**MECHANICS OF MATERIALS**

EF-321 L

**LAB Report**



Department of Mechanical Engineering

School of Engineering

University of Management and Technology, Lahore, Punjab, Pakistan

Program: \_\_\_\_\_\_\_\_Industrial Engineering\_\_\_\_\_

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Student I.D: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Course Learning Outcomes (CLOs):**

At the end of the course students should be able to:

* **CLO-1: Reacts** to standardized experimental procedure to take readings accurately. **(P2)**
* **CLO2: Measure** the results obtained from the experiments. **(P5)**
* **CLO-3: Comply** with instructions to perform experiments and respond to questions. **(A2)**

Note: \*P, A, C stand for psychomotor, affective, cognitive domains of Bloom’s taxonomy respectively. The numeric value refers to the corresponding level in each domain. For details regarding Bloom’s taxonomy, please see the annexure at the end of the manual.

**Mapping of CLOs to Program Learning Outcomes (PLOs):**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **Semester** | **Course Code** | **Title** | **Course Learning Outcomes** | **PLO 1** Engg . Knowledge | **PLO 2** Problem Analysis | **PLO 3** Solution Design | **PLO 4** Investigation | **PLO 5** Mod. Tool Usage | **PLO 6** Engr. & Society | **PLO 7** Env. & Sust. | **PLO 8** Ethics | **PLO 9** Team Work | **PLO 10** Communication | **PLO 11** Proj. Mgmt. | **PLO 12** Lifelong Learning |
| **5th** | **EF-321L** | **Mechanics of Materials lab** | * **CLO-1: Reacts** to standardized experimental procedure to take readings accurately. **(P2)** | **✓** |  |  |  |  |  |  |  |  |  |  |  |
| * **CLO2: Measure**  the results obtained from the experiments. **(P5)** |  |  |  |  | **✓** |  |  |  |  |  |  |  |
| **CLO-3: Comply**  with instructions to perform experiments and respond to questions. **(A2** |  |  |  |  |  |  |  |  | **✓** |  |  |  |

**Grade Evaluation Criteria**

|  |  |
| --- | --- |
| **Components** | **Marks** |
| Lab Sessional | 50 |
| Final Performance | 25 |
| Final Viva | 25 |
| Total | 100 |

|  |  |
| --- | --- |
| C:\Users\20223\Desktop\UMT_Logo_Pk.jpeg**UNIVERSITY OF MANAGEMENT AND TECHNOLOGY LAHORE**  **SCHOOL OF ENGINEERING**  **DAPARTMENT OF Mechanical ENGINEERING**  **Program: BS Industrial Engineering** | |
| **EF-321L**  **Mechanics OF Materials Lab (Updated)** | |
| **S.NO** | **EXPERIMENT TITLE** |
| **1** | Orientation of Mechanics of materials lab and to draw the layout of lab. |
| **2** | To verify the validity of Hooke’s law and determine the spring constant. |
| **3** | To determine the relationship between shear load and shear strain. |
| **4** | To find the shear modulus of bar under torsional loading. |
| **5** | To determine the tensile strength of a Mild steel bar with the help of universal testing machine |
| **6** | To determine the compressive strength of a Mild steel bar with the help of universal testing machine |
| **7** | To determine central deflection of Simply supported loaded at mid span. |
| **8** | To analyze the response of metal under bending and determine bending strength of the specimen. |
| **9** | To determine central deflection of a fixed ended beam loaded at mid span |
| **10** | To determine deflection for a cantilever beam |
| **11** | To determine the horizontal deflection and vertical deflection of different curved beams due to point loading. |

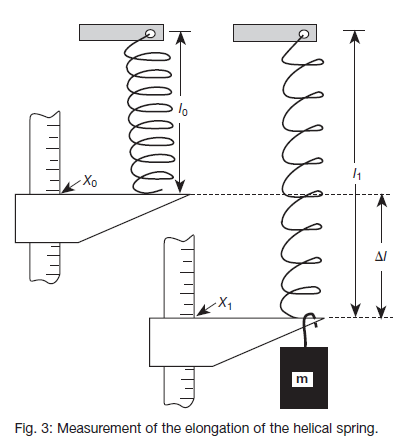
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| **EF-321 L Mechanics of Materials Lab** | **LAB 1** |

**Objective**

Orientation of Mechanics of materials lab.

**HOOK’SLAW**

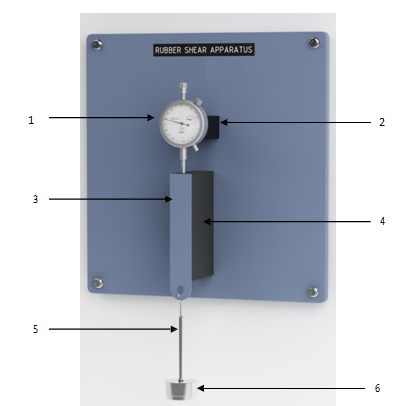
The Hooke’s Law Apparatus is a practical application of hook’s law of elasticity. This law is an approximation that states that the extension of a spring is in direct proportion with the load applied to it. Many materials obey this law as long as the load does not exceed the material's elastic limit. Materials for which Hooke's law is a useful approximation are known as linear-elastic or "Hookean" materials. Hooke's law in simple terms says that strain is directly proportional to stress.



**Figure** Error! No text of specified style in document.**‑1 Hooke's Law Apparatus**

**Shear Stress Apparatus:**

The force which tends to cut off or parts off one portion of the component from the other is called shear force.

****Stresses produced on the area under shear, due to shearing forces, are called shearing Stresses. Shear stress is denoted by **τ**.

**Figure** Error! No text of specified style in document.**‑2 Shear Stress Apparatus**

**Universal Testing Machine**

****A universal testing machine, also known as a universal tester materials testing machine or   
materials test frame, is used to test the tensile stress and compressive strength of materials.   
It is named after the fact that it can perform many standard tensile and compression tests on  
 materials, components, and structures.

Figure **Error! No text of specified style in document.**‑3Figure 3 Universal Testing Machine

According to the loading type, there are two kinds of tensile testing machines.

