Calculated mechanical properties of the tested specimens

| Material | Yield Stress(MPa) | Modulus of Elasticity (GPa) | UTS(MPa) | Ductility (from Δl): % | Ductility (from ΔA): % | Modulus of Resilience ($kJ/m^3$) | Fracture Stress: (MPa) |
|---|---|---|---|---|---|---|---|
| Al (1) | | | | | | | |
| Al (2) | | | | | | | |
| Steel (1) | | | | | | | |
| Steel (2) | | | | | | | |