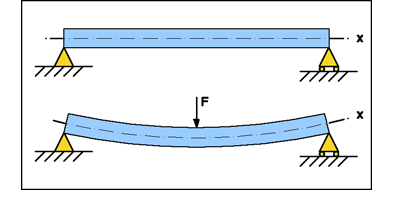
* **Screw Driven Testing Machine:** During the experiment, elongation rate is kept constant.
* **Hydraulic Testing Machine:** Keeps the loading rate constant.   
  The loading rate can be set depending on the desired time to fracture.

The Universal Testing Machine Apparatusunit consists of Tension and compression section   
as well as, a control box connected with computer for obtaining graph and required values

**Beams:**

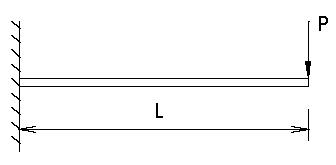
1. **Simply supported beam**

A simply supported beam is a type of beam that has pinned support at one end and roller support at the other end. Depending on the load applied, it undergoes shearing and bending. It is the one of the simplest structural elements in existence



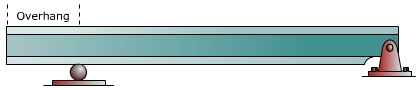
**Figure** Error! No text of specified style in document.**‑4 Simply supported beam**

1. **Cantilever beam**

A cantilever beam is fixed at one end and free at other end. It can be seen in the image below  
  


**Figure** Error! No text of specified style in document.**‑5 Cantilever beam**

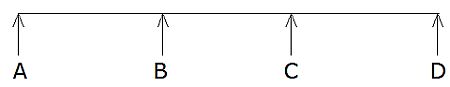
1. **Overhanging beam**

An overhanging beam is a beam that has one or both end portions extending beyond its supports. It may have any number of supports. If viewed in a different perspective, it appears as if it is has the features of simply supported beam and cantilever beam.  
  


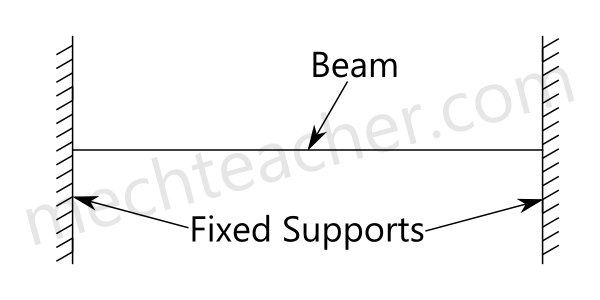
**Figure** Error! No text of specified style in document.**‑6 overhanging beam**

1. **Continuous beam**

A continuous beam has more than two supports distributed throughout its length. It can be understood well from the image below.



**Figure** Error! No text of specified style in document.**‑7 continuous beam**

1. .**Fixed beam** fixed beam is a type of beam whose both ends are fixed  
     
   

**Figure** Error! No text of specified style in document.**‑8 Fixed beam**

**Buckling Apparatus:**

There are usually two primary concerns when analyzing and designing structures: (1) the ability of the structure to support a specified load without experiencing excessive stress and (2) the ability of the structure to support a given load without undergoing unacceptable deformation. In some cases, however, stability considerations are important especially when the potential exists for the structure to experience a sudden radical change in its configuration. These considerations are typically made when dealing with vertical prismatic members supporting axial loads. Such structures are called columns. A column will buckle when it is subjected to a load greater than the critical load denoted by Pcr. That is, instead of remaining straight, it will suddenly become sharply curved as illustrated in Figure

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**Figure** Error! No text of specified style in document.**‑9 Buckling Apparatus**

**Procedure:**

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| **EF-321 L Mechanics of Materials Lab** | **LAB 2** |

**Objective**

To verify the validity of Hooke’s law and determine the spring constant.

**Apparatus**

Hooke’s law apparatus, Weights, scale, stand. Hanger.

**Theory**

**HOOK’SLAW**

The Hooke’s Law Apparatus is a practical application of hook’s law of elasticity. This law is an approximation that states that the extension of a spring is in direct proportion with the load applied to it. Many materials obey this law as long as the load does not exceed the material's elastic limit. Materials for which Hooke's law is a useful approximation are known as linear-elastic or "Hookean" materials. Hooke's law in simple terms says that strain is directly proportional to stress.

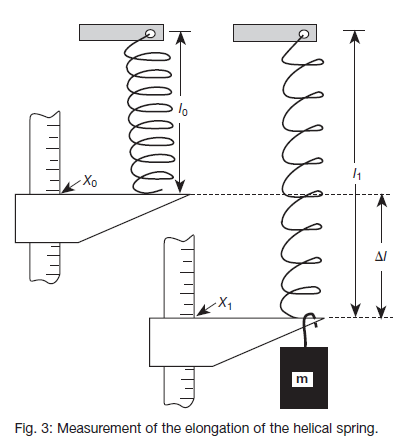
Mathematically, Hooke's law states that

Where

* **X** is the displacement of the spring's end from its equilibrium position (a distance, in SI units: meters);
* **F** is the restoring force exerted by the spring on that end (in SI units: N or kg•m/s2); and
* **K** is a constant called the rate or spring constant (in SI units: N/m or kg/s2).

When this holds, the behavior is said to be linear. If shown on a graph, the line should show a direct variation. There is a negative sign on the right-hand side of the equation because the restoring force always acts in the opposite direction of the displacement (for example, when a spring is stretched to the left, it pulls back to the right).

When forces act on a solid body, the resulting deformation (translation and rotation movements are suppressed in the following) depends to a large extent on the material as well as on the size and on the direction along which the exterior forces act. When the solid body regains its original shape after the exterior force stops acting, that is, the interior restoring forces of the material can bring the solid body back to its original equilibrium position, the material is called elastic.

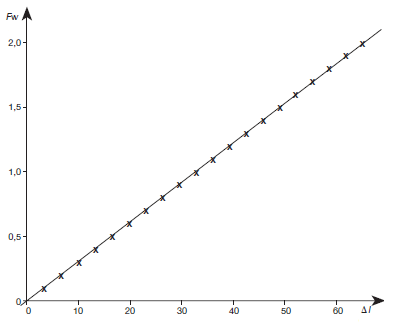
A helical spring is a very simple example of an elastic body (Fig.3). In addition, if deviations Δ*l* from the equilibrium position *l0* of the helical spring are not very large, the restoring force *FR* of the spring is found to be proportional to its elongation (or to its compression) Δ*l*:

**Figure** Error! No text of specified style in document.**‑10 Hooke's Law Apparatus**

This is Hooke’s law or the linear law of forces, where the proportionality constant D, which is a general magnitude of reference, is called the spring constant in the case of a helical spring. If an exterior force acts on the spring, such as the weight FW = m · g of a mass m (g = 9.81 m/s2: acceleration of terrestrial gravity) in this experiment, a new stable equilibrium is reached for the length of the spring , for which the weight mass m is equal to the restoring force of the spring.

The elongation of the helical spring is therefore proportional to the forces *FW* exerted by the weights:

as is also shown by the characteristic curves of a helical springs. The slope of the characteristic curves is the respective spring constant *K* of the helical springs.



**Figure** Error! No text of specified style in document.**‑11 characteristic curves of a helical springs**

Thus, forces required to cause a given elongation of the spring increase proportionally with the spring constant.

**Procedure:**

The first step is to note down the initial reading on the scale. After that apply load on the hanger and checked the extension produced in the spring this procedure is continued for four readings. After that it is unloaded an again note the reading. calculate the spring constant by given formula.

**Unit Assembly**

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**Figure** Error! No text of specified style in document.**‑12 Unit Assembly**

**Observations**

Initial length *lo*:

Initial position *xo*:

**For soft spring**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr.#** | **Force(N)** | **Loading** | **Unloading** | **Mean** | **Change In Length**  **ΔL** | **K=F\ ΔL(exp)** | **K(Th)** |
| 1 | 0.5 |  |  |  |  |  |  |
| 2 | 1.0 |  |  |  |  |  |
| 3 | 1.5 |  |  |  |  |  |
| 4 | 2.0 |  |  |  |  |  |
|  | | | | | | | |

**For Hard Spring**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr.#** | **Force(N)** | **Loading** | **Unloading** | **Mean** | **Change In Length**  **ΔL** | **K=F\ ΔL(exp)** | **K(Th)** |
| 1 | 3 |  |  |  |  |  |  |
| 2 | 6 |  |  |  |  |  |
| 3 | 9 |  |  |  |  |  |
| 4 | 12 |  |  |  |  |  |

## Procedure (Students’ own words)

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## Difficulties / Suggestions

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**Concluding Remarks / Comments**

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**Questions**

1. **Various methods to calculate spring constant?**

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1. **Why the values of experimental and theoretical spring constant different?**

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1. **How to improve experimental procedure?**

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| **EF-321 L Mechanics of Materials Lab** | **LAB 3** |

**Objective**

To determine the relationship between shear load and shear strain.

**Apparatus**

Rubber shear apparatus, Hanger, Weights, Dial Gauge,

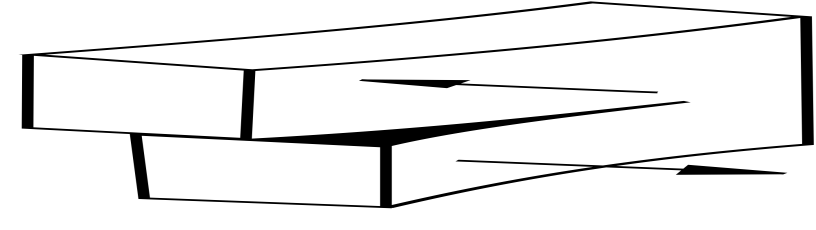
**Theory**

The force which tends to cut off or parts off one portion of the component from the other is called shear force.

Stresses produced on the area under shear, due to shearing forces, are called shearing Stresses. Shear stress is denoted by **τ**.

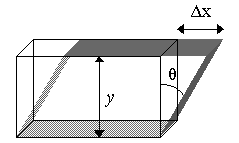
Mathematically,

**Shearing stress = Shearing force/ Area under shear**



**Figure** Error! No text of specified style in document.**‑13 Shear Stress**

Shearing strain is the angle of distortion. It can be represented by **γ.**



**Figure** Error! No text of specified style in document.**‑14 Shear Strain**

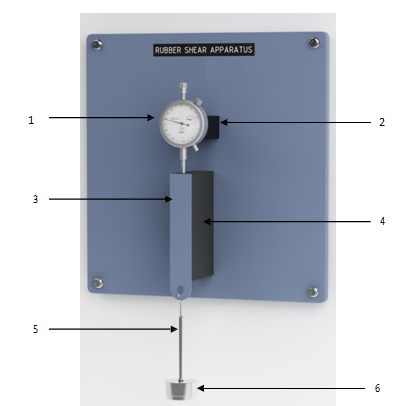
**θ=Tan-1(Δx\y)**

The constant of proportionality relating shear stress and shear strain is modulus of rigidity. It is represented by **G**.

Mathematically,

**G = Shear stress/ shear strain**

Units of G: Newton per square meter (N/m2) = Pascal (Pa) or pounds per square inch (psi)

**Apparatus assembly**

**Figure** Error! No text of specified style in document.**‑15 Apparatus Assembly**

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | Dial Gauge | 2. | Dial Gauge Holder |
| 3. | Flat Steel Bar | 4. | Shear Element (Rubber) |
| 5. | Weight Holder | 6. | Weights |

**Procedure:**

* First, measure the length width and height of rubber
* Set dial gauge to zero
* Apply the weight of 10N and increase to 100 N
* Using all thee these readings calculate the shear strain, shear stress, shear modulus.

**Observations**

Height=h=

Width=w=

Length=l=

Area= H\*w

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sr. No | Force  (N) | Shear Deformation-δs | | | γ=ᵟs\l | τ=F\A | G=τ\γ |
| Loading | Unloading | Mean |
| 1 | 10 |  |  |  |  |  |  |
| 2 | 20 |  |  |  |  |  |  |
| 3 | 30 |  |  |  |  |  |  |
| 4 | 40 |  |  |  |  |  |  |

## Procedure (Students’ own words)

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## Difficulties / Suggestions

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**Concluding Remarks / Comments**

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**Questions**

1. **Various methods to determine shear modulus of rubber?**

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1. **How to eradicate errors?**

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1. **How to improve experimental procedure?**

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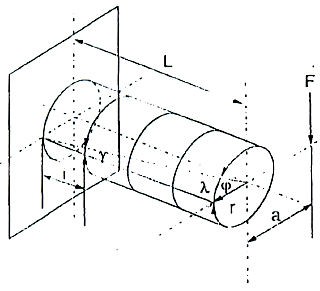
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| **EF-321 L Mechanics of Materials Lab** | **LAB 4** |

**Objective**

To find out the shear modulus of rods under torsional loading.

**Apparatus**

Torsion of bar apparatus, vernier caliper, weights.

**Theory**

**Figure** Error! No text of specified style in document.**‑16 Torsion**

L: Bar length r: Bar radius

r: Bar radius

φ: Torsion angle λ: Sector

y: Angle of slip

A cylindrical bar with length L is securely clamped at one end. If a force F is applied, which acts on the lever arm in a plane perpendicular to the bar axis, the oar is subjected to torsion by the moment

M = F ∙ a (1)

Where F: Force in N

a: Lever arm in m.

This load case is the basis for the experiment. One drill chuck act as a fixed clamp, while the other drill chuck (free end of bar) is on double ball bearings.

The lever arm is: a = 100 mm

The length of the test bar is given by the dimension between the front edges of the drill chuck clamping brackets. The tape measure suitable for internal measurements should be used to measure the length.

In some measurements, the torsion of the drill chucks or the cone shaped mandrels is negligible compared to the torsion of the test bars.

In most cases, the inherent torsion of the equipment is determined in a preliminary experiment and then taken into account.

The deflection of the load lever is so low as not to influence the measuring results. The moment of friction in the ball bearings does not influence the measuring results.

**Formula For Torsion**

**Shearing strain y:**

The shearing strain is the shearing strain of two cross sections to one another in terms of the unit of length L.

y = λ / L (2)

Reciprocal of coefficient of rigidity/ Reciprocal of shear modulus þ:

The reciprocal of the coefficient of rigidity is

þ = y / τt [mm2 / N] (3)

Modulus of elasticity in shear or rigidity G:

The glide ratio or reciprocal of coefficient of rigidity is the reciprocal value of the modulus of rigidity

G = 1 / þ [N / mm2] (4)

Shear stress τt : Hooke's law for torsion Shear stress on radius r

τt = G ∙ y (5)

Shear stress in surface area τtmax

Where Wp: Polar moment of resistance

Mt: Torsion moment

τtmax = Mt/Mp (6)

Angle of rotation in radian measure where Ip: Polar moment of inertia

φ = Mt ∙ L / G ∙ IP (7)

Angle of rotation in degrees

φ = 180o ∙ Mt ∙ L / π ∙ G ∙ IP (8)

Specific angle of rotation

The specific angle of rotation is an angle rotation related to the length

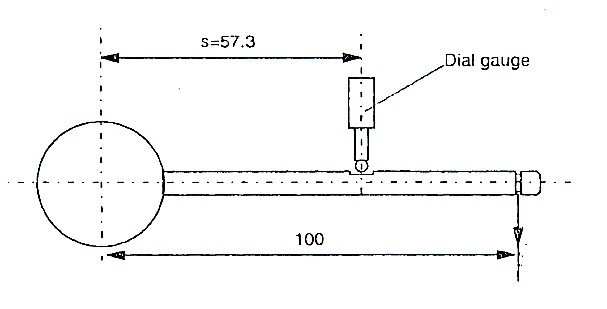
θ = Mt / G ∙ IP [ o / cm] ; [ 1 / cm] (9)

Polar moment of inertia for circular cross section

IP = π ∙ d4 / 16 (10)

Polar moment of resistance for circular cross section

WP = π ∙ d3 / 16 (11)

**The Torsion Load *Lever***

**Figure** Error! No text of specified style in document.**‑17 Load lever**

The dial gauge is a distance of s =57.3 mm from the axis of rotation.

φ = b/s

For a small angle:

For a small angle φ, the sector b can be very accurately replaced by direct display on the dial gauge y.

Then, φ = y/s = y/57. γmm

To simplify the conversion between degrees and radian measure, a distance of 57.3 mm has been selected.

Since: φ = φ”

β ∙ π = γ60o

1/57.3 = 1

Therefore

1mm on the dial gauge corresponds to an angle of rotation of 10

Note on modulus of elasticity in shear In many materials, the modulus of elasticity E of the material is specified rather than the modulus of elasticity in shear G.

The following relationship exists between G and E:

***G = m/2(m+1). E***

m: Poisson’s constant, for metals = 10/γ

G ≈ 0.385 ∙ E

**Procedure:**

1. Loosen the chucks with key.
2. Move the slider to hold the lever arm.
3. Place the test bar between the chucks by passing it from the extreme end of right-hand chuck.
4. Tighten the chucks by using chuck keys.
5. Set the dial gauge at the point marked as a line which is 59.3mm from central axis.
6. Pre stress the dial gauge to 10mm.
7. Now make the slider to move away.
8. Place hanger on the slot of lever arm. Make the value on dial gauge as zero by revolving the aluminum dial.
9. Add load and find out the torsion hence shear modulus.

**Observations**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sr. # | Diameter of rod  d (mm) | Length of specimen between chucks  L  (mm) | Load added m (Kg) | Displacement on dial gauge y  (mm) | Shear modulus G  (N/mm2) |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |

## Procedure (Students’ own words)

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_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## Difficulties / Suggestions

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**Concluding Remarks / Comments**

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**Questions**

1. **What types of error can occur during experiment?**

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1. **How to improve experimental procedure?**

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| **EF-321 L Mechanics of Materials Lab** | **LAB 5** |

**Objective**

To determine the tensile strength of a Mild steel bar with the help of universal testing machine also draw stress strain curve.

**Apparatus**

Universal testing machine, Mild steel specimen

**Theory**

**Universal Testing Machine**

A universal testing machine, also known as a universal tester materials testing machine or   
materials test frame, is used to test the tensile stress and compressive strength of materials.   
It is named after the fact that it can perform many standard tensile and compression tests on  
 materials, components, and structures.

According to the loading type, there are two kinds of tensile testing machines.

* **Screw Driven Testing Machine:** During the experiment, elongation rate is kept constant.
* **Hydraulic Testing Machine:** Keeps the loading rate constant.   
  The loading rate can be set depending on the desired time to fracture.

The Universal Testing Machine Apparatusunit consists of Tension and compression section   
as well as, a control box connected with computer for obtaining graph and required values

**Tension Test**

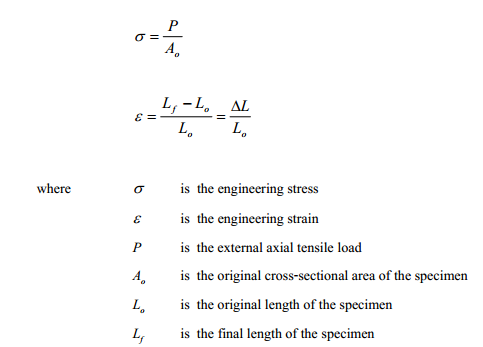
The tensile testing is carried out by applying longitudinal or axial load at a specific extension rate to a standard tensile specimen with known dimensions (gauge length and cross-sectional area perpendicular to the load direction) till failure.

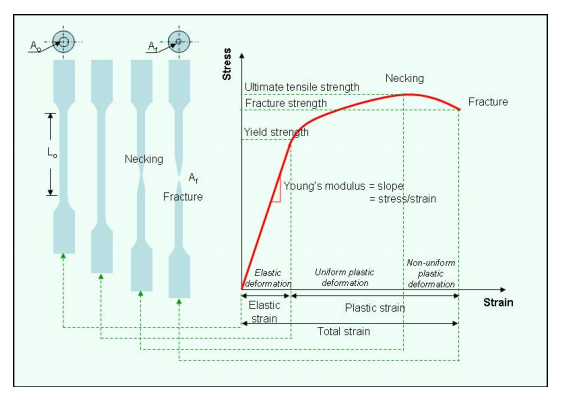
The most common type of test used to measure the mechanical properties of a material is the Tension Test. Tension test is widely used to provide basic design information on the strength of materials and is an acceptance test for the specification of materials. The major parameters that describe the stress-strain curve obtained during the tension test are the tensile strength (UTS), yield strength or yield point (σy), elastic modulus (E), percent elongation (ΔL%) and the reduction in area (RA%). Toughness, Resilience, Poisson’s ratio (ν) can also be found by the use of this testing technique.

**Stress and strain relationship**

When a specimen is subjected to an external tensile loading, the metal will undergo elastic

And plastic deformation. Initially, the metal will elastically deform giving a linear relationship of load and extension. These two parameters are then used for the calculation of the engineering stress and engineering strain to give a relationship as illustrated in figure.





**Figure** Error! No text of specified style in document.**‑18 Stress-Strain curve**

**Elastic *Region***

The part of the stress-strain curves up to the yielding point.

Elastic deformation is recoverable. In the elastic region, stress and strain are related to each other linearly.

**Hooke’s Law: σ =Ee**

The linearity constant E is called the elastic modulus which is specific for each type of material.

**Plastic Region**

The part of the stress-strain diagram after the yielding point.

At the yielding point, the plastic deformation starts. Plastic deformation is permanent. At the maximum point of the stress-strain diagram (UTS) at which necking starts.

***Tensile Strength*** is the maximum stress that the material can support.

**σUTS=Pmax/Ao**

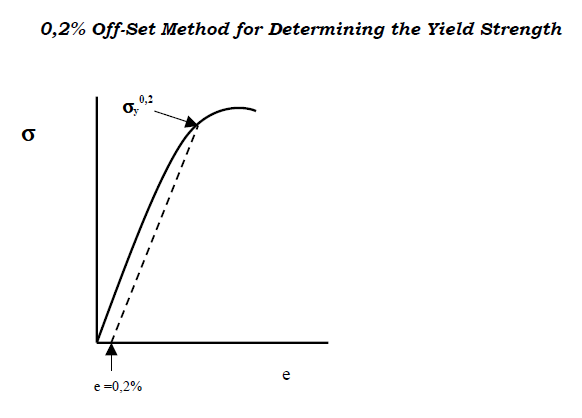
Because the tensile strength is easy to determine and is a quite reproducible property, it is useful for the purposes of specifications and for quality control of a product. Extensive empirical correlations between tensile strength and properties such as hardness and fatigue strength are often quite useful for brittle materials; the tensile strength is a valid criterion for design.

**Yield Strength**

Yield strength is the stress level at which plastic deformation starts. The beginning of first plastic deformation is called ***yielding***. It is an important parameter in design.

The stress at which plastic deformation or yielding is observed to begin depends on the sensitivity of the strain measurements. With most materials there is a gradual transition from elastic to plastic behavior, and the point at which plastic deformation begins is hard to define with precision. Various criteria for the initiation of yielding are used depending on the sensitivity of the strain measurement and the intended use of the data.

0.2% off-set method is a commonly used method to determine the yield strength. σy(0.2%) is found by drawing a parallel line to the elastic region and the point at which this line intersects with the stress-strain curve is set as the yielding point. An illustration of 0.2% off-set method is shown in the Figure.



**Figure** Error! No text of specified style in document.**‑19 Off-set method**

**Ultimate Tensile Strength**

Beyond yielding, continuous loading leads to an increase in the stress required to permanently deform the specimen as shown in the engineering stress-strain curve. At this stage, the specimen is strain hardened or work hardened. The degree of strain hardening depends on the nature of the deformed materials, crystal structure and chemical composition.

**Ductility**

Ductility is the degree of plastic deformation that a material can withstand before fracture. A material that experiences very little or no plastic deformation upon fracture is termed brittle. In general, measurements of ductility are of interest in three ways

To indicate the extent to which a metal can be deformed without fracture in metalworking operations such as rolling and extrusion.

To indicate to the designer, in a general way, the ability of the metal to flow plastically before fracture.To serve as an indicator of changes in impurity level or processing conditions. Ductility measurements may be specified to assess material quality even though no direct relationship exists between the ductility measurement and performance in service.

Ductility can be expressed either in terms of percent elongation (z) or percent reduction in area (q);



**Resilience**

Resilience is the capacity of a material to absorb energy when it is deformed elastically.

**Toughness**

Toughness ***is*** a measure of energy required to cause fracture.

**Poisson’s Ratio**

Poisson’s Ratiois the lateral contraction per unit breadth divided by the longitudinal extension per unit length.



**Procedures**

* Firstly, place the steel rod between two jaws of UTM
* One end is placed in upper jaw and other end is placed in lower jaw.
* Apply load with the help of UTM.
* The length of the rod increasing as we applying load with the help of UTM
* Then the point came where necking starts and after few seconds it will break.

**Observations**

Initial length =Lo=

Initial Diameter=Do

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No** | **Force**  **(KN)** | **Deformation**  **(δ)** | **ΔL** | **Strain=ΔL\L** | **Stress=F\A**  **(N\m2)** |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |

## Procedure (Students’ own words)

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## Difficulties / Suggestions

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**Concluding Remarks / Comments**

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**Questions**

1. **Types of errors during the experiment?**

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1. **How to improve experimental procedure?**

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| **EF-321 L Mechanics of Materials Lab** | **LAB 6** |

**Objective**

To find the compressive strength of materials using universal testing machine also draw stress strain curve.

**Apparatus**

Universal testing machine, Mild steel bar specimen, Vernier caliper

**Theory**

**Compression Test**

A compression test is a method for determining the behavior of materials under a compressive load. Compression tests are conducted by loading the test specimen between two plates and then applying a force to the specimen by moving the crossheads together. The compression test is used to determine elastic limit, proportionality limit, yield point, yield strength and compressive strength.

**Compressive Strength**

Compressive strengthis the maximum compressive stress that a material is capable of withstanding without fracture. Brittle materials fracture during testing and have a definite compressive strength value. The compressive strength of ductile materials is determined by their degree of distortion during testing.

Structure components such as columns and structures are subjected to compressive load in applications. These components are made of high compressive strength materials. Not all the materials are strong in compression. Several materials, which are good in tension, are poor in compression. Many materials poor in tension are good in compression. Cast iron is one such example. This strength is determined by conducting a compression test. During the test, the specimen is compressed and deformation vs. the applied is recorded.

Compression test is just opposite in nature to tensile test. Nature of deformation and fracture is quite different from that in tensile test. Compressive load tends to squeeze the specimen. Brittle materials are generally weak in tension but strong in compression. Hence this test is normally performed on cast iron, cement concrete etc. But ductile materials like Aluminum and mild steel which are strong in tension are also tested in compression.



**Procedures**

* First Place the specimen in the jaws of the UTM
* Apply the load on the specimen.
* The specimen starts deforming as when applied load on it.
* Note the reading as we noted in previous experiment.

**Observations & Calculations**

Initial length=Lo=

Original diameter=Do=

Area=Ao=

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sr. No** | **Force** | **Displacement** | **Change in length** | **strain** | **stress** | **Modulus of elasticity** |
|  | N | mm | mm |  | KN\m2 | KN\m2 |
| 1 |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |

## Procedure (Students’ own words)

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\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

## Difficulties / Suggestions

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Concluding Remarks / Comments**

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**Questions**

1. **How to eradicate the errors?**

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1. **How to improve experimental procedure?**

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|  |  |
| --- | --- |
| **EF-321 L Mechanics of Materials Lab** | **LAB 7** |

**Objective**

To determine central deflection of a simply supported beam loaded at mid span.

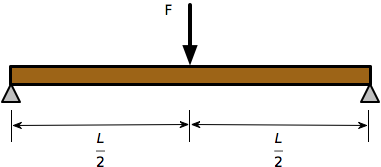
**Apparatus**

Fixed beam apparatus, hanger, weight, meter rod, vernier caliper, dial gauge.

**Theory**

**Simply Supported Beam**

A beam that is supported at both ends. It allows rotation at either end(support) but doesn't allow for vertical movement. As a result of this vertical reactions are produced at the supports as movement or displacement is not allowed in the vertical direction. But the supports are free from rotational moments (reactions).



**Figure** Error! No text of specified style in document.**‑20 Simply Supported Beam**

**Procedure**

* Set deflection of the beam apparatus\set dial indicator at zero\
* Apply a load and measure deflection using dial indicator
* Take a set of readings while loading and unloading the hanger and find the average value of experimental deflection
* Measure the length, width and height of the beam using meter rod and vernier caliper & calculate the theoretical value of deflection using the given formula
* Compare the experimental & theoretical values of deflection

**Observations and calculations**

Effective length of beam=L=…………in

Width of beam=w=………….in

Height of beam=h=…………in

Area Moment of inertia =I=wh3/12=…….in4

Modulus of Elasticity=E …………. psi

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sr. No | Experimental Deflection  ᵟce | | | Theoretical Deflection(in)  ᵟCT  =WL3\48EI |
| Loading | Unloading | Average |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |

## Procedure (Students’ own words)

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## Difficulties / Suggestions

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**Concluding Remarks / Comments**

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**Questions**

1. **Why there is a difference between experimental and theoretical values?**

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1. **What types of error can occur during experiment?**

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1. **How to improve experimental procedure?**

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| **EF-321 L Mechanics of Materials Lab** | **LAB 8** |

**Objective**

To analyze the response of metal under bending and determine bending strength of the specimen.

**Apparatus**

Bend specimens, micrometer or Vernier caliper, permanent pen, universal testing machine.

**Theory**

**Bend or flexure testing**

Bend or flexure testing is common in springs and brittle materials whose failure behaviors are linear such as concretes, stones, woods, plastics, glasses and ceramics. Other types of brittle materials such as powder metallurgy processed metals and materials are normally tested under a transverse flexure. Bend test is therefore suitable for evaluating strength of brittle materials where interpretation of tensile test result of the same material is difficult due to breaking of specimens around specimen gripping. The evaluation of the tensile result is therefore not valid since the failed areas are not included in the specimen gauge length.

**Experimental procedure**

* Set the load pointer to zero by adjusting the initial setting knob
* Dial gauge is fixed and the specimen for measuring the bending test.
* Gripe the specimen In bending fixtures
* Set the automatic graph recording system
* Start the m\c and take the reading.

**Observations & Calculations**

Length=L=

Diameter=

Y=Distance between neutral axis and outer fiber=

I=for circular beams=πr4\4

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sr. No | Load(W)  KN | Deflection  (ᵟ) | M=WL\4  (N.m) | σ=MY\I  (pa) | E=WL3\48ᵟI  (Pa) |
| 1 |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |

## Procedure (Students’ own words)

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## Difficulties / Suggestions

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**Concluding Remarks / Comments**

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**Questions**

1. **What types of error can occur during experiment?**

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1. **How to improve experimental procedure?**

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| **EF-321 L Mechanics of Materials Lab** | **LAB 9** |

**Objective**

To determine central deflection of a fixed ended beam loaded at mid span.

**Apparatus**

Fixed ended beam apparatus, hanger, weights, Vernier caliper

**Theory**

**Beam**

A beam is a structural element that is capable of withstanding load primarily by resisting against bending. The bending force induced into the material of the beam as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment

**Types of Beams**

Beams can be classified into many types based on three main criteria. They are as follows

**Based on geometry**

1. **Straight beam**

The beam which is straight along length is called straight beams. These beams can be used everywhere its one example is that is used in roofs framing.

1. **Curved beam**

It is a member that have curved axis and is subjected to bending. curved beams find applications in many machine members such as clampers, crane hooks, chains, and links

1. **Tapered beams**

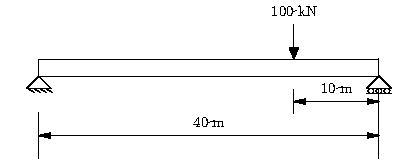
It is a member in which thickness of cross section changes gradually along axis.

**Based on the shape of cross section**

1. **I-beam** Beam with ‘I’ cross section
2. **T-beam** Beam with ‘T’ cross section
3. **C-beam** Beam with ‘C’ cross section

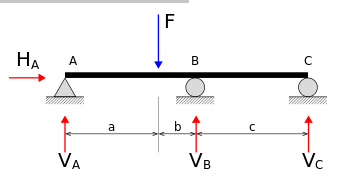
**Based on equilibrium conditions**

1. **Statically determinate beam**– For a statically determinate beam, equilibrium conditions alone can be used to solve reactions.

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**Figure** Error! No text of specified style in document.**‑21 Statically determinate beam**

1. **Statically indeterminate beam** – For a statically indeterminate beam, equilibrium conditions are not enough to solve reactions. Additional deflections are needed to solve reactions.

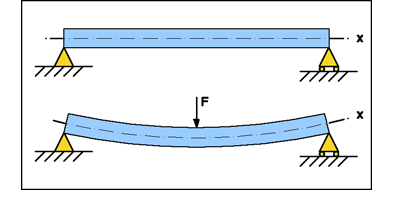


**Figure** Error! No text of specified style in document.**‑22 Statically indeterminate beam**

**Based on the type of support**

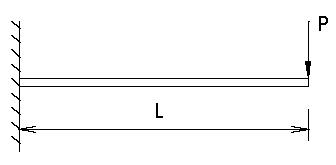
1. **Simply supported beam**

A simply supported beam is a type of beam that has pinned support at one end and roller support at the other end. Depending on the load applied, it undergoes shearing and bending. It is the one of the simplest structural elements in existence



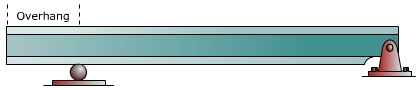
**Figure** Error! No text of specified style in document.**‑23 Simply Supported Beam**

1. **Cantilever beam**

A cantilever beam is fixed at one end and free at another end. It can be seen in the image below  
  


**Figure** Error! No text of specified style in document.**‑24 Cantilever beam**

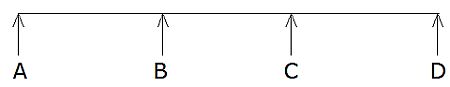
1. **Overhanging beam**

An overhanging beam is a beam that has one or both end portions extending beyond its supports. It may have any number of supports. If viewed in a different perspective, it appears as if it is has the features of simply supported beam and cantilever beam.  
  


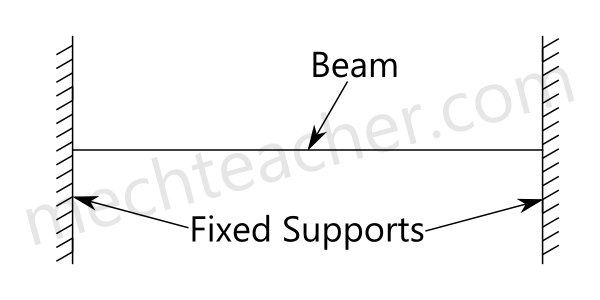
**Figure** Error! No text of specified style in document.**‑25 Overhanging beam**

1. **Continuous beam**

A continuous beam has more than two supports distributed throughout its length. It can be understood well from the image below.



**Figure** Error! No text of specified style in document.**‑26 Continuous beam**

1. . **Fixed beam** fixed beam is a type of beam whose both ends are fixed  
     
   

**Figure** Error! No text of specified style in document.**‑27 Fixed beam**

**Procedure**

* First of all, fixed the beam at both ends.
* Measure the length width and height of the beam by vernier caliper
* Set the dial gauge initially at zero
* Start applying the weight at the center of the beam
* Take readings by applying weights

**Observation & Calculations**

Effective length of beam, =L

Width of beam=w

Height of beam =h

Area moment of inertia=

Modulus of elasticity=

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sr. No | Applied load  (lb)  W | Experimental deflection  (in)  ᵟce | | | Theoretical deflection  (in)  ᵟcth=WL3/192I |
| Loading | Unloading | Mean |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |

## Procedure (Students’ own words)

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## Difficulties / Suggestions

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Concluding Remarks / Comments**

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**Questions**

1. **Why there is a difference between experimental and theoretical values?**

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1. **What types of error can occur during experiment?**

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1. **How to improve experimental procedure?**

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| **EF-321 L Mechanics of Materials Lab** | **LAB 10** |

**Objective**

To determine deflection for a cantilever beam.

**Apparatus**

Cantilever beam apparatus, hangers, vernier caliper, weights.

**Observation & Calculations**

Effective length of beam, =L

Area moment of inertia=

Modulus of elasticity=

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sr. No | Applied load  (lb)  W | Experimental deflection  (in)  ᵟex | | | Theoretical deflection  (in)  ᵟth=WL3/3EI |
| Loading | Unloading | Mean |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |

## Procedure (Students’ own words)

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## Difficulties / Suggestions

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**Concluding Remarks / Comments**

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**Questions**

1. **Define a cantilever beam?**

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1. **How strain energy store in beam?**

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1. **What is difference between strain energy method and double integration method?**

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| **EF-321 L Mechanics of Materials Lab** | **LAB 11** |

**Objective**

To determine the horizontal deflection and vertical deflection of different curved beams due to point loading.

**Apparatus**

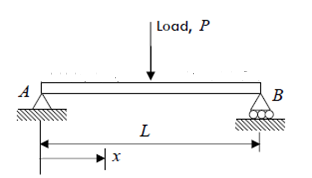
Beam, meter rod, hangers, spring balance, weights.

**Theory**

Though curved bars are not commonly found as structures by themselves, they are usually part of a mechanical member which has a combination of straight and curved elements. The study of how curved bars deflect is thus, important so as to estimate the total mechanical displacement of structures that incorporate curved sections. One of the more effective methods used to estimate deflections in curved bars come from Castigliano’s first theorem or from a unit-load method. This experiment puts the unit load approach to the test.

The Deformation of Curved Barswill demonstrate the actual behavior of curved bars set up in different configurations and comparisons will be made to the unit load method’s results. Sometimes, due to the complex nature of the integral involved, an approximate method such as Simpson’s Rule can be used instead of an analytical integration.

Energy method is a method of determining the stresses and deformations in structures subjected to both static and impact loading. For example, a beam such as shown in Fig. 1 that subjected to transverse loads, the strain energy associated with the normal stress is;



**Figure** Error! No text of specified style in document.**‑28 A simply supported Beam**



Here,

M = bending moment

E = Modulus of elasticity of beam material = ESS304 = 193-203 GPa

I = moment of inertia of the beam

EI = Flexural rigidity of beam

L = Length of beam

The moment of inertia of the beam can be found out by the following formula;

I=

Castigliano’s theorem states that the deflection *xj,* of the point of application of a load *Pj* measured along the line of action of *Pj* is equal to the partial derivative of the strain energy of the structure with the respect to the load *Pj.* It can be show as;



Hence, the theorem can be applied to determine deflections and slopes at various points of a given structure. The use of “dummy” loads enabled us to include points where no actual load was applied. The calculation of a deflection *xj* can be simplified if the differentiation with the respect to the load *Pj* was carried out before the integration. In the case of a beam, referring to equation (1) and (2), the deflection of a beam can be written as;



**Formulae:**



**Case 1**

Horizontal deflection and vertical deflection of ring beam due to point loading.

**Procedure**

* For the ring configuration, hang the ‘C’ hook from the bottom of the ring and attach the load hanger to it.
* The vertical dial is permanently set in its position while the right and left dials can be removed and used in the other experiments.
* Zero all three dials and read the initial zero-datum reading off them.
* Load the ring by increments of 5 N, up to 40 N. At each increment record the deflection at each dial and tabulate these in a table.

**Observations**

Width of ring=b=

Height of ring=h=

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sr.No | Load | Vertical Deflection(exp) | Horizontal deflection(exp) | | | Vertical deflection (th)  ΔV | Horizontal deflection (th)  ΔH |
| Left | Right | Total |
| 1 |  |  |  |  |  |  |  |
| 2 |  |  |  |  |  |  |  |
| 3 |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |

**Assignment**

* Draw the graph between vertical deflections (measured & calculated) on y- axis and load on x-axis.
* Draw the graph between Horizontal deflections (measured & calculated) on y- axis and load on x-axis

**Case 2**

Horizontal deflection and vertical deflection of semi-circle beam due to point loading.

**Procedure**

* Attach the hanger onto the semi-circle and apply a 2 N weight on it.
* This will stabilize the system and does not count as part of the weight that we will apply onto it..
* Secure the removable dials onto the semi-circle experiment setup to measure horizontal and vertical displacements.
* Zero the two dials and record the zero-datum reading.
* Load the member with weight increments of 2 N up to 14 N. At each increment record your results on a table.

**Observations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Load**  **(N)** | **Experimental Deflection**  **(mm)** | | **Theoretical Deflection**  **(mm)** | |
| **Horizontal** | **Vertical** | **Horizontal** | **Vertical** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Assignment**

* Draw the graph between vertical deflection (measured & calculated) on y-axis and load on x-axis.
* Draw the graph between Horizontal deflection (measured & calculated) on y- axis and load on x-axis.

## Procedure (Students’ own words)

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## Difficulties / Suggestions

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**Concluding Remarks / Comments**

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**Questions**

1. **Why there is a difference between experimental and theoretical values?**

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1. **What types of error can occur during experiment?**

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1. **How to improve experimental procedure?**

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